An Evaluation of Touch Points Created When Using Two Types of Glove Boxes

Nikita Shah, M.S.

Study Design

This non-blinded, non-randomized, simulated contamination, feasibility study that compares the surface area contamination that is generated on two types of glove boxes (SmartBoX versus Standard Box) following the removal of gloves by participants.

Project Objectives & Endpoints

Primary Objective: The purpose of this study was to characterize touch points on glove boxes as they relate to the area of contamination inside and outside of the glove boxes as measured by the percentage of area of contamination on the glove box surfaces.

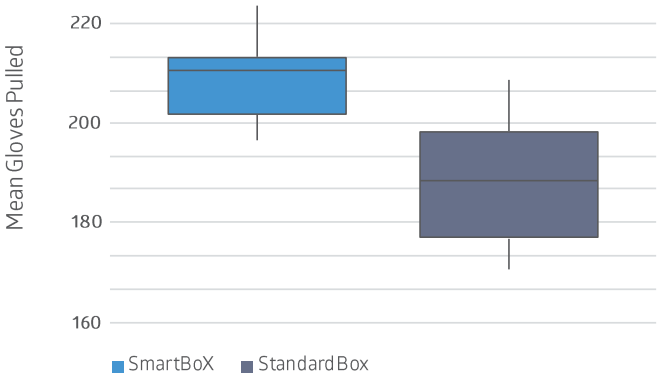
Primary Endpoint: The primary endpoints of this research study are to compare the mean number of gloves pulled, mean number of gloves lost, and number of contaminated boxes inside, outside, and total as well as contamination measured by the % area of contamination of the glove boxes.

Data Distribution

All analyses were conducted with 95% confidence in Rstudio (R Core Team (2022). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.)

The primary goal of this research study is to determine if the SmartBoX and Standard Box show a difference in mean gloves pulled, mean gloves lost, number of boxes contaminated (inside, outside, and total), and percent contamination (Inside, Outside and Total).

Graph 1. Mean Gloves Pulled for SmartBoX vs. Standard Box



Graph 2. Mean Gloves Lost for SmartBoX vs. Standard Box

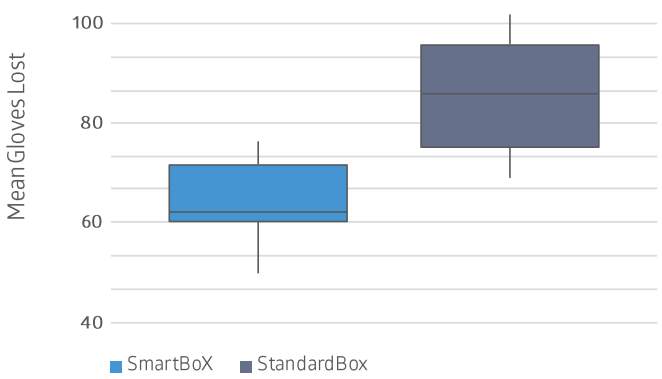
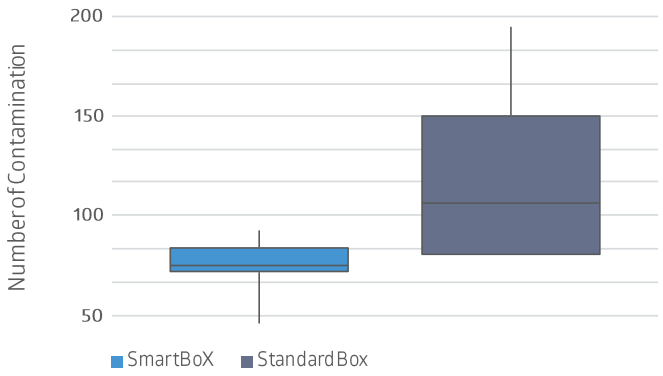


Table 1. Mean Gloves Pulled and Gloves Lost for SmartBoX vs. Standard Box

Measure	Group	N	Mean	Median	Standard Deviation	Minimum	Maxinum	Range
Gloves Lost	SmartBoX	15	48.20000	44	15.72169	25	86	61
Gloves Lost	Standard Box	15	77.86667	79	17.70338	53	103	50
Gloves Pulled	SmartBoX	15	201.80000	206	15.72169	164	225	61
Gloves Pulled	Standard Box	15	172.13333	171	17.70338	147	197	50

Descriptive statistics (Graph 1, Graph 2, Table 1) were employed to present mean values and distributions of the number of gloves pulled, number of gloves lost (calculated by 250 (total gloves in the box) - number of gloves pulled), number of contaminated boxes, percentage of area of contamination (inside and outside of boxes) and total contamination. A total of 15 participants for each box type were collected and participants pulled from the same box (15 groups). The calculation of gloves lost was determined by adding the total number of gloves pulled by all the participants using that box. SmartBox had more gloves pulled (mean = 201.8, sd = 15.72) than the Standard Box (mean = 172.13, sd = 17.7), and the Standard Box had more gloves lost (mean = 77.86, sd = 17.7) compared to SmartBoX (mean = 48.2, sd = 15.72). The Standard Box had a loss of 31.1% of gloves compared to Smart box which had a loss of 19.3%.

Graph 3. Number of Contaminated Boxes Inside



Graph 4. Percentage Contamination of Boxes Inside

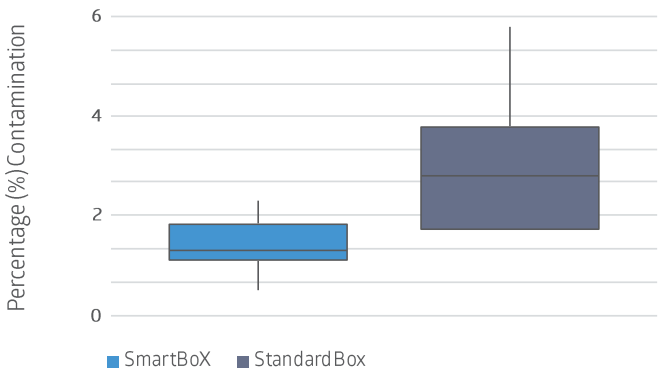
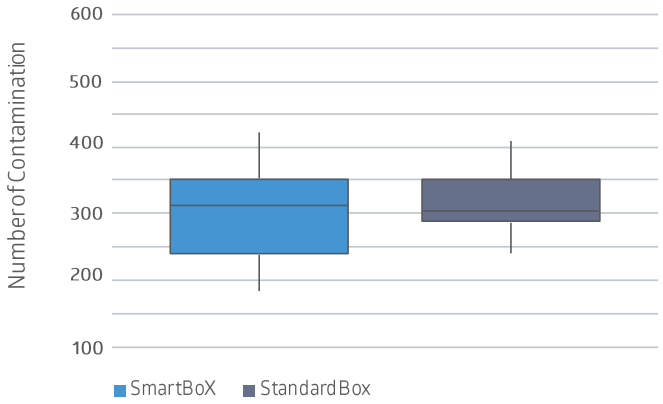


Table 2. Summary Statistics Inside the Box for SmartBox vs. Standard Box

Measure	Group	N	Mean	Median	Standard Deviation	Minimum	Maxinum	Range
Number of Boxes	SmartBoX	15	49.400000	47.000000	15.9050756	19.0000000	72.000000	17.500000
Number of Boxes	Standard Box	15	77.86667	79	17.70338	53	103	50
Percentage Area	SmartBoX	15	1.507937	1.434676	0.4855029	0.5799756	2.197802	0.534188
Percentage Area	Standard Box	15	2.961378	2.568022	1.4668891	1.6508713	5.900336	2.078875

In Graph 3 and Graph 4, and Table 2, the results are summarized for the number of boxes contaminated on the inside, and the percentage contamination. The Standard Box had 50% of the glove boxes fall within 84 boxes contaminated (IQR = 68, n= 15) and Smartbox had 50% of the boxes fall within 47 boxes contaminated (IQR = 17.5, n= 15). The Standard Box had 50% of the contamination fall within 2.56% (IQR = 2.07, n= 15) and Smartbox had 50% of the contamination fall within 1.43% (IQR = 17.5, n= 15). Here we see that the Standard Box had a larger median number of boxes contaminated and larger % contamination compared to SmartBox.

Graph 5. Number of Contaminated Boxes Outside



Graph 6. Percentage Contamination of Boxes Outside

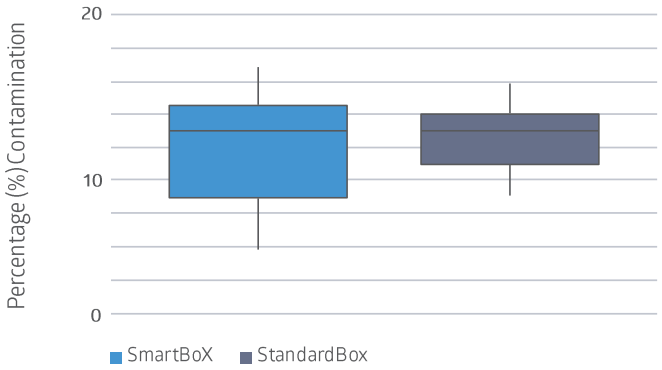
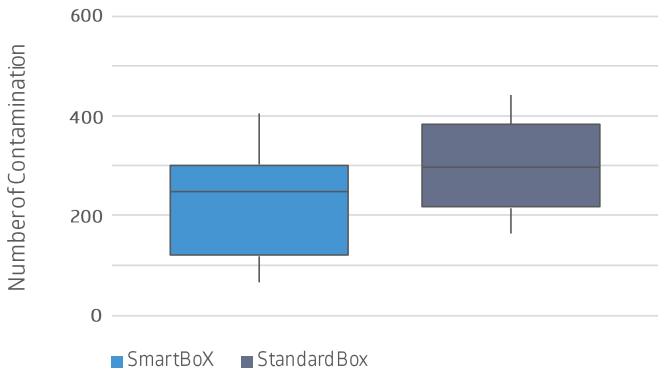


Table 3. Summary Statistics Outside the Box for SmartBox vs. Standard Box

Measure	Group	N	Mean	Median	Standard Deviation	Minimum	Maxinum	Range
Number of Boxes	SmartBoX	15	176.200000	204.000000	97.044320	40.000000	347.00000	160.500000
Number of Boxes	Standard Box	15	219.733333	199.000000	121.393967	98.000000	578.00000	86.500000
Percentage Area	SmartBoX	15	8.722772	10.099010	4.804174	1.980198	17.17822	7.945545
Percentage Area	Standard Box	15	10.734408	9.721544	5.930335	4.787494	28.23644	4.225696

In Graph 5 and Graph 6, and Table 3, the results are summarized for the number of boxes contaminated on the outside, and the percentage contamination. Here we see that the Standard Box had a larger number of boxes on average contaminated (SmartBoX = 176.0, Standard Box = 219.73) and the Standard Box larger % contamination (SmartBoX = 8.72% Standard Box= 10.73%) compared to SmartBox.

Graph 7. Number of Contaminated Boxes Total



Graph 8. Percentage Contamination of Boxes Total

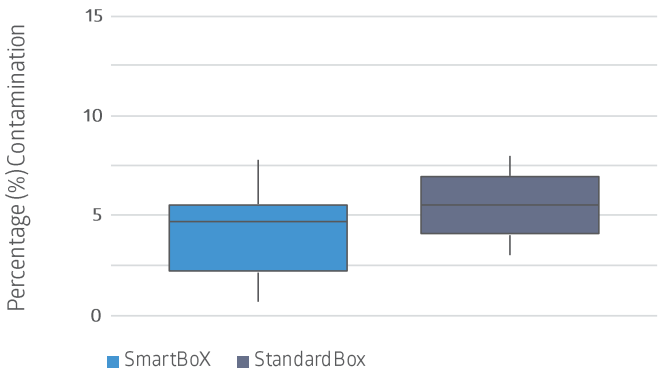


Table 4. Summary Statistics Total the Box for SmartBox vs. Standard Box

Measure	Group	N	Mean	Median	Standard Deviation	Minimum	Maxinum	Range
Number of Boxes	SmartBoX	15	225.600000	255.000000	105.379450	65.000000	405.000000	165.000000
Number of Boxes	Standard Box	15	316.600000	304.000000	145.914750	152.000000	727.000000	169.000000
Percentage Area	SmartBoX	15	4.814955	1.989793	1.227341	7.647281	3.115559	0.534188
Percentage Area	Standard Box	15	5.953366	5.716435	2.743790	2.858217	13.670553	3.177886

In Graph 7 and Graph 8, and Table 4, the results are summarized for the number of boxes contaminated on the outside, and the % contamination. The Standard Box had 50% of the glove boxes fall within 304 boxes contaminated (IQR = 169, n= 15) and Smart box had 50% of the boxes fall within 255 boxes contaminated (IQR = 165, n= 15). The Standard Box had 50% of the contamination fall within 5.7% (IQR = 3.17, n= 15) and Smartbox had 50% of the contamination fall within 4.81% (IQR = 3.11, n= 15). Here we see that the Standard Box had a larger median number of boxes contaminated and larger % contamination compared to Smart Box.

Statistical Results

The Paired T-Test was used to determine if there was a true difference in mean gloves pulled and gloves lost and The Wilcoxon Signed-Rank Test was used to determine if there was a true difference in the median gloves pulled, gloves lost, number of boxes contaminated (inside, outside, and total), and percent contamination (inside, outside, and total). Since the contamination dataset (number of boxes and % contamination) was not normally distributed and variances were not equal, a Wilcoxon Signed-Rank test, a non-parametric test to compare the paired median values is most appropriate across all 6 contamination comparisons for SmartBoX vs. Standard Box.

Table 5 below displays the results of the Paired T-Test for the Number of gloves pulled and Table 6 displays the results of number of gloves lost for both products. The p-value was found to be less than alpha = .05 at .0000739. This indicates that there is a true difference between the number of gloves pulled and the number of gloves lost for both SmartBoX and the Standard Box. We can conclude that the Standard Box lost an average of 11.8% more gloves from Smartbox (reversely SmartboX lost an average of 11.8% fewer gloves from the Standard Box) (Calculations shown in Figure 1).

Gloves lost calculation: The total number gloves in each box type is 250

250—(1st set of gloves pulled by Person 1 + 2nd set of gloves pulled by Person 2) = Gloves lost

SmartBoX:
Average gloves pulled from SmartBoX were 201

$\frac{250-201.8}{250} \times 100 = 19.3\%$ Gloves lost

Standard Box:
Average gloves pulled from Standard Box were 172.1

$\frac{250-172.1}{250} \times 100 = 31.1\%$ Gloves lost

31.1% — 19.3% = 11.8% Gloves lost difference between the boxes

	Regular glove box	SmartBoX	Savings
Size of glove box	250 gloves	250 gloves	—
Average number of gloves wasted	77.9 gloves	48.2 gloves	29.7 gloves
Percentage of box trashed	31.1%	19.3%	11.8%

Percentage difference from average number of wasted gloves

$\frac{48.2-77.9}{77.9} \times 100 = 38.1\%$ Reduction in waste per gloves

Percentage difference from average number of wasted gloves

$\frac{19.3\%-31.1\%}{31.1\%} \times 100 = 37.9$ Reduction in percent waste

Figure 1. Calculation of Gloves Pulled and Lost Comparison

Table 5. Paired T-Test of Gloves Pulled Comparison

	Result
Test-Statistic	5.5320220
P-Value	0.0000739

Table 6. Paired T-Test of Gloves Lost Comparison

	Result
Test-Statistic	-5.5320220
P-Value	0.0000739

Table 7 below displays the results of the Wilcoxon Signed-Rank test for the number of boxes contaminated on the inside and Table 8 displays the results of the percentage (%) contamination on the inside between the SmartBoX and the Standard Box. The p-value was found to be less than alpha = .05 at .0006104. This indicates that there is a true difference between the SmartBoX and the Standard Box. We can conclude that the Standard Box had a relative median percent (%) difference of 44% more contamination inside compared to Smartbox. (Calculation shown in Figure 2).

Figure 2. Relative Percent Difference Inside the Box Comparison

Contamination inside the box

$$\frac{\text{2.56\% Standard Box} - \text{1.43\% SmartBoX}}{\text{2.56\% Standard Box}} \times 100 = 44\% \text{ Difference in contamination}$$

Table 7. Wilcoxon Test of Number of Contaminated Boxes Inside

	Result
Test-Statistic	5.0000000
P-Value	0.0006104

Table 8. Wilcoxon Test of Percentage Contaminated Boxes Inside

	Result
Test-Statistic	5.0000000
P-Value	0.0006104

Table 9 below displays the results of the Wilcoxon Signed-Rank test for the number of boxes contaminated on the outside and Table 10 displays the results of the percentage (%) contamination on the inside between the SmartBoX and the Standard Box. The p-value was found to be greater than alpha = .05 at .083252 for the number of boxes and .1069 for the % contamination. This indicates that there is not a true difference between the SmartBoX and the Standard Box hence a relative percent difference was not calculated.

Table 9. Wilcoxon Test of Number of Contaminated Boxes Outside

	Result
Test-Statistic	29.000000
P-Value	0.083252

Table 10. Wilcoxon Test of % of Contaminated Boxes Outside

	Result
Test-Statistic	31.0000000
P-Value	0.1069946

Table 11 below displays the results of the Wilcoxon Signed-Rank test for the number of boxes contaminated on the total and Table 12 displays the results of the percentage (%) contamination altogether between the SmartBoX and the Standard Box. The p-value was found to be less than alpha = .05 at .0327 for the number of boxes and .0302 for the % contamination. This indicates that there is a true difference between the number of gloves pulled and the number of gloves lost for both SmartBoX and the Standard Box. We can conclude that the Standard Box had a median percent (%) difference of 15.7% more contamination total compared to Smartbox (Calculation in Figure 3)

Figure 3. Relative Percent Difference Comparison

Contamination inside the box

$$\frac{5.71\%\ \text{Standard Box} - 4.81\%\ \text{SmartBoX}}{5.71\%\ \text{Standard Box}} \times 100 = 15.7\%\ \text{Difference in contamination}$$

Table 11. Wilcoxon Test of Number of Contaminated Boxes Total

	Result
Test-Statistic	18.000000
P-Value	0.032767

Table 12. Wilcoxon Test of Percentage of Contaminated Boxes Total

	Result
Test-Statistic	22.0000000
P-Value	0.0301514

Summary and Conclusions

In reference to the primary objective of this research study, there is a significant difference between SmartBoX and the Standard Box in mean gloves pulled and mean gloves lost, median number of boxes contaminated (Inside and Total), and median percent contamination (Inside and Total). We can conclude SmartboX lost an average of 11.8% fewer gloves from the Standard Box. We can conclude that the Standard Box had a median percent (%) difference of 44% more contamination on the inside and 15.7% more contamination total compared to Smartbox. We can also conclude that there is not a significant difference in % contamination from the outside between SmartBoX and the Standard Box.

Appendix

Raw Data for Gloves Pulled and Gloves Lost:

Table 13. Raw Data for Gloves Pulled, SmartBox vs. Standard Box

Group No.	Box Type	Glove Count	Group No.	Box Type	Glove Count
1	SmartBox	193	1	Standard Box	179
2	SmartBox	209	2	Standard Box	196
3	SmartBox	200	3	Standard Box	196
4	SmartBox	191	4	Standard Box	155
5	SmartBox	209	5	Standard Box	197
6	SmartBox	206	6	Standard Box	150
7	SmartBox	191	7	Standard Box	157
8	SmartBox	223	8	Standard Box	156
9	SmartBox	196	9	Standard Box	171
10	SmartBox	164	10	Standard Box	165
11	SmartBox	225	11	Standard Box	182
12	SmartBox	186	12	Standard Box	165
13	SmartBox	217	13	Standard Box	194
14	SmartBox	210	14	Standard Box	147
15	SmartBox	207	15	Standard Box	172

Table 14. Raw Data for Gloves Lost, SmartBox vs. Standard Box

Group No.	Box Type	Glove Count	Group No.	Box Type	Glove Count
1	SmartBox	57	1	Standard Box	71
2	SmartBox	41	2	Standard Box	54
3	SmartBox	50	3	Standard Box	54
4	SmartBox	59	4	Standard Box	95
5	SmartBox	41	5	Standard Box	53
6	SmartBox	44	6	Standard Box	100
7	SmartBox	59	7	Standard Box	93
8	SmartBox	27	8	Standard Box	94
9	SmartBox	54	9	Standard Box	79
10	SmartBox	86	10	Standard Box	85
11	SmartBox	25	11	Standard Box	68
12	SmartBox	64	12	Standard Box	85
13	SmartBox	33	13	Standard Box	56
14	SmartBox	40	14	Standard Box	103
15	SmartBox	43	15	Standard Box	78

Table15. Raw Data for Contamination Inside SmartBoX vs. Standard Box

Group No.	Box Type	No. of Grid Boxes Contaminated	Percentage Area Contamination
1	SmartBoX	47	1.4346764
2	SmartBoX	44	1.3431013
3	SmartBoX	25	0.7631258
4	SmartBoX	51	1.5567766
5	SmartBoX	35	1.0683761
6	SmartBoX	43	1.3125763
7	SmartBoX	64	1.9536020
8	SmartBoX	19	0.5799756
9	SmartBoX	55	1.6788767
10	SmartBoX	70	2.1367521
11	SmartBoX	72	2.1978022
12	SmartBoX	58	1.7704518
13	SmartBoX	44	1.3431013
14	SmartBoX	44	1.3431013
15	SmartBoX	70	2.1367521

Group No.	Box Type	No. of Grid Boxes Contaminated	Percentage Area Contamination
1	Standard Box	60	1.8343014
2	Standard Box	56	1.7120147
3	Standard Box	54	1.6508713
4	Standard Box	182	5.5640477
5	Standard Box	57	1.7425864
6	Standard Box	87	2.6597371
7	Standard Box	112	3.4240293
8	Standard Box	137	4.1883216
9	Standard Box	54	1.6508713
10	Standard Box	56	1.7120147
11	Standard Box	193	5.9003363
12	Standard Box	149	4.5551819
13	Standard Box	67	2.0483033
14	Standard Box	84	2.5680220
15	Standard Box	105	3.2100275

Table16. Raw Data for Contamination Outside SmartBoX vs. Standard Boxbox

Group No.	Box Type	No. of Grid Boxes Contaminated	Percentage Area Contamination
1	SmartBoX	101	5.000000
2	SmartBoX	67	3.316832
3	SmartBoX	40	1.980198
4	SmartBoX	204	10.099010
5	SmartBoX	239	11.831683
6	SmartBoX	66	3.267327
7	SmartBoX	240	11.881188
8	SmartBoX	50	2.475248
9	SmartBoX	240	11.881188
10	SmartBoX	275	13.613861
11	SmartBoX	105	5.198020
12	SmartBoX	347	17.178218
13	SmartBoX	250	12.376238
14	SmartBoX	249	12.326733
15	SmartBoX	170	8.415842

Group No.	Box Type	No. of Grid Boxes Contaminated	Percentage Area Contamination
1	Standard Box	155	7.572057
2	Standard Box	133	6.497313
3	Standard Box	98	4.787494
4	Standard Box	181	8.842208
5	Standard Box	102	4.982902
6	Standard Box	129	6.301905
7	Standard Box	323	15.779189
8	Standard Box	199	9.721544
9	Standard Box	241	11.773327
10	Standard Box	178	8.695652
11	Standard Box	218	10.649731
12	Standard Box	578	28.236444
13	Standard Box	339	16.560821
14	Standard Box	220	10.747435
15	Standard Box	202	9.868100

Table 17. Raw Data for Contamination Total SmartBoX vs. Standard Box

Group No.	Box Type	No. of Grid Boxes Contaminated	Percentage Area Contamination
1	SmartBoX	148	2.794562
2	SmartBoX	111	2.095922
3	SmartBoX	65	1.227341
4	SmartBoX	255	4.814955
5	SmartBoX	274	5.173716
6	SmartBoX	109	2.058157
7	SmartBoX	304	5.740181
8	SmartBoX	69	1.302870
9	SmartBoX	295	5.570242
10	SmartBoX	345	6.514350
11	SmartBoX	177	3.342145
12	SmartBoX	405	7.647281
13	SmartBoX	294	5.551360
14	SmartBoX	293	5.532477
15	SmartBoX	240	4.531722

Group No.	Box Type	No. of Grid Boxes Contaminated	Percentage Area Contamination
1	Standard Box	215	4.042873
2	Standard Box	189	3.553968
3	Standard Box	152	2.858217
4	Standard Box	363	6.825874
5	Standard Box	159	2.989846
6	Standard Box	216	4.061677
7	Standard Box	435	8.179767
8	Standard Box	336	6.318165
9	Standard Box	295	5.547198
10	Standard Box	234	4.400150
11	Standard Box	411	7.728469
12	Standard Box	727	13.670553
13	Standard Box	406	7.634449
14	Standard Box	304	5.716435
15	Standard Box	307	5.772847

Scan to learn more