

SDM4 in R: Analysis of Variance (Chapter 26)

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June 13, 2018

Introduction and background

This document is intended to help describe how to undertake analyses introduced as examples in the Fourth Edition of *Stats: Data and Models* (2014) by De Veaux, Velleman, and Bock. More information about the book can be found at http://wps.aw.com/aw_deveaux_stats_series. This file as well as the associated R Markdown reproducible analysis source file used to create it can be found at <http://nhorton.people.amherst.edu/sdm4>.

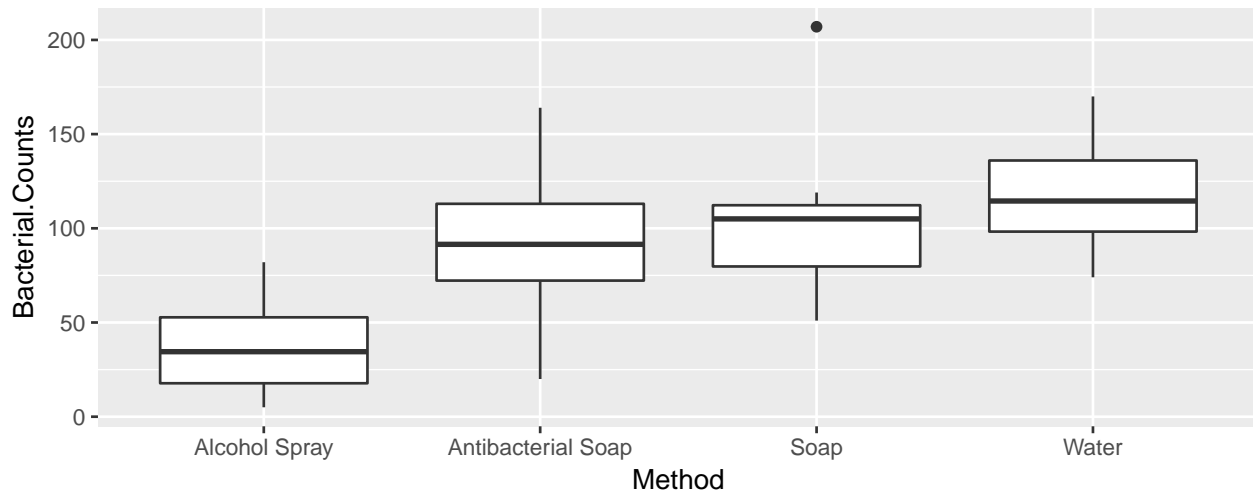
This work leverages initiatives undertaken by Project MOSAIC (<http://www.mosaic-web.org>), an NSF-funded effort to improve the teaching of statistics, calculus, science and computing in the undergraduate curriculum. In particular, we utilize the `mosaic` package, which was written to simplify the use of R for introductory statistics courses. A short summary of the R needed to teach introductory statistics can be found in the `mosaic` package vignettes (<http://cran.r-project.org/web/packages/mosaic>). A paper describing the `mosaic` approach was published in the *R Journal*: <https://journal.r-project.org/archive/2017/RJ-2017-024>.

Chapter 26: Analysis of variance

Section 26.1: Testing whether the means of several groups are zero

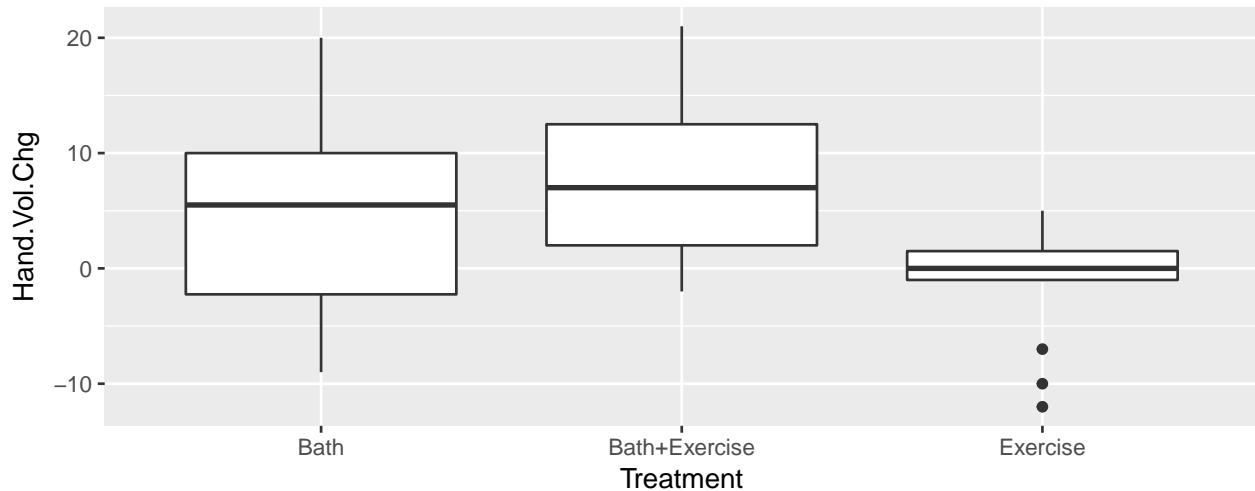
The graph in Figure 26.1 (page 747) can be generated using the `bwplot()` function.

```
Soap <- read.csv("http://nhorton.people.amherst.edu/sdm4/data/Bacterial_Soap.csv")
gf_boxplot(Bacterial.Counts ~ Method, data = Soap)
```



The example on page 750 considers the outcomes in hand volumes for three treatments post surgery.

```
Contrast <- read.csv("http://nhorton.people.amherst.edu/sdm4/data/Contrast_baths.csv")
gf_boxplot(Hand.Vol.Chg ~ Treatment, data = Contrast)
```



The summary statistics at the bottom of page 751 can be calculated using `favstats()`.

```
favstats(Bacterial.Counts ~ Method, data = Soap)
```

##	Method	min	Q1	median	Q3	max	mean	sd	n	missing
## 1	Alcohol Spray	5	17.75	34.5	52.75	82	37.5	26.560	8	0
## 2	Antibacterial Soap	20	72.25	91.5	113.00	164	92.5	41.963	8	0
## 3	Soap	51	79.75	105.0	112.25	207	106.0	46.959	8	0
## 4	Water	74	98.25	114.5	136.00	170	117.0	31.131	8	0

Section 26.2: The ANOVA table

The `aov()` function can be used to fit an analysis of variance model.

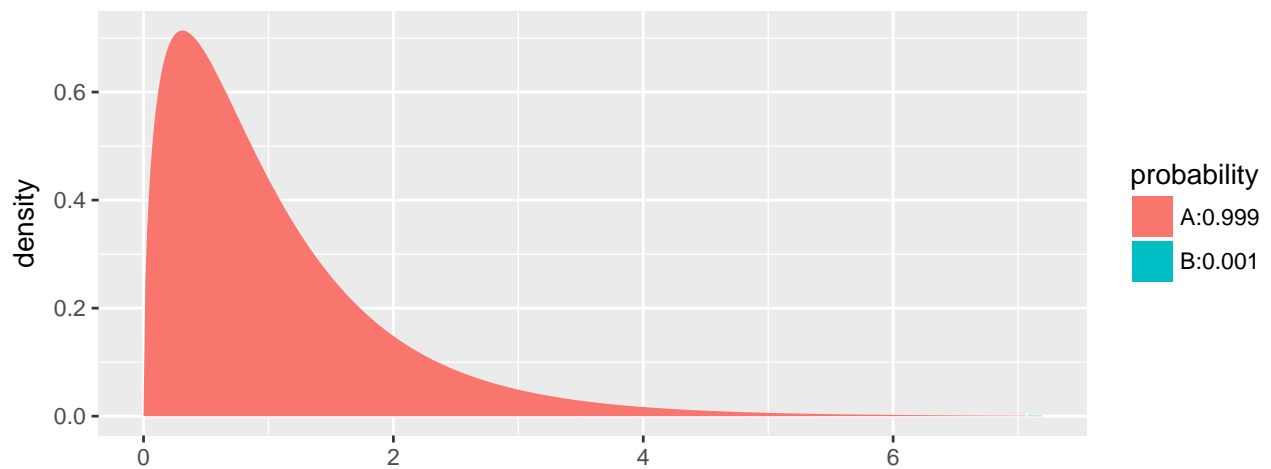
```
aovmod <- aov(Bacterial.Counts ~ Method, data = Soap)
summary(aovmod)
```

##	Df	Sum Sq	Mean Sq	F value	Pr(>F)
## Method	3	29882	9961	7.06	0.0011 **
## Residuals	28	39484	1410		

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

This model has 3 degrees of freedom for the model (numerator) and 28 degrees of freedom for the error (denominator). The `xpf()` function can replicate the calculation of the exact p-value (and generate Figure 26.4, page 754).

```
xpf(7.0636, df1 = 3, df2 = 28)
```



```
## [1] 0.99889
```

The treatment means can be generated using `model.tables()` (see page 757).

```
model.tables(aovmod)
```

```
## Tables of effects
##
## Method
## Method
##      Alcohol Spray Antibacterial Soap      Soap
##           -50.75           4.25       17.75
##           Water
##           28.75
```

The residual standard deviation can be calculated (page 759).

```
n <- 32
k <- 4
sp <- sqrt(sum(resid(aovmod)^2/(n-k)))
sp
```

```
## [1] 37.552
```

```
sqrt(1410)
```

```
## [1] 37.55
```

We can also see how the results are equivalent when fitting a regression model with indicators.

```
lmmod <- lm(Bacterial.Counts ~ Method, data = Soap)
msummary(lmmod)
```

##	Estimate	Std. Error	t value	Pr(> t)	
## (Intercept)	37.5	13.3	2.82	0.00863	**
## MethodAntibacterial Soap	55.0	18.8	2.93	0.00669	**
## MethodSoap	68.5	18.8	3.65	0.00107	**
## MethodWater	79.5	18.8	4.23	0.00022	***

##

Residual standard error: 37.6 on 28 degrees of freedom

Multiple R-squared: 0.431, Adjusted R-squared: 0.37

F-statistic: 7.06 on 3 and 28 DF, p-value: 0.00111