ORIGINAL RESEARCH

Internal quality control monitoring and evaluation of glucose and cholesterol by using sigma metrics and LJ charts interpretation

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ABSTRACT
Quality control in clinical laboratory testing systems has a significant impression to fulfil the expectation of clinicians and patients expectation for disease diagnosis and treatment. Regular runs of internal QC safeguard the precision and accuracy of tests and also conserve the quality of the laboratory. The veracity of internal quality samples is much important to meet the requirements of proficiency testing. The present study was designed to evaluate and monitoring of internal control glucose and total cholesterol in the clinical laboratory of Rama Hospital. The present results of quality control materials showed that Trends (loss of reliability) and shifts (abrupt changes in the control mean) were noted. Warning signs and violations of the rule were recorded and action initiated. The violation of the controls identifies system error and analytical bias, which is not always clinically relevant.

Key words: Internal quality control, glucose, cholesterol, westgard rule, sigma metrics

INTRODUCTION

In the meantime, the Hippocrates oath (first not harm) introduces to the medical professions. In clinical laboratory practice, this is applicable to minimize the error rate of laboratory results. Laboratory performances are monitored by the accuracy of results [1]. To maintain the accuracy of the laboratory, a good quality control procedure should be established. The clinical laboratory is the backbone of the current healthcare system due to its major involvement in the final decision of clinical diagnosis. The testing system of the clinical laboratory has been categorized as a pre-analytical, analytical and post-analytical system. To overcome testing system errors, there is a requirement fora valid quality control system in the laboratory. Presently there are two quality control systems i.e., Internal quality control (IQC) and external quality controls (EQC) are being constantly used to maintain reliable results [2]. Internal quality control (in-house) is a sample of borderline positivity of sample where sample materials matrix alike to the patient sample. Which offers a low-cost and flexible option to asses daily routine laboratory procedures. IQC measures systemic (accuracy) and random error (precision) whereas the degree/level of errors can be quantified by the sigma metrics [3].

Internal quality controls analysis in each analytical series, controls (normal), or pathological pooled sera issued to monitor day-to-day laboratory errors. The sample can be available commercially or it can be prepared manually. The unification of quality control samples is necessary to meet testing proficiency. Accuracy is defined by a degree of closeness of measured value to the analytical reference value

whereas precision is reproducibility and reliability of methodology. Accuracy and precision together can be used to determine the total errors in analytical phases. The value of controls within ± 2SD is a good sign and is considered reliable and can be reported if the value is beyond ± 2SD, then the results not be reported, and a fresh control sample should be run to reliability of tests [4]. So, for the betterment of entire laboratory tests and make aware to clinicians by results identification and analysis of errors at different phase to establish corrective action and troubleshooting patterns to improve the reproducibility and reliability of the clinical laboratory system [5]. Hence, the present study has the plan to evaluate and monitor internal quality control of glucose and total cholesterol by using Levey-Jennings (LJ) charts and interpretation through the application of rules for the interpretation of LJ charts.

MATERIALS AND METHODS

An analytical or observational type of study has been carried out in the department of biochemistry, Rama Medical College and Hospital, Kanpur, Uttar Pradesh, India after obtaining ethical approval Intuitional ethical committee.

QUALITY CONTROLS AND MATERIALS

Quality control monitoring and evaluation of serum glucose and total cholesterol were conducted by using Erba-Norm (Normal) by allowing the vial and AQUA-4 (supplied in the kit) to attain room temperature. Adding exactly 5 ml of AQUA-4 and allowing to stand for 30 minutes at rest in a light-protected place. Swirling the content gently to ensure homogeneity before using the sample for testing and then inserting it into the fully automatic analyzer EM200 and results collated for July 2022-October 2022. QC materials are pooled sera products (materials ideally made from human serum). The control products were in the form of liquid or freeze-dried (lyophilized) material and are composed of one or more constituents (analytes) of known concentration.

Majorly, two levels of controls being used to run on daily basis with subsequent interval of eight hours. The present study has monitored and observed the data for continuous four months of normal control for Blood glucose and cholesterol. Observed control values within + 2SD were considered a good sign and of patient's results obtained are reliable and can be reported whereas, with Control values beyond + 2SD then the results cannot be reported or considered.

STATISTICAL ANALYSIS

IQC data were collected and entered in a Microsoft Excel sheet and analysis was done by using SPSS statistical software version 21.00. IQC is calculated by using mean, SD, CV% and biasofa total of thirty days of internal normal controls every month. Total allowable error (TEa) values of various parameters were taken from Clinical Laboratories Improvement Act (CLIA) guidelines. Sigma value is calculated by the equation Sigma = (TEa-bias)/CV% and Bias was calculated by (Lab mean-Group mean) x 100/Group mean to check precision and accuracy [6, 7]. Statistical analysis is done in an excel sheet. Sigma values were represented in graphs from July 2022 to October 2022 for glucose and cholesterol. The operating point for each analyte was plotted in graphs with the help of an Excel sheet Westgard rules were followed to interpret the control data as follows [8]:

1. **12s:** One control observation exceeding the mean ±2SD used only as a "warning" rule that initiates testing of the control data by the other control rules
2. **13s:** One control observation exceeding the mean ±3SD is primarily sensitive to random error.
3. **22s:** Two consecutive control observations exceeding the same mean +2SD or mean-2SD are primarily sensitive to systematic error.
4. **R4s:** One observation exceeding the mean +2SD and another exceeding the mean-2SD is primarily sensitive to random error.
5. **41s:** Four consecutive observations exceeding the mean +1SD or the mean-1SD is primarily sensitive to systematic error.
6. **10x:** 10 consecutive control observations falling on one side of the mean (above or below, with no other requirement on the size of the deviations)-sensitive to systematic error.

Results & Observations

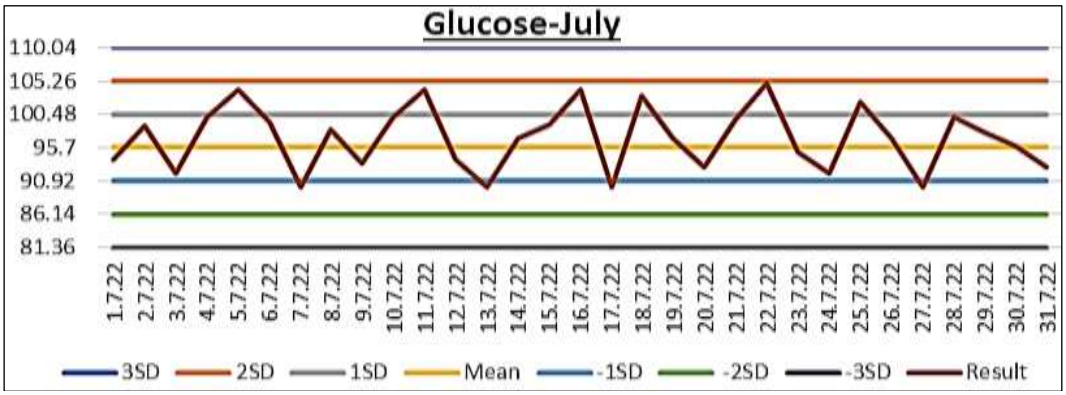
This analysis is based on monitoring of internal controls carried out on a day-to-day basis. The value in the Levey-Jeneys chart falls around the mean value of 95.72 within 1SD and 101.4 i.e., between 1SD and 2SD, was accepted for glucose. Similarly, a mean value that falls around 137.57 is within 1SD, and 140.44, which is between 1SD and 2SD was accepted for total cholesterol.

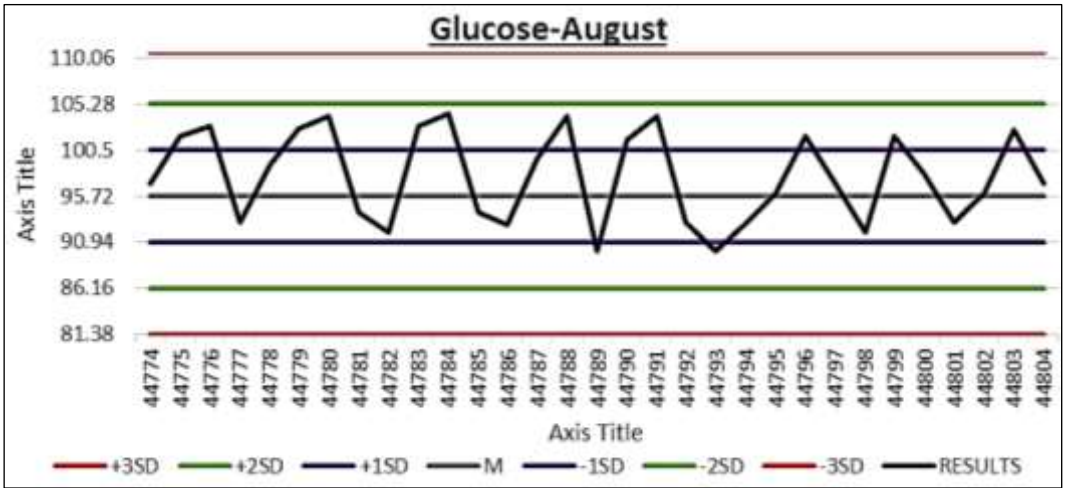
Table 1: Statistical analysis for multi-group comparison to identify accuracy

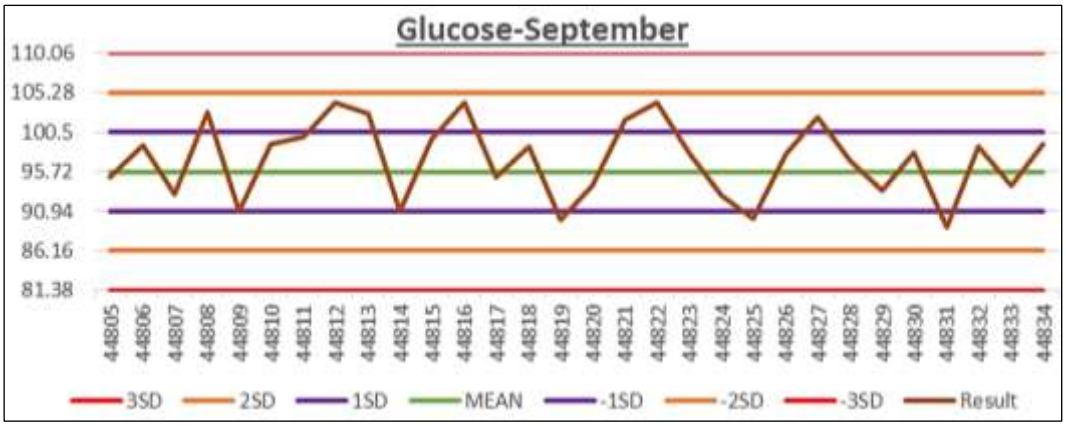
Variables	Standard Mean ± SD	Observed laboratory Mean			
		July	August	September	October
	Mean ± SD	Mean ±SD	Mean ±SD	Mean ± SD	Mean ± SD
Glucose	95.72±5.77	97.06±4.62	97.78±4.78	97.15±4.58	97.36±4.27
Total cholesterol	137.57±2.88	138.49±5.96	138.96±6.09	138.65±6.82	139.16±6.34

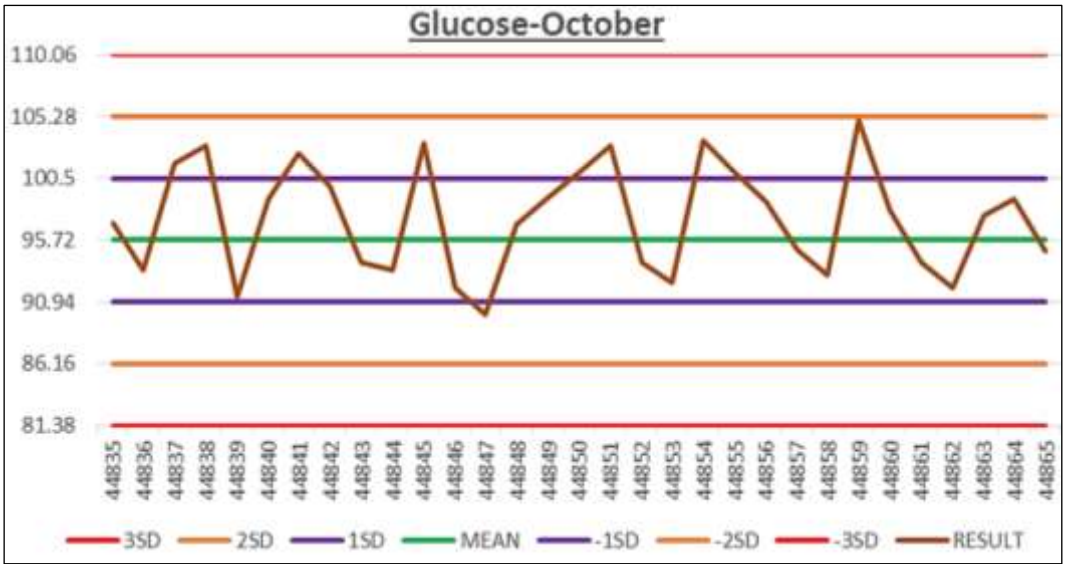
Table 2: Statistical analysis for Sigma bias

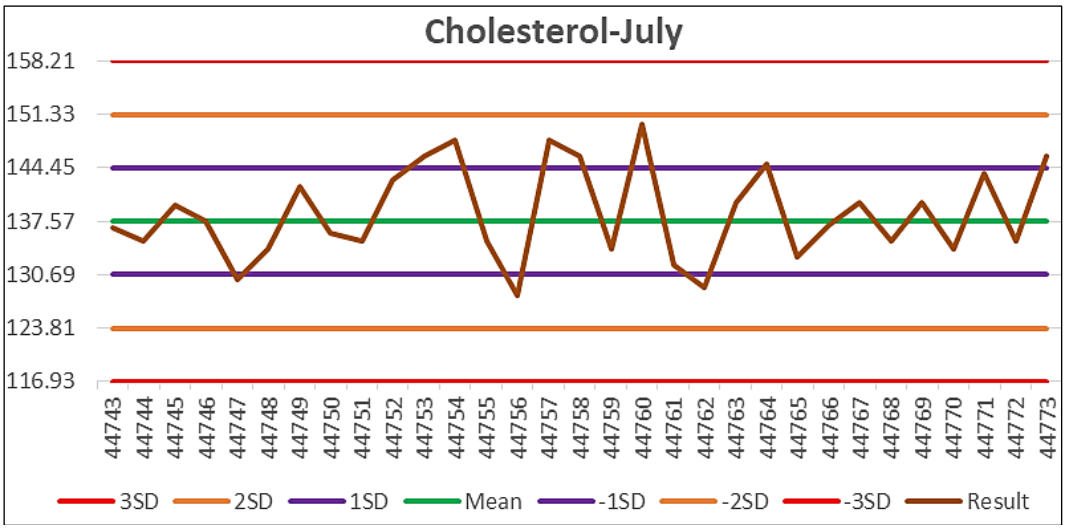
Variables	TEa (CLIA) (%)	July			August			September			October		
		CV (%)	BIAS (%)	Sigma (%)	CV (%)	BIAS (%)	Sigma (%)	CV (%)	BIAS (%)	Sigma (%)	CV (%)	BIAS (%)	Sigma (%)
Glucose	10% (3.9)	4.75	4.01	5.34	4.85	4.4	5.63	4.72	4.01	5.41	4.38	3.9	4.91
Total cholesterol	10% (3.8)	4.30	8.1	3.7	4.38	8.4	3.5	4.92	9.2	3.6	4.56	8.4	3.5

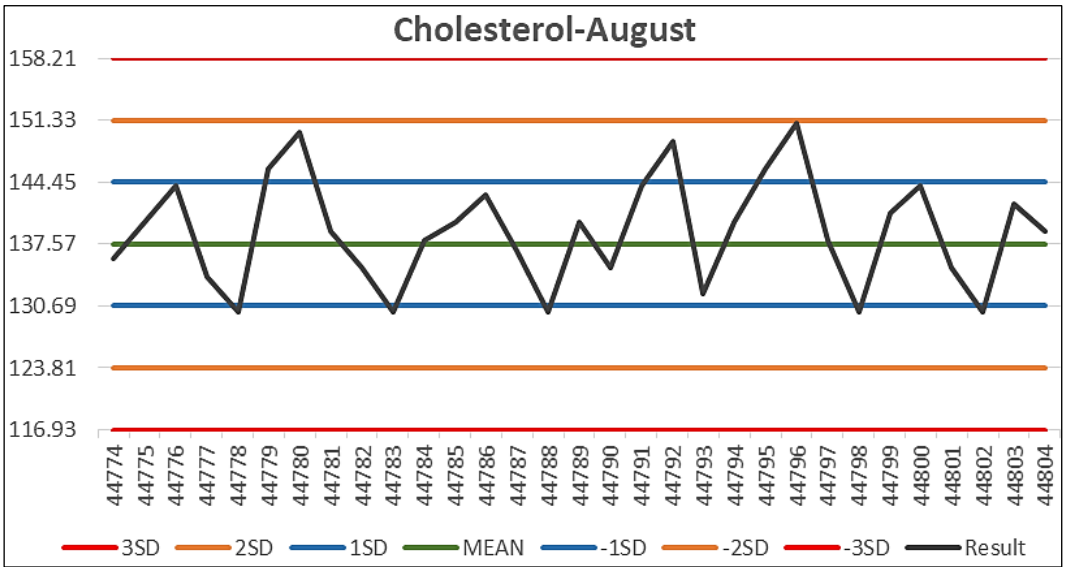


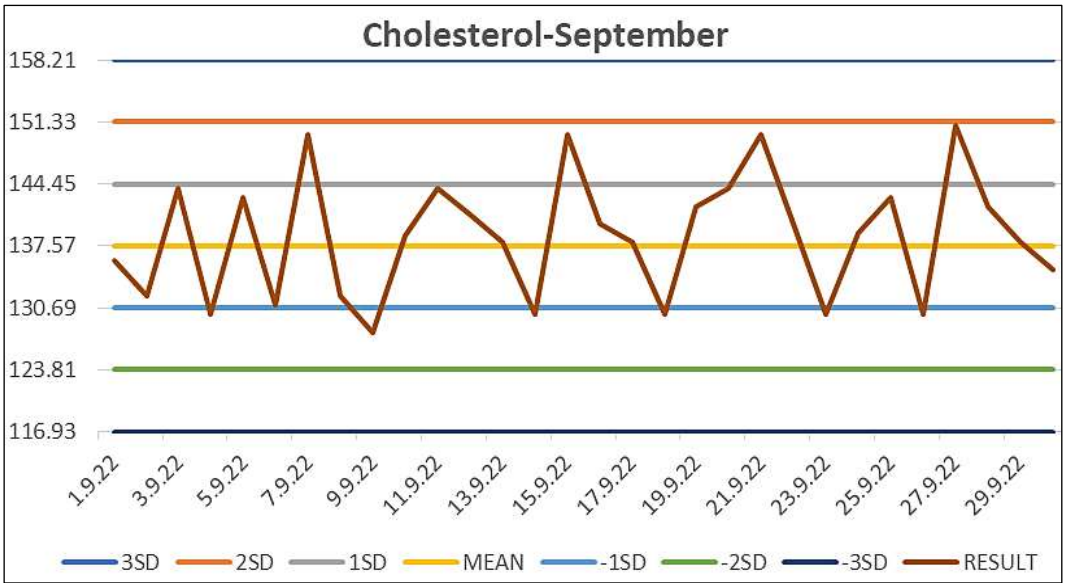


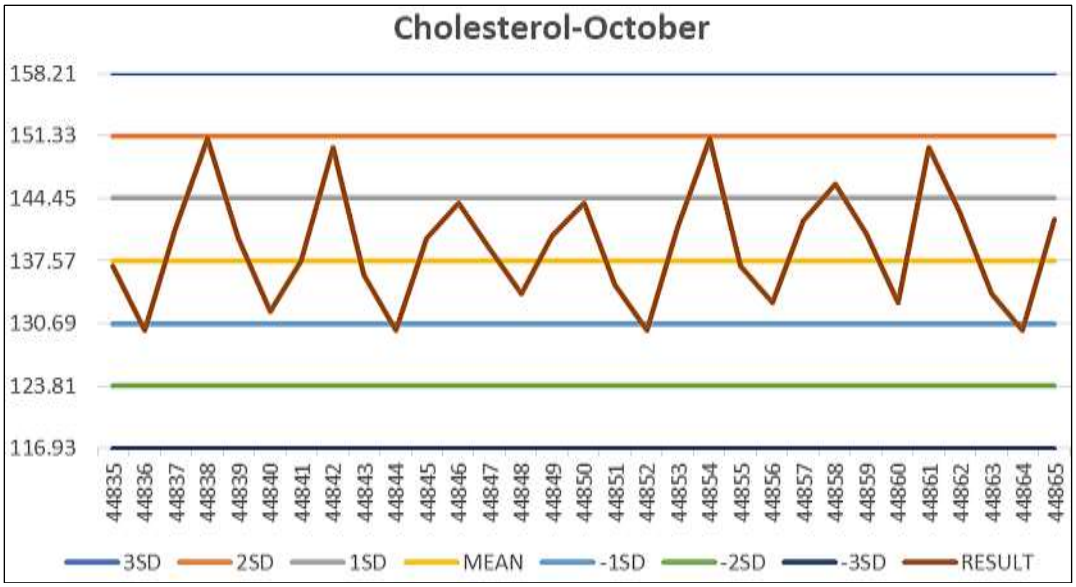












Graph 1: Month-wise representation of Blood glucose and cholesterol internal control by using LJ charts

DISCUSSION

Clinical decisions are majorly dependent on clinical laboratory parameters assessing or screening for appropriate diagnosis of diseases. Thus, to produce reliable, reproducible, and accurate laboratory results, internal quality control makes advancement for the betterment of results. So, clinicians and patients both can rely on it for diagnosis and prognosis of the disease. Trends (loss of reliability) and shifts (changes in mean) in the internal QC charts are the two major trends noted in the results of this study. Westgard rules for the analysis of systemic and random errors by using Levey-Jeneyscharts were followed to accept or reject the values [9]. The present stud evaluated and monitor internal quality data for July, August, September and October for blood glucose and total cholesterol. We have analyzedthe mean, standard deviation and coefficient of variation (CV%) of the results of all the thirty days of data of internal controls. Where we did not find many differences. The coefficient of variation was calculated by the ratio of the standard deviation to the mean of the results. The present study has observed a higher CV percentage that represents a greater level of dispersion around the mean. (Table-1)

Alvarez *et al*. (ISO 15189 standard) have rechartered colorimetric methods of a few biochemical parameters including glucose and cholesterol estimation in serum based on inter-laboratory comparison programs such as Bio-Rad External Quality Assurance (EQAS) and external quality control Statistical External Quality Control (SEQC) [10].

Six basic rules with LJ charts were followed in different groupings as a multi-rule procedure, where few rules have been used for the detection of random error while others were used for systematic error [2].

The LJ charts were prepared by calculating the mean and SD of the control material by analyzingit over 30

days. The concentration of the analyte is plotted on theY axis and the time of day on the X axis. Horizontal lines are drawn at mean, mean ±1 SD, ±2SD, and ±3 SD. Each day's data is plotted on the charts for the glucose and total cholesterol (Graph No-1).

Six Sigma metrics is one of the significant quality control tools implemented in all the laboratories to improve the quality of results, which is mainly used to evaluate the Quality control of performance in the clinical Biochemistry Laboratory employing value deviation from the standard values. Schoenmaker *et al*. has carried out a study to monitor the significance of sigma metrics in Quality control using sigma values [11].

The present study observed the blood glucose and cholesterol controls values over 4 months and evaluated six sigma metrics to improve the quality of patient results by analyzing and eliminating sources of defects. Test with a low sigma value i.e., less than ±3 SD indicates that appropriate action should be taken to improve process output or any other alternate methods (having accurate control materials) can be used [2].

In this study, we have assessed the sigma scale for only normal level QC and found imprecision in our selected parameters whereas, sigma values fall under the scale of 1-6 for all three months except September, Sigma values (not always clinically relevant in health care system) of September month for cholesterol beyond the six and it shows inaccuracy for the September month data. The bias score is also exceeding three for both parameters. This may be due to the materials storing temperature or there could be a human error. So, appropriate scrutiny is required for monitoring the performance of this parameter, to provide quality for patients test results.

CONCLUSION

1. The major functionality of a clinical laboratory is to provide accurate and reliable process output (patient results).
2. The present study uses six sigma parameters for the assessment and comparison of the performance of tests over four months by using internal quality control materials. In this study, we found a warning sign. It is not uncommon but this kind of sign helps to identify errors.
3. This study shows imprecision and BIAS (not always clinically relevant) for both variables exit their normal scale value, alarming that appropriate corrective action should be taken in terms of accuracy and imprecision.

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