MANOVA outlier assessment

2022-08-18

library(tidyverse)

## ── Attaching packages ─────────────────────────────────────── tidyverse 1.3.2 ──  
## ✔ ggplot2 3.3.6 ✔ purrr 0.3.4  
## ✔ tibble 3.1.8 ✔ dplyr 1.0.9  
## ✔ tidyr 1.2.0 ✔ stringr 1.4.0  
## ✔ readr 2.1.2 ✔ forcats 0.5.1  
## ── Conflicts ────────────────────────────────────────── tidyverse\_conflicts() ──  
## ✖ dplyr::filter() masks stats::filter()  
## ✖ dplyr::lag() masks stats::lag()

library(readxl)  
library(flextable)

##   
## Attaching package: 'flextable'  
##   
## The following object is masked from 'package:purrr':  
##   
## compose

library(extrafont)

## Registering fonts with R

library(writexl)  
library(rstatix)

##   
## Attaching package: 'rstatix'  
##   
## The following object is masked from 'package:stats':  
##   
## filter

#times new roman tables  
my\_ft\_theme <- function(ft, ...) {  
 # Remove vertical cell padding  
 ft <- padding(ft, padding.top = 0, padding.bottom = 0, part = "all")  
   
 # Change font to TNR 11  
 ft <- font(ft, fontname = "Times New Roman", part = "all")  
 ft <- fontsize(ft, part = "all", size = 12)  
 ft  
}

#remove identifiers and demographic data  
  
headscan\_full<-read\_excel("C:\\Users\\19177\\OneDrive - Colostate\\Desktop\\Dissertation\\headscan\_dissertation\\headscan\_full.xlsx")  
  
headscan\_full$AA\_C <- headscan\_full$AA\_C \*10  
headscan\_full$BGl\_C <- headscan\_full$BGl\_C \* 10  
headscan\_full$BiW\_C <- headscan\_full$BiW\_C \*10  
headscan\_full$BiW\_L <- headscan\_full$BiW\_L \*10  
headscan\_full$ChCh\_C <- headscan\_full$ChCh\_C \*10  
headscan\_full$GoSub\_C <- headscan\_full$GoSub\_C \*10  
headscan\_full$NRB\_L <- headscan\_full$NRB\_L \*10  
headscan\_full$ProA\_L <- headscan\_full$ProA\_L \*10  
headscan\_full$ProA\_C <- headscan\_full$ProA\_C \*10  
headscan\_full$ProS\_C <- headscan\_full$ProS\_C \*10  
headscan\_full$ProS\_L <- headscan\_full$ProS\_L \*10  
headscan\_full$SelP\_C <- headscan\_full$SelP\_C \*10  
headscan\_full$SelP\_L <- headscan\_full$SelP\_L \*10  
headscan\_full$SelDH\_C <- headscan\_full$SelDH\_C \*10  
headscan\_full$SelM\_L <- headscan\_full$SelM\_L \*10  
headscan\_full$SnasM\_C <- headscan\_full$SnasM\_C \*10  
headscan\_full$SmanM\_C <- headscan\_full$SmanM\_C \*10  
headscan\_full$SmanM\_L <- headscan\_full$SmanM\_L \*10  
headscan\_full$SnasM\_L <- headscan\_full$SnasM\_L \*10  
headscan\_full$TrHO\_C <- headscan\_full$TrHO\_C \*10  
headscan\_full$TrEJ\_C <- headscan\_full$TrEJ\_C \*10  
headscan\_full$TrGo\_C <- headscan\_full$TrGo\_C \*10  
headscan\_full$TrSel\_C <- headscan\_full$TrSel\_C \*10  
headscan\_full$TrSman\_C <- headscan\_full$TrSman\_C \*10  
headscan\_full$TrSnas\_C <- headscan\_full$TrSnas\_C \*10  
headscan\_full$TrTr\_C <- headscan\_full$TrTr\_C \*10  
headscan\_full$TrTr\_L <- headscan\_full$TrTr\_L \*10  
  
headscan\_full$gender <- as.factor(headscan\_full$gender)  
headscan\_full$race\_eth <- as.factor(headscan\_full$race\_eth)  
headscan\_full$age\_group <- as.factor(headscan\_full$age\_group)  
  
str(headscan\_full)

## tibble [2,016 × 33] (S3: tbl\_df/tbl/data.frame)  
## $ ID : chr [1:2016] "400-20201012-002" "400-20201012-003" "400-20201012-004" "400-20201012-005" ...  
## $ AA\_C : num [1:2016] 65 55 70 58 67 60 59 59 65 65 ...  
## $ BGl\_C : num [1:2016] 315 289 293 313 288 306 320 NA 300 277 ...  
## $ BiW\_C : num [1:2016] 130 127 143 140 137 130 141 138 143 150 ...  
## $ BiW\_L : num [1:2016] 115 108 121 109 104 106 109 111 113 116 ...  
## $ ChCh\_C : num [1:2016] 62 64 68 70 70 70 67 69 67 63 ...  
## $ GoSub\_C : num [1:2016] 93 93 115 93 103 100 79 106 85 102 ...  
## $ NRB\_L : num [1:2016] 17 18 19 21 19 14 17 18 16 17 ...  
## $ ProA\_L : num [1:2016] 28 25 31 23 28 28 26 27 32 28 ...  
## $ ProA\_C : num [1:2016] 31 27 33 27 31 29 27 29 34 31 ...  
## $ ProS\_C : num [1:2016] 18 20 14 13 22 22 19 14 26 24 ...  
## $ ProS\_L : num [1:2016] 17 18 14 13 20 20 18 12 24 22 ...  
## $ SelP\_C : num [1:2016] 42 41 51 45 47 48 46 42 47 44 ...  
## $ SelP\_L : num [1:2016] 42 41 51 44 47 48 46 41 46 44 ...  
## $ SelDH\_C : num [1:2016] 15 9 9 11 13 15 9 9 12 14 ...  
## $ SelM\_L : num [1:2016] 122 99 130 115 119 126 117 112 117 117 ...  
## $ SnasM\_C : num [1:2016] 82 55 84 74 73 80 78 76 64 75 ...  
## $ SmanM\_C : num [1:2016] 59 51 45 43 33 34 55 37 61 41 ...  
## $ SmanM\_L : num [1:2016] 55 50 45 42 33 34 50 36 59 40 ...  
## $ SnasM\_L : num [1:2016] 75 53 78 69 67 76 69 71 62 69 ...  
## $ TrHO\_C : num [1:2016] 179 163 169 166 159 162 169 NA 167 166 ...  
## $ TrEJ\_C : num [1:2016] 40 32 39 29 46 42 29 32 29 33 ...  
## $ TrGo\_C : num [1:2016] 84 57 70 61 68 70 75 61 67 64 ...  
## $ TrSel\_C : num [1:2016] 149 138 150 133 140 151 140 138 156 143 ...  
## $ TrSman\_C : num [1:2016] 177 145 178 147 157 164 149 159 151 160 ...  
## $ TrSnas\_C : num [1:2016] 163 142 167 145 152 157 148 149 157 NA ...  
## $ TrTr\_C : num [1:2016] 296 276 292 273 279 300 283 275 307 286 ...  
## $ TrTr\_L : num [1:2016] 155 141 156 149 146 146 147 151 157 144 ...  
## $ coder : chr [1:2016] "Kayna" "Kayna" "Kayna" "Kayna" ...  
## $ age : num [1:2016] 31 49 49 34 49 55 26 18 25 27 ...  
## $ gender : Factor w/ 4 levels "Female","Male",..: 2 1 2 2 2 2 2 2 2 2 ...  
## $ race\_eth : Factor w/ 8 levels "AIAN","Asian",..: 3 8 8 8 8 8 3 3 8 8 ...  
## $ age\_group: Factor w/ 3 levels "18-36","37-54",..: 1 2 2 1 2 3 1 1 1 1 ...

SA3\_data <- headscan\_full[c(1,2,4,5,7,8,12,14,16,17,25,27,28,31,32,33)]

SA3\_NAsums <- colSums(is.na(SA3\_data))  
  
SA3\_NAprops <- colMeans(is.na(SA3\_data))  
  
SA3\_NAprops1 <- as.data.frame(SA3\_NAprops)  
SA3\_NAprops1 <- rownames\_to\_column(SA3\_NAprops1, "var\_name")  
SA3\_NAprops1 <- SA3\_NAprops1 %>% slice(-c(1, 29:33))  
  
SA3\_NAsums1 <- as.data.frame(SA3\_NAsums)  
SA3\_NAsums1 <- rownames\_to\_column(SA3\_NAsums1, "var\_name")  
SA3\_NAsums1 <- SA3\_NAsums1 %>% slice(-c(1, 29:33))  
  
SA3\_NAs <- inner\_join(SA3\_NAprops1, SA3\_NAsums1, by = "var\_name", desc)  
  
SA3\_NAs$SA3\_NAprops<- round(SA3\_NAs$SA3\_NAprops, digits=4)  
  
SA3\_NAs$var\_name <- fct\_reorder(SA3\_NAs$var\_name, SA3\_NAs$SA3\_NAsums, .desc=TRUE)  
  
str(SA3\_NAs$SA3\_name)

## NULL

#Size 12 Table TNR  
flextable(SA3\_NAs) %>%  
 my\_ft\_theme()%>%   
 bold(part = "header") %>%   
 set\_caption("NA values for each MANOVA Variable") %>%   
 autofit() %>%   
 set\_header\_labels(values = list(var\_name = "Variable",  
 SA3\_NAprops = "Proportion of NA values",  
 SA3\_NAsums = "Count of NA values"))

**Table** : NA values for each MANOVA Variable

| **Variable** | **Proportion of NA values** | **Count of NA values** |
| --- | --- | --- |
| AA\_C | 0.0084 | 17 |
| BiW\_C | 0.0084 | 17 |
| BiW\_L | 0.0084 | 17 |
| GoSub\_C | 0.0630 | 127 |
| NRB\_L | 0.0074 | 15 |
| ProS\_L | 0.0094 | 19 |
| SelP\_L | 0.0074 | 15 |
| SelM\_L | 0.1111 | 224 |
| SnasM\_C | 0.1171 | 236 |
| TrSman\_C | 0.0655 | 132 |
| TrTr\_C | 0.0188 | 38 |
| TrTr\_L | 0.0169 | 34 |
| gender | 0.0040 | 8 |
| race\_eth | 0.0000 | 0 |
| age\_group | 0.0005 | 1 |

SA3\_data1 <- SA3\_data  
  
#race/eth  
SA3\_data1$race\_eth <-   
 recode\_factor(SA3\_data1$race\_eth, 'AIAN'= "Other",  
 'NHOPI' = "Other",  
 'PTNS' = "Other")  
  
#gender  
SA3\_data1$gender <-   
 recode\_factor(SA3\_data1$gender, 'Non-binary or Other'= "Other",  
 'Prefer not to say' = "Other")  
  
SA3\_data1$gender[is.na(SA3\_data1$gender)]="Other"  
  
  
summary(SA3\_data1)

## ID AA\_C BiW\_C BiW\_L   
## Length:2016 Min. :44.00 Min. :101.0 Min. : 82.0   
## Class :character 1st Qu.:57.00 1st Qu.:124.0 1st Qu.:104.0   
## Mode :character Median :61.00 Median :133.0 Median :111.0   
## Mean :61.25 Mean :133.4 Mean :111.2   
## 3rd Qu.:65.00 3rd Qu.:141.0 3rd Qu.:118.0   
## Max. :87.00 Max. :188.0 Max. :152.0   
## NA's :17 NA's :17 NA's :17   
## GoSub\_C NRB\_L ProS\_L SelP\_L   
## Min. : 45.00 Min. : 3.00 Min. :12.00 Min. :16.00   
## 1st Qu.: 88.00 1st Qu.:15.00 1st Qu.:17.00 1st Qu.:42.00   
## Median : 99.00 Median :18.00 Median :19.00 Median :44.00   
## Mean : 99.05 Mean :17.98 Mean :19.16 Mean :44.53   
## 3rd Qu.:108.00 3rd Qu.:21.00 3rd Qu.:21.00 3rd Qu.:47.00   
## Max. :424.00 Max. :72.00 Max. :42.00 Max. :65.00   
## NA's :127 NA's :15 NA's :19 NA's :15   
## SelM\_L SnasM\_C TrSman\_C TrTr\_C   
## Min. : 69.0 Min. : 44.0 Min. : 64.0 Min. :241.0   
## 1st Qu.:110.0 1st Qu.: 68.0 1st Qu.:143.0 1st Qu.:272.2   
## Median :116.0 Median : 75.0 Median :152.0 Median :282.0   
## Mean :116.2 Mean : 75.1 Mean :153.4 Mean :282.7   
## 3rd Qu.:123.0 3rd Qu.: 82.0 3rd Qu.:162.0 3rd Qu.:293.0   
## Max. :145.0 Max. :163.0 Max. :298.0 Max. :332.0   
## NA's :224 NA's :236 NA's :132 NA's :38   
## TrTr\_L gender race\_eth age\_group   
## Min. :127.0 Other : 14 Other : 38 18-36:991   
## 1st Qu.:141.0 Female:1063 Asian : 91 37-54:940   
## Median :146.0 Male : 939 Black : 548 55-72: 84   
## Mean :146.5 LatinX: 100 NA's : 1   
## 3rd Qu.:152.0 white :1239   
## Max. :173.0   
## NA's :34

#Dr. Erin Buchanan from Missouri State If there were missing data categories over 20%, I could replace the data? According to manova-9 notes

Otherwise, it seems like I have to delete the missing values. I did this for PCA as well.

SA3\_data2 <- SA3\_data1 %>% drop\_na()  
  
sum(is.na(SA3\_data1))

## [1] 892

2016-1710

## [1] 306

#306 observations were deleted when we dropped NAs. That is not bad considering there are 892 missing values

str(SA3\_data2)

## tibble [1,710 × 16] (S3: tbl\_df/tbl/data.frame)  
## $ ID : chr [1:1710] "400-20201012-002" "400-20201012-003" "400-20201012-004" "400-20201012-005" ...  
## $ AA\_C : num [1:1710] 65 55 70 58 67 60 59 59 65 65 ...  
## $ BiW\_C : num [1:1710] 130 127 143 140 137 130 141 138 143 150 ...  
## $ BiW\_L : num [1:1710] 115 108 121 109 104 106 109 111 113 116 ...  
## $ GoSub\_C : num [1:1710] 93 93 115 93 103 100 79 106 85 102 ...  
## $ NRB\_L : num [1:1710] 17 18 19 21 19 14 17 18 16 17 ...  
## $ ProS\_L : num [1:1710] 17 18 14 13 20 20 18 12 24 22 ...  
## $ SelP\_L : num [1:1710] 42 41 51 44 47 48 46 41 46 44 ...  
## $ SelM\_L : num [1:1710] 122 99 130 115 119 126 117 112 117 117 ...  
## $ SnasM\_C : num [1:1710] 82 55 84 74 73 80 78 76 64 75 ...  
## $ TrSman\_C : num [1:1710] 177 145 178 147 157 164 149 159 151 160 ...  
## $ TrTr\_C : num [1:1710] 296 276 292 273 279 300 283 275 307 286 ...  
## $ TrTr\_L : num [1:1710] 155 141 156 149 146 146 147 151 157 144 ...  
## $ gender : Factor w/ 3 levels "Other","Female",..: 3 2 3 3 3 3 3 3 3 3 ...  
## $ race\_eth : Factor w/ 5 levels "Other","Asian",..: 3 5 5 5 5 5 3 3 5 5 ...  
## $ age\_group: Factor w/ 3 levels "18-36","37-54",..: 1 2 2 1 2 3 1 1 1 1 ...

Next, identify univariate outliers

#AA\_C  
AA\_C\_out <- SA3\_data2 %>%   
 identify\_outliers(AA\_C)  
  
AA\_C\_out$extreme\_overall <- AA\_C\_out$is.extreme  
  
AA\_C\_out <- AA\_C\_out[c(1,2,19)]  
  
  
  
AA\_C\_out1 <- SA3\_data2 %>%   
 group\_by(race\_eth) %>%   
 identify\_outliers(AA\_C)  
  
AA\_C\_out1$extreme\_race\_eth <- AA\_C\_out1$is.extreme  
  
AA\_C\_out1 <- AA\_C\_out1[c(2,3,19)]  
  
  
  
  
AA\_C\_out2 <- SA3\_data2 %>%   
 group\_by(gender) %>%   
 identify\_outliers(AA\_C)  
  
AA\_C\_out2$extreme\_gender <- AA\_C\_out2$is.extreme  
  
AA\_C\_out2 <- AA\_C\_out2[c(2,3,19)]  
  
  
  
AA\_C\_out3 <- SA3\_data2 %>%   
 group\_by(age\_group) %>%   
 identify\_outliers(AA\_C)  
  
AA\_C\_out3$extreme\_age <- AA\_C\_out3$is.extreme  
  
AA\_C\_out3 <- AA\_C\_out3[c(2,3,19)]  
  
  
AA\_C\_extreme <- full\_join(AA\_C\_out, AA\_C\_out1, by=c('ID', 'AA\_C'))  
AA\_C\_extreme <- full\_join(AA\_C\_extreme, AA\_C\_out2, by=c('ID', 'AA\_C'))  
AA\_C\_extreme <- full\_join(AA\_C\_extreme, AA\_C\_out3, by=c('ID', 'AA\_C'))  
  
AA\_C\_extreme <-   
 filter(AA\_C\_extreme,   
 extreme\_overall == "TRUE" |   
 extreme\_race\_eth == "TRUE" |  
 extreme\_gender == "TRUE" |  
 extreme\_age == "TRUE" )  
  
  
AA\_C\_extreme$extreme\_overall <- as.character(AA\_C\_extreme$extreme\_overall)  
AA\_C\_extreme$extreme\_race\_eth <- as.character(AA\_C\_extreme$extreme\_race\_eth)  
AA\_C\_extreme$extreme\_gender <- as.character(AA\_C\_extreme$extreme\_gender)  
AA\_C\_extreme$extreme\_age <- as.character(AA\_C\_extreme$extreme\_age)  
   
AA\_C\_extreme[is.na(AA\_C\_extreme)]="Not Outlier"  
  
#Size 12 Table TNR  
flextable(AA\_C\_extreme) %>%  
 my\_ft\_theme()%>%   
 bold(part = "header") %>%   
 set\_caption("AA\_C Extreme Outliers (mean=61.25mm)")

**Table** : AA\_C Extreme Outliers (mean=61.25mm)

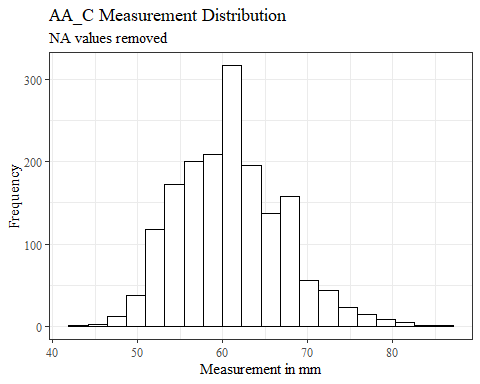
| **ID** | **AA\_C** | **extreme\_overall** | **extreme\_race\_eth** | **extreme\_gender** | **extreme\_age** |
| --- | --- | --- | --- | --- | --- |
| 400-20201012-012 | 45 | Not Outlier | TRUE | Not Outlier | Not Outlier |

#%>% set\_header\_labels(values = list(AA\_C = "Alare/AlareCont"))  
  
#Autofit Width Table TNR  
flextable(AA\_C\_extreme) %>%  
 my\_ft\_theme()%>%   
 bold(part = "header") %>%   
 set\_caption("AA\_C Extreme Outliers (mean=61.25mm)") %>%   
 fit\_to\_width(7.5) %>%   
 autofit

**Table** : AA\_C Extreme Outliers (mean=61.25mm)

| **ID** | **AA\_C** | **extreme\_overall** | **extreme\_race\_eth** | **extreme\_gender** | **extreme\_age** |
| --- | --- | --- | --- | --- | --- |
| 400-20201012-012 | 45 | Not Outlier | TRUE | Not Outlier | Not Outlier |

#%>% set\_header\_labels(values = list(AA\_C = "Alare/AlareCont"))  
  
ggplot(data=SA3\_data2, aes(x=AA\_C))+  
 geom\_bar(stat="bin", bins=20, color= "black", fill = "white")+  
 theme\_bw() + theme(text=element\_text(family= "Times New Roman"))+  
 labs(title="AA\_C Measurement Distribution",  
 subtitle = "NA values removed",  
 y="Frequency",  
 x="Measurement in mm")



#BiW\_C  
BiW\_C\_out <- SA3\_data2 %>%   
 identify\_outliers(BiW\_C)  
  
BiW\_C\_out$extreme\_overall <- BiW\_C\_out$is.extreme  
  
BiW\_C\_out <- BiW\_C\_out[c(1,3,19)]  
  
  
  
BiW\_C\_out1 <- SA3\_data2 %>%   
 group\_by(race\_eth) %>%   
 identify\_outliers(BiW\_C)  
  
BiW\_C\_out1$extreme\_race\_eth <- BiW\_C\_out1$is.extreme  
  
BiW\_C\_out1 <- BiW\_C\_out1[c(2,4,19)]  
  
  
  
  
BiW\_C\_out2 <- SA3\_data2 %>%   
 group\_by(gender) %>%   
 identify\_outliers(BiW\_C)  
  
BiW\_C\_out2$extreme\_gender <- BiW\_C\_out2$is.extreme  
  
BiW\_C\_out2 <- BiW\_C\_out2[c(2,4,19)]  
  
  
  
BiW\_C\_out3 <- SA3\_data2 %>%   
 group\_by(age\_group) %>%   
 identify\_outliers(BiW\_C)  
  
BiW\_C\_out3$extreme\_age <- BiW\_C\_out3$is.extreme  
  
BiW\_C\_out3 <- BiW\_C\_out3[c(2,4,19)]  
  
  
BiW\_C\_extreme <- full\_join(BiW\_C\_out, BiW\_C\_out1, by=c('ID', 'BiW\_C'))  
BiW\_C\_extreme <- full\_join(BiW\_C\_extreme, BiW\_C\_out2, by=c('ID', 'BiW\_C'))  
BiW\_C\_extreme <- full\_join(BiW\_C\_extreme, BiW\_C\_out3, by=c('ID', 'BiW\_C'))  
  
BiW\_C\_extreme <-   
 filter(BiW\_C\_extreme,   
 extreme\_overall == "TRUE" |   
 extreme\_race\_eth == "TRUE" |  
 extreme\_gender == "TRUE" |  
 extreme\_age == "TRUE" )  
  
  
BiW\_C\_extreme$extreme\_overall <- as.character(BiW\_C\_extreme$extreme\_overall)  
BiW\_C\_extreme$extreme\_race\_eth <- as.character(BiW\_C\_extreme$extreme\_race\_eth)  
BiW\_C\_extreme$extreme\_gender <- as.character(BiW\_C\_extreme$extreme\_gender)  
BiW\_C\_extreme$extreme\_age <- as.character(BiW\_C\_extreme$extreme\_age)  
   
BiW\_C\_extreme[is.na(BiW\_C\_extreme)]="Not Outlier"  
  
  
#Size 12 Table TNR  
flextable(BiW\_C\_extreme) %>%  
 my\_ft\_theme()%>%   
 bold(part = "header") %>%   
 set\_caption("BiW\_C Extreme Outliers (mean=133.4mm)")

**Table** : BiW\_C Extreme Outliers (mean=133.4mm)

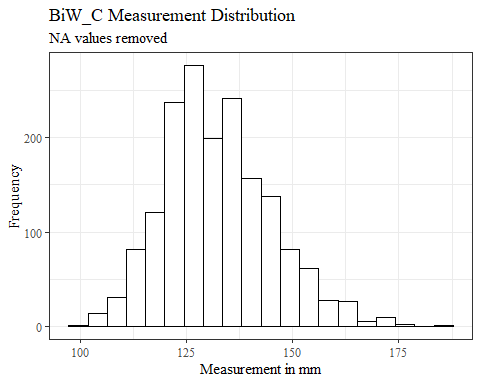
| **ID** | **BiW\_C** | **extreme\_overall** | **extreme\_race\_eth** | **extreme\_gender** | **extreme\_age** |
| --- | --- | --- | --- | --- | --- |
| 400-20210108-006 | 187 | FALSE | FALSE | TRUE | FALSE |

#%>% set\_header\_labels(values = list(BiW\_C = "Alare/AlareCont"))  
  
#Autofit Width Table TNR  
flextable(BiW\_C\_extreme) %>%  
 my\_ft\_theme()%>%   
 bold(part = "header") %>%   
 set\_caption("BiW\_C Extreme Outliers (mean=133.4mm)") %>%   
 fit\_to\_width(7.5)

**Table** : BiW\_C Extreme Outliers (mean=133.4mm)

| **ID** | **BiW\_C** | **extreme\_overall** | **extreme\_race\_eth** | **extreme\_gender** | **extreme\_age** |
| --- | --- | --- | --- | --- | --- |
| 400-20210108-006 | 187 | FALSE | FALSE | TRUE | FALSE |

#%>% set\_header\_labels(values = list(BiW\_C = "Alare/AlareCont"))  
  
ggplot(data=SA3\_data2, aes(x=BiW\_C))+  
 geom\_bar(stat="bin", bins=20, color= "black", fill = "white")+  
 theme\_bw() + theme(text=element\_text(family= "Times New Roman"))+  
 labs(title="BiW\_C Measurement Distribution",  
 subtitle = "NA values removed",  
 y="Frequency",  
 x="Measurement in mm")



#BiW\_L  
BiW\_L\_out <- SA3\_data2 %>%   
 identify\_outliers(BiW\_L)  
  
BiW\_L\_out$extreme\_overall <- BiW\_L\_out$is.extreme  
  
BiW\_L\_out <- BiW\_L\_out[c(1,4,19)]  
  
  
  
BiW\_L\_out1 <- SA3\_data2 %>%   
 group\_by(race\_eth) %>%   
 identify\_outliers(BiW\_L)  
  
BiW\_L\_out1$extreme\_race\_eth <- BiW\_L\_out1$is.extreme  
  
BiW\_L\_out1 <- BiW\_L\_out1[c(2,5,19)]  
  
  
  
  
BiW\_L\_out2 <- SA3\_data2 %>%   
 group\_by(gender) %>%   
 identify\_outliers(BiW\_L)  
  
BiW\_L\_out2$extreme\_gender <- BiW\_L\_out2$is.extreme  
  
BiW\_L\_out2 <- BiW\_L\_out2[c(2,5,19)]  
  
  
  
BiW\_L\_out3 <- SA3\_data2 %>%   
 group\_by(age\_group) %>%   
 identify\_outliers(BiW\_L)  
  
BiW\_L\_out3$extreme\_age <- BiW\_L\_out3$is.extreme  
  
BiW\_L\_out3 <- BiW\_L\_out3[c(2,5,19)]  
  
  
BiW\_L\_extreme <- full\_join(BiW\_L\_out, BiW\_L\_out1, by=c('ID', 'BiW\_L'))  
BiW\_L\_extreme <- full\_join(BiW\_L\_extreme, BiW\_L\_out2, by=c('ID', 'BiW\_L'))  
BiW\_L\_extreme <- full\_join(BiW\_L\_extreme, BiW\_L\_out3, by=c('ID', 'BiW\_L'))  
  
BiW\_L\_extreme <-   
 filter(BiW\_L\_extreme,   
 extreme\_overall == "TRUE" |   
 extreme\_race\_eth == "TRUE" |  
 extreme\_gender == "TRUE" |  
 extreme\_age == "TRUE" )  
  
  
BiW\_L\_extreme$extreme\_overall <- as.character(BiW\_L\_extreme$extreme\_overall)  
BiW\_L\_extreme$extreme\_race\_eth <- as.character(BiW\_L\_extreme$extreme\_race\_eth)  
BiW\_L\_extreme$extreme\_gender <- as.character(BiW\_L\_extreme$extreme\_gender)  
BiW\_L\_extreme$extreme\_age <- as.character(BiW\_L\_extreme$extreme\_age)  
   
BiW\_L\_extreme[is.na(BiW\_L\_extreme)]="Not Outlier"  
  
  
#Size 12 Table TNR  
flextable(BiW\_L\_extreme) %>%  
 my\_ft\_theme()%>%   
 bold(part = "header") %>%   
 set\_caption("BiW\_L Extreme Outliers (mean=111.2mm)")

**Table** : BiW\_L Extreme Outliers (mean=111.2mm)

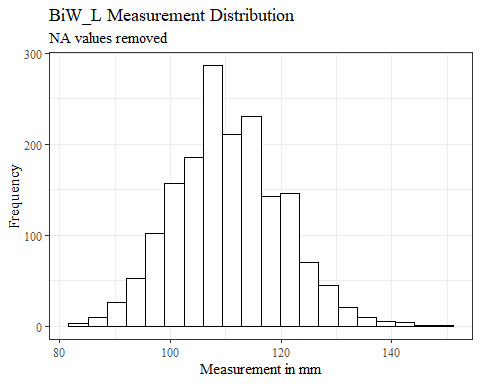
| **ID** | **BiW\_L** | **extreme\_overall** | **extreme\_race\_eth** | **extreme\_gender** | **extreme\_age** |
| --- | --- | --- | --- | --- | --- |

#%>% set\_header\_labels(values = list(BiW\_L = "Alare/AlareCont"))  
  
#Autofit Width Table TNR  
flextable(BiW\_L\_extreme) %>%  
 my\_ft\_theme()%>%   
 bold(part = "header") %>%   
 set\_caption("BiW\_L Extreme Outliers (mean=111.2mm)") %>%   
 fit\_to\_width(7.5)

**Table** : BiW\_L Extreme Outliers (mean=111.2mm)

| **ID** | **BiW\_L** | **extreme\_overall** | **extreme\_race\_eth** | **extreme\_gender** | **extreme\_age** |
| --- | --- | --- | --- | --- | --- |

#%>% set\_header\_labels(values = list(BiW\_L = "Alare/AlareCont"))  
  
ggplot(data=SA3\_data2, aes(x=BiW\_L))+  
 geom\_bar(stat="bin", bins=20, color= "black", fill = "white")+  
 theme\_bw() + theme(text=element\_text(family= "Times New Roman"))+  
 labs(title="BiW\_L Measurement Distribution",  
 subtitle = "NA values removed",  
 y="Frequency",  
 x="Measurement in mm")



#GoSub\_C  
GoSub\_C\_out <- SA3\_data2 %>%   
 identify\_outliers(GoSub\_C)  
  
GoSub\_C\_out$extreme\_overall <- GoSub\_C\_out$is.extreme  
  
GoSub\_C\_out <- GoSub\_C\_out[c(1,5,19)]  
  
  
  
GoSub\_C\_out1 <- SA3\_data2 %>%   
 group\_by(race\_eth) %>%   
 identify\_outliers(GoSub\_C)  
  
GoSub\_C\_out1$extreme\_race\_eth <- GoSub\_C\_out1$is.extreme  
  
GoSub\_C\_out1 <- GoSub\_C\_out1[c(2,6,19)]  
  
  
  
  
GoSub\_C\_out2 <- SA3\_data2 %>%   
 group\_by(gender) %>%   
 identify\_outliers(GoSub\_C)  
  
GoSub\_C\_out2$extreme\_gender <- GoSub\_C\_out2$is.extreme  
  
GoSub\_C\_out2 <- GoSub\_C\_out2[c(2,6,19)]  
  
  
  
GoSub\_C\_out3 <- SA3\_data2 %>%   
 group\_by(age\_group) %>%   
 identify\_outliers(GoSub\_C)  
  
GoSub\_C\_out3$extreme\_age <- GoSub\_C\_out3$is.extreme  
  
GoSub\_C\_out3 <- GoSub\_C\_out3[c(2,6,19)]  
  
  
GoSub\_C\_extreme <- full\_join(GoSub\_C\_out, GoSub\_C\_out1, by=c('ID', 'GoSub\_C'))  
GoSub\_C\_extreme <- full\_join(GoSub\_C\_extreme, GoSub\_C\_out2, by=c('ID', 'GoSub\_C'))  
GoSub\_C\_extreme <- full\_join(GoSub\_C\_extreme, GoSub\_C\_out3, by=c('ID', 'GoSub\_C'))  
  
GoSub\_C\_extreme <-   
 filter(GoSub\_C\_extreme,   
 extreme\_overall == "TRUE" |   
 extreme\_race\_eth == "TRUE" |  
 extreme\_gender == "TRUE" |  
 extreme\_age == "TRUE" )  
  
GoSub\_C\_extreme$extreme\_overall <- as.character(GoSub\_C\_extreme$extreme\_overall)  
GoSub\_C\_extreme$extreme\_race\_eth <- as.character(GoSub\_C\_extreme$extreme\_race\_eth)  
GoSub\_C\_extreme$extreme\_gender <- as.character(GoSub\_C\_extreme$extreme\_gender)  
GoSub\_C\_extreme$extreme\_age <- as.character(GoSub\_C\_extreme$extreme\_age)  
  
GoSub\_C\_extreme[is.na(GoSub\_C\_extreme)]="Not Outlier"   
  
#Size 12 Table TNR  
flextable(GoSub\_C\_extreme) %>%  
 my\_ft\_theme()%>%   
 bold(part = "header") %>%   
 set\_caption("GoSub\_C Extreme Outliers (mean=99.05mm)")

**Table** : GoSub\_C Extreme Outliers (mean=99.05mm)

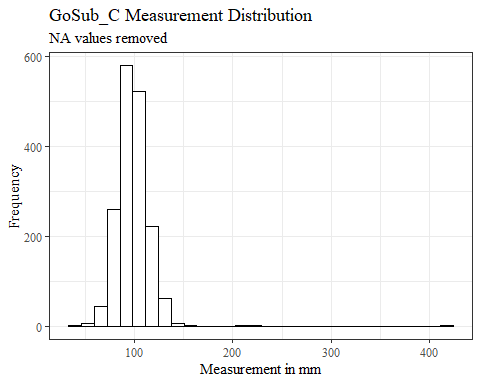
| **ID** | **GoSub\_C** | **extreme\_overall** | **extreme\_race\_eth** | **extreme\_gender** | **extreme\_age** |
| --- | --- | --- | --- | --- | --- |
| 400-20201203-004 | 208 | TRUE | TRUE | TRUE | TRUE |
| 400-20210216-006 | 217 | TRUE | TRUE | TRUE | TRUE |
| 400-20210129-009 | 424 | TRUE | TRUE | TRUE | TRUE |

#%>% set\_header\_labels(values = list(GoSub\_C = "Alare/AlareCont"))  
  
#Autofit Width Table TNR  
flextable(GoSub\_C\_extreme) %>%  
 my\_ft\_theme()%>%   
 bold(part = "header") %>%   
 set\_caption("GoSub\_C Extreme Outliers (mean=99.05mm)") %>%   
 fit\_to\_width(7.5) %>%   
 autofit

**Table** : GoSub\_C Extreme Outliers (mean=99.05mm)

| **ID** | **GoSub\_C** | **extreme\_overall** | **extreme\_race\_eth** | **extreme\_gender** | **extreme\_age** |
| --- | --- | --- | --- | --- | --- |
| 400-20201203-004 | 208 | TRUE | TRUE | TRUE | TRUE |
| 400-20210216-006 | 217 | TRUE | TRUE | TRUE | TRUE |
| 400-20210129-009 | 424 | TRUE | TRUE | TRUE | TRUE |

#%>% set\_header\_labels(values = list(GoSub\_C = "Alare/AlareCont"))  
  
ggplot(data=SA3\_data2, aes(x=GoSub\_C))+  
 geom\_bar(stat="bin", bins=30, color= "black", fill = "white")+  
 theme\_bw() + theme(text=element\_text(family= "Times New Roman"))+  
 labs(title="GoSub\_C Measurement Distribution",  
 subtitle = "NA values removed",  
 y="Frequency",  
 x="Measurement in mm")



#NRB\_L  
NRB\_L\_out <- SA3\_data2 %>%   
 identify\_outliers(NRB\_L)  
  
NRB\_L\_out$extreme\_overall <- NRB\_L\_out$is.extreme  
  
NRB\_L\_out <- NRB\_L\_out[c(1,6,19)]  
  
  
  
NRB\_L\_out1 <- SA3\_data2 %>%   
 group\_by(race\_eth) %>%   
 identify\_outliers(NRB\_L)  
  
NRB\_L\_out1$extreme\_race\_eth <- NRB\_L\_out1$is.extreme  
  
NRB\_L\_out1 <- NRB\_L\_out1[c(2,7,19)]  
  
  
  
  
NRB\_L\_out2 <- SA3\_data2 %>%   
 group\_by(gender) %>%   
 identify\_outliers(NRB\_L)  
  
NRB\_L\_out2$extreme\_gender <- NRB\_L\_out2$is.extreme  
  
NRB\_L\_out2 <- NRB\_L\_out2[c(2,7,19)]  
  
  
  
NRB\_L\_out3 <- SA3\_data2 %>%   
 group\_by(age\_group) %>%   
 identify\_outliers(NRB\_L)  
  
NRB\_L\_out3$extreme\_age <- NRB\_L\_out3$is.extreme  
  
NRB\_L\_out3 <- NRB\_L\_out3[c(2,7,19)]  
  
  
NRB\_L\_extreme <- full\_join(NRB\_L\_out, NRB\_L\_out1, by=c('ID', 'NRB\_L'))  
NRB\_L\_extreme <- full\_join(NRB\_L\_extreme, NRB\_L\_out2, by=c('ID', 'NRB\_L'))  
NRB\_L\_extreme <- full\_join(NRB\_L\_extreme, NRB\_L\_out3, by=c('ID', 'NRB\_L'))  
  
NRB\_L\_extreme <-   
 filter(NRB\_L\_extreme,   
 extreme\_overall == "TRUE" |   
 extreme\_race\_eth == "TRUE" |  
 extreme\_gender == "TRUE" |  
 extreme\_age == "TRUE" )  
  
NRB\_L\_extreme$extreme\_overall <- as.character(NRB\_L\_extreme$extreme\_overall)  
NRB\_L\_extreme$extreme\_race\_eth <- as.character(NRB\_L\_extreme$extreme\_race\_eth)  
NRB\_L\_extreme$extreme\_gender <- as.character(NRB\_L\_extreme$extreme\_gender)  
NRB\_L\_extreme$extreme\_age <- as.character(NRB\_L\_extreme$extreme\_age)  
  
  
NRB\_L\_extreme[is.na(NRB\_L\_extreme)]="Not Outlier"   
  
#Size 12 Table TNR  
flextable(NRB\_L\_extreme) %>%  
 my\_ft\_theme()%>%   
 bold(part = "header") %>%   
 set\_caption("NRB\_L Extreme Outliers (mean=17.98mm)")

**Table** : NRB\_L Extreme Outliers (mean=17.98mm)

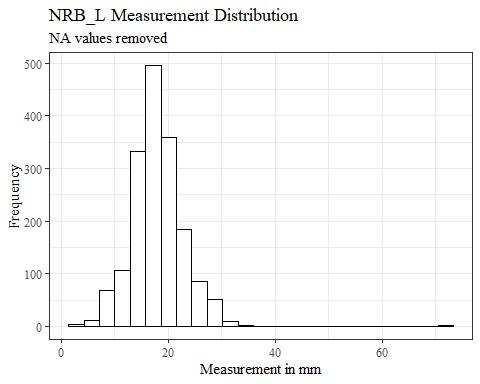
| **ID** | **NRB\_L** | **extreme\_overall** | **extreme\_race\_eth** | **extreme\_gender** | **extreme\_age** |
| --- | --- | --- | --- | --- | --- |
| 400-20201123-009 | 72 | TRUE | TRUE | TRUE | TRUE |

#%>% set\_header\_labels(values = list(NRB\_L = "Alare/AlareCont"))  
  
#Autofit Width Table TNR  
flextable(NRB\_L\_extreme) %>%  
 my\_ft\_theme()%>%   
 bold(part = "header") %>%   
 set\_caption("NRB\_L Extreme Outliers (mean=17.98mm)") %>%   
 fit\_to\_width(7.5) %>%   
 autofit

**Table** : NRB\_L Extreme Outliers (mean=17.98mm)

| **ID** | **NRB\_L** | **extreme\_overall** | **extreme\_race\_eth** | **extreme\_gender** | **extreme\_age** |
| --- | --- | --- | --- | --- | --- |
| 400-20201123-009 | 72 | TRUE | TRUE | TRUE | TRUE |

#%>% set\_header\_labels(values = list(NRB\_L = "Alare/AlareCont"))  
  
ggplot(data=SA3\_data2, aes(x=NRB\_L))+  
 geom\_bar(stat="bin", bins=25, color= "black", fill = "white")+  
 theme\_bw() + theme(text=element\_text(family= "Times New Roman"))+  
 labs(title="NRB\_L Measurement Distribution",  
 subtitle = "NA values removed",  
 y="Frequency",  
 x="Measurement in mm")



#ProS\_L  
ProS\_L\_out <- SA3\_data2 %>%   
 identify\_outliers(ProS\_L)  
  
ProS\_L\_out$extreme\_overall <- ProS\_L\_out$is.extreme  
  
ProS\_L\_out <- ProS\_L\_out[c(1,7,19)]  
  
  
  
ProS\_L\_out1 <- SA3\_data2 %>%   
 group\_by(race\_eth) %>%   
 identify\_outliers(ProS\_L)  
  
ProS\_L\_out1$extreme\_race\_eth <- ProS\_L\_out1$is.extreme  
  
ProS\_L\_out1 <- ProS\_L\_out1[c(2,8,19)]  
  
  
  
  
ProS\_L\_out2 <- SA3\_data2 %>%   
 group\_by(gender) %>%   
 identify\_outliers(ProS\_L)  
  
ProS\_L\_out2$extreme\_gender <- ProS\_L\_out2$is.extreme  
  
ProS\_L\_out2 <- ProS\_L\_out2[c(2,8,19)]  
  
  
  
ProS\_L\_out3 <- SA3\_data2 %>%   
 group\_by(age\_group) %>%   
 identify\_outliers(ProS\_L)  
  
ProS\_L\_out3$extreme\_age <- ProS\_L\_out3$is.extreme  
  
ProS\_L\_out3 <- ProS\_L\_out3[c(2,8,19)]  
  
  
ProS\_L\_extreme <- full\_join(ProS\_L\_out, ProS\_L\_out1, by=c('ID', 'ProS\_L'))  
ProS\_L\_extreme <- full\_join(ProS\_L\_extreme, ProS\_L\_out2, by=c('ID', 'ProS\_L'))  
ProS\_L\_extreme <- full\_join(ProS\_L\_extreme, ProS\_L\_out3, by=c('ID', 'ProS\_L'))  
  
ProS\_L\_extreme <-   
 filter(ProS\_L\_extreme,   
 extreme\_overall == "TRUE" |   
 extreme\_race\_eth == "TRUE" |  
 extreme\_gender == "TRUE" |  
 extreme\_age == "TRUE" )  
  
ProS\_L\_extreme$extreme\_overall <- as.character(ProS\_L\_extreme$extreme\_overall)  
ProS\_L\_extreme$extreme\_race\_eth <- as.character(ProS\_L\_extreme$extreme\_race\_eth)  
ProS\_L\_extreme$extreme\_gender <- as.character(ProS\_L\_extreme$extreme\_gender)  
ProS\_L\_extreme$extreme\_age <- as.character(ProS\_L\_extreme$extreme\_age)  
  
ProS\_L\_extreme[is.na(ProS\_L\_extreme)]="Not Outlier"   
  
#Size 12 Table TNR  
flextable(ProS\_L\_extreme) %>%  
 my\_ft\_theme()%>%   
 bold(part = "header") %>%   
 set\_caption("ProS\_L Extreme Outliers (mean=19.16mm)")

**Table** : ProS\_L Extreme Outliers (mean=19.16mm)

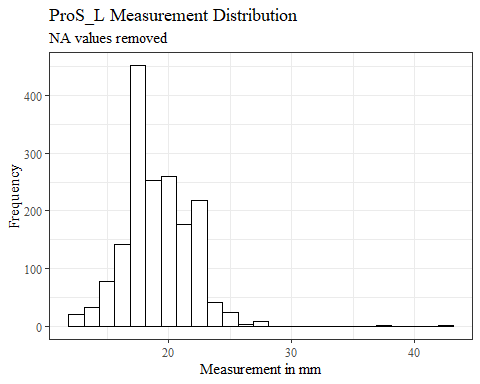
| **ID** | **ProS\_L** | **extreme\_overall** | **extreme\_race\_eth** | **extreme\_gender** | **extreme\_age** |
| --- | --- | --- | --- | --- | --- |
| 400-20201013-003 | 42 | TRUE | TRUE | TRUE | TRUE |
| 400-20210317-009 | 42 | TRUE | TRUE | TRUE | TRUE |
| 400-20210122-007 | 38 | TRUE | TRUE | TRUE | TRUE |

#%>% set\_header\_labels(values = list(ProS\_L = "Alare/AlareCont"))  
  
#Autofit Width Table TNR  
flextable(ProS\_L\_extreme) %>%  
 my\_ft\_theme()%>%   
 bold(part = "header") %>%   
 set\_caption("ProS\_L Extreme Outliers (mean=19.16mm)") %>%   
 fit\_to\_width(7.5) %>%   
 autofit

**Table** : ProS\_L Extreme Outliers (mean=19.16mm)

| **ID** | **ProS\_L** | **extreme\_overall** | **extreme\_race\_eth** | **extreme\_gender** | **extreme\_age** |
| --- | --- | --- | --- | --- | --- |
| 400-20201013-003 | 42 | TRUE | TRUE | TRUE | TRUE |
| 400-20210317-009 | 42 | TRUE | TRUE | TRUE | TRUE |
| 400-20210122-007 | 38 | TRUE | TRUE | TRUE | TRUE |

#%>% set\_header\_labels(values = list(ProS\_L = "Alare/AlareCont"))  
  
ggplot(data=SA3\_data2, aes(x=ProS\_L))+  
 geom\_bar(stat="bin", bins=25, color= "black", fill = "white")+  
 theme\_bw() + theme(text=element\_text(family= "Times New Roman"))+  
 labs(title="ProS\_L Measurement Distribution",  
 subtitle = "NA values removed",  
 y="Frequency",  
 x="Measurement in mm")



SelP\_L

#SelP\_L  
SelP\_L\_out <- SA3\_data2 %>%   
 identify\_outliers(SelP\_L)  
  
SelP\_L\_out$extreme\_overall <- SelP\_L\_out$is.extreme  
  
SelP\_L\_out <- SelP\_L\_out[c(1,8,19)]  
  
  
  
SelP\_L\_out1 <- SA3\_data2 %>%   
 group\_by(race\_eth) %>%   
 identify\_outliers(SelP\_L)  
  
SelP\_L\_out1$extreme\_race\_eth <- SelP\_L\_out1$is.extreme  
  
SelP\_L\_out1 <- SelP\_L\_out1[c(2,9,19)]  
  
  
  
  
SelP\_L\_out2 <- SA3\_data2 %>%   
 group\_by(gender) %>%   
 identify\_outliers(SelP\_L)  
  
SelP\_L\_out2$extreme\_gender <- SelP\_L\_out2$is.extreme  
  
SelP\_L\_out2 <- SelP\_L\_out2[c(2,9,19)]  
  
  
  
SelP\_L\_out3 <- SA3\_data2 %>%   
 group\_by(age\_group) %>%   
 identify\_outliers(SelP\_L)  
  
SelP\_L\_out3$extreme\_age <- SelP\_L\_out3$is.extreme  
  
SelP\_L\_out3 <- SelP\_L\_out3[c(2,9,19)]  
  
  
SelP\_L\_extreme <- full\_join(SelP\_L\_out, SelP\_L\_out1, by=c('ID', 'SelP\_L'))  
SelP\_L\_extreme <- full\_join(SelP\_L\_extreme, SelP\_L\_out2, by=c('ID', 'SelP\_L'))  
SelP\_L\_extreme <- full\_join(SelP\_L\_extreme, SelP\_L\_out3, by=c('ID', 'SelP\_L'))  
  
SelP\_L\_extreme <-   
 filter(SelP\_L\_extreme,   
 extreme\_overall == "TRUE" |   
 extreme\_race\_eth == "TRUE" |  
 extreme\_gender == "TRUE" |  
 extreme\_age == "TRUE" )  
  
SelP\_L\_extreme$extreme\_overall <- as.character(SelP\_L\_extreme$extreme\_overall)  
SelP\_L\_extreme$extreme\_race\_eth <- as.character(SelP\_L\_extreme$extreme\_race\_eth)  
SelP\_L\_extreme$extreme\_gender <- as.character(SelP\_L\_extreme$extreme\_gender)  
SelP\_L\_extreme$extreme\_age <- as.character(SelP\_L\_extreme$extreme\_age)  
  
SelP\_L\_extreme[is.na(SelP\_L\_extreme)] = "Not Outlier"   
  
#Size 12 Table TNR  
flextable(SelP\_L\_extreme) %>%  
 my\_ft\_theme()%>%   
 bold(part = "header") %>%   
 set\_caption("SelP\_L Extreme Outliers (mean=44.53mm)")

**Table** : SelP\_L Extreme Outliers (mean=44.53mm)

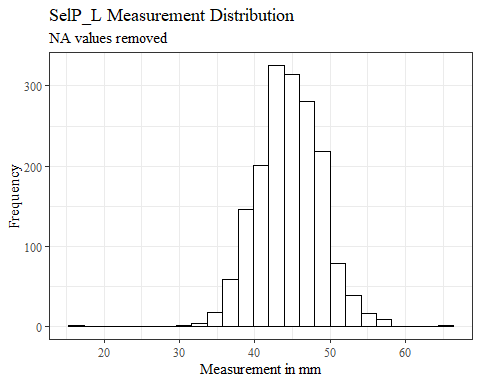
| **ID** | **SelP\_L** | **extreme\_overall** | **extreme\_race\_eth** | **extreme\_gender** | **extreme\_age** |
| --- | --- | --- | --- | --- | --- |
| 400-20201202-019 | 16 | TRUE | TRUE | TRUE | TRUE |
| 400-20210201-002 | 65 | FALSE | TRUE | TRUE | FALSE |
| 400-20201216-014 | 51 | Not Outlier | Not Outlier | TRUE | Not Outlier |
| 400-20210126-012 | 52 | Not Outlier | Not Outlier | TRUE | Not Outlier |

#%>% set\_header\_labels(values = list(SelP\_L = "Alare/AlareCont"))  
  
#Autofit Width Table TNR  
flextable(SelP\_L\_extreme) %>%  
 my\_ft\_theme()%>%   
 bold(part = "header") %>%   
 set\_caption("SelP\_L Extreme Outliers (mean=44.53mm)") %>%   
 fit\_to\_width(7.5) %>%   
 autofit

**Table** : SelP\_L Extreme Outliers (mean=44.53mm)

| **ID** | **SelP\_L** | **extreme\_overall** | **extreme\_race\_eth** | **extreme\_gender** | **extreme\_age** |
| --- | --- | --- | --- | --- | --- |
| 400-20201202-019 | 16 | TRUE | TRUE | TRUE | TRUE |
| 400-20210201-002 | 65 | FALSE | TRUE | TRUE | FALSE |
| 400-20201216-014 | 51 | Not Outlier | Not Outlier | TRUE | Not Outlier |
| 400-20210126-012 | 52 | Not Outlier | Not Outlier | TRUE | Not Outlier |

#%>% set\_header\_labels(values = list(SelP\_L = "Alare/AlareCont"))  
  
ggplot(data=SA3\_data2, aes(x=SelP\_L))+  
 geom\_bar(stat="bin", bins=25, color= "black", fill = "white")+  
 theme\_bw() + theme(text=element\_text(family= "Times New Roman"))+  
 labs(title="SelP\_L Measurement Distribution",  
 subtitle = "NA values removed",  
 y="Frequency",  
 x="Measurement in mm")



#SelM\_L  
SelM\_L\_out <- SA3\_data2 %>%   
 identify\_outliers(SelM\_L)  
  
SelM\_L\_out$extreme\_overall <- SelM\_L\_out$is.extreme  
  
SelM\_L\_out <- SelM\_L\_out[c(1,9,19)]  
  
  
  
SelM\_L\_out1 <- SA3\_data2 %>%   
 group\_by(race\_eth) %>%   
 identify\_outliers(SelM\_L)  
  
SelM\_L\_out1$extreme\_race\_eth <- SelM\_L\_out1$is.extreme  
  
SelM\_L\_out1 <- SelM\_L\_out1[c(2,10,19)]  
  
  
  
  
SelM\_L\_out2 <- SA3\_data2 %>%   
 group\_by(gender) %>%   
 identify\_outliers(SelM\_L)  
  
SelM\_L\_out2$extreme\_gender <- SelM\_L\_out2$is.extreme  
  
SelM\_L\_out2 <- SelM\_L\_out2[c(2,10,19)]  
  
  
  
SelM\_L\_out3 <- SA3\_data2 %>%   
 group\_by(age\_group) %>%   
 identify\_outliers(SelM\_L)  
  
SelM\_L\_out3$extreme\_age <- SelM\_L\_out3$is.extreme  
  
SelM\_L\_out3 <- SelM\_L\_out3[c(2,10,19)]  
  
  
SelM\_L\_extreme <- full\_join(SelM\_L\_out, SelM\_L\_out1, by=c('ID', 'SelM\_L'))  
SelM\_L\_extreme <- full\_join(SelM\_L\_extreme, SelM\_L\_out2, by=c('ID', 'SelM\_L'))  
SelM\_L\_extreme <- full\_join(SelM\_L\_extreme, SelM\_L\_out3, by=c('ID', 'SelM\_L'))  
  
SelM\_L\_extreme <-   
 filter(SelM\_L\_extreme,   
 extreme\_overall == "TRUE" |   
 extreme\_race\_eth == "TRUE" |  
 extreme\_gender == "TRUE" |  
 extreme\_age == "TRUE" )  
  
SelM\_L\_extreme$extreme\_overall <- as.character(SelM\_L\_extreme$extreme\_overall)  
SelM\_L\_extreme$extreme\_race\_eth <- as.character(SelM\_L\_extreme$extreme\_race\_eth)  
SelM\_L\_extreme$extreme\_gender <- as.character(SelM\_L\_extreme$extreme\_gender)  
SelM\_L\_extreme$extreme\_age <- as.character(SelM\_L\_extreme$extreme\_age)  
  
SelM\_L\_extreme[is.na(SelM\_L\_extreme)] = "Not Outlier"   
  
#Size 12 Table TNR  
flextable(SelM\_L\_extreme) %>%  
 my\_ft\_theme()%>%   
 bold(part = "header") %>%   
 set\_caption("SelM\_L Extreme Outliers (mean=116.2mm)")

**Table** : SelM\_L Extreme Outliers (mean=116.2mm)

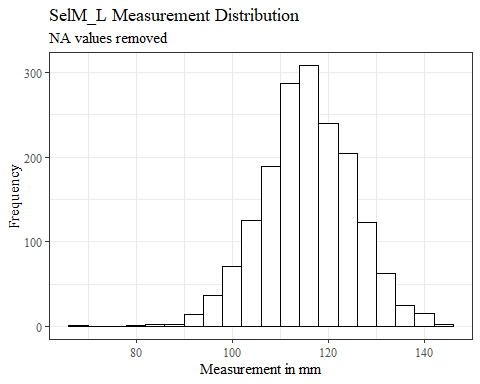
| **ID** | **SelM\_L** | **extreme\_overall** | **extreme\_race\_eth** | **extreme\_gender** | **extreme\_age** |
| --- | --- | --- | --- | --- | --- |
| 400-20201202-019 | 69 | TRUE | TRUE | TRUE | TRUE |

#%>% set\_header\_labels(values = list(SelM\_L = "Alare/AlareCont"))  
  
#Autofit Width Table TNR  
flextable(SelM\_L\_extreme) %>%  
 my\_ft\_theme()%>%   
 bold(part = "header") %>%   
 set\_caption("SelM\_L Extreme Outliers (mean=116.2mm)") %>%   
 fit\_to\_width(7.5) %>%   
 autofit

**Table** : SelM\_L Extreme Outliers (mean=116.2mm)

| **ID** | **SelM\_L** | **extreme\_overall** | **extreme\_race\_eth** | **extreme\_gender** | **extreme\_age** |
| --- | --- | --- | --- | --- | --- |
| 400-20201202-019 | 69 | TRUE | TRUE | TRUE | TRUE |

#%>% set\_header\_labels(values = list(SelM\_L = "Alare/AlareCont"))  
  
ggplot(data=SA3\_data2, aes(x=SelM\_L))+  
 geom\_bar(stat="bin", bins=20, color= "black", fill = "white")+  
 theme\_bw() + theme(text=element\_text(family= "Times New Roman"))+  
 labs(title="SelM\_L Measurement Distribution",  
 subtitle = "NA values removed",  
 y="Frequency",  
 x="Measurement in mm")



#SnasM\_C  
SnasM\_C\_out <- SA3\_data2 %>%   
 identify\_outliers(SnasM\_C)  
  
SnasM\_C\_out$extreme\_overall <- SnasM\_C\_out$is.extreme  
  
SnasM\_C\_out <- SnasM\_C\_out[c(1,10,19)]  
  
  
  
SnasM\_C\_out1 <- SA3\_data2 %>%   
 group\_by(race\_eth) %>%   
 identify\_outliers(SnasM\_C)  
  
SnasM\_C\_out1$extreme\_race\_eth <- SnasM\_C\_out1$is.extreme  
  
SnasM\_C\_out1 <- SnasM\_C\_out1[c(2,11,19)]  
  
  
  
  
SnasM\_C\_out2 <- SA3\_data2 %>%   
 group\_by(gender) %>%   
 identify\_outliers(SnasM\_C)  
  
SnasM\_C\_out2$extreme\_gender <- SnasM\_C\_out2$is.extreme  
  
SnasM\_C\_out2 <- SnasM\_C\_out2[c(2,11,19)]  
  
  
  
SnasM\_C\_out3 <- SA3\_data2 %>%   
 group\_by(age\_group) %>%   
 identify\_outliers(SnasM\_C)  
  
SnasM\_C\_out3$extreme\_age <- SnasM\_C\_out3$is.extreme  
  
SnasM\_C\_out3 <- SnasM\_C\_out3[c(2,11,19)]  
  
  
SnasM\_C\_extreme <- full\_join(SnasM\_C\_out, SnasM\_C\_out1, by=c('ID', 'SnasM\_C'))  
SnasM\_C\_extreme <- full\_join(SnasM\_C\_extreme, SnasM\_C\_out2, by=c('ID', 'SnasM\_C'))  
SnasM\_C\_extreme <- full\_join(SnasM\_C\_extreme, SnasM\_C\_out3, by=c('ID', 'SnasM\_C'))  
  
SnasM\_C\_extreme <-   
 filter(SnasM\_C\_extreme,   
 extreme\_overall == "TRUE" |   
 extreme\_race\_eth == "TRUE" |  
 extreme\_gender == "TRUE" |  
 extreme\_age == "TRUE" )  
  
SnasM\_C\_extreme$extreme\_overall <- as.character(SnasM\_C\_extreme$extreme\_overall)  
SnasM\_C\_extreme$extreme\_race\_eth <- as.character(SnasM\_C\_extreme$extreme\_race\_eth)  
SnasM\_C\_extreme$extreme\_gender <- as.character(SnasM\_C\_extreme$extreme\_gender)  
SnasM\_C\_extreme$extreme\_age <- as.character(SnasM\_C\_extreme$extreme\_age)  
  
SnasM\_C\_extreme[is.na(SnasM\_C\_extreme)] = "Not Outlier"   
  
#Size 12 Table TNR  
flextable(SnasM\_C\_extreme) %>%  
 my\_ft\_theme()%>%   
 bold(part = "header") %>%   
 set\_caption("SnasM\_C Extreme Outliers (mean=75.1mm)")

**Table** : SnasM\_C Extreme Outliers (mean=75.1mm)

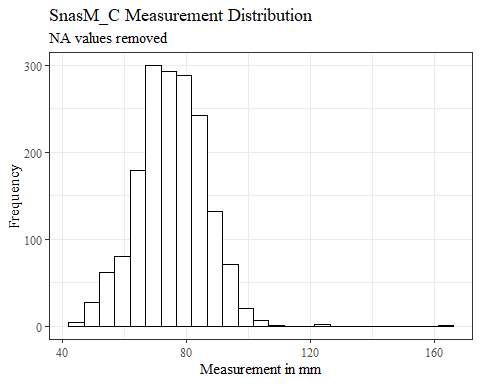
| **ID** | **SnasM\_C** | **extreme\_overall** | **extreme\_race\_eth** | **extreme\_gender** | **extreme\_age** |
| --- | --- | --- | --- | --- | --- |
| 400-20201013-003 | 124 | FALSE | FALSE | TRUE | FALSE |
| 400-20210317-009 | 125 | FALSE | TRUE | TRUE | FALSE |
| 400-20210203-001 | 163 | TRUE | TRUE | TRUE | TRUE |

#%>% set\_header\_labels(values = list(SnasM\_C = "Alare/AlareCont"))  
  
#Autofit Width Table TNR  
flextable(SnasM\_C\_extreme) %>%  
 my\_ft\_theme()%>%   
 bold(part = "header") %>%   
 set\_caption("SnasM\_C Extreme Outliers (mean=75.1mm)") %>%   
 fit\_to\_width(7.5) %>%   
 autofit

**Table** : SnasM\_C Extreme Outliers (mean=75.1mm)

| **ID** | **SnasM\_C** | **extreme\_overall** | **extreme\_race\_eth** | **extreme\_gender** | **extreme\_age** |
| --- | --- | --- | --- | --- | --- |
| 400-20201013-003 | 124 | FALSE | FALSE | TRUE | FALSE |
| 400-20210317-009 | 125 | FALSE | TRUE | TRUE | FALSE |
| 400-20210203-001 | 163 | TRUE | TRUE | TRUE | TRUE |

#%>% set\_header\_labels(values = list(SnasM\_C = "Alare/AlareCont"))  
  
ggplot(data=SA3\_data2, aes(x=SnasM\_C))+  
 geom\_bar(stat="bin", bins=25, color= "black", fill = "white")+  
 theme\_bw() + theme(text=element\_text(family= "Times New Roman"))+  
 labs(title="SnasM\_C Measurement Distribution",  
 subtitle = "NA values removed",  
 y="Frequency",  
 x="Measurement in mm")



#TrSman\_C  
TrSman\_C\_out <- SA3\_data2 %>%   
 identify\_outliers(TrSman\_C)  
  
TrSman\_C\_out$extreme\_overall <- TrSman\_C\_out$is.extreme  
  
TrSman\_C\_out <- TrSman\_C\_out[c(1,11,19)]  
  
  
  
TrSman\_C\_out1 <- SA3\_data2 %>%   
 group\_by(race\_eth) %>%   
 identify\_outliers(TrSman\_C)  
  
TrSman\_C\_out1$extreme\_race\_eth <- TrSman\_C\_out1$is.extreme  
  
TrSman\_C\_out1 <- TrSman\_C\_out1[c(2,12,19)]  
  
  
  
  
TrSman\_C\_out2 <- SA3\_data2 %>%   
 group\_by(gender) %>%   
 identify\_outliers(TrSman\_C)  
  
TrSman\_C\_out2$extreme\_gender <- TrSman\_C\_out2$is.extreme  
  
TrSman\_C\_out2 <- TrSman\_C\_out2[c(2,12,19)]  
  
  
  
TrSman\_C\_out3 <- SA3\_data2 %>%   
 group\_by(age\_group) %>%   
 identify\_outliers(TrSman\_C)  
  
TrSman\_C\_out3$extreme\_age <- TrSman\_C\_out3$is.extreme  
  
TrSman\_C\_out3 <- TrSman\_C\_out3[c(2,12,19)]  
  
  
TrSman\_C\_extreme <- full\_join(TrSman\_C\_out, TrSman\_C\_out1, by=c('ID', 'TrSman\_C'))  
TrSman\_C\_extreme <- full\_join(TrSman\_C\_extreme, TrSman\_C\_out2, by=c('ID', 'TrSman\_C'))  
TrSman\_C\_extreme <- full\_join(TrSman\_C\_extreme, TrSman\_C\_out3, by=c('ID', 'TrSman\_C'))  
  
TrSman\_C\_extreme <-   
 filter(TrSman\_C\_extreme,   
 extreme\_overall == "TRUE" |   
 extreme\_race\_eth == "TRUE" |  
 extreme\_gender == "TRUE" |  
 extreme\_age == "TRUE" )  
  
TrSman\_C\_extreme$extreme\_overall <- as.character(TrSman\_C\_extreme$extreme\_overall)  
TrSman\_C\_extreme$extreme\_race\_eth <- as.character(TrSman\_C\_extreme$extreme\_race\_eth)  
TrSman\_C\_extreme$extreme\_gender <- as.character(TrSman\_C\_extreme$extreme\_gender)  
TrSman\_C\_extreme$extreme\_age <- as.character(TrSman\_C\_extreme$extreme\_age)  
  
TrSman\_C\_extreme[is.na(TrSman\_C\_extreme)] = "Not Outlier"   
  
#Size 12 Table TNR  
flextable(TrSman\_C\_extreme) %>%  
 my\_ft\_theme()%>%   
 bold(part = "header") %>%   
 set\_caption("TrSman\_C Extreme Outliers (mean=153.4mm)")

**Table** : TrSman\_C Extreme Outliers (mean=153.4mm)

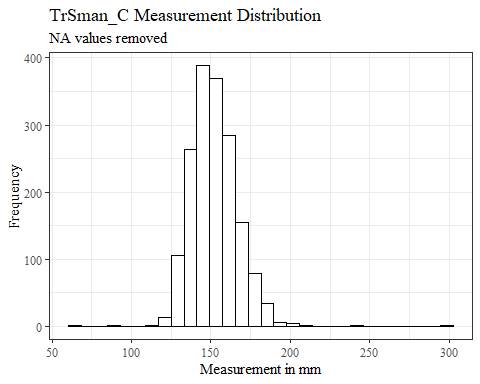
| **ID** | **TrSman\_C** | **extreme\_overall** | **extreme\_race\_eth** | **extreme\_gender** | **extreme\_age** |
| --- | --- | --- | --- | --- | --- |
| 400-20210216-006 | 298 | TRUE | TRUE | TRUE | TRUE |
| 400-20210120-002 | 64 | TRUE | TRUE | TRUE | TRUE |
| 400-20210129-009 | 246 | TRUE | TRUE | TRUE | TRUE |
| 400-20210203-009 | 87 | FALSE | FALSE | TRUE | TRUE |

#%>% set\_header\_labels(values = list(TrSman\_C = "Alare/AlareCont"))  
  
#Autofit Width Table TNR  
flextable(TrSman\_C\_extreme) %>%  
 my\_ft\_theme()%>%   
 bold(part = "header") %>%   
 set\_caption("TrSman\_C Extreme Outliers (mean=153.4mm)") %>%   
 fit\_to\_width(7.5) %>%   
 autofit

**Table** : TrSman\_C Extreme Outliers (mean=153.4mm)

| **ID** | **TrSman\_C** | **extreme\_overall** | **extreme\_race\_eth** | **extreme\_gender** | **extreme\_age** |
| --- | --- | --- | --- | --- | --- |
| 400-20210216-006 | 298 | TRUE | TRUE | TRUE | TRUE |
| 400-20210120-002 | 64 | TRUE | TRUE | TRUE | TRUE |
| 400-20210129-009 | 246 | TRUE | TRUE | TRUE | TRUE |
| 400-20210203-009 | 87 | FALSE | FALSE | TRUE | TRUE |

#%>% set\_header\_labels(values = list(TrSman\_C = "Alare/AlareCont"))  
  
ggplot(data=SA3\_data2, aes(x=TrSman\_C))+  
 geom\_bar(stat="bin", bins=30, color= "black", fill = "white")+  
 theme\_bw() + theme(text=element\_text(family= "Times New Roman"))+  
 labs(title="TrSman\_C Measurement Distribution",  
 subtitle = "NA values removed",  
 y="Frequency",  
 x="Measurement in mm")



#TrTr\_C  
TrTr\_C\_out <- SA3\_data2 %>%   
 identify\_outliers(TrTr\_C)  
  
TrTr\_C\_out$extreme\_overall <- TrTr\_C\_out$is.extreme  
  
TrTr\_C\_out <- TrTr\_C\_out[c(1,12,19)]  
  
  
  
TrTr\_C\_out1 <- SA3\_data2 %>%   
 group\_by(race\_eth) %>%   
 identify\_outliers(TrTr\_C)  
  
TrTr\_C\_out1$extreme\_race\_eth <- TrTr\_C\_out1$is.extreme  
  
TrTr\_C\_out1 <- TrTr\_C\_out1[c(2,13,19)]  
  
  
  
  
TrTr\_C\_out2 <- SA3\_data2 %>%   
 group\_by(gender) %>%   
 identify\_outliers(TrTr\_C)  
  
TrTr\_C\_out2$extreme\_gender <- TrTr\_C\_out2$is.extreme  
  
TrTr\_C\_out2 <- TrTr\_C\_out2[c(2,13,19)]  
  
  
  
TrTr\_C\_out3 <- SA3\_data2 %>%   
 group\_by(age\_group) %>%   
 identify\_outliers(TrTr\_C)  
  
TrTr\_C\_out3$extreme\_age <- TrTr\_C\_out3$is.extreme  
  
TrTr\_C\_out3 <- TrTr\_C\_out3[c(2,13,19)]  
  
  
TrTr\_C\_extreme <- full\_join(TrTr\_C\_out, TrTr\_C\_out1, by=c('ID', 'TrTr\_C'))  
TrTr\_C\_extreme <- full\_join(TrTr\_C\_extreme, TrTr\_C\_out2, by=c('ID', 'TrTr\_C'))  
TrTr\_C\_extreme <- full\_join(TrTr\_C\_extreme, TrTr\_C\_out3, by=c('ID', 'TrTr\_C'))  
  
TrTr\_C\_extreme <-   
 filter(TrTr\_C\_extreme,   
 extreme\_overall == "TRUE" |   
 extreme\_race\_eth == "TRUE" |  
 extreme\_gender == "TRUE" |  
 extreme\_age == "TRUE" )  
  
TrTr\_C\_extreme$extreme\_overall <- as.character(TrTr\_C\_extreme$extreme\_overall)  
TrTr\_C\_extreme$extreme\_race\_eth <- as.character(TrTr\_C\_extreme$extreme\_race\_eth)  
TrTr\_C\_extreme$extreme\_gender <- as.character(TrTr\_C\_extreme$extreme\_gender)  
TrTr\_C\_extreme$extreme\_age <- as.character(TrTr\_C\_extreme$extreme\_age)  
  
TrTr\_C\_extreme[is.na(TrTr\_C\_extreme)] = "Not Outlier"   
  
#Size 12 Table TNR  
flextable(TrTr\_C\_extreme) %>%  
 my\_ft\_theme()%>%   
 bold(part = "header") %>%   
 set\_caption("TrTr\_C Extreme Outliers (mean=282.7)")

**Table** : TrTr\_C Extreme Outliers (mean=282.7)

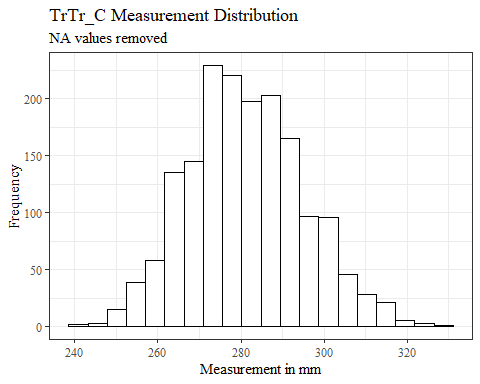
| **ID** | **TrTr\_C** | **extreme\_overall** | **extreme\_race\_eth** | **extreme\_gender** | **extreme\_age** |
| --- | --- | --- | --- | --- | --- |

#%>% set\_header\_labels(values = list(TrTr\_C = "Alare/AlareCont"))  
  
#Autofit Width Table TNR  
flextable(TrTr\_C\_extreme) %>%  
 my\_ft\_theme()%>%   
 bold(part = "header") %>%   
 set\_caption("TrTr\_C Extreme Outliers (mean=282.7)") %>%   
 fit\_to\_width(7.5) %>%   
 autofit

**Table** : TrTr\_C Extreme Outliers (mean=282.7)

| **ID** | **TrTr\_C** | **extreme\_overall** | **extreme\_race\_eth** | **extreme\_gender** | **extreme\_age** |
| --- | --- | --- | --- | --- | --- |

#%>% set\_header\_labels(values = list(TrTr\_C = "Alare/AlareCont"))  
  
ggplot(data=SA3\_data2, aes(x=TrTr\_C))+  
 geom\_bar(stat="bin", bins=20, color= "black", fill = "white")+  
 theme\_bw() + theme(text=element\_text(family= "Times New Roman"))+  
 labs(title="TrTr\_C Measurement Distribution",  
 subtitle = "NA values removed",  
 y="Frequency",  
 x="Measurement in mm")



#TrTr\_L  
TrTr\_L\_out <- SA3\_data2 %>%   
 identify\_outliers(TrTr\_L)  
  
TrTr\_L\_out$extreme\_overall <- TrTr\_L\_out$is.extreme  
  
TrTr\_L\_out <- TrTr\_L\_out[c(1,13,19)]  
  
  
  
TrTr\_L\_out1 <- SA3\_data2 %>%   
 group\_by(race\_eth) %>%   
 identify\_outliers(TrTr\_L)  
  
TrTr\_L\_out1$extreme\_race\_eth <- TrTr\_L\_out1$is.extreme  
  
TrTr\_L\_out1 <- TrTr\_L\_out1[c(2,14,19)]  
  
  
  
  
TrTr\_L\_out2 <- SA3\_data2 %>%   
 group\_by(gender) %>%   
 identify\_outliers(TrTr\_L)  
  
TrTr\_L\_out2$extreme\_gender <- TrTr\_L\_out2$is.extreme  
  
TrTr\_L\_out2 <- TrTr\_L\_out2[c(2,14,19)]  
  
  
  
TrTr\_L\_out3 <- SA3\_data2 %>%   
 group\_by(age\_group) %>%   
 identify\_outliers(TrTr\_L)  
  
TrTr\_L\_out3$extreme\_age <- TrTr\_L\_out3$is.extreme  
  
TrTr\_L\_out3 <- TrTr\_L\_out3[c(2,14,19)]  
  
  
TrTr\_L\_extreme <- full\_join(TrTr\_L\_out, TrTr\_L\_out1, by=c('ID', 'TrTr\_L'))  
TrTr\_L\_extreme <- full\_join(TrTr\_L\_extreme, TrTr\_L\_out2, by=c('ID', 'TrTr\_L'))  
TrTr\_L\_extreme <- full\_join(TrTr\_L\_extreme, TrTr\_L\_out3, by=c('ID', 'TrTr\_L'))  
  
TrTr\_L\_extreme <-   
 filter(TrTr\_L\_extreme,   
 extreme\_overall == "TRUE" |   
 extreme\_race\_eth == "TRUE" |  
 extreme\_gender == "TRUE" |  
 extreme\_age == "TRUE" )  
  
TrTr\_L\_extreme$extreme\_overall <- as.character(TrTr\_L\_extreme$extreme\_overall)  
TrTr\_L\_extreme$extreme\_race\_eth <- as.character(TrTr\_L\_extreme$extreme\_race\_eth)  
TrTr\_L\_extreme$extreme\_gender <- as.character(TrTr\_L\_extreme$extreme\_gender)  
TrTr\_L\_extreme$extreme\_age <- as.character(TrTr\_L\_extreme$extreme\_age)  
  
TrTr\_L\_extreme[is.na(TrTr\_L\_extreme)] = "Not Outlier"   
  
#Size 12 Table TNR  
flextable(TrTr\_L\_extreme) %>%  
 my\_ft\_theme()%>%   
 bold(part = "header") %>%   
 set\_caption("TrTr\_L Extreme Outliers (mean=146.5mm)")

**Table** : TrTr\_L Extreme Outliers (mean=146.5mm)

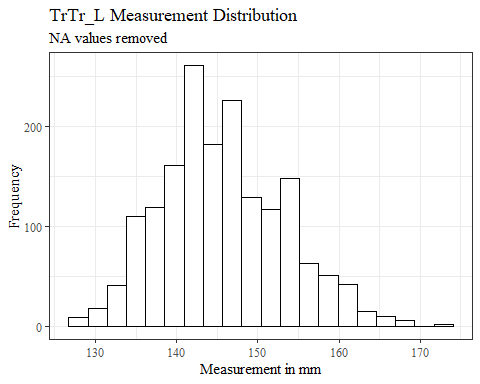
| **ID** | **TrTr\_L** | **extreme\_overall** | **extreme\_race\_eth** | **extreme\_gender** | **extreme\_age** |
| --- | --- | --- | --- | --- | --- |

#%>% set\_header\_labels(values = list(TrTr\_L = "Alare/AlareCont"))  
  
#Autofit Width Table TNR  
flextable(TrTr\_L\_extreme) %>%  
 my\_ft\_theme()%>%   
 bold(part = "header") %>%   
 set\_caption("TrTr\_L Extreme Outliers (mean=146.5mm)") %>%   
 fit\_to\_width(7.5) %>%   
 autofit

**Table** : TrTr\_L Extreme Outliers (mean=146.5mm)

| **ID** | **TrTr\_L** | **extreme\_overall** | **extreme\_race\_eth** | **extreme\_gender** | **extreme\_age** |
| --- | --- | --- | --- | --- | --- |

#%>% set\_header\_labels(values = list(TrTr\_L = "Alare/AlareCont"))  
  
ggplot(data=SA3\_data2, aes(x=TrTr\_L))+  
 geom\_bar(stat="bin", bins=20, color= "black", fill = "white")+  
 theme\_bw() + theme(text=element\_text(family= "Times New Roman"))+  
 labs(title="TrTr\_L Measurement Distribution",  
 subtitle = "NA values removed",  
 y="Frequency",  
 x="Measurement in mm")



##outliers  
mult\_out <- SA3\_data2  
  
  
#cutoff <- qchisq(1-.001, ncol(mult\_out[ , -c(1,14,15,16)]))  
  
  
mult\_out$mahal <- mahalanobis(mult\_out[ , -c(1,14,15,16)],  
 colMeans(mult\_out[ , -c(1,14,15,16)]),  
 cov(mult\_out[ , -c(1,14,15,16)]))  
  
mult\_out$p <- pchisq(mult\_out$mahal, df=11, lower.tail=FALSE)  
  
  
  
mult\_out$multv\_outlier <- with(mult\_out, ifelse(p < 0.001, 'TRUE', 'FALSE'))  
  
mult\_out <- mult\_out %>%   
 filter(multv\_outlier == TRUE)  
  
  
##df  
#summary(mahal < cutoff)  
  
#mult\_out2 <- SA3\_data2 %>%  
 #mahalanobis\_distance() %>%  
 #filter(is.outlier == TRUE) %>%  
 #as.data.frame()  
  
#mult\_out2  
  
##exclude outliers  
#noout = subset(nomiss, mahal < cutoff)

AA\_C\_extreme$offending <- "AA\_C univar"  
BiW\_C\_extreme$offending <- "BiW\_C univar"  
BiW\_L\_extreme$offending <- "BiW\_L univar"  
GoSub\_C\_extreme$offending <- "GoSub\_C univar"  
NRB\_L\_extreme$offending <- "NRB\_L univar"  
ProS\_L\_extreme$offending <- "ProS\_L univar"  
SelP\_L\_extreme$offending <- "SelP\_L univar"  
SelM\_L\_extreme$offending <- "SelM\_L univar"  
SnasM\_C\_extreme$offending <- "SnasM\_C univar"  
TrSman\_C\_extreme$offending <- "TrSman\_C univar"  
TrTr\_C\_extreme$offending <- "TrTr\_C univar"  
TrTr\_L\_extreme$offending <- "TrTr\_L univar"

all\_extreme <- full\_join(AA\_C\_extreme, BiW\_C\_extreme, by=c('ID',   
 'extreme\_overall',   
 'extreme\_race\_eth',   
 'extreme\_gender',  
 'extreme\_age',  
 'offending'))  
  
all\_extreme <- full\_join(all\_extreme, BiW\_L\_extreme, by=c('ID',   
 'extreme\_overall',   
 'extreme\_race\_eth',   
 'extreme\_gender',  
 'extreme\_age',  
 'offending'))  
  
all\_extreme <- full\_join(all\_extreme, GoSub\_C\_extreme, by=c('ID',   
 'extreme\_overall',   
 'extreme\_race\_eth',   
 'extreme\_gender',  
 'extreme\_age',  
 'offending'))  
  
all\_extreme <- full\_join(all\_extreme, NRB\_L\_extreme, by=c('ID',   
 'extreme\_overall',   
 'extreme\_race\_eth',   
 'extreme\_gender',  
 'extreme\_age',  
 'offending'))  
  
all\_extreme <- full\_join(all\_extreme, ProS\_L\_extreme, by=c('ID',   
 'extreme\_overall',   
 'extreme\_race\_eth',   
 'extreme\_gender',  
 'extreme\_age',  
 'offending'))  
  
all\_extreme <- full\_join(all\_extreme, SelP\_L\_extreme, by=c('ID',   
 'extreme\_overall',   
 'extreme\_race\_eth',   
 'extreme\_gender',  
 'extreme\_age',  
 'offending'))  
  
all\_extreme <- full\_join(all\_extreme, SelM\_L\_extreme, by=c('ID',   
 'extreme\_overall',   
 'extreme\_race\_eth',   
 'extreme\_gender',  
 'extreme\_age',  
 'offending'))  
  
all\_extreme <- full\_join(all\_extreme, SnasM\_C\_extreme, by=c('ID',   
 'extreme\_overall',   
 'extreme\_race\_eth',   
 'extreme\_gender',  
 'extreme\_age',  
 'offending'))  
  
all\_extreme <- full\_join(all\_extreme, TrSman\_C\_extreme, by=c('ID',   
 'extreme\_overall',   
 'extreme\_race\_eth',   
 'extreme\_gender',  
 'extreme\_age',  
 'offending'))  
  
all\_extreme <- full\_join(all\_extreme, TrTr\_C\_extreme, by=c('ID',   
 'extreme\_overall',   
 'extreme\_race\_eth',   
 'extreme\_gender',  
 'extreme\_age',  
 'offending'))  
  
all\_extreme <- full\_join(all\_extreme, TrTr\_L\_extreme, by=c('ID',   
 'extreme\_overall',   
 'extreme\_race\_eth',   
 'extreme\_gender',  
 'extreme\_age',  
 'offending'))

combin\_out <- full\_join(mult\_out, all\_extreme, by=c('ID'))  
  
str(combin\_out)

## tibble [28 × 36] (S3: tbl\_df/tbl/data.frame)  
## $ ID : chr [1:28] "400-20201013-003" "400-20201013-003" "400-20210210-009" "400-20210317-009" ...  
## $ AA\_C.x : num [1:28] 63 63 50 66 66 66 71 52 68 59 ...  
## $ BiW\_C.x : num [1:28] 143 143 131 128 128 136 156 164 161 133 ...  
## $ BiW\_L.x : num [1:28] 117 117 121 106 106 117 131 120 132 110 ...  
## $ GoSub\_C.x : num [1:28] 114 114 137 93 93 125 124 106 110 93 ...  
## $ NRB\_L.x : num [1:28] 18 18 18 16 16 72 26 19 27 20 ...  
## $ ProS\_L.x : num [1:28] 42 42 16 42 42 20 24 17 17 17 ...  
## $ SelP\_L.x : num [1:28] 43 43 45 42 42 40 46 43 43 16 ...  
## $ SelM\_L.x : num [1:28] 113 113 121 105 105 129 121 107 114 69 ...  
## $ SnasM\_C.x : num [1:28] 124 124 80 125 125 87 102 67 101 79 ...  
## $ TrSman\_C.x : num [1:28] 167 167 196 138 138 182 185 144 156 141 ...  
## $ TrTr\_C.x : num [1:28] 297 297 313 270 270 305 296 277 275 266 ...  
## $ TrTr\_L.x : num [1:28] 152 152 167 139 139 167 167 139 143 140 ...  
## $ gender : Factor w/ 3 levels "Other","Female",..: 2 2 3 2 2 3 3 2 3 2 ...  
## $ race\_eth : Factor w/ 5 levels "Other","Asian",..: 3 3 2 2 2 5 5 5 3 5 ...  
## $ age\_group : Factor w/ 3 levels "18-36","37-54",..: 2 2 1 2 2 1 3 3 2 2 ...  
## $ mahal : num [1:28] 235.4 235.4 31.3 269.6 269.6 ...  
## $ p : num [1:28] 3.17e-44 3.17e-44 9.90e-04 2.12e-51 2.12e-51 ...  
## $ multv\_outlier : chr [1:28] "TRUE" "TRUE" "TRUE" "TRUE" ...  
## $ AA\_C.y : num [1:28] NA NA NA NA NA NA NA NA NA NA ...  
## $ extreme\_overall : chr [1:28] "TRUE" "FALSE" NA "TRUE" ...  
## $ extreme\_race\_eth: chr [1:28] "TRUE" "FALSE" NA "TRUE" ...  
## $ extreme\_gender : chr [1:28] "TRUE" "TRUE" NA "TRUE" ...  
## $ extreme\_age : chr [1:28] "TRUE" "FALSE" NA "TRUE" ...  
## $ offending : chr [1:28] "ProS\_L univar" "SnasM\_C univar" NA "ProS\_L univar" ...  
## $ BiW\_C.y : num [1:28] NA NA NA NA NA NA NA NA NA NA ...  
## $ BiW\_L.y : num [1:28] NA NA NA NA NA NA NA NA NA NA ...  
## $ GoSub\_C.y : num [1:28] NA NA NA NA NA NA NA NA NA NA ...  
## $ NRB\_L.y : num [1:28] NA NA NA NA NA 72 NA NA NA NA ...  
## $ ProS\_L.y : num [1:28] 42 NA NA 42 NA NA NA NA NA NA ...  
## $ SelP\_L.y : num [1:28] NA NA NA NA NA NA NA NA NA 16 ...  
## $ SelM\_L.y : num [1:28] NA NA NA NA NA NA NA NA NA NA ...  
## $ SnasM\_C.y : num [1:28] NA 124 NA NA 125 NA NA NA NA NA ...  
## $ TrSman\_C.y : num [1:28] NA NA NA NA NA NA NA NA NA NA ...  
## $ TrTr\_C.y : num [1:28] NA NA NA NA NA NA NA NA NA NA ...  
## $ TrTr\_L.y : num [1:28] NA NA NA NA NA NA NA NA NA NA ...

combin\_out1 <- combin\_out[c(1,19,21,22,23,24,25)]  
  
combin\_out1$offending[is.na(combin\_out1$offending)] = "Not Univar Outlier"   
  
combin\_out1[is.na(combin\_out1)] = "Not Outlier"   
  
str(combin\_out1)

## tibble [28 × 7] (S3: tbl\_df/tbl/data.frame)  
## $ ID : chr [1:28] "400-20201013-003" "400-20201013-003" "400-20210210-009" "400-20210317-009" ...  
## $ multv\_outlier : chr [1:28] "TRUE" "TRUE" "TRUE" "TRUE" ...  
## $ extreme\_overall : chr [1:28] "TRUE" "FALSE" "Not Outlier" "TRUE" ...  
## $ extreme\_race\_eth: chr [1:28] "TRUE" "FALSE" "Not Outlier" "TRUE" ...  
## $ extreme\_gender : chr [1:28] "TRUE" "TRUE" "Not Outlier" "TRUE" ...  
## $ extreme\_age : chr [1:28] "TRUE" "FALSE" "Not Outlier" "TRUE" ...  
## $ offending : chr [1:28] "ProS\_L univar" "SnasM\_C univar" "Not Univar Outlier" "ProS\_L univar" ...

combin\_out1$multv\_outlier <- factor(combin\_out1$multv\_outlier, levels = c("TRUE", "FALSE", "Not Outlier"))  
combin\_out1$extreme\_overall <- factor(combin\_out1$extreme\_overall, levels = c("TRUE", "FALSE", "Not Outlier"))  
combin\_out1$extreme\_race\_eth <- factor(combin\_out1$extreme\_race\_eth, levels = c("TRUE", "FALSE", "Not Outlier"))  
combin\_out1$extreme\_gender <- factor(combin\_out1$extreme\_gender, levels = c("TRUE", "FALSE", "Not Outlier"))  
combin\_out1$extreme\_age <- factor(combin\_out1$extreme\_age, levels = c("TRUE", "FALSE", "Not Outlier"))  
  
  
arrange(combin\_out1, multv\_outlier + extreme\_overall)

## Warning in Ops.factor(multv\_outlier, extreme\_overall): '+' not meaningful for  
## factors

## # A tibble: 28 × 7  
## ID multv\_outlier extreme\_over…¹ extre…² extre…³ extre…⁴ offen…⁵  
## <chr> <fct> <fct> <fct> <fct> <fct> <chr>   
## 1 400-20201013-003 TRUE TRUE TRUE TRUE TRUE ProS\_L…  
## 2 400-20201013-003 TRUE FALSE FALSE TRUE FALSE SnasM\_…  
## 3 400-20210210-009 TRUE Not Outlier Not Ou… Not Ou… Not Ou… Not Un…  
## 4 400-20210317-009 TRUE TRUE TRUE TRUE TRUE ProS\_L…  
## 5 400-20210317-009 TRUE FALSE TRUE TRUE FALSE SnasM\_…  
## 6 400-20201123-009 TRUE TRUE TRUE TRUE TRUE NRB\_L …  
## 7 400-20201209-011 TRUE Not Outlier Not Ou… Not Ou… Not Ou… Not Un…  
## 8 400-20201214-021 TRUE Not Outlier Not Ou… Not Ou… Not Ou… Not Un…  
## 9 400-20201215-009 TRUE Not Outlier Not Ou… Not Ou… Not Ou… Not Un…  
## 10 400-20201202-019 TRUE TRUE TRUE TRUE TRUE SelP\_L…  
## # … with 18 more rows, and abbreviated variable names ¹​extreme\_overall,  
## # ²​extreme\_race\_eth, ³​extreme\_gender, ⁴​extreme\_age, ⁵​offending  
## # ℹ Use `print(n = ...)` to see more rows

#combin\_out1[with(combin\_out1, order("multv\_outlier", "extreme\_overall", "extreme\_race\_eth", "extreme\_gender", "extreme\_age")), ]

#Size 12 Table TNR  
flextable(combin\_out1) %>%  
 my\_ft\_theme()%>%   
 bold(part = "header") %>%   
 set\_caption("Univariate and Multivariate Outlier Status") %>%   
 autofit

**Table** : Univariate and Multivariate Outlier Status

| **ID** | **multv\_outlier** | **extreme\_overall** | **extreme\_race\_eth** | **extreme\_gender** | **extreme\_age** | **offending** |
| --- | --- | --- | --- | --- | --- | --- |
| 400-20201013-003 | TRUE | TRUE | TRUE | TRUE | TRUE | ProS\_L univar |
| 400-20201013-003 | TRUE | FALSE | FALSE | TRUE | FALSE | SnasM\_C univar |
| 400-20210210-009 | TRUE | Not Outlier | Not Outlier | Not Outlier | Not Outlier | Not Univar Outlier |
| 400-20210317-009 | TRUE | TRUE | TRUE | TRUE | TRUE | ProS\_L univar |
| 400-20210317-009 | TRUE | FALSE | TRUE | TRUE | FALSE | SnasM\_C univar |
| 400-20201123-009 | TRUE | TRUE | TRUE | TRUE | TRUE | NRB\_L univar |
| 400-20201209-011 | TRUE | Not Outlier | Not Outlier | Not Outlier | Not Outlier | Not Univar Outlier |
| 400-20201214-021 | TRUE | Not Outlier | Not Outlier | Not Outlier | Not Outlier | Not Univar Outlier |
| 400-20201215-009 | TRUE | Not Outlier | Not Outlier | Not Outlier | Not Outlier | Not Univar Outlier |
| 400-20201202-019 | TRUE | TRUE | TRUE | TRUE | TRUE | SelP\_L univar |
| 400-20201202-019 | TRUE | TRUE | TRUE | TRUE | TRUE | SelM\_L univar |
| 400-20201203-004 | TRUE | TRUE | TRUE | TRUE | TRUE | GoSub\_C univar |
| 400-20201204-018 | TRUE | Not Outlier | Not Outlier | Not Outlier | Not Outlier | Not Univar Outlier |
| 400-20201208-024 | TRUE | Not Outlier | Not Outlier | Not Outlier | Not Outlier | Not Univar Outlier |
| 400-20210216-006 | TRUE | TRUE | TRUE | TRUE | TRUE | GoSub\_C univar |
| 400-20210216-006 | TRUE | TRUE | TRUE | TRUE | TRUE | TrSman\_C univar |
| 400-20210120-002 | TRUE | TRUE | TRUE | TRUE | TRUE | TrSman\_C univar |
| 400-20210122-007 | TRUE | TRUE | TRUE | TRUE | TRUE | ProS\_L univar |
| 400-20210128-015 | TRUE | Not Outlier | Not Outlier | Not Outlier | Not Outlier | Not Univar Outlier |
| 400-20210129-009 | TRUE | TRUE | TRUE | TRUE | TRUE | GoSub\_C univar |
| 400-20210129-009 | TRUE | TRUE | TRUE | TRUE | TRUE | TrSman\_C univar |
| 400-20210201-002 | TRUE | FALSE | TRUE | TRUE | FALSE | SelP\_L univar |
| 400-20210203-001 | TRUE | TRUE | TRUE | TRUE | TRUE | SnasM\_C univar |
| 400-20210203-009 | TRUE | FALSE | FALSE | TRUE | TRUE | TrSman\_C univar |
| 400-20201012-012 | Not Outlier | Not Outlier | TRUE | Not Outlier | Not Outlier | AA\_C univar |
| 400-20210108-006 | Not Outlier | FALSE | FALSE | TRUE | FALSE | BiW\_C univar |
| 400-20201216-014 | Not Outlier | Not Outlier | Not Outlier | TRUE | Not Outlier | SelP\_L univar |
| 400-20210126-012 | Not Outlier | Not Outlier | Not Outlier | TRUE | Not Outlier | SelP\_L univar |

#%>% set\_header\_labels(values = list(TrTr\_L = "Alare/AlareCont"))  
  
#Autofit Width Table TNR  
flextable(combin\_out1) %>%  
 my\_ft\_theme()%>%   
 bold(part = "header") %>%   
 set\_caption("Univariate and Multivariate Outlier Status") %>%   
 autofit() %>%   
 fit\_to\_width(7.5)

**Table** : Univariate and Multivariate Outlier Status

| **ID** | **multv\_outlier** | **extreme\_overall** | **extreme\_race\_eth** | **extreme\_gender** | **extreme\_age** | **offending** |
| --- | --- | --- | --- | --- | --- | --- |
| 400-20201013-003 | TRUE | TRUE | TRUE | TRUE | TRUE | ProS\_L univar |
| 400-20201013-003 | TRUE | FALSE | FALSE | TRUE | FALSE | SnasM\_C univar |
| 400-20210210-009 | TRUE | Not Outlier | Not Outlier | Not Outlier | Not Outlier | Not Univar Outlier |
| 400-20210317-009 | TRUE | TRUE | TRUE | TRUE | TRUE | ProS\_L univar |
| 400-20210317-009 | TRUE | FALSE | TRUE | TRUE | FALSE | SnasM\_C univar |
| 400-20201123-009 | TRUE | TRUE | TRUE | TRUE | TRUE | NRB\_L univar |
| 400-20201209-011 | TRUE | Not Outlier | Not Outlier | Not Outlier | Not Outlier | Not Univar Outlier |
| 400-20201214-021 | TRUE | Not Outlier | Not Outlier | Not Outlier | Not Outlier | Not Univar Outlier |
| 400-20201215-009 | TRUE | Not Outlier | Not Outlier | Not Outlier | Not Outlier | Not Univar Outlier |
| 400-20201202-019 | TRUE | TRUE | TRUE | TRUE | TRUE | SelP\_L univar |
| 400-20201202-019 | TRUE | TRUE | TRUE | TRUE | TRUE | SelM\_L univar |
| 400-20201203-004 | TRUE | TRUE | TRUE | TRUE | TRUE | GoSub\_C univar |
| 400-20201204-018 | TRUE | Not Outlier | Not Outlier | Not Outlier | Not Outlier | Not Univar Outlier |
| 400-20201208-024 | TRUE | Not Outlier | Not Outlier | Not Outlier | Not Outlier | Not Univar Outlier |
| 400-20210216-006 | TRUE | TRUE | TRUE | TRUE | TRUE | GoSub\_C univar |
| 400-20210216-006 | TRUE | TRUE | TRUE | TRUE | TRUE | TrSman\_C univar |
| 400-20210120-002 | TRUE | TRUE | TRUE | TRUE | TRUE | TrSman\_C univar |
| 400-20210122-007 | TRUE | TRUE | TRUE | TRUE | TRUE | ProS\_L univar |
| 400-20210128-015 | TRUE | Not Outlier | Not Outlier | Not Outlier | Not Outlier | Not Univar Outlier |
| 400-20210129-009 | TRUE | TRUE | TRUE | TRUE | TRUE | GoSub\_C univar |
| 400-20210129-009 | TRUE | TRUE | TRUE | TRUE | TRUE | TrSman\_C univar |
| 400-20210201-002 | TRUE | FALSE | TRUE | TRUE | FALSE | SelP\_L univar |
| 400-20210203-001 | TRUE | TRUE | TRUE | TRUE | TRUE | SnasM\_C univar |
| 400-20210203-009 | TRUE | FALSE | FALSE | TRUE | TRUE | TrSman\_C univar |
| 400-20201012-012 | Not Outlier | Not Outlier | TRUE | Not Outlier | Not Outlier | AA\_C univar |
| 400-20210108-006 | Not Outlier | FALSE | FALSE | TRUE | FALSE | BiW\_C univar |
| 400-20201216-014 | Not Outlier | Not Outlier | Not Outlier | TRUE | Not Outlier | SelP\_L univar |
| 400-20210126-012 | Not Outlier | Not Outlier | Not Outlier | TRUE | Not Outlier | SelP\_L univar |

#%>% set\_header\_labels(values = list(TrTr\_L = "Alare/AlareCont"))

#write\_xlsx(combin\_out1, "C:\\Users\\19177\\OneDrive - Colostate\\Desktop\\Dissertation\\headscan\_dissertation\\combin\_out1.xlsx")

##exclude multivariate outliers  
SA3\_noout <- anti\_join(SA3\_data2, mult\_out, by="ID")  
  
1710-19

## [1] 1691

str(SA3\_noout)

## tibble [1,691 × 16] (S3: tbl\_df/tbl/data.frame)  
## $ ID : chr [1:1691] "400-20201012-002" "400-20201012-003" "400-20201012-004" "400-20201012-005" ...  
## $ AA\_C : num [1:1691] 65 55 70 58 67 60 59 59 65 65 ...  
## $ BiW\_C : num [1:1691] 130 127 143 140 137 130 141 138 143 150 ...  
## $ BiW\_L : num [1:1691] 115 108 121 109 104 106 109 111 113 116 ...  
## $ GoSub\_C : num [1:1691] 93 93 115 93 103 100 79 106 85 102 ...  
## $ NRB\_L : num [1:1691] 17 18 19 21 19 14 17 18 16 17 ...  
## $ ProS\_L : num [1:1691] 17 18 14 13 20 20 18 12 24 22 ...  
## $ SelP\_L : num [1:1691] 42 41 51 44 47 48 46 41 46 44 ...  
## $ SelM\_L : num [1:1691] 122 99 130 115 119 126 117 112 117 117 ...  
## $ SnasM\_C : num [1:1691] 82 55 84 74 73 80 78 76 64 75 ...  
## $ TrSman\_C : num [1:1691] 177 145 178 147 157 164 149 159 151 160 ...  
## $ TrTr\_C : num [1:1691] 296 276 292 273 279 300 283 275 307 286 ...  
## $ TrTr\_L : num [1:1691] 155 141 156 149 146 146 147 151 157 144 ...  
## $ gender : Factor w/ 3 levels "Other","Female",..: 3 2 3 3 3 3 3 3 3 3 ...  
## $ race\_eth : Factor w/ 5 levels "Other","Asian",..: 3 5 5 5 5 5 3 3 5 5 ...  
## $ age\_group: Factor w/ 3 levels "18-36","37-54",..: 1 2 2 1 2 3 1 1 1 1 ...

#write\_xlsx(SA3\_noout, "C:\\Users\\19177\\OneDrive - Colostate\\Desktop\\Dissertation\\headscan\_dissertation\\SA3\_noout.xlsx")