WORLD WIDE COVID-19 VACCINATION ISSUE

GROUP 3 :-

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Define Phase

Problem Statement

- Due to the global pandemic of COVID-19, Lots of people suffered from infection and death. The first problem is vaccine availability. Most developed countries have completed 2nd dose even booster shots, while some third world countries didn’t have enough vaccine for first dose.
- Second problem is vaccine quality. From different companies, vaccines have different protection rates. The third problem is the vaccine transportation issue. Right now only a few countries can make COVID-19 vaccines, how to quickly and safely deliver those vaccines to countries without vaccine development ability is a vital issue. Due to environmental sensitivity of the vaccine, it can only be stored in cold temperatures, which means the transportation must have a functional cooling system within the whole trip of delivery.
- Furthermore, the vaccine only has a short time to keep its potency, which means once the vaccine arrives at its destination, it must be quickly spread to the local health department for vaccination. Sending too many vaccines in a single time will cause waste if they don't allocate them properly. When we talk about the allocation of vaccines, the amount of medical personnel is another problem.
- If a country doesn't have enough doctors who can properly allocate and inject the COVID-19 vaccine to the citizens, it may cause more serious problems.
- We focused on three areas

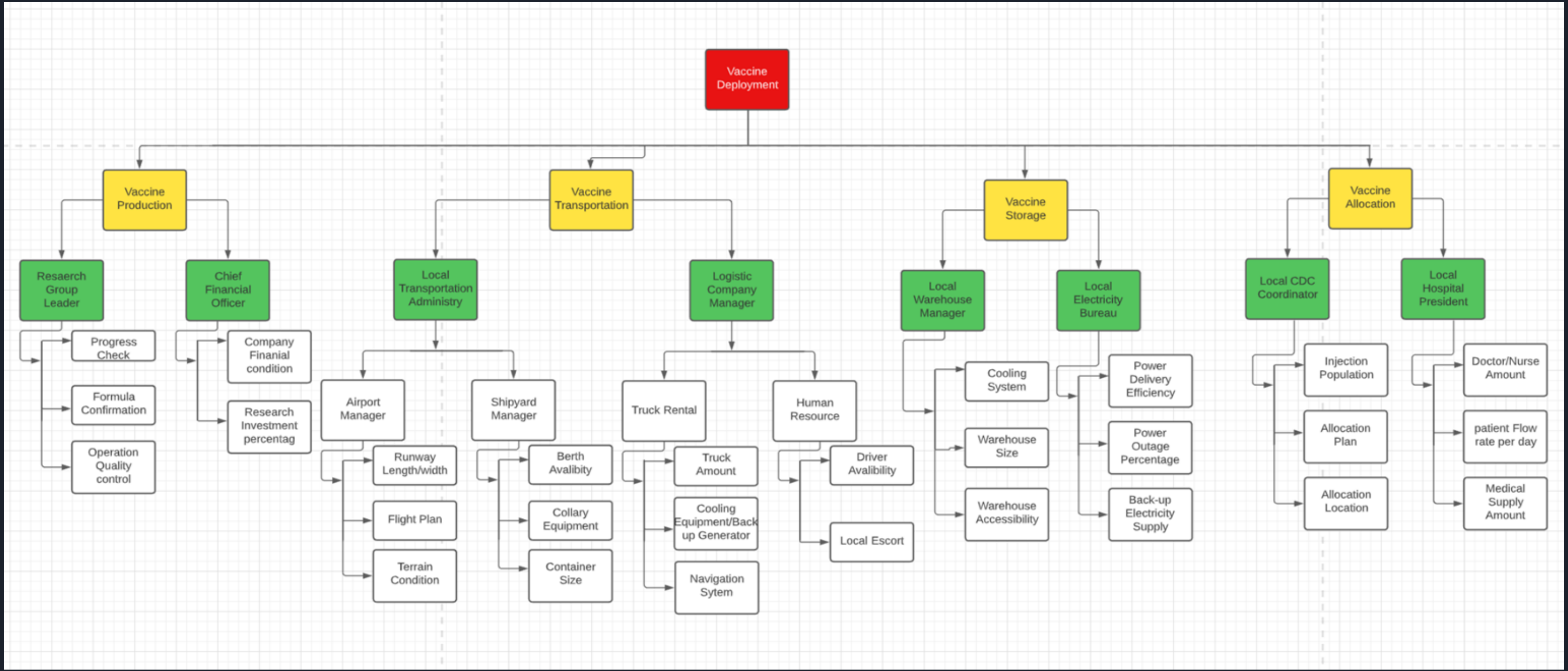
Brainstorming

Populations at Risk	Before	Response	After
Elderly	Low vaccination rate	Hire and train new personnel	Proper documentation
Sick	High costs	Effective transportation	Public perception
Poor	Low public knowledge	Public Information Campaigns	Updated training
Isolated	No transportation/ supply network	Research and study lowers costs	
Biased people	Need training	Effective Clinics	
3rd World Countries	Low staffing		

Flow Chart

Start
Did the patient recive the vaccine and its effects
Yes
Mission Accomplished
No
Why Not?
Vaccines didn't arive or were unusable
Other
Patient showed up and was not able to recive it
Vaccine was ineffective or even harmful
Increase Research and Testing
Patient was not at the vaccination site
Patient was not aware of the clinic location
Patient didnt know what time to be at the clinic or missed their Appointment
Increase Public Knowledge of Vaccination centers in theri comunities
Patient doesnt Trust the Vaccine
Increse Public Perception of the Vaccine so people understand its benefits
Why Not?
Damaged or contaminated before arival
Not Refrigerated
Not enough trucks, drivers, planes, boats, etc...
Hire or buy more drivers and vehicles
Why Not?
Ran out of Refridgerant on the Journey
Increase Refriderant on Tansports
Refriderator was Broken
Fix Unit and Find out why it failed to prevent more breakdowns
Operator Error
Improve Training and Screening for the Operators
Why Not?
Patient was not healthy enough or didnt have the right paper work
Improve public information about vaccine and requirments to get it
Not enough staff (Doctors/Nurses)
Train or hire more Staff
Clinic unprepared
Lack of supporting equipment
Purchase more equipment for the Clinics
Clinic is Unorganized
Hire a Profesional to Manage Organization and Paperwork
Improve documentation systems and more diligent record keeping

Organization Chart



COPQ Analysis (Cost of Poor Quality)

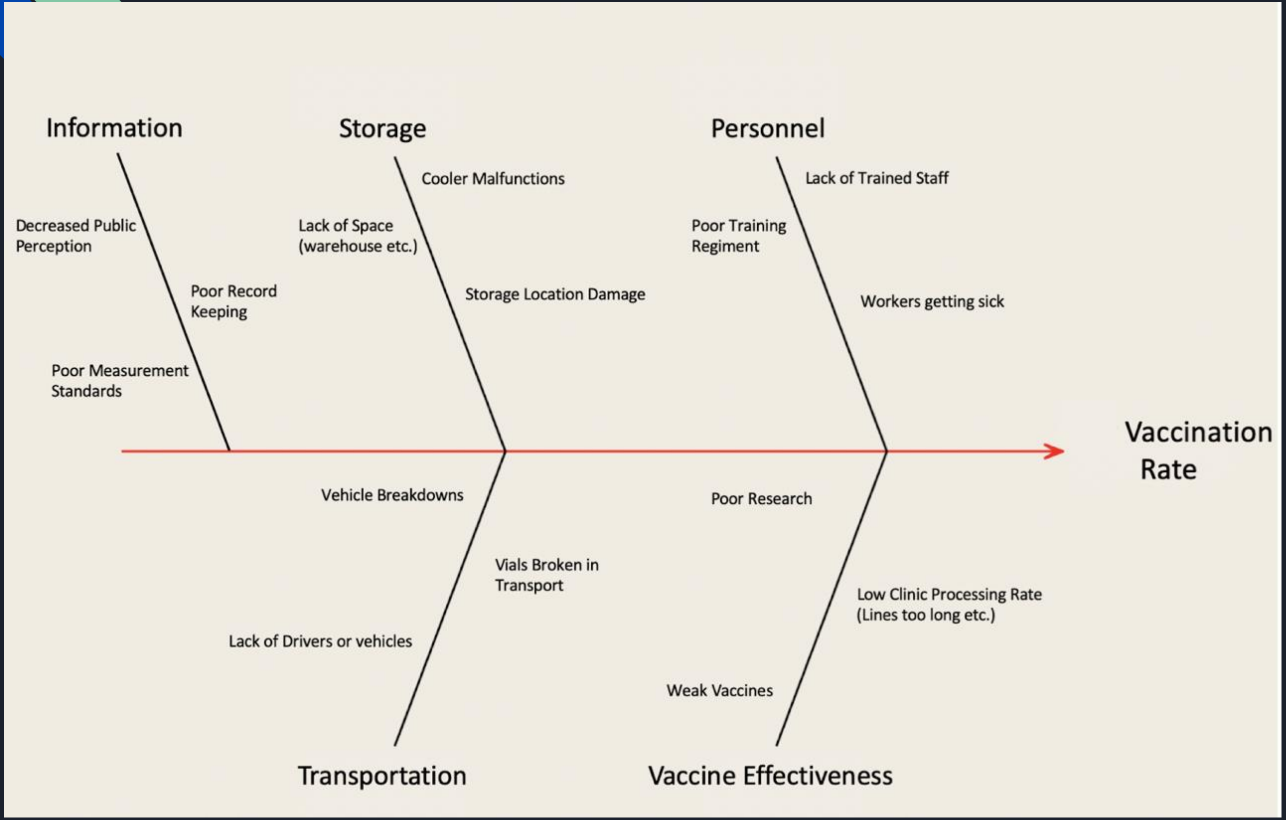
- Internal/External
  - Vaccine Development
  - Vaccine Transportation
  - Vaccine Storage
  - Vaccine Allocation
  - Vaccine Injection
  - Post Injection Screen

Process	Internal Failure	External Failure	Appraisal	Prevention
Vaccine Development	Wrong Formula, management decision	Company Bankrupt, natural disaster		continue researching, test, hire the proper managers and researcher
Vaccine Transportation	Air-con failure,, Refrigerant leak, bad packaging, Lack of workers	Car accident, boat sink, plane crash, poor travel conditions		Better Packaging, back-up air-con, optimize navigation with weather
Vaccine Storage	Air-con failure, lack of space	Fire,natural disasters, power outage	Warehouse manager, system engineer	Back up cooling equipment, Generators, smoke detector, cctv system.
Vaccine Allocation	Poor time management, poor planning	Population estimation error, lack of medical staff	Medical Staff, project manager	Acquire extra allocation center, hire more medical staff
Vaccine Injection	Vaccine contaminate, wrong dose, poor paperwork recording	People change mind		Proper training, better disinfection method
Post Injection Screen	Allergic reaction, patient hide allergic history, poor health of patient	Unknown medical history or underlying conditions	Doctor and nurse	Double check medical record, update recording system

Affinity Diagram

Transportation	Storage	Allocation	Injection
Trucks breaking down	Lack of space	Not enough vaccines for area	Untrained workers
Refrigerator failure	Cooling System fail	Lack of certified medical staff to distribute vaccine	Poor needle or other material quality
No airports	Destruction of storage		Poor Disinfection
No Ports	Damaged vaccines		
Lack of Driver			
Road Damage			

Fishbone Chart



The Fishbone or Ishikawa chart

Quality Assessment

Issues Diagnosis

- Vaccine Distribution and Effectiveness
- Public Health Issues
- Unclear or Poorly kept Documentation
- Miscommunication
- Extensive Public Health Codes and Regulations
- Issues with Refrigeration Failure
  - Storage and Transportation
- Lack or Loss of Resources
  - Transport Vehicles, Medical Staff, Storage, Funds
- Political and Social Issues

Temporary and Permanent Solutions

- Request/Increase budget to acquire more resources
  - Backup resources such as generators or extra personnel as well as overtime ability
- A centralized database and headquarters for keeping accurate records of all organizational activity
- Expedite shipping routes so vaccines stay on the trucks or planes for less time
  - (Refrigeration)
- Ads that direct people where to go and how to get the vaccine
  - (Political/Social Media)
- Create rules and plans for public and personnel safety in clinics
  - (Health codes)
- Invest in better or more refrigerators to mitigate number of doses wasted
- Develop an in depth communication system

Root Cause Analysis

1. Workshops, Public Outreach, Social Media Campaigns
2. Continued Research, Government Policies,
3. Improved Logistics, More Manufacturing Sites, More Vaccination Centers
4. Travel Restrictions, Vaccination Mandates
5. Diplomatic pacts, Better International Relations
6. Vaccine Mandates

Improvements

Measures to Assess Improvements

- Implementing a better records system will allow the organization to better track who is effectively receiving the vaccine and which nations or communities need further assessment and change
- Track who gets the virus after the vaccine and what their symptoms are to measure if more research needs to be done
- Check to make sure that the number of vaccinated people keeps increasing at a sufficient rate

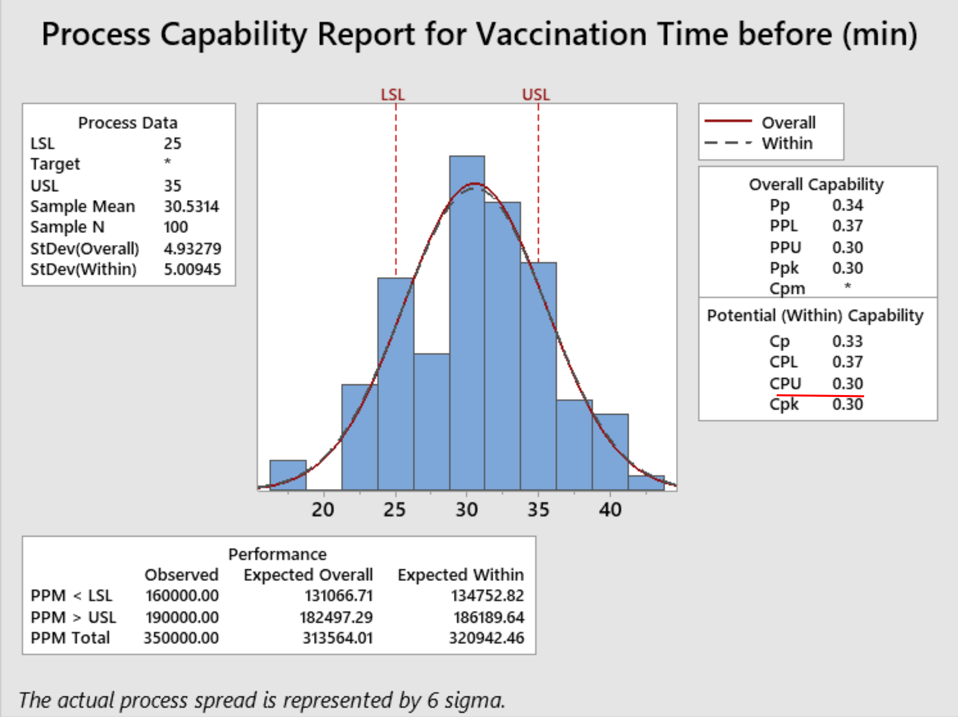
Sustainable Improvements

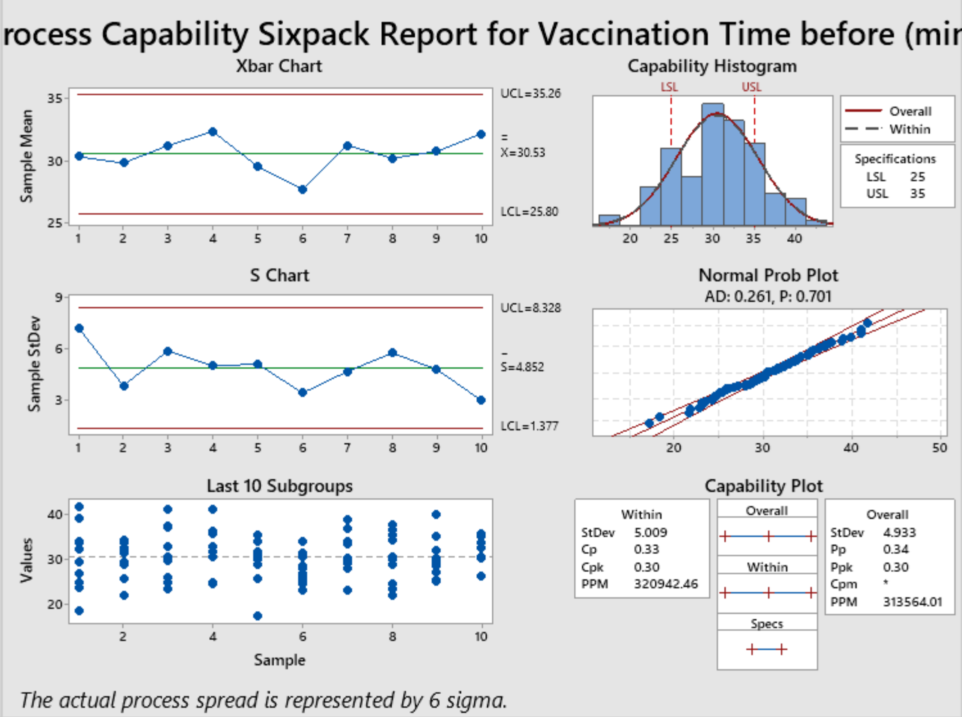
- According to the assessment above, apply necessary changes to the organization
- Ensure that the areas where vaccination rates are lower get increased analysis or funding so that the rates go up

Measure Phase

Process Capability

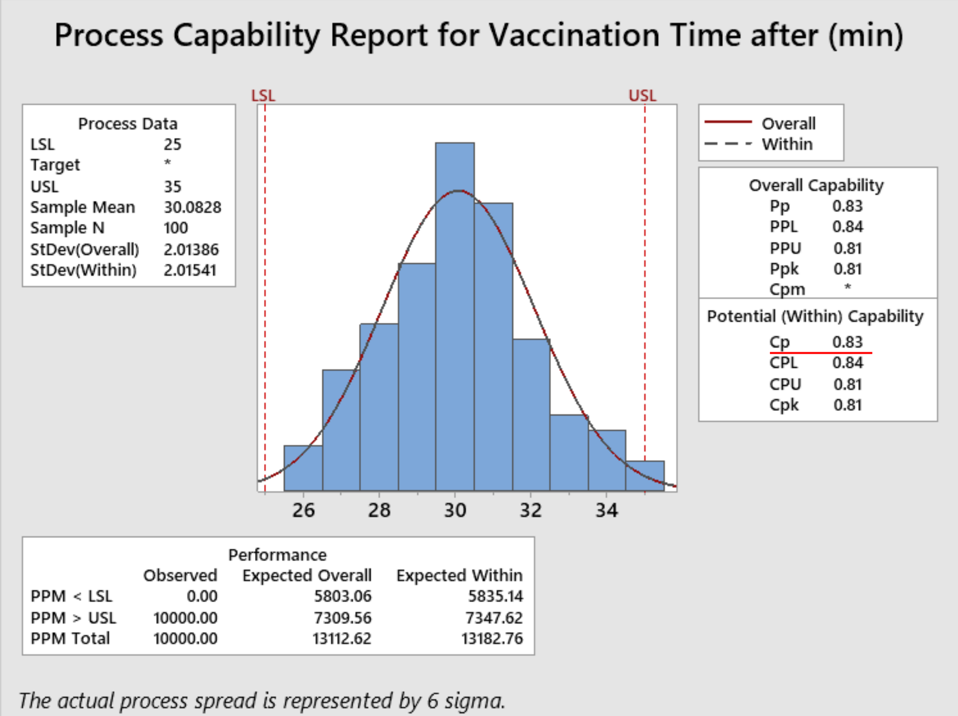
- Focus on Vaccine injection time per person.
- Avoiding long wait line, decrease possibilities of cross infection
- Original Plan: 25- 35 min/person
- Including record check, disinfection, injection, post-injection monitoring

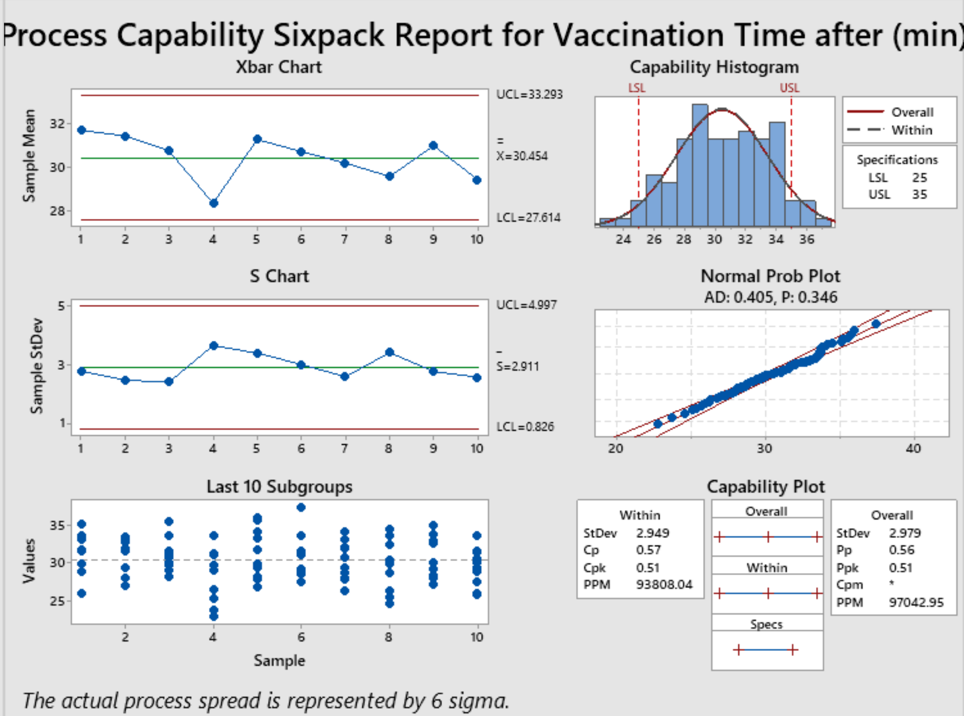




Updated process capability

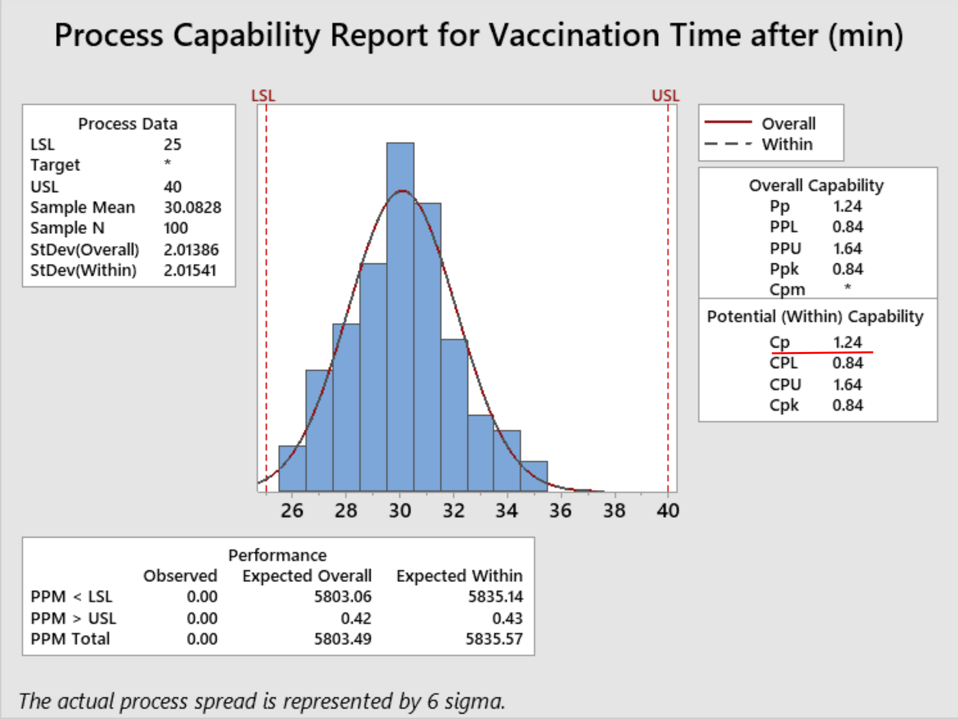
- With better training for medical personnel, the process time become more stable with mean time 30 mins and with standard deviation of 2.
- Still not good enough

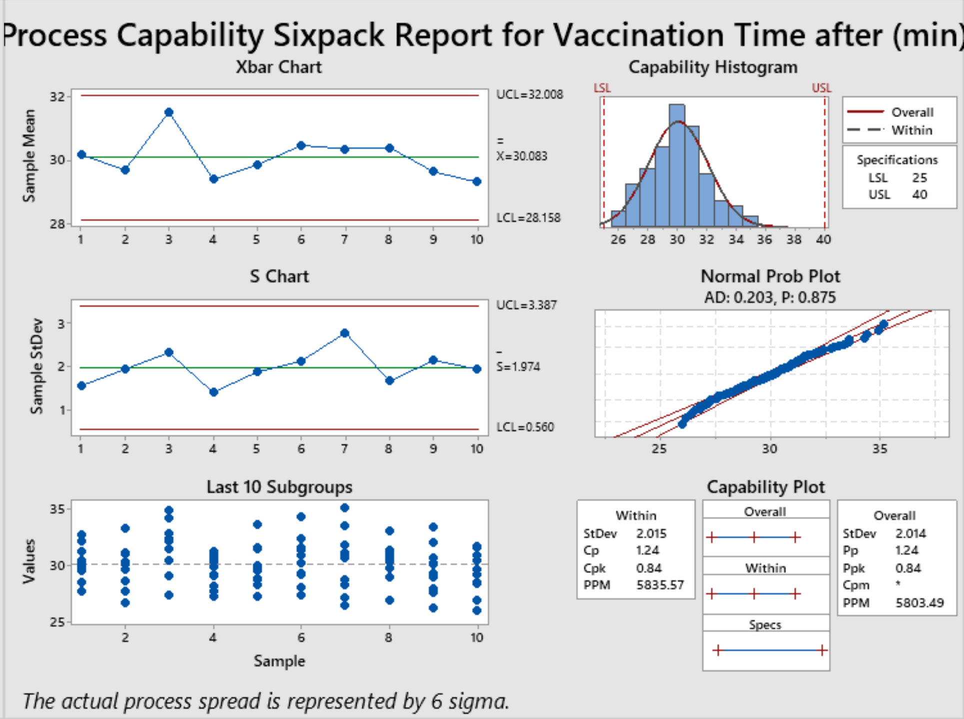




Final Update

- Leave more time in case of emergency
- Process time slot become 25-40 min/person





Analysis Phase

Design Of Experiments

For our vaccine allocation, we want to reach the monthly vaccination rate to 20% for a country, which means we can set our target response to 20%, with the LSL and USL from 10% to 30%. Right now we only reach 15.84% per month.

Factor definitions

A. Medical Staff – A lower score in this factor could be due to short staffing, overstaffing or poor training, while a higher score would suggest an optimized number of workers and better training

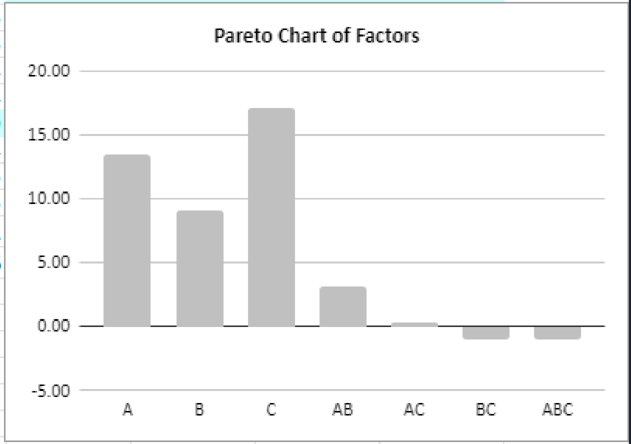
B. Transportation – A higher grade for transportation would denote the largest number of vaccines reaching the targeted destinations on time and intact

C. Storage – Storage pretrains to the keeping and documentation of the vaccines where a lower score could be obtained by refrigerator malfunction

Factor	Low	High	Units	Range	Midpoint	Val(+)	Val(-)
Staff	40	100	Personnel per Site	60	70	1	-1
Transportation	400	950	Vehicles	550	675	1	-1
Storage	500,000	4,000,000	Units of Vaccines	3,500,000	2,250,000	1	-1

DOE Data

		Design of Experiments										
		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	-2.56	-1.55	-2.59	-2.230	0.350
2	1	-1	-1	-1	-1	1	1	4.67	8.66	6.85	6.725	4.001
3	-1	1	-1	-1	1	-1	1	5.54	3.31	2.23	3.692	2.844
4	1	1	-1	1	-1	-1	-1	19.66	19.97	23.27	20.966	4.003
5	-1	-1	1	1	-1	-1	1	13.30	14.03	16.21	14.515	2.278
6	1	-1	1	-1	1	-1	-1	24.01	25.10	29.59	26.232	8.744
7	-1	1	1	-1	-1	1	-1	21.92	20.70	18.56	20.391	2.884
8	1	1	1	1	1	1	1	34.45	37.05	37.77	36.421	3.051
TotSum								120.98	127.27	131.88	126.71	28.16
SumY+	90.34	81.47	97.56	69.67	64.12	61.31	61.35					
SumY-	36.37	45.24	29.15	57.04	62.60	65.41	65.36					
AvgY+	22.59	20.37	24.39	17.42	16.03	15.33	15.34					
AvgY-	9.09	11.31	7.29	14.26	15.65	16.35	16.34					
Effect	**13.49**	**9.06**	**17.10**	**3.16**	**0.38**	**-1.02**	**-1.00**					
Var+	4.950	3.195	4.239	2.421	3.747	2.572	3.044					
Var-	2.089	3.843	2.799	4.618	3.292	4.467	3.995					
F	0.422	1.203	0.660	1.908	0.878	1.737	1.313					
regression	**6.747**	**4.528**	**8.551**	**1.579**	**0.190**	**-0.512**	**-0.501**					
SUM VAR	**1.430**	**-0.324**	**0.720**	**-1.099**	**0.228**	**-0.948**	**-0.476**					
Var. of Model		3.52		StdDv	1.88							
Var. of Effect		0.59		StdDv	0.77							
Student T (0.025;DF) =				2.473								
C.I. Half Width =				**1.894**								



Significant Factors & 95% CI Limits:

Factor	A	B	C	AB	AC	BC	ABC
Signific.	Yes	Yes	Yes	Yes	No	No	No
LwrLimit	11.60	7.16	15.21	1.26	-1.51	-2.92	-2.90
UprLimit	15.39	10.95	19.00	5.05	2.27	0.87	0.89

Regression Equation

Regression Equation in Uncoded Units

Response = 15.840 + 6.748 A + 4.530 B + 8.551 C

- We want our response close to 20, which is our Target value
- We can change the number of medical staff and number of trucks easily
- Unit of vaccines are hard to change, limited by storage capacity
- A = 0.3, B = 0.3, C = 0
- Response = 19.9912
- Based on our response, we got Cpm = 1.311. Process capable
- We can calculate our real value of factors
- We need 79 Medical Staff at each vaccination site, 758 Trucks per day and Storage facilities which capable of storing 2,250,000 vaccines per day

QFD (House of Quality)

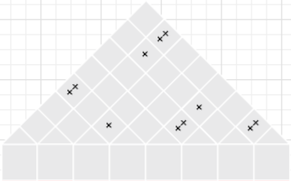
- Higher score means higher priority
- Empty Box means no relation
- Higher CTQ Score means most important aspect
- We had no negative correlations
- Competitor box shows how we measure against others

House of Quality

Zhaoning Song | March 3, 2022

Correlation matrix	
+ +	Strong positive
+	Positive
–	Negative
– –	Strong negative
	Not correlated

Relationship matrix		
⊙	Strong	9
○	Medium	3
△	Weak	1
	No assignment	0



	Priority		*Vaccine Research*	*Clinic Locations*	*Training*	Funding	Cooling Equipment	Electricity	Vehicles	Parking Spot	Competitor #1 (Competitor research)
Vaccine Development	7		9		3	9		3			3
Vaccine Transportation	5			3	3	1	9	1	9	9	9
Vaccine Storage	4			3	1	1	9	9	3	3	1
Vaccine Allocation	3			3	9	3	3	3		3	
Vaccine Injection	2		3	3	9	3	3				1
Post Injection Screen	1			3	9			1			1
Political Power	6		9		3	9		3			
CTQ Priority Score			123	45	112	141	96	90	57	66	
Percent of Total			16.8	6.2	15.3	19.3	13.2	12.3	7.8	9.1	

FMEA

Step	Description
1	verify the order for the vaccination

Failure Mode	Causes	Effects	Occ	Det	Sev	RPN	Actions
No order for the vaccine	Provider did not order the vaccine	Patient could be given the wrong vaccine Insurance will not pay for the vaccination Patient could go without a vaccine that is needed	9	2	2	36	check the MCIR, verify the order with the provider

Step	Description
2	verify the right patient with name and identification

Failure Mode	Causes	Effects	Occ	Det	Sev	RPN	Actions
wrong patient	failure to check the patient's name or identification	vaccine given to wrong patient; getting unnecessary vaccines or omission of a needed vaccine	9	1	1	9	Always check name and identification of the patient prior to administering the vaccine

Step	Description
3	verify the insurance or no insurance

Failure Mode	Causes	Effects	Occ	Det	Sev	RPN	Actions
failure to choose the correct vaccine based on insurance (our stock) or no insurance (health department stock)	failure to verify the correct insurance selection	patient will end up paying or our office will have to pay the health department	7	2	5	70	Verify with patient about any insurance changes prior to selecting the vaccine from stock

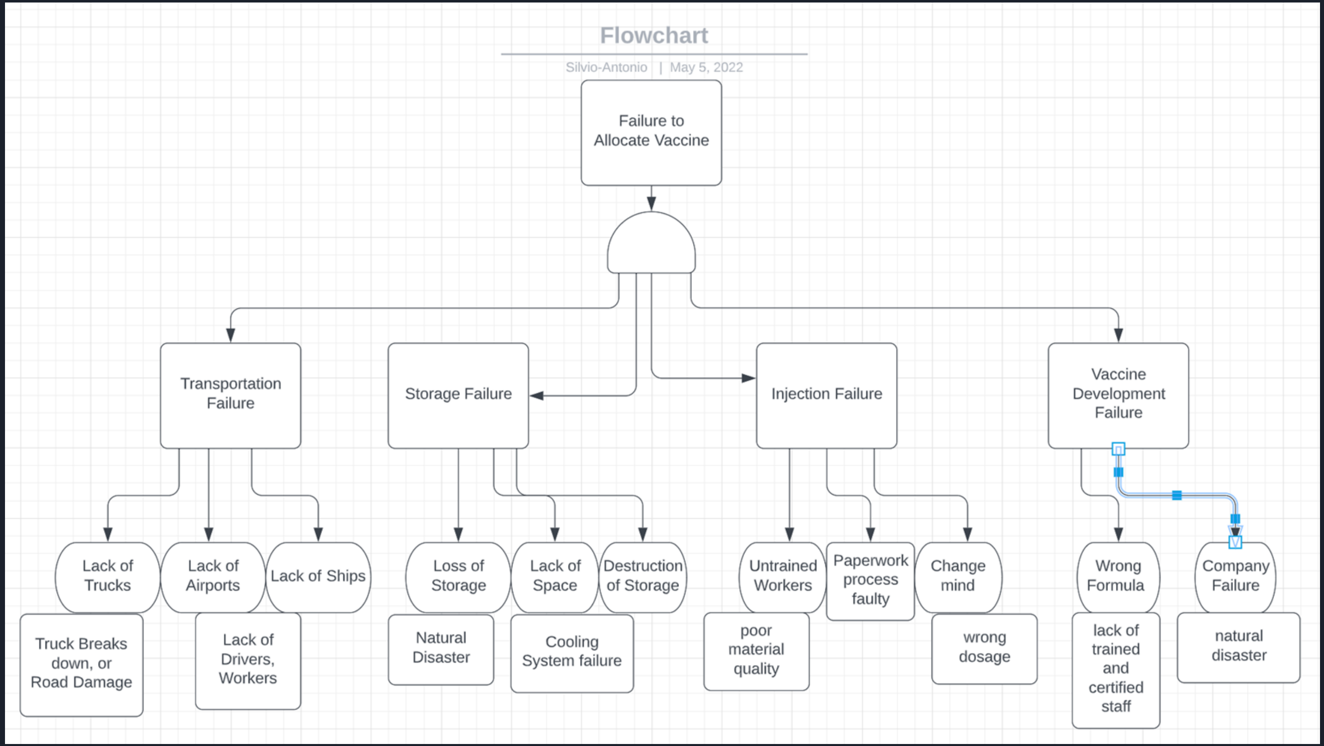
Step	Description
4	verify the right vaccine

Failure Mode	Causes	Effects	Occ	Det	Sev	RPN	Actions
choosing the wrong vaccine	failure to verify the needed vaccination failure to double check with another staff member	administration of unneeded vaccination failure of administration of the proper vaccination	9	2	2	36	always double check vaccine with another staff member

Step	Description
5	verifty the right dosage of vaccine

Failure Mode	Causes	Effects	Occ	Det	Sev	RPN	Actions
giving the wrong dose of vaccine	drawing up the wrong dose not double checking with another staff member	wrong dose (too little or too much) vaccine given to patient	7	10	2	140	always double check with another staff member prior to administration

FTA


Flowchart
Silvio-Antonio | May 5, 2022
Failure to Allocate Vaccine
Transportation Failure
Storage Failure
Injection Failure
Vaccine Development Failure
Lack of Trucks
Lack of Airports
Lack of Ships
Loss of Storage
Lack of Space
Destruction of Storage
Untrained Workers
Paperwork process faulty
Change mind
Wrong Formula
Company Failure
Truck Breaks down, or Road Damage
Lack of Drivers, Workers
Natural Disaster
Cooling System failure
poor material quality
wrong dosage
lack of trained and certified staff
natural disaster

Improvement

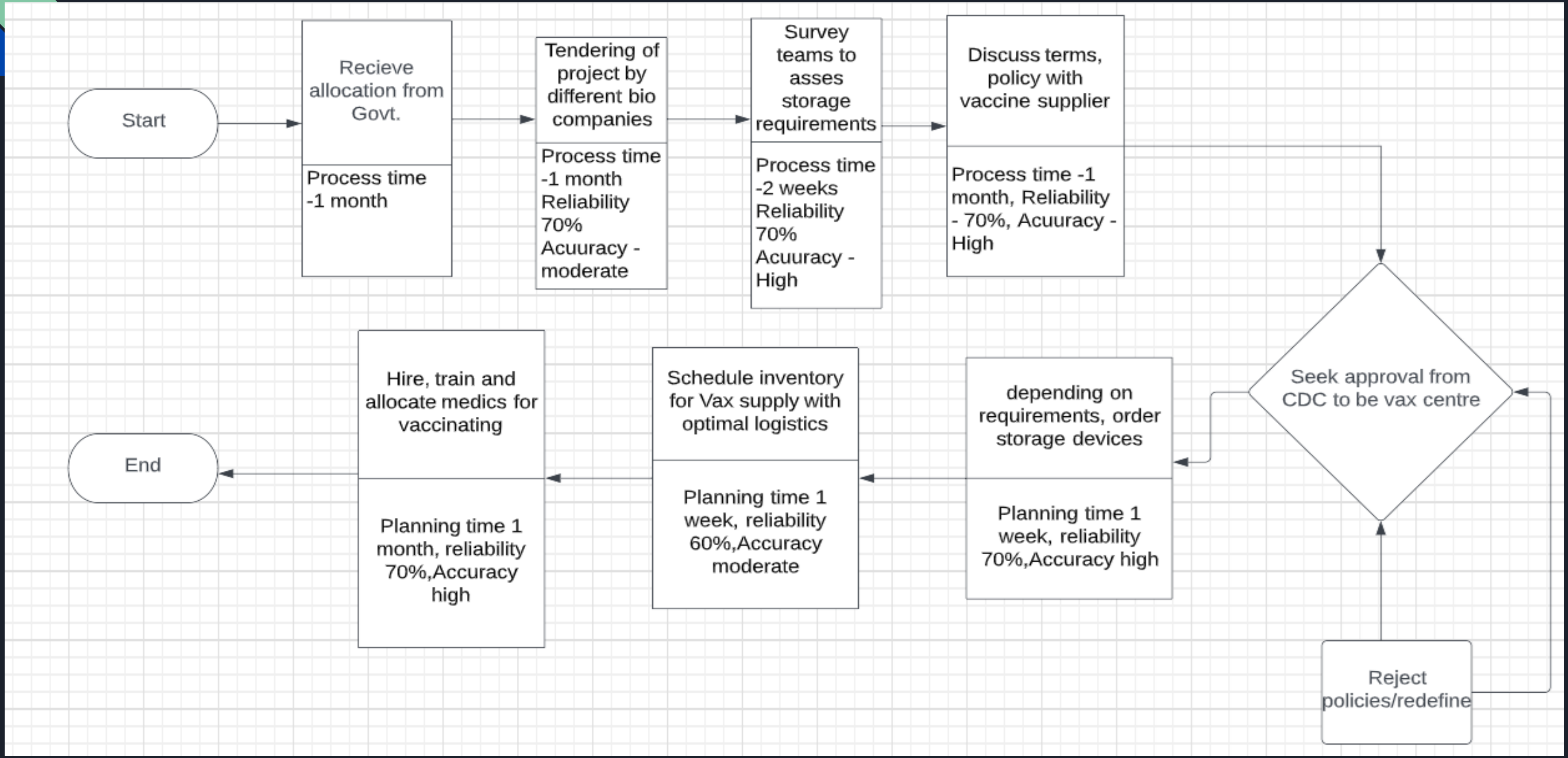
Lean Manufacturing

1. Developing essential medicines list
2. Partnering with the national academies
3. Partnering with the interagency
4. Advancing manufacturing capabilities
5. Creating a rating system for quality management maturity (QMM)
6. Detecting and Managing Supply chain disruptions
7. Allocating and distributing pharmaceuticals
8. Stopping unlawful Products
9. Coordinating Vaccine Supply Chain with industry

Value Stream Map

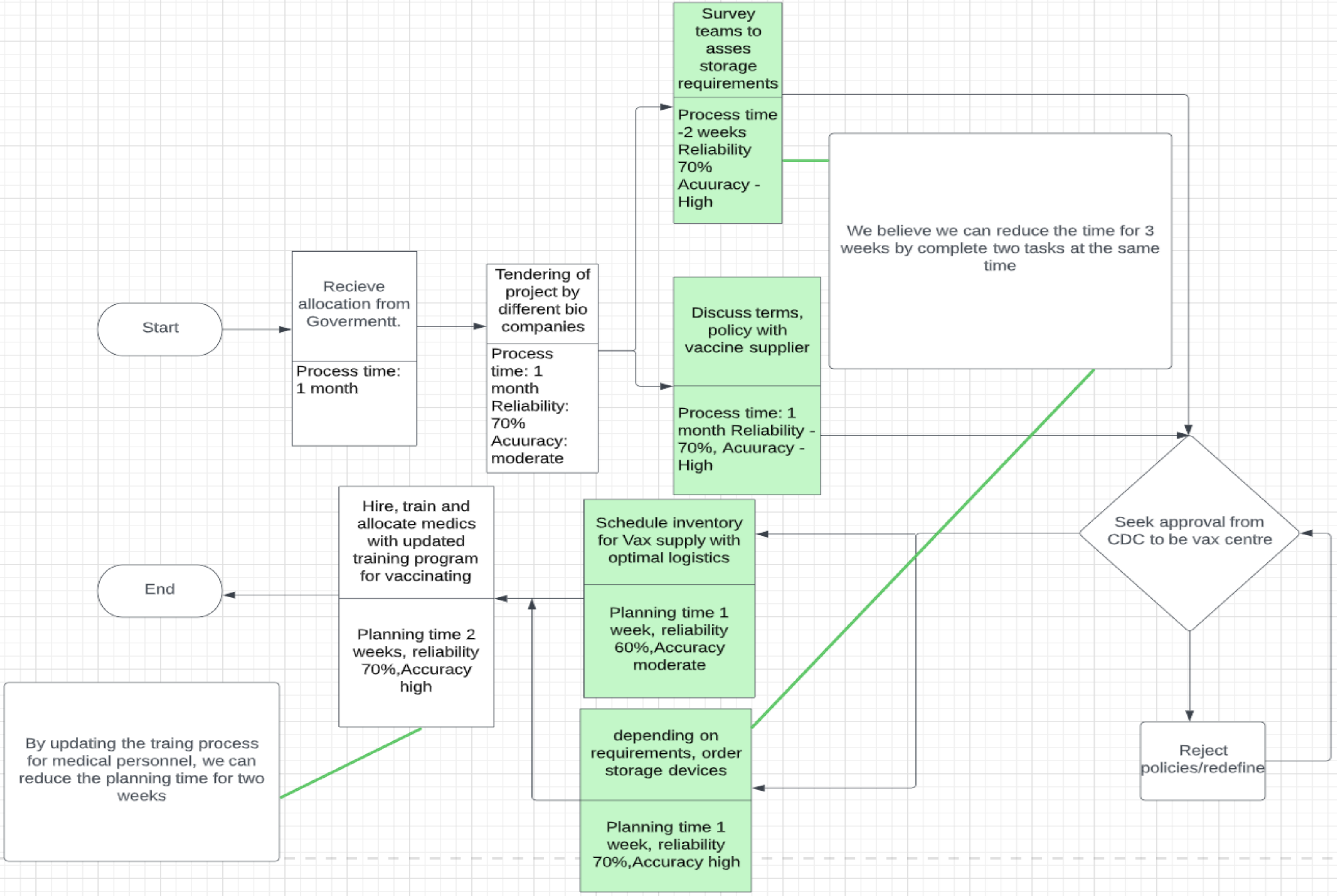
- Focusing on three different factors
  - Transportation
  - Personnel
  - Vaccine Allocation.
- By improving these three aspects we hope to improve the process and increase the vaccination rate in all communities, no matter how different or remote
- Make a matrix, parallely run tasks.

Current VSM



Start
Recieve allocation from Govt.
Process time -1 month
Tendering of project by different bio companies
Process time -1 month Reliability 70% Acuuracy - moderate
Survey teams to asses storage requirements
Process time -2 weeks Reliability 70% Acuuracy - High
Discuss terms, policy with vaccine supplier
Process time -1 month, Reliability - 70%, Acuuracy - High
Seek approval from CDC to be vax centre
Reject policies/redefine
depending on requirements, order storage devices
Planning time 1 week, reliability 70%,Accuracy high
Schedule inventory for Vax supply with optimal logistics
Planning time 1 week, reliability 60%,Accuracy moderate
Hire, train and allocate medics for vaccinating
Planning time 1 month, reliability 70%,Accuracy high
End

Future VSM



Survey teams to asses storage requirements
Process time -2 weeks Reliability 70% Acuuracy - High
We believe we can reduce the time for 3 weeks by complete two tasks at the same time
Start
Recieve allocation from Govermentt.
Process time: 1 month
Tendering of project by different bio companies
Process time: 1 month Reliability: 70% Acuuracy: moderate
Discuss terms, policy with vaccine supplier
Process time: 1 month Reliability - 70%, Acuuracy - High
Hire, train and allocate medics with updated training program for vaccinating
Planning time 2 weeks, reliability 70%,Accuracy high
Schedule inventory for Vax supply with optimal logistics
Planning time 1 week, reliability 60%,Accuracy moderate
Seek approval from CDC to be vax centre
End
By updating the traing process for medical personnel, we can reduce the planning time for two weeks
depending on requirements, order storage devices
Planning time 1 week, reliability 70%,Accuracy high
Reject policies/redefine

FUTURE VSM

- Use Takt time; $T = T_a/D$
- Bottlenecks avoided
- Reduce queue time

FUTURE PLANS OF US GOVT:

1. Work with global partners
2. Expand manufacturing capacity
3. Leverage Data

Control Phase

Acceptance Sampling Plan

OPERATING CHARACTERISTIC (OC) CURVE : -

- AN OPERATING CHARACTERISTIC (OC) CURVE IS A PROBABILITY CURVE FOR A SAMPLING PLAN THAT SHOWS THE PROBABILITY OF ACCEPTING LOTS WITH VARIOUS LOT QUALITY LEVELS (% DEFECTIVES).

- WE USED ACCEPTANCE SAMPLING METHOD AS IT ALLOWS US TO DETERMINE THE QUALITY OF A VACCINE BY SELECTING A SPECIFIED NUMBER FOR TESTING.

Method

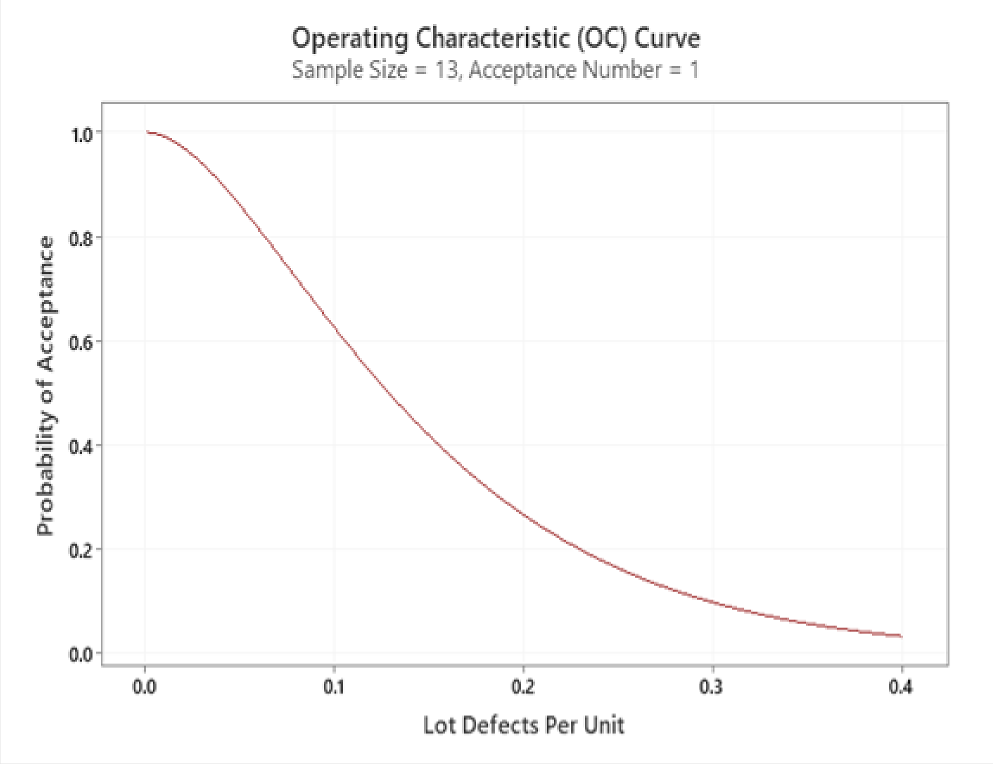
Acceptable Quality Level (AQL)	0.1
Producer's Risk (α)	0.5
Rejectable Quality Level (RQL or LTPD)	0.2
Consumer's Risk (β)	0.3

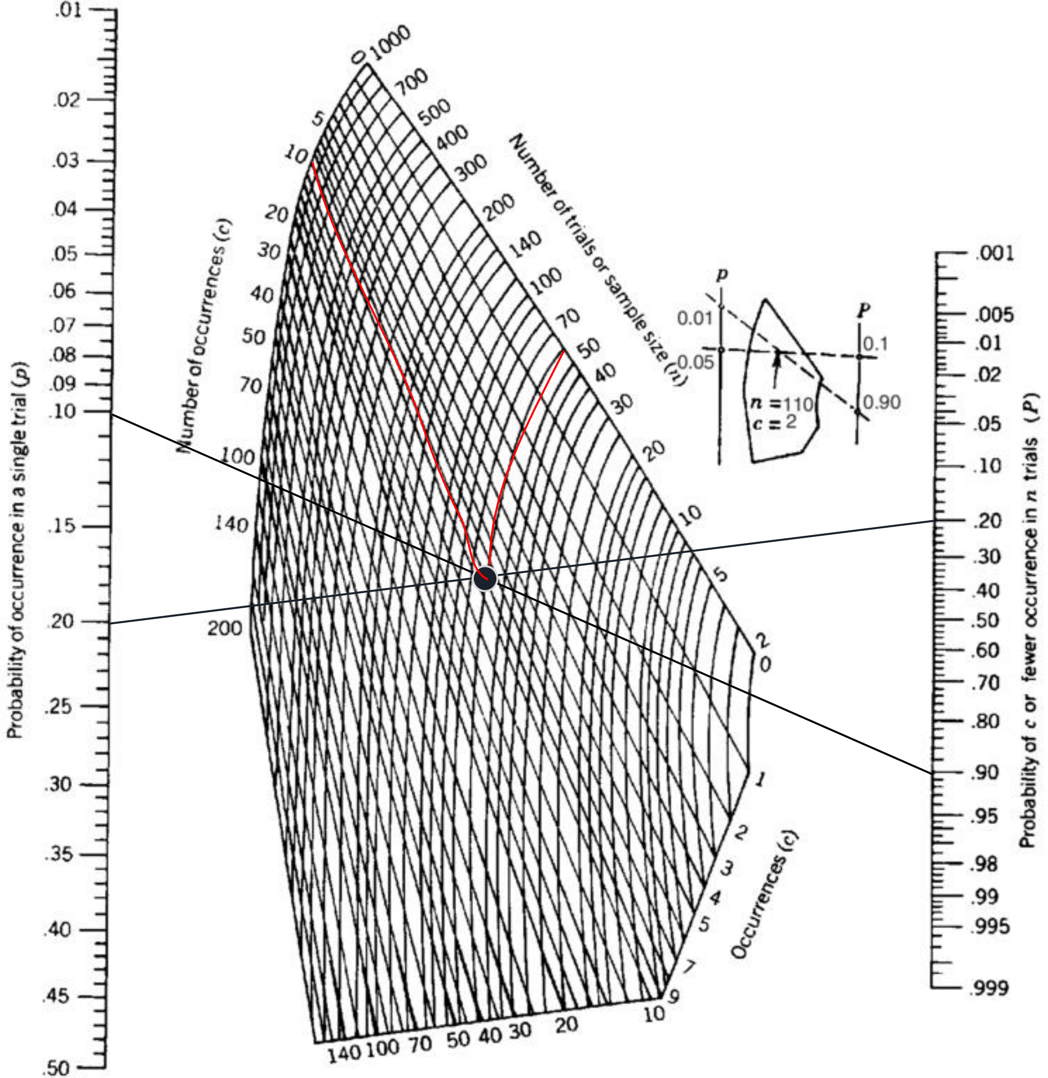
Generated Plan(s)

Sample Size	13
Acceptance Number	1

Accept lot if number of defects in 13 items ≤ 1; Otherwise reject.

Defects Per Unit	Probability Accepting	Probability Rejecting
0.1	0.627	0.373
0.2	0.267	0.733





Nomogram

By using Nomogram with our AQL and LTPD, we can find the intersection point of the two lines and project the point to sample size axis and number of occurrence axis to find our sampling plan.

Sample Size(n) = 55

Occurrences(c) = 8

Total Truck (N) = 950

ANSI Table

Table I—Sample size code letters

(See 9.2 and 9.3)

Lot or batch size			Special inspection levels				General inspection levels		
			S-1	S-2	S-3	S-4	I	II	III
2	to	8	A	A	A	A	A	A	B
9	to	15	A	A	A	A	A	B	C
16	to	25	A	A	B	B	B	C	D
26	to	50	A	B	B	C	C	D	E
51	to	90	B	B	C	C	C	E	F
91	to	150	B	B	C	D	D	F	G
151	to	280	B	C	D	E	E	G	H
281	to	500	B	C	D	E	F	H	J
501	to	1200	C	C	E	F	G	J	K
1201	to	3200	C	D	E	G	H	K	L
3201	to	10000	C	D	F	G	J	L	M
10001	to	35000	C	D	F	H	K	M	N
35001	to	150000	D	E	G	J	L	N	P
150001	to	500000	D	E	G	J	M	P	Q
500001	and	over	D	E	H	K	N	Q	R

Table II-A—Single sampling plans for normal inspection (Master table)

(See 9.4 and 9.5)

Sample size code letter	Sample size	Acceptance Quality Limits, *AQLs*, in Percent Nonconforming Items and Nonconformities per 100 Items (Normal Inspection)																									
		0.010	0.015	0.025	0.040	0.065	0.10	0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5	10	15	25	40	65	100	150	250	400	650	1000
		Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
A	2														↓	0 1		↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31
B	3													↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31	44 45
C	5												↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31	44 45	↑
D	8											↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31	44 45	↑	
E	13										↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31	44 45	↑		
F	20									↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑			
G	32								↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑						
H	50							↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑							
J	80						↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑								
K	125					↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑									
L	200				↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑										
M	315			↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑											
N	500		↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑												
P	800	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑													
Q	1250	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑														
R	2000	↑		1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑															

↓ = Use the first sampling plan below the arrow. If sample size equals, or exceeds, lot size, carry out 100 percent inspection.

↑ = Use the first sampling plan above the arrow.

Ac = Acceptance number.

Re = Rejection number.

Gage R&R

- Vaccine Protection Rate Measurement
    - Allows us to identify what proportion of the variation for our data is caused by the actual variation of what is measured and the variation due to the measuring device.
    - Our group uses gage R&R to evaluate the effectiveness of our vaccine protection rate and the quality of our system measuring that rate.

Gage R&R (Crossed)

Gage R&R for Measurement

Gage name: Covid Vaccine Factors
Date of study: 4/12/2022
Reported by: Zhaoning Song
Tolerance:
Misc:

Gage R&R

Variance Components

Source	VarComp	%Contribution (of VarComp)
Total Gage R&R	9.143	7.76
Repeatability	3.997	3.39
Reproducibility	5.146	4.37
Operator	5.146	4.37
Part-To-Part	108.645	92.24
Total Variation	117.788	100.00

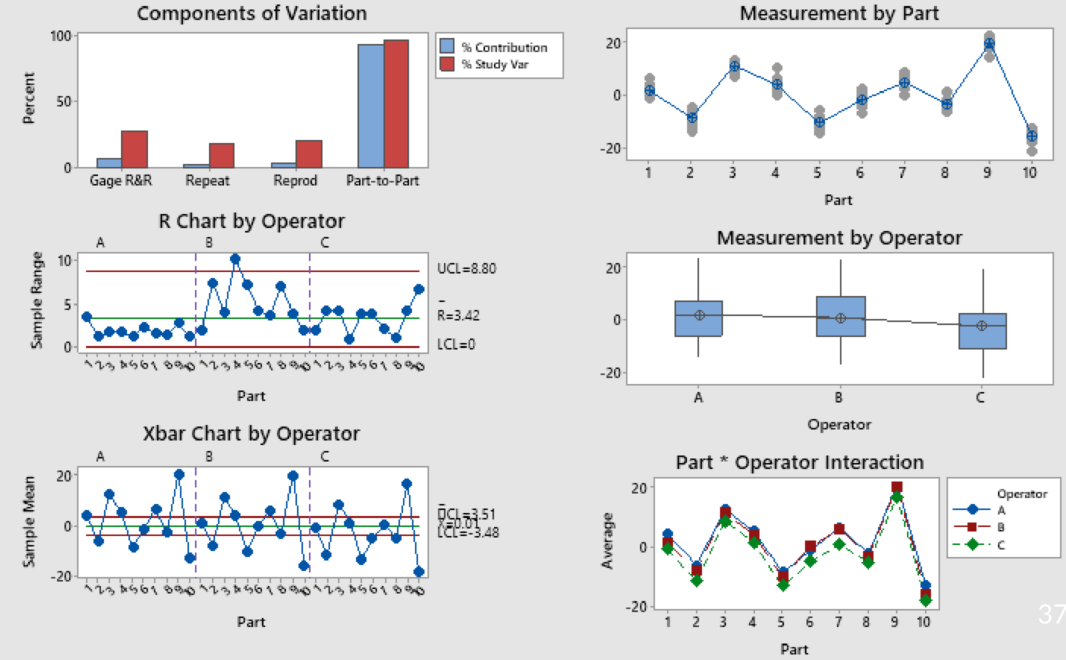
Gage Evaluation

Source	StdDev (SD)	Study Var (6 × SD)	%Study Var (%SV)
Total Gage R&R	3.0237	18.1423	27.86
Repeatability	1.9993	11.9960	18.42
Reproducibility	2.2684	13.6103	20.90
Operator	2.2684	13.6103	20.90
Part-To-Part	10.4233	62.5396	96.04
Total Variation	10.8530	65.1180	100.00

Number of Distinct Categories = 4

Gage R&R (ANOVA) Report for Measurement

Gage name: Covid Vaccine Factors
Date of study: 4/12/2022
Reported by: Zhaoning Song
Tolerance:
Misc:



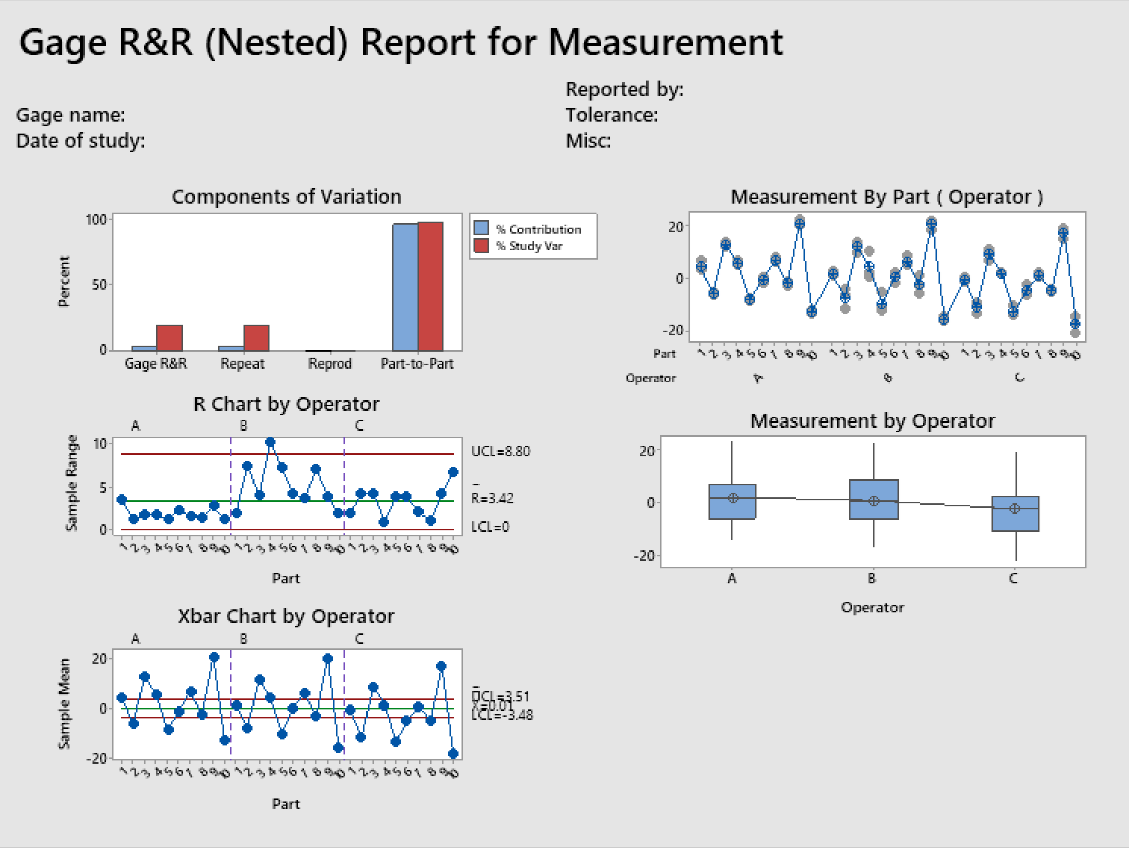
Gage R&R (Nested)

Variance Components

Source	VarComp	%Contribution (of VarComp)
Total Gage R&R	4.598	4.08
Repeatability	4.598	4.08
Reproducibility	0.000	0.00
Part-To-Part	107.999	95.92
Total Variation	112.597	100.00

Gage Evaluation

Source	StdDev (SD)	Study Var (6 × SD)	%Study Var (%SV)
Total Gage R&R	2.1443	12.8661	20.21
Repeatability	2.1443	12.8661	20.21
Reproducibility	0.0000	0.0000	0.00
Part-To-Part	10.3923	62.3536	97.94
Total Variation	10.6112	63.6672	100.00



Gage R&R– Appraisers

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

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

All Appraisers vs Standard

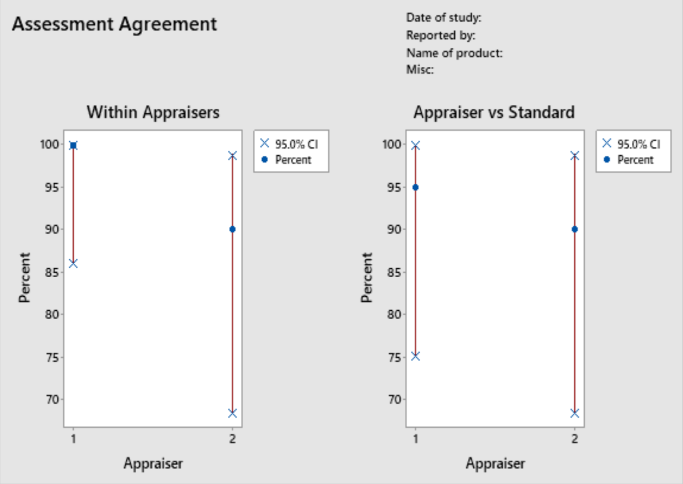
Assessment Agreement

# 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



Control Chart

- An X-bar and R (range) chart used with processes that have a subgroup size of two or more. The standard chart for variables data, X-bar and R charts can tell if a process is stable and predictable.
- The p-chart is used to monitor the proportion of nonconforming units in a sample, where the sample proportion nonconforming the ratio of the number of nonconforming units to the sample size.
- The c-chart is a control chart used to monitor "count"-type data, typically total number of defects per unit.
- Here, we are considering the control charts of X bar, Percent defective and No. of defective in the samples, for vaccine delivering trucks, and the acceptable limits for the vaccines produced itself.

X-Bar Charts

Range Chart

$$UCL = D_4\bar{R}$$

$$CL = \bar{R} = \sum R_i \Big/ k$$

$$R_i = Max(X_i) - Min(X_i)$$

$$LCL = D_3\bar{R}$$

Average (Xbar) Chart

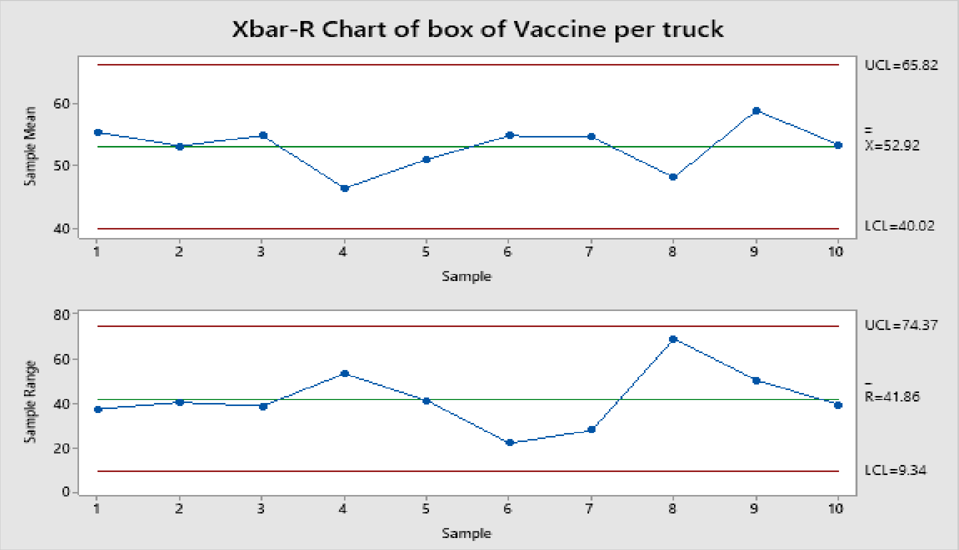
$$UCL = \bar{\bar{X}} + A_2\bar{R}$$

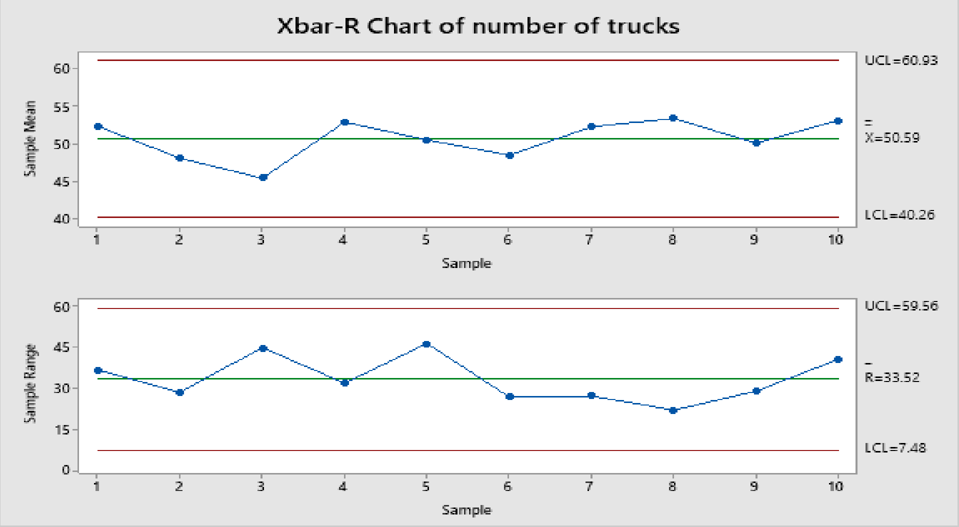
$$CL = \bar{\bar{X}} = \sum_{i=1,k} \bar{X}_i \Big/ k$$

$$LCL = \bar{\bar{X}} - A_2\bar{R}$$

k = number of subgroups
n = number of samples in a subgroup
A_2, D_3 and D_4 are constants based on n

Normal distribution



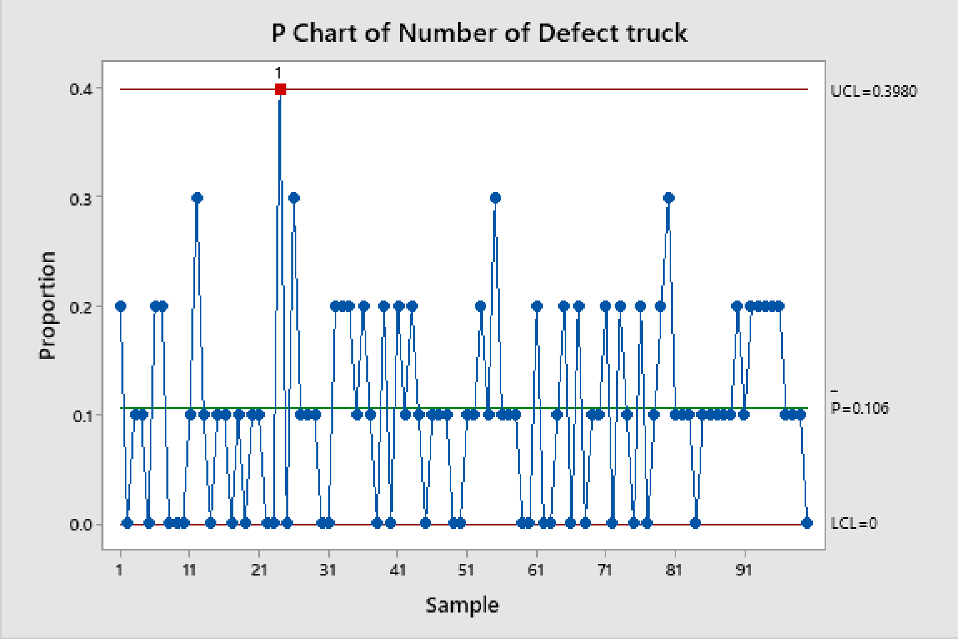


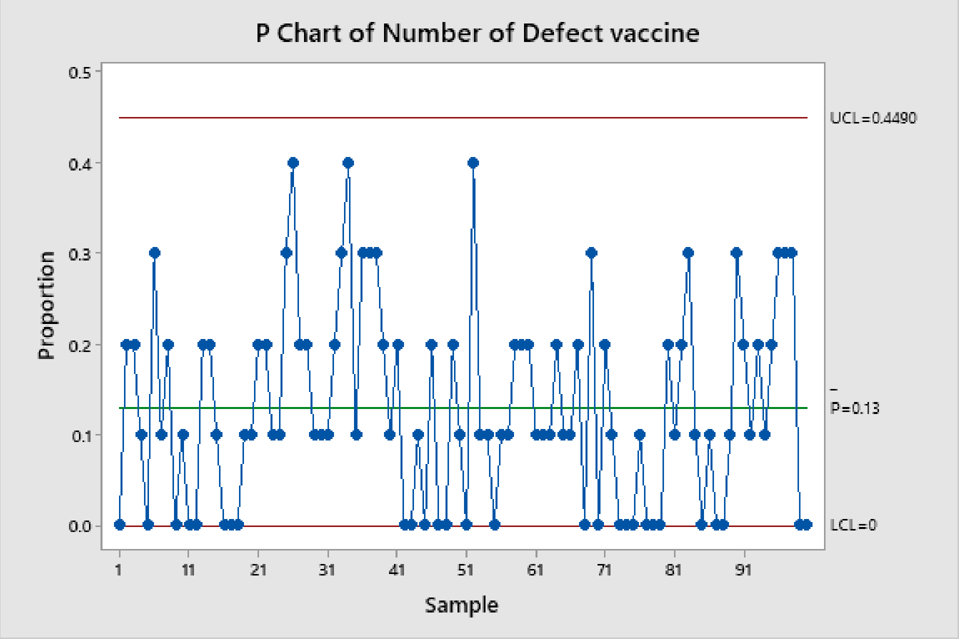
P Charts

Binomial Distribution

$$LCL = p - 3\sqrt{p(1-p)/n} =$$

$$UCL = p + 3\sqrt{p(1-p)/n} =$$



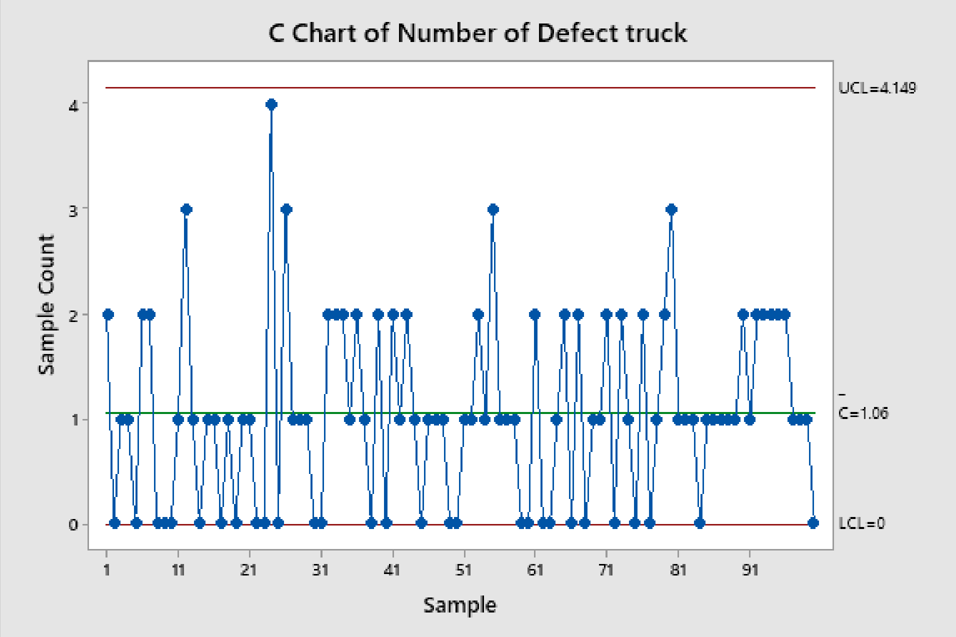


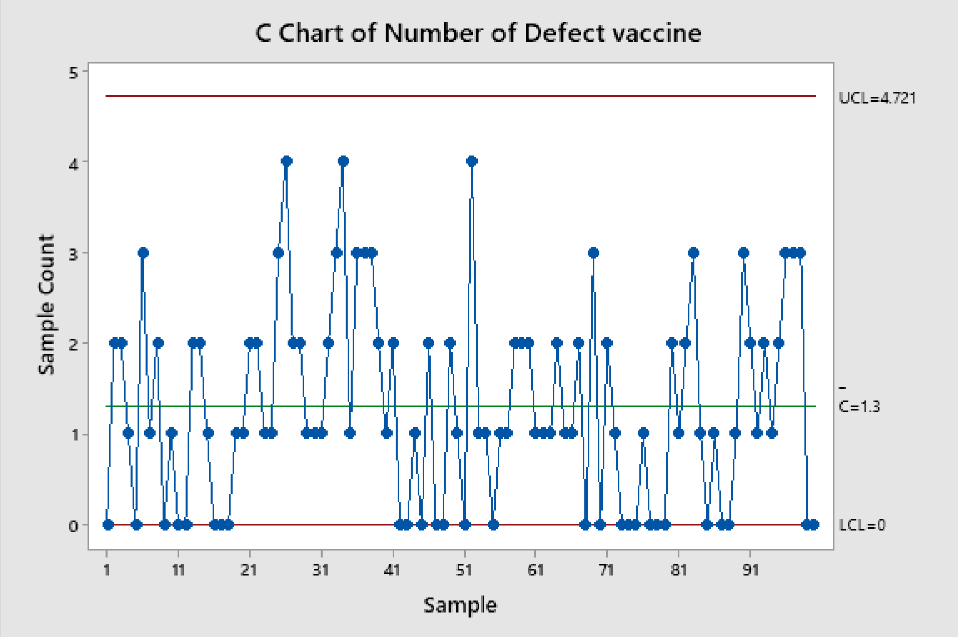
C Chart

Poisson Distribution

Mean (Target) = λ; UCL = $\lambda + 3\sqrt{\lambda}$; and

LCL = $\lambda - 3\sqrt{\lambda}$ (if LCL is > 0; otherwise LCL = 0)





Reliability

- The probability that a device will function according to its specifications
- Based on our project, the refrigerator is the key factor to keep vaccine potency.
- It is necessary to figure out the reliability of refrigerator

Three Test Methods:

- Complete Sample
- Failure Censored
- Time Censored

Complete Sample

Refrigenator Failure Time
34.0432661
88.65319939
101.7130879
172.3930781
195.4018529
235.1577889
649.6396429
952.7762964
999.3017379
1673.963027
1878.344751
1919.386942
1963.374842
2033.479886
3165.274591

Sample Size (N)	15	
alpha (Confidence Level)	0.05	
T (Sum of Failure Time)	16062.9	
a. 95% CI for MTTF and FR		
Chi-Square		
X^2 (2n, 1-alpha/2)	16.791	
X^2 (2n, alpha/2)	46.979	
	Lower	Upper
MTTF (95% CI)	683.8334	1913.275
FR (95% CI)	0.000523	0.001462
b. 95% Lower Confidence Bound for MTTF		
Develop 90% CI		
alpha (Confidence Level)	0.1	
Chi-Square		
X^2 (2n, 1-alpha)	20.599	
MTTF Lower Bound	1559.580949	
c. 95% Upper Confidence Bound FR		
Develop 90% CI		
FR Upper Bound	0.000641198	
d. 95% CI for Reliability		
Mission Time	850	
R	0.579831	

- Complete 15 sample to test until all of them failed
- Cost too much time and Money

Confidence Interval for Mean time to Failure (MTTF):

$$\left(\frac{2T}{X^2_{2n,1-\alpha/2}}; \frac{2T}{X^2_{2n;\alpha/2}}\right)$$

Confidence Interval for Failure Rate (FR):

FR = 1/MTTF

Confidence Bound:

$$\text{Mean} = \frac{2T}{\chi^2_{2n,1-\alpha}}$$

Failure Censored

Refrigerator Failure Time
34.0432661
88.65319939
101.7130879
172.3930781
195.4018529
235.1577889
649.6396429
952.7762964
999.3017379
1673.963027
1878.344751
1919.386942
1963.374842
2033.479886
3165.274591

Sample Size (k)	3
alpha (Confidence Level)	0.05
T (Sum of Failure Time)	1444.967

a. 95% CI for MTTF and FR		
Chi-Square		
X^2 (2k, 1-alpha/2)	1.237	
X^2 (2k, alpha/2)	14.449	
	Lower	Upper
MTTF (95% CI)	200.0092	2336.244
FR (95% CI)	0.000428	0.005

b. 95% Lower Confidence Bound for MTTF	
Develop 90% CI	
alpha (Confidence Level)	0.1
Chi-Square	
X^2 (2k, 1-alpha)	2.204
MTTF Lower Bound	1311.221967

c. 95% Upper Confidence Bound FR	
Develop 90% CI	
FR Upper Bound	0.000762647

d. 95% CI for Reliability	
Mission Time	850
R	0.52296

- Truncated at 3rd failure
- Not cost much time
- We don't know when the remaining units fail

Confidence Interval for Reliability: R

$$R(T) = \exp(-T * FR)$$

Time Censored

Refrigenator Failure Time
34.0432661
88.65319939
101.7130879
172.3930781
195.4018529
235.1577889
649.6396429
952.7762964
999.3017379
1673.963027
1878.344751
1919.386942
1963.374842
2033.479886
3165.274591

Sample Size (k)	6	
alpha (Confidence Level)	0.05	
T (Sum of Failure Time)	5327.362	
a. 95% CI for MTTF and FR		
Chi-Square		
X^2 (2k+2, 1-alpha/2)	5.629	
X^2 (2k+2, alpha/2)	26.119	
	Lower	Upper
MTTF (95% CI)	407.93	1892.827
FR (95% CI)	0.000528	0.002451
b. 95% Lower Confidence Bound for MTTF		
Develop 90% CI		
alpha (Confidence Level)	0.1	
Chi-Square		
X^2 (2k+2, 1-alpha)	7.79	
MTTF Lower Bound	1367.743844	
c. 95% Upper Confidence Bound FR		
Develop 90% CI		
FR Upper Bound	0.000731131	
d. 95% CI for Reliability		
Mission Time	850	
R	0.537159	

- Limited Time failure test
- Never know when units still working after limited time.
- Limited test time: 500 hours
- Complete sample test give us highest reliability.

Conclusion

In this project, we used different quality engineering methods. By Using Different methods we Analyze the problems and improve our project.

- The Flow Chart visually displays the sequence of activities of vaccine storage and transportation.
- The Organization chart let us to know about production of vaccine and distribution of vaccine.
- By COPQ and affinity diagram we get to know about the problems in the vaccine transportation and storage.
- Process capabilities indicates the statistical quality control of vaccine.
- Design of Experiment helps us in planning , conducting , analyzing and interpreting controlled tests to evaluate the factors.
- The FMEA leads the Vaccination project to the right path.
- Value stream map(VSM) helps us to improve the vaccine transportation, vaccine allocation process and make our allocation faster and more efficient.
- By Applying sampling plan we can sort out the factors that we need to improve in Vaccine transportation.
- We also find a way to calculate the reliability of our equipment.

From this project, we can visually see the improvement of our vaccine allocation procedure.

Reference

1. MFE634 Lecture Notes

https://blackboard.syracuse.edu/ultra/courses/_464807_1/cl/outline

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2. https://www.medicalcountermeasures.gov/barda/influenza-and-emerging-infectious-diseases/coronavirus/pharmaceutical-manufacturing-in-america/

THANK YOU….!!!