

Using the Penn Biostat LaTeX Templates

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INFORM●MATICS



Why LaTeX?

- ◆ It's a document preparation system for high-quality typesetting.
- ◆ Controls all the page layout, fonts, formatting for you through a style file.
- ◆ Control over large documents containing sectioning, cross-references, tables and figures.
- ◆ Typesetting of complex mathematical formulas.
- ◆ Advanced typesetting of mathematics with AMS-LaTeX.
- ◆ **Automatic generation of bibliographies and indexes.**

Penn Biostat LaTeX Templates

- ◆ **Available from Biostat Research Website:**
 - <https://dbe.med.upenn.edu/biostat-research/resources-educational>
- ◆ **Separate zipped bundles for:**
 - MS Thesis
 - PhD Dissertation
- ◆ **Templates created to ensure your submission meets Penn's formatting requirements.**
 - http://www.upenn.edu/provost/dissertation_resources
 - Check requirements haven't changed since last date template updated
 - Word template available from Provost's office

Penn Biostat LaTeX Templates












◆ MS bundle contains:

- pennbiostatms.sty
 - thesisex_2017.tex
 - thesisex_2017.pdf
 - dissertationex.bib
 - anvil.jpg
- style file that controls formatting
 - example LaTeX file to work from
 - compiled LaTeX document
 - example LaTeX bibliography file
 - figure used by the example file

◆ PhD bundle contains:

- pennbiostat_biblatex.sty
 - dissertationex2017.tex
 - dissertationex2017.pdf
 - dissertationex.bib
 - RR1.jpg
- style file that controls formatting
 - example LaTeX file to work from
 - compiled LaTeX document
 - example LaTeX bibliography file
 - figure used by the example file

Penn Biostat LaTeX Templates

Name	Date modified	Type	Size
 anvil.jpg	11/16/2012 3:49 PM	JPG File	38 KB
 dissertationex.bib	3/6/2014 5:57 PM	BibTeX Database	4 KB
 dissertationex2017.pdf	3/2/2017 12:56 PM	Adobe Acrobat D...	181 KB
 dissertationex2017.tex	3/2/2017 12:56 PM	LaTeX Document	14 KB
 pennbiostat_biblatex.sty	3/2/2017 12:45 PM	LaTeX Style	12 KB
 pennbiostat_MS_LaTeXtemplate_2017b.zip	4/20/2017 2:35 PM	Compressed (zipp...	158 KB
 pennbiostat_PhD_LaTeXtemplate_2017.zip	3/2/2017 1:23 PM	Compressed (zipp...	182 KB
 pennbiostatms.sty	4/20/2017 3:26 PM	LaTeX Style	10 KB
 RR1.jpg	7/24/2012 3:10 PM	JPG File	81 KB
 thesisex_2017.pdf	4/20/2017 3:26 PM	Adobe Acrobat D...	124 KB
 thesisex_2017.tex	4/20/2017 3:26 PM	LaTeX Document	11 KB

PhD Dissertation Template – <dissertationex2017.tex>

```
1 \documentclass[10pt]{report} % Acceptable font sizes are 10 to 12 pts depending on font type. Arial
  (10pt), Courier New (10pt), Times New Roman (12pt) or Verdana (10pt).
2 % This template used Arial 10pt. Note that lengths in the style file may need to be changed if a
  different size and font are used.
3
4 % Commands needed for using Biblatex instead of natbib.
5 % NB: If you have biber installed, change backend=bibtex to backend=biber for better formatting
6 \usepackage[backend=bibtex,style=authoryear-comp,firstinits=true,terseinits=true,maxcitenames=3
  ,maxbibnames=99,dashed=false,natbib=true]{biblatex}
7 \DeclareNameAlias{sortname}{last-first}
8 \DeclareFieldFormat[article,incollection,unpublished]{title}{#1}%No quotes for article titles
9 \DeclareFieldFormat[thesis]{title}{\mkbibemph{#1}} % Theses like book titles
10 \DeclareBibliographyDriver{article}{%
11   \usebibmacro{bibindex}%
12   \usebibmacro{begentry}%
13   \usebibmacro{author/translator+others}%
14   \setunit{\labelnamepunct}\newblock
15   \usebibmacro{title}%
16   \newunit
17   \printlist{language}%
18   \newunit\newblock
19   \usebibmacro{byauthor}%
20   \newunit\newblock
21   \usebibmacro{bytranslator+others}%
22   \newunit\newblock
```

Line 53 Column 1 Character 2360 UTF-8 CR+LF OVR READ UF NUM RF

PhD Dissertation Template – Preamble

```
46 % Style files needed to format dissertation correctly
47 \usepackage{pennbiostat_biblatex}
48 \usepackage{helvet} % Use to get arial type font
49
50 % This package automatically includes the packages:
51 % amsmath, amssymb, amsfonts, graphicx, verbatim, setspace, calc, array, tabularx, booktabs, tocloft,
52 % remreset, titlesec, parskip, url
53
54 % Make changes below this line
55 %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
56 %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
57
58 % All of your own packages go here
59 % \usepackage{epstopdf} % Include this package if you have eps figures to be included
60 \usepackage{multirow}
61
62 % Bibliography files go here. Use a separate \addbibresource for each .bib file. File extension is
63 % needed.
64 \addbibresource{dissertationex.bib}
65
66 \hyphenation{} % Hyphenation hints
```

PhD Dissertation Template – Preamble

```
67 \title{How to Catch the Road-Runner}
68 \author{Joe A. Student} % Your name
69 \date{2016} % Only put the year here
70 \supervisor{Wile E. Coyote}
71 \supervisortitle{Assistant Professor of TNT}
72 %\cosupervisor{Duffy Duck} % Comment out if not needed
73 %\cosupervisortitle{Associate Professor of WB} % Comment out if not needed
74 \gradchair{Nandita Mitra, Professor of Biostatistics} % This needs to be the graduate group chair.
    Check BGS website for current chair
75 \committee{Elma Fudd, Associate Professor of WB} % Your committee chair should be listed first
76 \committee{Sylvester the Cat, Associate Professor of WB}
77 \committee{Marvin the Martian, Professor of TNT}
78
79 \acknowledgement{I would like to thank \ldots}
80
81 \abstract{No more than 350 words. It is normally a single paragraph, consists of four parts: the
    statement of the problem;
82 the procedure and methods used to investigate the problem; the results of the investigation; and the
    conclusions.
83 The abstract is published online by ProQuest in ``Dissertation Abstracts International'', providing
    information to interested
84 readers about the general content of the dissertation.}
85
86 \begin{document}
```


PhD Dissertation Template – Main Text

```
102 \begin{mainf}
103 % THIS IS WHERE YOU CAN START ADDING CONTENT.
104 % RECOMMEND USING \include{} statements to split the chapters into manageable files.
105 % \include{introduction}
106 % \include{chapter1}
107
108 % Note the use of the \chpt command. DO NOT USE \chapter.
109
110 \chpt{Introduction} \label{chpt:intro}
111
112 This chapter should give an overview of the motivation for and methods to be presented. Also,
113 includes a paragraph(s) outlining what comes in the following chapters. Make sure you use the
114 \verb!\chpt! command to create chapters in order to conform to university formatting requirements.
115
116 \section{Sections}
117 Sections can be created using the \verb!\section! command.
118
119 \subsection{Subsections}
120 Subsections can be created using the \verb!\subsection! command.
121
122 Make sure you check the margins for all pages. If latex gives an overflow warning - check it out. The
123 most common causes of text in the margins are:
124
125 \begin{itemize}
126 \item {\bf Formulae:} LaTeX will not split a formula onto another line if it goes into the margins.
127 You will get a warning message but LaTeX will compile normally with the formula even running off the
```

PhD Dissertation Template – Main Text

- ◆ **Can split document into multiple .tex files:**

```
\begin{mainf}
```

```
\include{introduction}
```

- links in file <introduction.tex>

```
\include{chapter1}
```

- links in file <chapter1.tex>

```
\include{chapter2}
```

```
\include{chapter3}
```

```
\include{discussion}
```

```
\end{mainf}
```

- ◆ **Allows compiling by file to check for errors:**

```
\includeonly{chapter1,chapter2}
```

- only include chapters 1 & 2
when compiling

```
\begin{document}
```

- must come directly before
\begin{document}

PhD Dissertation Template – Appendices

```
---
223 \end{mainf}
224
225 % Use environment appendix1 if there is only 1 appendix (no numbering needed)
226 \begin{appendix1}
227 \chpt{Notation}
228 \end{appendix1}
229
230 % Use environment appendixm if there are multiple appendices that need numbering
231 \begin{appendixm}
232 \chpt{Notation}\label{append:notation}
233 \section{Chapter 2 Notation}
234
235 \chpt{Software}\label{append:software}
236 \end{appendixm}
237
238 \begin{bibliof}
239 \printbibliography[title={BIBLIOGRAPHY}]
240 \end{bibliof}
241
242 \end{document}
```

Labels / Cross References

- ◆ **LaTeX uses cross-references and labels to ensure all numbering is correct.**
 - Never type a number of a chapter, section, figure, table, equation, etc!

- ◆ **Use `\label{}` to name parts to cross-reference.**

```
\chpt{Introduction} \label{chpt:intro}
```

```
\caption{My figure of the data}\label{fig:data}
```

- ◆ **Use `\ref{}` to cross-reference the number in the text.**

See chapter `\ref{chpt:intro}` for more information.

shown in Figure `\ref{fig:data}`

Figure~`\ref{fig1}`

~ prevents LaTeX wrapping a line between Figure and the number. No spaces!

References

- ◆ Are controlled using biblatex, a bibliography file and citation commands in the .tex file.
- ◆ Never manually type a reference in your document!
- ◆ BibLaTeX help:
 - <https://www.sharelatex.com/blog/2013/07/31/getting-started-with-biblatex.html>
- ◆ All citations should be placed in a bibliography file (*.bib)
- ◆ In your .tex file use:
 - Inline citation: `\cite{ten2000mix}` → Ten Have et al., 2000
 - Parenthesized citation:
`\citep[e.g.][]{pin2006eff}` → (e.g. Pinheiro and Chao, 2006)
 - Multiple parenthesized citations: `\citep{ten2000mix,pin2006eff}`

Bibliography File

- ◆ **Contains all details for each reference.**

```
@ARTICLE{li2010mod,
```

key used in `\cite{}` commands to link to reference

```
author = "Li,Y and Wileyto,E P and Heitjan,D",
```

```
title = "Modeling smoking cessation data with alternating states and  
a cure fraction using frailty models",
```

```
journal = "Statistics in Medicine",
```

```
volume = 29,
```

```
pages = {627-638},
```

```
year = 2010 }
```

- ◆ **Can contain references you don't use in the .tex file.**
 - If not cited, they won't be included in your reference list.
- ◆ **Use { } to maintain capitals in titles.** E.g. {HIV}

Bibliography File

Creation of BibTeX entries:

- ◆ **OttoBib** - search for books by ISBN.
- ◆ **Google Scholar** - click the “Scholar preferences” link. Under Bibliography Manager select “Show links to import citations into: BibTeX.” Save preferences

[PDF\] Linear and nonlinear mixed effects models](#)

[J Pinheiro... - R package version, 2007 - tycho-if-a.mirrorservice.org](#)

This method function calculates the empirical autocorrelation function for the residuals from a gls fit. If a grouping variable is specified in form, the autocorrelation values are calculated using pairs of residuals within the same group; otherwise all possible residual pairs are ...

[Cited by 851](#) - [Related articles](#) - [View as HTML](#) - [All 117 versions](#) - [Import into BibTeX](#)

- ◆ **TeXMed** – converts PubMed / Medline entries into BibTeX format.

<http://www.bioinformatics.org/texmed/>



[Version 2.0.5, February 2010, for suggestions and comments please contact [Arne Muller](#), [download TeXMed](#), [Emacs mode for TeXMed](#)]

The query gets submitted to NCBI PubMed. The chosen articles can then be exported (converted) in BibTeX format. [Get Help ...](#)

[Search tips](#) & [search field/tag descriptions](#)

query might be: "sternberg mj" "MacCallum" [au] bioinformatics [ta]

Received 13 references

 incl. abstract link article ids (requires \usepackage{hyperref})

1. PMID [20558995](#), [bibtex](#) [JOURNAL ARTICLE]

Bastone, LA, Spielman, RS, Wang, X, Ten Have, TR, Putt, ME (2010). A Latent Class Model for Testing for Linkage and Classifying Families when the Sample May Contain Segregating and Non-Segregating Families. *Hum. Hered.*, 70, 2:75-91.

2. PMID [19397586](#), [bibtex](#) [Journal Article, Research Support, N.I.H., Extramural]

Almirall, D, Ten Have, T, Murphy, SA (2010). Structural nested mean models for assessing time-varying effect moderation. *Biometrics*, 66, 1:131-9.

3. PMID [18759831](#), [bibtex](#) [Journal Article, Research Support, N.I.H., Extramural]

Lin, JY, Ten Have, TR, Elliott, MR (2009). Nested Markov compliance class model in the presence of time-varying noncompliance.

Exported References will appear here ...

trying to export 2 references ...

§ 19397586

@Article{pmid19397586,

Author="Almirall, D. and Ten Have, T. and Murphy, S. A. ",

Title="{S}tructural nested mean models for assessing time-varying effect moderation",

Journal="Biometrics",

Year="2010",

Volume="66",

Pages="131--139",

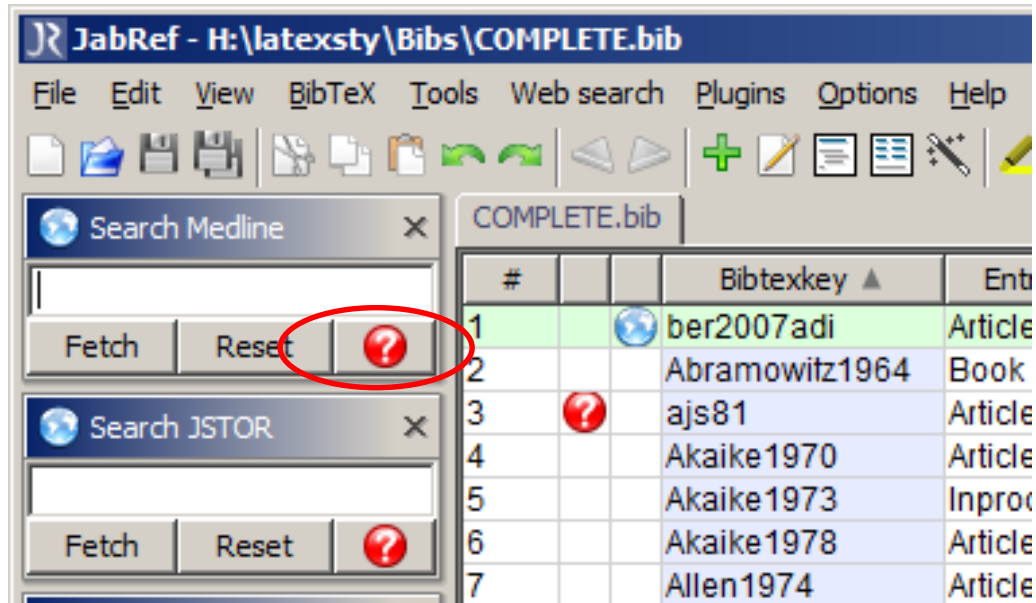
Month="Mar"

Bibliography File

Managing BibTeX entries:

◆ JabRef

- <http://jabref.sourceforge.net/>
- Java based graphical front end to manage BibTeX databases
- Can directly import references from online



JabRef - H:\latexsty\Bibs\COMPLETE.bib

File Edit View BibTeX Tools Web search Plugins Options Help

Search Medline

Fetch Reset

Search JSTOR

Fetch Reset

Groups

All Entries

...FDA

Settings

COMPLETE.bib

#		Bibtexkey	Entry...	Author	Title	Year	Journal
175		Kohn1991	Article	Kohn et al.	The Performance of Cross-Validation and ...	1991	#jasa#
176	?	Kohn1992	Article	Kohn et al.	Nonparametric Spline Regression with Aut...	1992	Biometrika
177	?	Konishi1...	Article	Konishi and Kitagawa	Generalised Information Criteria in Model S...	1996	#biok#
178	?	Kosorok1...	Article	Kosorok and Chao	The Analysis of Longitudinal Ordinal Respo...	1996	#jasa#
179		Kuk1995	Article	Kuk	Asymptotically unbiased estimation in gene...	1995	#jrssb#
180	?	Laird1982	Article	Laird and Ware	Random-Effects Models for Longitudinal D...	1982	#bio#
181	?	Laird1992	Article	Laird et al.	Longitudinal Studies with Continuous Res...	1992	Statistical...
182		Lancaster...	Article	Lancaster and Intrator	Panel data with survival: Hospitalization of {...	1998	#jasa#
183		Lange1995	Article	Lange	A Gradient Algorithm locally equivalent to th...	1995	#jrssb#
184	?	Lee1999	Article	Lee and Solo	Bandwidth Selection for Local Linear Regre...	1999	Computat...
185		Lehmann...	Article	Lehmann	Some concepts of dependence	1966	Annals of ...
186	?	Li1984	Article	Li	Consistency for Cross-Validated Nearest N...	1984	#anst#
187	?	Li1987	Article	Li	Asymptotic Optimality for $\{C\}_n$ $\{C\}_l$	1987	#anst#

Required fields Optional fields General Abstract Review BibTeX source

Article

Author: Laird,N.M. and Ware,J.H.

Title: Random-Effects Models for Longitudinal Data

Journal: #bio# Toggle abbreviation

Year: 1982

Volume: 38

Pages: 963-974

Bibtexkey: Laird1982

Status: Displaying no groups.

Compiling the Dissertation

- ◆ Multiple steps needed to “Build”
 1. Run LaTeX -> PDF
 2. Run BibTeX - Needed to find references
 3. Run LaTeX -> PDF
 4. Run LaTeX -> PDF
- ◆ Depending on build set-up, may be able to just run LaTeX -> PDF twice
- ◆ Must run LaTeX at least twice at end to get all numbering correct.

LaTeX Overfull \hbox Warnings



- ◆ **Your dissertation will be rejected if you don't fix these.**
- 1. **Formulae: LaTeX will not wrap if they go into the margins.**
 - You will get a warning message but LaTeX will compile normally with the formula even running off the side of the page.
- 2. **Long Words: Manually help LaTeX hyphenate.**
 - If a long word will just end into the margin, and LaTeX is not sure where to hyphenate to split the word over two lines, it may let it run into the margin.
 - Control the hyphenation manually to keep within the margins using the `\hyphenation{}` hints command at the top of the template. Example:
`\hyphenation{rep-re-sent-a-tive,matlab,er-go-nom-ic}`
- 3. **Verbatim:** Use of the verbatim environment removes all of LaTeX's formatting controls for that section.
 - You must manually add line returns to prevent overflow.

Some Useful Packages

◆ *verbatim*

- Allows you to type exact text.
- Great for software output.

Matlab:

```
\begin{boxedverbatim}
```

```
>> A = .4*ones(3)
```

```
A =
```

```
0.4000    0.4000    0.4000
0.4000    0.4000    0.4000
0.4000    0.4000    0.4000
```

```
\end{boxedverbatim}
```

Matlab:

```
>> A = .4*ones(3)
```

```
A =
```

```
0.4000    0.4000    0.4000
0.4000    0.4000    0.4000
0.4000    0.4000    0.4000
```

Some useful packages - Tables

- ◆ ***longtable***

- allows table that extends over multiple pages to be split

- ◆ ***multirow***

- allows table columns to span multiple rows / columns.

		Primes			
		2	3	5	7
Powers	504	3	2	0	1
	540	2	3	1	0
Powers	gcd	2	2	0	0
	lcm	3	3	1	1

min
max

```
\usepackage{multirow}
```

```
...
```

```
\begin{tabular}{cc|c|c|c|c|1}
```

```
\cline{3-6}
```

```
& & \multicolumn{4}{|c|}{Primes} \\ \cline{3-6}
```

```
& & 2 & 3 & 5 & 7 \\ \cline{1-6}
```

```
\multicolumn{1}{|c|}{\multirow{2}{*}{Powers}} &
```

```
\multicolumn{1}{|c|}{504} & 3 & 2 & 0 & 1 & \\ \cline{2-6}
```

```
\multicolumn{1}{|c|}{} &
```

```
\multicolumn{1}{|c|}{540} & 2 & 3 & 1 & 0 & \\ \cline{1-6}
```

```
\multicolumn{1}{|c|}{\multirow{2}{*}{Powers}} &
```

```
\multicolumn{1}{|c|}{gcd} & 2 & 2 & 0 & 0 & min \\ \cline{2-6}
```

```
\multicolumn{1}{|c|}{} &
```

```
\multicolumn{1}{|c|}{lcm} & 3 & 3 & 1 & 1 & max \\ \cline{1-6}
```

```
\end{tabular}
```

Some useful packages - Figures

- ◆ ***wrapfig***

- allows text to wrap around the figure, instead of the figure taking up an entire line.

- ◆ ***subfig***

- place several figures (or tables) into one figure (table) with separate caption options.



(a) A gull

(b) A tiger

(c) A mouse

Figure 1: Pictures of animals


```
\usepackage{subfig}
...

\begin{figure}%
  \centering
  \subfigure[A gull]{...}\qqquad
  \subfigure[A tiger]{...}\qqquad
  \subfigure[A mouse]{%
    \label{3figs-c}%
    ...}%
  \caption{Pictures of animals}\label{3figs}
\end{figure}
```

Equations

- ◆ **Define complex commonly used symbols at start of document.**

```
\newcommand{\vc}[1]{\mbox{\boldmath{\$ {#1} \$}}}
```

```
\newcommand{\yij}{\vc{y}_{ij}}
```

```
\newcommand{\bSb}{\vc{b}^T \vc{\Sigma}_u \vc{b}}
```

```
\newcommand{\cov}{\operatorname{cov}}
```

```
\newcommand{\var}{\operatorname{var}}
```

```
\newcommand{\tr}{\operatorname{tr}}
```

- ◆ **Reference equations using `\eqref{}` to automatically get parentheses. E.g**

equation `\eqref{eq:integration}` \longrightarrow equation (1.2)

Equations

Environments in amsmath package:

◆ *align*

- nicer multiline equation alignment.

$$\begin{aligned} \nu^{(k+1)} &= \nu^{(k)} + (\mathbf{X}'_1 E(\mathbf{M})^{(k)} \mathbf{X}_1)^{-1} \mathbf{X}'_1 E(\tilde{\mathbf{Y}})^{(k)} \\ \hat{\alpha}_2 &= \left(\sum_i \mathbf{X}_{2i}^T \mathbf{X}_{2i} \right)^{-1} E \sum_i \mathbf{X}_{2i}^T (\mathbf{r}_i - \mathbf{1}_{n_i} \mathbf{b}^T \mathbf{u}_i) \\ \hat{\mathbf{b}} &= E \left(\sum_i n_i \mathbf{u}_i \mathbf{u}_i^T \right)^{-1} E \sum_i \mathbf{u}_i \mathbf{1}_{n_i}^T (\mathbf{r}_i - \mathbf{X}_{2i} \alpha_2) \\ \hat{\Sigma}_{\mathbf{u}} &= \left(\sum_i n_i \right)^{-1} E \sum_i n_i \mathbf{u}_i \mathbf{u}_i^T \\ \hat{\Sigma}_{\beta} &= \left(\sum_i n_i \right)^{-1} E \sum_{ij} \beta_{ij} \beta_{ij}^T \\ \hat{s}^2 &= \left(\sum_i n_i \right)^{-1} E \sum_i (\mathbf{r}_i - \mathbf{X}_{2i} \alpha_2 - \mathbf{1}_{n_i} \mathbf{b}^T \mathbf{u}_i)^T \\ &\quad \times (\mathbf{r}_i - \mathbf{X}_{2i} \alpha_2 - \mathbf{1}_{n_i} \mathbf{b}^T \mathbf{u}_i) \end{aligned}$$

$$\begin{aligned} \nu^{(k+1)} &= \nu^{(k)} + (\mathbf{X}'_1 E(\mathbf{M})^{(k)} \mathbf{X}_1)^{-1} \mathbf{X}'_1 E(\tilde{\mathbf{Y}})^{(k)} \\ \hat{\alpha}_2 &= \left(\sum_i \mathbf{X}_{2i}^T \mathbf{X}_{2i} \right)^{-1} E \sum_i \mathbf{X}_{2i}^T (\mathbf{r}_i - \mathbf{1}_{n_i} \mathbf{b}^T \mathbf{u}_i) \\ \hat{\mathbf{b}} &= E \left(\sum_i n_i \mathbf{u}_i \mathbf{u}_i^T \right)^{-1} E \sum_i \mathbf{u}_i \mathbf{1}_{n_i}^T (\mathbf{r}_i - \mathbf{X}_{2i} \alpha_2) \\ \hat{\Sigma}_{\mathbf{u}} &= \left(\sum_i n_i \right)^{-1} E \sum_i n_i \mathbf{u}_i \mathbf{u}_i^T \\ \hat{\Sigma}_{\beta} &= \left(\sum_i n_i \right)^{-1} E \sum_{ij} \beta_{ij} \beta_{ij}^T \\ \hat{s}^2 &= \left(\sum_i n_i \right)^{-1} E \sum_i (\mathbf{r}_i - \mathbf{X}_{2i} \alpha_2 - \mathbf{1}_{n_i} \mathbf{b}^T \mathbf{u}_i)^T \\ &\quad \times (\mathbf{r}_i - \mathbf{X}_{2i} \alpha_2 - \mathbf{1}_{n_i} \mathbf{b}^T \mathbf{u}_i) \end{aligned}$$

```

\begin{align*}
\vc{\nu}^{\{k+1\}} &=
\vc{\nu}^{\{k\}} + (\vc{X}_{\{1\}}'E(\vc{M})^{\{k\}}\vc{X}_{\{1\}})^{\{-1\}}
\vc{X}_{\{1\}}'E(\tilde{\vc{Y}})^{\{k\}} \\
\halR &= \left( \sum_i \XRi^T \XRi \right)^{\{-1\}}
E \sum_i \vc{X}_{\{2i\}}^T (\vc{r}_{\{i\}} - \vc{1}_{\{n_i\}}) \vc{b}^T \ui \\
\hb &= E \left( \sum_i n_i \ui \ui^T \right)^{\{-1\}}
E \sum_i \ui \vc{1}_{\{n_i\}}^T (\vc{r}_{\{i\}} - \vc{X}_{\{2i\}} \vc{\alpha}_{\{2\}}) \\
\hsigu &= \left( \sum_i n_i \right)^{\{-1\}}
E \sum_i n_i \ui \ui^T \\
\hsigb &= \left( \sum_{ij} n_{ij} \right)^{\{-1\}}
E \sum_{ij} \vc{\beta}_{\{ij\}} \vc{\beta}_{\{ij\}}^T \\
\hsigR &= \left( \sum_i n_i \right)^{\{-1\}}
E \sum_i (\vc{r}_{\{i\}} - \vc{X}_{\{2i\}} \vc{\alpha}_{\{2\}} - \vc{1}_{\{n_i\}}) \vc{b}^T \ui)^{\{T\}} \\
&\quad \times (\vc{r}_{\{i\}} - \vc{X}_{\{2i\}} \vc{\alpha}_{\{2\}} - \vc{1}_{\{n_i\}}) \vc{b}^T \ui) \\
\end{align*}

```

Equations

Environments:

◆ *alignat*

- align equations at more than one place.

◆ *split*

- use inside *equation*, *align*, etc. to split an equation over multiple lines with multiline equation getting only one reference number.

```
\begin{equation}\label{xx}  
\begin{split}  
a&=b+c-d\\  
&\quad +e-f\\  
&=g+h\\  
&=i  
\end{split}  
\end{equation}
```

$$(2) \quad \begin{aligned} a &= b + c - d \\ &\quad + e - f \\ &= g + h \\ &= i \end{aligned}$$

Equations

Environments:

◆ *multline*

- align first line of equation on the left, last line on the right, and center middle lines.

```
\begin{multline}
a+b+c+d+e+f\\
+i+j+k+l+m+n
\end{multline}
```

$$(3) \quad \begin{array}{l} a + b + c + d + e + f \\ + i + j + k + l + m + n \end{array}$$

◆ *gather*

- center alignment of all equations.

Equations

Useful commands in amsmath package:

- ◆ `\intertext{ }`
 - place correctly formatted lines of text in middle of equation without affecting alignment.

The second two simulations were performed assuming the true underlying model was the shared parameter model below with 30% and 50% censoring rates respectively.

$$\begin{aligned}\text{logit}(\mu_{jkt}) = & -3.4 + 2.3(I_{t=2}) + 2(\text{iron}) + 0.1(\text{time}) \\ & + \beta_{j1} + (\text{time})\beta_{j2}, \quad t = 1, 2\end{aligned}$$

$$\begin{aligned}\log(r_j) = & 1.2 + 0.13(\text{iron}) + 0.1(\text{length of ESRD}) \\ & + \beta_{j1} + 0.1\beta_{j2} + \varepsilon_j\end{aligned}$$

where

$$\begin{aligned}\begin{pmatrix} \beta_{j1} \\ \beta_{j2} \end{pmatrix} & \sim N \left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 0.8 & 0.1 \\ 0.1 & 0.2 \end{pmatrix} \right), \\ \varepsilon_j & \sim N(0, 0.7),\end{aligned}$$

and μ_{jkt} is the cumulative probability of having the outcome $\leq t$ at the k -th time point for the j -th subject. Two

The second two simulations were performed assuming the true underlying model was the shared parameter model below with 30\% and 50\% censoring rates respectively.

```

\begin{align*}
\mbox{logit}(\mu_{jkt})=&-
3.4+2.3(I_{t=2})+2(\mbox{iron})+0.1(\mbox{time})\backslash\backslash
&\; +\beta_{j1}+(\mbox{time})\beta_{j2}, \quad \quad \quad t=1,2\backslash\backslash
\log(r_{j})=&1.2+0.13(\mbox{iron})+0.1(\mbox{length of ESRD})\backslash\backslash
&\; +\beta_{j1}+0.1\beta_{j2}+\err_{j} \quad \backslash\backslash
\intertext{where }
\left(\begin{array}{cc} \beta_{j1}\backslash\backslash \beta_{j2} \end{array}\right)
\sim & N \left(\begin{array}{cc} \%
0\backslash\backslash 0
\end{array}\right), \left(\begin{array}{cc} \%
0.8 \quad & 0.1\backslash\backslash
0.1 \quad & 0.2
\end{array}\right), \quad \backslash\backslash
\err_{j} \sim & N(0,0.7),
\end{align*}

```


Equations

Useful commands in amsmath package:

◆ `\left.` `\right.`

- used to let LaTeX set delimiter sizes correctly over multiple lines of equations.

$$\begin{aligned} & \phi(\mathbf{y}_{ij} | \mathbf{X}_{1ij}, \mathbf{u}_i, \beta_{ij}, \hat{\varphi}) \\ &= \prod_i^N \prod_j^{n_i} \prod_k^{n_{ij}} \left(\frac{\exp(\alpha_{01} + \mathbf{x}_{1ijk}^T \boldsymbol{\alpha}_1 + T)}{1 + \exp(\alpha_{01} + \mathbf{x}_{1ijk}^T \boldsymbol{\alpha}_1 + T)} \right)^{y_{ijk1}} \\ & \times \prod_{t=2}^{S-1} \left(\frac{\exp(\alpha_{01} + \dots + \alpha_{0t} + \mathbf{x}_{1ijk}^T \boldsymbol{\alpha}_1 + T)}{1 + \exp(\alpha_{01} + \dots + \alpha_{0t} + \mathbf{x}_{1ijk}^T \boldsymbol{\alpha}_1 + T)} \right)^{y_{ijkt}} \\ & - \frac{\exp(\alpha_{01} + \dots + \alpha_{0(t-1)} + \mathbf{x}_{1ijk}^T \boldsymbol{\alpha}_1 + T)}{1 + \exp(\alpha_{01} + \dots + \alpha_{0(t-1)} + \mathbf{x}_{1ijk}^T \boldsymbol{\alpha}_1 + T)} \\ & \times \left(1 - \frac{\exp(\alpha_{01} + \dots + \alpha_{0S} + \mathbf{x}_{1ijk}^T \boldsymbol{\alpha}_1 + T)}{1 + \exp(\alpha_{01} + \dots + \alpha_{0S} + \mathbf{x}_{1ijk}^T \boldsymbol{\alpha}_1 + T)} \right)^{y_{ijkS}}, \end{aligned}$$

```

\begin{align*}
\phi(\mathbf{y}_{ij} | \mathbf{x}_y, \mathbf{u}_i, \mathbf{v}_c\{\beta\}_{ij}, \hat{\mathbf{v}}_c\{\varphi\}) \ \backslash\backslash
&= \dots \ \backslash\backslash
& \times \prod_{t=2}^S
1) \left( \frac{\text{exp}(\alpha_{01} + \dots + \alpha_{0t} + \mathbf{v}_c\{\mathbf{x}\}_{1ijk}^T \mathbf{v}_c\{\alpha\}_{1+T})}{1 + \text{exp}(\alpha_{01} + \dots + \alpha_{0t} + \mathbf{v}_c\{\mathbf{x}\}_{1ijk}^T \mathbf{v}_c\{\alpha\}_{1+T})} \right) \ \backslash\backslash
& \left( - \frac{\text{exp}(\alpha_{01} + \dots + \alpha_{0(t-1)} + \mathbf{v}_c\{\mathbf{x}\}_{1ijk}^T \mathbf{v}_c\{\alpha\}_{1+T})}{1 + \text{exp}(\alpha_{01} + \dots + \alpha_{0(t-1)} + \mathbf{v}_c\{\mathbf{x}\}_{1ijk}^T \mathbf{v}_c\{\alpha\}_{1+T})} \right)^{y_{ijkt}} \ \backslash\backslash
& \dots \ \backslash\backslash
T&= \dots
\end{align*}

```

Equations

Useful commands in amsmath package:

- ◆ `\shoveleft{}` `\shoveright{}`
 - aligns equation to the left / right of the line.

```
\begin{multline}
```

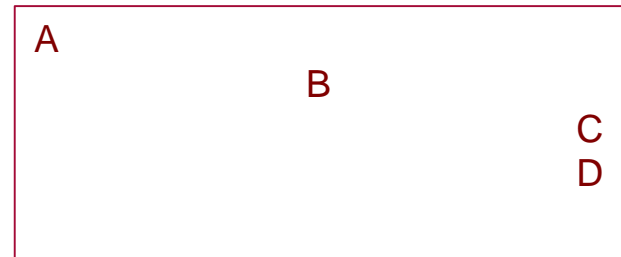
```
A\\
```

```
B\\
```

```
\shoveright{C}\\
```

```
D
```

```
\end{multline}
```



LaTeX Resources

◆ Good intro to LaTeX at:

- <https://www.latex-project.org/>
- <https://en.wikibooks.org/wiki/LaTeX>

◆ Books:

- <https://www.latex-project.org/help/books/>
- Frank Mittelbach, Michel Goossens, Johannes Braams, David Carlisle, Chris Rowley (2004). **The LaTeX Companion, 2nd edition.**