Quality control in Hematology

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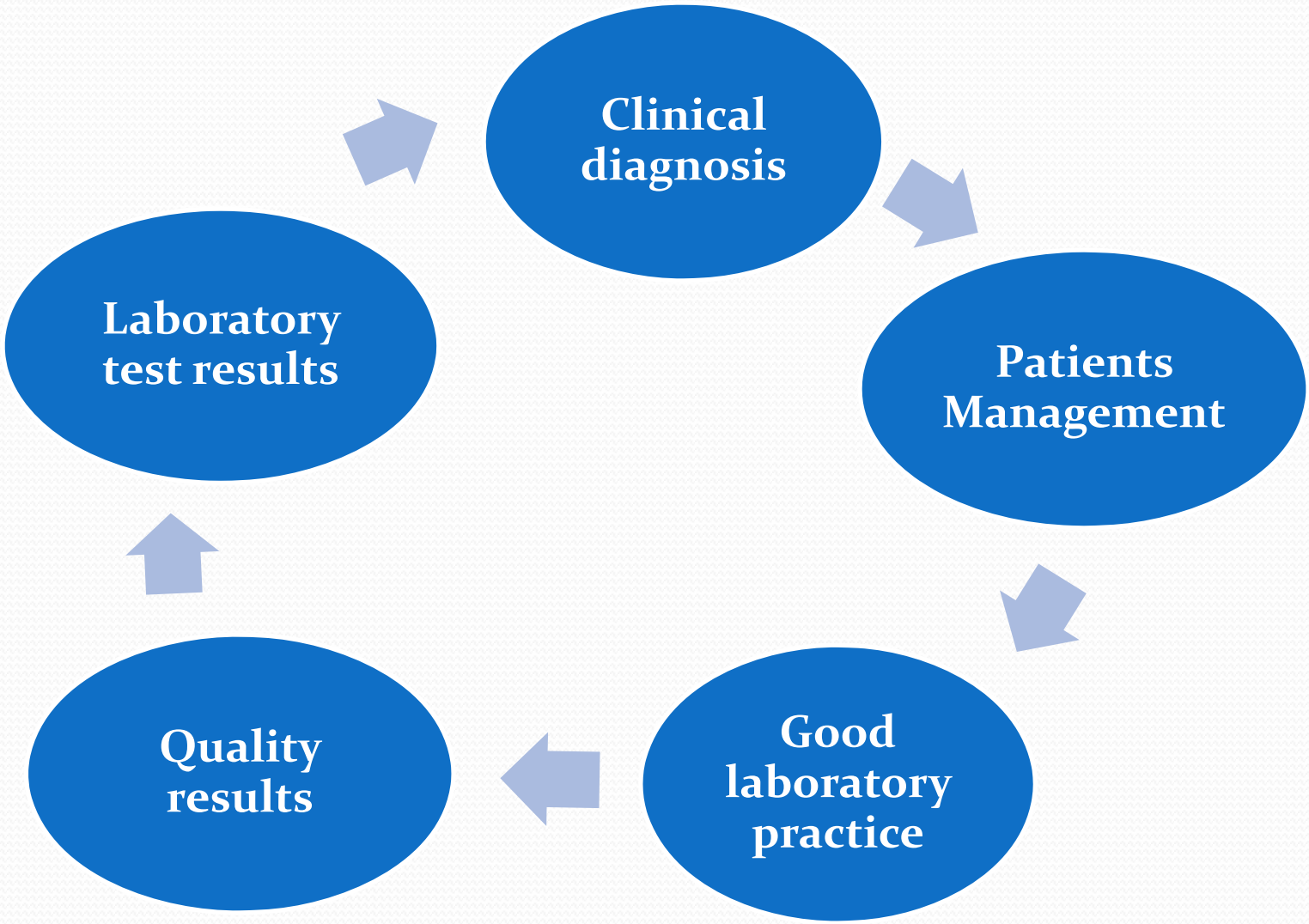

Clinical diagnosis
Patients Management
Good laboratory practice
Quality results
Laboratory test results

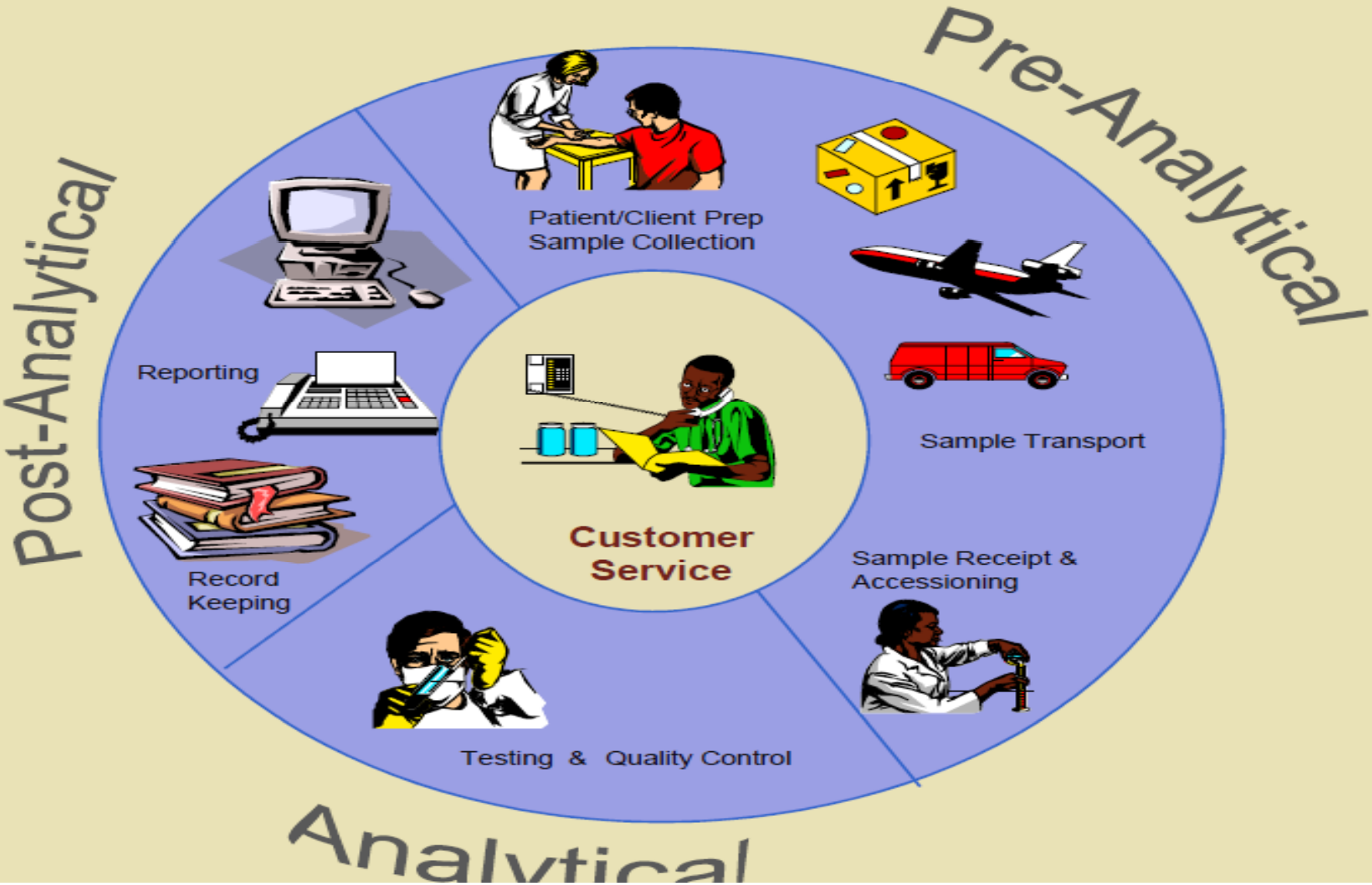
Quality is assured at

Pre-analytical

Analytical

post-analytical

The Quality Assurance Cycle



Pre analytical Phase

Examination request form

Blood collection

Blood collection

- Stress and exercise

- Prolonged use of tourniquet

- Type of EDTA K3 vs K2

- Specimen mismatch /mix-up

- Blood to anticoagulant ratio

- Transcription error

- Proper Transportation

- Sample accession

- Rejection criteria

Quality management of Analytical Phase

Internal Quality control (IQC)

External Quality control (EQAS)

Standardization

Terminologies – IQC & EQAS

- Precision
- Accuracy
- Calibration
- Carryover
- Control
- Calibrator
- Standardization
- Validation

- Levey-Jennings chart
- Mean
- Standard Deviation
- Control Limits
- Coefficient of Variation
- Westgard Rules
- Z-Score

STATISTICS

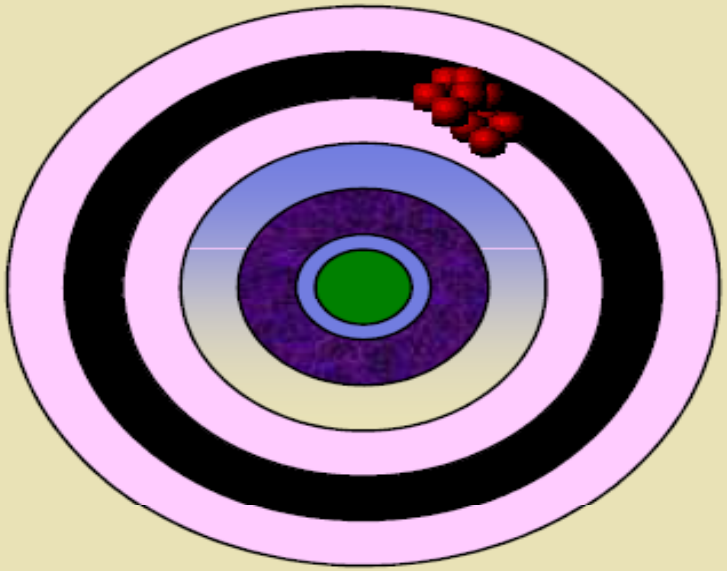
STATISTICAL APPROACH

PRECISION (REPRODUCIBILITY)

- **Definition**

  Precision refers to the reproducibility of a result.

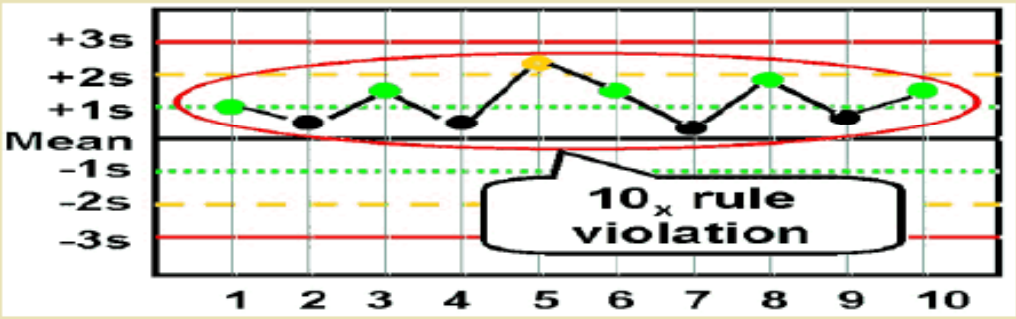
- **Comparing QC terms to a target** Figure illustrates that the results are precise (close together) but not accurate (they are not in the bull's-eye).



- **Checking precision is required while**

  -calibration

  -troubleshooting



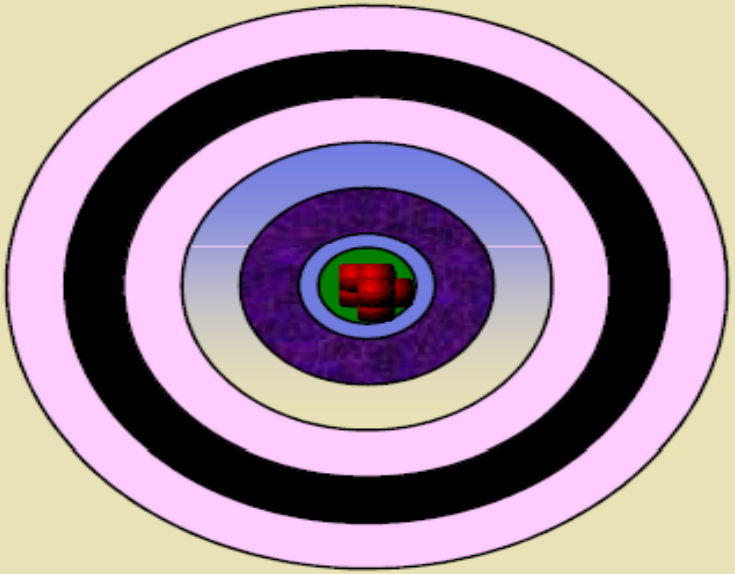
ACCURACY

- **Definition**

  Closeness of a result to the true (accepted) value.

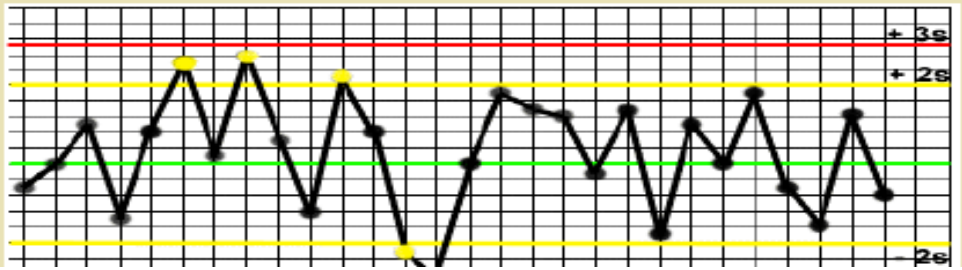
  NOTE: Before determining accuracy, first determine precision.

- **Comparing QC terms to a target** Figure illustrates that the results are accurate (in the bull's-eye) and precise (close together).



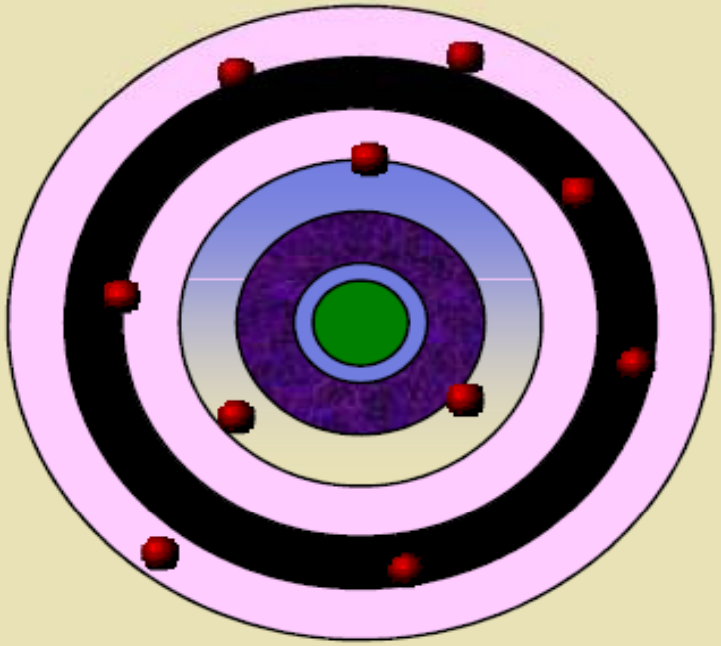
NOTE

- You cannot have accuracy without precision.
- However, you can have precision without accuracy.



NEITHER ACCURACY NOT PRECISION

- This figure illustrates that the results are neither accurate nor precise.
- None of the results are close together, and none of them are in the bull's-eye.



Setting accuracy

Calibration

Is done to standardize the instrument for accuracy.

Calibrator

Certified Reference Material (CRM) used to calibrate a measurement on an analyzer.

Cal-Factors

If any deviation from calibration references is observed necessary calibration correction factors are applied to set the accuracy of the instrument.

CARRYOVER

- Carryover is defined as a number of cells remaining behind following the cycling of a blood sample.
- This test is performed to determine if one sample interferes with the accurate analysis of the next sample.
- Ideally, carryover Shall be very low.

Measure a specimen with a high concentration in triplicate, immediately followed by a specimen with a low concentration in triplicate.

$$\text{Carry over (\%)} = \frac{l_1 - l_3}{h_3 - l_3} \times 100$$

Where l_1 and l_3 are the results of the first and third measurements of the samples with a low concentration and h_3 is the third measurement of the sample with a high concentration.

How to create L-J chart?

By using simple statistics

- Mean → TARGET
- Standard Deviation (SD)
- ± 1SD
- ± 2SD
- ± 3SD

→ CONTROL LIMITS

- Coefficient of Variation (CV %)

Creating L-J chart …

First step – Calculate Target Value

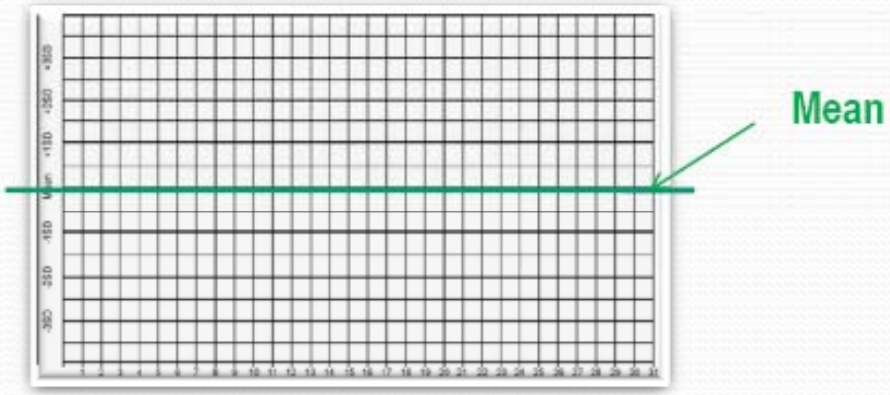
- **Mean** ($\overline{x}$) is the sum of all the measurements (Σ) divided by the number of measurements (n)

- Formula $\overline{x} = \sum x_i / n$

Where

x_i = each data point

n = the number of data points in the set



SD Calculation

Where,

$$S.D. = \sqrt{\frac{\sum\left(x - \bar{x}\right)^2}{n-1}}$$

$\sum$ = sum of

x = any single observed value

$\bar{x}$ = average value

n = total number of observed values

Here n = 20

Mean

$\bar{x}$ = 2000 / 20 = 100

SD

SD = √ 157 / (20-1)

SD = 2.87

Calculation Procedure	No. of runs	A (x_i)	B ($x - x_i$)	C $(x - x_i)^2$
1. List values in column A	1	95	-5	25
2. Add column A, comes to 2000	2	100	0	0
3. Divide total of column A by	3	101	+1	1
no. of values (see mean	4	102	+2	4
formula), comes to 100	5	97	-3	9
4. This is the average or mean	6	103	+3	9
value	7	101	+1	1
5. In column B list the difference	8	99	-1	1
in values of column A from	9	98	-2	4
the average values of column	10	100	0	0
A from the average value	11	95	-5	25
100, disregard + or – signs	12	101	+1	1
6. Square each value and place	13	105	+5	25
in column C	14	100	0	0
7. Add values in column C	15	98	-2	4
8. Divide the total of column C	16	101	+1	1
by number of values minus 1	17	97	-3	9
(see SD formula)	18	106	+6	36
9. Determine the square root of	19	100	0	0
8.37 which comes to 2.89.	20	101	+1	2
this is the standard deviation		**2000**		**157**

Creating L-J chart …

Third step – Calculate Control Limits (± 1SD, ± 2SD, ± 3SD)

Mean + (3 x SD) = + 3SD

Mean + (2 x SD) = + 2SD

Mean + (1 x SD) = + 1SD

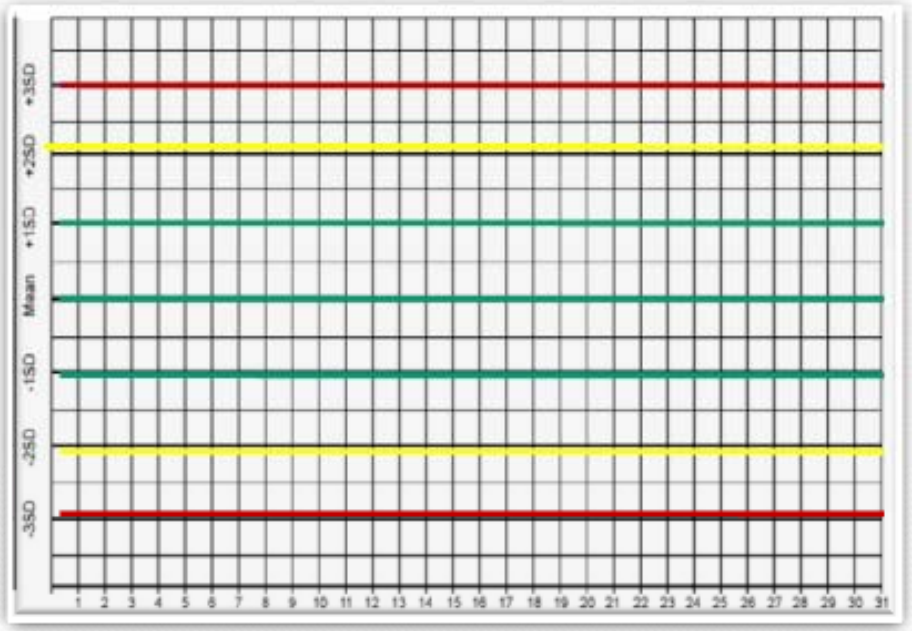
Upper Control Limits

Mean - (1 x SD) = - 1SD

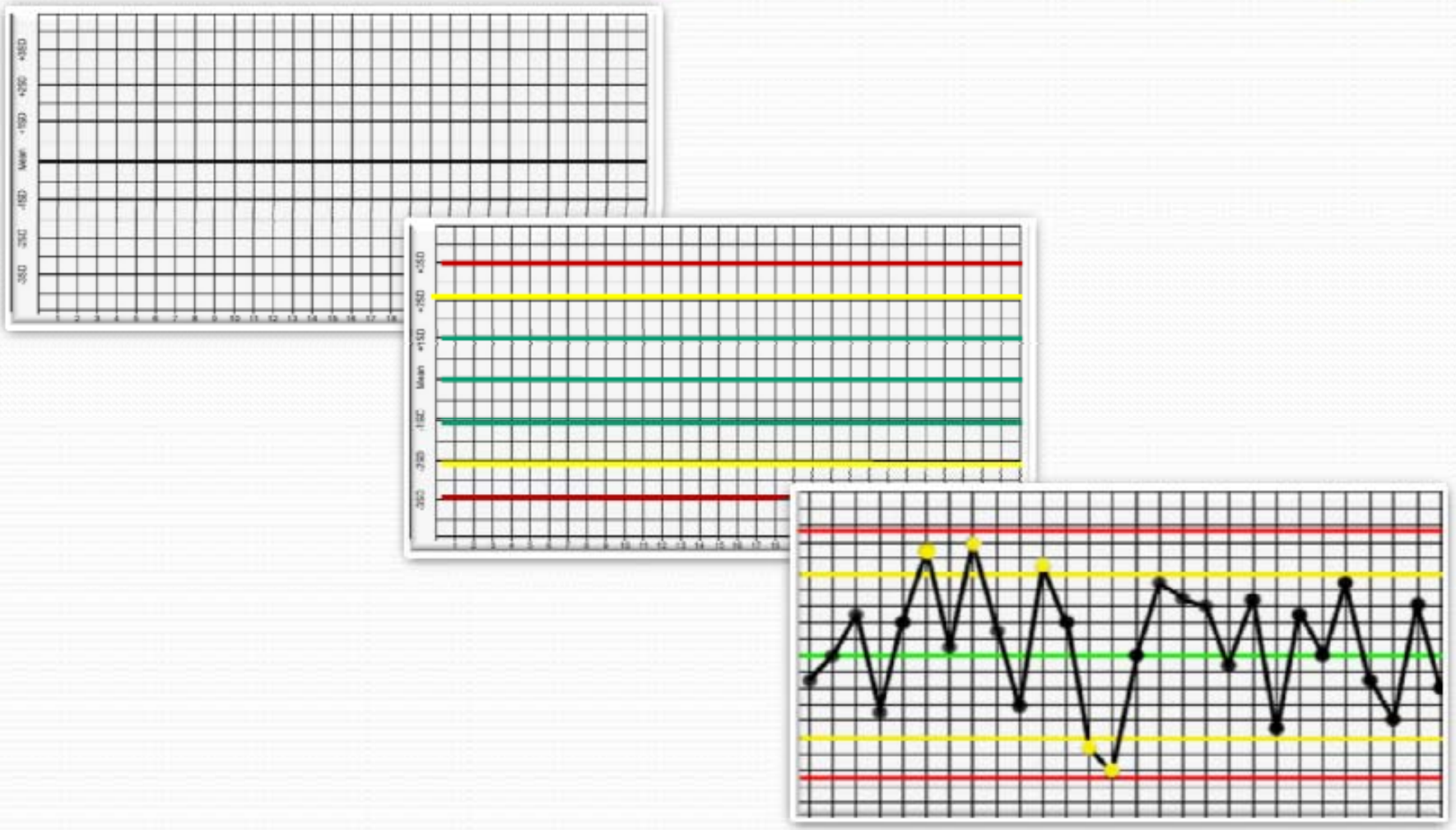
Mean - (2 x SD) = - 2SD

Mean - (3 x SD) = - 3SD

Lower Control Limits



L-J chart is ready for QC monitoring



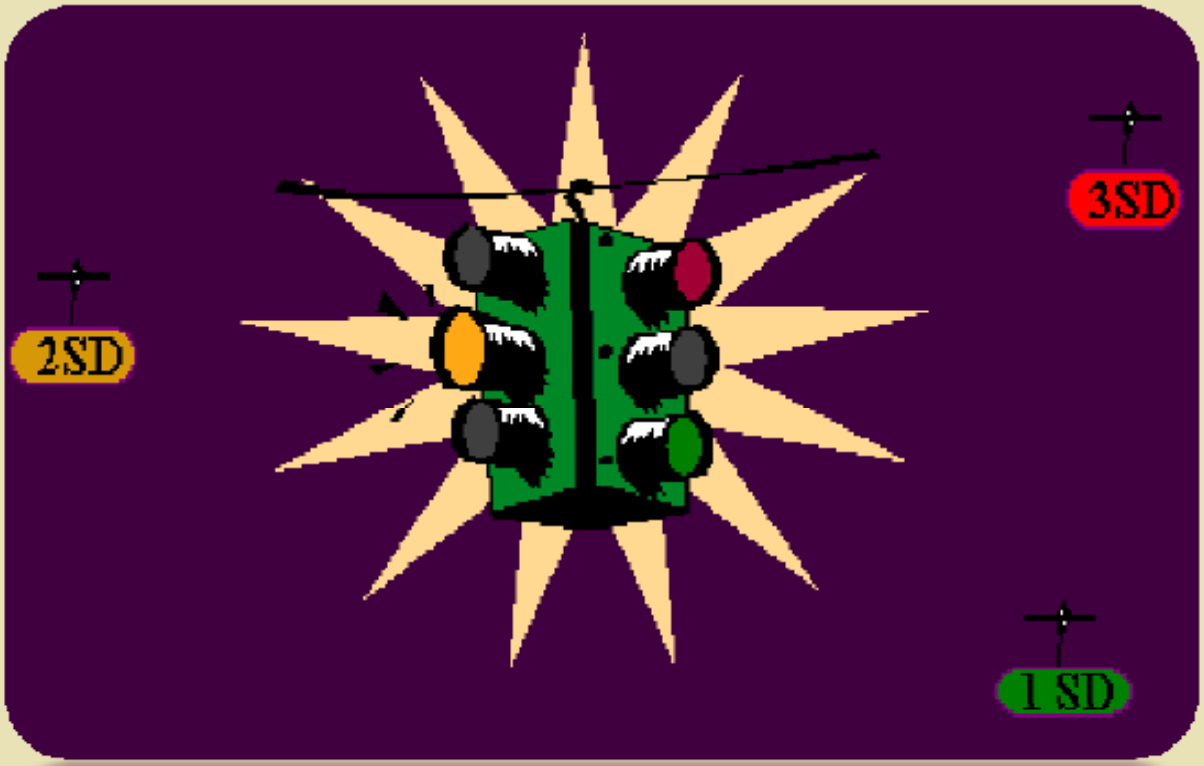
Dispersion simplified

Coefficient of variation (%CV)

- CV is another way of indicating standard deviation, related to the actual measurement, so that variation at different levels can be compared.
- Formula

$$C.V.= \frac{S.D.}{\overline{X}} \times 100$$

- It is expressed as a percentage (%CV).



IQC

IQC of Haematology Analyzer

- Start up and background count

- Running tri-level commercial control/ pooled plasma

- Monitoring QC data
  - LJ charts
  - Applying Westgard's rule
  - Monitoring %CV

When commercial control is out Check for

- QC material (open vial expiry, stability, storage, deterioration)

- Analyzer (Background, reagent expiry, opening date, Instrument status , priming, aperture cleaning etc)

- Rerun control

- If problem still persists, run fresh QC material, call service engineer

Other additives to IQC

Comparative studies

Rerun sample on same analyzer

Run on another analyzer with special mode

Correlate with peripheral blood smear finding

Maintenance of analyzer

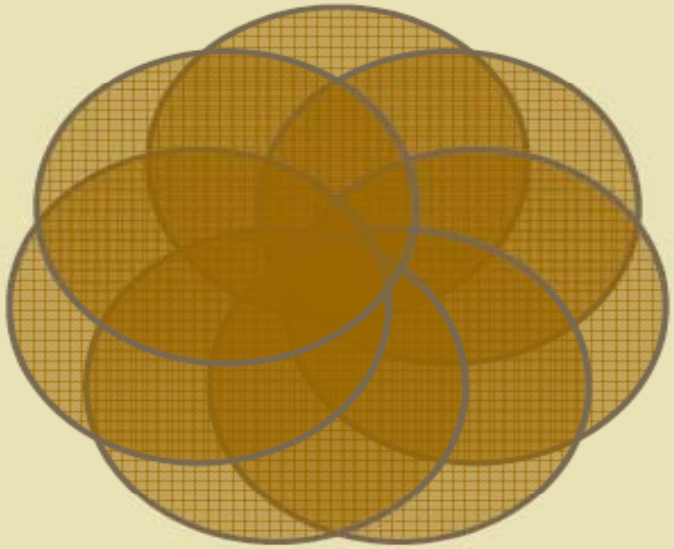
Peripheral smear study not required for all CBCs

Probable criteria when peripheral smear is made

Absolute lymphocytosis in any new case > 5 x 10^9/L

Absolute monocytosis in any new case > 1 x 10^9/L

Absolute basophilia in any new case > 0.1 x 10^9/L



Blast flag in the scatter plot in any new case.
Platelet clump flag and PIC/POC
(Plt count <100)

All new cases of leukemia.

New cases of Bicytopenia / pancytopenia :

- Hemoglobin < 10 gm%
- Total Leukocyte Count <4 x 10^9/L
- Platelet Count < 100 x 10^9/L

Total Leukocyte Count or Platelet Count vote out even after rerun.

External Quality Assessment (Proficiency Testing)

EQAS (National)

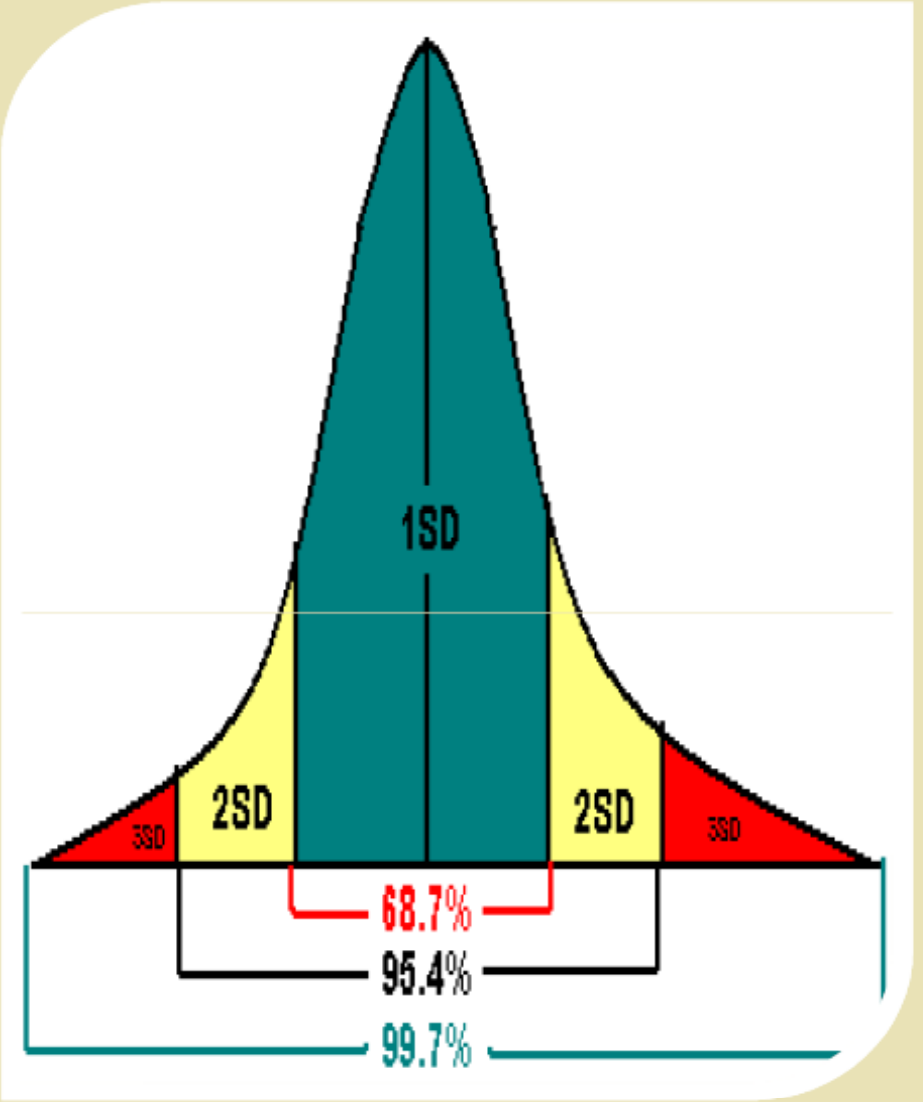
AIIMS for CBC , Retic count, Peripheral smear
CMC Vellore for coagulation

EQAS (International)

CAP for CBC, Coagulation, ESR, Flowcytometry etc

Normal Distribution Curve
or
Gaussian curve

Describes events or data that occur symmetrically about the mean.



<u>Out of 100 events</u>

68.7 will fall within ±1 SD

95.4 will fall within ± 2 SD

99.7 will fall within ±3 SD

Comparative performance evaluation

Z-Score

	A - 1	A - 2	A - 3	A - 4	A - 5	A - 6	A - 7	A - 8	A - 9	A-10	A-11	A-12	MEAN	SD
WBC	5.9	6.3	6.2	5.2	6.3	6.2	5.9	6.3	6.2	5.9	6.3	6.2	6.1	0.3
HGB	13.1	12.9	12.7	13.1	12.9	12.7	13.1	12.9	12.7	13.1	12.9	12.7	12.9	0.2
PLT	262	246	255	262	246	255	262	246	300	262	246	255	258.1	14.9

Z-SCORE	A - 1	A - 2	A - 3	A - 4	A - 5	A - 6	A - 7	A - 8	A - 9	A-10	A-11	A-12
WBC	-0.55	0.70	0.39	-2.74	0.70	0.39	-0.55	0.70	0.39	-0.55	0.70	0.39
HGB	1.17	0.00	-1.17	1.17	0.00	-1.17	1.17	0.00	-1.17	1.17	0.00	-1.17
PLT	0.26	-0.81	-0.21	0.26	-0.81	-0.21	0.26	-0.81	2.82	0.26	-0.81	-0.21

Z SCORE SCALING :-

< ±0.5 - Excellent performance

±0.5 to ±1.0 - Satisfactory

±1 to ±2 - Acceptable

> ±2 - Defect requiring attention

$$\text{Z Score} = \frac{\text{Observed value - Weighted mean}}{\text{SD}}$$

If EQAS PT is not available

Split sample analysis

Inter-laboratory comparision program (ILCP)

Quality Management of Post-Analytical Phase

Reporting

Sample retention

Record retention

Reanalysis of sample (Rerun)

Parameters	Nature of problem (flags)	Measures taken
WBC criteria	White population plots displayed in the scatter plot	Rerun in WBC extended mode, manual mode.
RBC criteria	Flagging for RRBC	Rerun in resistant RBC cycle mode.
Hb criteria	H and H fail	Rerun. (IF POSSIBLE ON ANOTHER ANALYZER)
Platelet criteria	Delta PIC/POC flag is displayed along with low platelet in PIC	Check for clot, mix sample thoroughly and rerun. Rerun in manual mode.
Others	Short sample flag displayed . Cellular interference flag. H and H check fail flag.	Check for clot, mix sample thoroughly and rerun. Ask for repeat collection.

Report format

The report shall contains at least the following information: ISO 15189:2007 Clause 5.8.3 (a to q)

- clear, unambiguous identification of the examination including, where appropriate, the measurement procedure
- the identification of the laboratory that issued the report
- unique identification and location of the patient, where possible, and destination of the report
- name or other unique identifier of the requester and the requester's address
- date and time of primary sample collection, when available and relevant to patient care, and time of receipt by the laboratory
- date and time of release of report which if not on the report shall be ready accessible when needed
- source and system (or primary sample type)
- results and examinations reported in SI units or units traceable to SI units where applicable
- biological reference interval, where applicable
- interpretation of results, where appropriate
- other comments (e.g. quality or adequacy of samples which may have compromised with the result, etc)
- identification of the person authorizing the release of results
- if relevant, original and corrected results
- signature of authorization of the person checking or releasing the report is received.

Before Report dispatch … Delta Check

A formal way of testing for aberrant results is known as `delta check`. The blood count parameters should not differ from recent tests in the previous 2-3 weeks by more than a certain amount.

The difference should generally be not more than:

For Hb and RBC	For WBC	For Platelet count
10 %	20-25 %	50 %

Assuming that the patient's clinical condition has not altered significantly

Delta check must be done before dispatch of the report.
This is only possible if the previous report of the patient and the clinical condition is provided.

Before Report dispatch…
Authenticate

Each and every result generated is scrutinized and authenticated by the staff running the sample.

During report delivery

- The person at the dispatch counter delivers the reports to the identified individual.
- The receiver's identity, name and signature are taken and the time and date of dispatch is recorded in the register.

Alert the clinician for report with critical values

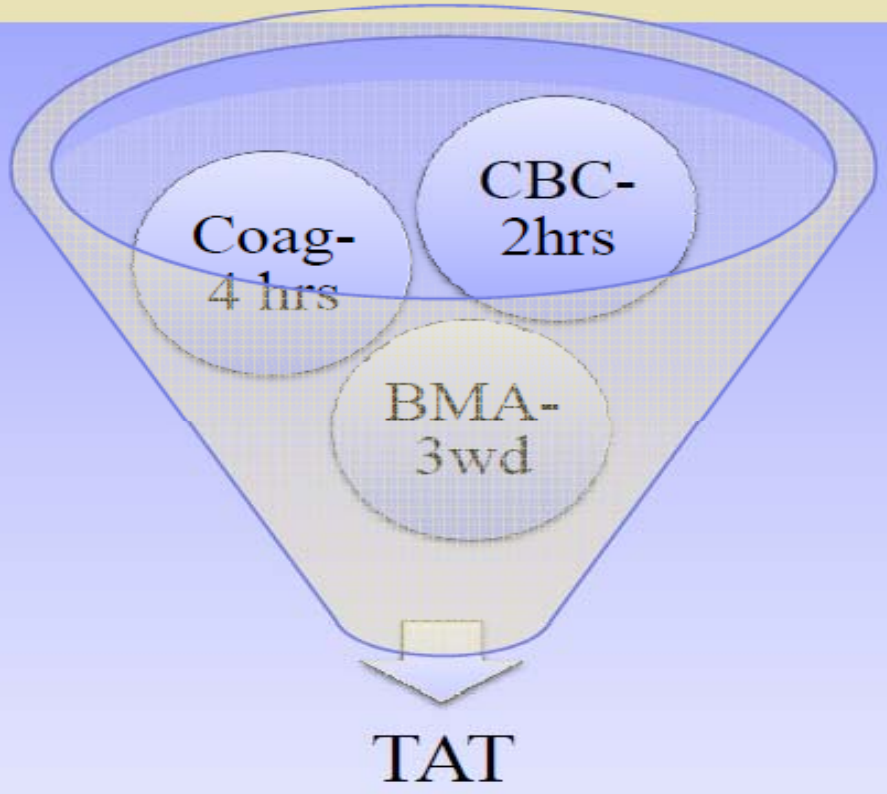
- Laboratory define the critical / alert values and has procedures for reporting such results to the treating clinician immediately. The records of such procedures are maintained.

Telephonic reporting

- Discourage - Telephonic reports
- Consider genuine cases
  - critical values / OT patients / ICU patients
- Record the details
  - parameter value told
  - requester's identity
  - reason of the urgency
  - read back of the report

Turn Around Time (TAT)

The laboratory takes responsibility for reporting the results within the specified turn around time.



The requester i.e. the clinician is notified in case of delay in examination only in such cases where the delay can compromise patients care.

Quality Indicator – "TAT shall be monitored on periodic basis for continual improvement"

Alteration of report

- If any alteration of report is done, record
  - date and time,
  - signature of person responsible
  - reasons of alteration
  - alteration made

Method

A single line across over the original data is made such that the original data remain legible.

Sample retention

- Post analysis the sample is retained for a stipulated time period for the following reasons
  - Repeat examination due to erroneous results obtained during the first cycle of examination or due to analytical failure.
  - Additional or further examinations of same primary sample.

Safe disposal of sample

Reference -Maharashtra Pollution Control Board

Color Coding	Type of Container	Waste Category
Yellow	Plastic Bag	Waste from laboratory contaminated with blood and body fluids including cotton, gloves, and other contaminated material
Yellow	Puncture proof container	**Waste sharps** Needles, syringes, glass; etc. that may cause puncture and cuts.
Black	Plastic bag	Paper, stationeries and non-contaminated wastes

Record retention

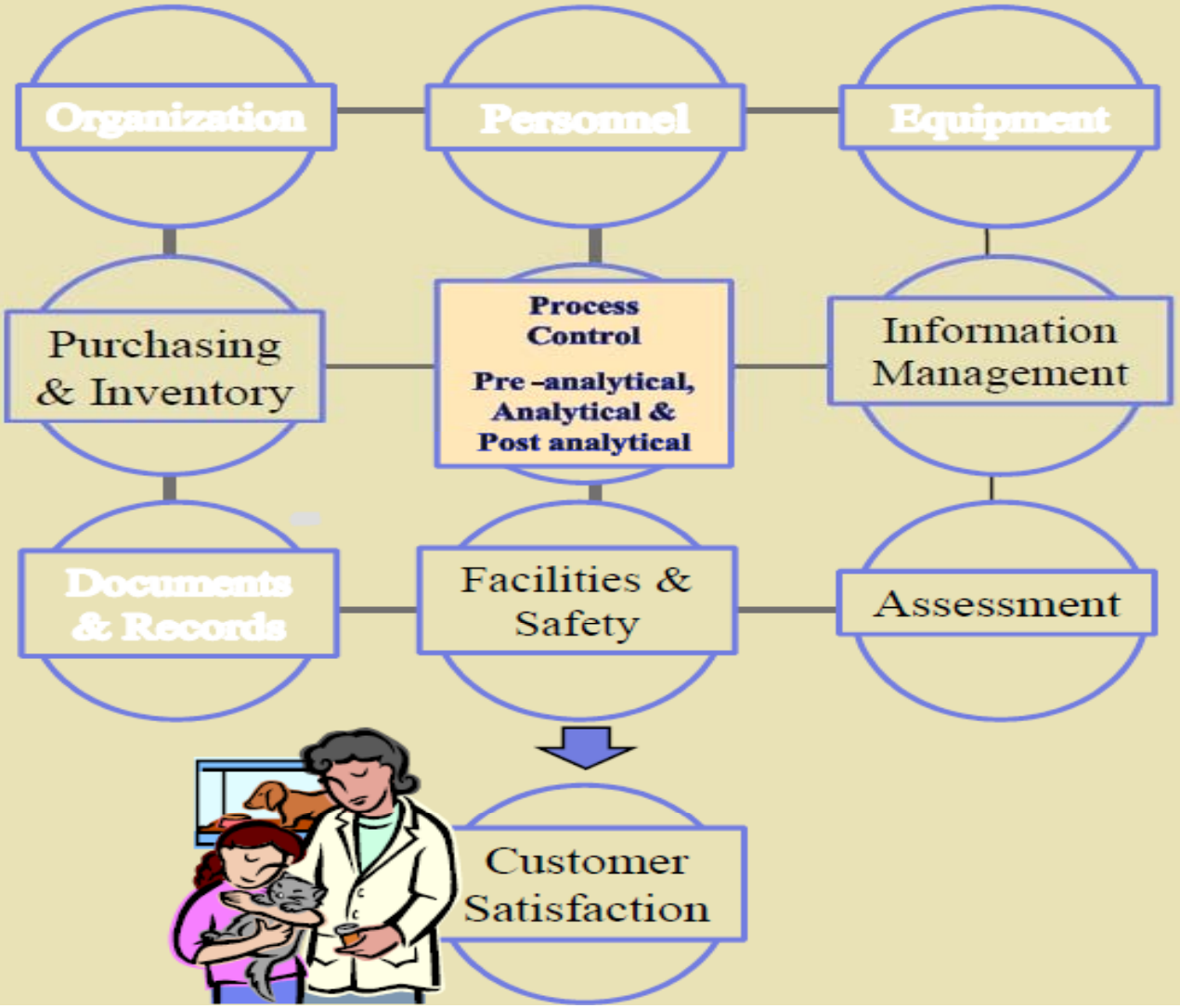
- Reason for retention
  - prompt retrieval of the information
- Retention time
  - the length of time that reported data are retained may vary as long as medically relevant.

e.g. of records

S.No.	Type of record
a	Request forms
b	Examination results and reports
c	Instrument printouts
d	Examination procedures
e	Laboratory work-books or sheets
f	Accession records
g	Calibration functions and conversion factors
h	Quality control records
i	Complaints and action taken
j	Records of internal and external audits
k	External quality assessment records/inter laboratory comparisons
l	Quality improvement records
m	Instrument maintenance records, including internal and external calibration records
n	documentation, certificates of supplies, package inserts
o	Incident / accident records and action taken
p	Staff training and competency records

Summary …

TQM


Organization
Personnel
Equipment
Purchasing & Inventory
Process Control
Pre -analytical, Analytical & Post analytical
Information Management
Documents & Records
Facilities & Safety
Assessment
Customer Satisfaction

THANK YOU