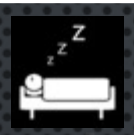
SLEEP IMPROVEMENT PROJECT SYRACUSE UNIVERSITY MBC638

JOHN FIELDS

15 MAR 2019

SLEEP IMPROVEMENT PROJECT
Process Owner: John Fields

Key Dates --->	Launch 1/2/19	Define 1/2/19 – 1/15/19	Measure 1/16/19 – 2/14/19	Analyze 2/15/19 – 2/22/19	Improve 2/23/19 – 3/6/19	Control 3/7/19-3/13/19



DEFINE

Problem

Insufficient sleep is causing decreased focus and retention of information for my graduate classes

Impact

Increasing sleep by 1 hour per night has been shown to increase test scores which would result in a higher starting salary after graduate school which would equate to ~$17,980 in increased income over the next 20 years

Result – The mean for my sleep in 2018 was 6.60 hours per night. The mean for my sleep during the measure phase of this project was 7.29 hours per night.

Goal – Increase Total Sleep per night from 7.29 to 7.60 hours (4% improvement)

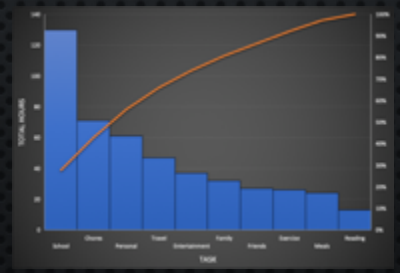
MEASURE

Data Collection (n=30)

(Y) Total Sleep Time = F (X1-Exercise, X2-Sleep Start, X3-Reading, X4-Friends, X5-Meals, X6-Personal, X7-Travel, X8-Entertainment, X9-Family, X10-School, X11-Day, X12-Chores)

Result

School, Chores and Personal time were the top categories for time spent over the 30 days that data was collected during the measure phase.



ANALYZE

Tools Utilized

Pareto, Box Plot, Scatter Plot, Regression, Correlation

Impact

Exercise and Sleep Start had the largest correlation with Sleep (Y). Sleep Start had the lowest P-value.

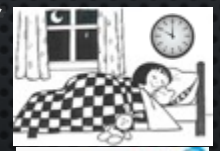
Correlation	
	Sleep
Sleep	1
Chores	-0.0846185
Personal	-0.0444781
Travel	-0.1381513
Entertainme	-0.0344234
Family	-0.2138632
Friends	0.14999761
Exercise	0.50098336
Meals	0.35347871
Reading	0.102583
School	-0.1035098
Sleep Start	-0.6972062
Weekend	0.24081385

Regression	*P-value*
Intercept	2.81336E-08
Exercise	0.00559556
Sleep Start	2.61908E-05

Result

Although, more time is spent on School, Chores and Personal Time, the analysis indicated a focus on going to bed earlier and increasing exercise would increase Total Sleep (Y).

$\hat{y} = 20.07 + .32x_1 - .55x_2$

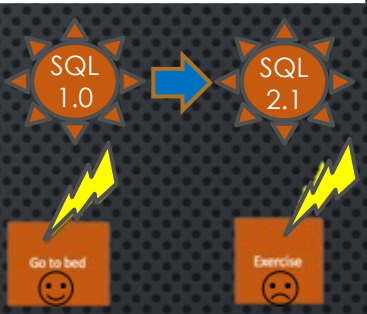


If sleep start mean = 11pm and exercise mean =1 hour per day, the mean predicted sleep from the regression formula is 7.74 hours

IMPROVE

Total Sleep Improved from 7.29 to 7.54 hours, but was this statistically significant?

- *Data Collection (n=12)*
- *Sample size > 7 was needed*



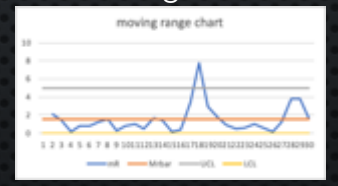
11:36 -> 11:00 .88 HR -> .65HR

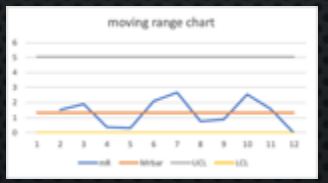
Although the mean time and SQL improved, a Two-Sample Hypothesis Test for Continuous Data had a p-value of .24. Using alpha = .05, sleep time did not increase a statistically significant amount so the Null Hypothesis m1>=m2 is not rejected

Ho: m1>=m2
Ha: m1<m2

CONTROL

A new control chart would be created to compare with the Measure (left) and Improve (right) to monitor the process during Control.



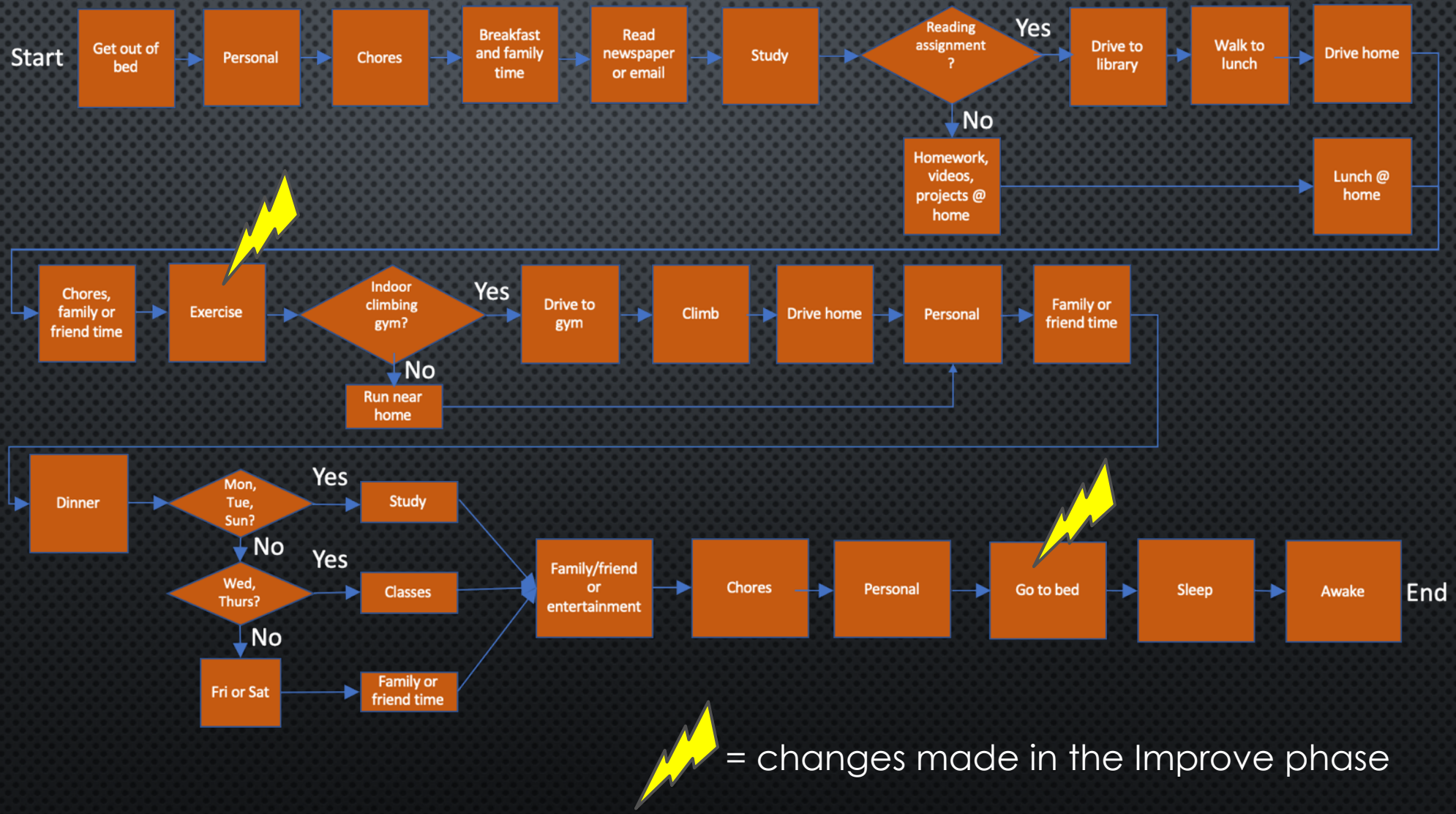


CONCLUSION

Although the Total Sleep (Y) mean was increased during the improve phase, the null hypothesis was not rejected due to only a 24% certainty in the hypothesis test. More data collection and analysis is needed to determine if the improvements were too small or the wrong X variables were selected.

SLEEP IMPROVEMENT PROJECT
Define - Process Map

- WHY – Creating a process map helps to visualize a process so you can have a clearer picture of how it works and find opportunities for improvement
- DEFINITION – Documenting the steps in a process provides visual examples of the flow of tasks, people, information and interdependencies
- RESULT– After the Analyze Phase, process changes were implemented to (1) increase the Exercise mean from .88 to 1 hour per day (2) decrease bedtime to a mean = 11pm



SLEEP IMPROVEMENT PROJECT
Measure - Data Measurement Plan

Measurement Error:

- An Apple iOS app called Hours was used to collect continuous data over a 24 hour period. During the Measure & Analyze Phases, an average of 23.7 hours of data was collected each day so .3 hours was missed
- For travel days away from home, there is additional error in the total sleep time and first fell asleep time due to having to manually track this rather than with the automated SleepTracker system at my home

Performance Measure	Data Type	Data Source and Location	How Will Data Be Collected	Who Will Collect Data	When Will Data Be Collected	Target Sample Size (aggregated by day)	Definition
Hours Sleeping	Continuous	SleepTracker app cloud	Automated via sensor	J. Fields	Daily	30	The duration of sleep each night
Hours Family	Continuous	Hours app cloud	Semi-automated via app on iPhone	J. Fields	Daily	30	Time spent with my spouse or children
Hours Chores	Continuous	Hours app cloud	Semi-automated via app on iPhone	J. Fields	Daily	30	Time spent doing housework, shopping, maintenance
Hours School	Continuous	Hours app cloud	Semi-automated via app on iPhone	J. Fields	Daily	30	Time spent studying or attending class
Hours Entertainment	Continuous	Hours app cloud	Semi-automated via app on iPhone	J. Fields	Daily	30	Time spent watching TV, listening to music
Hours Meals	Continuous	Hours app cloud	Semi-automated via app on iPhone	J. Fields	Daily	30	Time spent eating or preparing meals
Hours Personal	Continuous	Hours app cloud	Semi-automated via app on iPhone	J. Fields	Daily	30	Time spent for personal hygiene, dressing
Hours Travel	Continuous	Hours app cloud	Semi-automated via app on iPhone	J. Fields	Daily	30	Time spent in car/air travel
Hours Friends	Continuous	Hours app cloud	Semi-automated via app on iPhone	J. Fields	Daily	30	Time spent with friends
Hours Exercise	Continuous	Hours app cloud	Semi-automated via app on iPhone	J. Fields	Daily	30	Time spent exercising
Hours Reading	Continuous	Hours app cloud	Semi-automated via app on iPhone	J. Fields	Daily	30	Time spent for personal reading of newspapers, books, e-mail
Time First Fell Asleep	Continuous	SleepTracker app cloud	Automated via sensor	J. Fields	Daily	30	The time when sleep started each night
Weekend or Weekday	Discrete	Excel	Manually	J. Fields	Daily	30	Weekend or weekday for the day measured

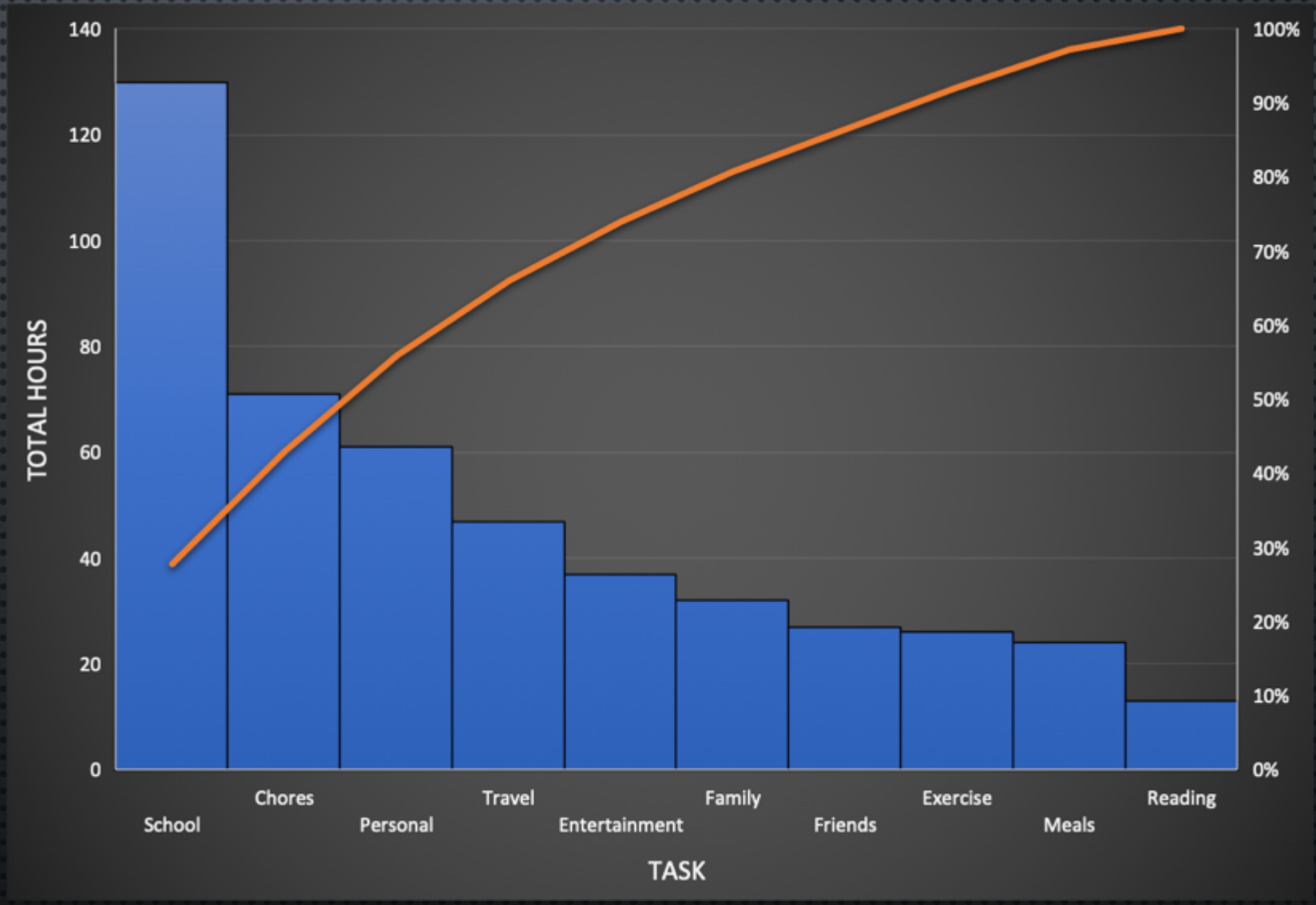
SLEEP IMPROVEMENT PROJECT
Analyze – Sigma Quality Level (SQL)

- WHY
  - SQL can be used to determine if a process is capable of meeting stakeholder requirements
- DEFINITION
  - SQL serves as an indicator of how often defects are likely to occur in processes, parts or products
- RESULT
  - A defect is defined as a night where the total sleep duration is less than 7.6 hours per night

	Before	After
Defect opportunities per unit	1	1
Units produced	30	12
Total possible defects	30	12
Total actual defects	21	3
Defect per opportunity rate	70%	25%
DPMO	700,000	250,000
SQL value	1.0	2.1

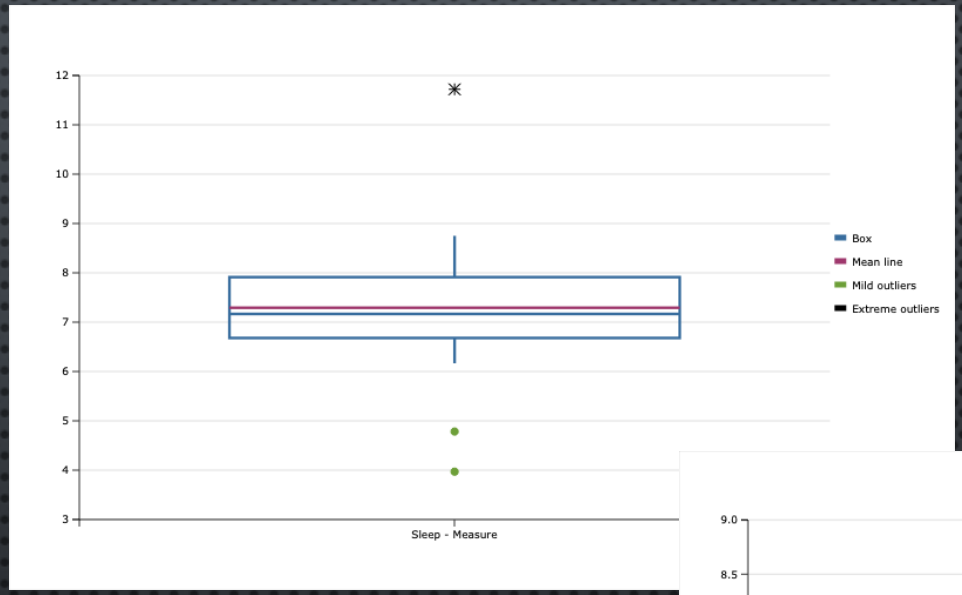
SLEEP IMPROVEMENT PROJECT
Analyze – Pareto Chart

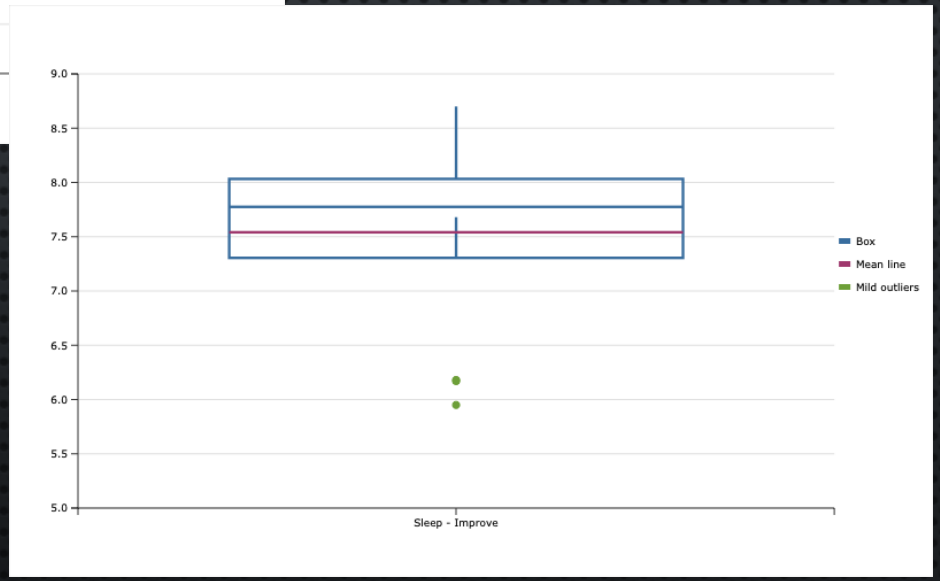
- WHY
  - A Pareto Chart shows the X variables as bars in decreasing order from left to right and the cumulative percent as a line
- DEFINITION
  - Pareto Principle: 20% of the sources cause 80% of the problem
- RESULT
  - The Pareto Chart helped to understand the distribution of time across the different X variables. However, it did not help to understand which X's had the biggest impact on Total Sleep (Y). Other statistical techniques would help to answer this question.



SLEEP IMPROVEMENT PROJECT
Analyze – Box & Whisker Plot

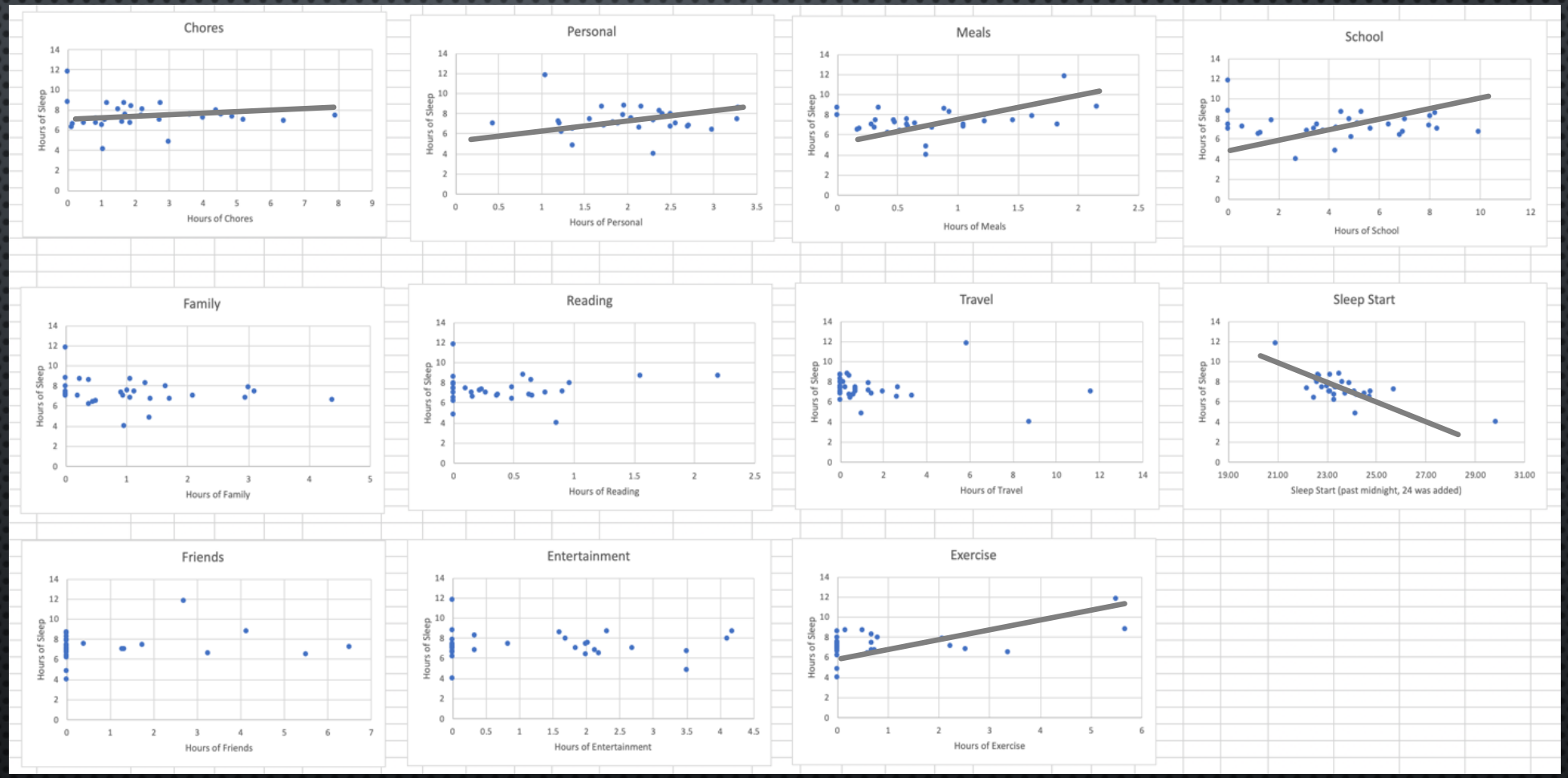
- WHY
  - A Box & Whisker plot was used to compare the medians and outliers from the Measure and Improve phases
- DEFINITION
  - A graphical tool to compare different medians and to show the variation in different groups of data
- RESULT
  - During the Measure phase, the mean and median lines were close to each other and there was one extreme outlier
  - During the Improve phase, the "box" shows more concentrated data values and the lower "whisker" is inside the box. There were no extreme outliers in this phase.





SLEEP IMPROVEMENT PROJECT
Analyze – Scatterplots

- WHY - A graphical representation was used to see if there is a relationship between the X's and Y (total sleep time)
- DEFINITION – A scatterplot is used to summarize the relationship between two quantitative variables that have been measured on the same element
- RESULT – The scatterplots for the X variables indicated a slight positive linear pattern for Chores, Personal, Meals, School and Exercise. Sleep Start showed a stronger negative relationship with two outliers.



SLEEP IMPROVEMENT PROJECT
Analyze – Multiple Linear Regression

- WHY – To understand the relationship between the process output (y) and the process inputs (x's) that could affect it
- DEFINITION
  - P = probability
  - Adjusted R Square = explains the variability
  - Multiple R = correlation coefficient
- RESULT
  - The multiple linear regression on all continuous X values shows that Sleep Start has the only low P-value
  - Exercise had a high P-value but was included in the second regression equation because it had a higher correlation (.5) as shown on the next slide
  - A second regression was performed with only Sleep Start and Exercise as X's and this resulted in the Regression formula shown
  - These two X's explain 59% of the variability (Adjusted R Square) and have 78% correlation (Multiple R). Since these values are lower than desired, a hypothesis test will be performed to validate the hypothesis below:
    - Ho: m1>=m2
    - Ha: m1<m2

Multiple Regression - All Except Weekend/Weekday

Regression Statistics	
Multiple R	0.862858156
R Square	0.744524198
Adjusted R Squa	0.588400096
Standard Error	0.853854599
Observations	30

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	11	38.2445359	3.47677599	4.768797331	0.001752155
Residual	18	13.1232182	0.72906768		
Total	29	51.3677541			

	Coefficients	Standard Err	t Stat	P-value
Intercept	22.51615098	3.47243877	6.48424709	0.0000
Chores	0.096978872	0.13057402	0.74271183	0.4672
Personal	0.234096898	0.31069814	0.75345446	0.4609
Travel	0.159039946	0.11101492	1.4325998	0.1691
Entertainment	0.089939685	0.14592963	0.61632231	0.5454
Family	0.017800597	0.18271773	0.09742129	0.9235
Friends	0.264601389	0.15526566	1.70418482	0.1055
Exercise	0.180515991	0.18262763	0.98843744	0.3360
Meals	0.405644288	0.36243488	1.11921978	0.2778
Reading	0.659639948	0.36142037	1.82513217	0.0846
School	0.037796177	0.13419027	0.28166108	0.7814
Sleep Start	-0.738005849	0.14128128	-5.2236635	0.0001

Multiple Regression - Exercise, Sleep Start

Regression Statistics	
Multiple R	0.784388808
R Square	0.615265802
Adjusted R Square	0.586766972
Standard Error	0.855546862
Observations	30

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	31.60482239	15.80241119	21.5891604	2.50998E-06
Residual	27	19.76293169	0.731960433		
Total	29	51.36775407			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	20.06989428	2.607799703	7.696102681	2.81336E-08	14.71913127
Exercise	0.315834029	0.104900548	3.010794846	0.00559556	0.100595884
Sleep Start	-0.551707615	0.109116128	-5.056150941	2.61908E-05	-0.775595416

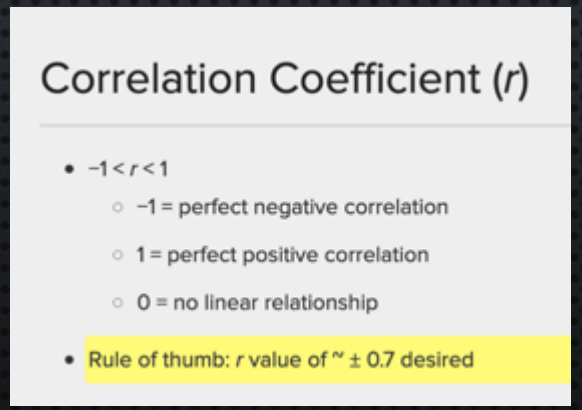
Regression Equation: $\hat{y} = 20.07 + .32x_1 - .55x_2$

X_1 = Exercise, X_2 = Sleep Start

SLEEP IMPROVEMENT PROJECT
Analyze – Correlation

- WHY – Correlation was used to determine the strength of the linear relationship between the X variables and Y
- DEFINITION – Correlation (R) is a measure of the strength and direction of the linear relationship. However, correlation by itself does not imply causation and other factors must be considered when using this tool.
- RESULT
  - Exercise had a positive correlation of .5
  - Sleep Start had a negative correlation of .7

Correlation													
	Sleep	*Chores*	*Personal*	*Travel*	*Entertainment*	*Family*	*Friends*	*Exercise*	*Meals*	*Reading*	*School*	*Sleep Start*	*Weekend*
Sleep	1												
Chores	-0.0846185	1											
Personal	-0.0444781	-0.0554263	1										
Travel	-0.1381513	-0.1684814	-0.4258616	1									
Entertainme	-0.0344234	-0.0402959	0.15632593	-0.3597041	1								
Family	-0.2138632	-0.0154391	0.3288527	-0.124628	-0.1580432	1							
Friends	0.14999761	-0.0448641	-0.4020727	0.18813373	-0.2160481	-0.1787061	1						
Exercise	0.50098336	-0.3560683	-0.1347337	0.1049668	-0.2677169	-0.1127451	0.42005082	1					
Meals	0.35347871	-0.0107273	-0.1607993	0.15328365	-0.3117448	-0.2671087	0.01491062	0.43535154	1				
Reading	0.102583	-0.0640852	0.11164708	-0.0896734	0.29047635	-0.2200051	-0.2452614	-0.0563395	-0.0676304	1			
School	-0.1035098	-0.2216249	0.5138637	-0.5494558	0.30567906	0.12404391	-0.6290375	-0.4302084	-0.2266357	0.10850959	1		
Sleep Start	-0.6972062	0.0448438	-0.1093214	0.48097667	-0.0778888	0.03857356	0.19570952	-0.2151418	-0.150019	0.06000688	-0.3092194	1	
Weekend	0.24081385	0.08600302	-0.1275527	0.12776646	-0.2317899	0.02420309	0.78335723	0.40610401	-0.0412334	-0.3605791	-0.5988005	0.01771241	1



SLEEP IMPROVEMENT PROJECT
Analyze - Sample Size

- WHY – Allows you to answer the question, "How many samples should I take?"
- DEFINITION –The sample size (n) for continuous data can be calculated if you know:
  - z* = the level of confidence you desire
  - $\hat{\sigma}$ = variability in the population
  - E= the margin of error
- RESULT
  - 7 samples would need to be collected to detect a change in total sleep time
  - 12 samples are planned to be collected during the improve stage which should provide a valid sample size

$$n = \left[\frac{z * \hat{\sigma}}{E}\right]^2$$

$z * @ 95\% \; confidence = 1.96$

$\hat{\sigma} = 1.33$

$E = 1$

$$n = \left[\frac{1.96 * 1.33}{1}\right]^2 = 6.8 \cong 7$$

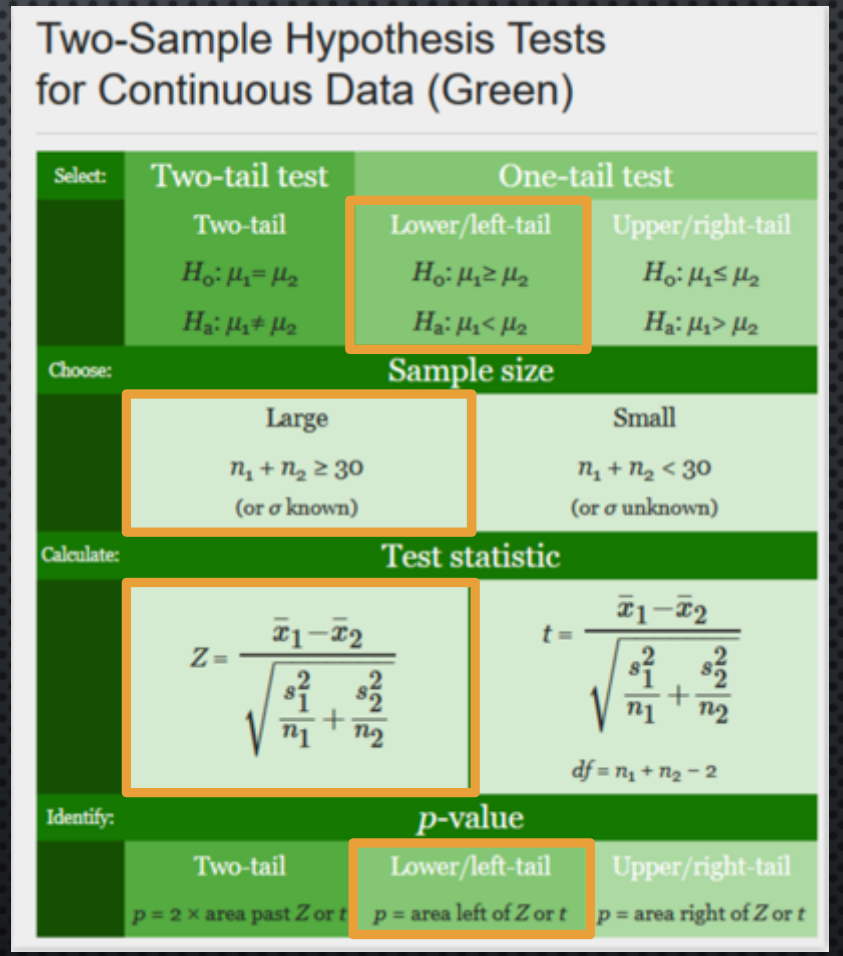
SLEEP IMPROVEMENT PROJECT
Improve –Descriptive Statistics & Hypothesis Testing

- WHY – Hypothesis testing uses statistics to tell us the probability that a hypothesis is true
- DEFINITION – The Hypothesis calculation determines the Z or t value. The probability (p-value)can then be looked up in a table and if this is below alpha (typically .05) then the Original Hypothesis (Ho) is null and the Alternative Hypothesis (Ha) is accepted as true
- RESULT
  - Hypothesis:
    - Ho: m1>=m2
    - Ha: m1<m2
    - m1 = mean total sleep in Measure
    - m2 = mean total sleep in Improve
  - Although the mean value for total sleep increased from 7.29 to 7.54 hours, there is not a statistical difference in the data sets since p=.25 which is higher than our alpha of p=.05
  - Therefore, Ho: m1>=m2 is not rejected

Descriptive Statistics - Measure 1	
Mean	7.292444444
Standard Error	0.242988468
Median	7.166666667
Mode	7.416666667
Standard Deviation	1.33090265
Sample Variance	1.771301865
Kurtosis	4.287269091
Skewness	0.655680663
Range	7.75
Minimum	3.97
Maximum	11.72
Sum	218.7733333
Count	30
	7.4701E+171

Descriptive Statistics - Improve 2	
Mean	7.540833333
Standard Error	0.268690591
Median	7.775
Mode	#N/A
Standard Deviation	0.930771511
Sample Variance	0.866335606
Kurtosis	-0.532514392
Skewness	-0.810052291
Range	2.75
Minimum	5.95
Maximum	8.7
Sum	90.49
Count	12
	7.4701E+171

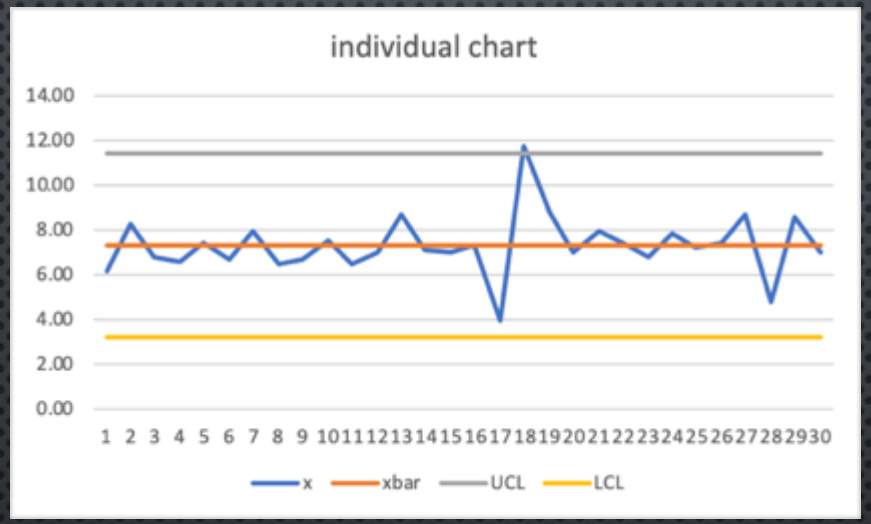
TWO SAMPLE HYPOTHESIS TEST FOR CONTINUOUS DATA (GREEN) n>=30, lower/left-tail
Ho: m1>=m2
Ha: m1<m2
Mean Process Time
X1 = 7.2924
X2 = 7.5408
Standard Deviation
S1 = 1.33090265
S2 = .930771511
Sample Size
N1 = 30
N2 = 12
Z=(7.2924-7.5408)/(SQRT((1.3309^2/30)+(0.9308^2/12)))
-0.685669479
p=.2483

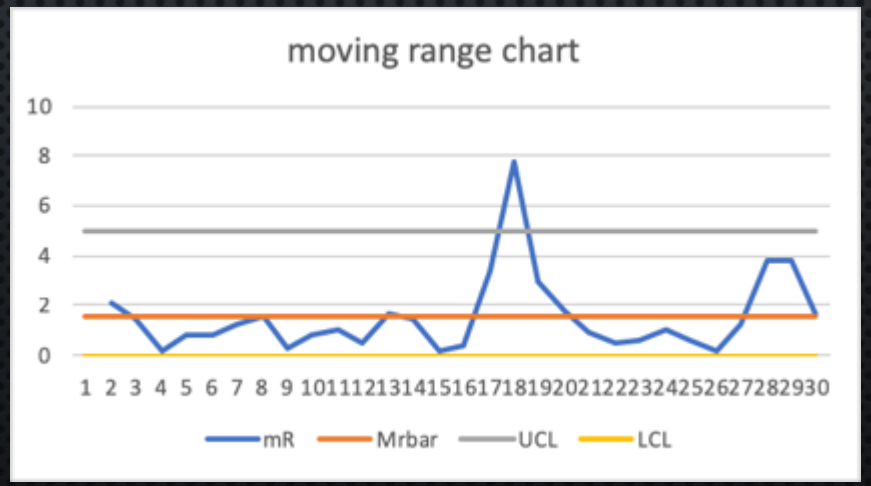


SLEEP IMPROVEMENT PROJECT
Control – Control Chart

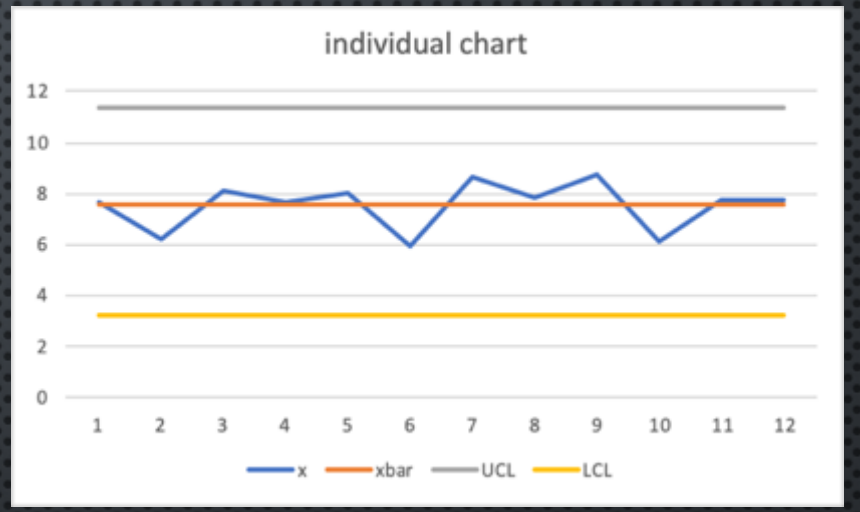
- WHY – Control charts show the variations in a process and allow you to visually see if a process is consistent and predictable
- DEFINITION – Control charts are a tool which calculates the moving range and individual x variables over time to see if these fall within the upper and lower control limits of a process
- RESULT
  - During the Measure Phase, the process was out of control on Day 18 when there was a significant change in the sleep pattern
  - During the Improve Phase, the process was under control and within the Upper and Lower Control limits

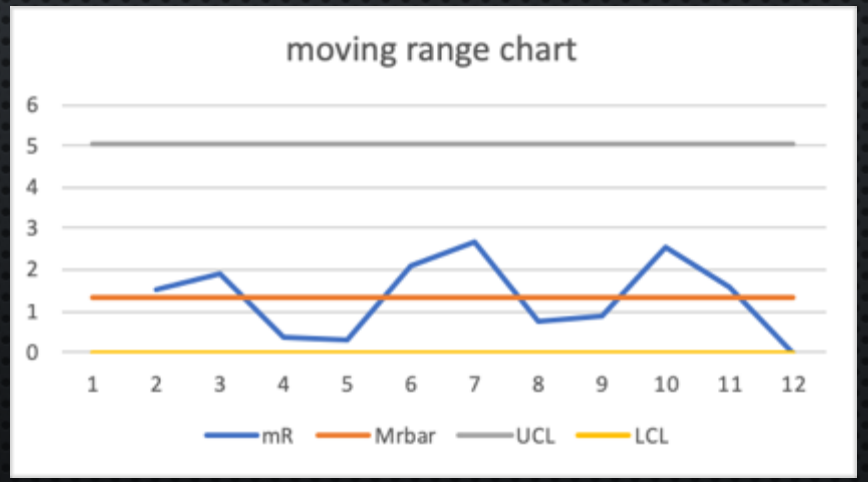
MEASURE PHASE





IMPROVE PHASE





SLEEP IMPROVEMENT PROJECT
Conclusion

- The goal for this project was to increase Total Sleep per night from 7.29 to 7.60 hours (4%)
- During the Analyze Phase, the regression/correlation analysis showed that Sleep Start and Exercise were the two X's that if changed could have the greatest impact on my Y (Total Sleep)
- By going to bed at a mean of 11pm and exercising 1 hour per day, the regression formula predicted that Total Sleep would increase from 7.29 to 7.74 hours per night
- During the Improve Phase, the Sleep Start mean improved from 11:36 to 11:00pm. Unfortunately, Exercise decreased during Improve from .88 to .65 hours per day.
- At the end of the Improve Phase, the mean for Total Sleep per night increased from 7.29 to 7.54 hours per night (3.4% increase). This was close to the goal of 7.60 hours (4% increase).
- When conducting a left-tail, two-sample hypothesis test, the p-value was .24 which was higher than my alpha value of .05. So, although there was an improvement in Total Sleep, we can not conclude with 95% certainty that the improvement was statistically significant.
- Ho: m1>=m2 is not rejected
  - m1=mean total sleep during Measure
  - m2=mean total sleep during Improve
- More data collection and analysis is needed to determine if the improvements were too small or the wrong X variables were selected during the Analyze phase