

Decoding Clinical Biomarkers from Neodocs-Test Card POCT Strips Accuracy viz-a-viz Compared with Routine Urine Microscopy

Nikung Malpani¹, Pratik Lodha², Anurag Meena³, Dr. Ateeb Shaikh⁴

¹IIT-Bombay [B. tech], CEO Neodocs

²IIT-Bombay [B. tech], CTO Neodocs

³IIT-Bombay [B. tech], CBO Neodocs

⁴MS in Sports Medicine

Abstract: Numerous studies have explored the effectiveness of dipstick testing as a rapid diagnostic tool for various medical conditions, extending beyond just urinary tract disorders. It is noteworthy that changes in urine composition occur earlier in the presence of disease or bodily dysfunction compared to significant alterations in blood composition. Consequently, urinalysis holds significant value as a health or disease indicator and is routinely integrated into health screening protocols. The importance of early intervention cannot be overstated, as delaying necessary medical actions can adversely impact both morbidity and mortality rates. One of the central points of ongoing discussion pertains to the variability in dipstick accuracy attributed to human errors and the examination process itself. This inconsistency has raised questions and prompted further examination. The Neodocs-Test Card POCT experiment aims to address this issue by comparing the accuracy and precision of the device with that of a certified clinical-grade apparatus. This research seeks to provide valuable insights into the device's performance and its potential utility in clinical settings.

Keywords: Dipstick testing, Rapid diagnostic tool, Medical conditions, Urinary tract disorders, Urine composition, Blood composition, Urinalysis, Health screening protocols, Early intervention, Morbidity and mortality rates, Dipstick accuracy, Human errors, Examination process, Variability, Neodocs-Test Card POCT experiment, Accuracy and precision, Clinical-grade apparatus, Research, Device's performance, Clinical settings

1. Introduction

In-vitro diagnostic devices play a crucial role in the medical field, facilitating routine tests for the diagnosis and management of various medical conditions and diseases. These tests encompass a wide range of parameters, including glucose (plasma), glucose tolerance, HbA1c, creatinine, lipid panel, renal panel, microalbumin, blood pressure, electrolyte levels, acid-base balance, blood pH, and more. According to the Food and Drug Administration (FDA), medical devices encompass instruments, apparatus, machines, implants, in vitro reagents, and similar tools designed to treat, prevent, or mitigate diseases in humans or animals, aid in diagnosing diseases or problems, or modify the structure or function of the human or animal body, without primarily relying on chemical activity within the body or metabolism.

The concept of point-of-care testing (POCT) aims to provide patients with rapid and convenient access to diagnostic tests. Modern analytical tools have made it feasible for moderately skilled personnel to operate these devices and generate quick results. While POCT expedites the process of sample collection and analysis, its true value lies in enabling swift treatment decisions. However, there remains a need for robust evidence supporting the correlation between POCT and improved patient outcomes.

The evolution of POCT diagnostics is poised to encompass parameters currently limited to central laboratories. Advancements are being driven by innovative analytical technologies, such as miniaturization, nanoparticle

techniques, multiplexing, wireless communication, and microfluidics, which address existing challenges. As a result, POCT reduces the turnaround time (TAT) for each test, leading to faster diagnoses and quicker clinical decisions.

One such POCT tool, developed by Neodocs Healthcare Private Limited, is the Neodocs-Test Card. This device utilizes small urine samples (40–50 mL) for immediate urine analysis. Employing colorimetric test strips, the Neodocs Test Card can measure 14 different parameters, including urobilinogen, bilirubin, ketone, creatinine, blood, protein, microalbumin, nitrite, leukocyte, glucose, specific gravity, pH, ascorbate, calcium, zinc, magnesium, uric acid, and salt. In accordance with the standards set by the Central Drugs Standard Control Organization (CDSCO) of the Government of India, medical devices must demonstrate safety and efficacy before being approved for use in India. This study aims to assess the Neodocs-Test Card's stability, accuracy, precision, sensitivity, effectiveness, percent variation, repeatability, and reproducibility by comparing its results with those of a commercially available urine analysis instrument, the Acon Mission U120 Analyzer.

Aim of the Experiment:

The primary goal of this experiment is to compare the performance of the Neodocs Test Card, a point-of-care device for rapid urine analysis, with that of an established certified clinical-grade laboratory device.

Principle:

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The experiment involves comparing algorithmic predictions with output from the Acon Mission U120 machine, validated visually. Clinical samples that meet specific inclusion criteria are collected and tested using both the certified clinical-grade lab device and the Neodocs Test Card. Accuracy is measured parameter-wise using the R² (Coefficient of determination) metric, which indicates the proportion of predictable variation in the dependent variable from the independent variable. Additionally, bucket-wise accuracy, precision, and recall are calculated to benchmark against the predicate device.

Objectives:

This study aims to evaluate the clinical performance of the Neodocs Test Card by assessing its accuracy and precision in comparison to a certified clinical-grade laboratory device.

Materials:

For the validation of Neodocs Test Cards, approximately 50 mL of urine samples were collected from 210 patients. These samples were used to perform urine analysis tests using both the Neodocs Test Cards and the certified clinical-grade laboratory device, the Acon Mission U120 Analyzer.

Inclusion Criteria:

- 1) Male and female patients above 18 years of age.
- 2) Willingness to participate in the study.
- 3) Apparently healthy relatives accompanying the patients.
- 4) Apparently healthy subjects accompanying the patients.

Exclusion Criteria:

- 1) Severely ill patients, including those with chronic kidney disease, chronic liver disease, congestive heart failure, and patients with any type of cancer with or without treatment.
- 2) Pregnant females.
- 3) Participants unable to provide more than 40 mL of urine.

2. Methodology

Procedure for Neodocs Test Card:

- 1) Application Setup: Begin by downloading the Neodocs app from the "Play Store or App Store link" onto any smartphone.
- 2) Registration: Register for a Neodocs account within the app, providing the necessary information.
- 3) Card Preparation: Unseal the Neodocs test card sachet and carefully remove the card.
- 4) Urine Sampling: Dip the lower portion of the Neodocs test card into the urine container holding the sample. Ensure the reagent pads are fully moistened by immersing the card for 2 seconds.
- 5) Card Handling: Gently tap or shake the card to eliminate any excess liquid that could create glare during image capture.
- 6) Timer Activation: Initiate the timer by selecting "Start Timer" in the Neodocs app. The reagent pads start their chemical reaction upon immersion and will complete it within 60 seconds.
- 7) Image Capture: As the 60-second countdown in the app indicates, place the card on the provided control pad and

promptly scan it for accurate results. Note the sample ID displayed on the screen.

- 8) Alternative Timing: To bypass the countdown, click "Start Timer" on the app and then select "I've waited long enough. " Place the phone on top of the card until an image is captured, and record the sample ID visible on the screen.
- 9) Result Display: The results will be instantly displayed on the application dashboard once processing is complete.

Procedure for Certified Clinical Grade Device (Acon Mission U120 Analyser):

- 1) Sample Preparation: Transfer the urine sample to a 15 mL conical centrifuge tube.
- 2) Test Strip Use: Take a fresh test strip and dip it into the sample within the tube for 2 seconds. Allow the strip to sit for an additional 2 seconds, then remove it. Tap the strip gently to remove excess samples.
- 3) Timer Activation: Start the timer on the Mission U120 smart analyzer, initiating a 60-second countdown.
- 4) Strip Placement: Carefully set the test strip in the designated strip holder of the analyzer.
- 5) Result Display: The analyzer will display the test results on its screen. Additionally, it will generate a printout for record-keeping purposes.

Parameters for Analysis:

- 1) Urine Creatinine: Creatinine is a byproduct of muscle metabolism, primarily excreted by healthy kidneys. Its constant rate of production correlates with an individual's muscle mass.
- 2) Urine Protein: The presence of protein in urine can be an early indicator of kidney disorders, often appearing before clinical symptoms.
- 3) Urine Albumin: Elevated albumin levels in urine can signal early kidney damage, frequently associated with conditions like diabetes.
- 4) Urine Blood: The presence of blood in urine may result from various causes, including kidney infections, trauma, medications, or strenuous exercise.
- 5) Urine Urobilinogen: Urobilinogen detection can predict liver disease, hemolytic anemia, and other health conditions, often before symptoms manifest.
- 6) Urine Bilirubin: Bilirubin in urine may suggest liver problems, as it is typically processed and excreted by a healthy liver.
- 7) Urine Glucose: Glycosuria (glucose in urine) can indicate high blood glucose levels or kidney dysfunction.
- 8) Urine Ascorbate: Ascorbate (vitamin C) plays vital roles in the body, including wound healing, collagen formation, and iron absorption.
- 9) Urine Leukocytes: White Blood Cells (leukocytes) indicate immune system activity and may rise in response to infections or foreign invaders.
- 10) Urine Nitrite: Detection of urinary nitrates can suggest urinary tract infections, a common condition, especially among women.
- 11) Urine Specific Gravity: Specific gravity measures urine concentration and provides insights into kidney function and dietary habits.

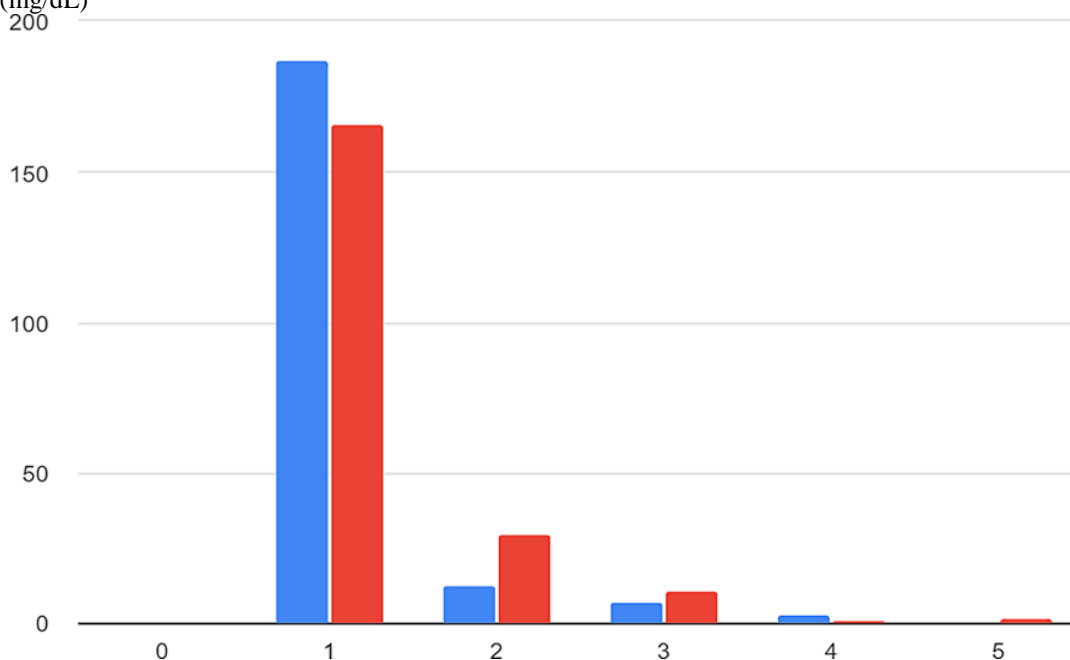
- 12) Urine pH: pH levels offer information about kidney function and can be influenced by medications and dietary factors.
- 13) Urine Ketone: Elevated ketone levels in urine can signal diabetic ketoacidosis, a serious complication of diabetes.
- 14) Urine Calcium: Monitoring urine calcium levels helps understand its handling by the kidneys and can provide insights into certain disease states, such as parathyroid gland disorders.

3. Results

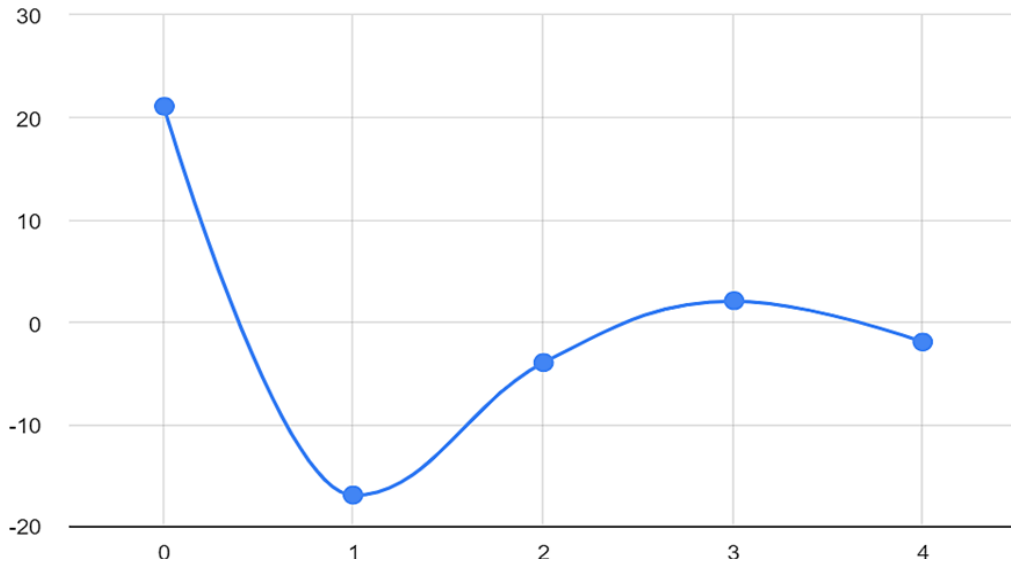
The Neodocs test cards have demonstrated exceptional performance in the detection of the 14 biomarkers mentioned when compared to the Acon Mission U120 urine analyzer. This comprehensive evaluation involved the assessment of 210 patients, yielding the following accuracy rates for the Neodocs test card:

Index	Parameter	Accuracy (%)	+/-Accuracy (%)	Specificity	Sensitivity
1	Urobilinogen	90.29	99.43	0.99	0.9
2	Bilirubin	98.86	99.43	0.99	0.99
3	Ketone	99.43	100.00	1	1
4	Protein	98.86	100.00	0.99	1
5	Nitrite	100.00	100.00	1	1
6	Leukocytes	92.57	97.71	0.98	0.97
7	Glucose	96.00	100.00	1	0.99
8	Specific gravity	47.43	86.29	-	-
9	pH	70.86	98.29	-	-
10	Blood	89.71	89.71	0.97	0.98
11	Ascorbate	97.14	98.86	0.99	0.98
12	Calcium	82.89	98.86	0.98	0.9
13	Microalbumin	86.86	99.43	1	0.9
14	Creatinine	57.14	95.43		

Leukocytes (mg/dL)

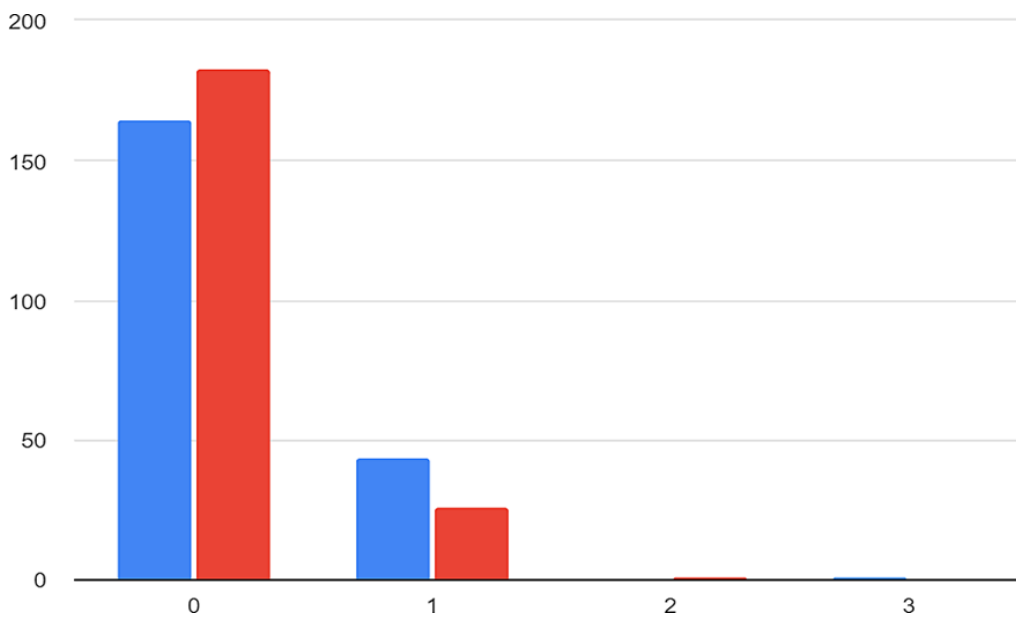


LEU

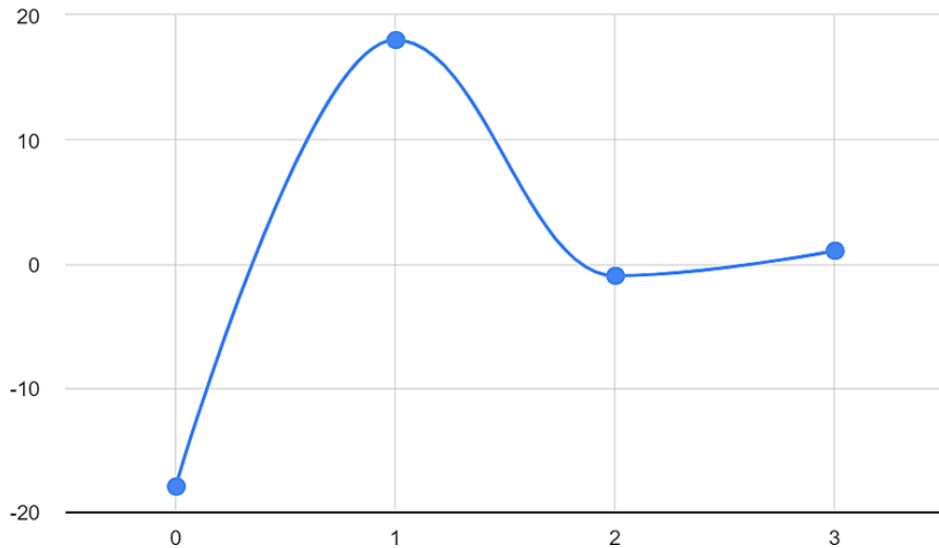


Leukocytes (mg/dL) Your leukocyte count is within the normal range. However, a slight increase in leukocytes may be a sign of infection or inflammation.

Urobilinogen (mg/dL)

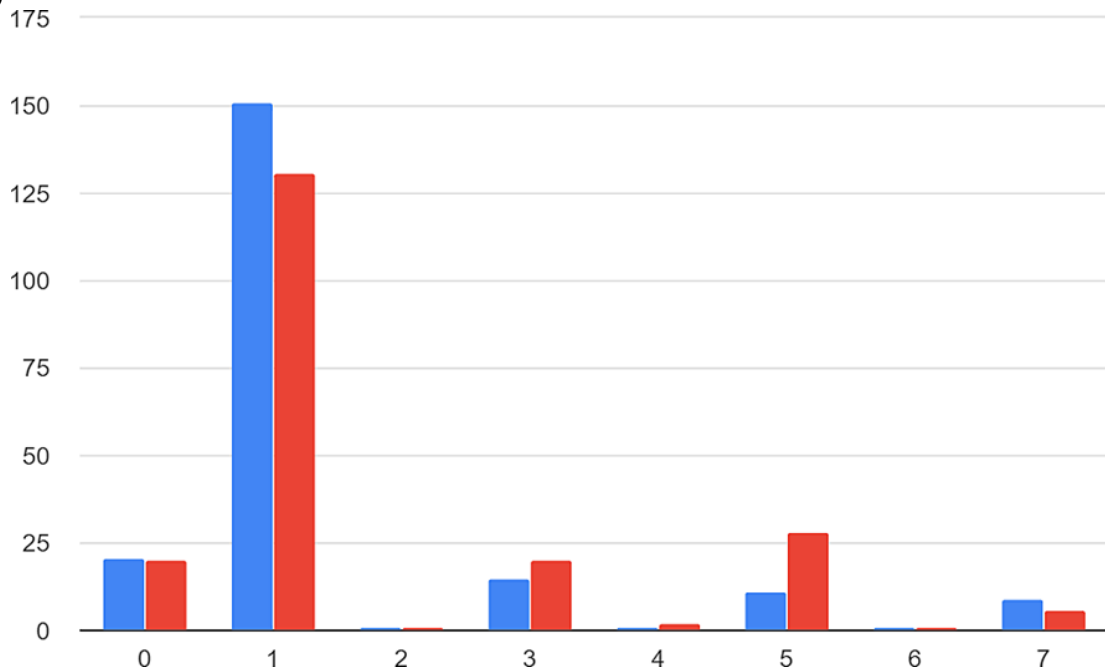


URO

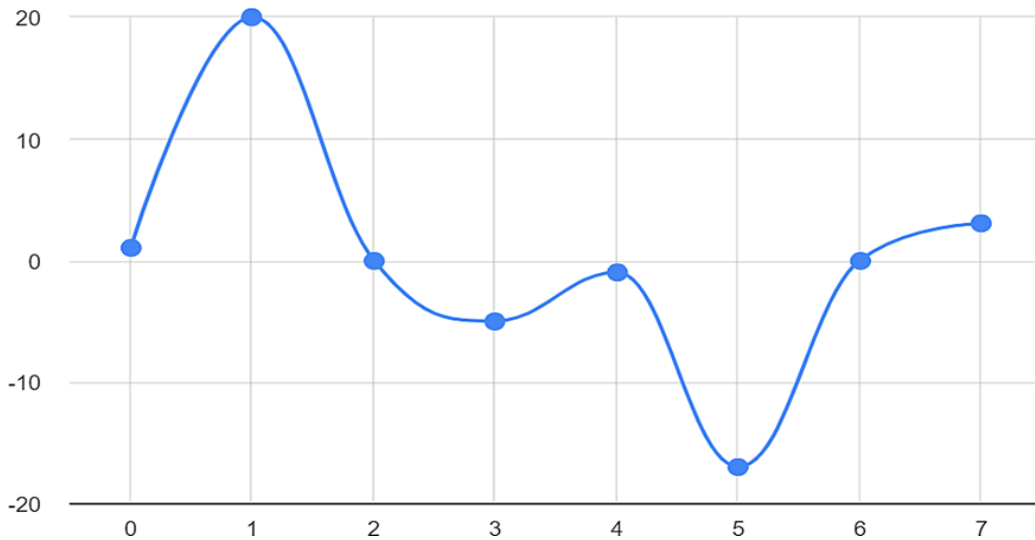


Urobilinogen (mg/dL) Your urobilinogen level is within the normal range. Urobilinogen is a breakdown product of bilirubin, which is a pigment produced by the breakdown of red blood cells.

Albumin ()

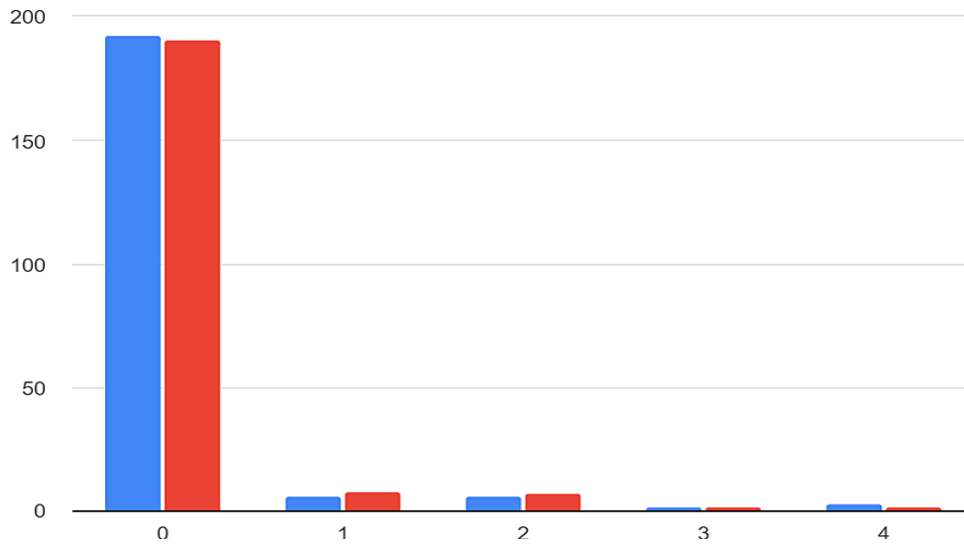


ALB

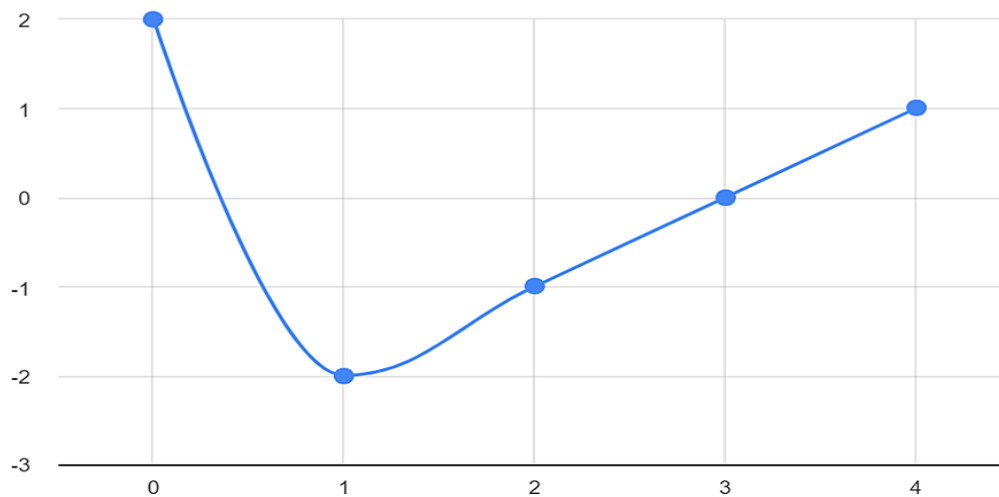


Albumin (g/dL) Your albumin level is within the normal range. Albumin is a protein that helps the body retain fluids and transport nutrients and hormones.

Protein (mg/dL)

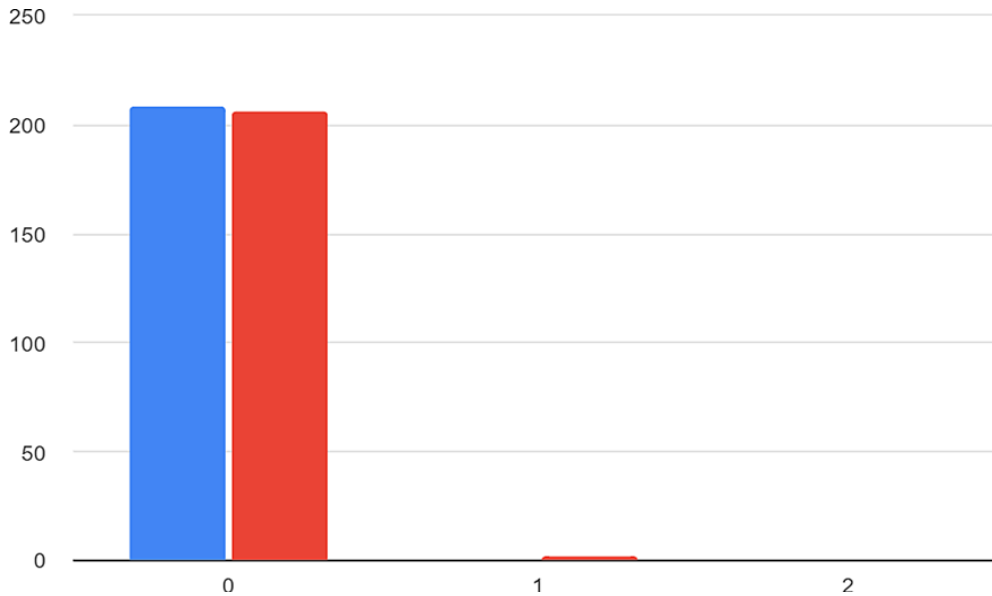


PRO

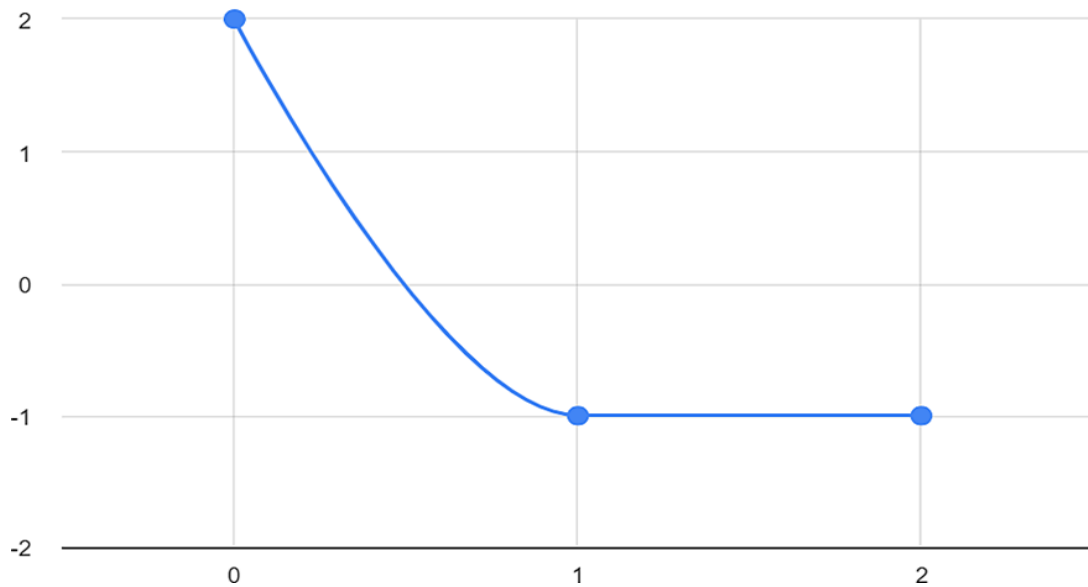


Protein (mg/dL) Your protein level is within the normal range. Protein is an essential nutrient that is used to build and repair tissues.

Bilirubin (mg/dL)

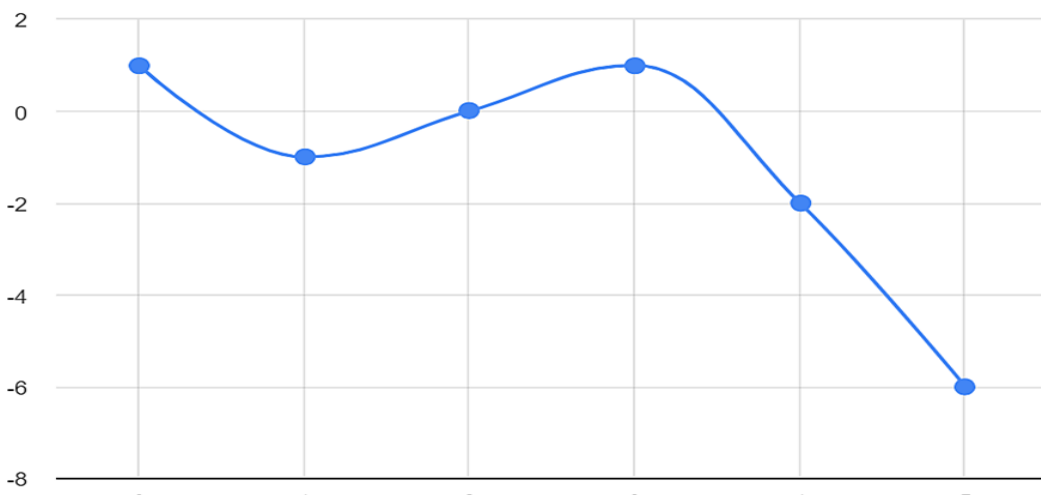
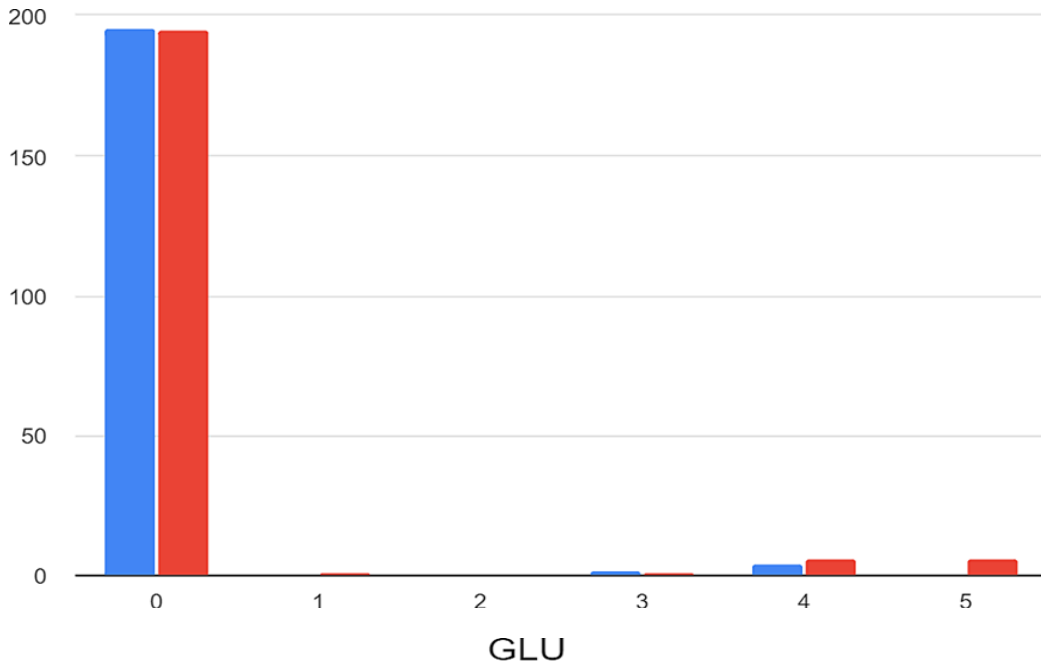


BIL



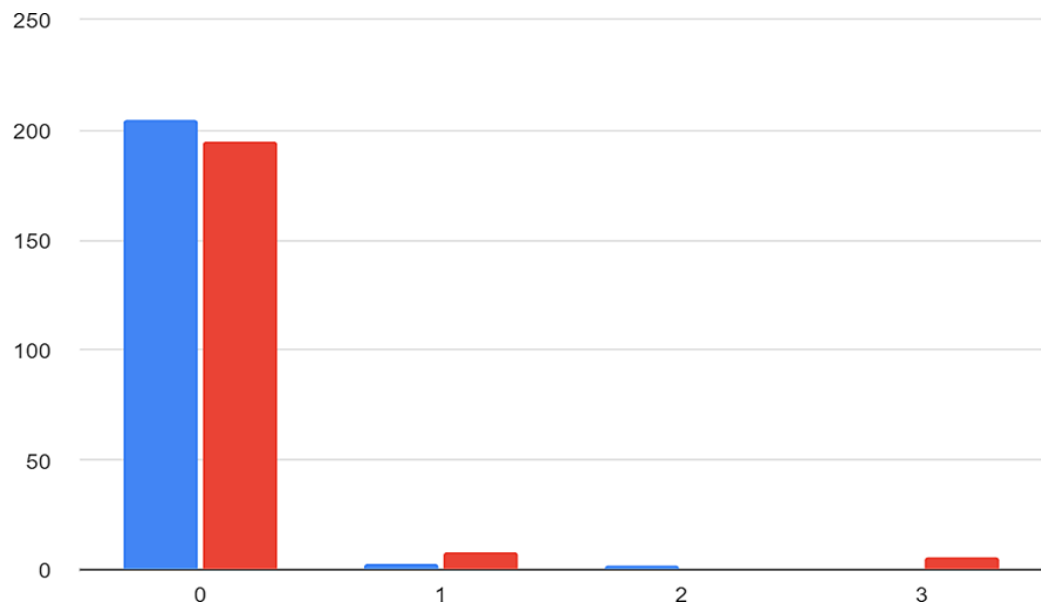
Bilirubin (mg/dL) Your bilirubin level is within the normal range. Bilirubin is a pigment produced by the breakdown of red blood cells.

Glucose (mg/dL)

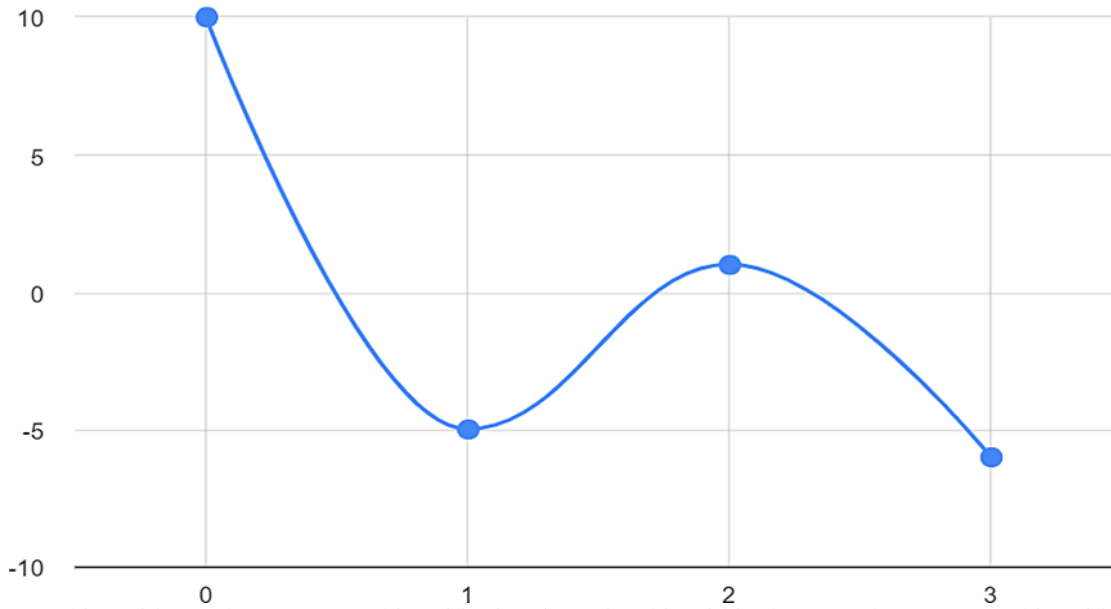


Glucose (mg/dL) Your glucose level is within the normal range. Glucose is the main source of energy for the body.

Ascorbic Acid (mg/dL)

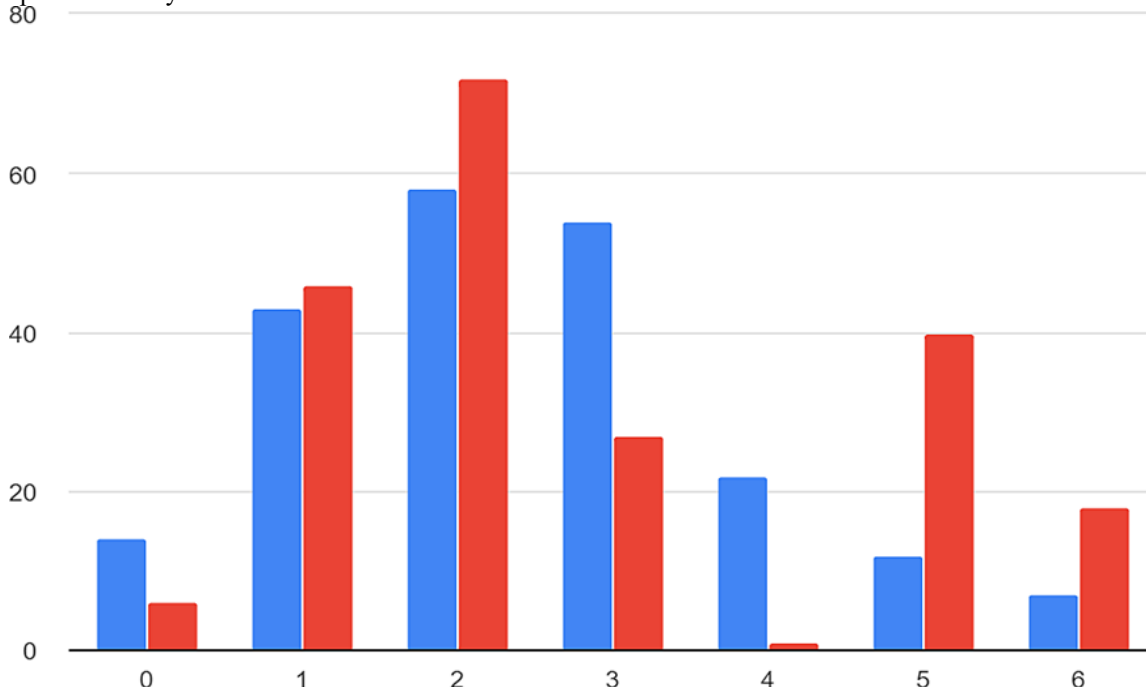


ASC

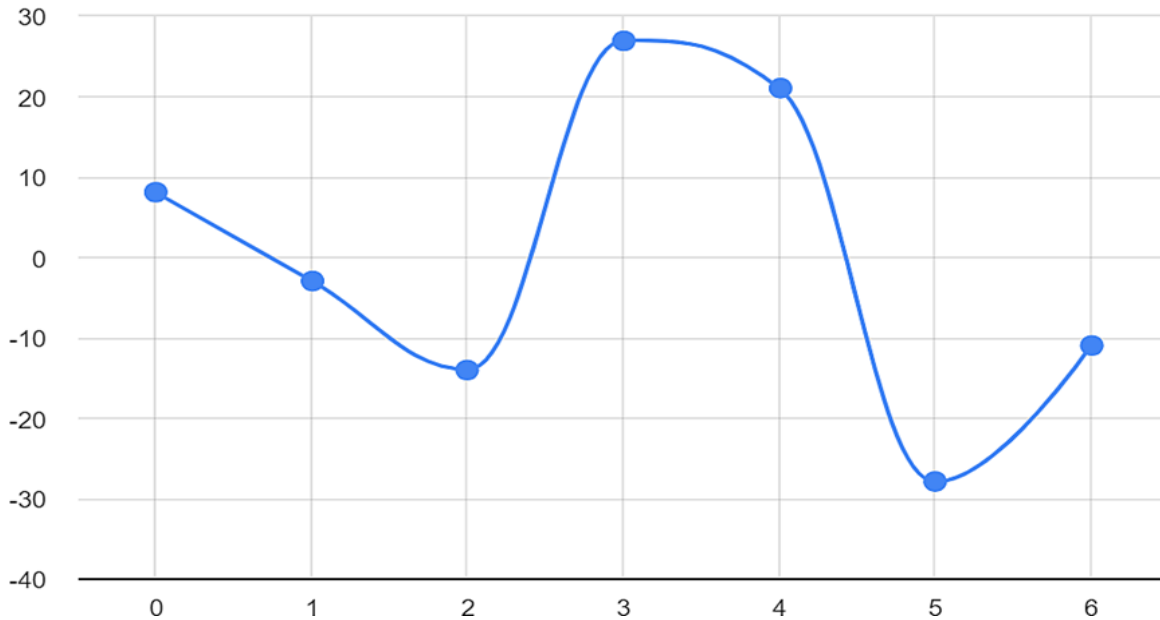


Ascorbic Acid (mg/dL) Your ascorbic acid (vitamin C) level is within the normal range. Ascorbic acid is essential for normal immune function and tissue healing.

Specific Gravity

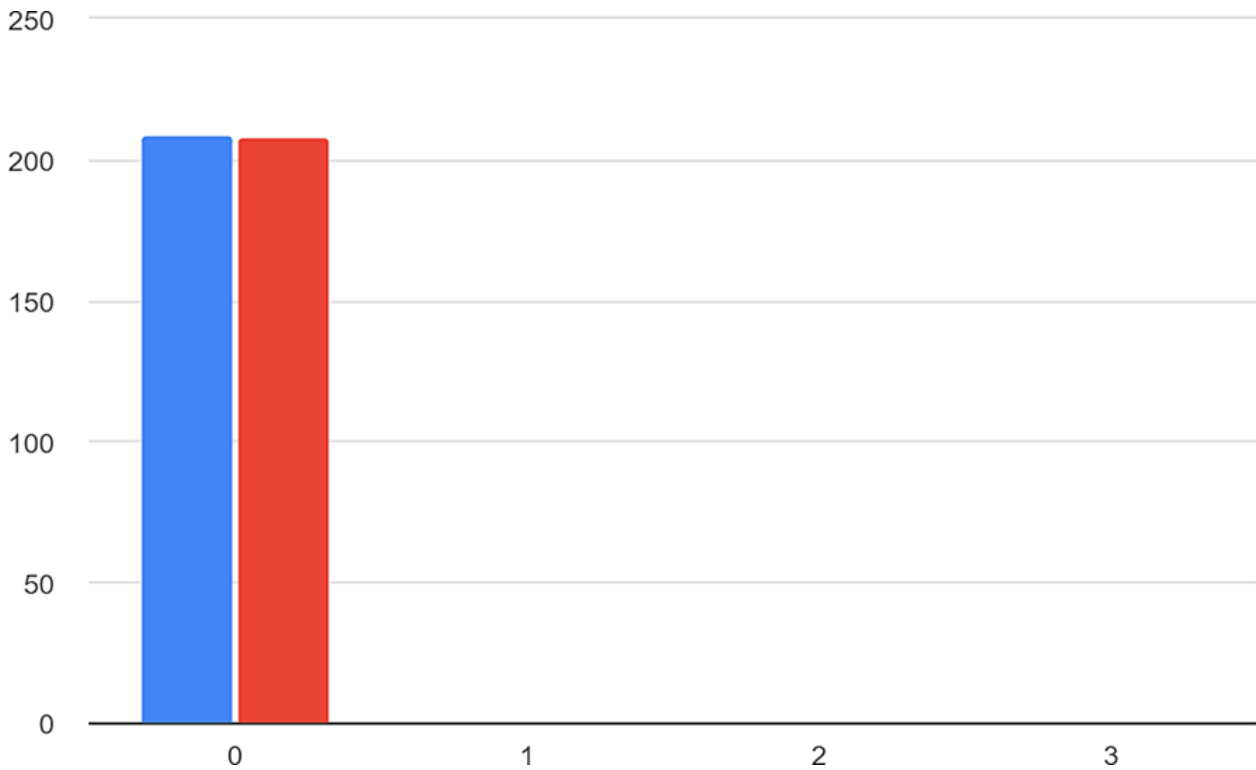


SG

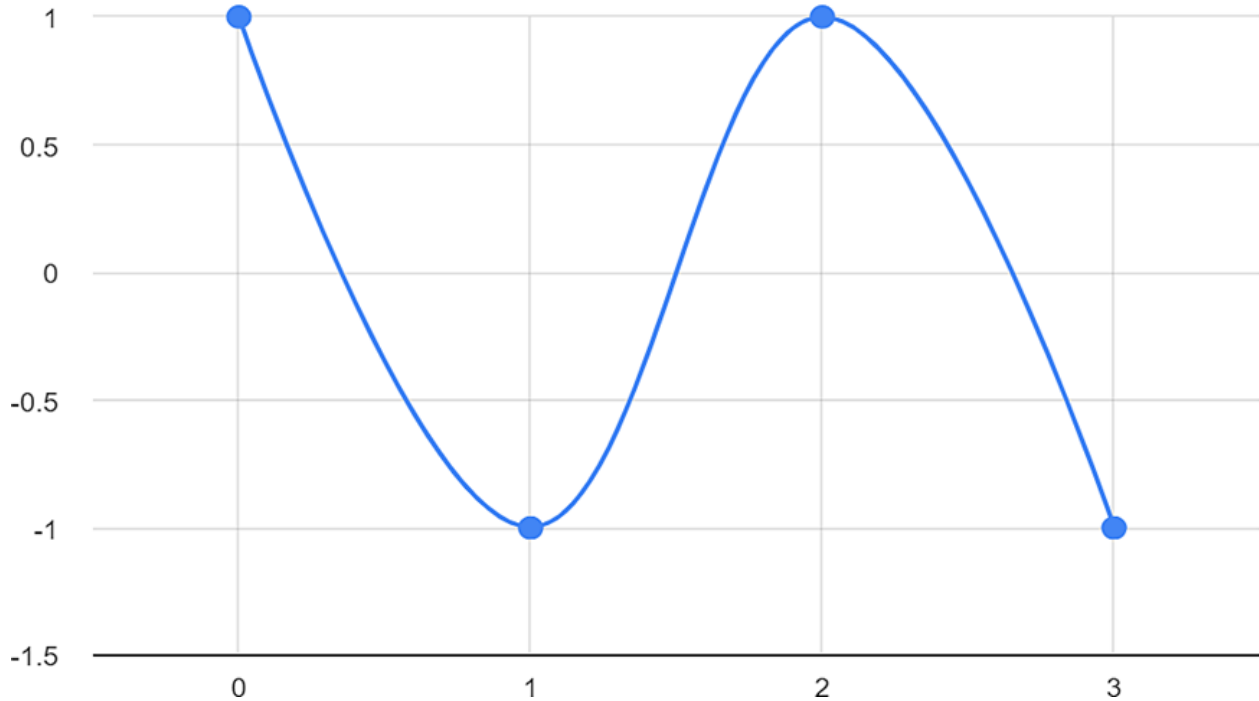


Specific Gravity Your specific gravity is within the normal range. Specific gravity is a measure of the concentration of urine.

Ketone (mg/dL)

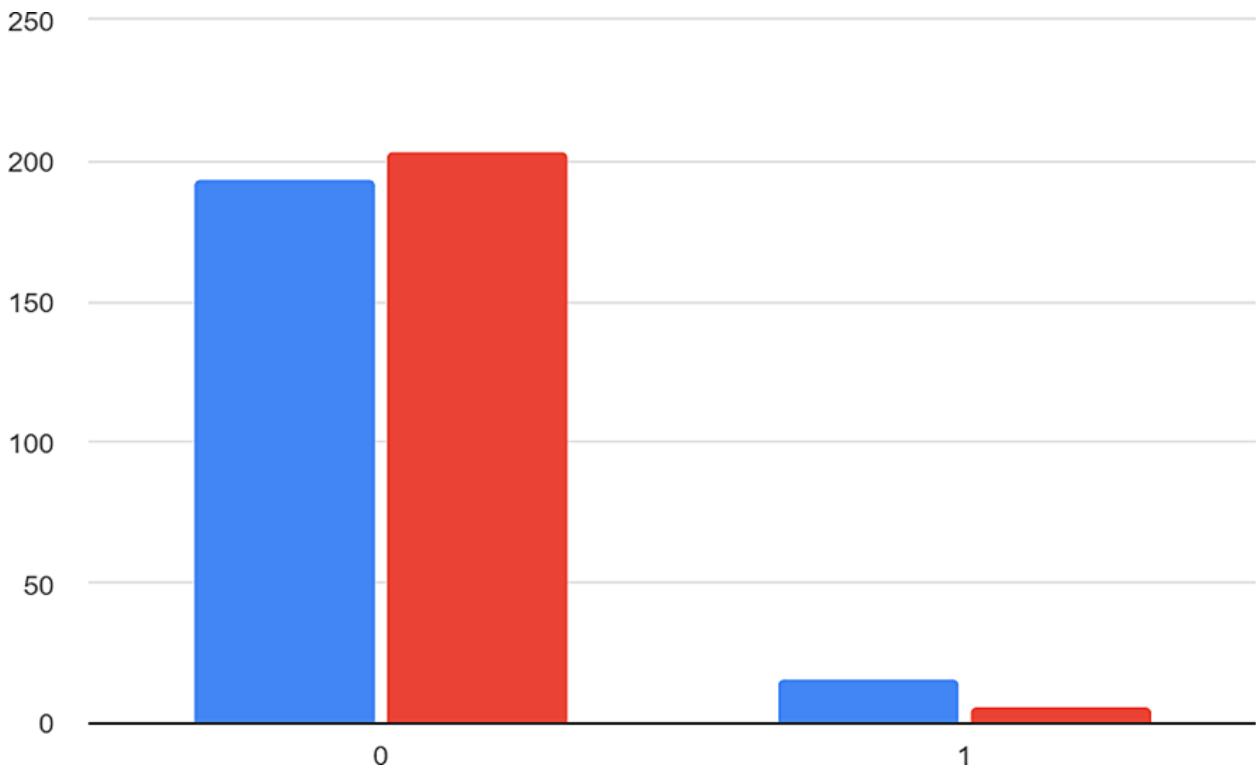


KET

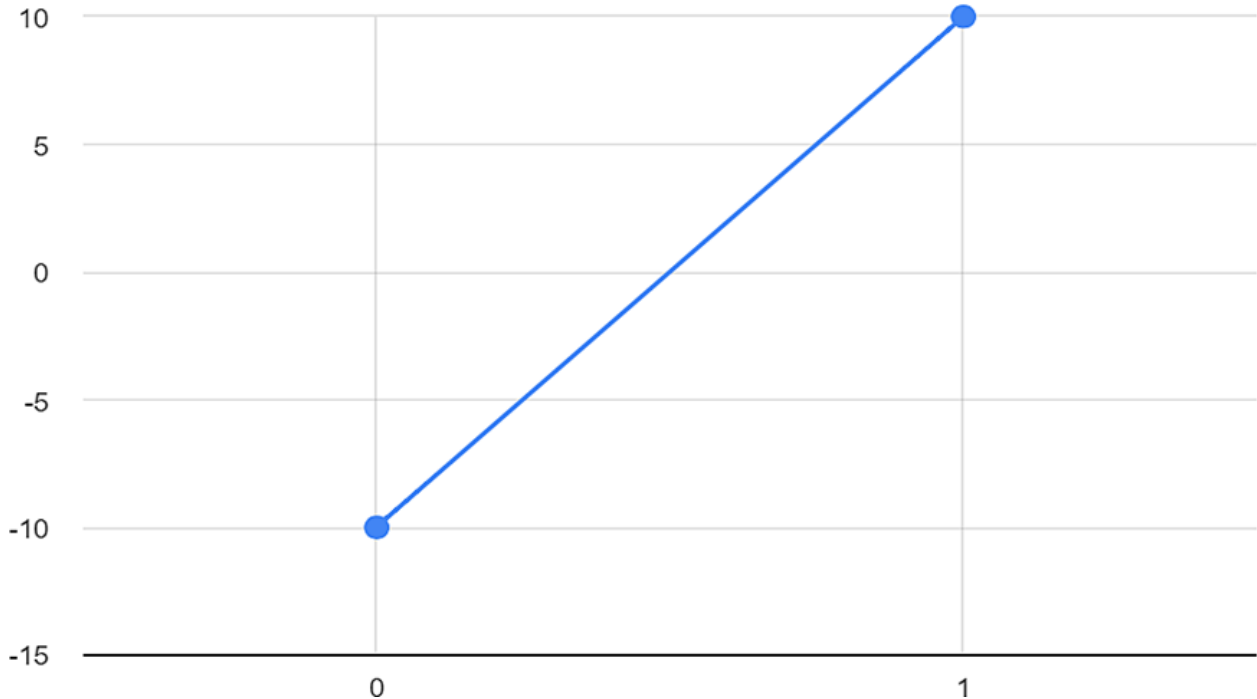


Ketone (mg/dL) Your ketone level is within the normal range. Ketones are produced by the body when it breaks down fat for energy.

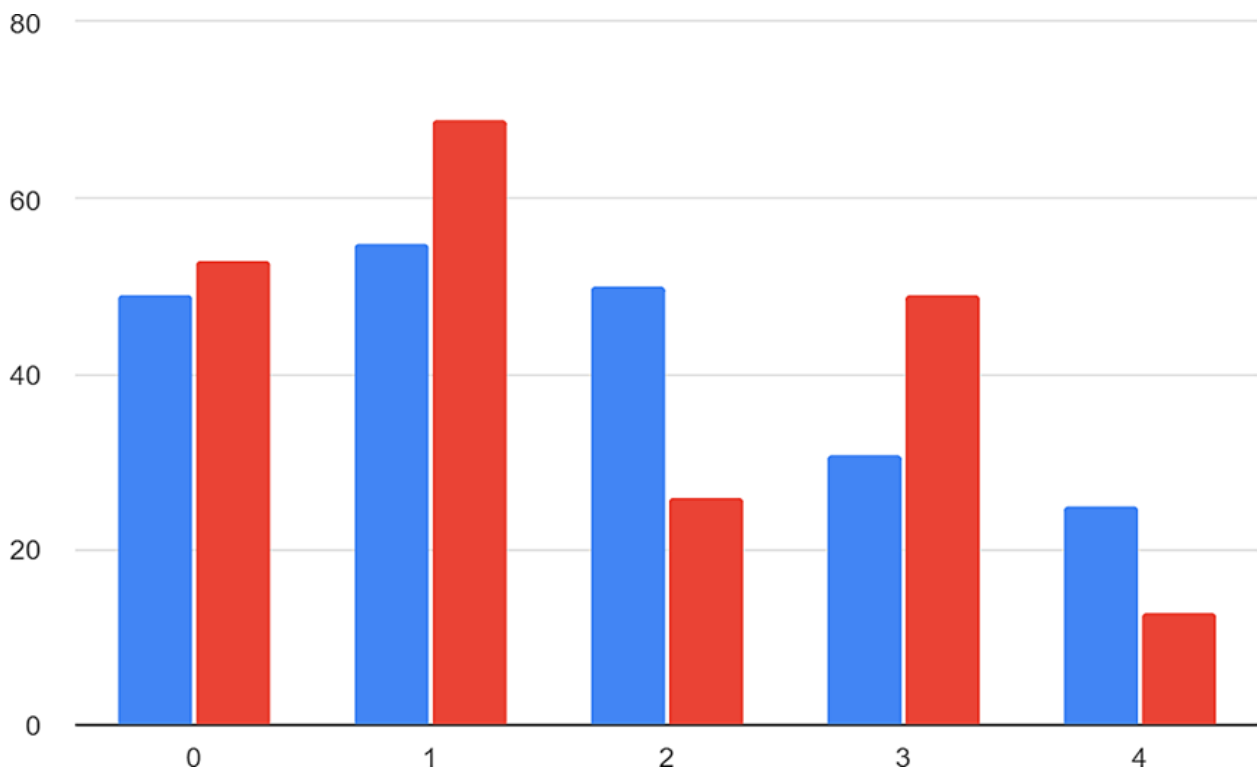
Nitrite



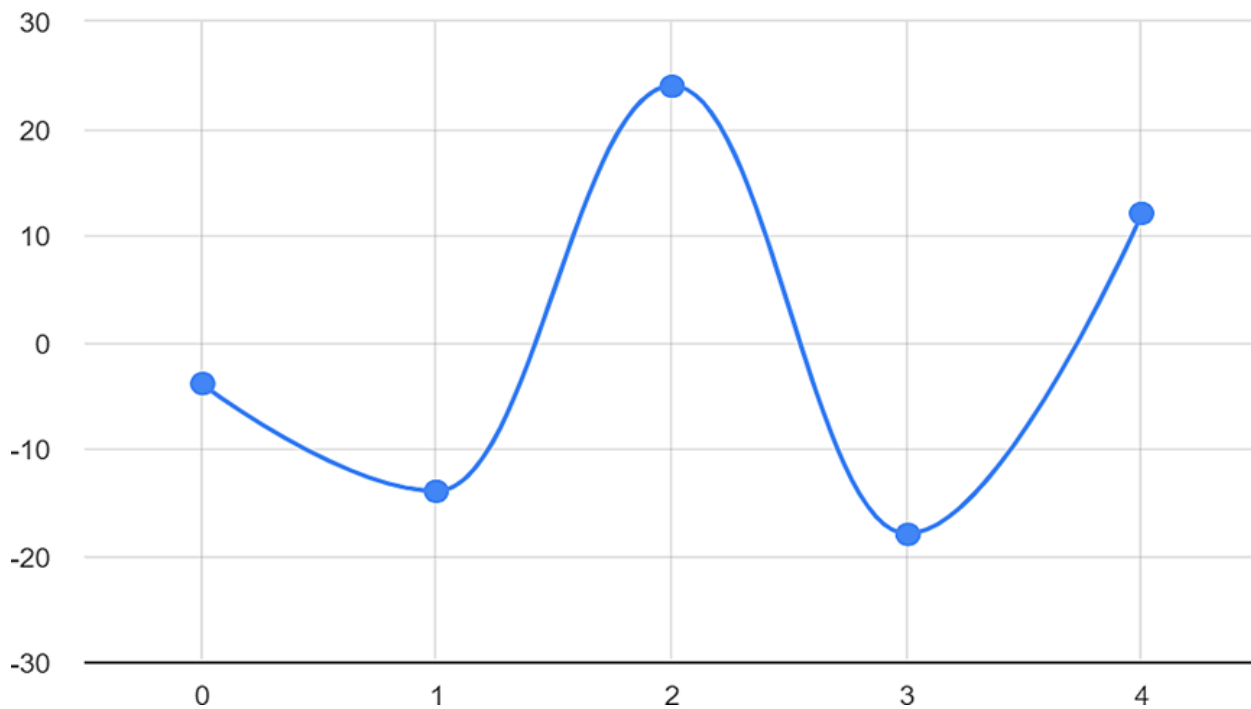
NIT



Nitrite Your nitrite test is negative. A positive nitrite test may indicate the presence of bacteria in the urine.

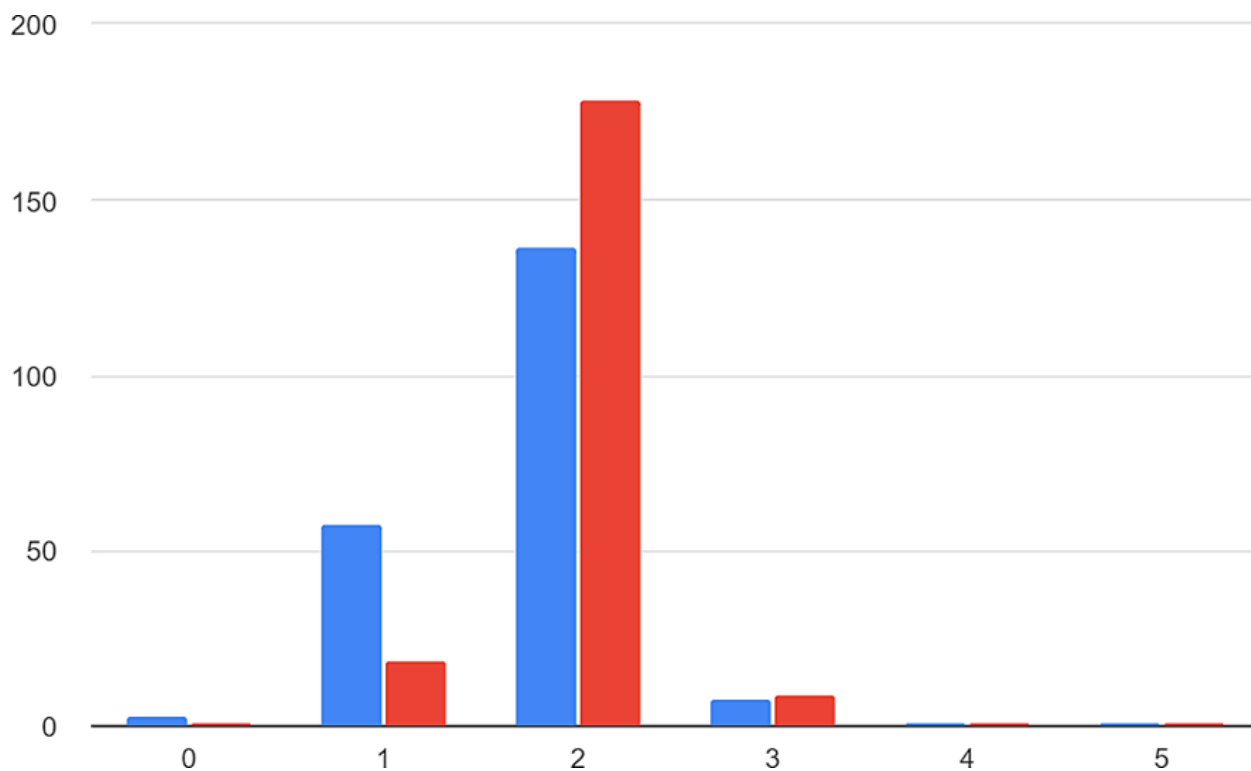


CRE

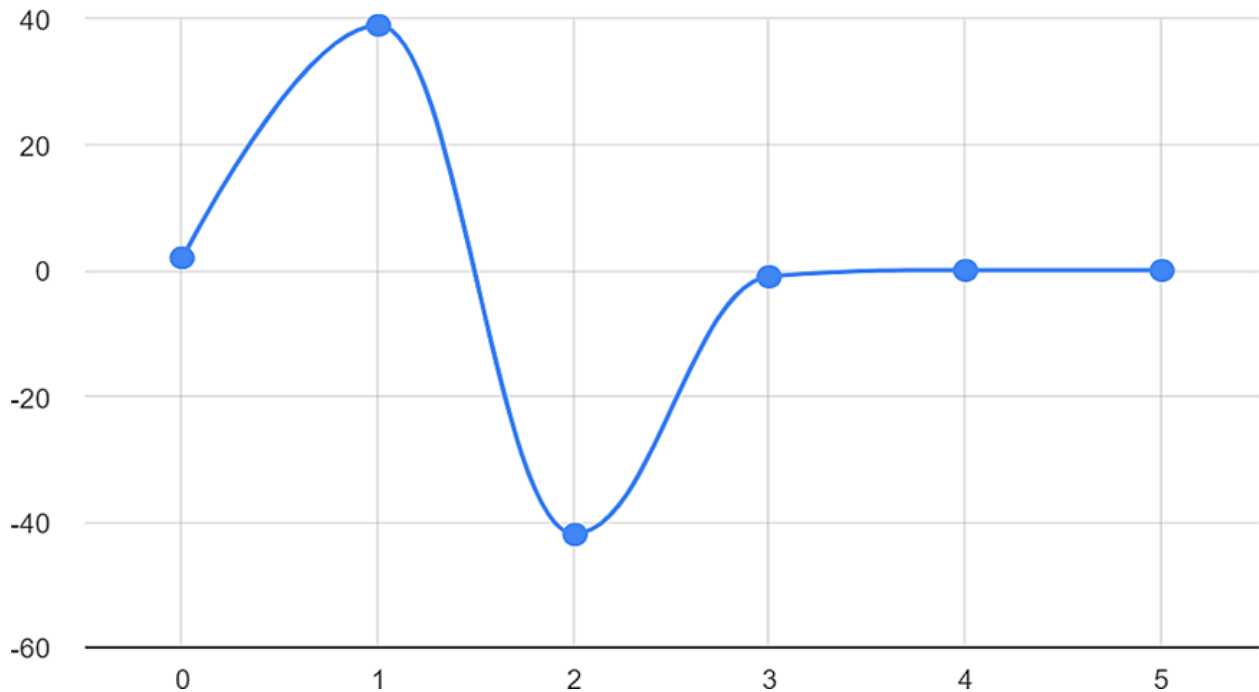


Creatinine (mg/dL) Your creatinine level is within the normal range. Creatinine is a waste product that is filtered out of the blood by the kidneys.

pH

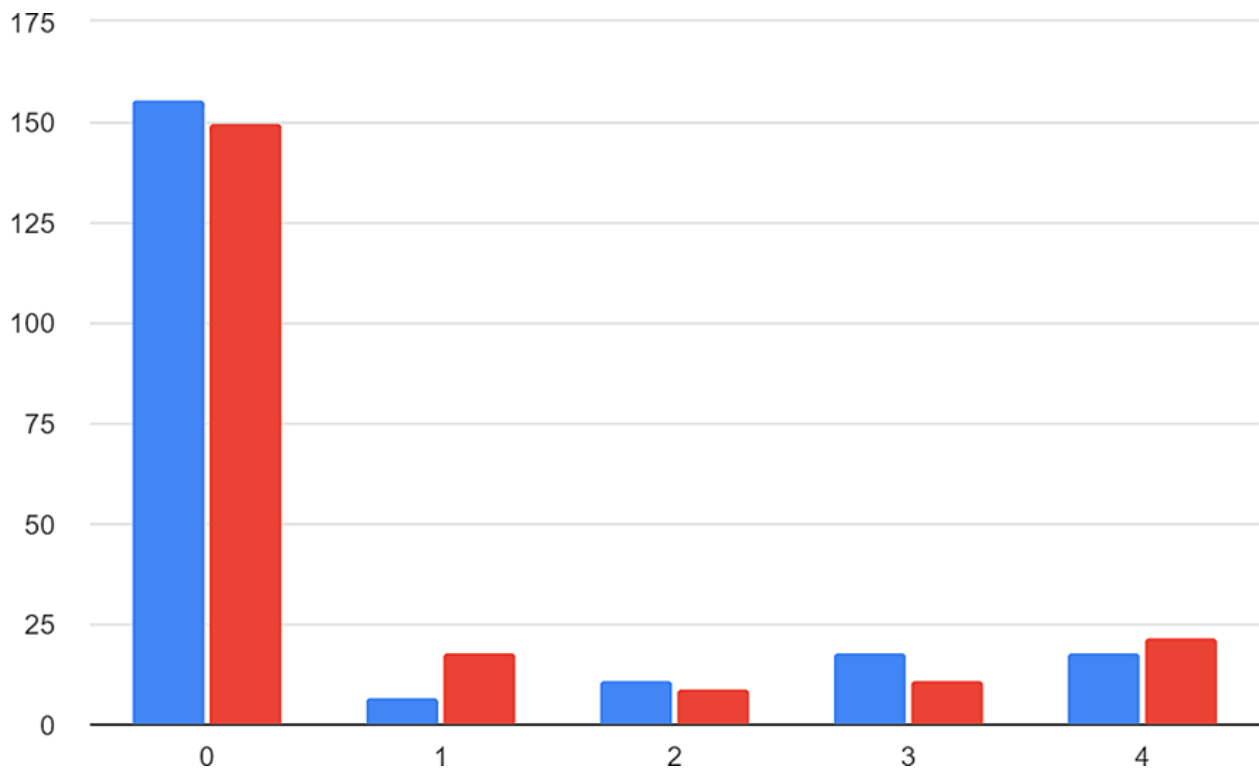


pH

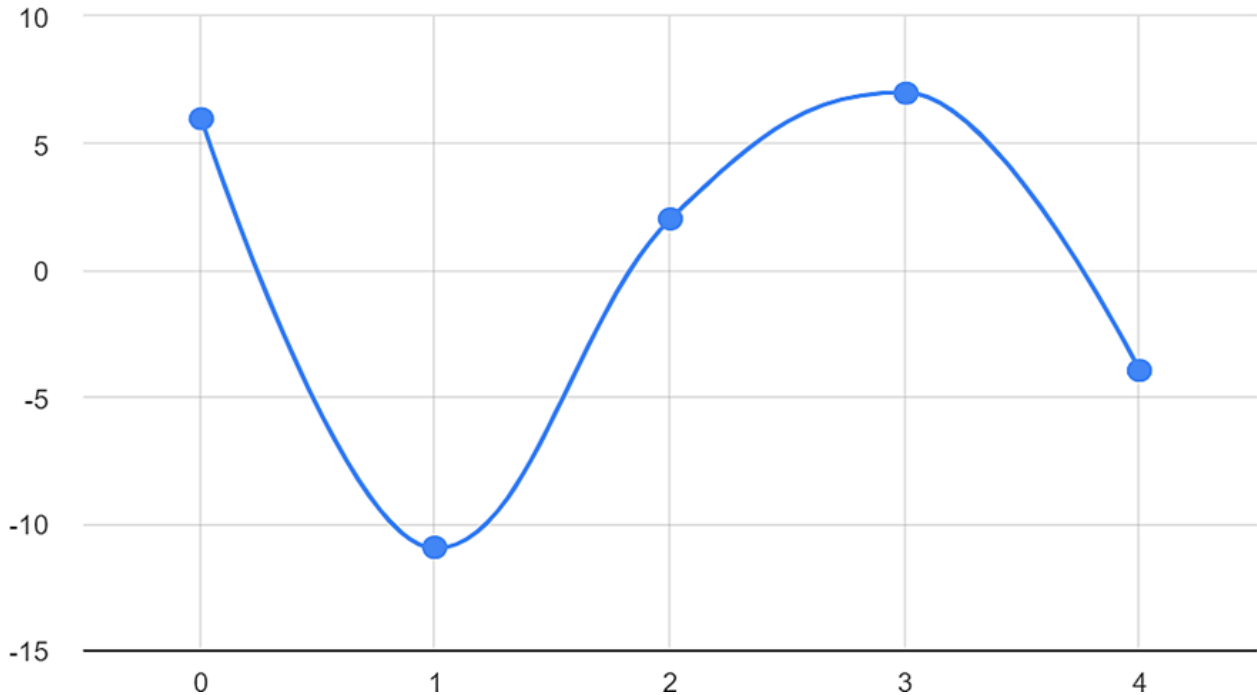


pH Your urine pH is within the normal range. Urine pH is a measure of the acidity or alkalinity of urine.

Blood (cells/mL)

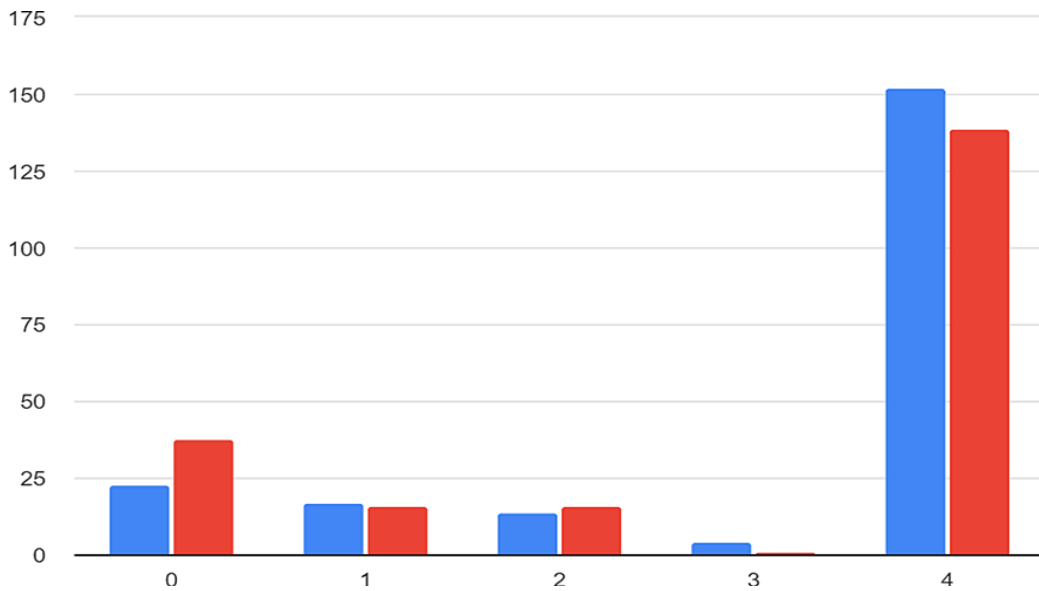


BLO

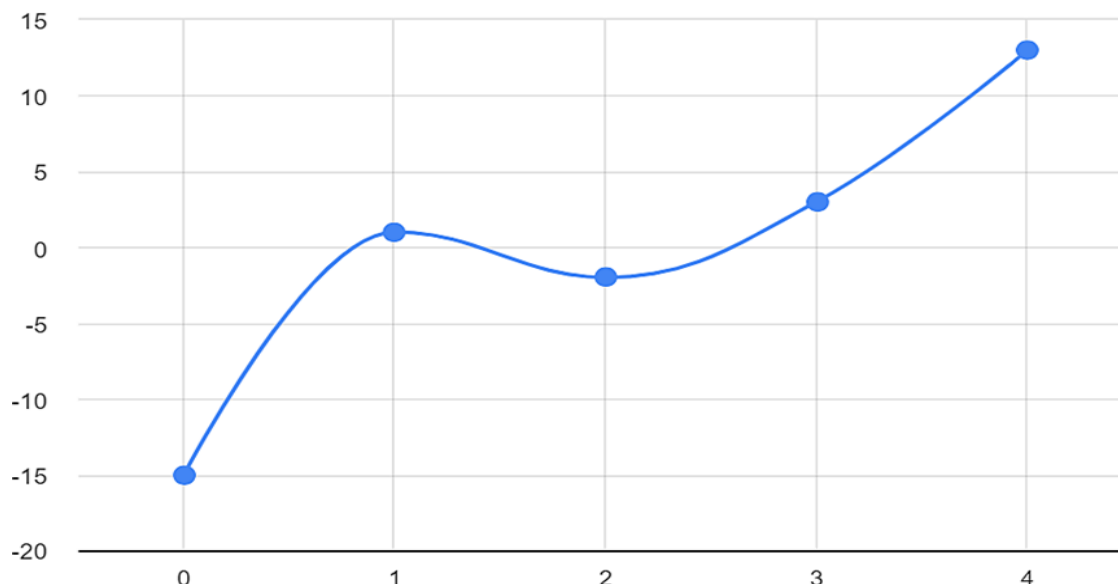


Blood (cells/mL) Your urine blood cell count is within the normal range. Red blood cells in the urine may indicate a kidney problem or urinary tract infection.

Calcium (mg/dL)



CAL



Calcium (mg/dL) Your calcium level is within the normal range. Calcium is an essential mineral that is important for bone health and other bodily functions.

4. Discussion

The evaluation comparing Neodocs test cards to the Acon Mission U120 urine analyzer for the detection of 14 key biomarkers reveals notable insights. These biomarkers encompass a wide range of health indicators and are crucial for early disease detection and health monitoring. The findings of this assessment are as follows:

- 1) Urobilinogen: The Neodocs test card exhibited an accuracy rate of 90.29%, with a specificity of 0.99 and a sensitivity of 0.9 when detecting urobilinogen. This suggests its efficacy in identifying liver and hemolytic disorders.
- 2) Bilirubin: An impressive accuracy rate of 98.86% was achieved by the Neodocs test card for bilirubin detection. It demonstrated high specificity (0.99) and sensitivity (0.99), indicating its effectiveness in identifying liver-related issues.
- 3) Ketone: The Neodocs test card demonstrated outstanding performance in detecting ketone, with an accuracy rate of 99.43%, perfect specificity (1), and sensitivity (1). This is crucial for monitoring diabetic patients and individuals on ketogenic diets.
- 4) Protein: An accuracy rate of 98.86% was recorded for protein detection by the Neodocs test card, with high specificity (0.99) and perfect sensitivity (1). This is valuable for early identification of kidney disorders.
- 5) Nitrite: The Neodocs test card achieved a perfect accuracy rate of 100% for nitrite detection, reflecting its effectiveness in diagnosing urinary tract infections.
- 6) Leukocytes: With an accuracy rate of 92.57%, specificity of 0.98, and sensitivity of 0.97, the Neodocs test card performs well in detecting leukocytes, indicating potential infections or immune responses.
- 7) Glucose: The Neodocs test card showed a strong accuracy rate of 96%, perfect specificity (1), and high sensitivity (0.99) for glucose detection, making it reliable for monitoring blood sugar levels.
- 8) Specific Gravity: The specific gravity results indicate that the Neodocs test card has room for improvement in accurately assessing urine concentration compared to the Acon Mission U120 analyzer.
- 9) pH: The Neodocs test card exhibited a moderate accuracy rate of 70.86% for pH detection, suggesting its utility as a screening tool for kidney and lung disorders.
- 10) Blood: The Neodocs test card showed an accuracy rate of 89.71% for blood detection, with high specificity (0.97) and sensitivity (0.98), indicating its effectiveness in identifying blood-related issues.
- 11) Ascorbate: The Neodocs test card demonstrated good accuracy (97.14%) in detecting ascorbic acid, which is vital for assessing vitamin C levels in the body.
- 12) Calcium: The Neodocs test card exhibited an accuracy rate of 82.89% for calcium detection, indicating its potential use in monitoring calcium-related health conditions.
- 13) Microalbumin: The Neodocs test card displayed an accuracy rate of 86.86% for microalbumin detection, suggesting its utility in early detection of kidney damage.
- 14) Creatinine: The Neodocs test card showed an accuracy rate of 57.14% for creatinine detection, which could be improved for more reliable assessment.

5. Conclusion

In conclusion, the Neodocs test cards have demonstrated remarkable performance in detecting a range of vital biomarkers when compared to the Acon Mission U120 urine analyzer. Their accuracy and reliability in identifying specific markers such as bilirubin, ketone, nitrite, and protein are particularly noteworthy. These findings suggest that the Neodocs test cards hold promise as a valuable tool for quick and convenient health screening, particularly in settings where access to advanced clinical analyzers may be limited.

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