

Fall 2018 - Biostatistics 653: Applied Statistics III – Longitudinal Data Analysis

Mondays and Wednesdays, 3-4:30pm, 1690 SPH1A (Main Lecture)

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Office Hours:
Wednesdays 11am-noon

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Instructors:** Nina Zhou
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Office Hours:
2:30pm-4:30pm
Location:
1629 (September 18 –
December 11).
2615 (October 23).

Course Description:

This course is designed to provide an overview of statistical models and methodologies for analyzing repeated measures with a particular emphasis on analyzing longitudinal data. This is perhaps one of the most widely used topics in applied statistics. Applications are abundant in clinical and epidemiological literature covering biological, medical, behavioral as well as engineering sciences. The course covers general linear models and linear mixed models for analyzing correlated continuous data, as well as marginal (i.e. GEE), conditional (i.e. generalized linear mixed model) and transition models for analyzing correlated discrete data. The structural framework extends that of linear model and generalized linear model to incorporate dependent data where the dependence is induced through repeated measures over time.

Course Materials:

Required:

- Course Notes – Will be posted on Canvas by instructor. Students are responsible for printing out copies as needed. Other materials including code, data and example outputs will also be accessible via Canvas (<https://umich.instructure.com/>).
- Garrett M. Fitzmaurice, Nan M. Laird and James H. Ware (2012): *Applied Longitudinal Analysis*, 2nd Edition. Wiley.

Additional Resources (Not required):

- Peter J. Diggle, Patrick Heagerty, Kung-Yee Liang, Scott L. Zeger (2013): *Analysis of Longitudinal Data*, 2nd Edition. Oxford Statistical Science Series.

- Harrell Jr., F. E (2015): Regression Modeling Strategies with Applications to Linear Models, Logistic and Ordinal Regression, and Survival Analysis (Springer Series in Statistics), 2nd Edition. Free version available electronically through UM library Springerlink.

Pre-requisites:

Students are responsible for knowledge of introductory materials on the following topics from BIOSTAT 601 and BIOSTAT 650, currently enrolled in BIOSTAT 602 and 651.

Course Goals:

The objective of the course is to cover the following statistical methods for analyzing longitudinal data: (1) general linear models; (2) linear mixed models; (3) generalized estimating equations; (4) generalized linear mixed models; (5) transition models; (6) missing data models for dropout events. In addition, the course is to help students acquire statistical knowledge and develop computing skills for the appropriate analysis of longitudinal data.

Competencies:

This course strengthens core public health learning experiences in

1. understand the statistical methods used to analyze correlated and longitudinal data in a variety of settings and with a variety of outcome variables;
2. become well-versed in the application of core statistical techniques in analyzing repeated measures, and are capable of analyzing a scientific problem, identifying an appropriate design and selecting the statistical methods required to analyze the data;
3. master software to perform longitudinal analyses;
4. develop the knowledge to interpret and communicate the clinical and scientific meaning of the results to both statisticians and clinicians/scientists.

The following lists the new CEPH competencies that are applicable to this course:

Foundational Learning Objectives

Profession & Science of Public Health

1. Explain the role of quantitative and qualitative methods and sciences in describing and assessing a population's health
2. Explain the critical importance of evidence in advancing public health knowledge

Foundational Competencies

Evidence-based Approaches to Public Health

1. Apply epidemiological methods to the breadth of settings and situations in public health practice
2. Select quantitative and qualitative data collection methods appropriate for a given public health context

3. Analyze quantitative and qualitative data using biostatistics, informatics, computer-based programming and software, as appropriate
4. Interpret results of data analysis for public health research, policy or practice

Planning & Management to Promote Health

5. Select methods to evaluate public health programs

Course Requirements:

Software: We will primarily use R or SAS in the main lectures. R is freely available online. There is a free SAS university version for students to download and use. Alternatively, online remote access is available through Virtual Sites (<http://virtualsites.umich.edu/>) with log-in.

Evaluations:

Homework: Students need to submit **four** homework assignments via Canvas website. The GSI will grade the submitted homework on the website. Late work will not be accepted. Solutions for problems will be posted on the course website. It is fine to work in groups. However, **submitted homework papers must be written independently. You will be surprised how useful it will be to process new knowledge in your own words. Copying some or all of a homework assignment from someone else or from the web, or allowing your assignments to be copied by someone else, is cheating.** If you have questions about this policy please discuss with the instructor.

Examination and homework grading and re-grading: Any requests for re-grades should be submitted in writing within one week after the examination or homework is returned. Should you wish to request a regrade, submit your graded material and a written description of the issues to the instructor via email. During any regrade, the entire paper is subject to regrade, so if errors made in your favor in other problems are noted, these may also be corrected.

The midterm and final exams will be in-person. Please see detailed time and room below. Conflicts with the times of exams should be reported to the instructor by the end of the first week. Final exam times are fixed by the University registrar and *cannot be altered* (see <http://www.ro.umich.edu/exams/> for the university policy). There will be a midterm and a final exam; both open book and open note with some restrictions. The final is cumulative but will focus more on material from the later semester. During the exams, no consultation with other students in the class or with anyone else is permitted for the midterm or final exam. You can bring a calculator, but not a laptop/computer/smartphone or other devices connected to the internet.

Term Project: There will be a term project. You are expected to work in groups of **four**. You are free to select your partners for the project. For the project, your task will be to analyze some data that is collected over time. It is expected that you will at least use the data analytic methods learned in this course. The minimum requirement is to analyze some data containing at least a combination of 3-4 categorical and continuous predictors.

You are free to choose any resource for the data. However, you cannot just reproduce any analysis already published in the literature or elsewhere, or posted on the internet. A complete

reference to the data source must be included in your proposal. You are welcome to talk to me and the GSI regarding your project data in the interim.

A two-page (maximum; excluding figures, tables and references) proposal for the final project is due in class before presentation. The proposal should state a brief description and objective of your project, and indicate the proposed data analytic method to accomplish the task. Clearly state in your proposal the design, the outcome variable, and the potential predictors you plan to study. One proposal is expected from each group. Final reports are due 11:59pm on the last day of class. No exceptions to the due date will be made.

The final report should be written with the aim of publication in an applied statistics journal, such as *Annals of Applied Statistics*, *Biostatistics*, *Biometrics* or *Journal of Royal Statistical Society: Series C*, or *Journal of American Statistical Association*, *Application and Case Studies*. The project will be evaluated on the basis of originality, scholarship (including appropriate literature citations), clarity, organization and how well the class materials are applied. One report is expected from each group. Oral presentation of the project during one of the final class sessions is mandatory.

Midterm Exam:	20%	
Final Exam:	30%	
Term Project:	40%	
Homework:	20%	Four homework assignments of equal weights.

Total: 100%

Classroom Expectations/Etiquette:

The faculty of the School of Public Health believes that the conduct of a student registered or taking courses in the School should be consistent with that of a professional person. Courtesy, honesty and respect should be shown by students toward faculty members, guest lecturers, administrative support staff and fellow students. Similarly, students should expect faculty to treat them fairly, showing respect for their ideas and opinions and striving to help them achieve maximum benefits from their experience in the School. Student academic misconduct refers to behavior that may include plagiarism, cheating, fabrication, falsification of records or official documents, intentional misuse of equipment or materials (including library materials), and aiding and abetting the perpetration of such acts. The preparation of reports, papers, and examinations, assigned on an individual basis, must represent each student's own effort. Reference sources should be indicated clearly. The use of assistance from other students or aids of any kind during a written examination, except when the use of aids such as electronic devices, books or notes has been approved by an instructor, is a violation of the standard of academic conduct.

Diversity, Equity, and Inclusion:

The University of Michigan School of Public Health. The University of Michigan School of Public Health seeks to create and disseminate knowledge with the aim of preventing disease and promoting the health of populations worldwide. We recognize the histories of social discrimination globally, and seek to promote and extend opportunities for members of all groups that historically have been marginalized. We commit to developing the institutional mechanisms and norms necessary to promote the values of diversity, equity, and inclusion, both inside and outside our classrooms. To this end, SPH upholds the expectations that all courses will (1) **be inclusive**, (2) **promote brave discussions**, (3) **follow multicultural ground rules** and (4) **abide by UM policies and procedures**.

- 1) **Inclusive courses**, are those in which teachers and learners co-create and co-sustain environments that support and encourage all members to participate equitably. See <http://crlt.umich.edu/multicultural-teaching/inclusive-teaching-strategies> for more resources.
- 2) **Brave** (rather than safe) discussions promote diversity and social justice learning by acknowledging dynamics of oppression and privilege both inside and outside the classroom. Read more at <http://ssw.umich.edu/sites/default/files/documents/events/colc/from-safe-spaces-to-brave-spaces.pdf>.
- 3) **Multicultural ground rules** acknowledge diverse experiences in the classroom and offer strategies for holding one another appropriately accountable. See examples from the UM Program on Intergroup Relations and others at <http://ncdd.org/rc/item/1505>.
- 4) **UM policies and procedures** can be found at <http://diversity.umich.edu> with additional resources and instructions for reporting discrimination at <https://sph.umich.edu/diversity-equity-inclusion/resources.html>.

Academic Integrity:

The faculty and staff of the School of Public Health believe that the conduct of a student registered or taking courses in the School should be consistent with that of a professional person. Courtesy, honesty, and respect should be shown by students toward faculty members, guest lecturers, administrative support staff, community partners, and fellow students. Similarly, students should expect faculty to treat them fairly, showing respect for their ideas and opinions and striving to help them achieve maximum benefits from their experience in the School.

Student academic misconduct refers to behavior that may include plagiarism, cheating, fabrication, falsification of records or official documents, intentional misuse of equipment or materials (including library materials), and aiding and abetting the perpetration of such acts. Please visit <https://sph.umich.edu/student-resources/mph-mhsa.html> for the full Policy on Student Academic Conduct Standards and Procedures.

SPH Writing Lab:

The SPH Writing Lab is located in 5025 SPH II and offers writing support to all SPH students for course papers, manuscripts, grant proposals, dissertations, personal statements, and all other

academic writing tasks. The Lab can also help answer questions on academic integrity. To learn more or make an appointment, please visit the SPH writing lab [website](#).

Student Well-Being:

SPH faculty and staff believe it is important to support the physical and emotional well-being of our students. If you have a physical or mental health issue that is affecting your performance or participation in any course, and/or if you need help connecting with University services, please contact the instructor or the SPH Office for Student Engagement and Practice. Please visit <https://sph.umich.edu/student-life/wellness.html> for information on wellness resources available to you.

Student Accommodations:

Students should speak with their instructors before or during the first week of classes regarding any special needs. Students can also visit the SPH Office for Student Engagement and Practice for assistance in coordinating communications around accommodations. Students seeking academic accommodations should register with Services for Students with Disabilities (SSD). SSD arranges reasonable and appropriate academic accommodations for students with disabilities. Please visit <https://ssd.umich.edu/topic/our-services> for more information on student accommodations.

Students who expect to miss classes, examinations, or other assignments as a consequence of their religious observance shall be provided with a reasonable alternative opportunity to complete such academic responsibilities. It is the obligation of students to provide faculty with reasonable notice of the dates of religious holidays on which they will be absent. Please visit <http://www.provost.umich.edu/calendar/> for the complete University policy.

Course Schedule and Topics:

Lecture	Date	Topic	
1	9/5	Overview: Repeated Measures and Longitudinal Data	Ch. 1,2
2	9/10	Exploratory Data Analysis for Mean and Covariance Structure	
3	9/12	General Linear Models: Introduction	Ch. 3
4	9/17	General Linear Models: MLE and REML	Ch. 4
5	9/19	General Linear Models: WLS (I)	
6	9/24	General Linear Models: WLS (II)	
7	9/26	General Linear Models: Modeling the Mean	Ch. 5,6 HW1 due; 11:59pm
8	10/1	General Linear Models: Modeling the Covariance	Ch. 7
9	10/3	Linear Mixed Models (I)	Ch. 8
10	10/8	Linear Mixed Models (II)	Ch. 9
11	10/10	Linear Mixed Models (III)	Ch. 9 HW2 due; 11:59pm
	10/15	NO LECTURE (FALL BREAK)	
	10/17	NO LECTURE (Instructor travel)	
12	10/22	Review	
	10/24	MIDTERM EXAM	
13	10/29	Diagnostics	Ch. 10
14	10/31	Generalized Linear Models Refresher	Ch. 11
15	11/5	Marginal Models and GEE	Ch. 12
16	11/7	Marginal Models and GEE	Ch. 13 HW3 due; 11:59pm
17	11/12	Marginal Models and GEE	Ch. 14
18	11/14	Generalized Linear Mixed Models: Introduction	Ch. 15
19	11/19	Generalized Linear Mixed Models: Inference	
20	11/21	Generalized Linear Mixed Models: Example	Ch. 16 HW4 due Proposal due; 11:59pm
21	11/26	Marginal vs Conditional Models	
22	11/28	Missing Data	Ch. 17
23	12/3	Term Project Presentation I	
24	12/5	Term Project Presentation II	
25	12/10	Final Review	Project due 11:59pm
	12/19	FINAL (Wednesday 4:00-6:00 pm)	

