Mel and Enid Zuckerman College of Public Health
University of Arizona

SYLLABUS
Longitudinal and Mixed Effects Models (BIOS 684)
FALL 2020

Time: Monday and Wednesday (1:00pm – 2:15pm)

Location: HSI 321 or on Zoom

Instructor(s) and Contact Information:
Jin Zhou
Office: Drachman A242
Phone: 520-626-1393
Email: jzhou@arizona.edu

Xiaoxiao Sun
Office: Drachman A226
Phone: 520-626-7008
Email: xiaosun@arizona.edu

Instructor Availability: Appointment needed

Catalog Description: This course introduces basic concepts of linear algebra that are essential for understanding more advanced statistical modeling methodology. This knowledge is used to understand the General Linear Model (GLM), which includes linear regression, ANOVA, and other special applications and modern methods for the analysis of repeated measures, correlated outcomes and longitudinal data, including the unbalanced and incomplete data sets characteristic of biomedical research. Topics include an introduction to matrices for statistics, general linear models, analysis of correlated data, random effects models, and generalized linear mixed models.

Course Description: This course covers modern methods for the analysis of repeated measures, correlated outcomes, and longitudinal data, including the unbalanced and incomplete data that are characteristic of biomedical research. Topics include an introduction to the analysis of longitudinal data, the analysis of response profiles, fitting parametric curves, covariance pattern models, random effects and growth curve models, generalized linear models for longitudinal data including generalized estimating equations (GEE), and generalized linear mixed models (GLMMs).

Course Prerequisites: CPH 576A, CPH 576B

Course Objectives:

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Describe the statistical methods utilized to analyze longitudinal data in a variety of settings and with a variety of types of outcome variables.

- Analyze a scientific problem that requires repeated measurements, identify an appropriate design, and identify the statistical methods required to analyze the data.
- Utilize R to perform longitudinal analyses of data generated from randomized and observational studies with repeated measures designs.
- Apply modern methods for the analysis of longitudinal data to a range of settings encountered in biomedical and public health research.
- Interpret and communicate the clinical/scientific meaning of the results of your longitudinal analysis.

**Competencies Obtained:**

**Analytical Skills:**
- Defines a problem
- Determines appropriate uses and limitations of data
- Understanding basic research designs used in public health
- Makes relevant inferences from data

**Communication Skills:**
- Communicates effectively both in writing and orally (unless a handicap precludes one of those forms of communication)
- Interpreting and presenting accurately and effectively demographic, statistical, and scientific information for professional and lay audiences adapting and translating public health concepts to individuals and communities
- Leading and participating in groups to address specific issues, including ability to work in teams, span organizational boundaries and cross systems

**Course Notes:** Notes will be posted online before lecture

**Required Texts or Readings:**

**Course Requirements:** Successful completion of all homework, examinations, and active class participation.

**Grading Scale/Student Evaluation and Policies:** Homework assignments will be from the texts, and readings. The instructor will provide problems. Due dates will be given for each assignment. Late homework will not be accepted. On both homework and examinations, partial credit will be given, so always show your work and be as neat and clear as possible. Exams and homework contribute to your final grade as follows:

- Homework: 30%
- Midterm: 40%
- Final Project: 30%

In addition to the final presentation on the course project, students are required to write a final report on the course project.

University policy regarding grades and grading systems is available at: [http://catalog.arizona.edu/policy-type/grade-policies](http://catalog.arizona.edu/policy-type/grade-policies)

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A: 90 or higher
B: 80-89
C: 70-79
D: 60-69
E: 59 or less

### Course Schedule:

<table>
<thead>
<tr>
<th>Class</th>
<th>Date</th>
<th>Topics</th>
<th>Readings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>08/24/2020</td>
<td>Introduction to the course</td>
<td>Lecture notes 1</td>
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<tr>
<td>2</td>
<td>08/26/2020</td>
<td>Linear algebra review</td>
<td>Lecture notes 2</td>
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<tr>
<td>3</td>
<td>08/31/2020</td>
<td>Introduction to SAS and R</td>
<td>Lecture notes 3</td>
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<tr>
<td>4</td>
<td>09/02/2020</td>
<td>Introduction to linear regression</td>
<td>Lecture notes 4</td>
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<tr>
<td>5</td>
<td>09/09/2020</td>
<td>Basic concepts</td>
<td>Lecture notes 5, FLW (Chapter 2)</td>
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<tr>
<td>6</td>
<td>09/14/2020</td>
<td>Statistical basis I</td>
<td>Lecture notes 6, FLW (Chapter 3)</td>
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<tr>
<td>7</td>
<td>09/16/2020</td>
<td>Statistical basis II</td>
<td>Lecture notes 7, FLW (Chapter 4)</td>
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<tr>
<td>8</td>
<td>09/21/2020</td>
<td>Modeling the mean-analysis of response profiles</td>
<td>Lecture notes 8, FLW (Chapter 5)</td>
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<tr>
<td>9</td>
<td>09/23/2020</td>
<td>Modeling the mean-1 df contrast</td>
<td>Lecture notes 9, FLW (Chapter 5)</td>
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<tr>
<td>10</td>
<td>09/28/2020</td>
<td>Modeling the mean-parametric curves</td>
<td>Lecture notes 10, FLW (Chapter 7)</td>
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<tr>
<td>11</td>
<td>09/30/2020</td>
<td>Modeling the covariance</td>
<td>Lecture notes 11, FLW (Chapter 7)</td>
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<tr>
<td>12</td>
<td>10/05/2020</td>
<td>Lab</td>
<td>Lecture notes 12</td>
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<tr>
<td>13</td>
<td>10/07/2020</td>
<td>Synthesis of ideas of analyzing longitudinal data</td>
<td>Lecture notes 13</td>
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<td>14</td>
<td>10/12/2020</td>
<td>Two-stage mixed model</td>
<td>Lecture notes 14, FLW (Chapter 8)</td>
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<tr>
<td>15</td>
<td>10/14/2020</td>
<td>Linear mixed effects models</td>
<td>Lecture notes 15</td>
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<tr>
<td>16</td>
<td>10/19/2020</td>
<td>Lab</td>
<td>Lecture notes 16</td>
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<tr>
<td>17</td>
<td>10/21/2020</td>
<td>Linear mixed effects model and prediction</td>
<td>Lecture notes 17, FLW (Chapter 8)</td>
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<tr>
<td>18</td>
<td>10/26/2020</td>
<td>Assessing model fit</td>
<td>Lecture notes 18</td>
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<tr>
<td>19</td>
<td>10/28/2020</td>
<td>Exam review</td>
<td>Lecture notes 19</td>
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<tr>
<td>20</td>
<td>10/29/2020</td>
<td>Midterm exam</td>
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<tr>
<td>21</td>
<td>11/02/2020</td>
<td>Aspects of design of longitudinal studies</td>
<td>Lecture notes 20, FLW (Chapter 9 &amp; 20)</td>
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<td>22</td>
<td>11/04/2020</td>
<td>Introduction to GLM and Extensions of GLM to Longitudinal Data</td>
<td>Lecture notes 21, FLW (Chapter 11 &amp; 12)</td>
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<td>23</td>
<td>11/09/2020</td>
<td>GEE</td>
<td>Lecture notes 22, FLW (Chapter 12 &amp; 13)</td>
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<td>24</td>
<td>11/16/2020</td>
<td>Lab</td>
<td>Lecture notes 23</td>
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<td>25</td>
<td>11/18/2020</td>
<td>GLMM</td>
<td>Lecture notes 24</td>
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<td>26</td>
<td>11/23/2020</td>
<td>Comparison of marginal and mixed effects models</td>
<td>Lecture notes 25</td>
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<td>27</td>
<td>11/25/2020</td>
<td>Lab</td>
<td>Lecture notes 26</td>
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<td>28</td>
<td>11/30/2020</td>
<td>Missing data</td>
<td>Lecture notes 27, FLW (Chapter 17)</td>
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<td>29</td>
<td>12/02/2020</td>
<td>Multilevel models</td>
<td>Lecture notes 28, FLW (Chapter 22)</td>
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<tr>
<td>30</td>
<td>12/07/2020</td>
<td>Semiparametric models I</td>
<td>Lecture notes 29</td>
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<tr>
<td></td>
<td>12/09/2020</td>
<td>Semiparametric models II</td>
<td>Lecture notes 30</td>
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<tr>
<td></td>
<td>12/17/2020</td>
<td>Take home final due</td>
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**Required Statements:**

**Communications:** You are responsible for reading emails sent to your UA account from your instructor and the announcements that are placed on the course web site. Information about readings, news events, your grades, assignments and other course related topics will be communicated to you with these electronic methods. The official policy can be found at: https://www.registrar.arizona.edu/personal-information/official-student-email-policy-use-email-official-correspondence-students

**Accessibility and Accommodations:**
At the University of Arizona, we strive to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability or pregnancy, you are welcome to let me know so that we can discuss options. You are also encouraged to contact Disability Resources (520-621-3268) to explore reasonable accommodation. If our class meets at a campus location: Please be aware that the accessible table and chairs in this room should remain available for students who find that standard classroom seating is not usable. For additional information on Disability Resources and reasonable accommodations, please visit http://drc.arizona.edu/students

**Code of Academic Integrity**
Students are encouraged to share intellectual views and discuss freely the principles and applications of course materials. However, graded work/exercise must be the product of independent effort unless otherwise instructed. Students are expected to adhere to the UA Code of Academic Integrity, available through the office of the UA Dean Students: http://deanofstudents.arizona.edu/policies-and-codes/code-academic-integrity

**Classroom Behavior:** (Statement of expected behavior and respectful exchange of ideas):
Present policies to foster a positive learning environment, including use of cell phones, mobile devices, etc.). Students are expected to be familiar with the UA Policy on Disruptive Student Behavior in an Instructional Setting found at: http://policy.arizona.edu/education-and-student-affairs/disruptive-behavior-instructional-setting

**Threatening Behavior Policy:** The UA Threatening Behavior by Students Policy prohibits threats of physical harm to any member of the University community, including to one’s self, http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students

**Nondiscrimination and Anti-Harassment Policy:**
The University of Arizona is committed to creating and maintaining an environment free of discrimination, http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy

**UA Smoking and Tobacco Policy:**
The purpose of this Policy is to establish the University of Arizona’s (University) commitment to protect the health of University faculty, staff, students, and visitors on its campuses and in its vehicles, http://policy.arizona.edu/ethics-and-conduct/smoking-and-tobacco-policy

**Syllabus Changes:** Information contained in the course syllabus, other than the grade and absence policies, may be subject to change with reasonable advance notice, as deemed appropriate by the instructor.

**Plagiarism:** What counts as plagiarism?
- Copying and pasting information from a web site or another source, and then revising it so that it sounds like your original idea.
- Doing an assignment/essay/take home test with a friend and then handing in separate assignments that contain the same ideas, language, phrases, etc.

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• Quoting a passage without quotation marks or citations, so that it looks like your own.
• Paraphrasing a passage without citing it, so that it looks like your own.
• Hiring another person to do your work for you, or purchasing a paper through any of the on- or off-line sources.

**Flex in-person:** This class is scheduled to be taught in the FLEX IN-PERSON modality. During our class meetings, we will respect CDC guidelines, including **limited seating to increase physical distancing and appropriately-worn face coverings.** See below for the University’s policy on wearing face coverings in University buildings. [Official language: https://president.arizona.edu/news/2020/07/administrative-directive-use-face-coverings]

The Disability Resource Center is available to explore face coverings and accessible considerations if you believe that your disability or medical condition precludes you from utilizing any face covering or mask option. DRC will explore the range of potential options as well as remote course offerings. Should DRC determine an accommodation to this directive is reasonable, DRC will communicate this accommodation with your instructor.

**If you feel sick:**
Stay home. Except for seeking medical care, avoid contact with others and do not travel. Notify your instructors if you will be missing an in person or online course.
Campus Health is testing for COVID-19 - please call (520) 621-9202 before you come in.
Campus Health is testing individuals who are concerned that they are infected with or have been exposed to COVID-19.
They continue to test only students, staff, and faculty of the University at this time.
Campus Health providers will evaluate patients and order testing if appropriate.
Visit the Campus Health website for more information.
Visit the UArizona COVID-19 page for regular updates
If you are experiencing unexpected barriers to your success in your courses, please note the Dean of Students Office is a central support resource for all students and may be helpful. The Dean of Students Office can be reached at 520-621-2057 or DOS-deanofstudents@email.arizona.edu.

Students who need to miss a class, or series of classes, due to illness or the need to quarantine/isolate are responsible for emailing their course instructor, with copy to the Dean of Students at DOS-deanofstudents@email.arizona.edu, to let them know of the need, as soon as possible. There is no need for a medical excuse to be provided for absence of up to a week.
Students are responsible for completing any work that they might miss due to illness or the need to quarantine/isolate, including assignments, quizzes, tests and exams.
Students are responsible for communicating with their instructor(s) via the means of communication established by the instructor(s), e.g., via D2L, email, text message, etc.
Students who need to miss more than one week of classes in any one semester will be required to provide a doctor’s note of explanation to DOS-deanofstudents@email.arizona.edu. The Dean of Students Office will communicate the receipt of the note (with expected end date) out to the relevant faculty.

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