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A mathematical analysis of dialysis report and kidney function tests; a case study

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ABSTRACT

Chronic kidney disease (CKD) patients are need to do kidney functioning tests in a regular interval due to this time money as well as energy are affected. This study determines the difference of standard deviation of the patient's weight, systolic blood pressure (BP) and diastolic BP pre- and post-dialysis and observe the changes that takes place in the patients' health. Moreover, as the kidney functioning tests are time consuming and expensive, therefore in order to save time and money we want to give a mathematical solution for the benefit of mankind. The data of the CKD patients has been collected from medical college and hospital, Assam. The data collection was done randomly selecting 5 CKD patients and the data comprises of the body weight, BP of the patient pre dialysis and post dialysis. Analysis the data with some statistical tools (standard deviation, σ) and interpret the result. The difference of standard deviation of the patient's weight, BP of systolic and diastolic are measure pre and post dialysis, it is found either the patient is approaching towards good health or not.

Case Report

Implication for health policy/practice/research/medical education:
Since undergoing kidney function tests frequently is time consuming and expensive, therefore in order to save money and time, we can calculate the difference of standard deviation of the patients weight, systolic blood pressure, diastolic blood pressure and give an assumption that whether the patient's further reports will be normal or not and whether he need to go for further kidney function tests or not.

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Introduction

Chronic kidney disease (CKD) is nothing but a term known as umbrella which describes the damage kidney or a disease in the glomerular filtration rate (GFR)lasting for three months or more than 3 months. The term CKD, which is associated with reduce of the quality of human life, rise health care expenditures and early death. The consequences of an untreated CKD give end- stage kidney disease (ESKD) that means last stage of CKD (1). There is hazards that compromise cardiovascular disease, diabetes hypertension and obesity. As per recent report shows that 10% percent of the US population aged 20 years and older are suffering of CKD (2-4).

Diabetes is the primary cause of CKD. As per recent research on US population for the aged 20 years and above more than 35% with diabetes has CKD (5). Hypertension is the second most reason followed by glomerulonephritis and pyelonephritis; polycystic, hereditary or congenital disorder; and renal cancers. With the increasing prevalence of diabetes and hypertension among Indians there is concomitant increase in the prevalence of chronic renal failure and it is approximately estimated to be 6.3% (6). In India there has been an alarming increase in the death rate attribute to renal failure; it has increased from 1.9% in 2000 to 3.04% in 2015 (7).

Chronic kidney disease has been classified into five stages by the national kidney foundation. Stage 5 results when the kidneys cannot remove the body's metabolic wastes or perform their regulatory functions; thus, renal replacement therapies are required to sustain life. Screening and early intervention are important, because not all patients progress to stage 5 CKD. Patients with CKD are at increased risk for cardiovascular disease, which is the leading cause of morbidity and mortality (8). Treatment of hypertension, anemia, and hyperglycemia and detection of proteinuria all help to slow disease progression and improve patient outcomes. Phages are depending on the GFR. Standard rate of GFR is 125 mL/ min/ 1.73 m^2.

Some of the clinical manifestations/symptoms of

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CKD are:

1. Increased blood urea and serum creatinine level.
2. Edema starting as puffiness of face in the early morning and later bilateral pedal edema.
3. Weight gain.
4. Reduction in urine output.
5. Hiccoughs, nausea, vomiting, anorexia Breathing difficulty due to fluid overload.
6. Electrolyte abnormalities: pulmonary crackles, ECG changes pertaining to hyperkalemia,
7. Renal osteodystrophy-osteoporosis of bones.
8. Anemia.
9. Pruritus due to deposition of urea in the skin assessment and diagnostic findings.

Objectives

Primary objectives

1. To determine the difference of standard deviation of the patient's weight, systolic blood pressure (BP) and diastolic BP, pre dialysis and post dialysis and observe the changes that takes place in the patients' health.
2. Moreover as the Kidney function tests (KFT) are time consuming and expensive, so in order to save time and money we want to give a mathematical solution for the benefit of mankind.

Secondary objectives

1. To determine the variable of different CKD patient of their dialysis.
2. To determine standard deviation of pre-and post-dialysis.

Some mathematical terms and definitions

1. Variance: It is the expectation of the squared deviation of a random variable from its mean, and this measurement shows how far a set of (random) numbers are spread out from their mean. Formula is given by

$$\sum_{i=1}^{n} \frac{(x_i - \bar{x})^2}{N}$$

2. Standard deviation: A standard deviation (σ) is a measure of how dispersed the data is in relation to the mean. Low and high values of (σ) means data are clustered around the mean and data are more spread out respectively. Formula is given by

$$\sqrt{\sum_{i=1}^{n} \frac{(x_i - \bar{x})^2}{N}}$$

$X_i = each\ value\ of\ the\ data,$

$\bar{X} = the\ value\ value$

$N = number\ of\ population$

Case Presentation

The data of the CKD patients has been collected from Jorhat medical college and hospital, Jorhat, Assam. Prior permission was obtained from the medical superintendent of Jorhat medical college and hospital, Jorhat, Assam. The data collection was conducted randomly selecting five CKD patients and the data comprises of the body weight, BP, of the patient pre dialysis and post dialysis.

The following tables are the patient wise details with the KFT reports and evaluation of standard deviation of pre and post dialysis (self-explanatory).

Patient 1

Here the patient one is undergoing dialysis since the month of January, 2022. Tables 1 and 2 show some of the random dialysis done to the patients and also the body weight and BP, pre-dialysis and post-dialysis.

Patient 2

Here the patient 2 is undergoing dialysis since the month of December, 2021. Tables 3 and 4 show some of the

Table 1. Kidney function tests of patient 1 with date

KFT	Date: 06.4.2022	Date: 25.5.2022
Hemoglobin	6.7 mg/dL	7.2 mg/dL
Blood urea	90 mg/dL	79 mg/dL
Serum creatinine	7.2 mg/dL	6.5 mg/dL

KFT, Kidney function tests.

Table 2. Mathematical calculation of the patient 1 regarding number of dialysis

N= 14 (number of dialysis)	Pre-dialysis	Post-dialysis
Mean weight	64.81	62.064
Standard deviation (mean weight)	1.740	1.390
Mean systolic BP	171.29	177.5
Standard deviation (systolic BP)	13.69	19.556
Mean diastolic BP	89.21	88
Standard deviation (diastolic BP)	7.45	9.64

BP, blood pressure.

Table 3. Kidney function tests of patient 2 with date

KFT	Date: 19.04.2022	Date: 28.05.2022
Hemoglobin	9.2 mg/dL	10.6 mg/dL
Blood urea	14 mg/dL	13 mg/dL
Serum creatinine	6.5 mg/dL	5.2 mg/dL

KFT, Kidney function tests.

Table 4. Mathematical calculation of the patient 2 regarding number of dialysis

N= 10 (number of dialysis)	Pre-dialysis	Post-dialysis
Mean weight	55.67	53.273
Standard deviation (mean weight)	0.5034	0.53503
Mean systolic BP	167	188.9
Standard deviation (systolic BP)	20.06102	27.65843
Mean diastolic BP	99.1	104.3
Standard deviation (diastolic BP)	14.19018	38.8671

BP, blood pressure.

random dialysis done to the patients and the body weight and BP, pre dialysis and post dialysis.

Patient 3

Here the patient 3 is undergoing dialysis since the month of April, 2022. Tables 5 and 6 show some of the random dialysis done to the patients and also the body weight and BP, pre dialysis and post dialysis.

Patient 4

Here the patient 4 is undergoing dialysis since the month of February, 2022. Tables 7 and 8 show some of the random dialysis done to the patients and also the body weight and BP, pre dialysis and post dialysis.

Patient 5

Here the patient 5 is undergoing dialysis since the month of August,2021. Tables 9 and 10 show some of the random dialysis done to the patients and also the body weight and BP, pre dialysis and post dialysis.

Table 5. Kidney function tests of patient 3 with date

KFT	Date: 20.04.2022	Date: 25.05.2022
Hemoglobin	11.2 mg/dL	13.7 mg/dL
Blood urea	10.6 mg/dL	9.9 mg/dL
Serum creatinine	6.2 mg/dL	5.1 mg/dL

KFT, Kidney function tests.

Table 6. Mathematical calculation of the patient 3 regarding number of dialysis

N= 10 (number of dialysis)	Pre-dialysis	Post-dialysis
Mean weight	55.67	53.273
Standard deviation (mean weight)	0.5034	0.53503
Mean systolic BP	167	188.9
Standard deviation (systolic BP)	20.06102	27.65843
Mean diastolic BP	99.1	104.3
Standard deviation (diastolic BP)	14.19018	38.8671

BP, blood pressure.

Table 7. Kidney function tests of patient 4 with date

KFT	Date: 03.04.2022	Date: 27.05.2022
Hemoglobin	8.2 mg/dL	10.1 mg/dL
Blood urea	10.2 mg/dL	8.2 mg/dL
Serum creatinine	4.8 mg/dL	3.2 mg/dL

KFT, Kidney function tests.

Table 8. Mathematical calculation of the patient 4 regarding number of dialysis

N= 14 (number of dialysis)	Pre-dialysis	Post-dialysis
Mean weight	43.8	43.0
Standard deviation (mean weight)	0.14944	0.59560
Mean systolic BP	163.7148	163.85
Standard deviation (systolic BP)	121.4949	15.36158
Mean diastolic BP	102.2857	95.07143
Standard deviation (diastolic BP)	7.7576	12.86297

BP, blood pressure.

Table 9. Kidney function tests of patient 4 with date

KFT	Date: 09.04.2022	Date: 30.05.2022
Hemoglobin	12.6 mg/dL	9 mg/dL
Blood urea	8.6 mg/dL	10.4 mg/dL
Serum creatinine	4.4 mg/dL	6.9 mg/dL

KFT, Kidney function tests.

Table 10. Mathematical calculation of the patient 4 regarding number of dialysis

N= 10 (number of dialysis)	Pre-dialysis	Post-dialysis
Mean weight	79.01	76.2
Standard deviation (mean weight)	2.68	0.764314
Mean systolic BP	148.62	161.5
Standard deviation (systolic BP)	13.1140	8.0847
Mean diastolic BP	86.764	84.43
Standard deviation (diastolic BP)	7.79722	6.31547

BP, blood pressure.

Statistical analysis and interpretation

We have collected the data for minimum 10 dialysis of a particular patient. We have collected the report of KFT of same patient as well.

We randomly considered five CKD patients and determined the standard deviation of their weight pre dialysis and post dialysis. Then we took the difference of their standard deviation (weight) pre- and post-dialysis (Table 11) and found that the difference of standard deviation of patient 1, patient 2, patient 3, patient 4 is less than 1 and the medical report of the patients that we have collected shows that their health is progressing toward good health. But in the case of patient 5 we found that the difference of the standard deviation of their weight pre- and post-dialysis is more than 1. Furthermore the medical report of the patient shows that the health of the patient is deteriorating with time.

In the above Table 12, we randomly considered five CKD patients and determined the standard deviation of their systolic BP pre dialysis and post dialysis. Then we took the difference of their standard deviation (systolic BP) pre-and post-dialysis and found that the difference of standard deviation of patient 1, patient 2, patient 3, patient 4 is more than 1(considerably a larger value) and the medical report of the patients that we have collected shows that their health is progressing toward good health. However, in the case of patient 5 we found that the difference of the standard deviation of their systolic BP pre and post dialysis is less than 1(considerably a small value). Moreover, the medical report of the patient shows that the health of the patient is deteriorating with time.

In Table 13, we randomly considered 5 CKD patients and determined the standard deviation of their diastolic BP pre-dialysis and post-dialysis. Then we took the difference of their standard deviation (diastolic BP) pre- and post-dialysis and found that the difference of standard deviation of patient 1, patient 2, patient 3, patient 4 is more

Table 11. Analysis of standard deviation of weight for pre and post dialysis

Patients number	Standard deviation of weight (Pre-dialysis) σ1	Standard deviation of weight (Post-dialysis) σ2	Difference of standard deviation σ1–σ2
1	1.74002	1.3904	0.34962 < 1
2	0.5034	0.52503	0.02163 < 1
3	1.27410	1.27410	0.56055 < 1
4	0.41955	0.59560	0.17605 < 1
5	2.687128	0.764314	1.922814 > 1

Table 12. Analysis of standard deviation of systolic BP (blood pressure) for pre-and post-dialysis

Patients number	Standard deviation of weight (Pre-dialysis) σ1	Standard deviation of weight (Post-dialysis) σ2	Difference of standard deviation σ1–σ2
1	19.0787	26.10513	7.02643
2	20.06102	27.65843	7.59741
3	16.4781	21.16559	4.68749
4	12.4949	15.36158	2.86668
5	13.1140	13.0847	0.0293 < 1

Table 13. Analysis of standard deviation of diastolic BP (blood pressure) for pre-and post-dialysis

Patients number	Standard deviation of weight (Pre-dialysis) σ1	Standard deviation of weight (Post-dialysis) σ2	Difference of standard deviation σ1–σ2
1	7.45425	9.63966	2.18541
2	14.19018	38.8617	23.80
3	9.02003	5.48862	3.53141
4	7.75766	12.86297	5.10531
5	7.79722	6.9342	0.86 <1

than 1(considerably a larger value) and the medical report of the patients that we have collected shows that their health is progressing toward good health. But in the case of patient 5 we found that the difference of the standard deviation of their diastolic BP pre and post dialysis is less than 1 (considerably a small value). Also the medical report of the patient shows that the health of the patient is deteriorating with time.

Major findings of the study

- If the difference of standard deviation of the patients for weight pre-and post-dialysis, is less than 1, then the patient is approaching towards good health and the medical report itself shows that.
- If the difference of standard deviation of the patient systolic BP pre-and post- dialysis is considerably a larger value (>1) then the patient is approaching towards good health. If the difference is less than 1 or (considerably a small value) then the health of the patient is deteriorating gradually.
- If the difference of standard deviation of the patient diastolic BP pre-and post- dialysis is considerably a larger value (>1) then the patient is approaching towards good health. If the difference is less than 1 or (considerably a small value) then the health of the patient is deteriorating gradually.

Conclusion

From the research study, it was found that if the difference of standard deviation of the patients weight pre-and post-dialysis, is less than 1, then the patient is approaching towards good health and the medical report itself shows the validation of our study and If the difference of standard deviation of the patient systolic BP pre and post dialysis is considerably a larger value (>1) then the patient is approaching towards good health. If the difference is less than 1 or (considerably a small value) then the health of the patient is deteriorating gradually. If the difference of standard deviation of the patient diastolic BP pre and post dialysis is considerably a larger value (>1) then the patient is approaching towards good health. If the difference is less than 1 or (considerably a small value) then the health of the patient is deteriorating gradually. Consequently from the above study, we can give the conclusion as follows. Since undergoing KFT tests frequently is time consuming and expensive hence in order to save money and time,

we can calculate the difference of standard deviation of the patients weight, systolic BP, diastolic BP and give an assumption that whether the patient's further reports will be normal or not and whether he need to go for further KFT tests or not.

Future scope of the study

Despite the area covered in this dissertation work, many problems and applications may remain unsolved. The topic still further can be developed into the following areas;

1. In the paper, we input parameters and calculations that only focuses on the primary data available. However, some secondary data for each individual patient (diet of the patient, genetic information of the patient) may be used.
2. In the paper, we are dealing only with standard deviation but there are plenty of parameters and tools that may be conducted for better results.
3. This paper may be extended by studying various types of other diseases like how diabetes affects kidneys, how high BP affects kidneys.
4. This paper may also be extended using fuzzy set theory to interpret more accuracy in the results.

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Ethical issues

This case report was conducted in accord with the World Medical Association Declaration of Helsinki. Patients have given us the written informed consents for publication as the case report. The author has observed ethical issues (including plagiarism, data fabrication, and double publication).

Conflicts of interest

The author declares that he has no competing interests.

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