2016

Summarized Portfolio: Ebola Eradication

A COLLECTION OF WORKS

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Overview

Ebola has plagued Africa since 1976 and continues to take the lives of thousands each year. Although international organizations and numerous countries donate billions of dollars in resources and aid, the virus continues to spread and a vaccine still does not exist. The team has been tasked with the goal of evaluating the current procedure for Ebola treatment and its eradication, diagnosing the process faults, and implementing a remedy in an attempt to completely eradicate the virus.

Assessment and Analysis of COPQ

Non-Conformity

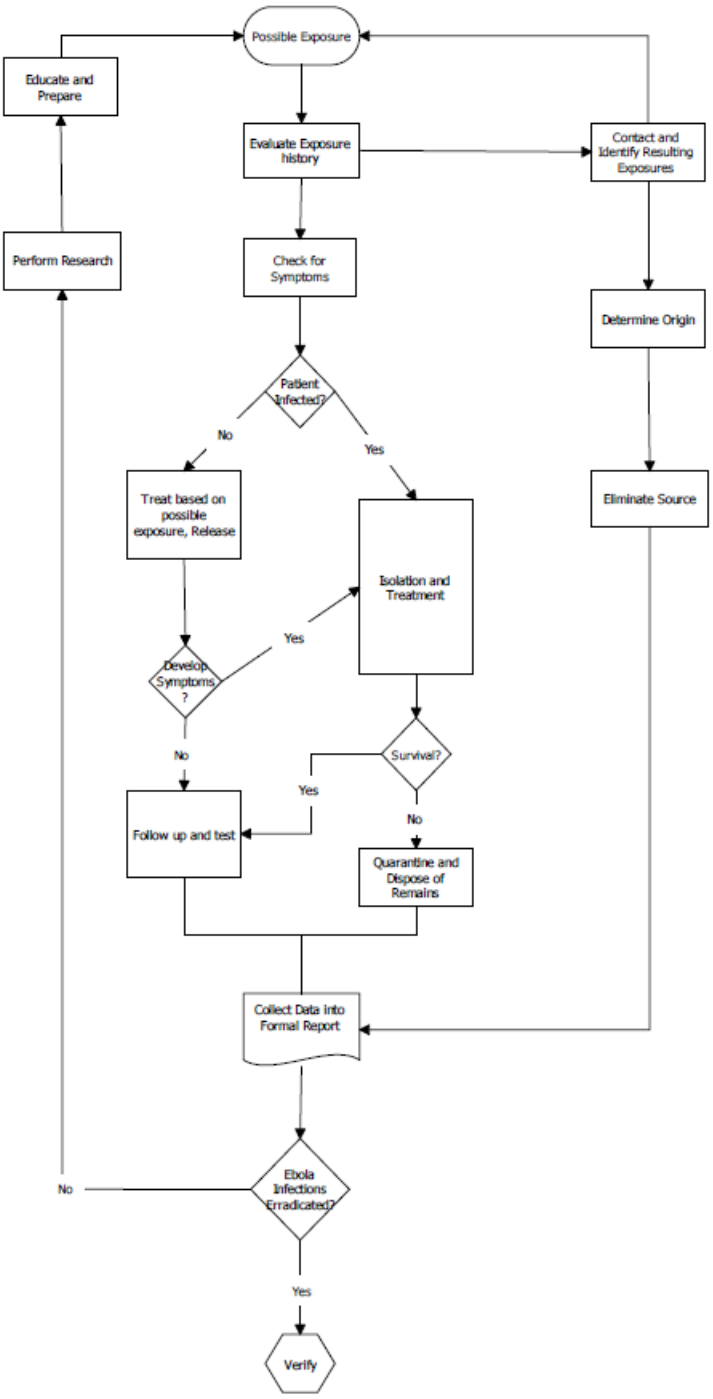
- Inconsistant Treatment Practices
  - Spread of Virus
  - Death
  - Cost of Continued Treatments
- Government Regulations
  - Travel Policies
  - Spread Across Boarders
  - New Outbreaks
  - Animal Contacts
- Training
  - Improper Sanitation - Spread of virus
  - Improper Treatment Schedule - Continued Treatment or Death
- Awareness
  - Further Contact with Infected

Inefficient Processes

- Cleaning Process
- Hospital Management
  - Patient Management
  - Medication Management
  - Training
  - Treatment Process
  - Patient Evaluation
- Inefficient Governance Processes
  - Population Control
  - Border Control
  - Water Control

Lost Opportunities

- R+d value loss
- Erradication
- Cleaner Environment
- Border Relations
- Tourism
- Population Happiness
- Economic Issues
- Number of Healthcare staff


Possible Exposure
Educate and Prepare
Evaluate Exposure history
Contact and Identify Resulting Exposures
Perform Research
Check for Symptoms
Determine Origin
Patient Infected?
No
Yes
Treat based on possible exposure, Release
Isolation and Treatment
Eliminate Source
Develop Symptoms ?
Yes
No
Survival?
Yes
No
Follow up and test
Quarantine and Dispose of Remains
Collect Data into Formal Report
Ebola Infections Erradicated?
No
Yes
Verify

Six Sigma DMAIC

DEFINE:

After several outbreaks, Ebola is still spreading. Case fatality rates have varied from 25% to 90% in the past outbreaks. The average case fatality rate is around 50%.

Using a Cost of Poor Quality analysis (below), it has been determined that some projects to consider

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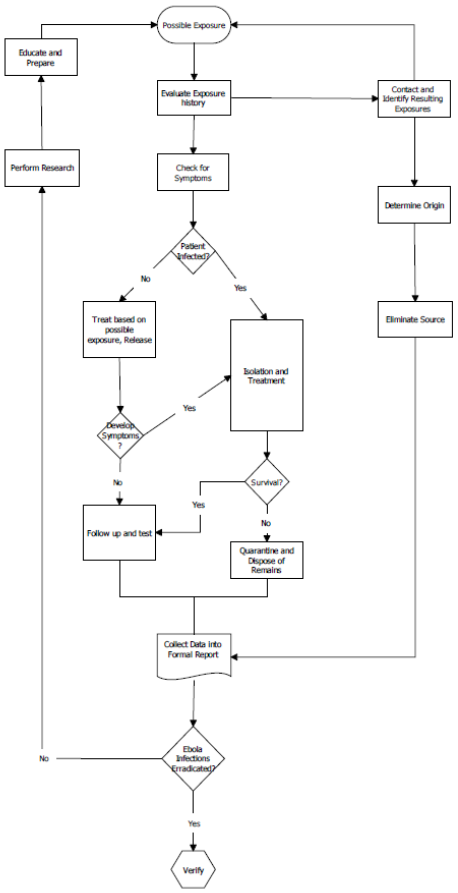
working on are border controls, public awareness, treatment practices, and government processes.

In order to ensure success in dealing with the stated problem, the project chosen looks to address the Ebola treatment procedure due to its manageable scope. Our mission is to address any issues with the current treatment process such that the spread of the Ebola virus, especially to healthcare workers, is significantly reduced and the average case fatality rate is reduced to 30%.

MEASURE:

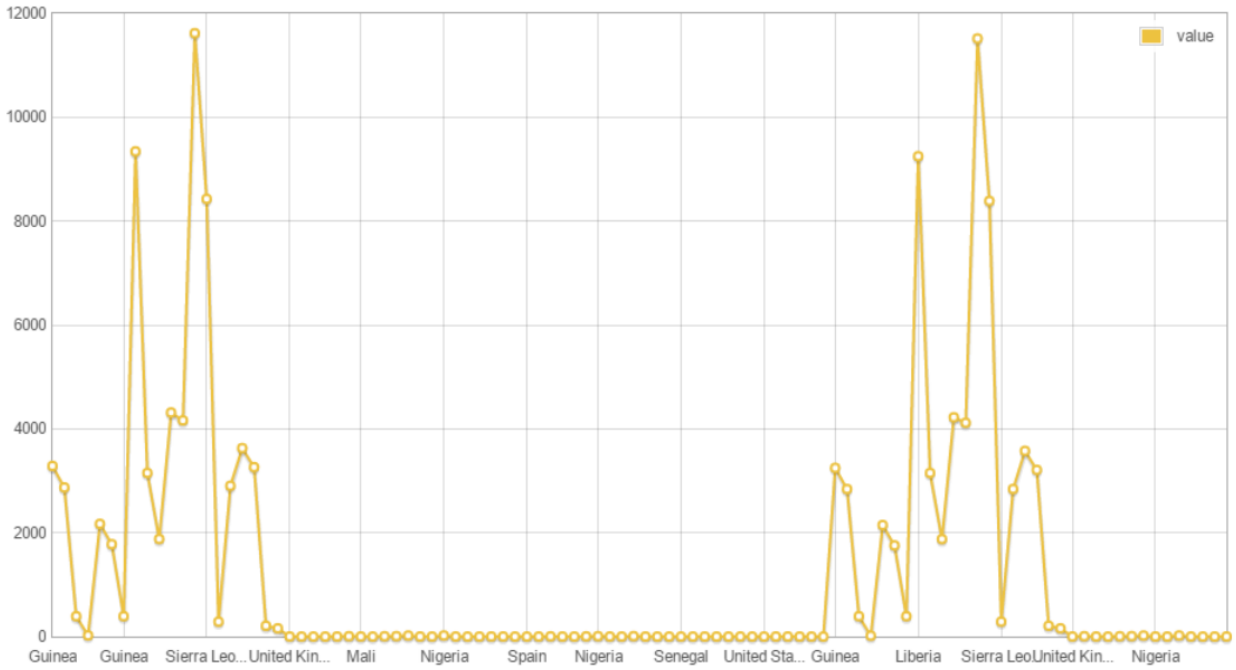
First, a process map was created to identify the general process associated with Ebola containment and annihilation (below). Limiting our scope down to the treatment portion of the process and brainstorming pointed the team towards the causes for spread and high mortality rates.



In order to properly identify the issues facing this process, data about the following parameters will be measured: successful Ebola identification rates, death rates, treatment success/failure rates, contagion exposures and transmissions, properly trained staff ratios, proper training rates, isolation room availability, inventories, and hospital policies. The measurement of these parameters will be accomplished using Pareto Charts, cause-and-effect diagrams, stratification, graphs and charts, and process capability analysis.

ANALYZE:

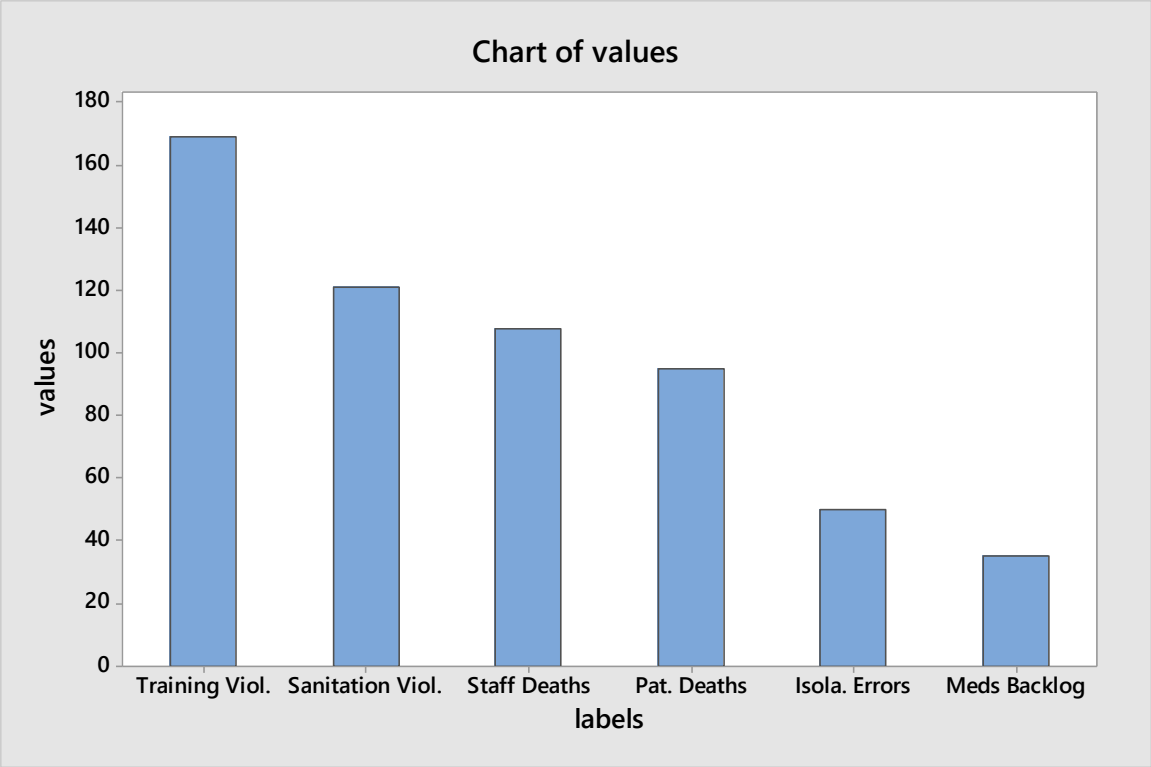
Below is an analysis of the cumulative infections versus the regions of identification. This helps us



determine what areas to focus on.

Once the areas of poor quality have been identified, hospitals in those regions are then analyzed for the parameters mentioned above. The next page shows a listing of the various hospitals in the areas in question that have displayed infections. After collecting data from the health workers, ratios were generated from the list presented and the chart following it. It was theorized that lack of medicine/vaccines/supplies, consistent training/practice, and poor hospital sanitation standards may be the cause of high spread and mortality rates.

Hospitals	Isolation rooms	trained nursing staff	trained dr	trained sanitation staff	VSV-EBOVA Vaccine	Fluids (BAGS)	Big O2 (tanks)	General Meds (Cases)	Succesful Ident.	Deaths
1	2	4	7	16	0	199	32	142	20	16
2	4	12	4	17	0	226	30	203	9	13
3	6	11	6	20	0	210	37	155	8	18
4	4	14	3	35	0	199	28	239	11	22
5	4	4	7	40	0	167	21	160	1	7
6	4	13	6	32	0	194	29	173	12	9
7	5	10	5	34	0	236	24	142	14	17
8	6	14	3	43	0	288	34	270	13	12
9	6	9	8	30	0	245	36	158	16	15
10	2	12	7	45	0	291	33	171	12	15
11	4	14	7	30	0	278	26	159	7	25
12	3	7	6	37	0	168	21	233	25	16
13	6	7	8	17	0	256	30	226	11	0
14	3	6	3	24	0	167	31	257	6	18
15	6	7	4	30	0	277	32	211	21	16
16	2	8	2	36	0	242	38	278	24	6
17	4	7	3	41	0	275	34	152	0	3
18	3	5	2	39	0	278	23	227	25	9
19	2	14	7	29	0	250	23	226	20	3
20	4	12	3	31	0	163	40	263	9	24
21	6	5	4	35	0	283	39	280	18	18
22	4	15	2	18	0	169	26	246	3	11
23	3	14	6	43	0	167	26	210	19	25
24	3	9	7	37	0	296	24	147	1	21
25	6	13	2	35	0	154	27	194	14	11
26	4	13	2	20	0	276	39	154	11	24
27	2	14	2	37	0	263	29	216	8	24
28	4	11	3	33	0	160	30	206	16	11
29	6	13	5	29	0	269	25	227	24	16
30	6	14	2	31	0	293	26	268	8	22



IMPROVE:

Some suggested solutions to the death rates include the following:

- enforce sanitation standards
- provide further staff training
- increase and improve isolation rooms
- advocate for advancement of vaccine administration
- increase on-hand medication, PPE, and sanitation supplies
- Practice infection control and sterilization measures
- Using lean, re-arrange rooms to facilitate the transformation to an isolation room.

Using these suggestions, an improvement plan has been created that will require the coordination of the major hospitals in the region. Each hospital will form a board of knowledgeable nurses, doctors, and sanitary staff to review medical and sanitation supplies as well as current practices regarding isolation, sanitation, and treatment (IST). A list of necessary supplies will be generated and purchased as soon as

funds become available. Individual hospitals may have different local practices regarding IST, thus the board will amend current procedures to reflect proper IST procedures and use incentives to promote new policies. Once the reviews are complete, the board will be disbanded and administrative hospital staff will schedule consistent training programs and emergency drills. Some staff will resist the training and drills but using incentive programs and encouraging positive results should ease the transition

CONTROL:

In order to continue the new set of standards, a new board consisting of highly trained medical and managerial staff should be created at each hospital whose sole responsibility is to monitor the processes associated with Ebola/Viral containment. Consistent training of new and seasoned staff should be influenced with a certification program such that certified staff, while first to deal with an outbreak, will either earn slightly more or be allowed first pick of shifts. Quality audits on best-practices and Ebola/viral containment procedures should be held consistently to monitor staff progress and refine current procedures.

Quality Function Deployment

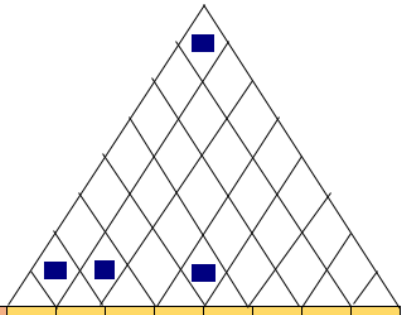
The following break downs were used to build a QFD. The final results indicate that training and proper equipment are priority.

		Customer Needs						
		Medication	Vaccination	Sanitation	Training	Reports/Data	Awareness	Proper Equipment
Customer	Patients	9	9	5	3		3	
	Doctors	9	9	5	5	5		9
	Nurses	5	5	9	9		3	5
	Sanitation Staff			9	5		3	9
	Researchers					9		9
	Public		9				9	

		Diagnose	Medicate	Monitor	Documentation	Cleaning/Disinfectant Supplies	Hospital Infrastructure	R&D
Customer Needs	Medication	9	9					5
	Vaccination				5			9
	Sanitation					9	1	
	Training			5	1			
	Reports/Data				9			9
	Awareness				5			5
	Proper Equipment					9	9	
	0							
	0							

Product Features								
Product Features	Diagnose							
	Medicate							
	Monitor							
	Documentation							
	Cleaning/Disinfectant Supplies							
	Hospital Infrastructure							
	R&D							
	0							
	0							

		Process	Control	Features				
		Quality Audits	Improvement Board					
Product Features	Diagnose	1	5					
	Medicate	5	1					
	Monitor	1	5					
	Documentation	9	9					
	Cleaning/Disinfectant Supplies	-	1					
	Hospital Infrastructure	5	1					
	R&D	-	1					
	0							
	0							



Quality Characteristics / Customer Requirements	Priority	Training	Procedures	Researchers	Proper Equipment	Sanitary Supplies	Reports/Data	Facilities	Funding
Nurses and Doctors	7	9	9		9	5		5	
Vaccination	6			9	9		5	1	9
Medicines	5			9			5	1	
Sanitation	4	9	5		5	9			
Border Patrol	3	9	5		9			1	5
Quarantine Rooms	2		9		5			9	
Administrators	1						5	1	9
CTQ Priority Score		126	116	99	174	71	60	68	78

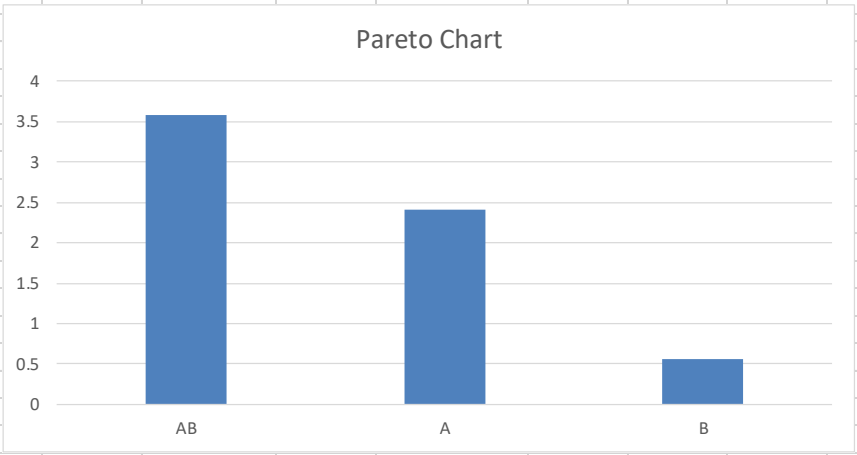
LEGEND		
Priority	7	Highest
	1	Lowest
Relationships	9	Stronger
	3	Medium
	1	Small
	■	Positive
	●	Negative

DOE

For a design of experiments, the team chose to test whether it the level of nurse training or age of equipment was having an effect. In this case, the level of training was the largest attributing factor.

			Level of Nurse	Training	(A)
		Normal	(-)	Enhanced	(+)
		1.34	5.24	5.38	6.02
Generation of Instruments	Old (-)	4.56	4.2	5.45	5.9
		5.98	7.49	8.22	11
	New (+)	6.92	7.02	9.72	10.36

	Run	A	B	AB	Avg	S2
	1	**-1**	-1	1	3.835	2.952633
	2	**1**	**-1**	**-1**	5.6875	0.102225
	3	-1	1	-1	6.8525	0.400092
	4	1	1	1	9.825	1.417967
	Y+	15.5125	16.6775	13.66		
	Y-	10.6875	9.5225	12.54		
	avgY+	7.75625	8.33875	6.83		
	avgY-	5.34375	4.76125	6.27		
	Effect	2.4125	3.5775	0.56		

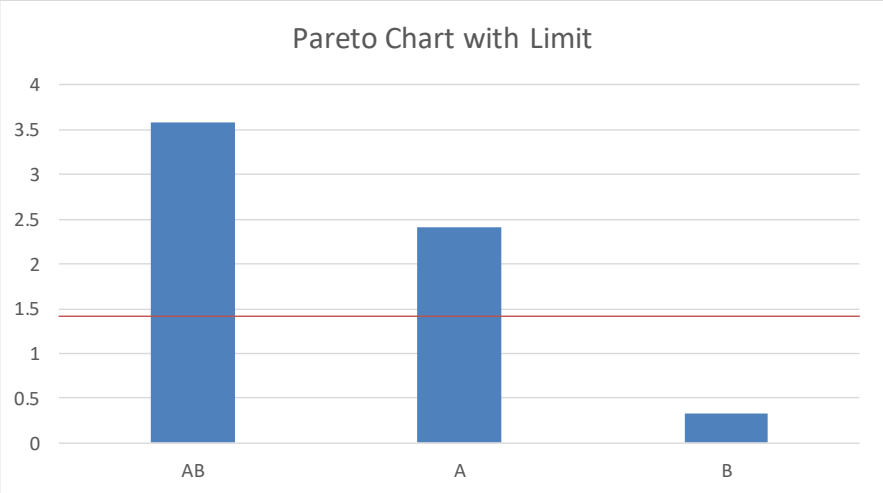


	Regressio	Estimators				
Reg. Coef.	b1	b2	b3			
Estimat.	1.20625	1.78875	0.28			

	Variance of Experiment:		Standard Deviation of Experiment:		
	Se^2	1.218229167		Se	1.103734

	Variance of Effect		Stand. Dev. Of Effect:		
	Seff^2	0.304557292	Seff	0.551867	

	Deg. Of Freedom			Alpha:	0.025			
	DoF:	12		T-Value:	2.560033			
		C.L. Width	1.412798					
	Significance							
Factor	A	B	AB					
Effect	2.4125	3.5775	0.56					
Significant?	Yes	Yes	No					



Supply Chain and VSM

Supply Chain

The next step was to identify the supply chain involved and create a value stream map of our patient experience. The basic tables can be seen on the next page in landscape view. For an in-depth view, please access “HW 08 – Ebola Supply Chain” in the ‘Homework and Supplemental File’ section. The tables show a strategy that the hospitals and their supply chain can employ to create a more responsive system. In the original ordering strategy, necessary medication orders were predicted based on a moving average of the remaining inventory from the previous two weeks. This is done to avoid ordering too much in the case of a slight increase in Ebola cases in an individual week. This is viewed as a good strategy because the cost of storing overflow inventory is twice the cost of storing standard inventory. However, this model neglects the cost of shortage, which is twice as much as the cost of storing excess inventory. This cost is so high because in a shortage, patients who remain untreated are more likely to infect others and die (can lead to lawsuits, more patients, expensive cleanup). It is recommended that, to take the shortage into account, a more responsive and cautious ordering strategy be employed. To do this, instead of basing orders on a moving average of the previous two weeks, the hospital should base orders on the remaining inventory in the current week only. This will allow for quicker response time, which is crucial to preventing the Ebola outbreak from progressing. By adjusting the "lower inventory limit," excess inventory can be minimized.

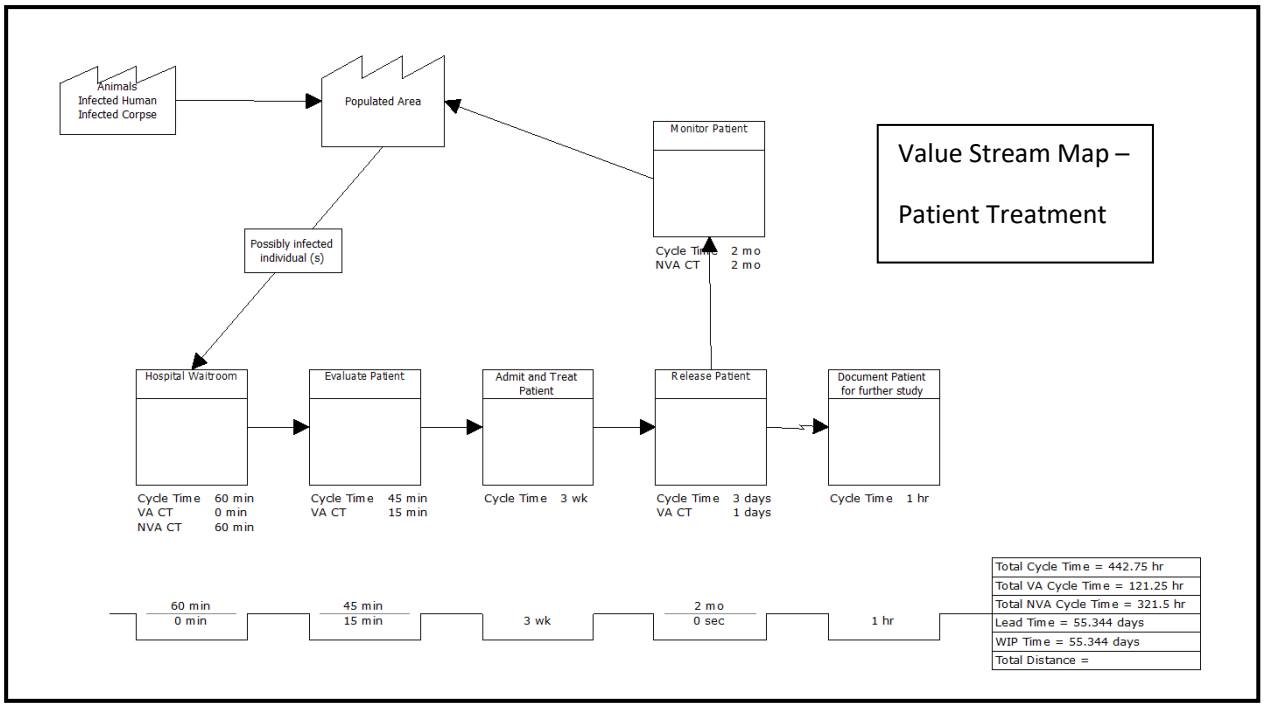
Producer

Lead Time	1	week	**Gross Requirements**		0	0	0	0	0	150	250	350	700	1950	6900	21650	69650	176150	506300
Lot Size	50	patients	**Beginning Inventory**		80	80	80	80	80	80	30	-80	-180	-680	-1780	-6630	-21480	-61480	-175960
Inventory Max	80	patients	**Remaining Inventory**	80	80	80	80	80	80	-70	-130	-280	-580	-1830	-6730	-21530	-69580	-176030	-506280
Cost of inventory	5		**Order (cases)**		0	0	0	0	0	3	5	7	14	39	138	433	1393	3523	10125
Cost of Overflow	10		**Order (patients)**		0	0	0	0	0	150	250	350	700	1950	6900	21650	69650	176150	506300
Cost of Shortage	20		**Order Receipt**		0	0	0	0	0	0	180	290	360	-780	1980	-6780	26680	-81680	106480
Lower Inventory Limit (Chosen by Hospitals)	10	patients	**Cost of Inventory**		400	400	400	400	400	400	250	-400	-900	-2500	-8880	-33200	-107800	-307400	-879700
			Cost of Over		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Cost of Shortage		0	0	0	0	0	1800	3600	5800	13400	37800	134400	430800	1293000	3528400	11924000
Total Cost Before Outbreak	2005	$/5 weeks	**Total Cost**		400	400	400	400	400	1800	3850	5800	18900	32500	135380	392800	1032900	3222900	11924850
Total Cost During Outbreak	1356925	$/10 weeks																	
Average Cost Before Outbreak	400	$/week	Restricted		0	0	0	0	0	80	50	-80	-180	-580	-1780	-6630	-21480	-61480	-175960
Average Cost During Outbreak	1356925	$/week	Behind		0	0	0	0	0	70	130	290	680	1840	6720	21540	69580	176030	506280

B53:W55B59B55:Y58B53:AA55

VSM

It is also important to see the cycle taken by an infected individual and how long the process takes to cure them. The following value stream map is a cycle of patients from infection to, in this case, being cured. Most of the non-value added time is in monitoring the patient. While it may be important, it would be out of the scope of responsibility for most hospitals. We suggest an external agency be tasked with monitoring patients.



Gage R&R Metrology MSA Study

The data below represents five nurses and their measurements of patient's temperature. Training about taking a temperature is largely dependent on age and location of instruction. The staff is currently using glass thermometers which can be used in several locations on a human's body. It is important to get an accurate temperature because if a person begins to sweat due to a fever, Ebola is now present on the entire body, increasing the chance to spread dramatically.

Patient	Nurse A	Nurse B	Nurse C	Nurse D	Nurse E
1	99.48	101.68	99.83	99.62	99.57
1	99.62	101.74	99.30	99.31	99.56
1	99.27	101.51	99.42	100.12	99.18
2	100.19	100.73	97.47	98.23	100.81
2	97.56	99.42	100.61	97.80	100.96
2	100.44	98.01	99.99	99.77	99.16
3	101.86	101.93	102.43	102.52	100.82
3	101.30	100.40	101.73	102.77	102.87
3	102.17	103.50	102.79	100.04	101.97
4	98.48	98.68	97.39	98.85	99.30
4	98.29	97.08	99.43	98.16	98.94
4	97.16	99.24	98.96	97.33	99.30
5	100.52	102.32	102.51	101.47	102.22
5	100.26	100.51	102.97	100.78	101.27
5	102.81	100.90	102.34	100.85	102.09
6	102.00	105.69	99.78	100.12	103.67
6	102.47	104.01	100.23	101.93	105.26
6	104.35	101.82	105.11	102.45	105.77
7	99.73	99.06	98.04	99.65	99.11
7	99.60	99.83	98.43	99.78	99.54
7	99.11	99.75	97.72	98.03	98.67
8	102.23	102.23	101.34	100.70	101.40
8	100.62	100.94	101.01	102.69	102.37
8	100.25	101.44	101.41	102.00	102.94
9	101.64	99.42	98.30	98.48	99.27
9	99.91	101.71	101.70	100.73	98.59
9	101.53	98.63	101.29	101.76	101.98
10	101.21	102.41	102.61	102.78	102.51
10	102.55	101.86	102.61	102.46	101.24
10	101.42	101.79	101.67	102.17	101.15

This data was put into Minitab and a Gauge R&R was performed. The following data was produced.

Gage R&R Study - ANOVA Method

Two-Way ANOVA Table With Interaction

Source	DF	SS	MS	F	P
Sample	9	302.659	33.6288	23.4671	0.000
Operator	4	7.755	1.9388	1.3529	0.270
Sample * Operator	36	51.589	1.4330	1.2189	0.220
Repeatability	100	117.562	1.1756		
Total	149	479.565			

Two-Way ANOVA Table Without Interaction

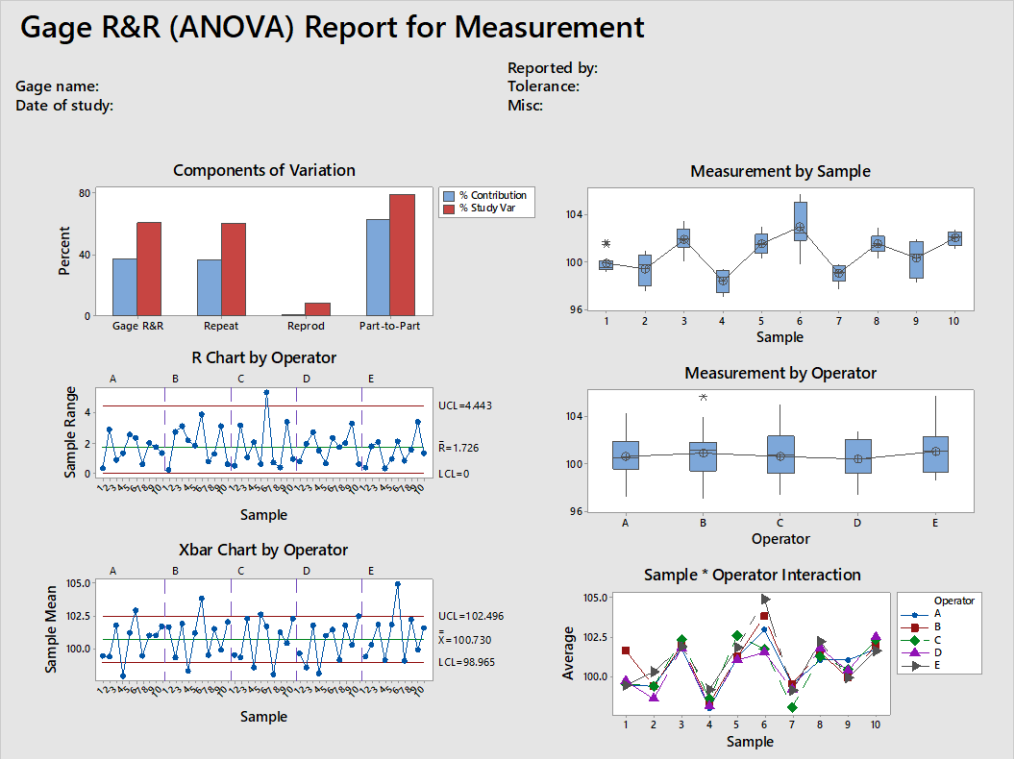
Source	DF	SS	MS	F	P
Sample	9	302.659	33.6288	27.0380	0.000
Operator	4	7.755	1.9388	1.5588	0.189
Repeatability	136	169.151	1.2438		
Total	149	479.565			

Gage R&R

Source	VarComp	%Contribution (of VarComp)
Total Gage R&R	1.26693	36.98
Repeatability	1.24376	36.30
Reproducibility	0.02317	0.68
Operator	0.02317	0.68
Part-To-Part	2.15900	63.02
Total Variation	3.42593	100.00

Source	StdDev (SD)	Study Var (6 × SD)	%Study Var (%SV)
Total Gage R&R	1.12558	6.7535	60.81
Repeatability	1.11524	6.6914	60.25
Reproducibility	0.15221	0.9132	8.22
Operator	0.15221	0.9132	8.22
Part-To-Part	1.46935	8.8161	79.38
Total Variation	1.85093	11.1056	100.00

Number of Distinct Categories = 1



The following data is representative of two doctors at a hospital and their appraisal of 20 different patient charts. The attribute column represents the actual data for each patient while the result column represents the decision made by the doctors. It is important that doctors are trained correctly and are diagnosing patients uniformly otherwise, patients will not receive appropriate care.

Patient	Attribute	Doctor	Result	Patient	Attribute	Doctor	Result
1	ebola	1	ebola	1	ebola	2	ebola
2	no	1	no	2	no	2	no
3	no	1	no	3	no	2	no
4	no	1	no	4	no	2	no
5	no	1	no	5	no	2	no
6	no	1	no	6	no	2	no
7	no	1	no	7	no	2	no
8	no	1	no	8	no	2	no
9	no	1	no	9	no	2	no
10	no	1	no	10	no	2	no
11	no	1	no	11	no	2	no
12	no	1	no	12	no	2	no
13	no	1	no	13	no	2	no
14	no	1	no	14	no	2	no
15	ebola	1	ebola	15	ebola	2	ebola
16	ebola	1	ebola	16	ebola	2	ebola
17	ebola	1	no	17	ebola	2	no
18	no	1	no	18	no	2	no
19	ebola	1	ebola	19	ebola	2	ebola
20	no	1	no	20	no	2	no
1	ebola	1	ebola	1	ebola	2	ebola
2	no	1	no	2	no	2	no
3	no	1	no	3	no	2	no
4	no	1	no	4	no	2	no
5	no	1	no	5	no	2	no
6	no	1	no	6	no	2	no
7	no	1	no	7	no	2	no
8	no	1	no	8	no	2	no
9	no	1	no	9	no	2	no
10	no	1	no	10	no	2	no
11	no	1	no	11	no	2	no
12	no	1	no	12	no	2	no
13	no	1	no	13	no	2	no
14	no	1	no	14	no	2	no
15	ebola	1	ebola	15	ebola	2	ebola
16	ebola	1	ebola	16	ebola	2	no
17	ebola	1	no	17	ebola	2	ebola
18	no	1	no	18	no	2	no
19	ebola	1	ebola	19	ebola	2	ebola
20	no	1	no	20	no	2	no

The data was put into Minitab and an Attribute Agreement Analysis was performed. This was done because the data above is not numerical but, rather, qualitative. The output from that analysis can be seen on the following pages.

Attribute Agreement Analysis for Result

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          Ebola     1.0000  0.223607  4.47214     0.0000
           no        1.0000  0.223607  4.47214     0.0000
2          Ebola     0.6875  0.223607  3.07459     0.0011
           no        0.6875  0.223607  3.07459     0.0011
```

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


Fleiss' Kappa Statistics

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

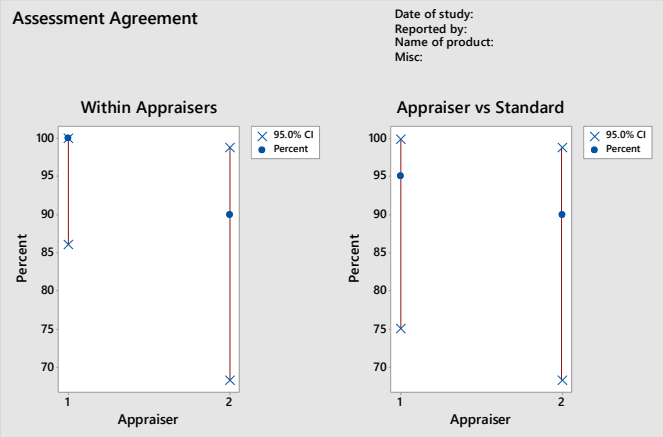
Matched: All appraisers' assessments agree with the known standard.

Fleiss' Kappa Statistics

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

Kendall's Correlation Coefficient

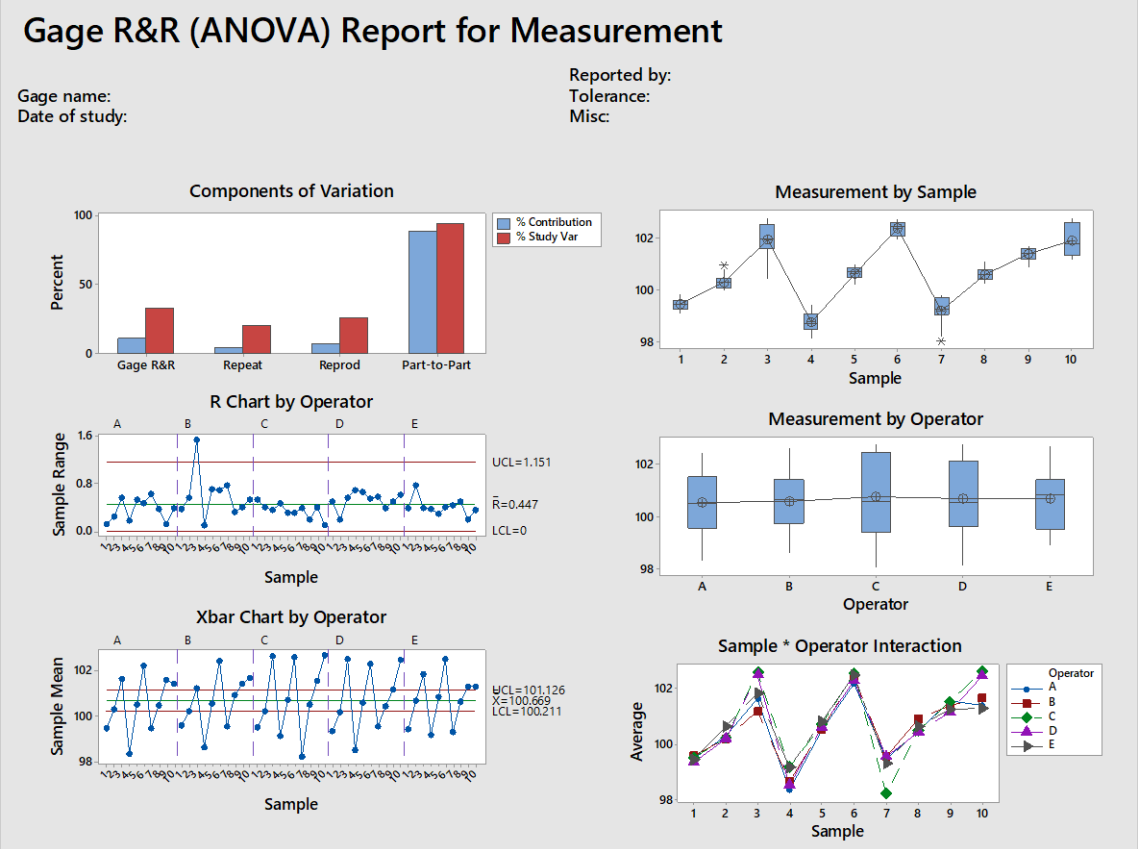
Only one or two distinct values in assessments and standards. Kendall's coefficients not computed.



Addressing the issues requires new equipment and a great deal of training about this threat specifically. The changes in this hospital were made and the team saw an improvement in consistency and reliability.

%Contribution

Source	VarComp	(of VarComp)
Total Gage R&R	0.18626	10.96
Repeatability	0.06790	3.99
Reproducibility	0.11836	6.96
Operator	0.00000	0.00
Operator*Sample	0.11836	6.96
Part-To-Part	1.51384	89.04
Total Variation	1.70010	100.00



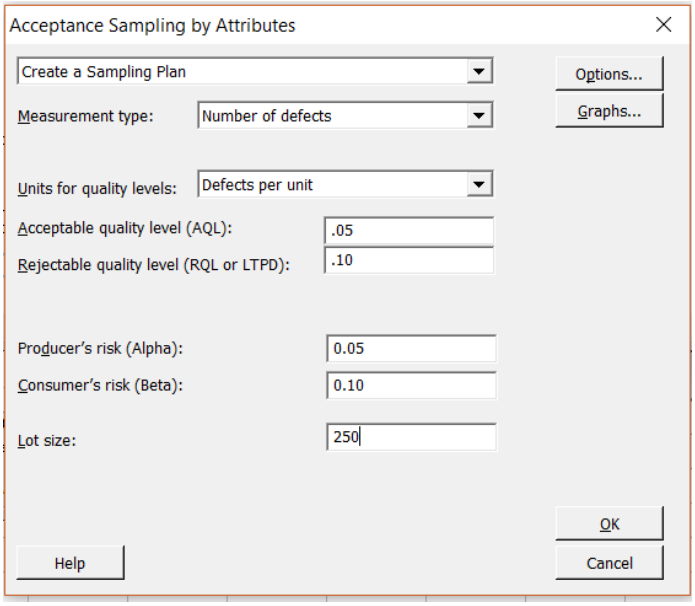
The overall tightness of measurements increased dramatically and the percentage of variation due to gauges dropped dramatically. The doctors being tested improved slightly too and the day-side has had less complaints in the past month.

Acceptance Sampling Plan

There were two schools of thought on how to test patients that appear to have Ebola. One camp believed that judging by symptoms and doing an occasional blood test was sufficient in catching Ebola as the tests costs hundreds per person. The other camp believed that the cost of failure to properly identify an infected patient warranted 100% testing. For those that believed that testing a sample size was effective, the following data was determined.

Distributions	**AQL**	**LTPD**
Binomial	**p = 0.05**	**p = 0.1**

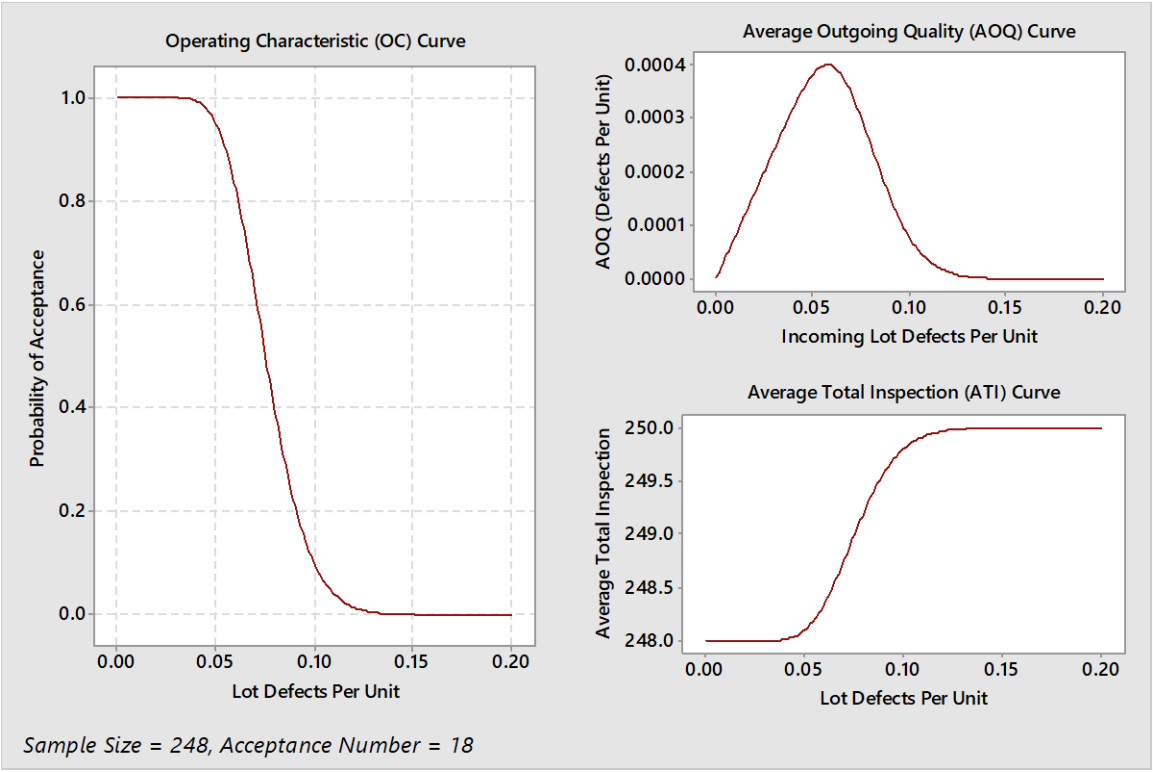
To find the best sampling plan with the parameter listed above, we began by consulting a binomial nomograph to obtain a starting point. Drawing lines based on our parameters, as shown in Appendix A, our team assessed a decent starting point to be n = 250 and c = 17. The following data was entered into Minitab:



The result of the analysis can be seen below and lists the appropriate plan as n = 248 and c = 18.

Acceptance Sampling by Attributes

```
Measurement type:  Number of defects
Lot quality in defects per unit
Lot size:  250
Use Poisson distribution to calculate probability of acceptance


Acceptable Quality Level (AQL)          0.05
Producer's Risk (α)                     0.05

Rejectable Quality Level (RQL or LTPD)  0.1
Consumer's Risk (β)                     0.1


Generated Plan(s)

Sample Size        248
Acceptance Number   18

Accept lot if number of defects in 248 items ≤ 18;  Otherwise reject.


 Defects  Probability  Probability
Per Unit    Accepting    Rejecting      AOQ    ATI
    0.05        0.951        0.049  0.00038  248.1
    0.10        0.099        0.901  0.00008  249.8

Average outgoing quality limit (AOQL) = 0.00040 at 0.05772 defects per unit.
```



It is important to note that the probability of acceptance for AQL, which should theoretically be 1-α= .95, is listed at 0.951. The probability related to LTPD = 0.1 theoretically should be β = 0.1 and is listed as 0.099 for this plan. This evidence supports that the plan of n = 248 and c = 18 is acceptable and ready to implement. To test this theory, data was generated using a binomial distribution where the probability was either the average of AWL and LTPD or twice the value of LTPD (p = 0.075 and p = 0.20). The data is represented by Appendix B. For the first situation, where p = 0.075, the amount of rejected products was 18 which is just at our acceptable limit. For the second situation, where p = 0.2, the amount of rejected is 51, which is outside of our acceptable limit. These results are to be expected and lends credit to the plan such that our team believes that n = 248 and c = 18 is acceptable.

For the camp that believed that 100% testing should occur, a much simpler calculation was necessary. Using the following variables, the breakeven cost was determined to be roughly 5% against a misdiagnosis rate of 10 to 15%. Therefore, the logic behind blood testing every patient is valid.

p = .10 - .25 depending on environment

I = cost of testing patient for Ebola = $224

A = cost of tracking down patients and testing = $2,250 + 2,240 = $4,490

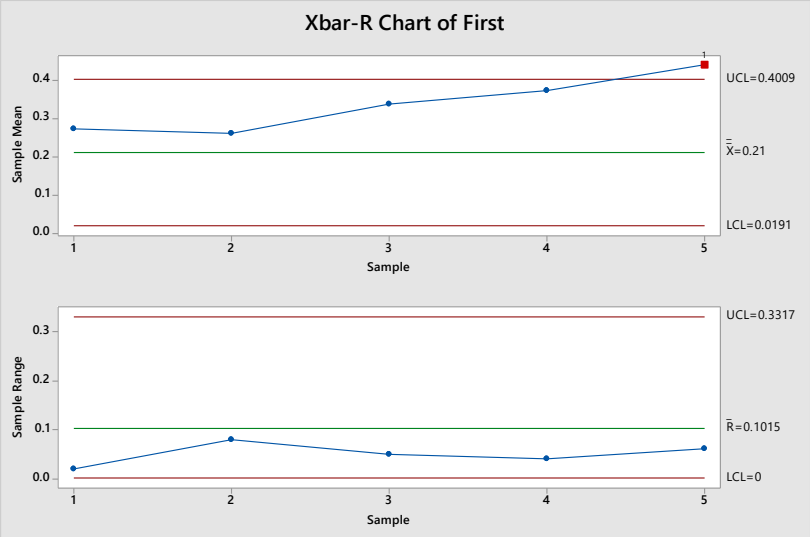
P(b) = break-even point = I/A = 224/4490 = .049

SPC Chart Example

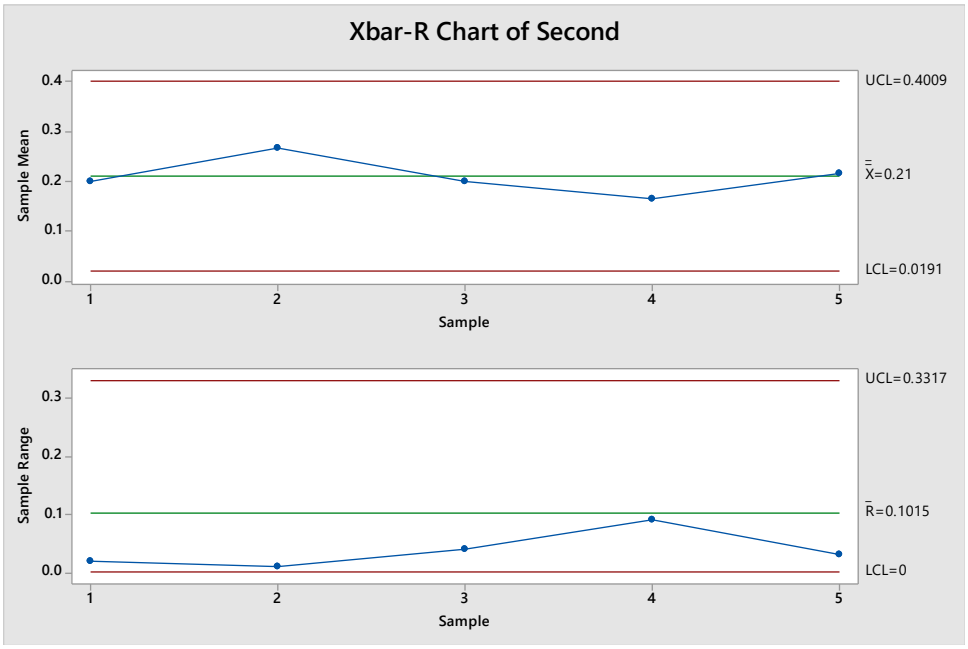
Last year, the average death rate in patients diagnosed with Ebola was .21 with a standard deviation of .09. The government is using these figures to monitor three urban hospitals to follow their progress throughout the year. The three hospitals have been monitored for ten months and their death rates of diagnosed Ebola patients can be seen below.

Month	First	Second	Third
1	0.26	0.21	0.33
2	0.28	0.19	0.31
3	0.22	0.26	0.35
4	0.30	0.27	0.29
5	0.31	0.22	0.24
6	0.36	0.18	0.26
7	0.35	0.12	0.19
8	0.39	0.21	0.21
9	0.41	0.20	0.15
10	0.47	0.23	0.16

The following graphs were produced based on the numbers from last year. The show that hospital number one was slightly above the average for last year but has gotten much worse and is performing outside of the standard deviation. This is troublesome and could be an indication of poor practices.

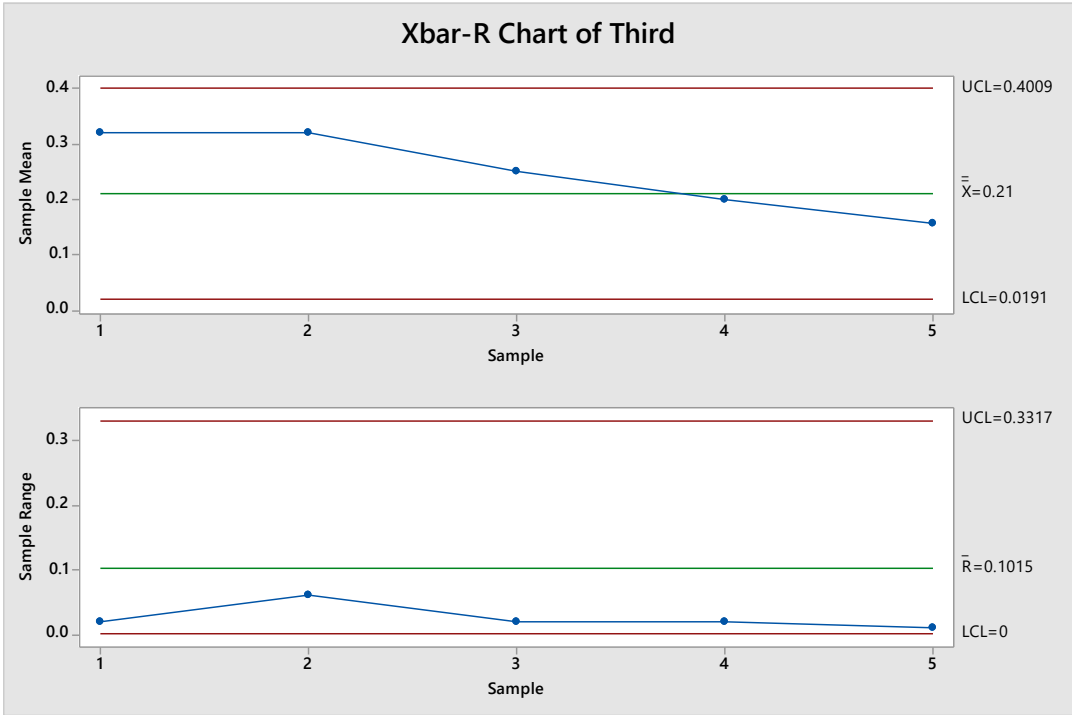


Hospital 2 has not seen much of a difference from last year's mean and is an indication that something



must be done to change the status quo of the facility.

Hospital 3 appears to have been performing poorly at the beginning of the year but has been continuously improving. This is a sign that quality of care is improving.



FMEA Reliability Analysis

With our initial goal of eradicating Ebola in mind, the team developed a FMEA with suggestions for remedying and the initial results after implementation. It appears that outbreaks in major cities are still a major threat and continued public outreach and education is suggested.

FAILURE MODE AND EFFECTS ANALYSIS

Process:	Ebola Containment	Responsibility:	A. Smith	FMEA number:	123456		
Model:	Current	Prepared by:	A. Smith	Page :	1 of 1		
Core Team:	A. Smith, M. Seibel, R. Shi, S. Ravichandran, V. Samantula, S. Shah			FMEA Date (Orig):	4/15/2016	Rev:	1

Process Function	Potential Failure Mode	Potential Effect(s) of Failure	Sev	Class	Potential Cause(s)/ Mechanism(s) of Failure	Occur	Current Process Controls	Detec	RPN	Recommended Action(s)	Responsibility and Target Completion Date	Action Results				
												Actions Taken	Sev	Occ	Det	RPN
Eliminate Ebola	Hospital Staff Infected	Hospital wide spread	9	Y	Mis-used equipment/ Failure to Follow Procedures	4	Quarantine training and instructions	3	108	Immediate Training and Sanitation of affected rooms	Management Staff nurses, doctors, and Sanitation DUE: 1 month	Re-training and purchase of new equipment	9	2	3	54
	Fellow Patients Infected	Virus leaves hospital, Staff become infected	9	Y	Improper Sanitation	4	Sanitation Training and chemical use	3	108	Increased sanitation rounds in public areas / Immediate training	Management Staff and Sanitation DUE: 1 week	Rounds Increased and New Training Methods Used	9	2	2	36
	Crossing into national territory	Infection of populated area	6	Y	Poor inspection at borders / Lax border laws	5	Screening in large border areas such as airports, railways, etc.	9	270	Tighten border regulations / Mandate screening / Limit or stop border crossing	Government Regulators, Police, Disease Control DUE: 3 months	Population Crossing Severely Limited	6	2	5	60
	Outbreak in Cities	Mass infections	9	Y	Poor Education of Populate / Inadequate living conditions	5	Flyers and Billboards	9	405	Teach Children / Travel door to door / Media Ads	Government Regulators, Media Outlets, WHO, UN DUE: 2 Months	Teaching in school and door to door through IN program	9	3	4	108
	Outbreak in Rural Areas	Death of entire villages / Re-infection	7	Y	Poor Education / Conflicting Local Traditions	4	Local Health Representatives Inspect Villages and Handle Human Aspect	4	112	Convince Local Villages of Necessary Practices / Exhume and Burn Infected Remains	Local Governments and Health Care Providers DUE: Continuously	Road Trip taken by care givers to educate and inspect villages	7	2	2	28

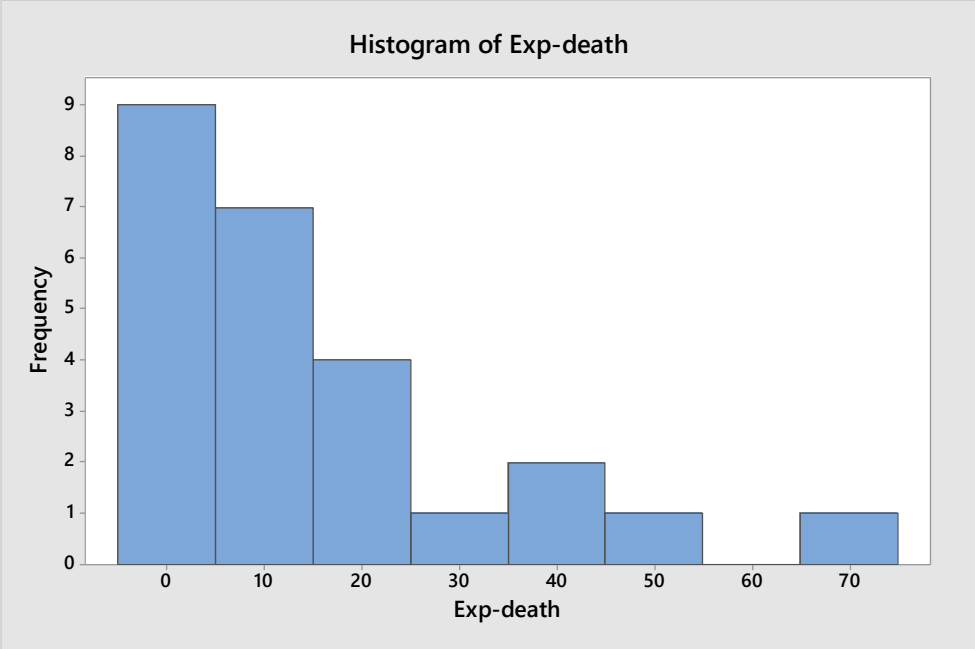
Reliability Tools and Analysis

We will use an exponential distribution to represent our mean time to failure (MTTF). The data is representative of the average time to death for an Ebola patient under current quality standards. We generated 25 measurements with a mean of 18 days.

1.1 Reference Data and Calculations

The data generated and a histogram of said data can be seen below.

Exp-death
30.79644
0.382546
8.316035
2.553958
21.90514
69.84523
1.540454
37.84053
7.816958
4.313416
18.15716
0.291554
11.71763
5.040343
52.31805
17.80882
23.45096
0.559145
5.166476
2.32172
39.2665
10.46008
4.828428
2.747696
5.692029



Sum of Exp-death

```
Sum of Exp-death = 385.137
```

Mean of Exp-death

```
Mean of Exp-death = 15.4055
```

Standard Deviation of Exp-death

```
Standard deviation of Exp-death = 18.0357
```

Failure Rate

```
FR = 1 / Mean = 1 / 15.4055 = .065
```

Some general figures can be drawn from the data above.

1.2 Reference Data Calculations

For calculation of MTTF with a confidence level, we must first define that our total time is the sum of all test times, T = 385.137, and that our degrees of freedom are 2*n, where n = 25 (number of trials).

1.2.1 95% Confidence Interval for the MTTF

The inputs necessary for the calculation of our confidence interval are:

n = 25

α = 0.05

T = 385.137

$$\chi^2_{2n,\frac{\alpha}{2}} = \chi^2(50,.025) = 32.36$$

$$\chi^2_{2n,1-\frac{\alpha}{2}} = \chi^2(50,.975) = 71.42$$

$$\mu = \left(\frac{2*T}{\chi^2_{2n,1-\frac{\alpha}{2}}}, \frac{2*T}{\chi^2_{2n,\frac{\alpha}{2}}}\right) = \left(\frac{770.274}{71.42}, \frac{770.274}{32.26}\right) = (10.785\,, 23.88)$$

1.2.2 95% Confidence Interval for Failure Rate (FR)

$$Failure\ Rate = \frac{1}{Mean\ Life} = \left(\frac{1}{23.88}, \frac{1}{10.785}\right) = (.0479\,, .0927)$$

1.2.3 90% Confidence Bounds for MTTR and FR

$$\chi^2_{2n,\frac{\alpha}{2}} = \chi^2(50,.05) = 34.76$$

$$\mu = \left(\frac{2*T}{\chi^2_{2n,\frac{\alpha}{2}}}\right) = \left(\frac{700.274}{34.76}\right) = (20.146)$$

$$Failure\ Rate = \frac{1}{Mean\ Life} = \left(\frac{1}{20.146}\right) = (.0496)$$

1.3 Estimating based on 5th failure

When testing, we can limit the amount of time we wait by making assumptions based on a certain number of failures. In our case, we chose the 10th death (failure) to mark our confidence intervals. The 10th failure time was 4.31 days and our Degrees of Freedom are 12 (10+2).

1.3.1 95% Confidence Interval for MTTF

For this method, we use the following inputs and formulas to generate our total time T and our confidence interval via a Chi-Squared distribution:

$$n = 25$$
$$\alpha = .05$$
$$T = \sum_{i=1}^{10} X_i + (n-i) * X_n = 250.12$$
$$\chi^2_{2n,\frac{\alpha}{2}} = \chi^2(12, .025) = 4.4$$
$$\chi^2_{2n,1-\frac{\alpha}{2}} = \chi^2(12, .975) = 23.34$$
$$\mu = \left(\frac{2*T}{\chi^2_{2n,1-\frac{\alpha}{2}}}, \frac{2*T}{\chi^2_{2n,\frac{\alpha}{2}}}\right) = \left(\frac{500.24}{23.34}, \frac{500.24}{4.4}\right) = (21.43\,, 113.69\,)$$

1.3.2 95% Confidence Interval for the FR

$$Failure\ Rate = \frac{1}{Mean\ Life} = \left(\frac{1}{113.69}, \frac{1}{21.43}\right) = (.0088\,, .047)$$

1.3.3 90% Confidence Bounds for MTTR and FR

$$\chi^2_{2n,\frac{\alpha}{2}} = \chi^2(12, .05) = 5.23$$
$$\mu = \left(\frac{2*T}{\chi^2_{2n,\frac{\alpha}{2}}}\right) = \left(\frac{500.24}{5.23}\right) = (9.56)$$
$$Failure\ Rate = \frac{1}{Mean\ Life} = \left(\frac{1}{9.56}\right) = (.01045)$$

1.4 Estimating after 10 days

When testing, we can limit the amount of time we wait by making assumptions based on a certain number of failures. In our case, we chose to wait 10 days for the CI. After 10 days, there were 14 failures.

1.4.1 95% Confidence Interval for MTTF

For this method, we use the following inputs and formulas to generate our total time T and our confidence interval via a Chi-Squared distribution:

$$k = 14$$
$$n = 25$$
$$\alpha = .05$$
$$T = 25 * 10 = 250$$
$$\chi^2_{2k+2,\frac{\alpha}{2}} = \chi^2(30, .025) = 16.79$$
$$\chi^2_{2k+2,1-\frac{\alpha}{2}} = \chi^2(30, .975) = 46.98$$
$$\mu = \left(\frac{2 * T}{\chi^2_{2n,1-\frac{\alpha}{2}}}, \frac{2 * T}{\chi^2_{2n,\frac{\alpha}{2}}}\right) = \left(\frac{500}{46.98}, \frac{500}{16.79}\right) = (10.64, 29.77)$$

1.4.2 95% Confidence Interval for the FR

$$Failure\ Rate = \frac{1}{Mean\ Life} = \left(\frac{1}{29.77}, \frac{1}{10.64}\right) = (.0336, .094)$$

1.4.3 90% Confidence Bounds for MTTR and FR

$$\chi^2_{2k+2,\frac{\alpha}{2}} = \chi^2(30, .05) = 18.49$$
$$\mu = \left(\frac{2 * T}{\chi^2_{2n,\frac{\alpha}{2}}}\right) = \left(\frac{20}{18.49}\right) = (1.08)$$
$$Failure\ Rate = \frac{1}{Mean\ Life} = \left(\frac{1}{1.08}\right) = (.9245)$$

As expected, the bounds for the truncated results are not the same as those of the for an entire trial but it is important to note that the confidence intervals for the truncated test after time 10 days were extremely close in comparison to the truncated data after 4 deaths. This assessment is fitting however, considering only 4 failures out of the full 35 makes for a difficult assessment.

Final Topic Conclusions of Study

A great deal of the data pointed towards the necessity of proper training of staff, more accurate or updated equipment, and a greater need for isolation space. Many of the cities are impoverished and overpopulated, contributing to the spread of the virus. Although training was increased and policy changes reacted to the study, it is clear that there are not enough resources being used effectively to support entire eradication of the virus. While continued quality assessment will help to further reduce the seemingly continuous spread of the virus, only Ebola specific medicines and a vaccine will completely remove the threat. The human aspect of quality is entirely too dynamic in this situation and even best practices have their limitations.