Covid-19 Vaccine Rollout

Group 3

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Introduction

- COVID 19 is a contagious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The first case was reported in Wuhan China and the it quickly spread all over the globe. On March 11, 2020, the WHO declared COVID-19 a global pandemic.

- As the number of cases and deaths increased around the globe, scientists and researchers hurried to find a vaccine. The urgency to create a vaccine for COVID-19 led to compressed schedules that shortened the standard vaccine development timeline, in some cases combining clinical trial steps over months, a process typically conducted sequentially over years.

- By mid-summer, Moderna and Pfizer had established themselves as the leaders in the race to develop a COVID-19 vaccine. Moderna hopes to have 20 million doses available by the end of 2020, with Pfizer saying that 50 million doses of their vaccine will be available globally by then.

Objectives

01

Implement a safe and accessible Covid 19 Vaccine administration

02

Vaccinate based on the priority

03

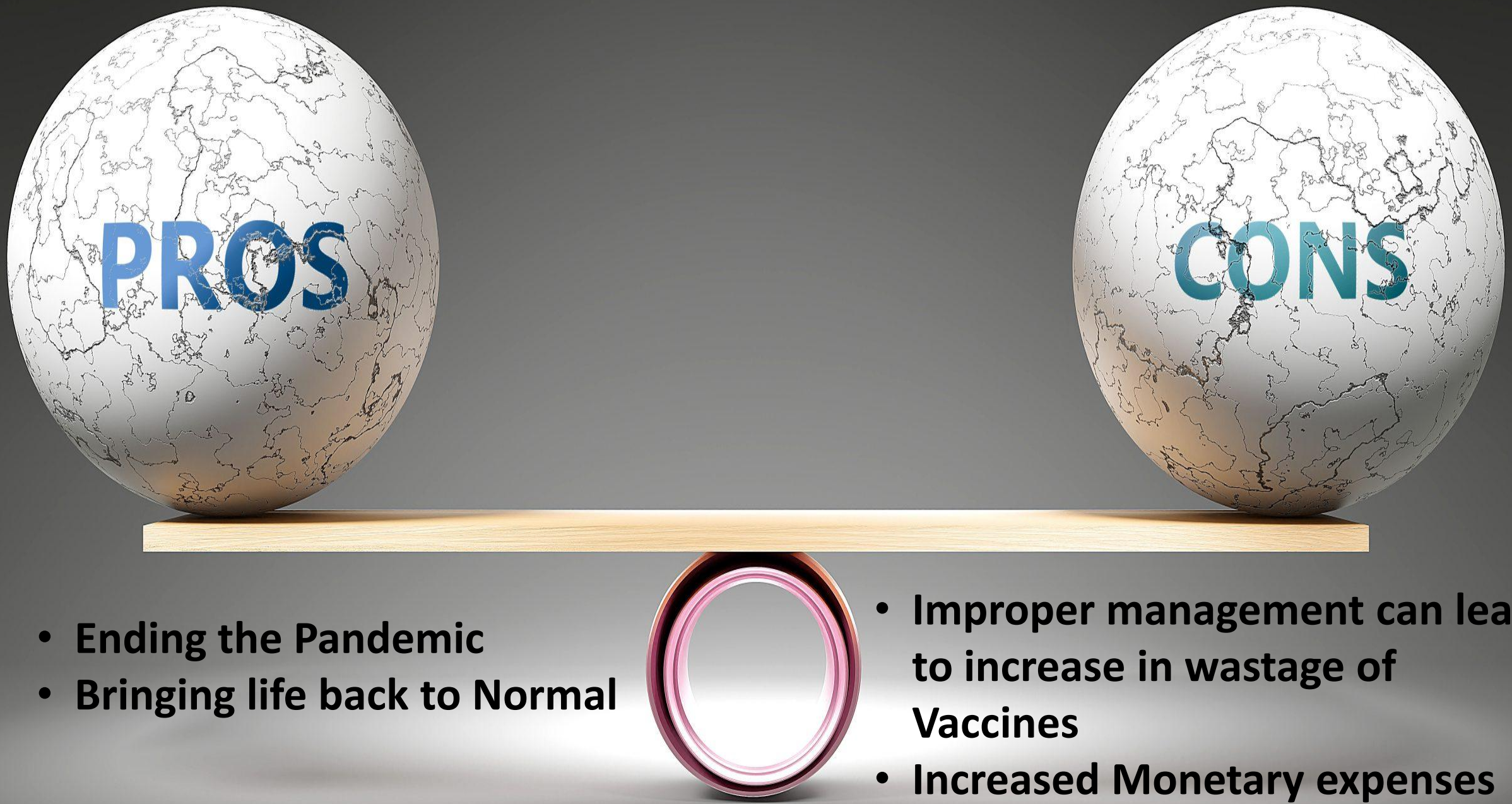
Vaccinate 100% of population

04

Ensure that there are no side effects for vaccination

05

Distribute vaccines efficiently



- Ending the Pandemic
- Bringing life back to Normal

- Improper management can lead to increase in wastage of Vaccines
- Increased Monetary expenses

Affinity Diagram

Data

Row	Production	Distribution	Transportation
1	Manufacturing Equipment	Warehouses	Trucks
2	Raw Material	Suppliers	Railways
3	Storing Equipment	Inventory	Delivery services(Eg: UPS, Fedx)
4	Operators	Accountants	Drivers
5	Quality control		Airways
6			Mechanics
7			Maintenance
8			Loaders

Row	Administration	vaccination
1	Computers	Vaccination center
2	Doctors	Nurses
3	Inventory control system	Syringes
4	Internet	Sterilizing Equipments
5	Database	Cotton

Cost of Poor Quality

COPQ	Internal	External	Appraisal	Prevention
Less than expected delivery of vaccines	▪ Low rate of production ▪ Machinery failure	• Bad Weather	• Increase Productivity	• Increase number of reliable suppliers • Prepare for emergencies
Difficulty in reaching testing centers	▪ Testing center not in close proximity	▪ Not enough public transport	▪ Better transport facilities	▪ Provide vaccinations at local drug store
Lack of proper vaccine storage facilities	▪ Faulty temperature control storage equipment	▪ Bad weather ▪ Electrical failure	▪ Backup Generators	▪ Separate electrical grid for all vaccine storage locations
Improper scheduling of Vaccines	▪ Improper inventory records	▪ People not showing up to get the vaccine	▪ Ordering vaccines based on the number of people scheduled	▪ Confirming Appointments and maintaining proper inventory records

Quality Assessment

List of individuals to Interview:

- Head of Authorization
- Head of Prioritization
- Head of Allocation
- Head of Center for Disease control (CDC)

Quality Assessment: Q&A

Head of Authorization:

- On what basis is the government deciding which state gets how many vaccines?

→ Each state will get a certain amount, determined by how many adults live there

- If a state demands more vaccines than allocated, how do you plan to authorize their demand?

→ Depending on how urgent the situation is, the state shall determine if and how many batches need to be released

- Will the state authorize the use of this vaccine for the new strains of coronavirus?

→ At this moment, the current vaccine is prone to the new strains of coronavirus

Quality Assessment: Q&A

Head of Prioritization :

- On what basis is the priority assigned to provide the vaccine?

→ There are multiple groups, and these groups have phases that are followed by the state. The groups are classified into age, race, ethnicity and underlying medical conditions.

- If there's an outbreak of the coronavirus among young adults in a locality, would they take priority over the allotted group?

→ That would be decided on the situation and how dire it is

- How do you prioritize between two states in an emergency?

→ Depending on how many cases are found and the demography, the call will be taken

Quality Assessment: Q&A

Head of Allocation:

- How do you expect transparency in allocate the vaccine?

→ We have stationed security personnel at every center. Every person coming in to get vaccinated has a vaccine card and their information is stored in the database.

- What is the allocated timeline that has been decided for each batch of vaccine to reach a distribution center?

→ Every other tuesday, a batch comes in to the center. Provided there are a lot of vaccines still parked at the center, we send a batch later in the week.

- How would you allocate the number of vaccines if there are multiple distribution centers over the city?

→Depending on demographics, we send more or less number of batches to the decided centers.

Quality Assessment: Q&A

Head of Distribution :

- How will the COVID-19 vaccine be rolled out?

→ The general population will receive the vaccine based on age and medical conditions. People who have a higher chance of getting very sick or dying will receive the vaccine first

- What are the requirement to preserve the vaccine while it is in transportation?

→ We have developed a special transport box the size of a suitcase, packed with dry ice and installed with GPS trackers. Each reusable box can keep up to 5,000 doses of the vaccine at the right temperature for 10 days, if sealed.

- Is the transportation system full-proof to move the vaccine without being affected?

→ Yes, we haven't had a complain about inefficient transport carriers

Quality Assessment: Q&A

Head of Centers for Disease Control(CDC) :

- How have different groups been responding to the vaccine?

→ People have only reported mild symptoms after receiving the 2nd dose of the vaccine

- How would you classify if a vaccine has gone bad?

→ Out of range temperature will signify if the vaccines are fit to use or not

- How do you plan to maintain sanitization and a controlled environment at every distribution center?

→ There are front line workers and powered generators to help maintain the right environment for the vaccine

Six Sigma

Phases of Six sigma:

- Define
- Measure
- Analyze
- Improve
- Control

Project Selection

Name of Project	Pros	Cons	Final Selection
Create an effective vaccine administration plan	More number of people vaccinated in a day and efficient use of vaccines and workforce	Difficulty in following criteria-based selection	✗
Create an effective vaccine distribution plan	Increased reachability to people due to a greater number of vaccination centers	Inefficient distribution to various locations	✓
Create a plan to deliver vaccinations at home	Easily accessible to elder people	Failure to administer vaccine vials correctly	✗

Define Phase

Project Charter

Communication Plan

SIPOC Diagram

Project Charter

Project Name:	Vaccine Rollout Plan
Business/Location: (2)	Vaccine Distribution Center
Champion: (3)	Vaccine Distribution Head
Project Description/Mission: (4)	Create an effective vaccination plan to ensure people get the vaccine is easily available.
Problem Statement: (5)	The Vaccine Rollout plan in Central New York which began on 16th December has been very ineffective with only 5% of the people approved for the vaccine being fully vaccinated.
Business Case: (6)	An effective distribution plan will ensure public safety and end to the global pandemic.
Deliverables: (7)	Vaccinate 100% of the people of Central New York in 6 months.
Goals/Metrics: (8)	Goals: Identify defects in the current vaccine rollout plan. Metrics: Daily Vaccination Numbers, Daily appointment numbers.
Process & Owner: (9)	Process: Vaccine Distribution Owner: Vaccine Distribution Head
Project Scope Is: (10)	Increasing daily vaccination numbers.
Key Customers: (11)	Internal: Vaccine storing warehouses. External: General Public
Customer Expectations: (12)	Easy Reachability to vaccine locations.
Project Completion: (13)	03/28/2021
Expected Resource Needs: (14)	Process engineers, Delivery personnel, Doctors, Nurses and security personnel.

Communication Plan

Department	Method	Purpose (why & what)	Meeting type	Frequency	Notes
Representatives responsible for Daily production of Vaccines	E-mail updates, in-person presentations, invite to tollgates, weekly meetings	Buy-in, Information, Action	Bilateral	Weekly, at tollgate	Responsible to increase or decrease the production of daily vaccines
Representative from transportation agencies	E-mail updates, in-person presentations, invite to tollgates, weekly meetings	Information, Action	Bilateral	Weekly, at tollgate	Responsible for safe transport of vaccine from Production centers to Vaccine centers
Representative from warehousing agency	E-mail updates, in-person presentations, invite to tollgates, weekly meetings	Information, Action	Bilateral	Weekly, at tollgate	Responsible for providing technical support for machines and providing ample space for maintain social distancing protocols
Representative from Hospital	E-mail updates, in-person presentations,invite to tollgates, weekly meetings	Information, Action	Bilateral	Weekly	Responsible for doctors and nurses at the vaccination center
Representative from security agency	E-mail updates,invite to tollgates, weekly meetings	Information, Action	Bilateral	Daily, at tollgate	Responsible for the security personnel at the vaccination center
Representative from Software development company	E-mail updates,invite to tollgates, weekly meetings	Information, Action	Bilateral	Daily, at tollgate	Responsible for data collection

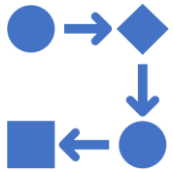
SIPOC Diagram

Suppliers	Input	Process	Output	Customers
Vaccine Producing companies (Pfizer, Moderna, etc.)	Should have vaccine doses readily available to distribute to vaccination centers	Produce Vaccines	Producing the right amount of vaccines to ensure there is no shortage in supply	Front-line workers, restaurant workers, in-class teaching professionals, military personnel, students and more
Transportations companies	Should have the right mode of transport for effective distribution as per distribution plan.	Transport the vaccines from the production center to vaccination centers	Making sure the vaccines reach the vaccination without any damage	
Warehousing agencies	Should have big enough warehouses to be made into vaccination centers with the required equipment.	Installation and maintenance of required equipment to safely store vaccines		
Hospitals	Should have enough staff to vaccinate people	Provide Doctors and nurses to make sure the vaccines are given correctly	Doctors and nurses reporting on time not causing any absentees which make sure the vaccine is given correctly	
Security agencies	Should have enough personnel to provide security at the vaccination centers.	Ensure everyone entering the vaccination centers are following social distancing protocols	Provide safety and security to the employees as well as the people coming in to get the vaccine	
Software Development Companies	Should have a software that would allow people to register for the vaccine	Record and store data of people coming in for the vaccine	Collect data to make sure everyone is getting vaccinated	

Measure Phase

KPI’s

Ishikawa Diagram

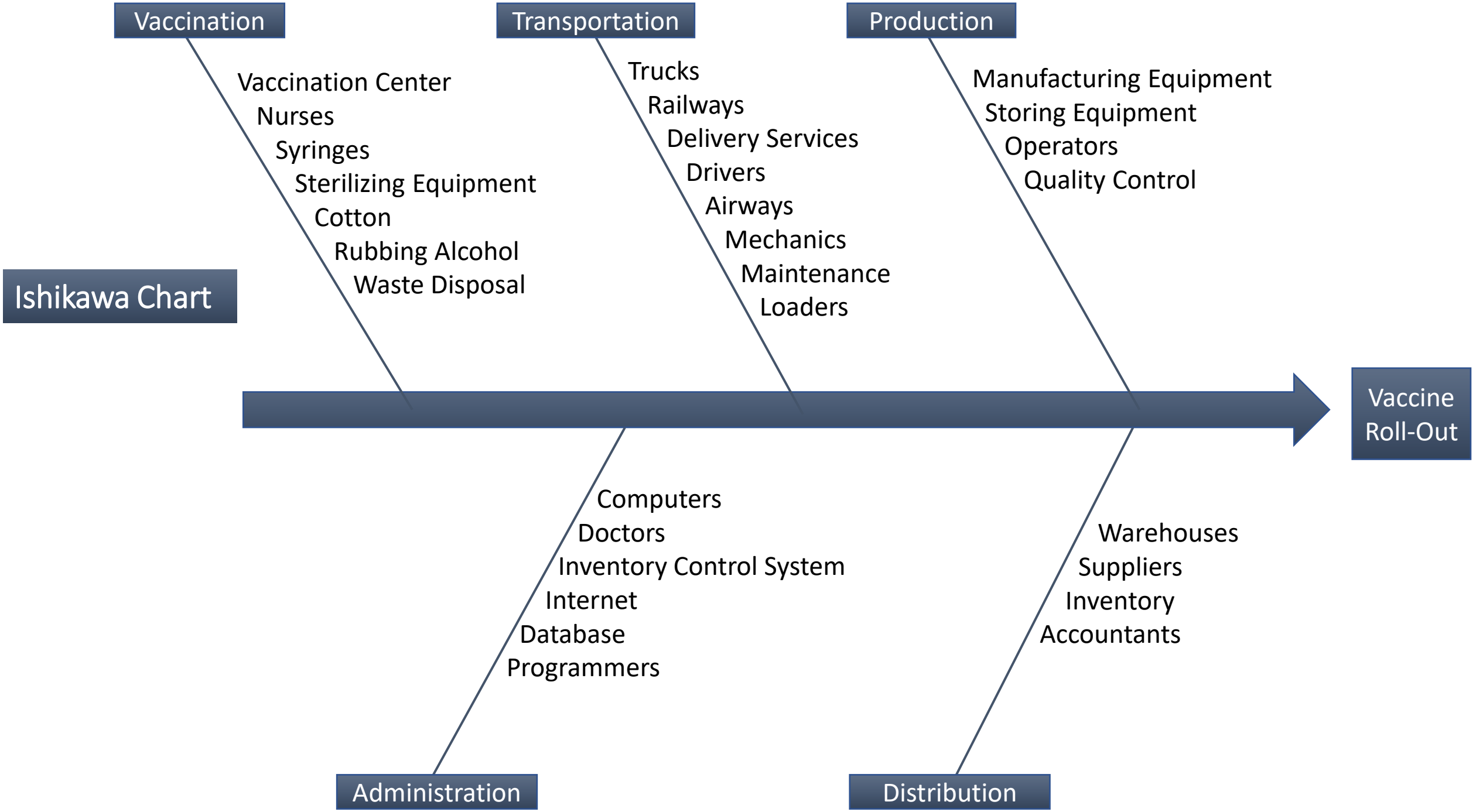


Process Flow chart

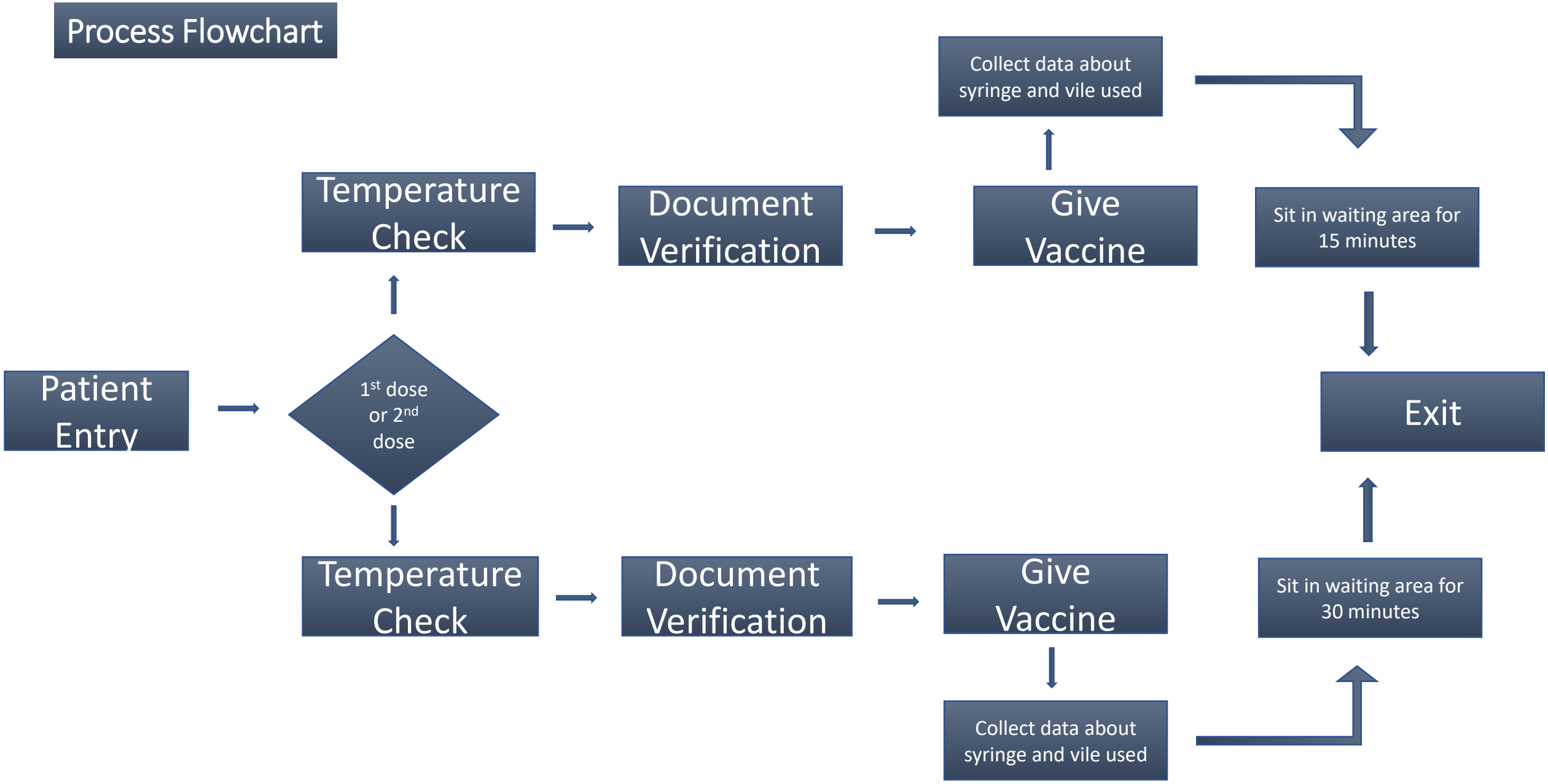
Data Collection Plan

Key Performance Indicators (KPI's)

- Number of daily appointments
- Number of no-shows
- Number of partially vaccinated people
- Number of fully vaccinated people


Ishikawa Chart
Vaccination
Vaccination Center
Nurses
Syringes
Sterilizing Equipment
Cotton
Rubbing Alcohol
Waste Disposal
Transportation
Trucks
Railways
Delivery Services
Drivers
Airways
Mechanics
Maintenance
Loaders
Production
Manufacturing Equipment
Storing Equipment
Operators
Quality Control
Vaccine Roll-Out
Administration
Computers
Doctors
Inventory Control System
Internet
Database
Programmers
Distribution
Warehouses
Suppliers
Inventory
Accountants

Process Flowchart



Data Collection Plan

Record information about each patient:

- Date of first dose
- Race
- Ethnicity
- Age
- Gender
- Mode of transport to Vaccination Center
- Occupation

Analyze Phase

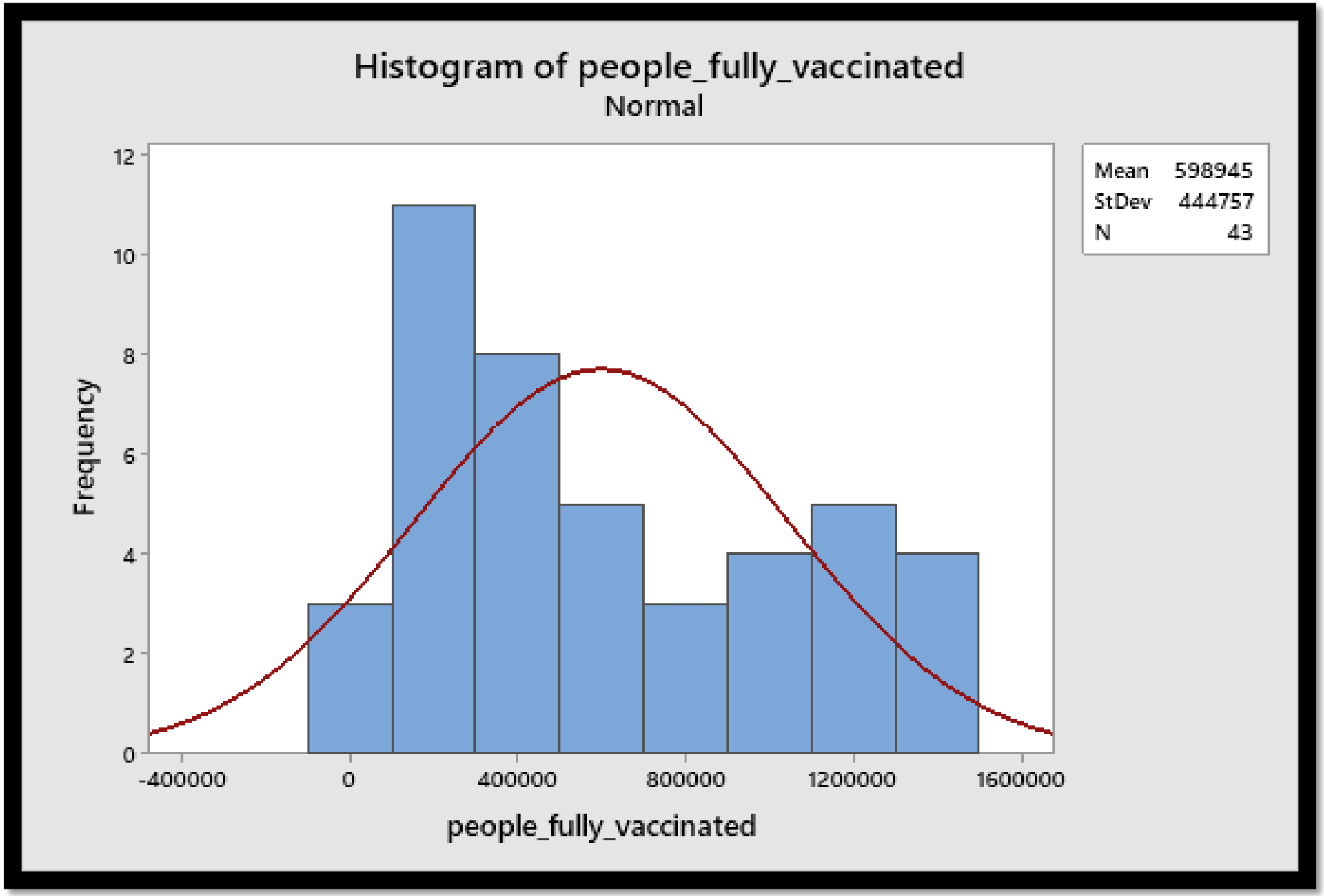
Histograms

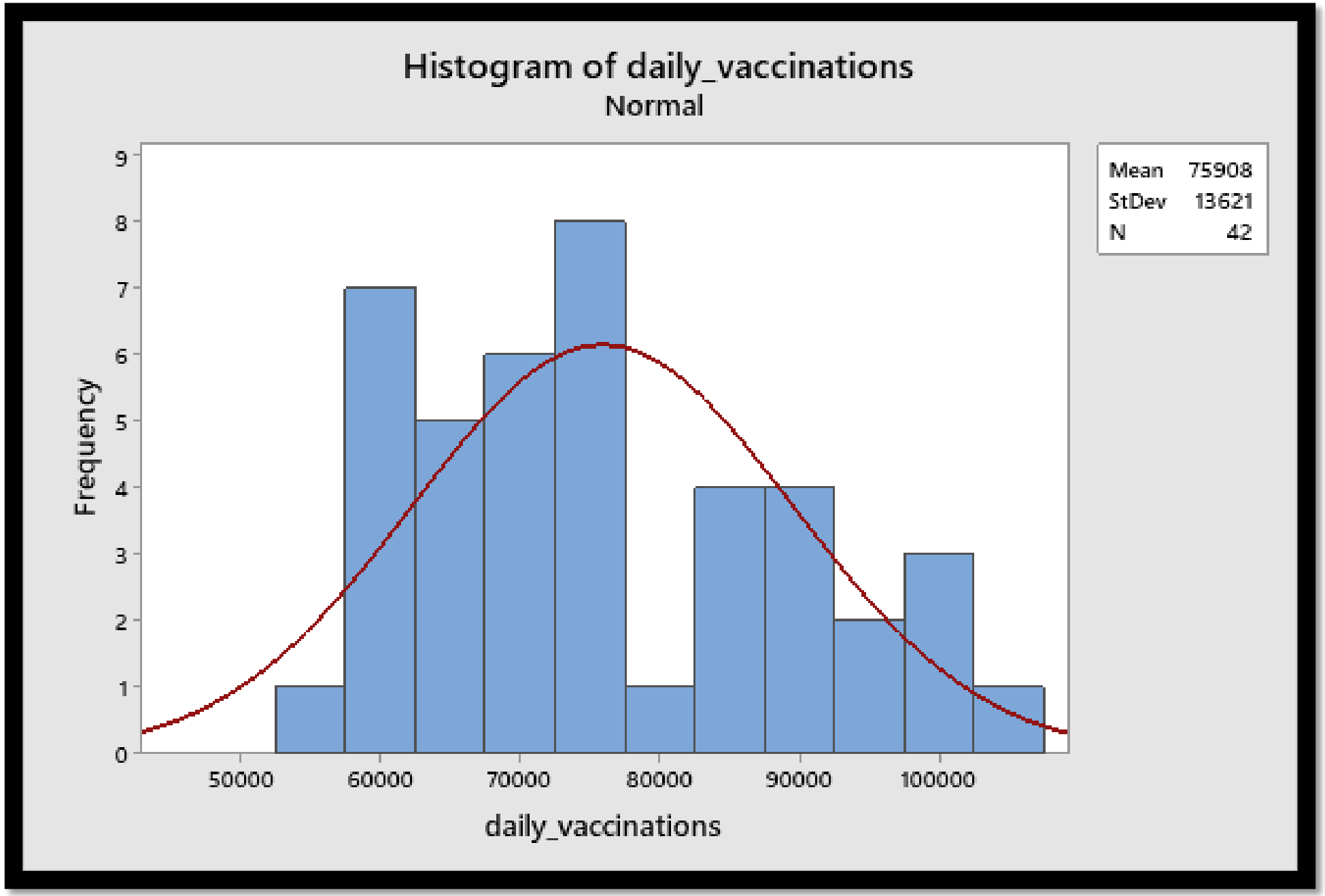
Scatter Plot

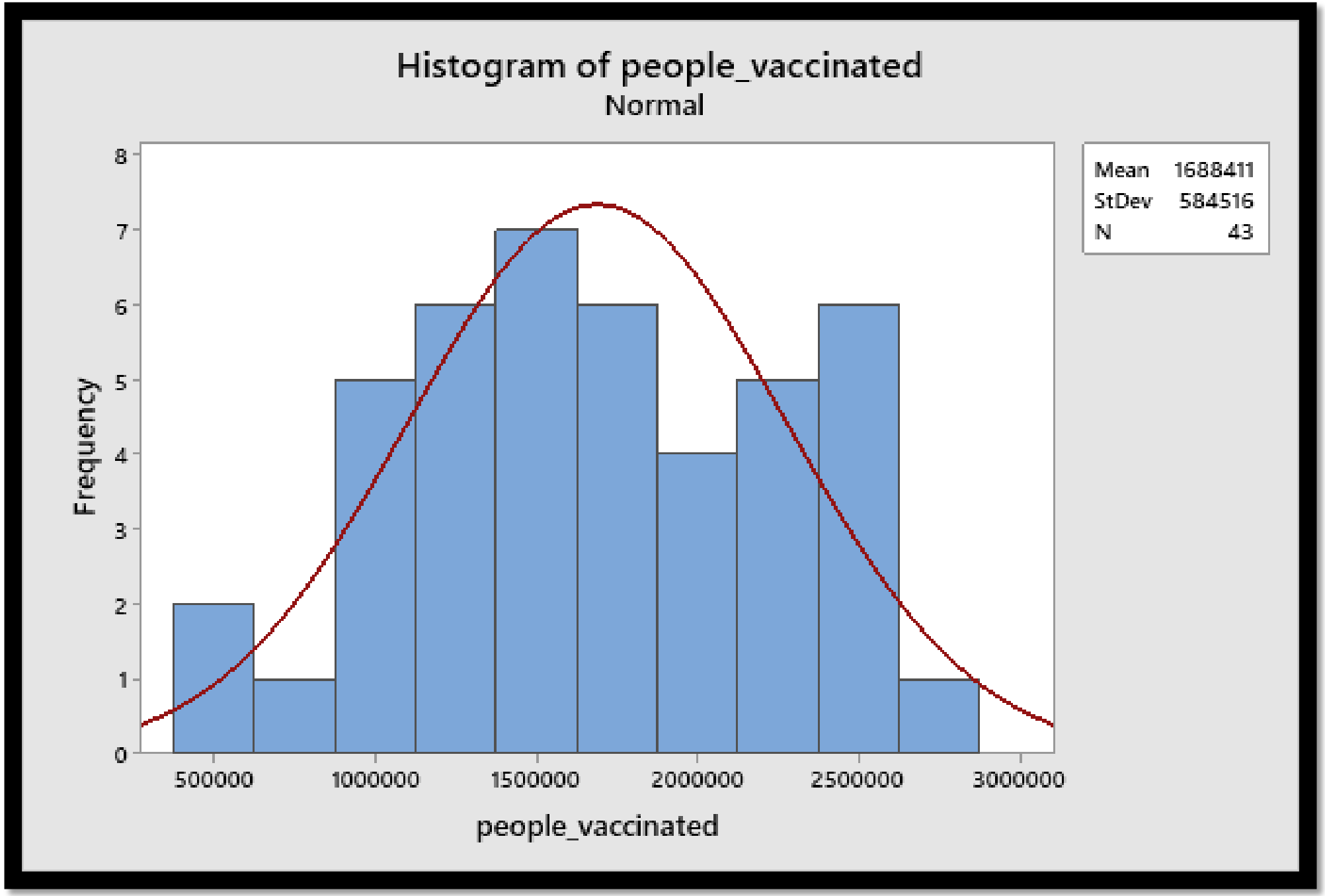
Box-Plot

Pareto Analysis

Process capability six-pack Analysis

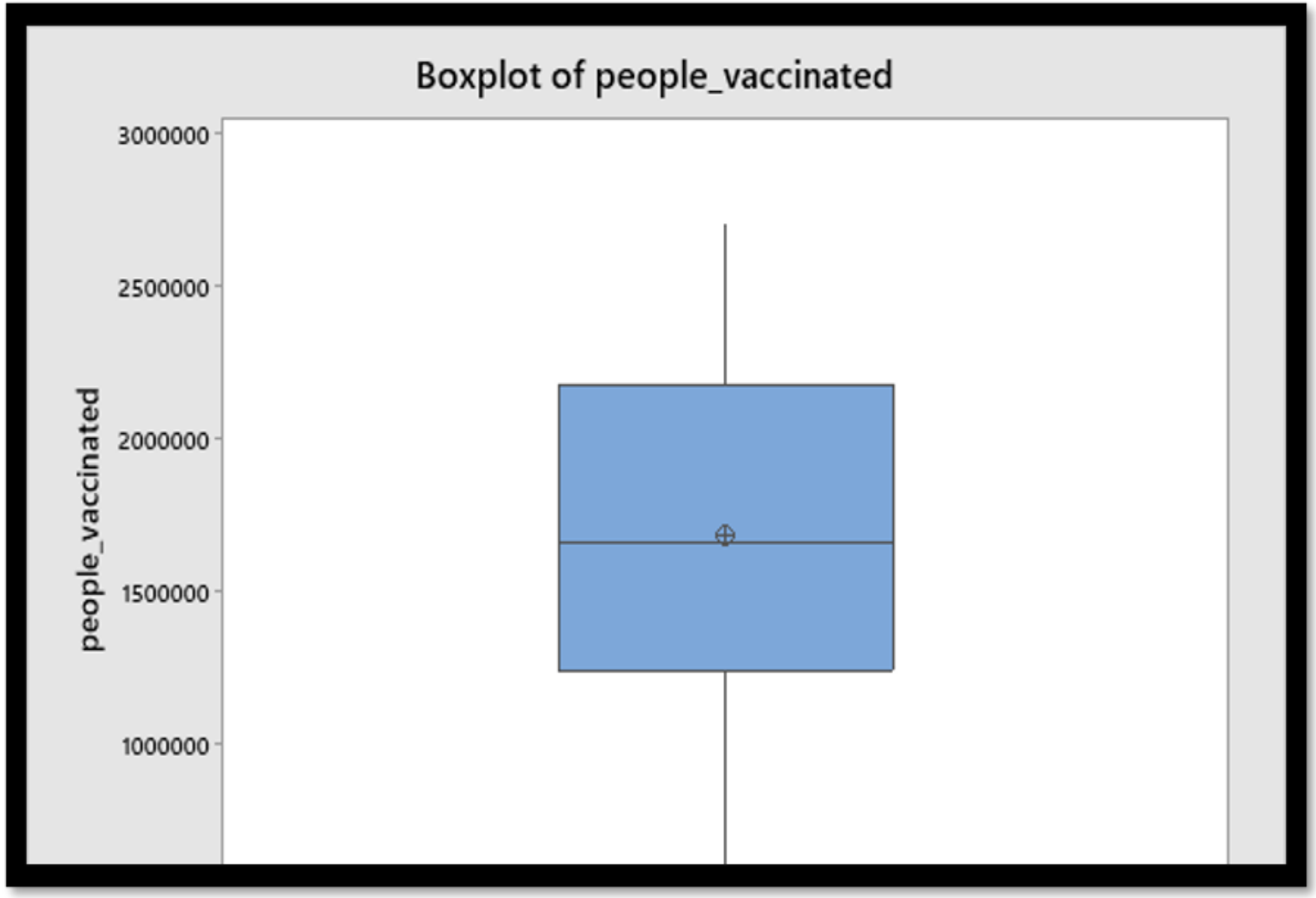

Histogram of people_fully_vaccinated
Normal
Mean 598945
StDev 444757
N 43
Frequency
0
2
4
6
8
10
12
-400000
0
400000
800000
1200000
1600000
people_fully_vaccinated


Histogram of daily_vaccinations
Normal
Mean 75908
StDev 13621
N 42
Frequency
0
1
2
3
4
5
6
7
8
9
50000
60000
70000
80000
90000
100000
daily_vaccinations


Histogram of people_vaccinated
Normal
Mean 1688411
StDev 584516
N 43
Frequency
0
1
2
3
4
5
6
7
8
500000
1000000
1500000
2000000
2500000
3000000
people_vaccinated

Box-plot of People Vaccinated

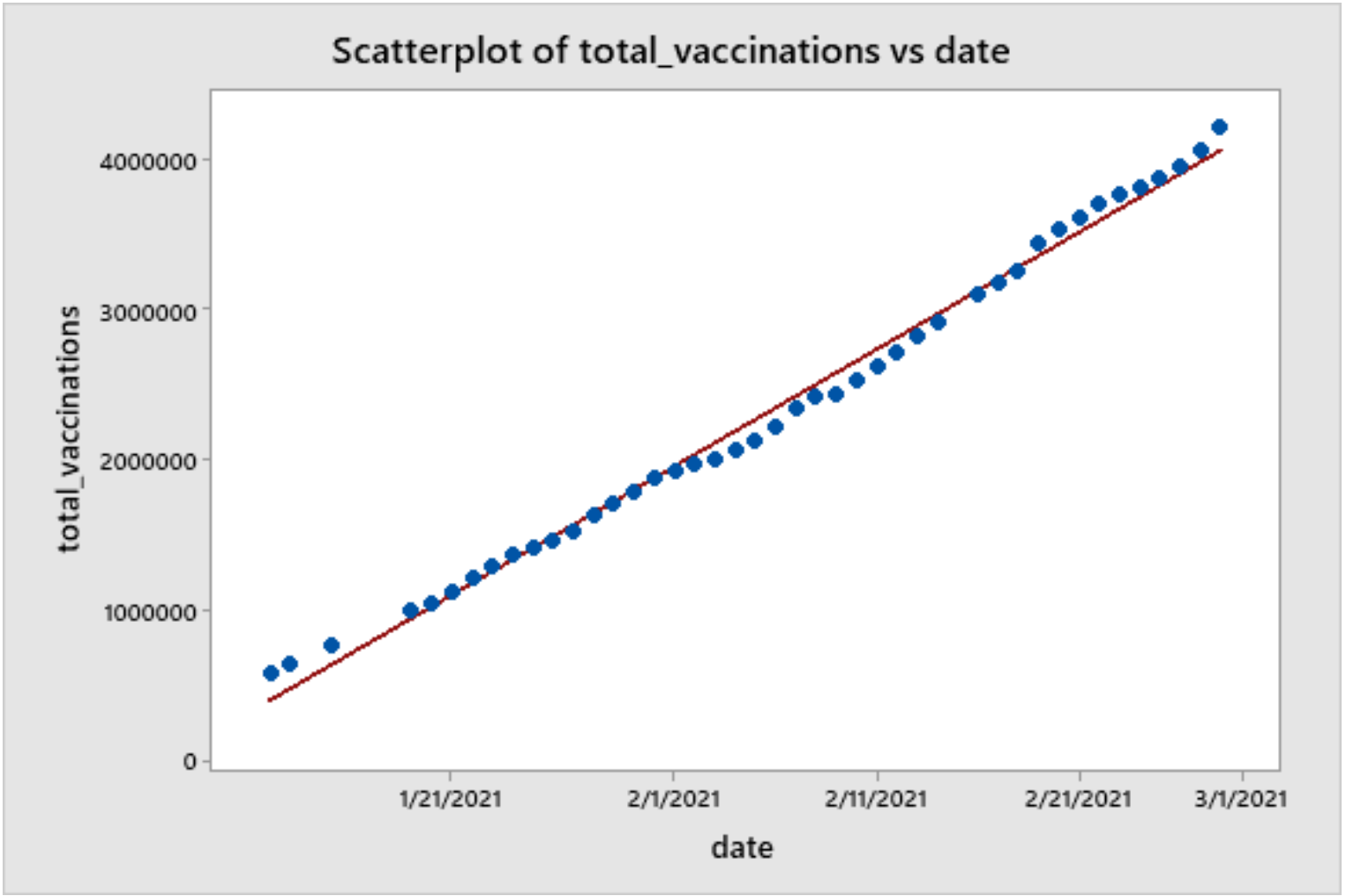
- The median is 1.5 million in NY state.
- The mean is almost as equal to the median.
- The 25th percentile is 1.25 million.
- The 75th percentile is 2.2 million.



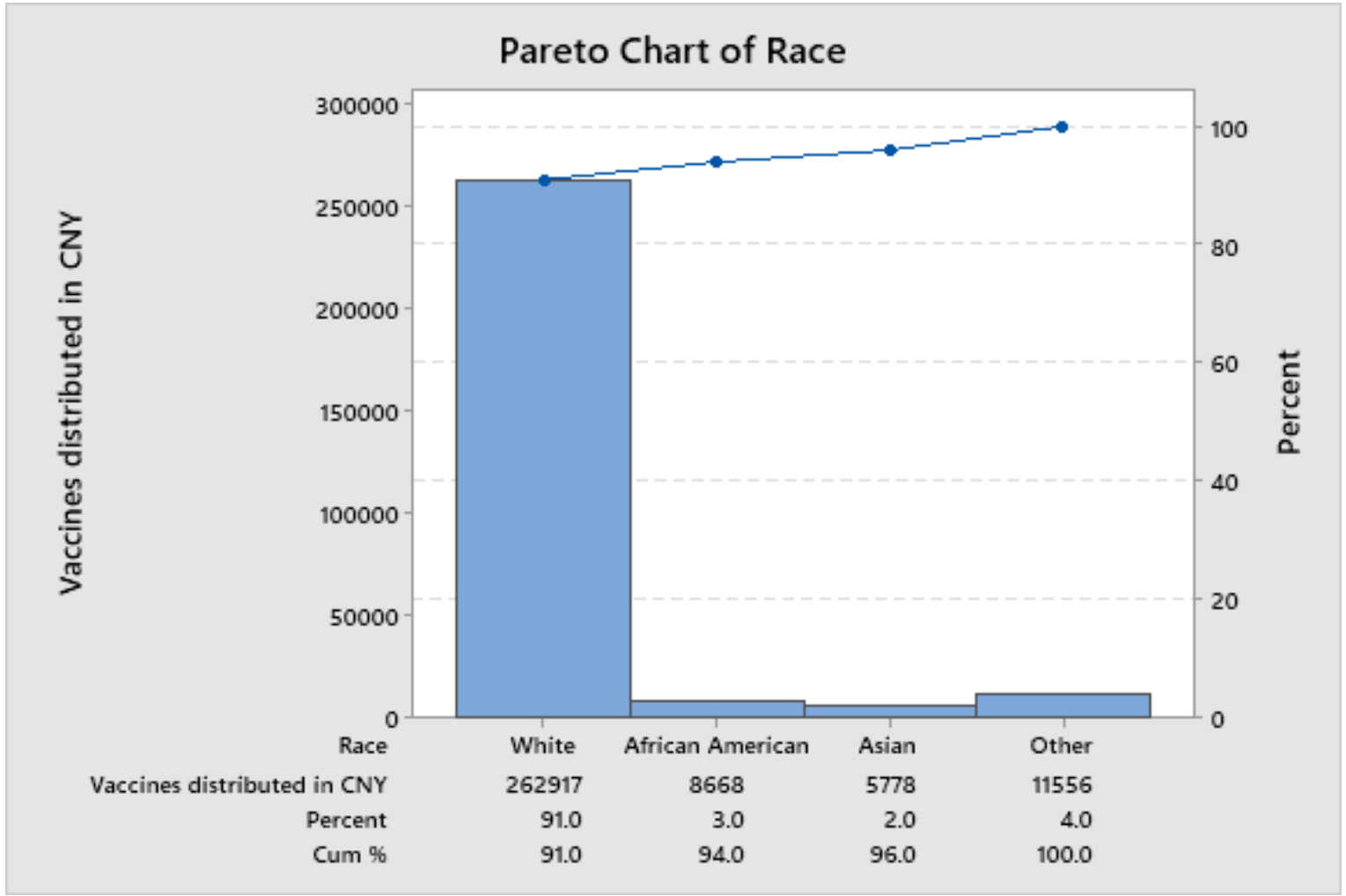
Scatter plot of total vaccinations

The regression line shows a positive trend

With every passing date, number of vaccinations keep increasing

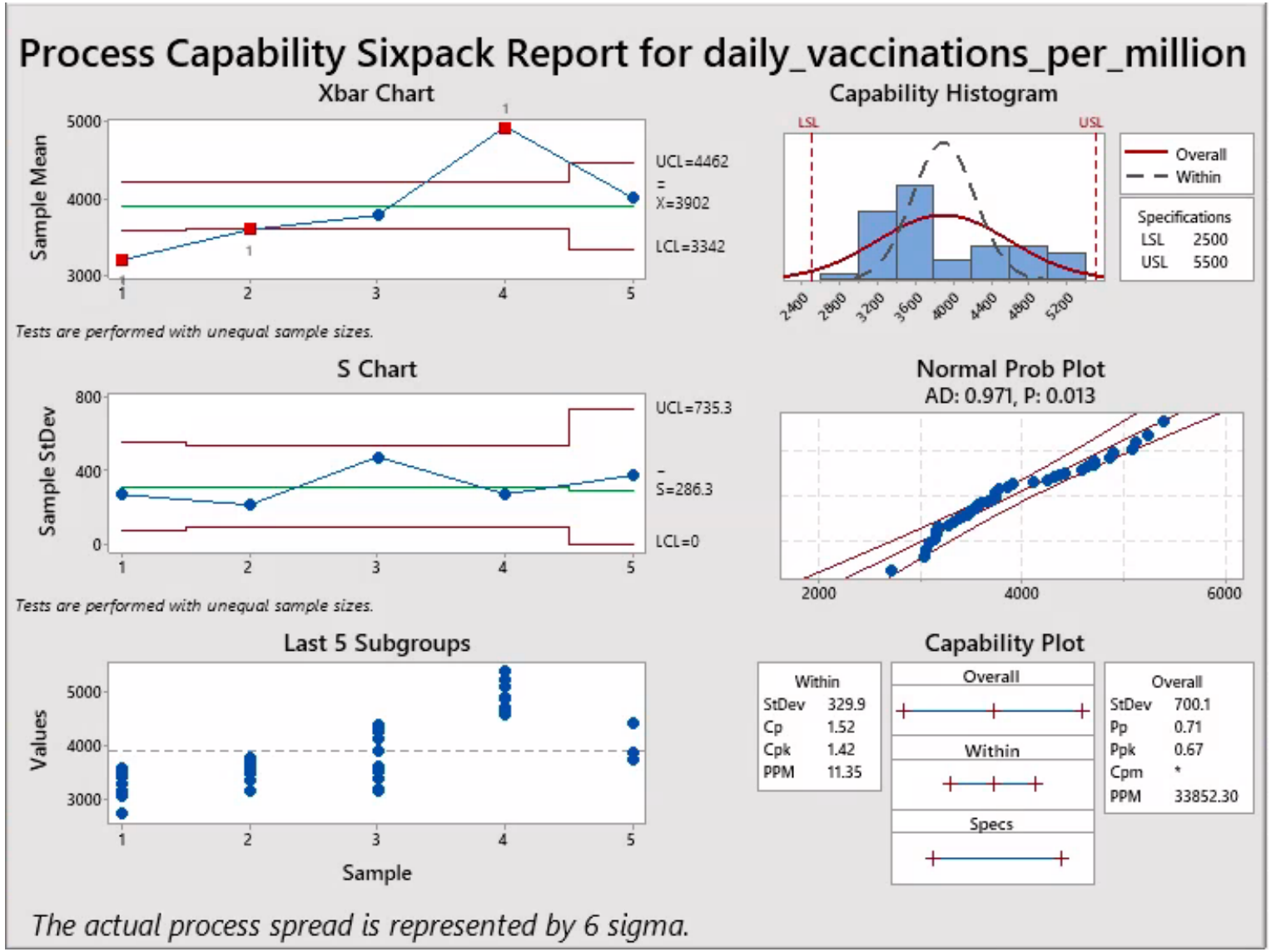


Pareto chart of Daily Vaccinations by Race in Central New York



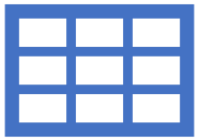
Race	White	African American	Asian	Other
Vaccines distributed in CNY	262917	8668	5778	11556
Percent	91.0	3.0	2.0	4.0
Cum %	91.0	94.0	96.0	100.0

Process Capability Six-pack Analysis

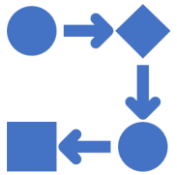


Improve Phase

FMEA chart



Criteria Selection Matrix



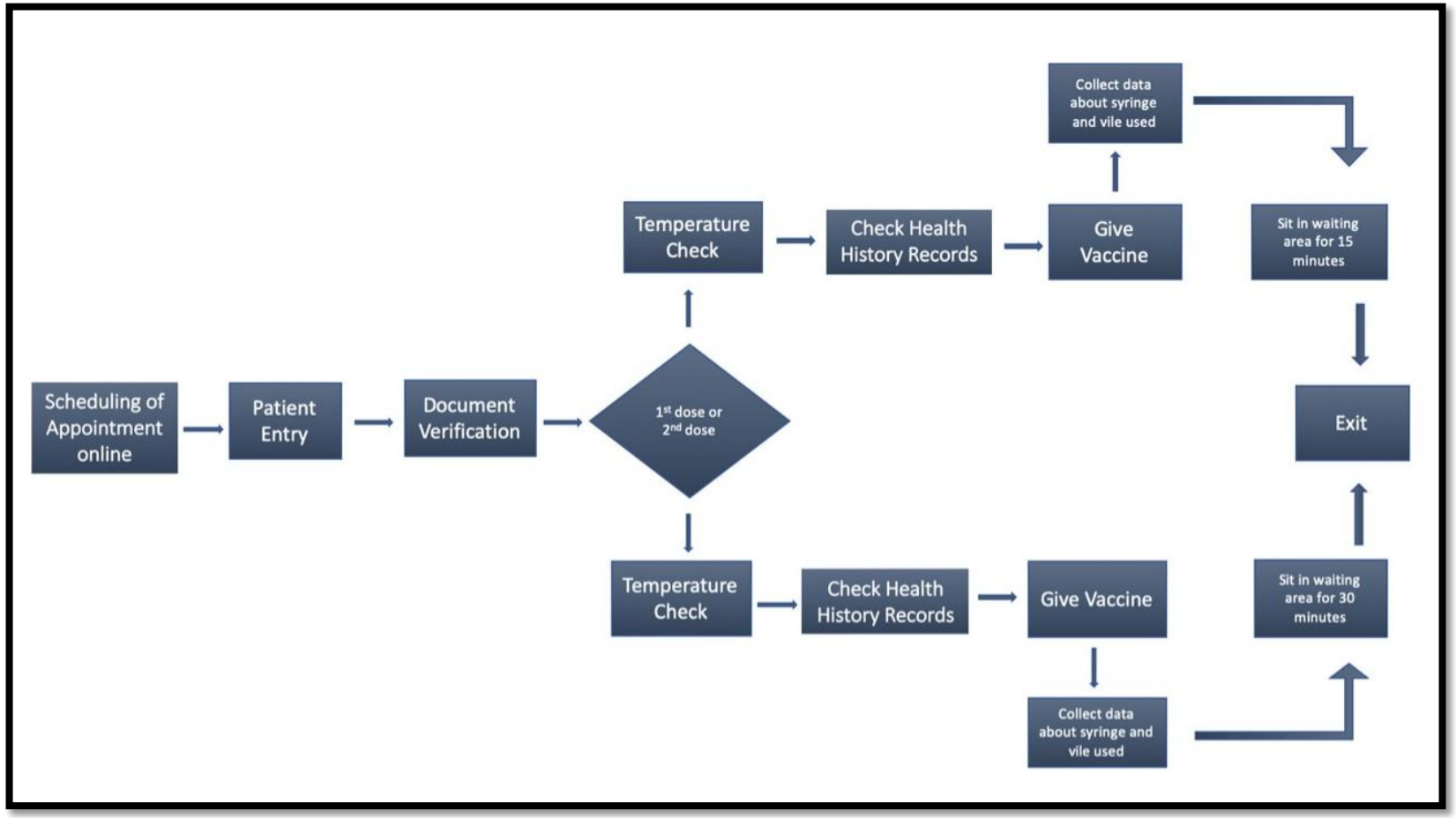
Improved Process Flow-chart

Failure-Mode-Effect Analysis

Process Function	Potential Failure Mode	Severity	Potential Effect of Failure	Probability of occurrence	Potential Cause	Probability of Detection	Recommended Action	Risk Preference no
Patient Entry	No patients entering	6	Vaccine not utilized properly	4	Vaccination center not easily accessible, Bad weather	1	Look at Patients booking and order vaccines accordingly	24
1st dose or 2nd dose	Administrating the wrong dose	8	Can be deadly for the patient	4	Administration system failure, Patients not aware or no record kept on them	8	Keep the system updated	256
Temperature Check	Wrong temperature recorded	7	Patient not fit for vaccine	2	Thermometer malfunction	8	Check thermometer regularly	112
Vaccination	Failure of the cold chain, inadequate viral dose, and host immune factors, such as persistence of passively acquired maternal immunity.	9	Life threatening for the patients	3	No background of patients	9	Patients health history records needed	243
Data collection	Data not collected properly or labelled improperly	2	vaccination records not proper	3	Human error	6	Double check before making final analysis	36
Waiting after administration	Failure to maintain social distancing protocols	1	Cross contamination	4	Too many patients entering at once	1	Schedule vaccinations to ensure social distancing protocols	4

Criteria Selection Matrix					
Criteria	**Weight**	**0-45**	**45-65**	**65+**	**Totals**
Front Line Workers	3	1	2	3	18
People with Underlying Disease	3	1	3	3	15
Essential Workers	2	1	2	2	10
Healty people	1	1	2	3	6

Improved Process Flow Chart



Improvements in new distribution plan

- Make vaccines available at various location rather than having one single vaccination center.
- Simplify the appointment selection process.
- Keep track of people who have received first dose in-case of any side-effects.
- Creating an awareness plan of locations where the vaccine will be available.

Control Phase

Document Improved Process

Validate Measurement System

Determine Final Process Capability

Implement Process Controls

Monitor Process Controls

Design for Six Sigma(DFSS)

Phases of Six sigma:

- Define
- Measure
- Analyze
- Design
- Verify

Define Phase

Project Charter

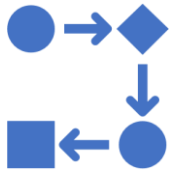
Communication Plan

SIPOC Diagram

Measure Phase

KPI’s

IshiKawa Diagram



Process Flow chart

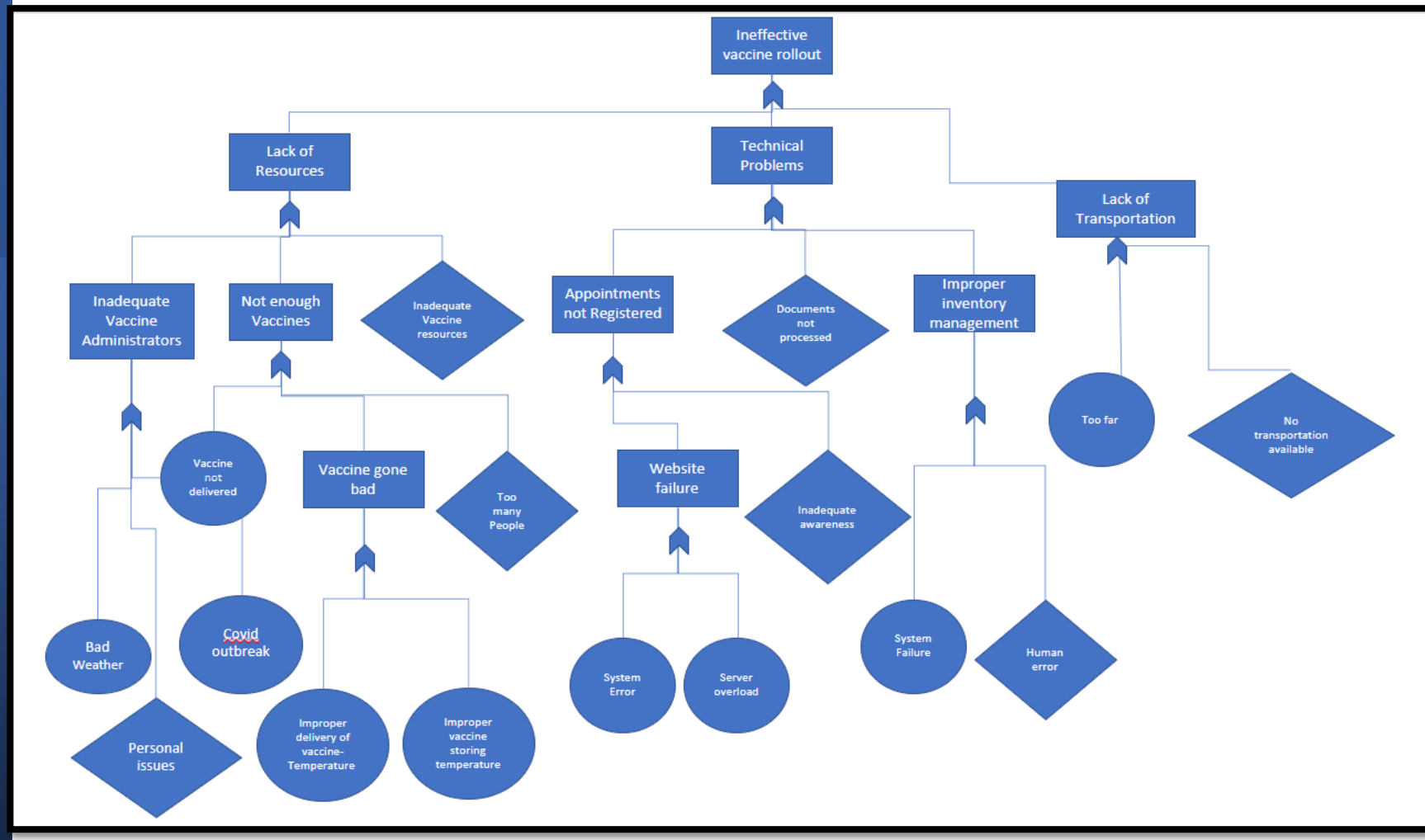
Data Collection Plan

Data Collection Plan

Record information about each patient:

- Date of first dose
- Race
- Ethnicity
- Age
- Gender
- Mode of transport to Vaccination Center
- Occupation

Fault Tree Diagram (FTA)

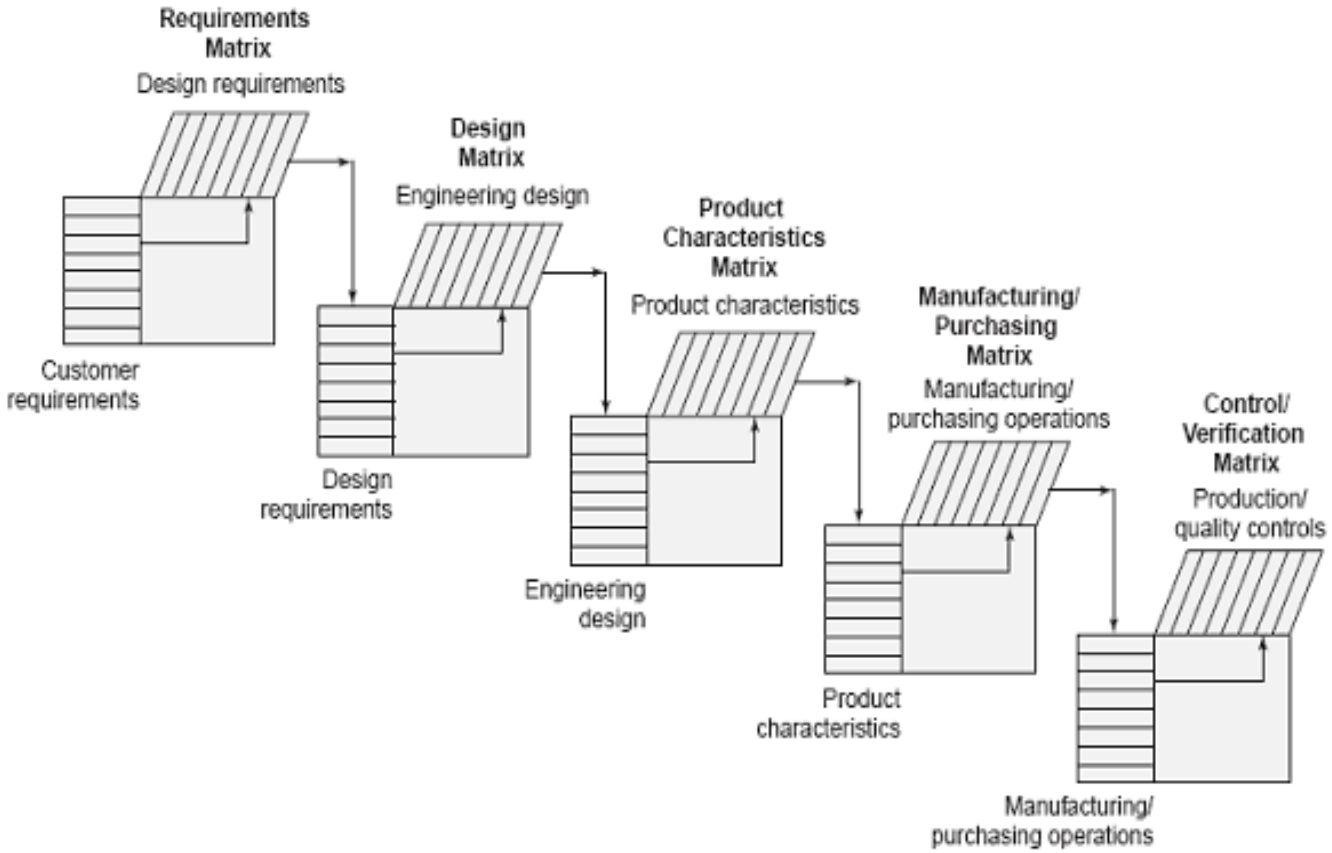


Design Phase

Key Performance Indicators	Description of Design
No. of Daily Appointments	• Make a user-friendly website which is easily accessible by everyone to register for the vaccine. • Make a full-proof website to avoid any kind of technical failure.
No. of No-shows	• Send a reminder email and text message to avoid no shows. • Have good storage facilities for the vaccine in case of excess inventory.
No. of Partially Vaccinated People	• Keep a proper record of data of partially vaccinated people and keeping them informed regarding their second dose of the vaccine. • Make sure these people have regular checks regarding side effects after the first dose.
No. of Fully Vaccinated People	• Keep a proper record of data of fully vaccinated people to track of how many people in the area are yet to be vaccinated. • Ask feedback from these people regarding the side effects after the second dose.

Quality Function Deployment (QFD):

Figure 2 — Waterfall relationship of QFD matrices



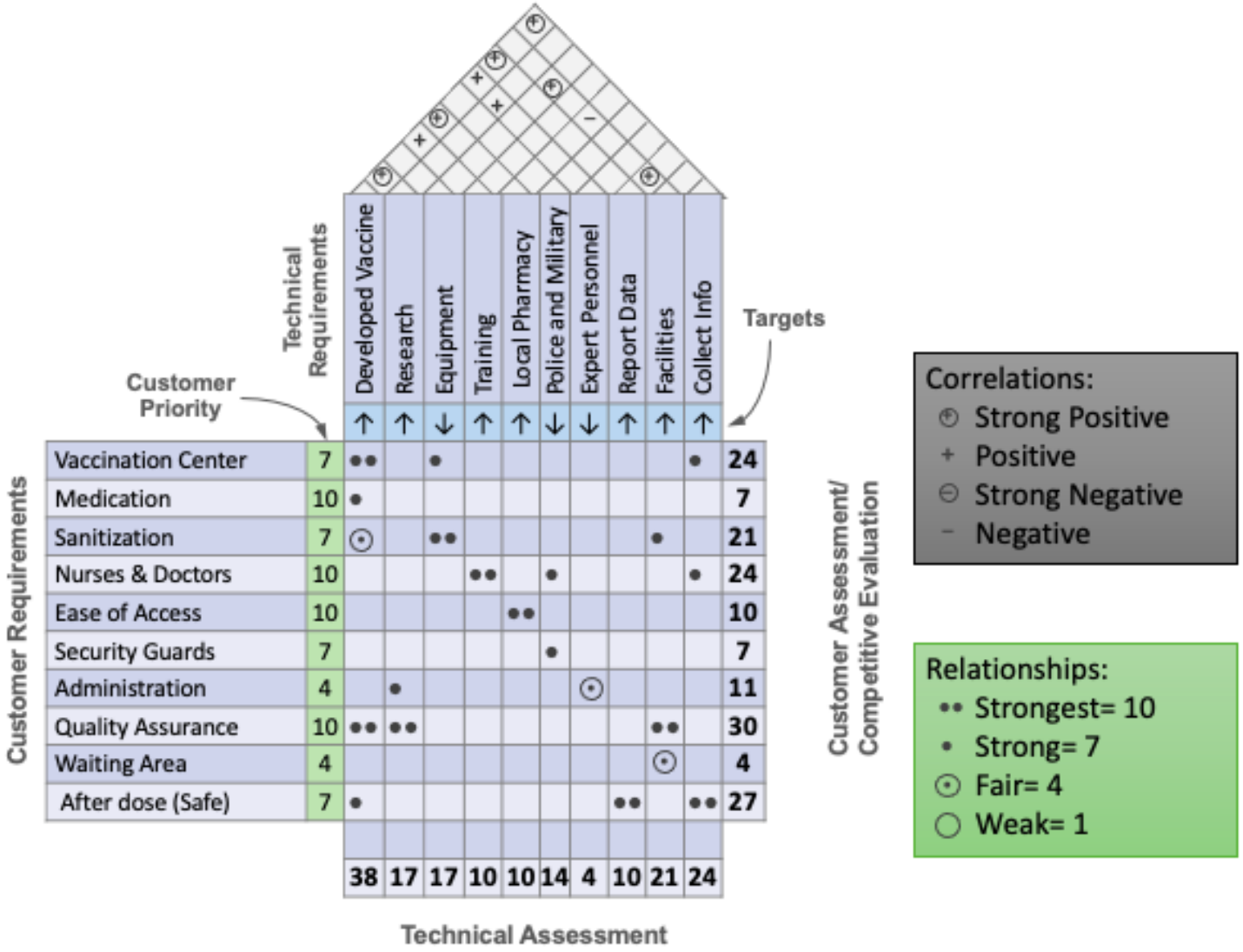
Customer Requirements

- Vaccination Center
- Medication
- Sanitization
- Nurses & Doctors
- Ease of Access
- Security Guards
- Administration
- Quality Assurance
- Waiting Area
- After dose (Safe)

Technical Requirements

- Developed Vaccine
- Research
- Equipment
- Training
- Local Pharmacy
- Police and Military
- Expert Personnel
- Report Data
- Facilities
- Collect Info

Quality Function Deployment (QFD)



Verify Phase

Key Performance Indicators	Verification of Design
No. of Daily Appointments	Have an IT team available 24*7 to handle any kind of technical failure.
No. of No-shows	• Make a check-list of people who did not show up. • Ensure that these people are contacted regarding the reason for a no-show.
No. of Partially Vaccinated People	• Make a list of details like name, age, race, gender, contact information, occupation and date of next dose. • Make a list of side-effects from the feedback received and inform the people who come in for the first dose regarding the same.
No. of Fully Vaccinated People	• Make a list to ensure the number of vaccines still needed to vaccinate the entire area. • Have a list of side-effects listed to warn people coming in for the second shot.

Design of Experiments (DOE)

What is design of experiments?

Design of experiments (DOE) is defined as a branch of applied statistics that deals with planning, conducting, analyzing, and interpreting controlled tests to evaluate the factors that control the value of a parameter or group of parameters – ASQ.org

Below is the table for first DOE analysis experiment:

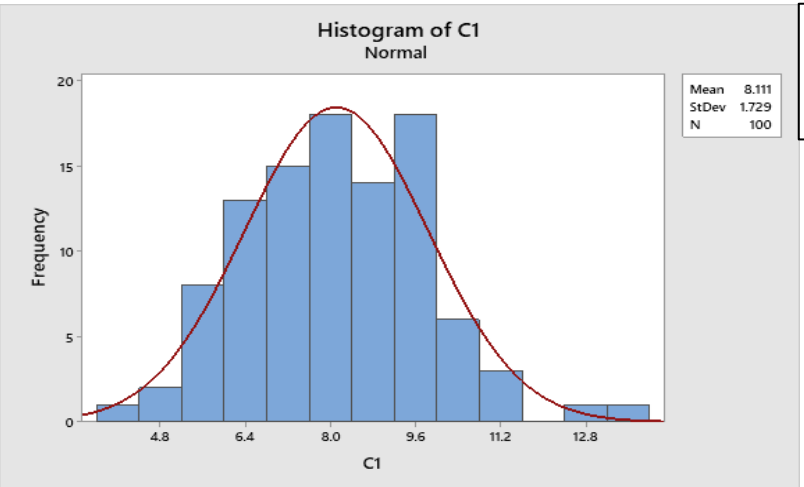
Factorial Experiments 2^3 (Three Replications/Treatment)								Run Results				
Run	A	B	C	AB	AC	BC	ABC	Y1	Y2	Y3	Avg.	Var.
1	-1	-1	-1	1	1	1	-1	-2.49522	-2.4232	-1.07	-1.995	0.649
2	1	-1	-1	-1	-1	1	1	3.561609	0.72755	3.72	2.669	2.834
3	-1	1	-1	-1	1	-1	1	-1.70987	-0.75186	-0.58	-1.014	0.371
4	1	1	-1	1	-1	-1	-1	10.97971	11.63553	12.04	11.551	0.285
5	-1	-1	1	1	-1	-1	1	10.51655	4.122255	7.75	7.463	10.284
6	1	-1	1	-1	1	-1	-1	14.7701	17.99574	15.45	16.07	2.894
7	-1	1	1	-1	-1	1	-1	11.18758	12.09465	11.09	11.458	0.306
8	1	1	1	1	1	1	1	19.7119	15.0226	18.31	17.681	5.793
TotSum								66.52	58.42	66.71	7.99	23.42

SumY+	47.97	39.68	52.67	34.7	30.74	29.81	26.8
SumY-	15.91	24.21	11.21	29.18	33.14	34.07	37.09
AvgY+	11.99	9.92	13.17	8.68	7.69	7.45	6.7
AvgY-	3.98	6.05	2.8	7.3	8.29	8.52	9.27
Effect	8.01	3.87	10.37	1.38	-0.6	-1.06	-2.57
Var+	2.952	1.689	4.819	4.253	2.427	2.396	4.82
Var-	2.902	4.165	1.035	1.601	3.427	3.458	1.033
F	0.983	2.467	0.215	0.377	1.412	1.444	0.214

Var. of Model	2.93	StdDv	1.71
Var. of Effect	0.49	StdDv	0.7
Student T (0.025;DF) =	2.473		
C.I. Half Width =	1.727		

This process has an average of 7.99 with a standard deviation of 1.71 and C.I. half width of 1.727.

Step 1: Determining process capability.

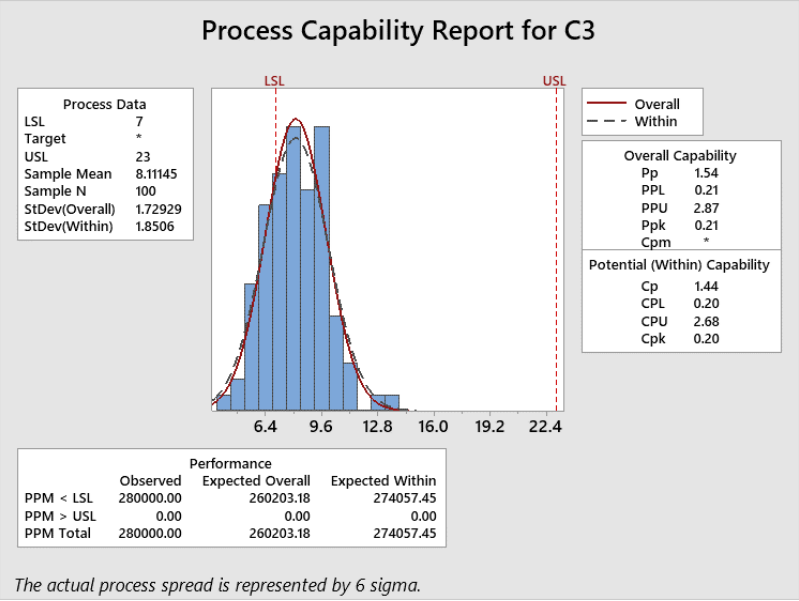


The specifications for implementing an effective vaccine roll-out are : 7 for the lower specification limit and 23 for upper specification limit.

Before improvement, the process capability ratio C_{pk} *is*

$$Cpk = \min\left(\frac{\bar{X}-LSL}{3\sigma}, \frac{USL-\bar{X}}{3\sigma}\right) = \min\left(\frac{7.99-7}{3(1.71)}, \frac{23-7}{3(1.71)}\right) = \min(0.193, 3.12) = 0.193$$

Since calculated Cpk is less than expected value of 1.33 hence the process is unacceptable and not centered.



After calculating the Cpk values we decided that we needed to improve the current process in order to do so we calculated a value of Cp:

$$Cp = \frac{USL - LSL}{6\sigma} = \frac{23 - 7}{6(1.71)} = 1.56$$

Since the value of Cp is greater than the accepted value of 1.33 this process will be acceptable if the data is centered.

Step 2: Inputs and outputs to be investigated

There are three key factors for an effective vaccine roll-out:

- Effective vaccine
- Storing equipment
- Administration staff

Step 3 : Determine required outputs

Step 4: Creating a Design matrix for factors:

A : Effective Vaccine

B: Storing Equipment

C: Administration staff

Factorial Experiments 2^3 (Three Replications/Treatment)							
Run	A	B	C	AB	AC	BC	ABC
1	-1	-1	-1	1	1	1	-1
2	1	-1	-1	-1	-1	1	1
3	-1	1	-1	-1	1	-1	1
4	1	1	-1	1	-1	-1	-1
5	-1	-1	1	1	-1	-1	1
6	1	-1	1	-1	1	-1	-1
7	-1	1	1	-1	-1	1	-1
8	1	1	1	1	1	1	1

Step 5: Determining High and low values for each factor

Factor	Low	High	Unit	Range	Mid-Pt	Val(-)	Val(+)
A (Humidity)	70	100	Percent	30	85	-1	+1
B (Temperature	100	200	F	100	150	-1	+1
C (Supplier)	1	2	Unit	1	1.5	-1	+1

Step 6: Performing the experiment and recording its results

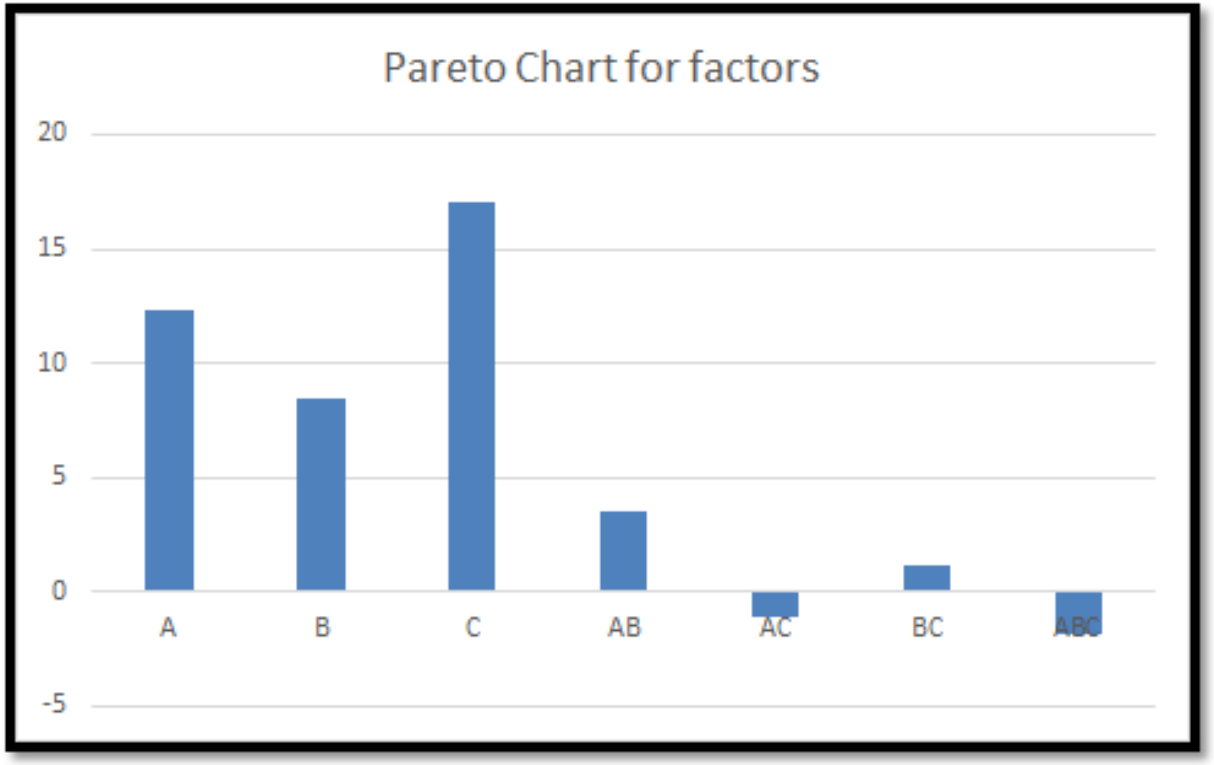
Run Results				
Y1	Y2	Y3	Avg.	Var.
-2.49522	-2.4232	-1.07	-1.995	0.649
3.561609	0.72755	3.72	2.669	2.834
-1.70987	-0.75186	-0.58	-1.014	0.371
10.97971	11.63553	12.04	11.551	0.285
10.51655	4.122255	7.75	7.463	10.284
14.7701	17.99574	15.45	16.07	2.894
11.18758	12.09465	11.09	11.458	0.306
19.7119	15.0226	18.31	17.681	5.793
66.52	58.42	66.71	7.99	23.42

Step 7: Calculating effects and interactions for each factor

SumY+	47.97	39.68	52.67	34.7	30.74	29.81	26.8
SumY-	15.91	24.21	11.21	29.18	33.14	34.07	37.09
AvgY+	11.99	9.92	13.17	8.68	7.69	7.45	6.7
AvgY-	3.98	6.05	2.8	7.3	8.29	8.52	9.27
Effect	**8.01**	**3.87**	**10.37**	**1.38**	**-0.6**	**-1.06**	**-2.57**
Var+	2.952	1.689	4.819	4.253	2.427	2.396	4.82
Var-	2.902	4.165	1.035	1.601	3.427	3.458	1.033
F	0.983	2.467	0.215	0.377	1.412	1.444	0.214

Step 8 : Determining the significance of the effects for each factor and for each interaction by comparing them with the confidence interval half-width (must be greater than 1.71 units to be significant) in the table or the Pareto chart.

Factor	A	B	C	AB	AC	BC	ABC
Signific.	Yes	Yes	Yes	Yes	No	No	No
Lwr Limit	9.57	5.74	14.38	0.7944	-1.557	-1.5	0.7955
Upper Limit	21.84	11.14	19.77	6.185	3.83	3.88	2.965



Step 9: Determining regression equation

The regression factors are:

a0 $= \bar{x} = 7.99$

a1 $= \frac{1}{2}(Eff_A) = \frac{1}{2}(8.01) = 4.005$

a2 $= \frac{1}{2}(Eff_B) = \frac{1}{2}(3.87) = 1.935$

a3 $= \frac{1}{2}(Eff_B) = \frac{1}{2}(3.87) = 1.935$

Thus, the regression equation is:

$$Response = a_0 + a_1 A + a_2 B + a_3 C = 7.99 + (4.005)A + (1.935)B + (5.185)C$$

Step 10:Determining new mean and target values

Coded Data		
Factor	Coded	Data
One	0.3	89.5
Two	0.6	180
Three	-0.4	1.3

To achieve our new mean, we decided our factor A to be the maximum value the factor B was reduced to half its value and the factor C is used as its max value

$\overline{x_2} =$ **7.99+ 4.005(1) + 1.935(0.5)+ 1.935(1)= 14.895**

Our new target value is **T = 15**

Step 11: Determining capability of new values

Coded Data		
Factor	Coded	Data
One	0.3	89.5
Two	0.6	180
Three	-0.4	1.3

Using the new mean value we checked the capability of our process using taguchi capability method Cpm:

$$C_{pm} = \frac{USL - LSL}{6\sqrt{\sigma^2 + (T - \bar{x}_2)^2}} = \frac{23 - 7}{6\sqrt{(1.71)^2 + (15 - 14.895)^2}} = \mathbf{1.55}$$

Since the value of Cpm is greater than 1.33 hence we can say that our process is **Capable.**

Step 12: Determining capable values of each factor

Coded Data		
Factor	Coded	Data
One	0.3	89.5
Two	0.6	180
Three	-0.4	1.3

By using the coded values, we determined new values that made our process capable

Real A=0.5·A·Range_A+MidPt_A=0.5(1)(40)+60=80%
Real B=0.5·B·Range_B+MidPt_B=0.5(0.5)(30)+45=53%
Real C=0.5·C·Range_C+MidPt_C=0.5(1)(20)+40=50%

Minitab Analysis

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		16.732	0.547	30.57	0.000	
A	12.267	6.133	0.547	11.21	0.000	1.00
B	8.435	4.218	0.547	7.71	0.000	1.00
C	17.078	8.539	0.547	15.60	0.000	1.00
AB	3.487	1.744	0.547	3.19	0.006	1.00
AC	-1.135	-0.568	0.547	-1.04	0.315	1.00
BC	1.185	0.593	0.547	1.08	0.295	1.00
ABC	-1.903	-0.951	0.547	-1.74	0.101	1.00

Model Summary

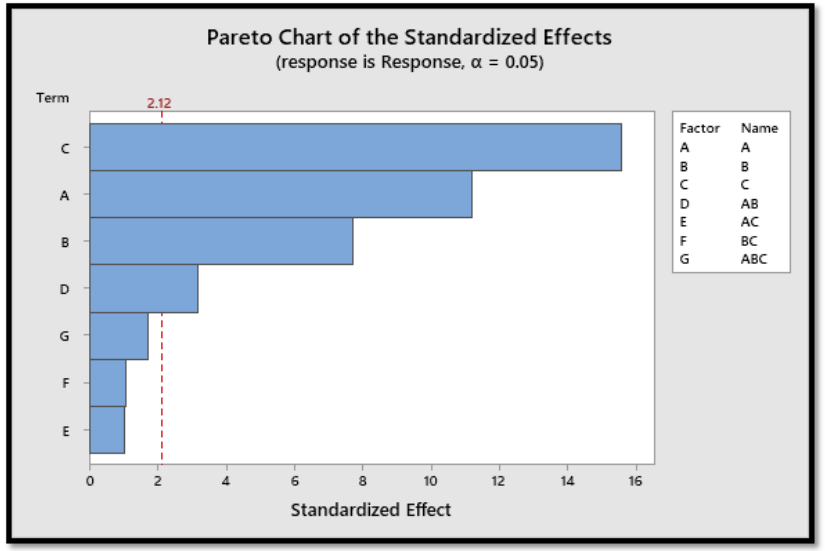
S	R-sq	R-sq(adj)	R-sq(pred)
3.03929	96.53%	93.92%	86.10%

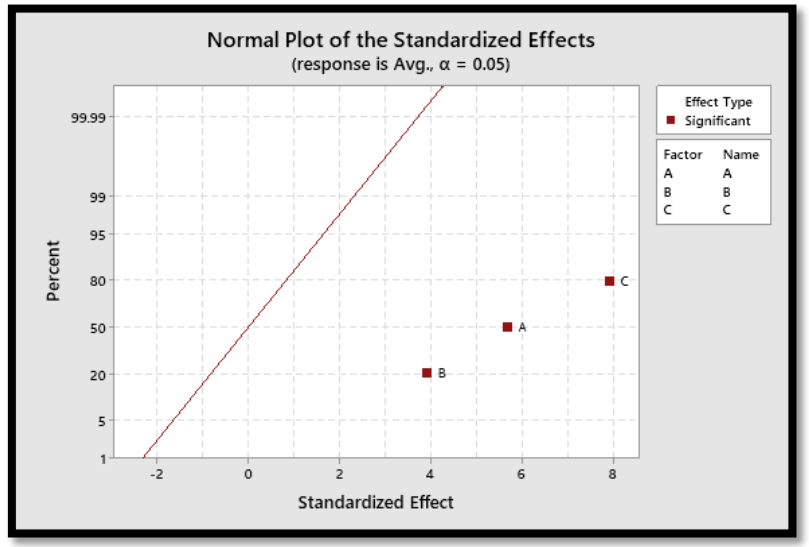
Analysis of Variance

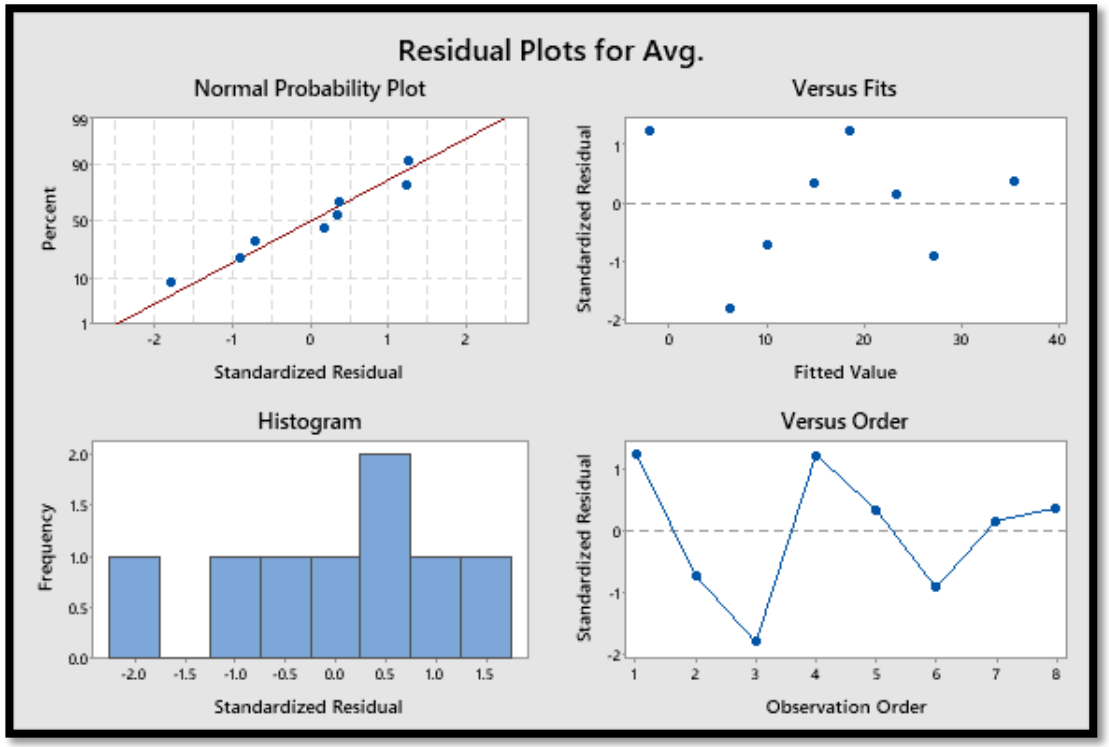
Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	3	1026.58	342.193	37.04	0.002
Linear	3	1026.58	342.193	37.04	0.002
A	1	300.94	300.939	32.58	0.005
B	1	142.31	142.314	15.41	0.017
C	1	583.32	583.325	63.15	0.001
Error	4	36.95	9.237		
Total	7	1063.53			

Interpreting Minitab results

It is significant from the charts that factors A (effective vaccine), B (storing equipment) and C (Administration staff) are significant





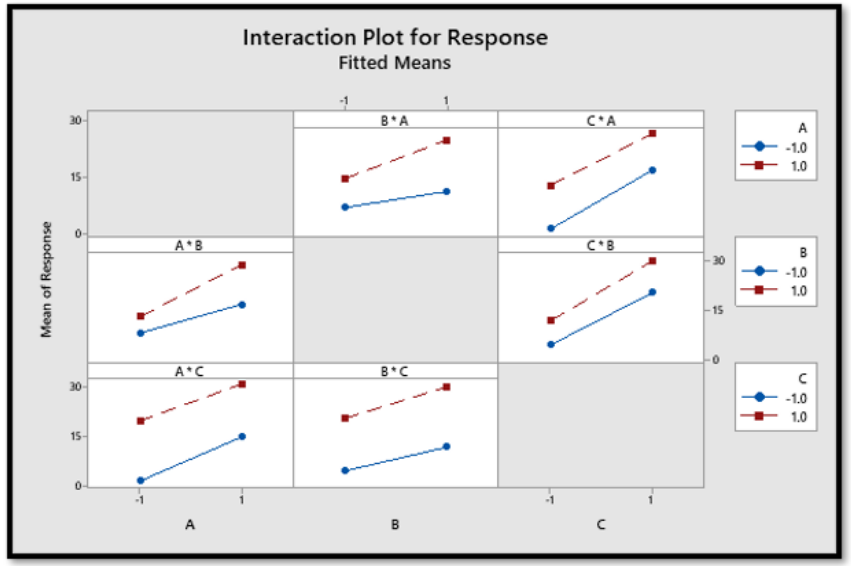


Factorial Analysis

After performing factorial analysis, we get the following charts:

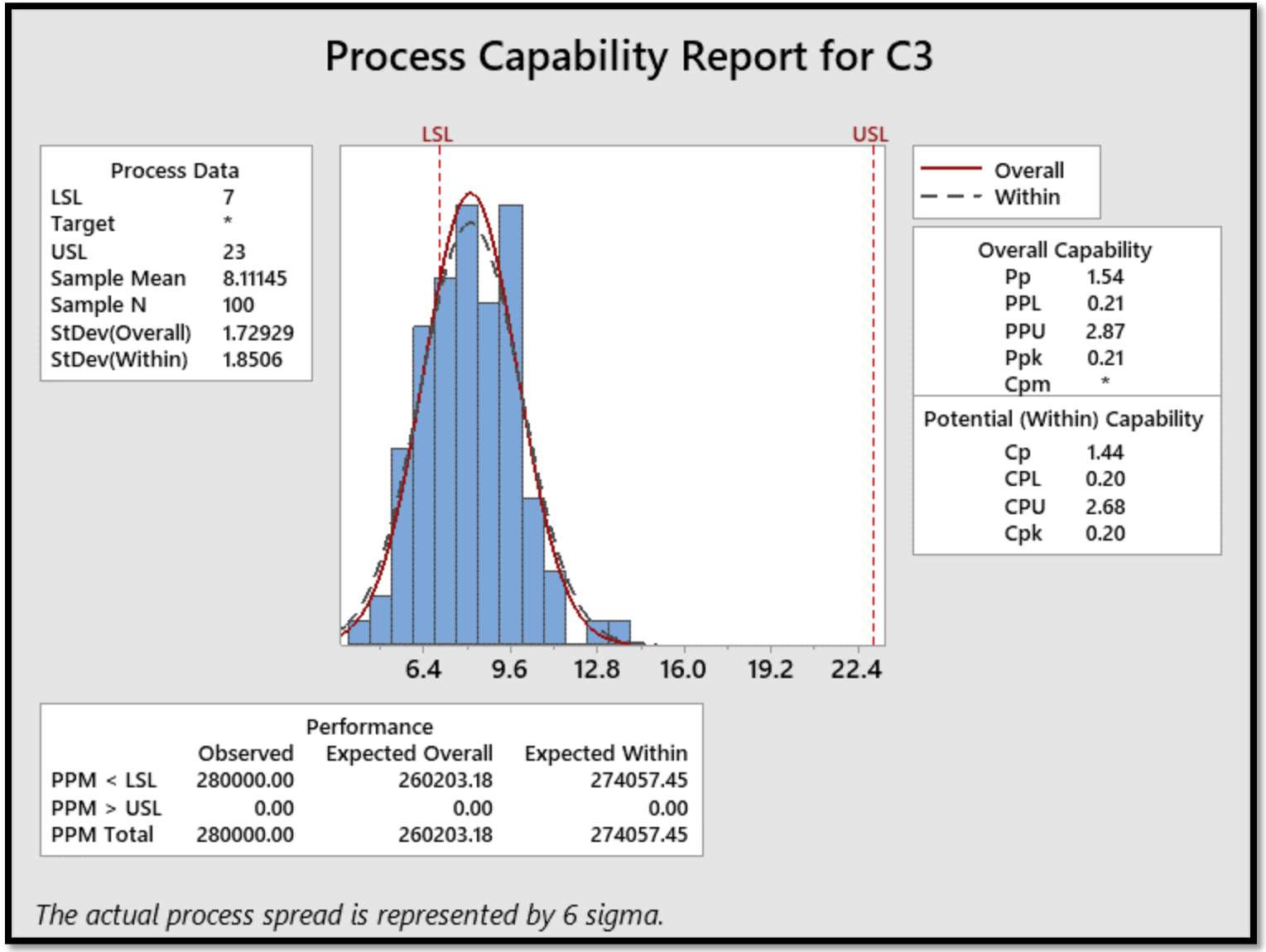
The factors A and C have a quicker rise in response to factor B.

The factors A and B have more interaction between each other than between factor A-C or factor B-C



Process capability

Thus, to implement an effective vaccine roll-out we need 80% of the vaccines to be effective, 54% of the storing equipment to work correctly and 50% of the administration staff to show up for work.



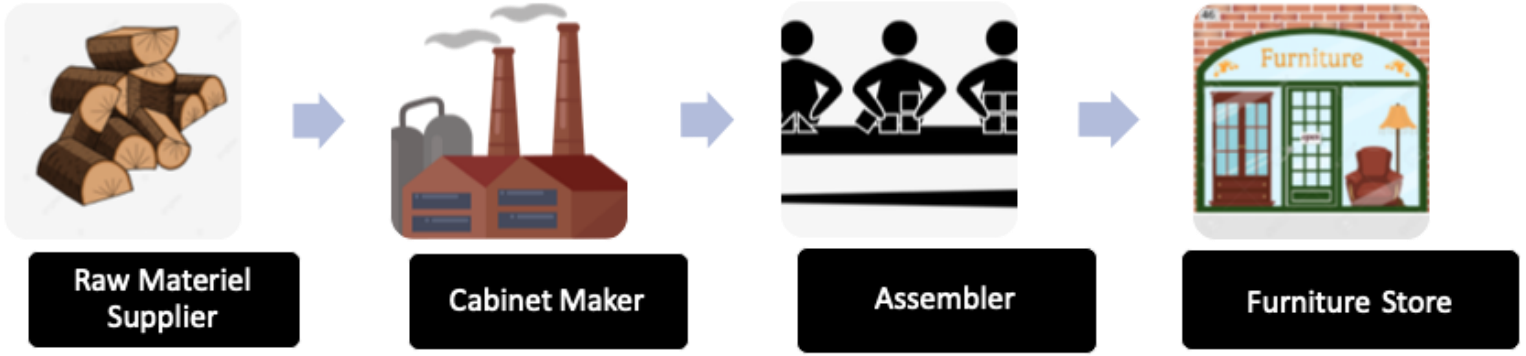
Supply Chain Management

Supply Chain Management, it is the process of managing the movement of goods and services to end users from suppliers in shape of raw material to finished goods in a very efficient and effective way. These all-chained activities are glued by information technology and wheeled by money.

Benefits of Supply Chain Management

- Better Collaboration
- Improved Quality Control
- Higher Efficiency Rate
- Keeping Up With Demand
- Shipping Optimization
- Reduced Overhead Costs
- Improved Risk Mitigation
- Improved Cash Flow

Supply Chain Network



Supply Chain Game

- The supply chain game helps students consider the distribution of resources and associated costs. Assume you're the owner of a furniture store. Your furniture supplier assembles it by receiving the required wood pieces from his own supplier, who cuts and prepares them. We need to figure out how many things the cabinet manufacturer and assembler manufacture each week, how much inventory the furniture store has each week, and how much each subsystem and the whole device costs.

Item	Cabinet Maker	Assembler	Furniture Store
Production/Sale	N1	N2	N3
Inventory Max	9	10	8
Cost of Inventory	$ 1	$ 2	$ 5
Cost of Overflow	$ 3	$ 4	$ 10
Cost of Shortage	$ 7	$ 6	$ 7
Random/Selection	Judgement	Judgement	Distribution J

Assumptions
No Lead Time
Full Inventory in Week 0
Batch size of 4 units per batch
40% of inventory as safety stock

Where
N1 = 7+GrpNo
N2 = 8+GrpNo
N3 = 6+GrpNo

Case 1: Given Maximum Inventory

Item	Cabinet Maker	Assembler	Furniture Store
Production/Sale	10	11	9
Inventory Max	9	10	8
Cost of Inventory	$ 1	$ 2	$ 5
Cost of Overflow	$ 3	$ 4	$ 10
Cost of Shortage	$ 7	$ 6	$ 7
Random/Selection	Judgement	Judgement	Distribution J

Assumptions
No Lead Time
Full Inventory in Week 0
Batch size of 4 units per batch
40% of inventory as safety stock

- With the given Maximun Inventory we calculated the total cost to be **$650.**

Furniture Store

Week		1	2	3	4	5	6	7	8	9	10	
Actual Sale	0	6	1	4	0	7	5	7	7	9	9	
Forecast	0	5	5	5	5	5	5	5	5	5	5	
Inventory	8	7	8	8	8	6	6	4	2	0	0	
Shortage	0	0	0	0	0	0	0	0	0	2	4	
Overfolw	0	0	3	1	5	0	0	0	0	0	0	
Cost of Inventory	$ 40.00	$ 35.00	$ 40.00	$ 40.00	$ 40.00	$ 30.00	$ 30.00	$ 20.00	$ 10.00	$ -	$ -	$ 285.00
Cost of Overflow	$ -	$ -	$ 30.00	$ 10.00	$ 50.00	$ -	$ -	$ -	$ -	$ -	$ -	$ 90.00
Cost of shortage	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 14.00	$ 28.00	$ 42.00
Total cost												$ 417.00

Assembler

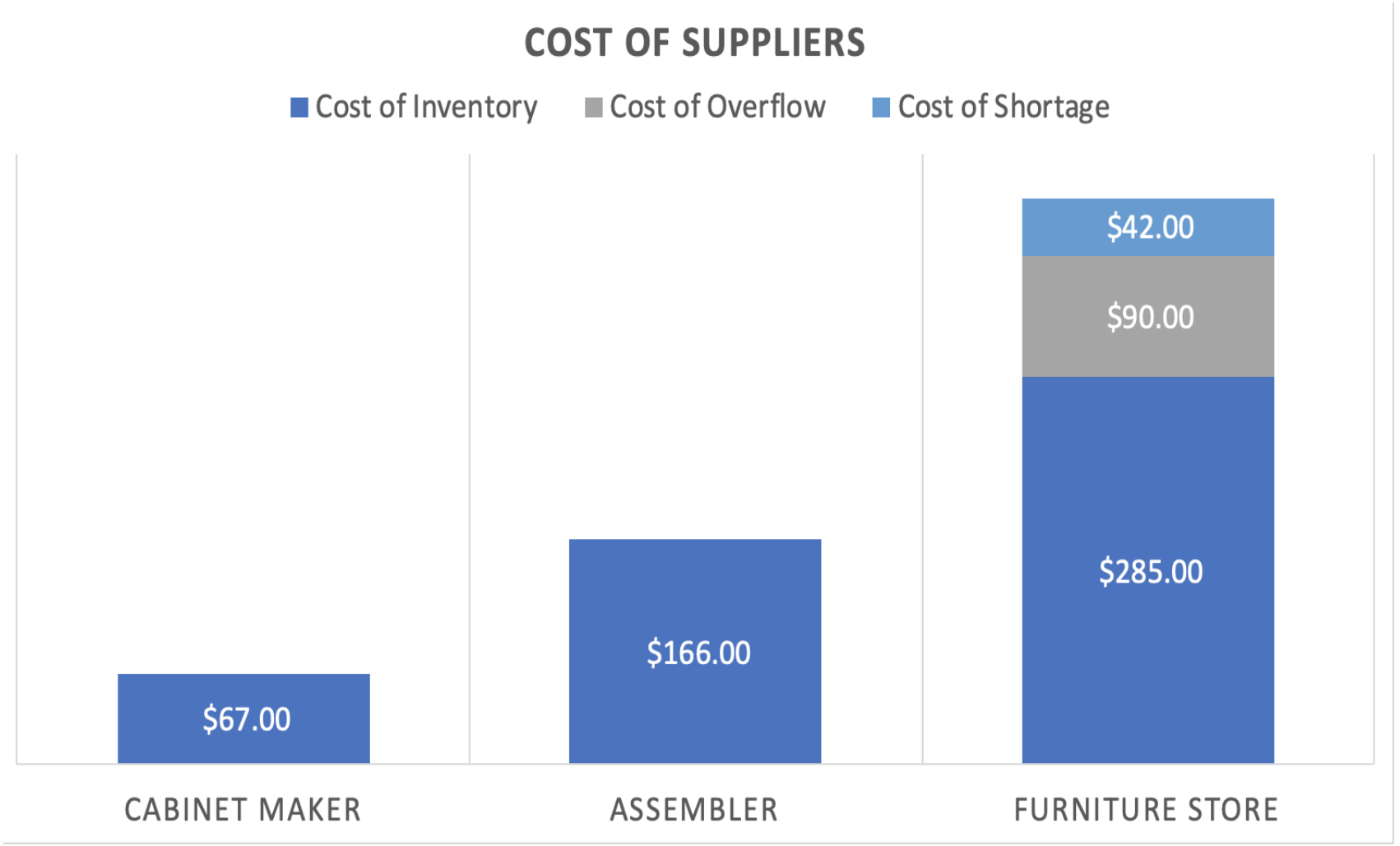
Week		1	2	3	4	5	6	7	8	9	10	
Forecast		5	5	5	5	5	5	5	5	5	5	
Inventory	10	5	8	7	6	5	8	7	10	9	8	
Gross requirments	0	0	8	4	4	4	8	4	8	4	4	
Shortage	0	0	0	0	0	0	0	0	0	0	0	
Overfolw	0	0	0	0	0	0	0	0	0	0	0	
Cost of Inventory	$ 20.00	$ 10.00	$ 16.00	$ 14.00	$ 12.00	$ 10.00	$ 16.00	$ 14.00	$ 20.00	$ 18.00	$ 16.00	$ 166.00
Cost of Overflow	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Cost of shortage	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total cost												$ 166.00

Cabinet Maker

Week		1	2	3	4	5	6	7	8	9	10	
Gross requirments	0	0	0	4	4	4	8	0	8	8	4	
Inventory	9	9	9	5	5	5	5	5	5	5	5	
Net requirment	0	0	0	0	4	4	8	0	8	8	4	
Shortage	0	0	0	0	0	0	0	0	0	0	0	
Overfolw	0	0	0	0	0	0	0	0	0	0	0	
Cost of Inventory	$ 9.00	$ 9.00	$ 9.00	$ 5.00	$ 5.00	$ 5.00	$ 5.00	$ 5.00	$ 5.00	$ 5.00	$ 5.00	$ 67.00
Cost of Overflow	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Cost of shortage	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total cost												$ 67.00

Total cost	$ 650.00

Case 1: Given Maximum Inventory



Case 2: Reducing Maximun Inventory

Item	Cabinet Maker	Assembler	Furniture Store
Production/Sale	10	11	9
Inventory Max	8	9	7
Cost of Inventory	$ 1	$ 2	$ 5
Cost of Overflow	$ 3	$ 4	$ 10
Cost of Shortage	$ 7	$ 6	$ 7
Random/Selection	Judgement	Judgement	Distribution J

Assumptions
No Lead Time
Full Inventory in Week 0
Batch size of 4 units per batch
40% of inventory as safety stock

With the given Maximun Inventory we calculated the total cost to be **$562.**

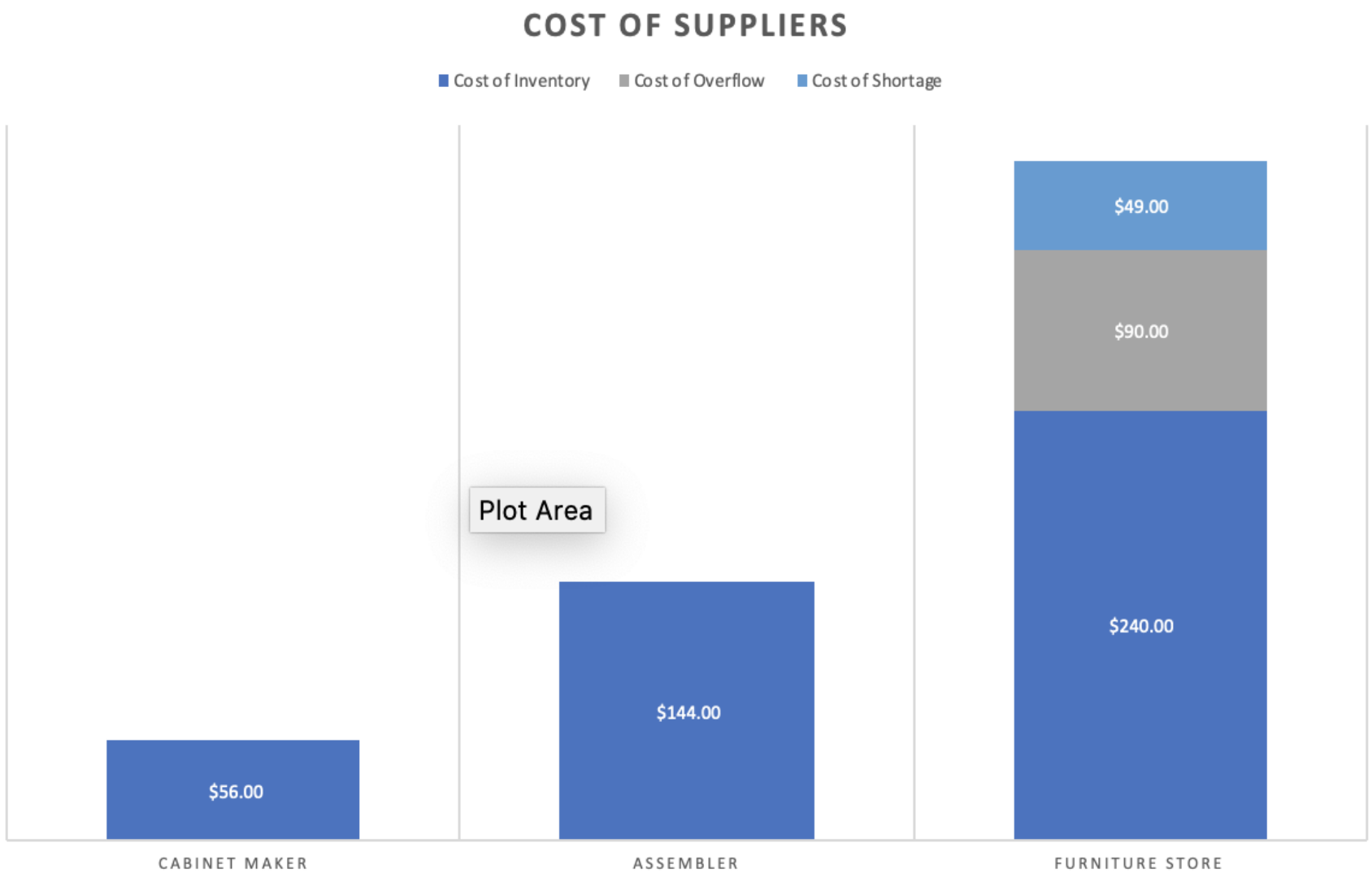
Furniture Store	Week		1	2	3	4	5	6	7	8	9	10	
	Actual Sale	0	6	1	4	0	7	5	7	7	9	9	
	Forecast	0	5	5	5	5	5	5	5	5	5	5	
	Inventory	7	6	7	7	7	5	5	3	1	0	0	
	Shortage	0	0	0	0	0	0	0	0	0	3	4	
	Overfolw	0	0	3	1	5	0	0	0	0	0	0	
	Cost of Inventory	$ 35.00	$ 30.00	$ 35.00	$ 35.00	$ 35.00	$ 25.00	$ 25.00	$ 15.00	$ 5.00	$ -	$ -	$ 240.00
	Cost of Overflow	$ -	$ -	$ 30.00	$ 10.00	$ 50.00	$ -	$ -	$ -	$ -	$ -	$ -	$ 90.00
	Cost of shortage	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 21.00	$ 28.00	$ 49.00
	Total cost												$ 379.00

Assembler	Week		1	2	3	4	5	6	7	8	9	10	
	Forecast		5	5	5	5	5	5	5	5	5	5	
	Inventory	9	4	7	6	5	4	7	6	9	8	7	
	Gross requirments	0	0	8	4	4	4	8	4	8	4	4	
	Shortage	0	0	0	0	0	0	0	0	0	0	0	
	Overfolw	0	0	0	0	0	0	0	0	0	0	0	
	Cost of Inventory	$ 18.00	$ 8.00	$ 14.00	$ 12.00	$ 10.00	$ 8.00	$ 14.00	$ 12.00	$ 18.00	$ 16.00	$ 14.00	$ 144.00
	Cost of Overflow	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Cost of shortage	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Total cost												$ 144.00

Cabinet Maker	Week		1	2	3	4	5	6	7	8	9	10	
	Gross requirments	0	0	0	4	4	4	8	0	8	8	4	
	Inventory	8	8	8	4	4	4	4	4	4	4	4	
	Net requirment	0	0	0	0	4	4	8	0	8	8	4	
	Shortage	0	0	0	0	0	0	0	0	0	0	0	
	Overfolw	0	0	0	0	0	0	0	0	0	0	0	
	Cost of Inventory	$ 8.00	$ 8.00	$ 8.00	$ 4.00	$ 4.00	$ 4.00	$ 4.00	$ 4.00	$ 4.00	$ 4.00	$ 4.00	$ 56.00
	Cost of Overflow	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Cost of shortage	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Total cost												$ 56.00

	Total cost	$ 579.00

Case 2: Reducing Maximum Inventory



Case 3: Incresing Maximun Inventory

Item	Cabinet Maker	Assembler	Furniture Store
Production/Sale	10	11	9
Inventory Max	10	11	9
Cost of Inventory	$ 1	$ 2	$ 5
Cost of Overflow	$ 3	$ 4	$ 10
Cost of Shortage	$ 7	$ 6	$ 7
Random/Selection	Judgement	Judgement	Distribution J

Assumptions
No Lead Time
Full Inventory in Week 0
Batch size of 4 units per batch
40% of inventory as safety stock

With the given Maximun Inventory we calculated the total cost to be **$755.**

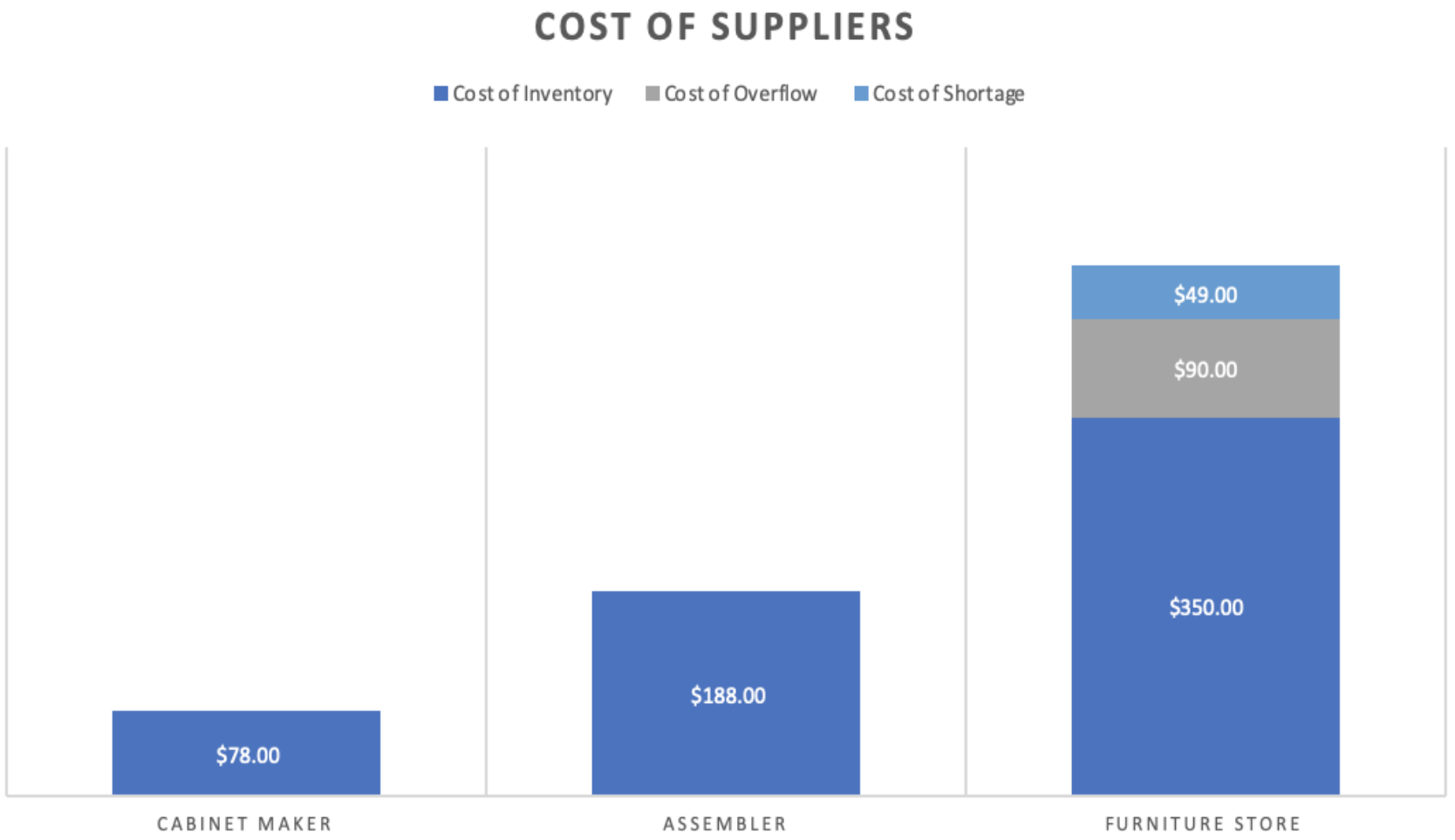
Furniture Store	Week		1	2	3	4	5	6	7	8	9	10	
	Actual Sale	0	6	1	4	0	7	5	7	7	9	9	
	Forecast	0	5	5	5	5	5	5	5	5	5	5	
	Inventory	9	8	9	9	9	7	7	5	3	2	2	
	Shortage	0	0	0	0	0	0	0	0	0	3	4	
	Overfolw	0	0	3	1	5	0	0	0	0	0	0	
	Cost of Inventory	$ 45.00	$ 40.00	$ 45.00	$ 45.00	$ 45.00	$ 35.00	$ 35.00	$ 25.00	$ 15.00	$ 10.00	$ 10.00	$ 350.00
	Cost of Overflow	$ -	$ -	$ 30.00	$ 10.00	$ 50.00	$ -	$ -	$ -	$ -	$ -	$ -	$ 90.00
	Cost of shortage	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 21.00	$ 28.00	$ 49.00
	Total cost												$ 489.00

Assembler	Week		1	2	3	4	5	6	7	8	9	10	
	Forecast		5	5	5	5	5	5	5	5	5	5	
	Inventory	11	6	9	8	7	6	9	8	11	10	9	
	Gross requirments	0	0	8	4	4	4	8	4	8	4	4	
	Shortage	0	0	0	0	0	0	0	0	0	0	0	
	Overfolw	0	0	0	0	0	0	0	0	0	0	0	
	Cost of Inventory	$ 22.00	$ 12.00	$ 18.00	$ 16.00	$ 14.00	$ 12.00	$ 18.00	$ 16.00	$ 22.00	$ 20.00	$ 18.00	$ 188.00
	Cost of Overflow	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Cost of shortage	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Total cost												$ 188.00

Cabinet Maker	Week		1	2	3	4	5	6	7	8	9	10	
	Gross requirments	0	0	0	4	4	4	8	0	8	8	4	
	Inventory	10	10	10	6	6	6	6	6	6	6	6	
	Net requirment	0	0	0	0	4	4	8	0	8	8	4	
	Shortage	0	0	0	0	0	0	0	0	0	0	0	
	Overfolw	0	0	0	0	0	0	0	0	0	0	0	
	Cost of Inventory	$ 10.00	$ 10.00	$ 10.00	$ 6.00	$ 6.00	$ 6.00	$ 6.00	$ 6.00	$ 6.00	$ 6.00	$ 6.00	$ 78.00
	Cost of Overflow	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Cost of shortage	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Total cost												$ 78.00

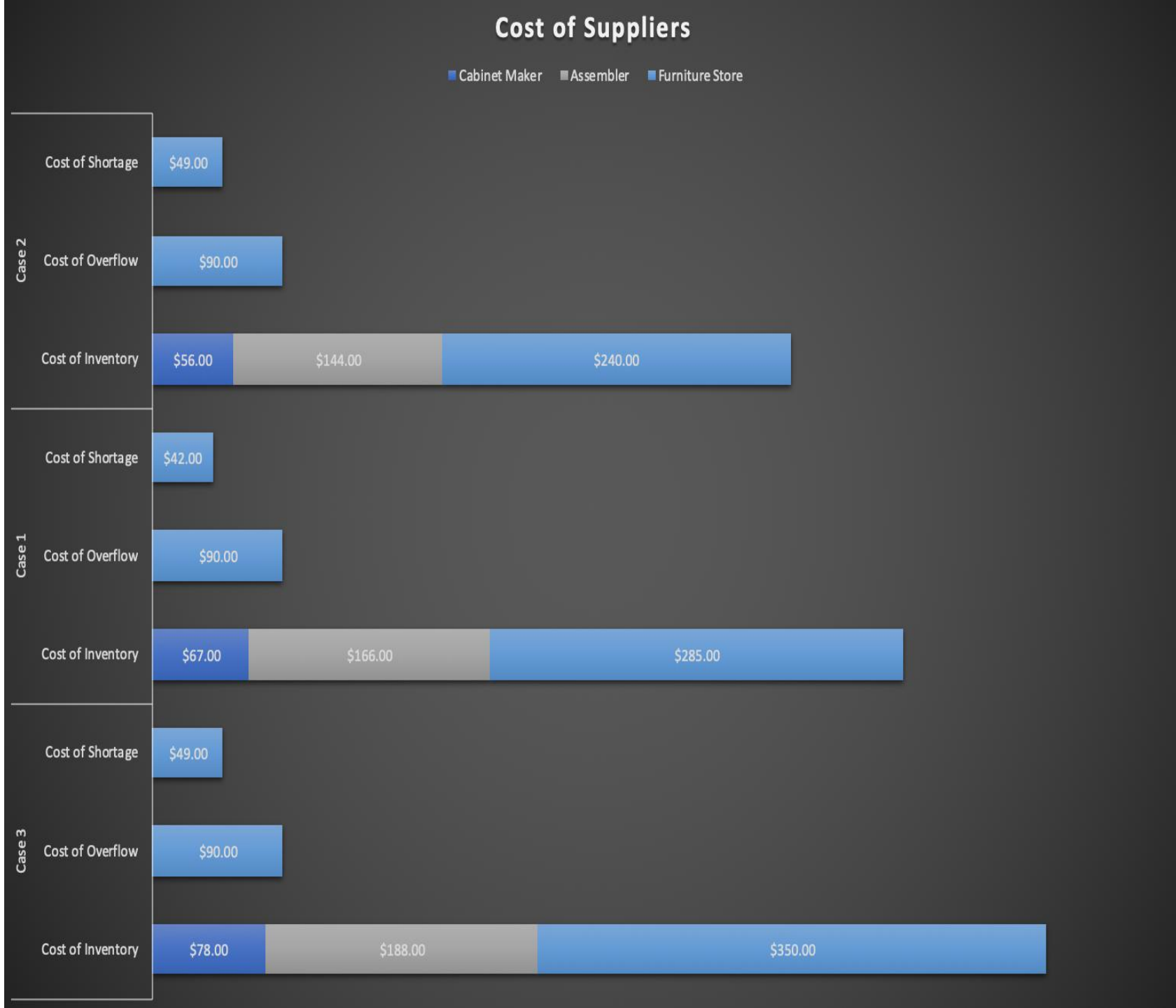
	Total cost	$ 755.00

Case 3: Increasing Maximum Inventory



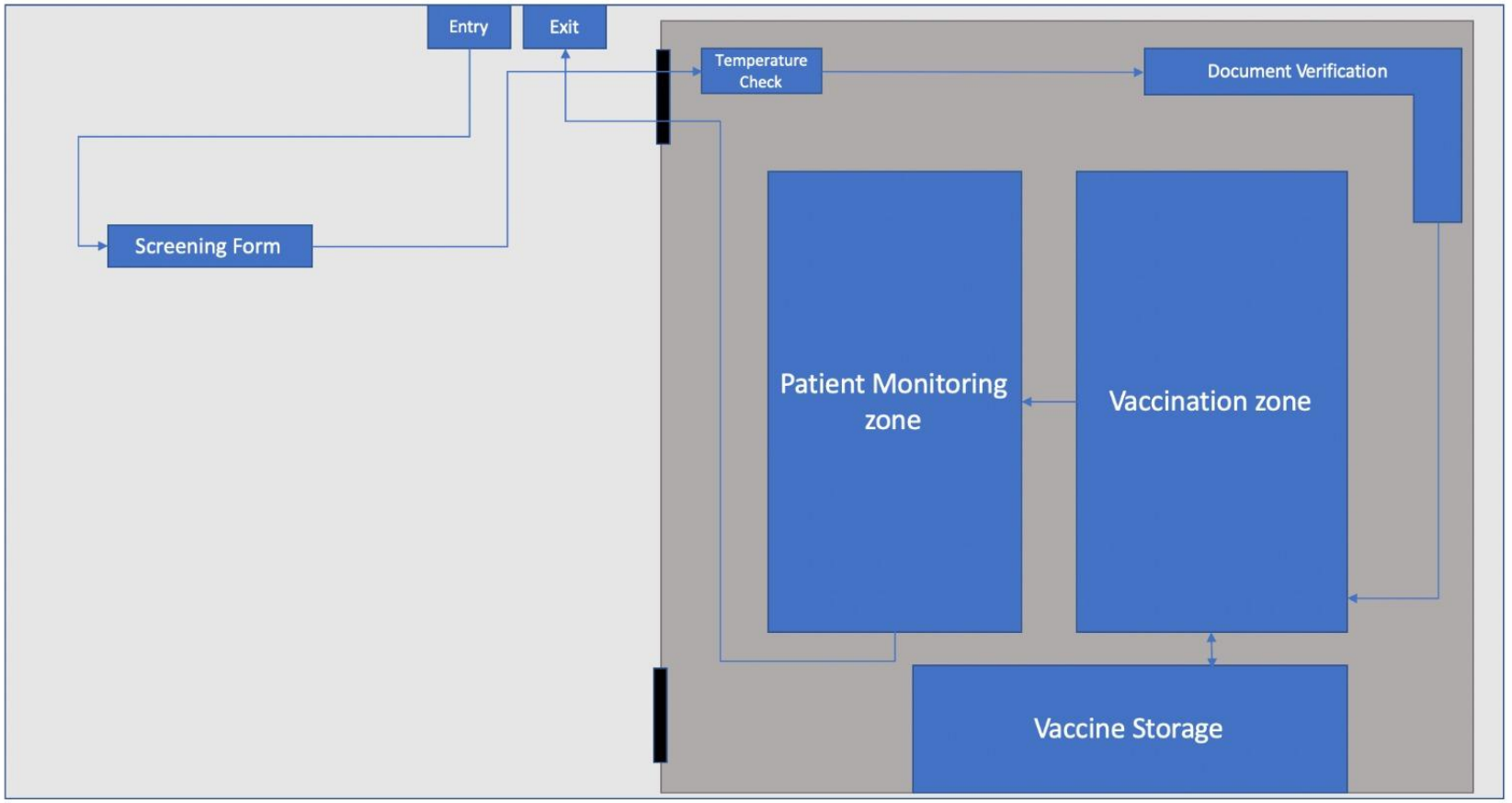
Comparing of all cases

In our analysis we found out that when we reduced the Inventory we saved money



Value Stream Map

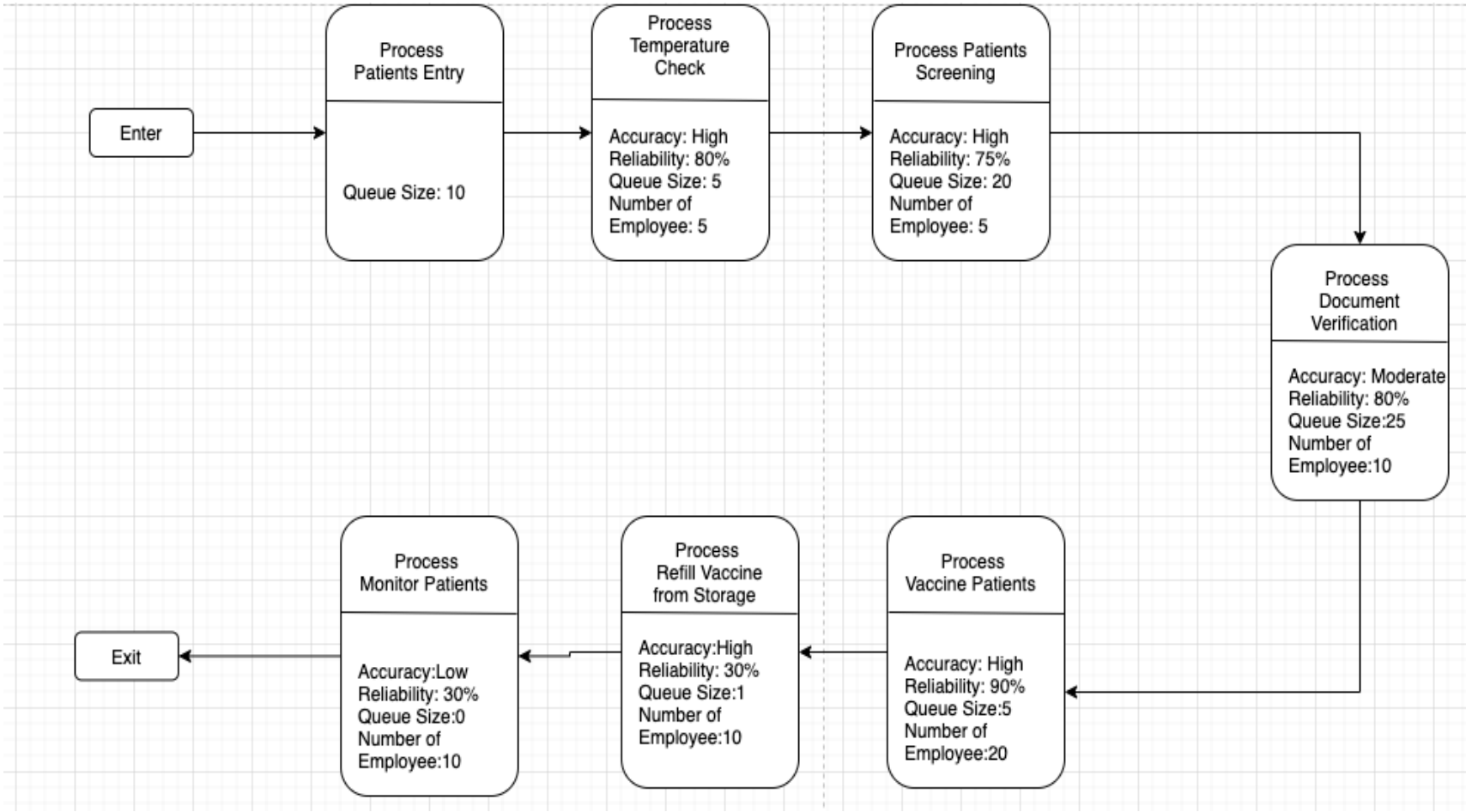
Original Process Layout



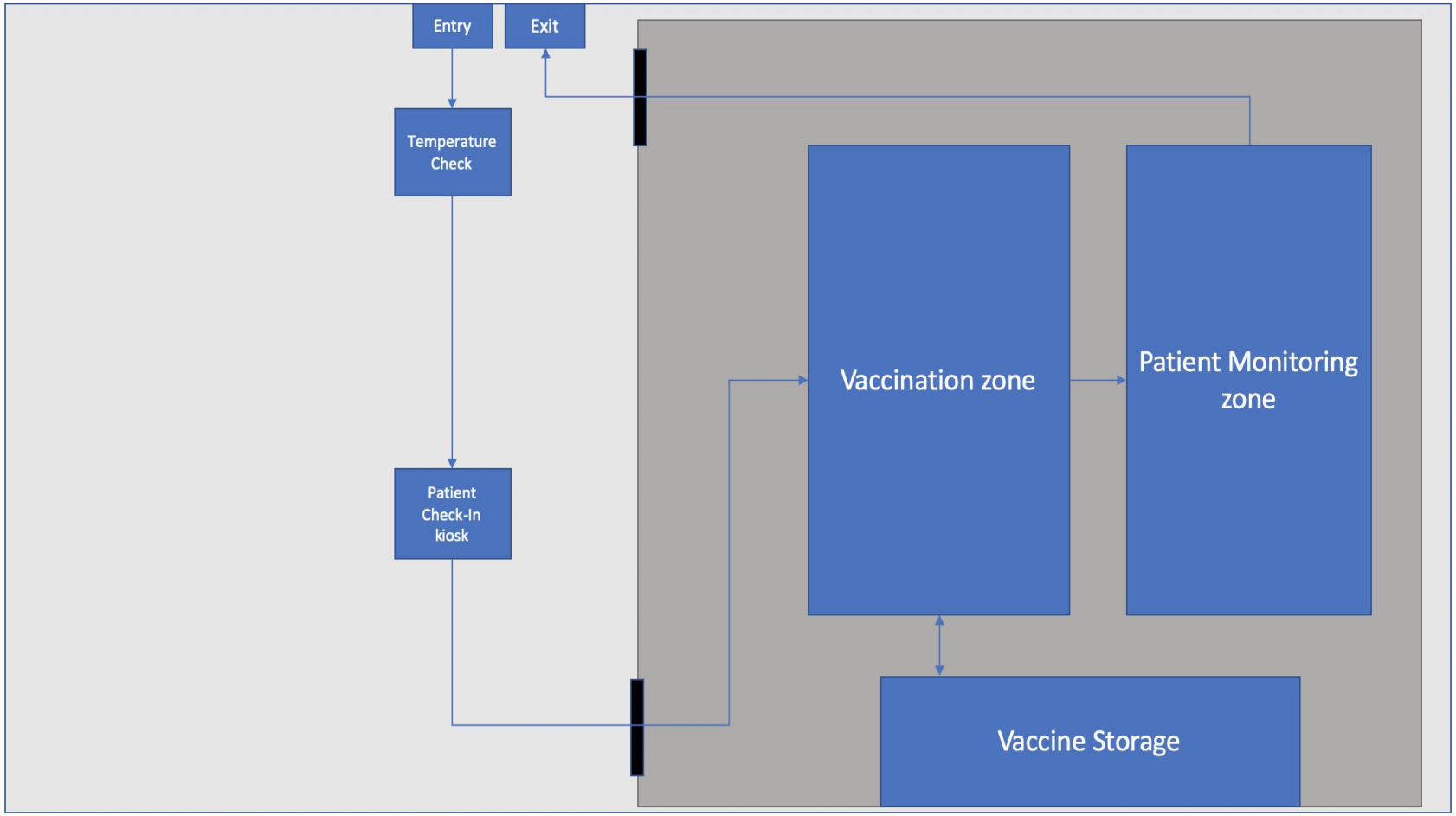
Original Value Stream Map Tabular form

Step Number	Process	Accuracy	Reliability	Queue size	Number of employees	Time taken (Secs)
1	Patient entry			10		5
2	Temperature Check	High	80%	5	5	20
3	Patient Screening	High	75%	20	5	300
4	Document verification	Moderate	80%	25	10	300
5	Vaccinate patient	High	90%	5	20	180
6	Refill vaccines from storage	High	30%	1	10	420
7	Monitor patient	Low	30%	0	10	900
8	Patient exit					15

Original Value Stream Map



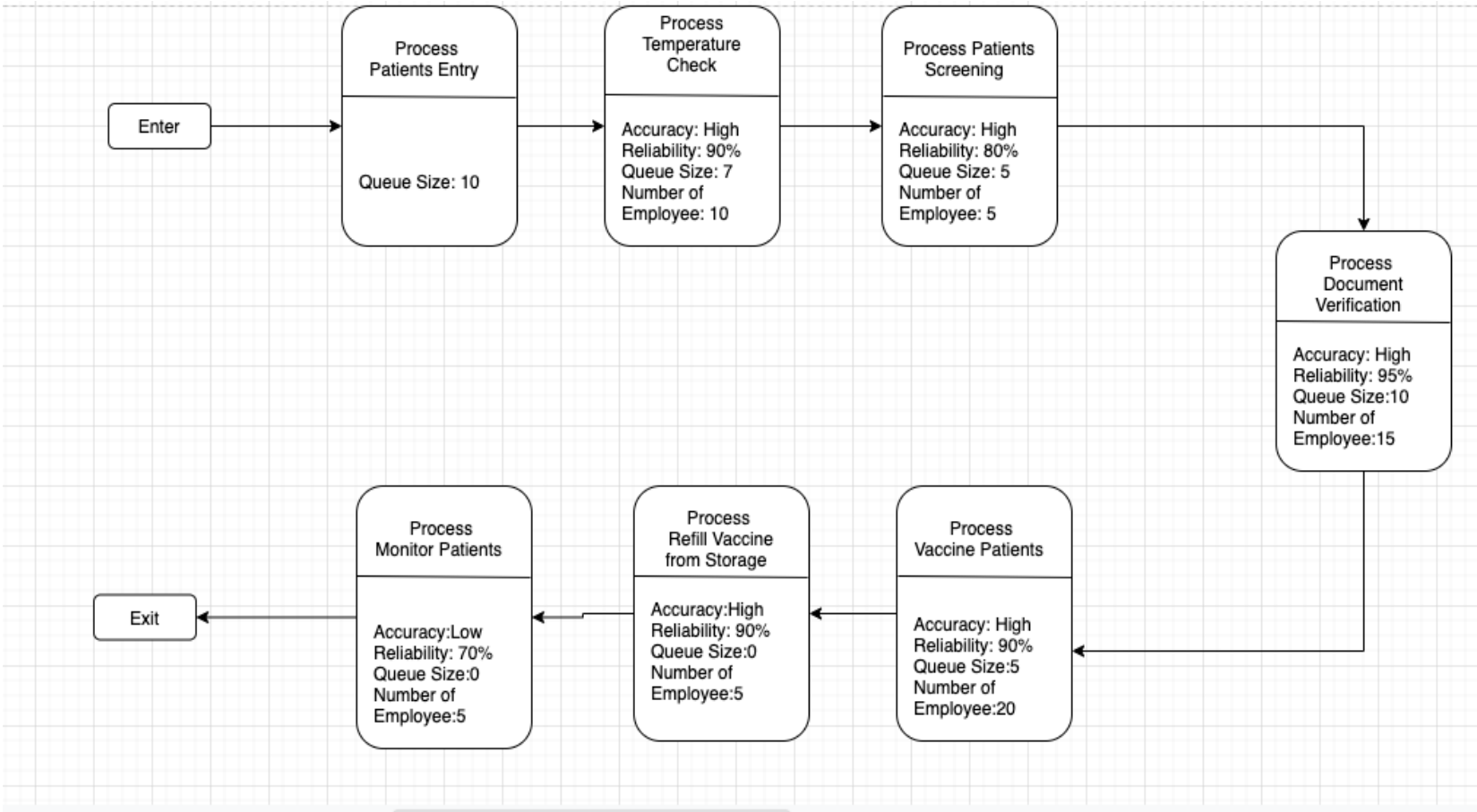
Improved Process Layout



Improved Value Stream Tabular Form

Step Number	Process	Accuracy	Reliability	Queue size	Number of employees	Time taken (Secs)
1	Patient entry			10		5
2	Patient Screening	High	90%	7	10	180
3	Temperature Check	High	80%	5	5	20
4	Document verification	High	95%	10	15	270
5	Vaccinate patient	High	90%	5	20	180
6	Refill vaccines from storage	High	90%	0	5	180
7	Monitor patient	High	70%	0	5	900
8	Patient exit					15

Improved Value Stream Map



Difference in Parameters after Improvement

- The reliability is increased, queue size and time taken decreased for patient screening by workforce re-allocation for each process.
- The reliability is increased, queue size and time taken decreased for document verification by workforce re-allocation for each process.
- The reliability of refilling vaccines from storage is increased and time taken to refill them is decreased by allocating highly reliable employees.
- The reliability of monitoring the patient is increased by allocating highly reliable employees

Measurement System Analysis

- Qualitative & Quantitative Gage R&R Minitab Analysis
- Part: The variation that is from the parts.
- Operator: The variation that is from the operators.
- Operator*Part: The variation that is from the operator and part interaction. An interaction exists when an operator measures different parts differently.
- Error or repeatability: The variation that is not explained by part, operator, or the operator and part interaction.

Continuous Gage R&R Study – Dataset

Part	Operator	Measurement
1	A	0.29
1	A	0.41
1	A	0.64
2	A	-0.56
2	A	-0.68
2	A	-0.58
3	A	1.34
3	A	1.17
3	A	1.27
4	A	0.47
4	A	0.5
4	A	0.64
5	A	-0.8
5	A	-0.92
5	A	-0.84
6	A	0.02
6	A	-0.11
6	A	-0.21
7	A	0.59
7	A	0.75
7	A	0.66
8	A	-0.31
8	A	-0.2
8	A	-0.17
9	A	2.26
9	A	1.99
9	A	2.01
10	A	-1.36
10	A	-1.25
10	A	-1.31

Part	Operator	Measurement
1	B	0.08
1	B	0.25
1	B	0.07
2	B	-0.47
2	B	-1.22
2	B	-0.68
3	B	1.19
3	B	0.94
3	B	1.34
4	B	0.01
4	B	1.03
4	B	0.2
5	B	-0.56
5	B	-1.2
5	B	-1.28
6	B	-0.2
6	B	0.22
6	B	0.06
7	B	0.47
7	B	0.55
7	B	0.83
8	B	-0.63
8	B	0.08
8	B	-0.34
9	B	1.8
9	B	2.12
9	B	2.19
10	B	-1.68
10	B	-1.62
10	B	-1.5

Part	Operator	Measurement
1	C	0.04
1	C	-0.11
1	C	-0.15
2	C	-1.38
2	C	-1.13
2	C	-0.96
3	C	0.88
3	C	1.09
3	C	0.67
4	C	0.14
4	C	0.2
4	C	0.11
5	C	-1.46
5	C	-1.07
5	C	-1.45
6	C	-0.29
6	C	-0.67
6	C	-0.49
7	C	0.02
7	C	0.01
7	C	0.21
8	C	-0.46
8	C	-0.56
8	C	-0.49
9	C	1.77
9	C	1.45
9	C	1.87
10	C	-1.49
10	C	-1.77
10	C	-2.16

Continuous Gage R&R Study – Results

Two-Way ANOVA Table With Interaction

Source	DF	SS	MS	F	P
Part	9	88.3619	9.81799	492.291	0.000
Operator	2	3.1673	1.58363	79.406	0.000
Part * Operator	18	0.3590	0.01994	0.434	0.974
Repeatability	60	2.7589	0.04598		
Total	89	94.6471			

α to remove interaction term = 0.05

Two-Way ANOVA Table Without Interaction

Source	DF	SS	MS	F	P
Part	9	88.3619	9.81799	245.614	0.000
Operator	2	3.1673	1.58363	39.617	0.000
Repeatability	78	3.1179	0.03997		
Total	89	94.6471			

Part-operator variation is not significant **(P-value = 0.974 > 0.05)**. Part and operator variations are significant **(P-value = 0.000 > 0.05)**.

Continuous Gage R&R Study – Results

- Part-operator variation is not significant **(P-value = 0.974 > 0.05)**. Part and operator variations are significant **(P-value = 0.000 > 0.05)**.

- Percent study variation for total gage R&R is 27.86% (which is between 10% and 30%) indicates **the process is acceptable depending on the application, cost of measuring device, cost of repair, other factors.**

Gage R&R

Variance Components

Source	VarComp	%Contribution (of VarComp)
Total Gage R&R	0.09143	7.76
Repeatability	0.03997	3.39
Reproducibility	0.05146	4.37
Operator	0.05146	4.37
Part-To-Part	1.08645	92.24
Total Variation	1.17788	100.00

Gage Evaluation

Source	StdDev (SD)	Study Var (6 × SD)	%Study Var (%SV)
Total Gage R&R	0.30237	1.81423	27.86
Repeatability	0.19993	1.19960	18.42
Reproducibility	0.22684	1.36103	20.90
Operator	0.22684	1.36103	20.90
Part-To-Part	1.04233	6.25396	96.04
Total Variation	1.08530	6.51180	100.00

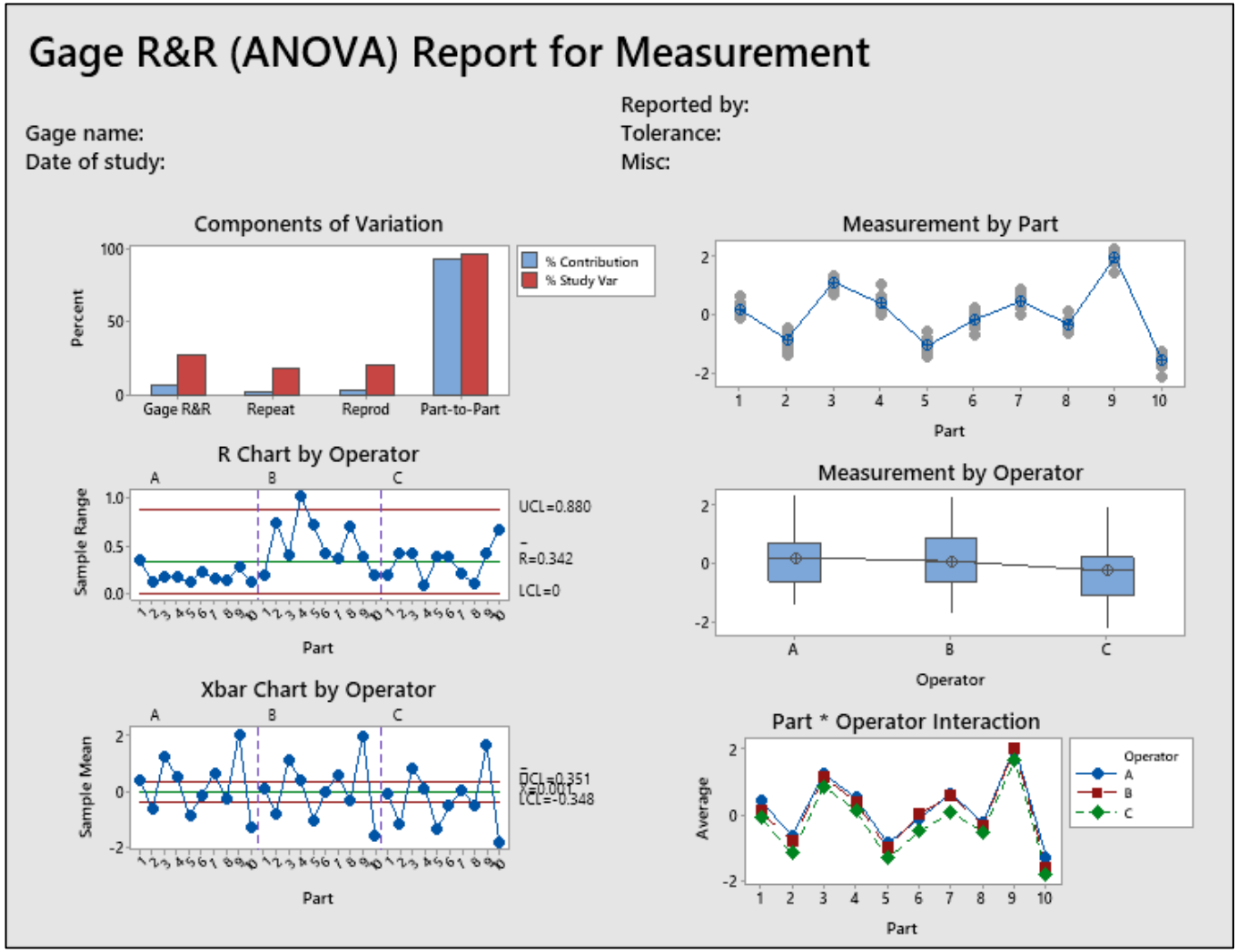
Number of Distinct Categories = 4

Continuous Gage R&R Study – Results

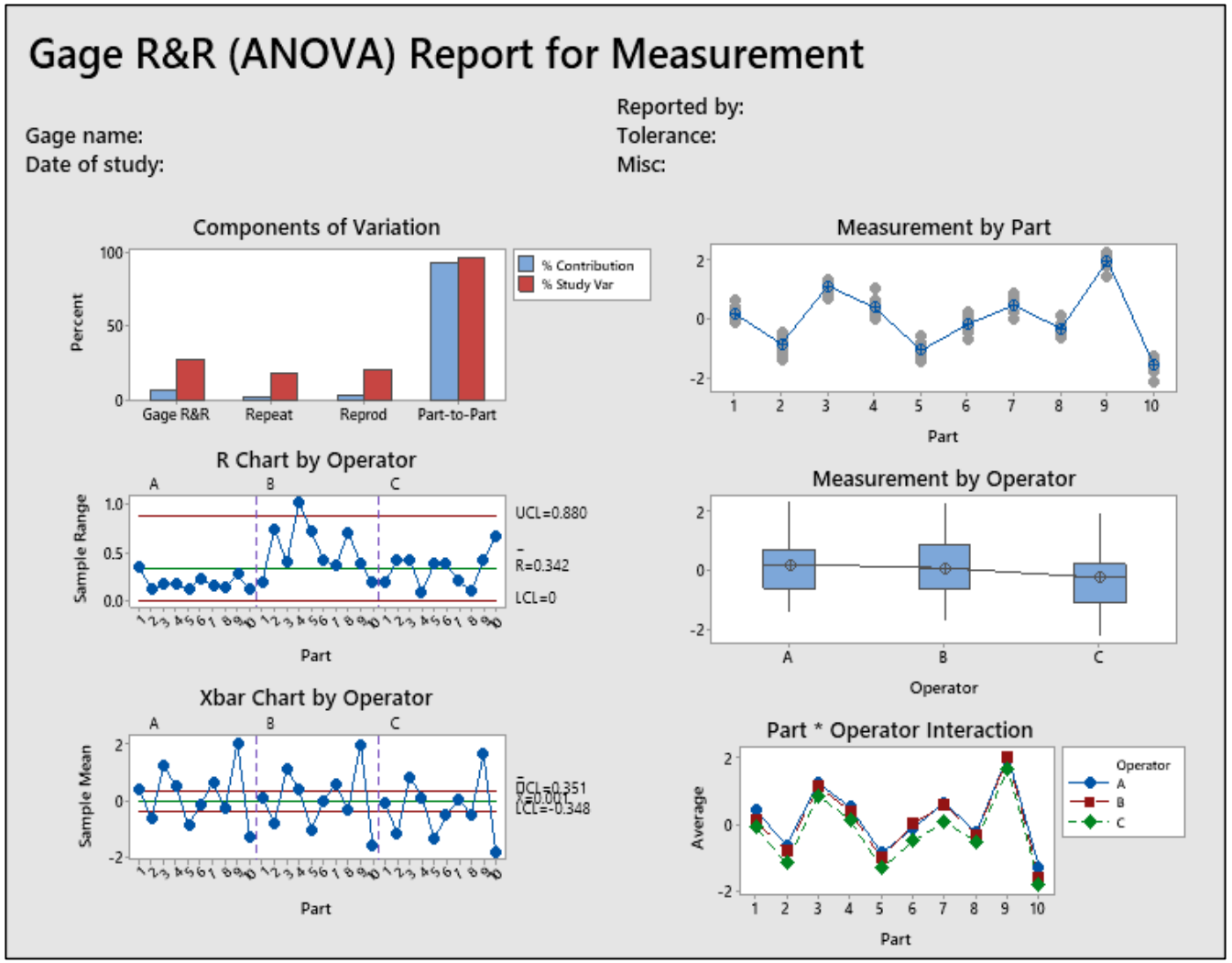
The percentage contribution of part-to-part is larger than total gage R&R, thus **the variation is mostly due to difference between parts.**

The range of subgroups indicate whether the operators could measure consistently over time as all points should fall within the control limits. **Operator B measures just one point outside the upper control limit.**

The means of subgroups indicate whether the parts are measured consistently over time as all points should fall outside the control limits. **More variation between part averages is expected as most points fall outside the control limits.**



Continuous Gage R&R Study – Results



It must be determined whether multiple measurements for each part are about the same. **Parts 4 and 10 have the largest variation.**

It must be determined whether there is difference in the total average measurements between operators. **Operator C has a slightly lower average for measurements but is like those of Operators A and B.**

The trend of measurements for each operator indicate whether there is difference in average measurements for each part between operators. **Operator C measures consistently higher on some parts and lower on other parts which adds bias to measurements.**

Attributes Gage R&R Study – Dataset

1

Sample	Attribute	Inspector	Result
1	go	1	go
2	no	1	no
3	no	1	no
4	no	1	no
5	no	1	no
6	no	1	no
7	no	1	no
8	no	1	no
9	no	1	no
10	no	1	no
11	no	1	no
12	no	1	no
13	no	1	no
14	no	1	no
15	go	1	go
16	go	1	go
17	go	1	no
18	no	1	no
19	go	1	go
20	no	1	no

2

Sample	Attribute	Inspector	Result
1	go	1	go
2	no	1	no
3	no	1	no
4	no	1	no
5	no	1	no
6	no	1	no
7	no	1	no
8	no	1	no
9	no	1	no
10	no	1	no
11	no	1	no
12	no	1	no
13	no	1	no
14	no	1	no
15	go	1	go
16	go	1	go
17	go	1	no
18	no	1	no
19	go	1	go
20	no	1	no

3

Sample	Attribute	Inspector	Result
1	go	2	go
2	no	2	no
3	no	2	no
4	no	2	no
5	no	2	no
6	no	2	no
7	no	2	no
8	no	2	no
9	no	2	no
10	no	2	no
11	no	2	no
12	no	2	no
13	no	2	no
14	no	2	no
15	go	2	go
16	go	2	go
17	go	2	no
18	no	2	no
19	go	2	go
20	no	2	no

4

Sample	Attribute	Inspector	Result
1	go	2	go
2	no	2	no
3	no	2	no
4	no	2	no
5	no	2	no
6	no	2	no
7	no	2	no
8	no	2	no
9	no	2	no
10	no	2	no
11	no	2	no
12	no	2	no
13	no	2	no
14	no	2	no
15	go	2	go
16	go	2	no
17	go	2	go
18	no	2	no
19	go	2	go
20	no	2	no

Attributes Gage R&R Study – Results

Within Appraisers

Assessment Agreement

Appraiser	# Inspected	# Matched	Percent	95% CI
1	20	20	100.00	(86.09, 100.00)
2	20	18	90.00	(68.30, 98.77)

 # Matched: Appraiser agrees with him/herself across trials.

Fleiss' Kappa Statistics

Appraiser	Response	Kappa	SE Kappa	Z	P(vs > 0)
1	go	1.0000	0.223607	4.47214	0.0000
	no	1.0000	0.223607	4.47214	0.0000
2	go	0.6875	0.223607	3.07459	0.0011
	no	0.6875	0.223607	3.07459	0.0011

Within appraisers, appraiser 1 has a perfect agreement between trials (Kappa value = 1) and appraiser 2 has strong association between trials (Kappa value = 0.6875).

Each Appraiser vs Standard

Assessment Agreement

Appraiser	# Inspected	# Matched	Percent	95% CI
1	20	19	95.00	(75.13, 99.87)
2	20	18	90.00	(68.30, 98.77)

 # Matched: Appraiser's assessment across trials agrees with the known standard.

Assessment Disagreement

Appraiser	# no / go	Percent	# go / no	Percent	# Mixed	Percent
1	1	20.00	0	0.00	0	0.00
2	0	0.00	0	0.00	2	10.00

 # no / go: Assessments across trials = no / standard = go.
 # go / no: Assessments across trials = go / standard = no.
 # Mixed: Assessments across trials are not identical.

Fleiss' Kappa Statistics

Appraiser	Response	Kappa	SE Kappa	Z	P(vs > 0)
1	go	0.856631	0.158114	5.41781	0.0000
	no	0.856631	0.158114	5.41781	0.0000
2	go	0.856631	0.158114	5.41781	0.0000
	no	0.856631	0.158114	5.41781	0.0000

For each appraiser against the standard, both appraisers have a near perfect agreement between trials (Kappa values = 0.856631).

Between Appraisers

Assessment Agreement

# Inspected	# Matched	Percent	95% CI
20	18	90.00	(68.30, 98.77)

 # Matched: All appraisers' assessments agree with each other.

Fleiss' Kappa Statistics

Response	Kappa	SE Kappa	Z	P(vs > 0)
go	0.84375	0.0912871	9.24282	0.0000
no	0.84375	0.0912871	9.24282	0.0000

Between appraisers, the responses have a near perfect agreement between trials (Kappa value = 0.84375).

Attributes Gage R&R Study – Results

All Appraisers vs Standard

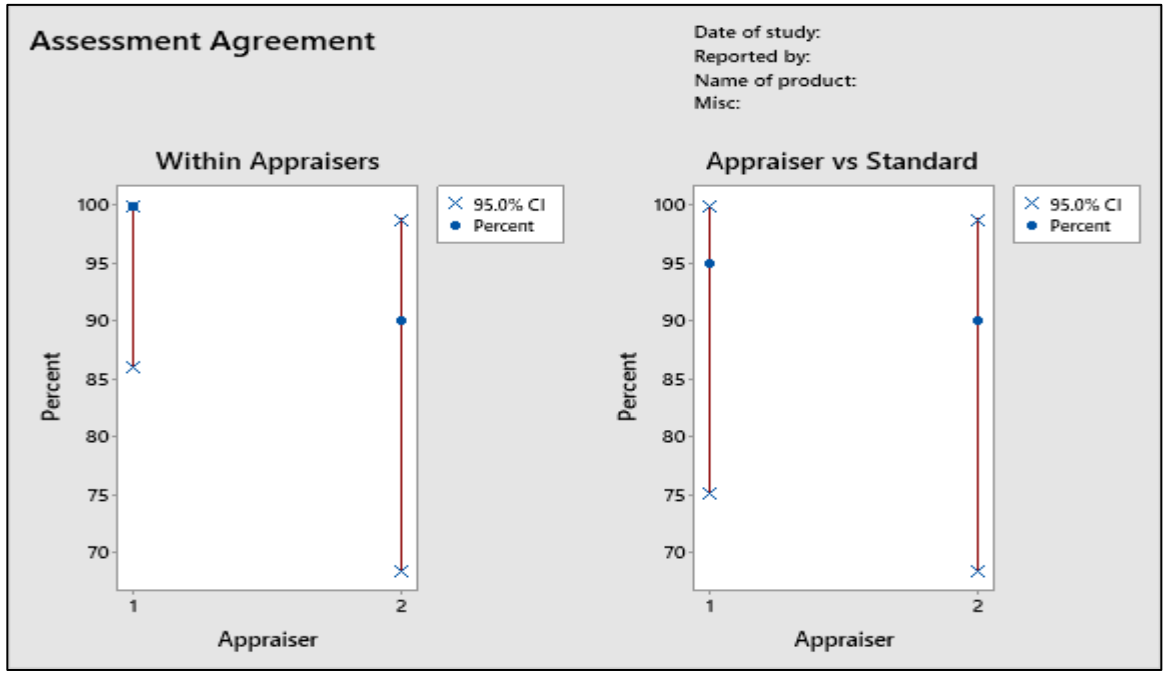
Assessment Agreement

# Inspected	# Matched	Percent	95% CI
20	18	90.00	(68.30, 98.77)

 # Matched: All appraisers' assessments agree with the known standard.

Fleiss' Kappa Statistics

Response	Kappa	SE Kappa	Z	P(vs > 0)
go	0.856631	0.111803	7.66194	0.0000
no	0.856631	0.111803	7.66194	0.0000



For all appraisers against the standard, the responses have a near perfect agreement between trials (Kappa value = 0.856631).

Rating consistency for each appraiser is represented by the blue dot. **Appraiser 1 has the most consistent ratings with approximately 100% consistency, while appraiser 2 has the least consistent ratings with a lower consistency.**

Rating correctness for each appraiser is represented by the blue dot. **Appraiser 1 has the most correct ratings, while appraiser 2 has the least correct ratings.**

Acceptance Sampling

- **Acceptance sampling** is a method used to accept or reject product based on a random **sample** of the product.
- The **purpose of acceptance sampling** is to sentence lots (accept or reject) rather than to estimate the quality of a lot.
- An approach between no inspection and full inspection

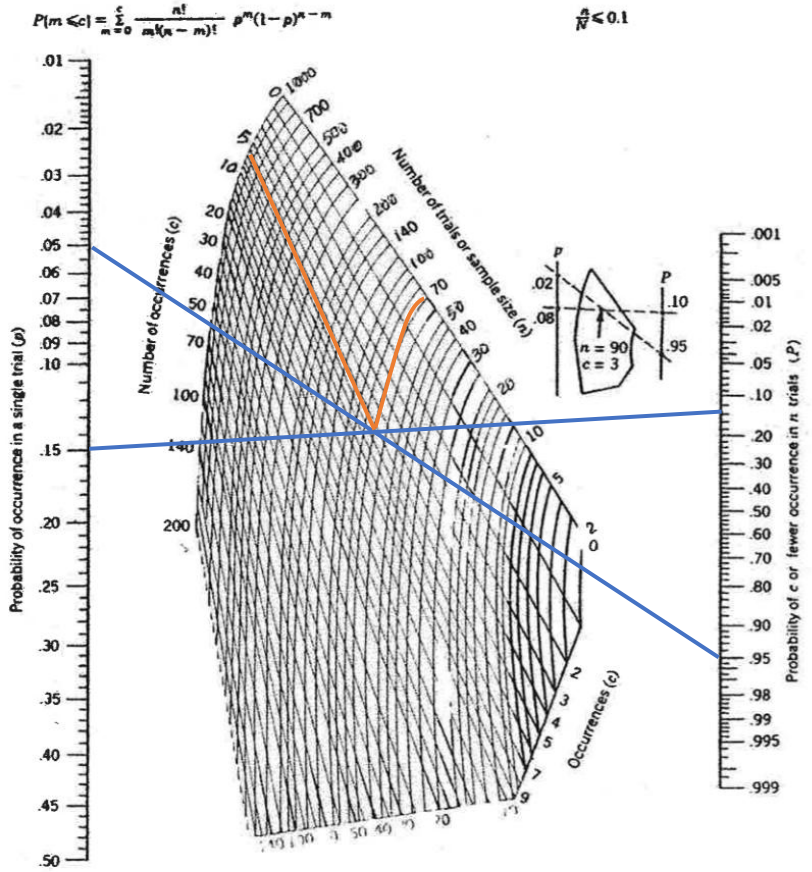
Acceptance Sampling: Parameters

- **Producer's risk (α):** The first type risk is that a lot with good quality is rejected.
- **Consumer's risk (β)**: The second type risk is that a lot with bad quality accepted.
- **Acceptable quality level (AQL):** The percent defective that is the base line requirement for the quality of the producer's product
- **Lot tolerance percent defective (LTPD):** A pre-specified high defect level that would be unacceptable to the consumer
- **Lot size (N)**: The total number of products tested

Acceptance Sampling – Nomogram

Method	
Acceptable Quality Level (AQL)	0.05
Producer's Risk (α)	0.05
Rejectable Quality Level (RQL or LTPD)	0.15
Consumer's Risk (β)	0.15

n= 70
C=5



Note:
If p is less than 0.01, set $k \times p$ on the p-scale and multiply the values on the n-scale by k, where $k = 0.01/p$ (taking k to the next higher integer).

Figure 13-9
Binomial nomograph.

Acceptance Sampling – Nomogram

OC, AOQ, and ATI Curves:

- **Operating characteristic (OC) curve** – the probability curve for sampling plan that shows the probabilities of accepting lots with various LTPDs with probability of acceptance P_a and is based on the binomial distribution

$$P_a = \sum_{d=0}^{c} \frac{n!}{d!(n-d)!} p^d (1-p)^{n-d}$$

- **Average outgoing quality (AOQ) curve** – the average defective rate in a released lot with a correlation between the quality of incoming and outgoing materials, assuming reject lots are 100% inspected and all defectives are removed

$$AOQ = \frac{P_a p(N-n)}{N}$$

- **Average total inspection (ATI) curve** – the average inspection rate in a lot with a correlation between the quality of incoming materials and the number of items needed to be inspected

$$ATI = n + (1 - P_a)(N - n)$$

Acceptance Sampling – Binomial Distribution in Minitab

Method

Acceptable Quality Level (AQL)	0.05
Producer's Risk (α)	0.05
Rejectable Quality Level (RQL or LTPD)	0.15
Consumer's Risk (β)	0.15

Our acceptance sampling plan with AQL, LTPD, α,β are shown.

Generated Plan(s)

Sample Size	65
Acceptance Number	6

Accept lot if number of defects in 65 items ≤ 6; Otherwise reject.

Defects Per Unit	Probability Accepting	Probability Rejecting	AOQ	ATI
0.05	0.952	0.048	0.04074	83.4
0.15	0.147	0.853	0.01883	393.5

- The values obtained for sample size n and the accepted number of defectives c are 65 and 6, respectively. Our group would test 65 people and only 6 would be the minimum accepted number for the lot being analyzed. The probability of acceptance, the probability of rejection, the AOQ, and the ATI are shown for AQL and LTPD.

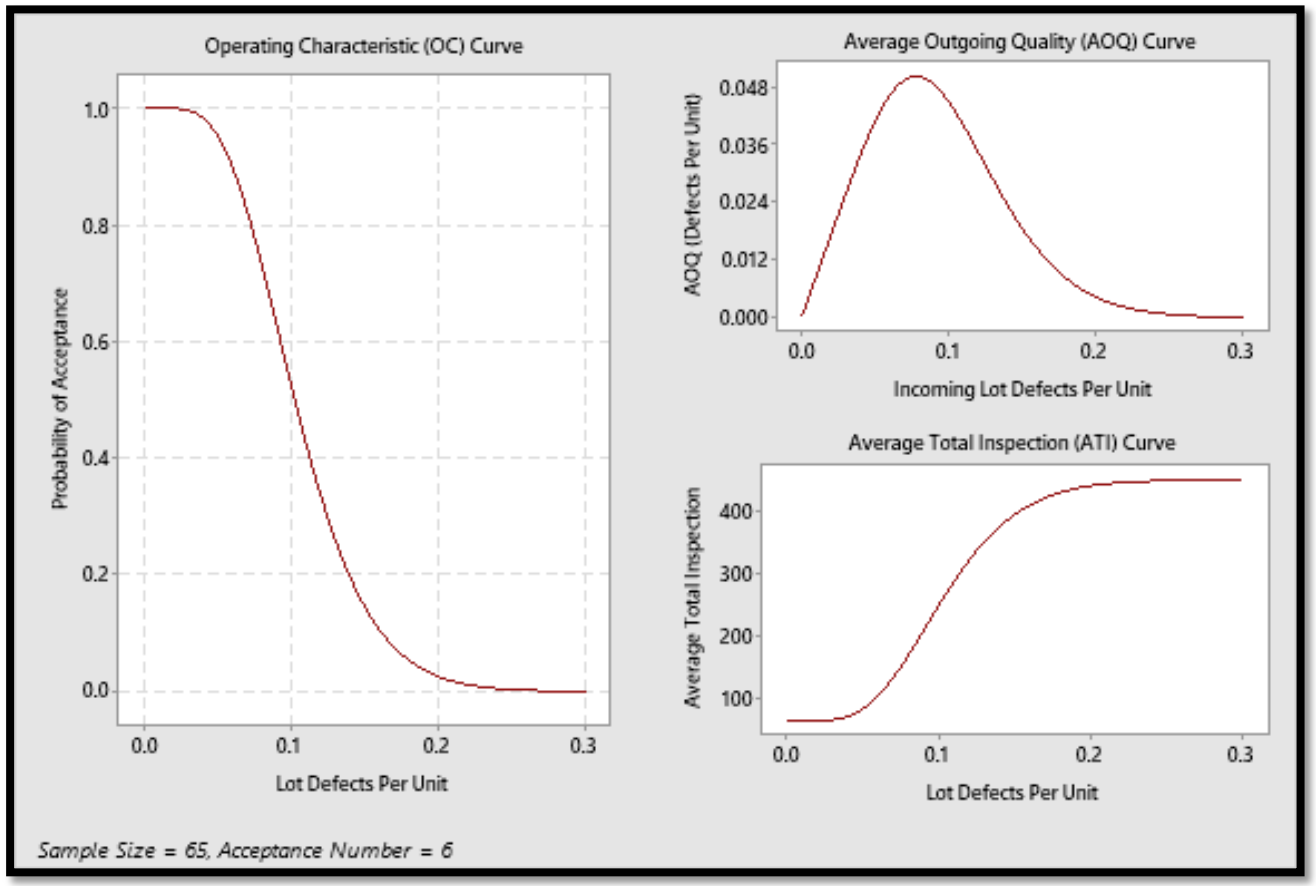
Average Outgoing Quality Limit(s) (AOQL)

AOQL	At Defects per Unit
0.05018	0.07802

- The AOQ limit is the worst possible quality that results from the rectifying inspection program. Here, the AOQ limit is 0.05018 when the defects per unit is 0.007802.

Acceptance Sampling – Nomogram

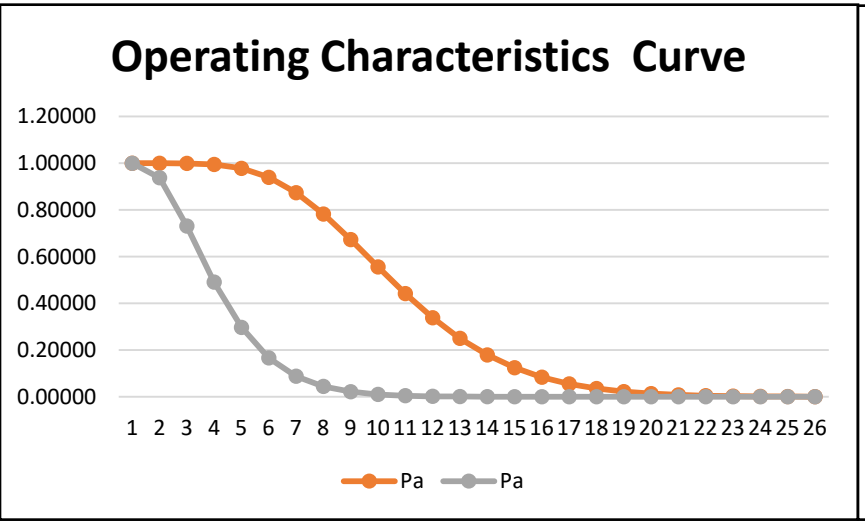
The probability of acceptance for each lot decreases as the fraction of defective lots per unit increases.

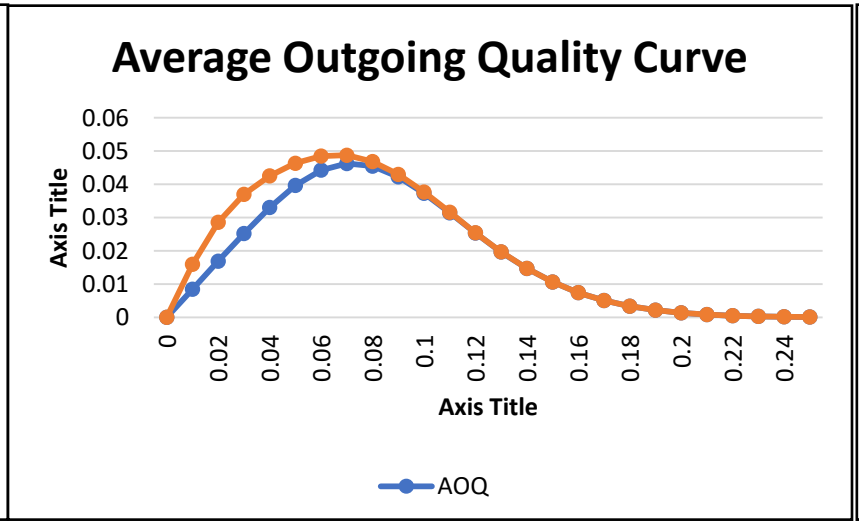


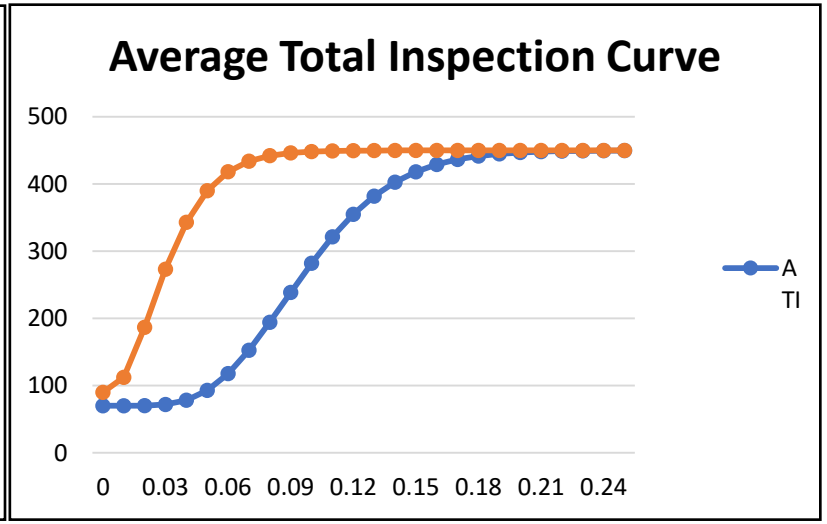
Outgoing lot quality is accepted with a low fraction of incoming defectives or rejected and eliminated/ replaced with a high fraction of incoming defectives. The AOQ limit is the maximum of the AOQ curve.

The average total inspection for each lot increases as the fraction of defective lots per unit increases.

Acceptance Sampling – Nomogram







Comparing the OC, AOQ, and ATI curves for n and c between the binomial nomogram method ($n = 70, c = 6$) and Minitab ($n = 90, c = 2$), both are approximately equal. Since, it is difficult to obtain exact n and c from the binomial nomogram method, we have taken approximate those values.

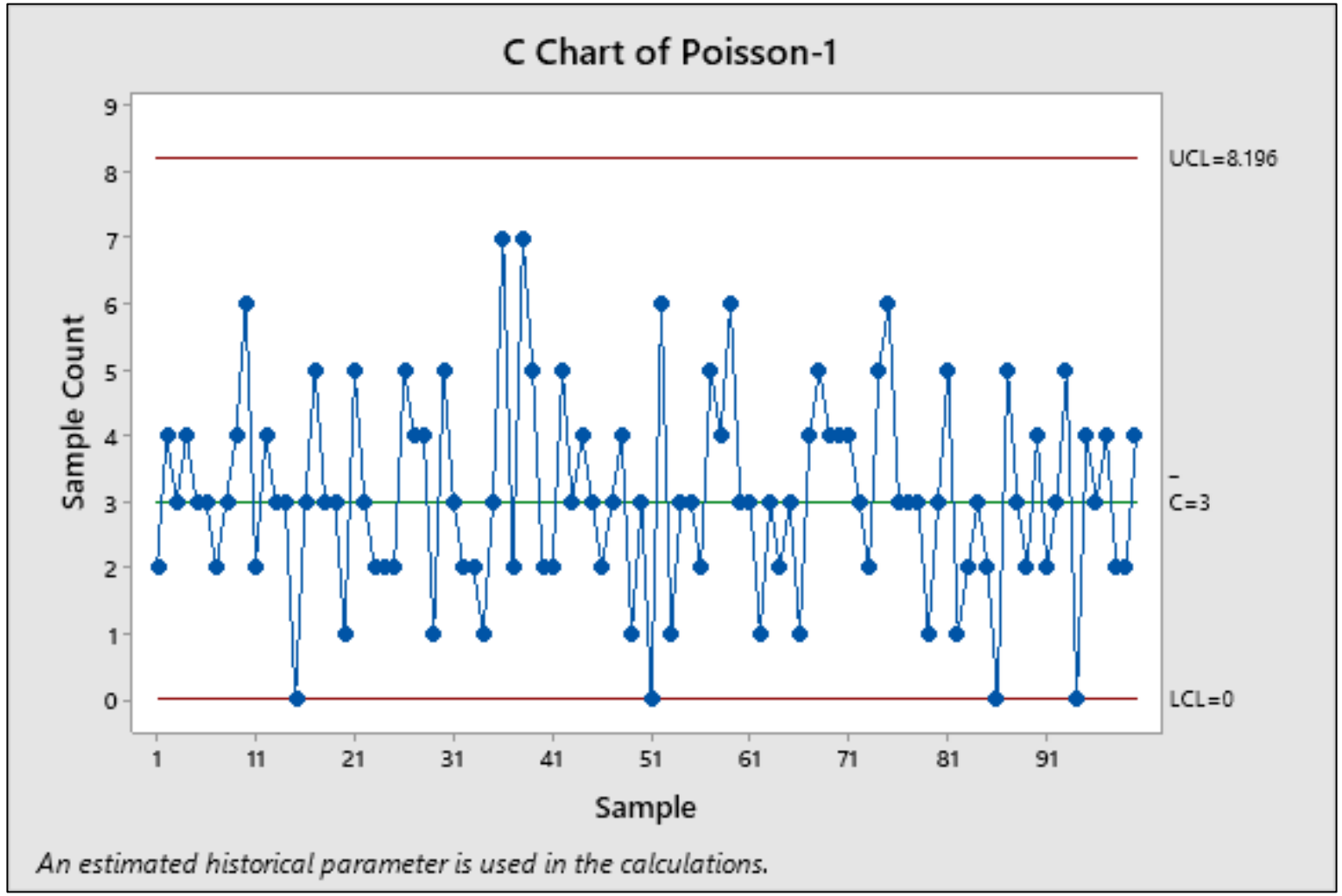
Statistical Process Control (SPC)

- Statistical Process Control Charts are used to track the performance of output over time.
- The control charts below represent samplings from our process over time (perhaps in quarterly intervals). We see that over time (charts 1-4) our process begins to become unstable.
- What do SPC Charts detect ?
  - Changes in process average
  - Changes in process variation
  - One-off changes such as special causes

Poisson Distribution

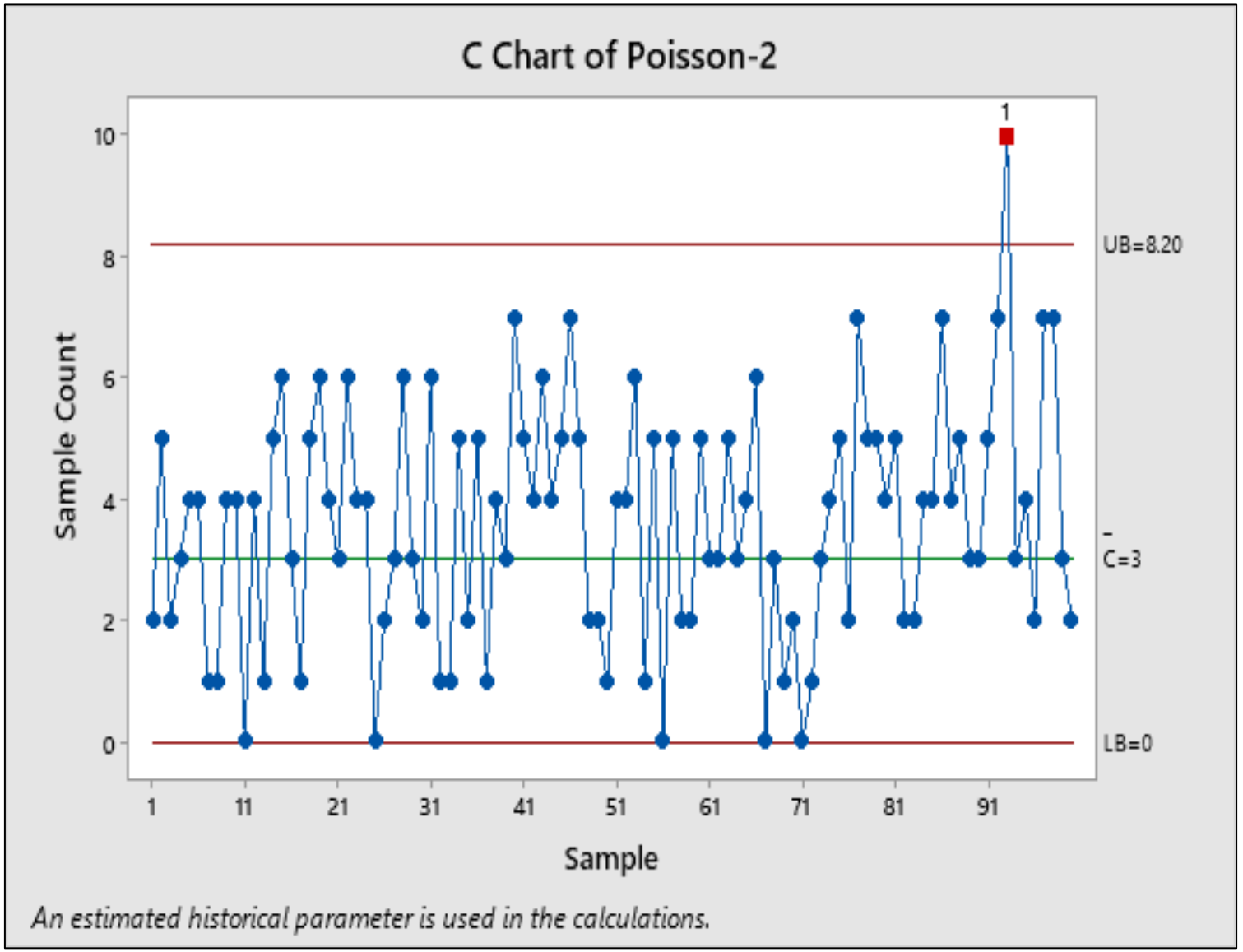
- We will use the Poisson distribution to represent out defect counts.
- Since we are dealing with defect counts, which is an attribute of the item (widget) we will use a C-chart to represent the data.

C Chart of Poisson distribution with mean of 3 and UCL = 8.196 and LCL=0



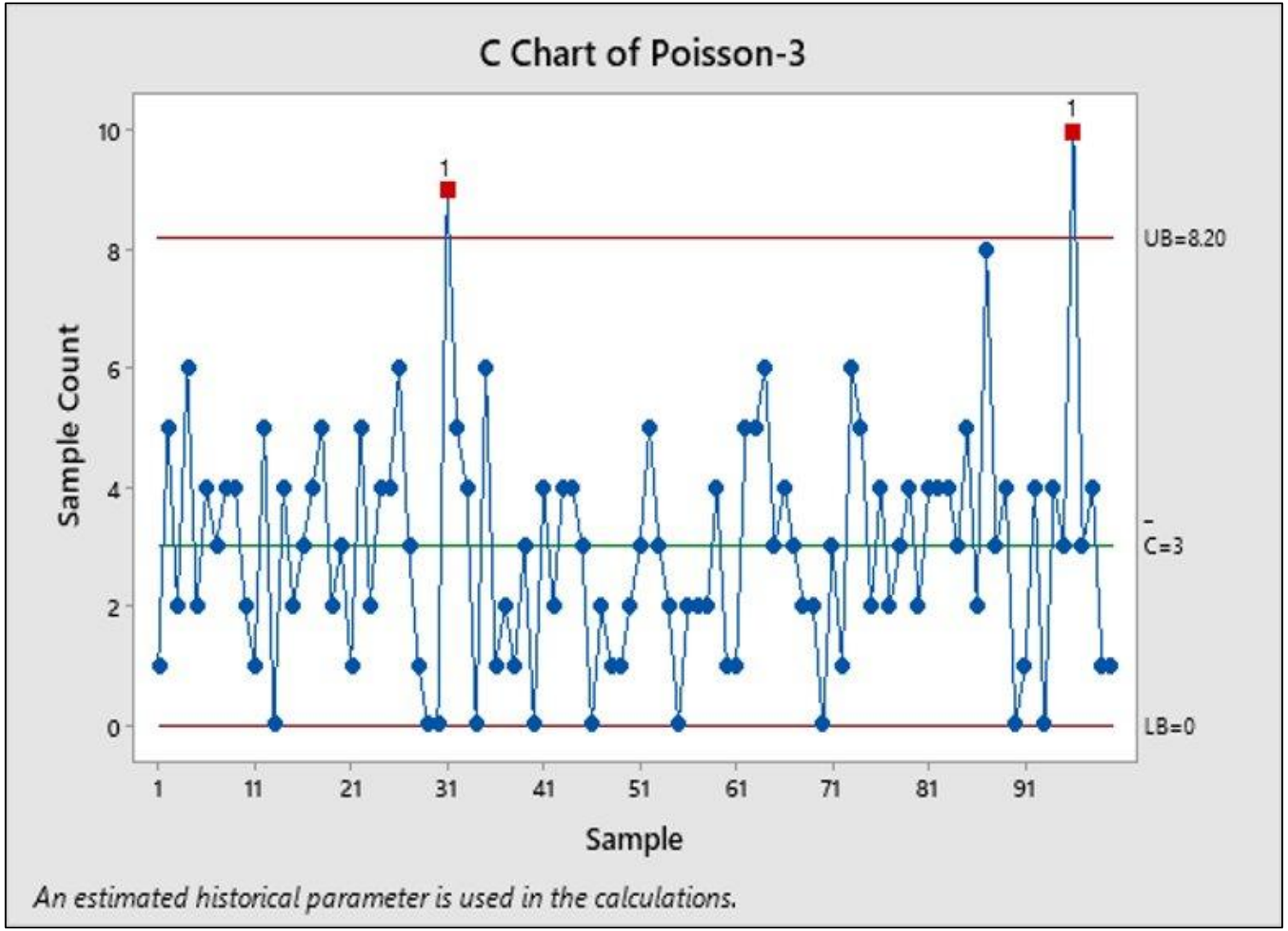
Detecting Process changes

We notice that sample count 92 is more than upper limit of 8.20, thus failing the process at this point.



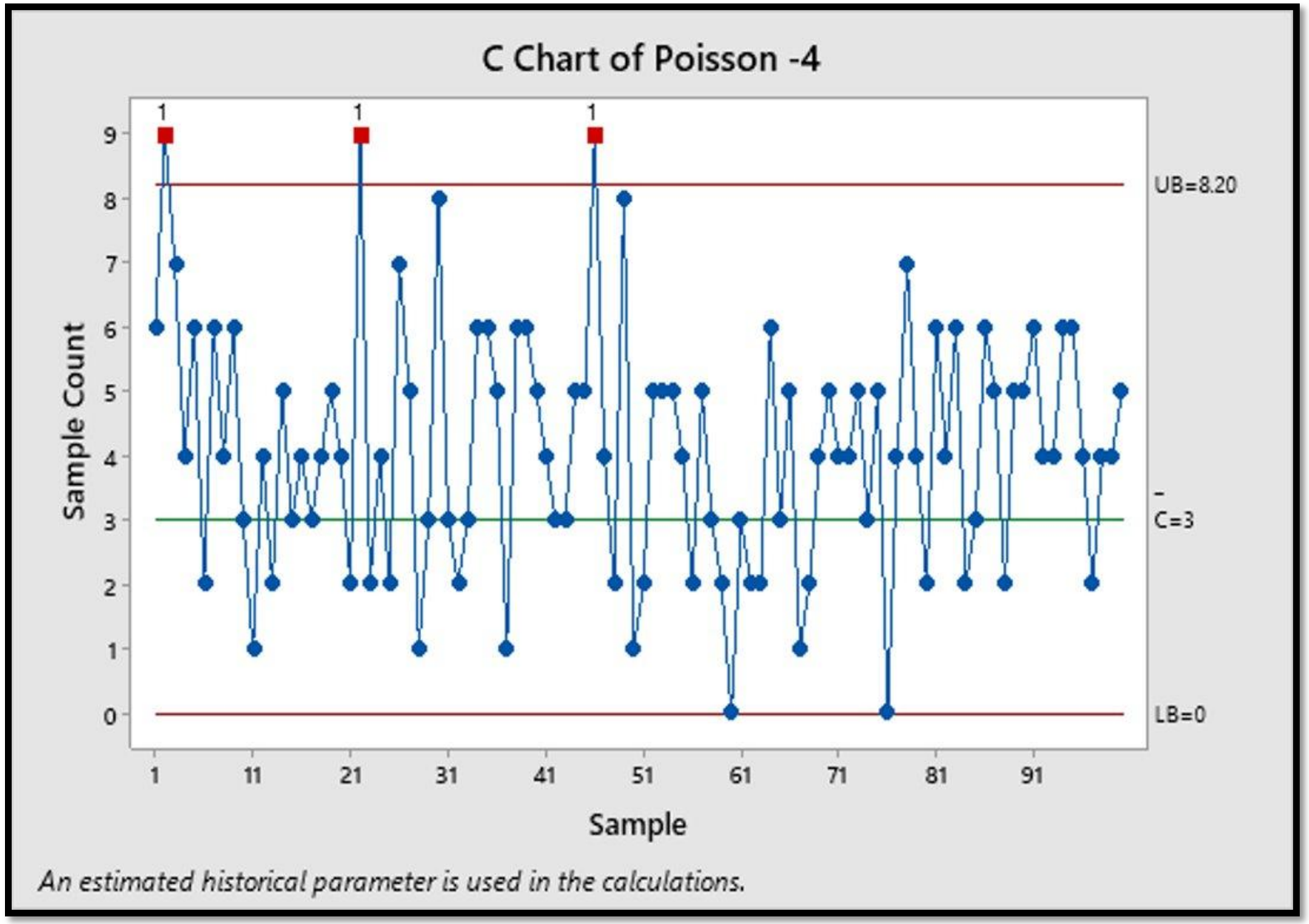
Detecting Process changes

Here sample count 3 and 95 is more than upper limit of 8.20, thus failing the process at this point.



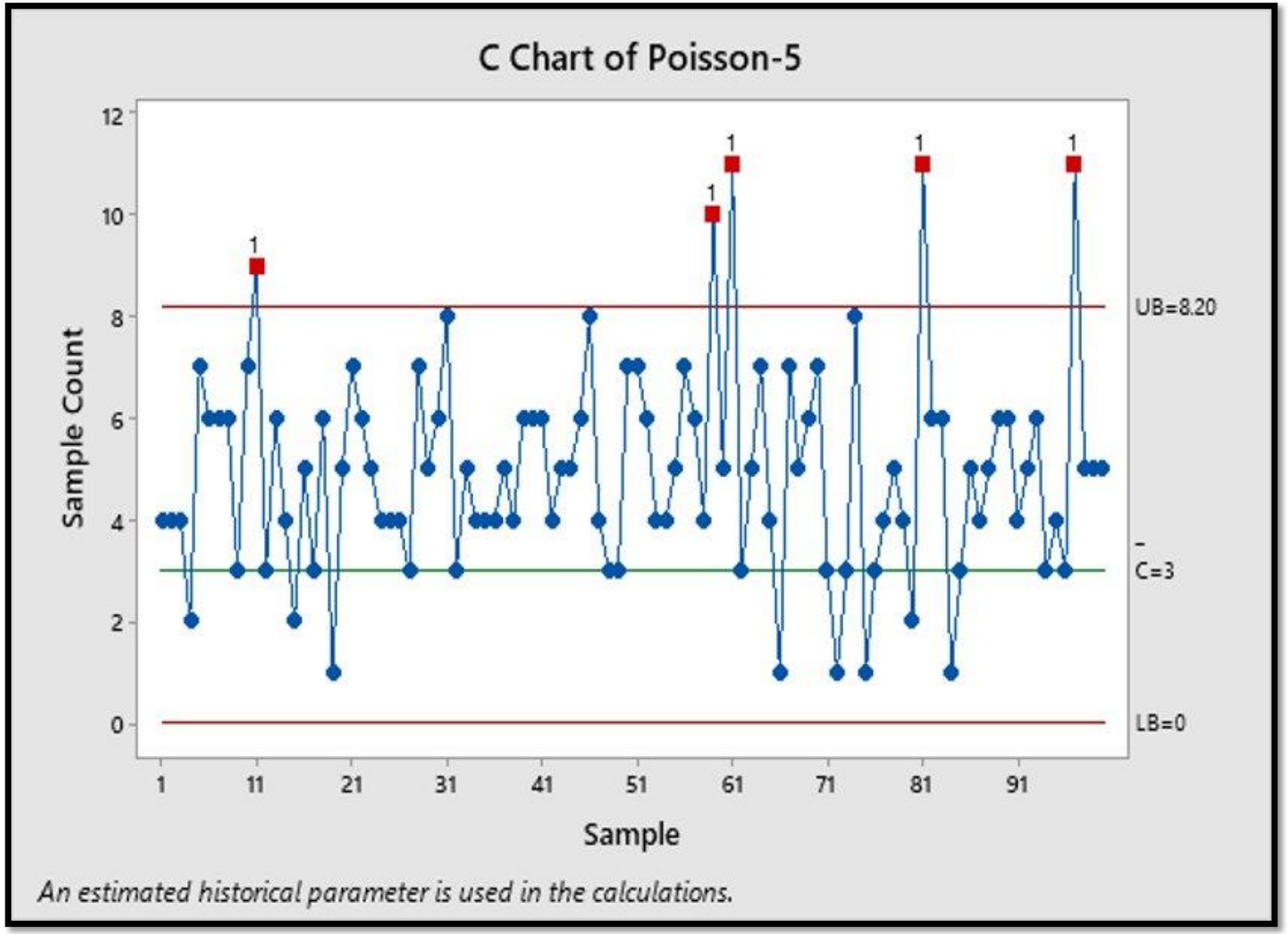
Detecting Process changes

Here sample count 1, 22 and 49 is more than upper limit of 8.20, thus failing the process at this point.



Detecting Process changes

Here sample count 11, 60, 61, 81 and 95 is more than upper limit of 8.20, thus failing the process at this point.

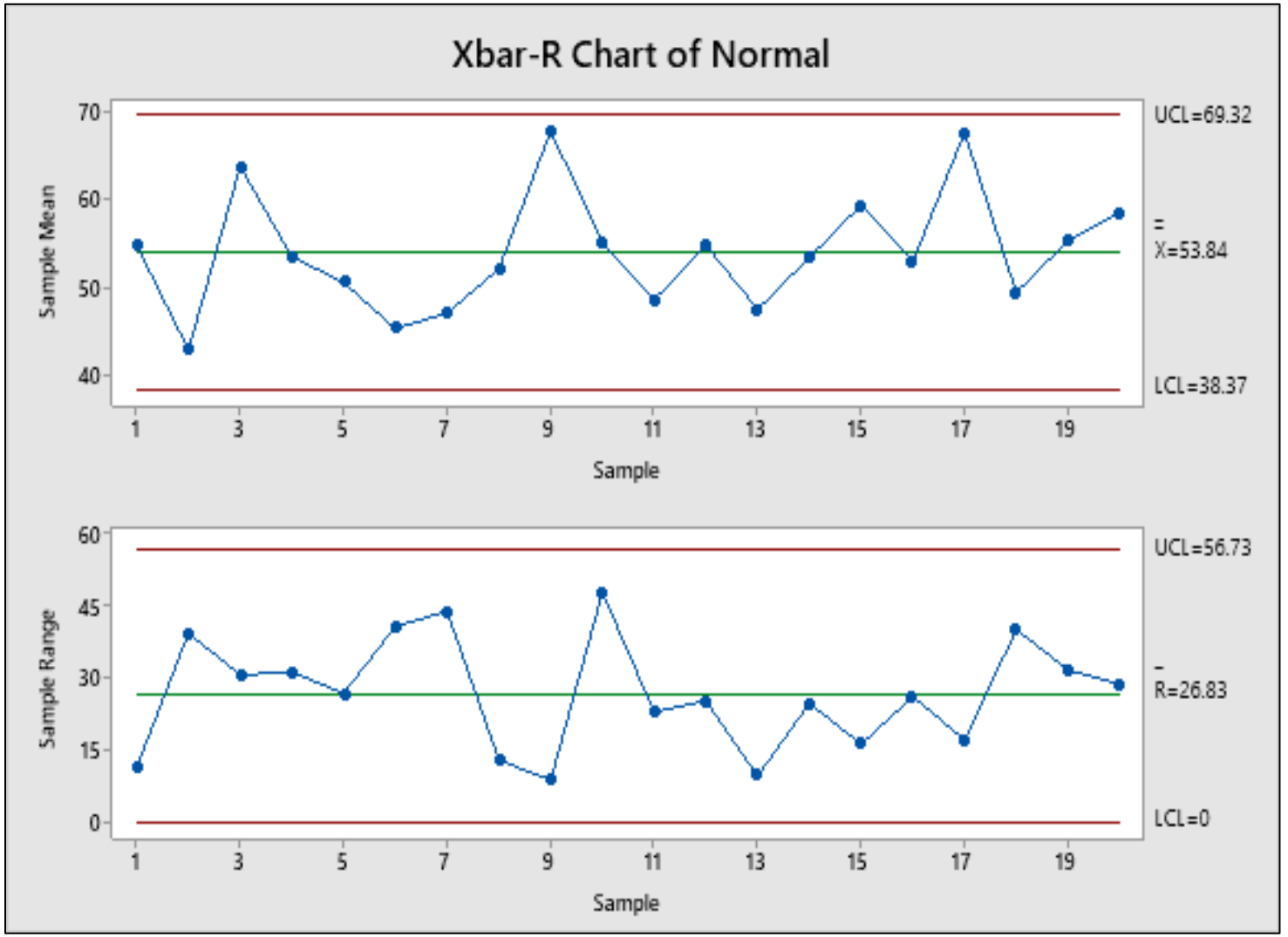


Normal Distribution

- We will use the Normal distribution to represent out weight measurements.
- Since we are dealing with weight, which is a continuous variable we will use an X-bar-R chart to represent the data.

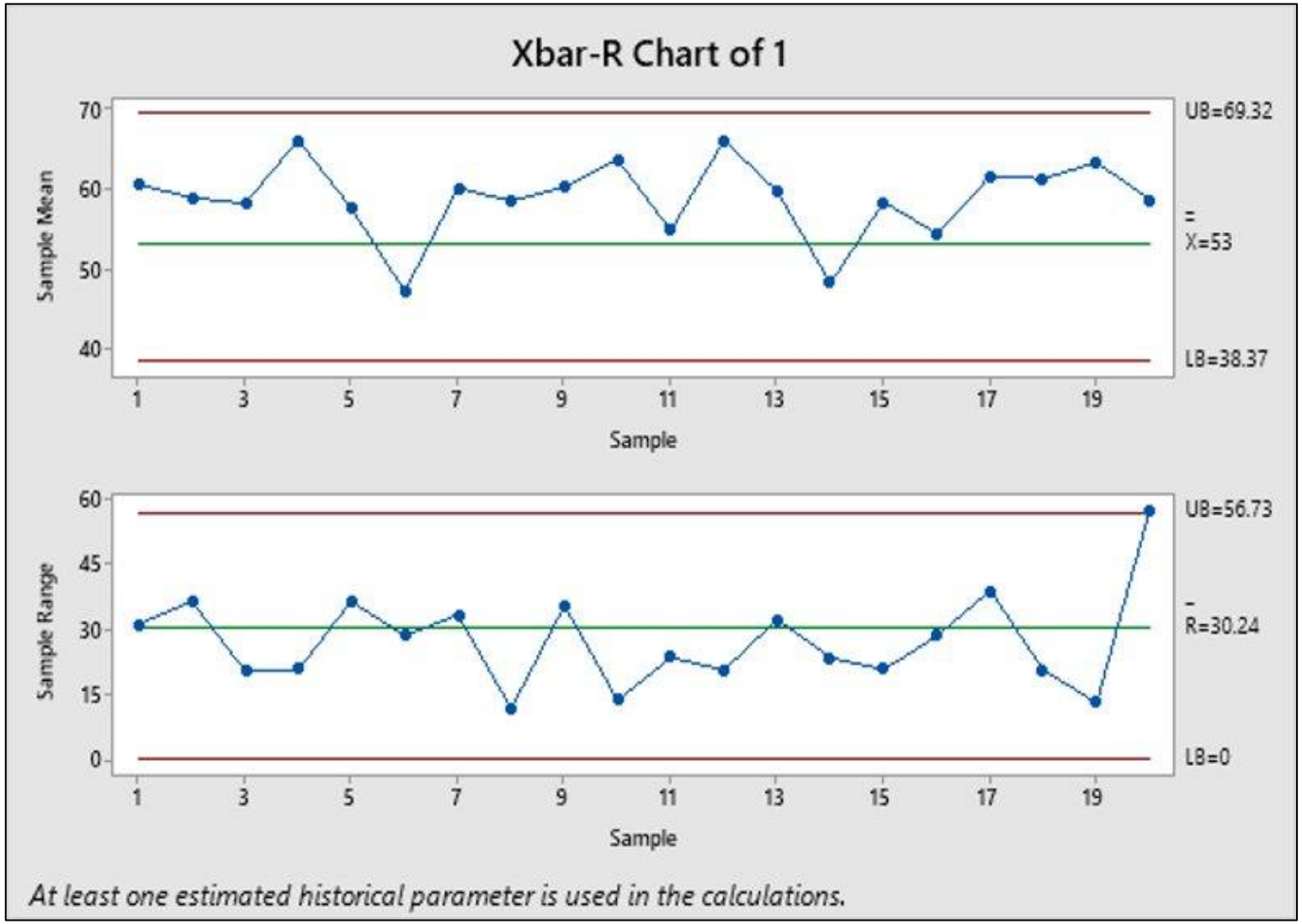
Detecting Process Changes

Xbar-R Chart of Normal : mean=53, SD=13



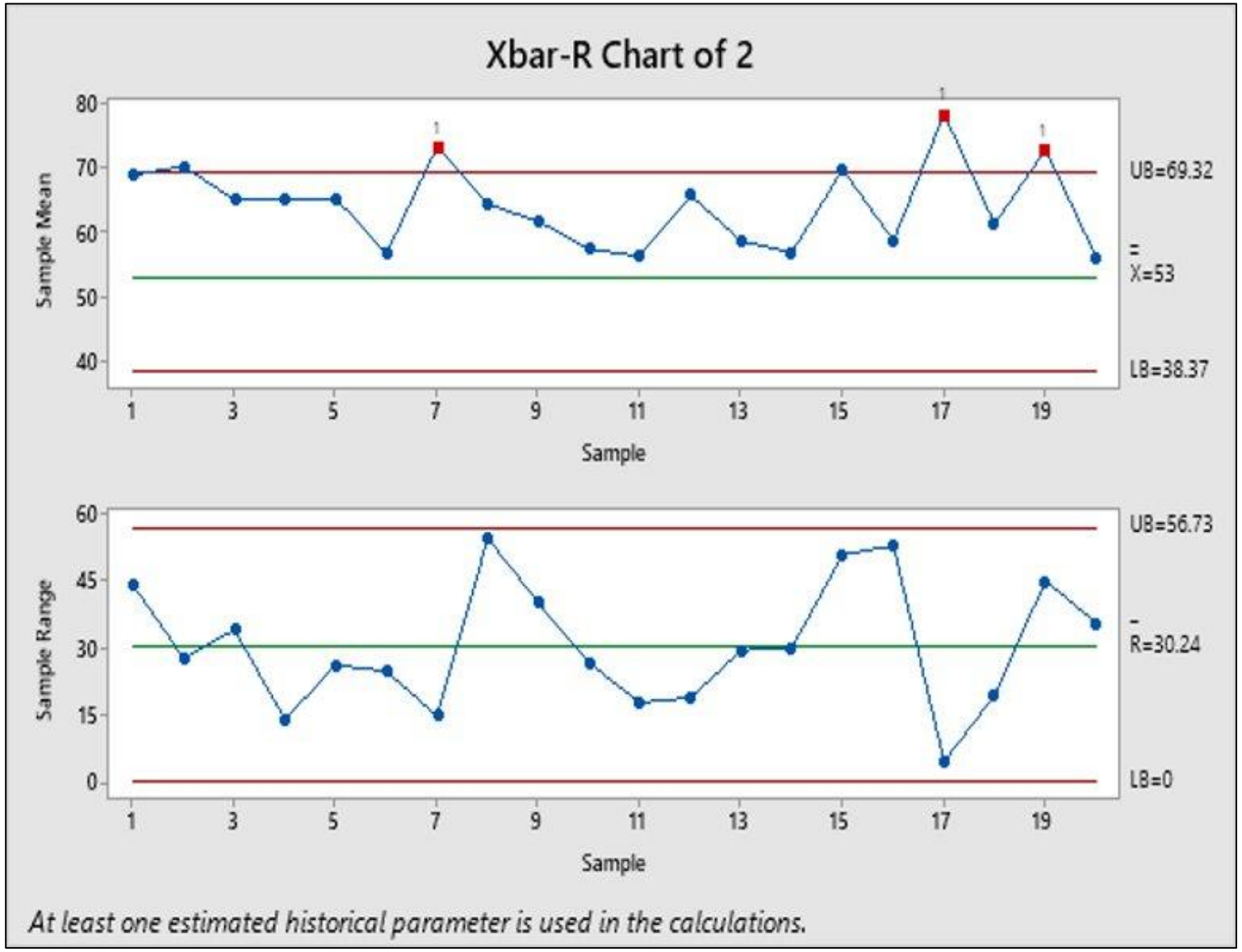
Detecting Process Changes

Xbar-R Chart of 1: mean=58, SD=13



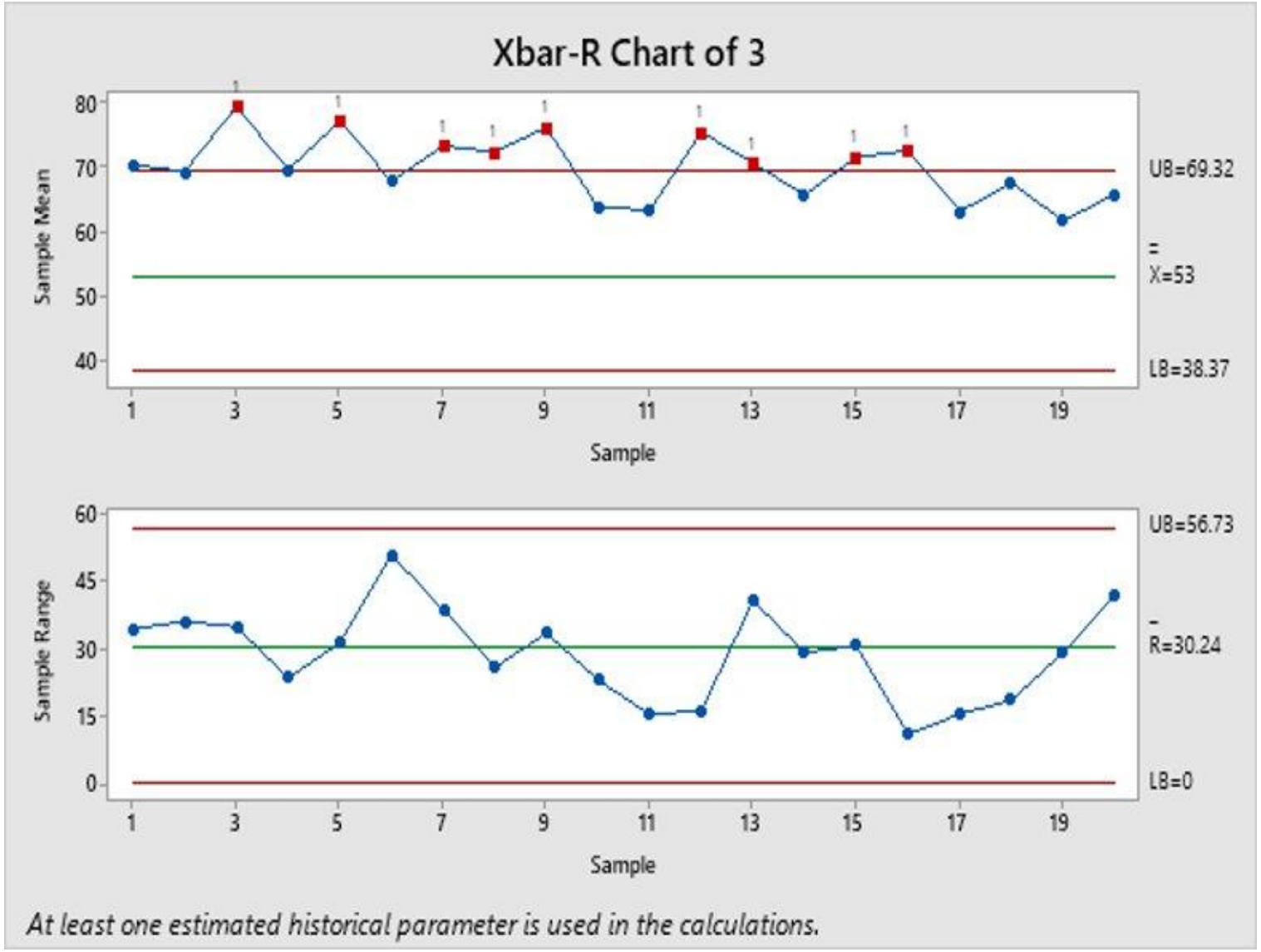
Detecting Process Changes

Xbar-R Chart of 2: mean=63 , SD=13



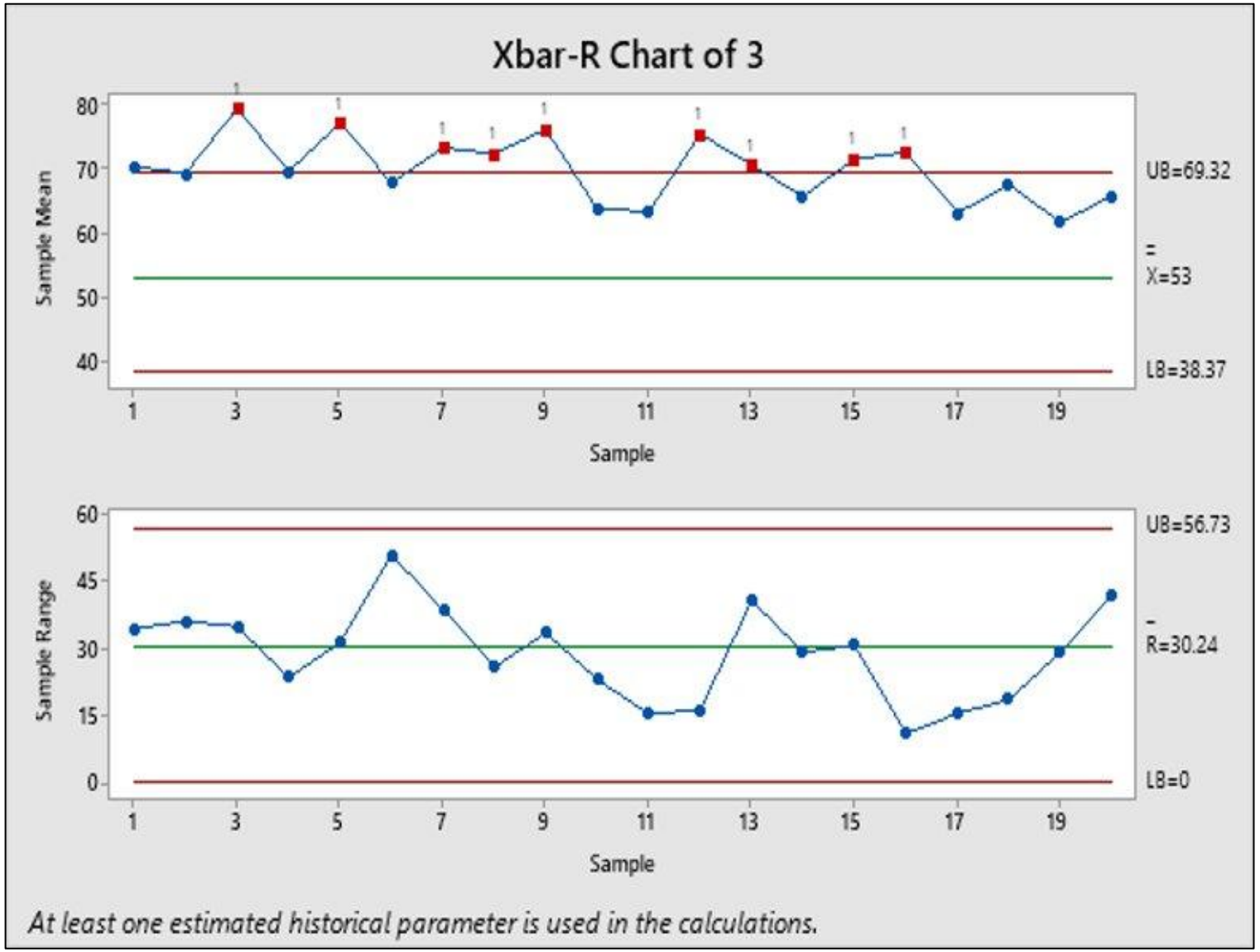
Detecting Process Changes

Xbar-R Chart of 3: mean=70 , SD=13



Detecting Process Changes

- Xbar-R Chart of 4: mean=53 , SD=22
- We see from (charts 2-4) our sampling plots are moving farther from the mean. While one or two points may indicate a random cause that can be investigated further to s how a process that is not performing within controls.



Conclusion

After analyzing the data for the current vaccination roll-out we conclude that:

- The current layout of the vaccination centers can be improved to reduce the time taken by patients in the center.
- The vaccine distribution can be handled in an improved way so that it is available to people of all ages and races.
- After performing design of experiments, we see that there are three main factors responsible for an effective roll-out and varying them will change the outputs of our process considerably.
- After performing SPC, we know the required upper and lower bounds to keep our process in control.
- Although the change in the current process might be difficult to implement but it is crucial for us execute it to end this global pandemic.


Thank You