Example Data Analysis Report Reproducible Research Using knitr with markdown

Introduction

This document serves as an example data analysis report generated using R for the analysis, markdown for the markup report writing language, and knitr to bring everything together. The data set used is a fictitious as was generated for example purposes only. The purpose of this document is to provide an example of reproducible research.

Disclaimer I'm not an expert at markdown. There *are* better ways to do this. I prefer working in LaTeX and have not done much with Markdown. In general, there does seem to be a growing community of markdown users. Please feel free to fork the repo and improve upon this example.

Reproducing this report These are the steps required for reproducing this report.

1. Install R on your computer.

2. Suggested installs: pandoc and/or a markdown viewer for your web browser

3. Open R, install the knitr package if the package is not on your system.

```
install.packages("knitr", repos = "http://cran.rstudio.com")
```

4. Set the working directory in R to the same directory as this file exists in. Run the following commands in R,

```
library(knitr)
knit(input = "basicsMarkdown.Rmd")
```

5. The above R code will generate the file basicsMarkdown.md. Use pandoc http://johnmacfarlane.net/pandoc/ to convert the markdown into other file formats, inlcuding LaTeX, html, .docx,

```
pandoc(input = "basicsMarkdown.md", format = "docx")  # transform the .md to
.docx
```

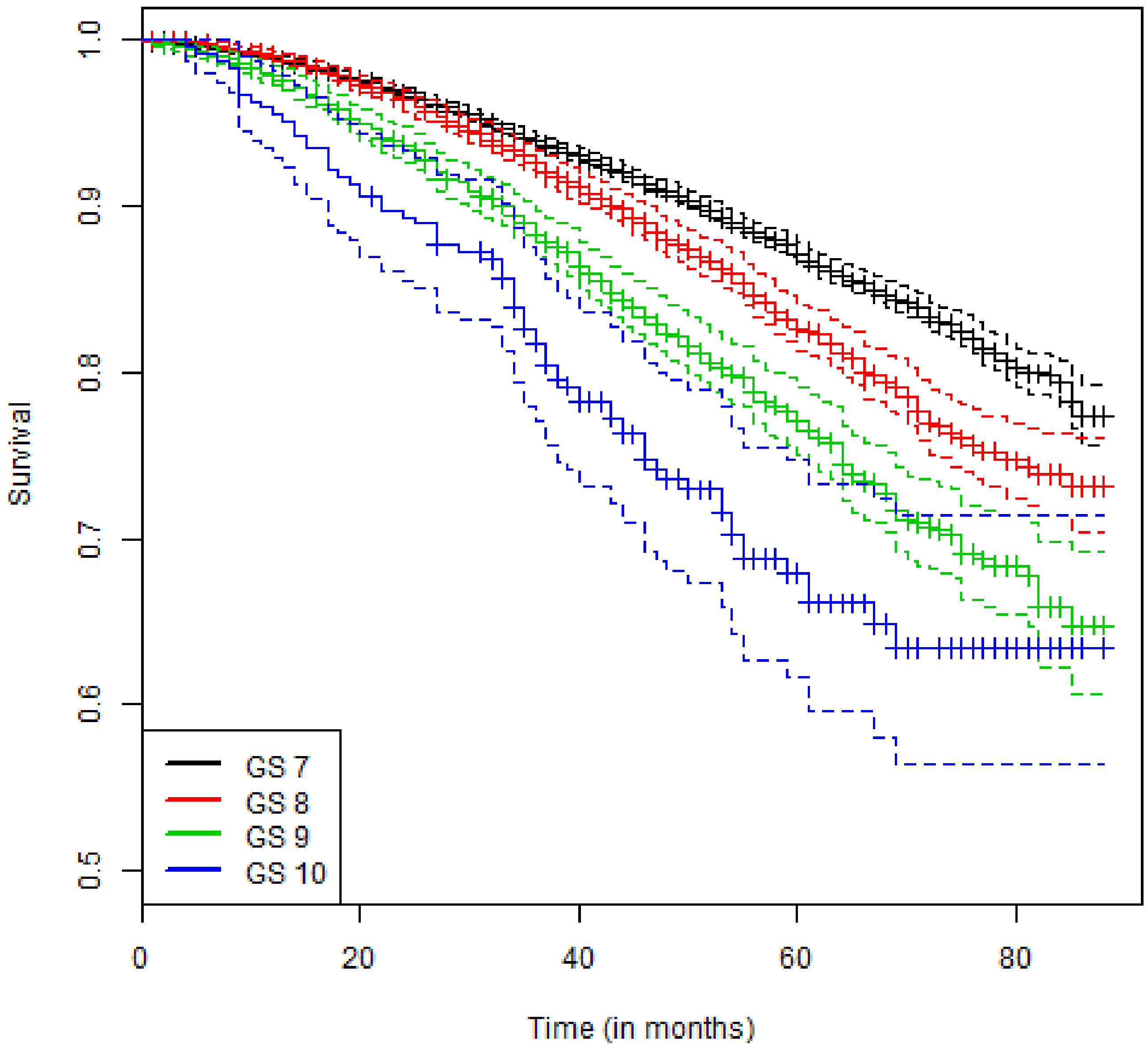
Analysis Methods

Overall survival analysis was done using both Kaplan-Meier estimates and Cox proportional hazard regression models.
The analysis was done in R version 3.0.1 (2013-05-16) and the survival analysis was done using the survival package. Statistical significance was set at the 0.05 level.

Analysis and Results

The data set consisted of 19,039 records. A summary of the data set is presented in the table below. Reported values are counts and percentages... (I need to learn more about markdown tables to make this pretty.)

id	overall	overall	GS 7	GS 7	GS 8	GS 8	GS 9	GS 9	GS 10	GS 10
	n	%	n	%	n	%	n	%	n	%
[40,50)	3,051	16.03	2,145	16.52	544	14.82	323	15.10	39	15.98
[50,70)	5,945	31.23	4,259	32.80	1,005	27.38	608	28.42	73	29.92
[70,85]	10,043	52.75	6,582	50.69	2,121	57.79	1,208	56.47	132	54.10
Era 1	8,615	45.25	5,869	45.19	1,659	45.20	970	45.35	117	47.95
Era 2	10,424	54.75	7,117	54.81	2,011	54.80	1,169	54.65	127	52.05
[0, 10) ng/ml	11,567	60.75	8,410	64.76	1,997	54.41	1,038	48.53	122	50.00
[10, 20) ng/ml	4,372	22.96	2,845	21.91	927	25.26	531	24.82	69	28.28
[20, Inf) ng/ml	3,100	16.28	1,731	13.33	746	20.33	570	26.65	53	21.72
T Stage 1	9,668	50.78	7,110	54.75	1,699	46.29	770	36.00	89	36.48
T Stage 2	8,189	43.01	5,360	41.28	1,657	45.15	1,065	49.79	107	43.85
T Stage 3/4	1,182	6.21	516	3.97	314	8.56	304	14.21	48	19.67
Observed Deaths	2,755		1,611		598		473		73	



plot of chunk km_plot

We are primarily interested in the differences in survival between patients with different Gleason scores. The figure below presents the Kaplan-Meier survival estimates by Gleason score. As expected, the higher the Gleason score, the worse the survival. It should also be noted that even after seven years of tracking patients the median survival time is not estimable. The lowest survival estimate is 63.43%.

Both univariable and multivariable Cox proportional hazard regression models were fitted for overall survival by the age, era of treatment, T stage, PSA, and Gleason score of the patient. Results for all the regression models are presented in the following output.

Univariable Results The following table are the univariable cox ph regression results.

id	HR	LCL	UCL	p-value
[40,50)	Reference			
[50,70)	0.95	0.84	1.09	0.4807
[70,85]	1.62	1.44	1.81	< 0.0001
Era 1	Reference			
Era 2	0.83	0.76	0.90	< 0.0001
T Stage 1	Reference			
T Stage 2	1.19	1.10	1.29	< 0.0001
T Stage 3/4	1.54	1.34	1.77	< 0.0001
[0, 10) ng/ml	Reference			
[10, 20) ng/ml	1.45	1.32	1.58	< 0.0001
[20, Inf) ng/ml	1.62	1.47	1.78	< 0.0001
GS 7	Reference			
GS 8	1.34	1.22	1.47	< 0.0001
GS 9	1.92	1.73	2.12	< 0.0001
GS 10	2.74	2.17	3.46	< 0.0001

As exapected, higher gleason scores are associated with higher hazards.

Multivariable Results A multivariable cox ph regression model was fitted and the results are presented below.

id	HR	LCL	UCL	p-value
[40,50)	Reference			
[50,70)	0.96	0.84	1.10	0.5550
[70,85]	1.61	1.43	1.80	< 0.0001
Era 1	Reference			
Era 2	0.84	0.77	0.92	< 0.0001

T Stage 1	Reference			
T Stage 2	1.12	1.03	1.21	0.0063
T Stage 3/4	1.24	1.07	1.43	0.0033
[0, 10) ng/ml	Reference			
[10, 20) ng/ml	1.36	1.24	1.48	< 0.0001
[20, Inf) ng/ml	1.50	1.36	1.66	< 0.0001
GS 7	Reference			
GS 8	1.23	1.12	1.35	< 0.0001
GS 9	1.73	1.55	1.91	< 0.0001
GS 10	2.48	1.96	3.14	< 0.0001

The results of a univariable regression model indicated that Patients treated in Era 2 had statistically better survival than patients treated in Era 1, HR = 0.83 (95% CI: 0.76,0.90), and there was no appreciable difference in the hazard ratio found in the multivariable regression model, HR = 0.84 (95% CI: 0.77,0.92). As expected, as patients increase in age, T Stage increase, PSA increase, and Gleason score increases, the hazard also increases.

The hazard ratio between Gleason 8 and Gleason 7, from the multivariable Cox proportional hazard regression model, is HR = 1.23 (95% CI: 1.12,1.35).
Further analysis of the pairwise comparisons of the hazards between all four Gleason scores can be provided upon request.

Conclusions

The conclusions section for a data analysis report would generally be used to summarize the results presented in the analysis and results section, list any limitations to the study, and generate some discussion topics. Seeing how the purpose of *this* report was to show illustrate the use of knitr, the conclusions will focus on reproducible research.

Using knitr to write data analysis reports were the written report and the data analysis methods is a version of literate programming. When written well, the report are robust to changes in the data set, but more importantly, every element of the report is commented directly or contextually.

In addition to using knitr, a very powerful tool for authoring reports, both as a sole author, or as a collaboration, is to use version control software. I prefer git, but another viable option is subversion. RStudio has built-in features to working with either. Repository hosting on github.com or bitbucket.org are helpful, but on public servers (private repos are possible, but think about the physical location of the data storage). The git server software can be purchased and set up behind institutional firewalls.

```r
# for reproducability, print out the session infor for the packages, and
# versions of the packages, used to run the anlaysis and create this
# document.
print(sessionInfo(), local = FALSE)
```

```
## R version 3.0.1 (2013-05-16)
## Platform: x86_64-w64-mingw32/x64 (64-bit)
## 
## attached base packages:
## [1] splines   stats     graphics  grDevices utils     datasets  methods  
## [8] base     
## 
## other attached packages:
## [1] gdata_2.13.2    survival_2.37-4 knitr_1.5      
## 
## loaded via a namespace (and not attached):
## [1] evaluate_0.5.1 formatR_0.10   gtools_3.1.1   stringr_0.6.2 
## [5] tools_3.0.1
```