RUTGERS
School of Public Health

Course Title: *Applied Longitudinal Data Analysis*

Course Number: *BIST 0650*

Course Location: *School of Public Health Building, Room 1A/B*

Course Date & Time: *Tuesday 3:00 pm – 5:30 pm*

Course Instructor: *Yong Lin, Ph.D., Professor, Biostatistics and Epidemiology Department, School of Public Health, Rutgers University, Room 214 in School of Public Health Building, Phone: (732)-235-5513, email: linyo@sph.rutgers.edu*

Office Hours: *Tuesday 2:00pm – 3:00pm, and by appointment*

Course Assistant: *None*

Course Website: *canvas.rutgers.edu*

Required Course Text: *Peter Diggle, Patrick Heagerty, Kung-Yee Liang and Scott Zeger (2002) Analysis of Longitudinal Data, Second Edition. Oxford University Press, New York. ISBN: 978-0198524847*

Garrett Fitzmaurice, Nan Laird and James Ware (2011) Applied Longitudinal Analysis. Wiley; 2nd edition. ISBN13: 9780470380277

Additional/Supplemental Readings/Resources:

- *Ramon C. Littell, George A. Milliken, Walter W. Stoup, Russell D. Wolfinger, Oliver Schabenberger (2006). SAS System for Mixed Models, 2nd edtion. SAS Institute, Cary, NC. ISBN: 978-1590475003*
- *Jose C. Pinheiro and Douglas M. Bates, Mixed Effects Models in S and S-Plus (2000), Springer. ISBN: 978-1441903174*

Course Description: *Longitudinal data consists of multiple measures over time on a sample of individuals. The analysis of longitudinal data requires much more sophisticated methodologies due to the correlation introduced by repeated measurements. This course covers modern statistical techniques for longitudinal data from an applied perspective. Emphasis will be on data analysis and interpretation. Topics include characteristics of the longitudinal design, graphical exploration of the mean and correlation structure, linear mixed effects models and multilevel modeling, maximum likelihood and restricted maximum likelihood estimation, modeling the variance-covariance structures, inference for random effects, logistic and Poisson mixed effects model for binary and count data, marginal models and generalized estimating equations, and model diagnostics. Analysis of real and substantial data sets using statistical software SAS and R will be integrated throughout.*

Selected Concentration Competencies Addressed: *Each Department identifies competencies for each degree offered. The competencies addressed in this course include:*

- *Conduct appropriate statistical analysis of data to solve medical and public health problems;*
- *Reinforce use statistical computer packages to organize, analyze, and report collected data*
- *Design experimental and observational studies in biomedical, clinical and public health research;*
- *Conduct complex statistical analyses for a broad range of applications*
- *Communicate the results of statistical studies both in writing and orally to investigators and lay community members.*

Please visit the Concentration webpages on the School of Public Health's website at sph.rutgers.edu for additional competencies addressed by this course for other degrees and concentrations.

Course Objectives: *By the completion of this course, students will:*

a) Identify the special features of longitudinal designs, describe how these features might relate to the analysis. Manipulate the data in a way suitable for longitudinal analysis.
b) Graphically explore and present the longitudinal data.
c) Use SAS Proc mixed and R lme4 package to analyze continuous longitudinal data. Correctly specify fixed and random effects and covariance structure. Interpret the SAS and/or R output.
d) Use SAS Proc glimmix and nlmixed and R lme4 package to perform logistic and Poisson mixed effects modeling for repeated binary or count data.
e) Use SAS genmod and R gee function to analyze repeated binary or count data using generalized estimating equation techniques.
f) Predict the impact of missing data on standard statistical inference and for a particular situation, be able to choose between the common approaches for handling missing values.
g) Plan and design a longitudinal study. Use an appropriate method to analyze a particular study and interpret the result.

Course Requirements and Grading:

- *Lectures will be given each week.*
- *Six to seven homework will be assigned. Students are allowed to work in groups on homework if they like, but no one should copy directly from someone else's paper.*
- *Both in-class midterm and final examinations will be open book.*
- *The R software can be downloaded free of charge from http://www.r-project.org. The SAS software can be leased through the university's software service, or use SAS OnDemand for Academics https://welcome.oda.sas.com/login*

The course grade will be based on homework assignments, the midterm exam, the final exam, and class participation. The relative weight given to each of these components is

• *Attendance, Participation and Class Activities*	*5%*
• *Homework*	*40%*
• *Midterm Exam*	*25%*
• *Final Exam*	*30%*

Total: *100%.*

Grading Policy:

94 – 100	*A*
90 – <94	*A-*
87 – <90	*B+*
84 – <87	*B*
80 – <84	*B-*
77 – <80	*C+*
70 – <77	*C*
<70	*F*

Course Schedule: (Tentative)

Date	Class	Topic(s)
09/06	1	*Definition, features, and objectives of longitudinal studies*
09/13	2	*Exploratory data analysis (EDA) and presentation of longitudinal data*
09/20	3	*Linear Models (I):* *–Introduction, Mean and correlation models, Estimation* *SAS Proc mixed*
09/27	4	*Linear Models (II):* *–Fitting correlation models;* *–Inferences in Mean (part 1): F-test, CI and LRT* *R function lm, SAS Proc mixed*
10/04	5	*Linear Models (III):* *–Inferences in Mean (part 2): F-test, CI and LRT;* *–Inferences for Covariance/Correlation Models: ML estimates and CIs for Covariance Parameters, ReML for Covariance Parameters* *SAS Proc mixed, R package nlme*
10/11	6	*Linear Models (IV):* *–Sensitivity to Correlation Model; –Generalized estimating equation* *Linear Mixed Models (I): Introduction* *SAS Proc mixe, genmod R function gee*
10/18	7	*Linear Mixed Models (II):* *–Model Building and Model Diagnostics;* *SAS Proc mixed, glimmix, R package nlme*
10/25	8	***Midterm exam***
11/01	9	*Generalized Linear Model (I):* *– Marginal model and generalized estimating equation,* *SAS Proc genmod, R package gee*
11/08	10	*Generalized Linear Model (II):* *– Logistic for binary data and Log-Linear model for count data* *SAS Proc glimmix, nlmixed, R packages gee, geepack*
11/15	11	*Generalized Linear (subject-specific) Mixed Effects Models (GLMM)* *SAS Proc glimmix, genmod, nlmixed, R package lme4*
11/22		***Thanksgiving Recess***
11/29	12	*Generalized Linear Model (III): – Modeling association for binary data, ordinal data, and sample size calculation* *SAS Proc genmod*
12/06	13	*Missing data analysis in longitudinal study (I)* *SAS Proc mi, mianalyze*
12/13	14	*Missing data analysis in longitudinal study (II);*

		Final Review
12/20	15	***Final Exam***

Learning Management System: Canvas will be used extensively throughout the semester for course syllabus, assignments, announcements, communication and/or other course-related activities. It is the student's responsibility to familiarize themselves with Canvas and check it regularly. If you have difficulties accessing Canvas, please inform the instructor and Canvas Support (help@canvas.rutgers.edu). Canvas is accessible at canvas.rutgers.edu.

School of Public Health Honor Code: The School of Public Health Honor Code is found in the School Catalog (sph.rutgers.edu/academics/catalog.html). Each student bears a fundamental responsibility for maintaining academic integrity and intellectual honesty in his or her graduate work. For example, all students are expected to observe the generally accepted principles of scholarly work, to submit their own rather than another's work, to refrain from falsifying data, and to refrain from receiving and/or giving aid on examinations or other assigned work requiring independent effort. In submitting written material, the writer takes full responsibility for the work as a whole and implies that, except as properly noted by use of quotation marks, footnotes, etc., both the ideas and the works used are his or her own. In addition to maintaining personal academic integrity, each student is expected to contribute to the academic integrity of the School community by not facilitating inappropriate use of her/his own work by others and by reporting acts of academic dishonesty by others to an appropriate school authority. It should be clearly understood that plagiarism, cheating, or other forms of academic dishonesty will not be tolerated and can lead to sanctions up to and including separation from the Rutgers School of Public Health.

Students with Disabilities: Rutgers University welcomes students with disabilities into all of the University's educational programs. In order to receive consideration for reasonable accommodations, a student must apply for Services by first completing a Registration Form with the Rutgers Office of Disability Services (ODS) at ods.rutgers.edu. The student will also be required to participate in an ODS intake interview and provide documentation. If reasonable accommodations are granted, ODS will provide you with a Letter of Accommodations which should be shared with your instructors as early in your courses as possible.

Commitment to Safe Learning Environment: The Rutgers School of Public Health is committed to helping create a safe learning environment for all students and for the School as a whole. Free expression in an academic community is essential to the mission of providing the highest caliber of education possible. The School encourages civil discourse, reasoned thought, sustained discussion, and constructive engagement. Provocative ideas respectfully presented are an expected result. An enlightened academic community, however, connects freedom with responsibility. The School encourages all students to disclose any situations where you may feel unsafe, discriminated against, or harassed. Harassment or discrimination of any kind will be not tolerated and violations may lead to disciplinary actions.

Student Well-Being: The School of Public Health recognizes that students may experience stressors or challenges that can impact both their academic experience and their personal well-being. If the source of your stressors or challenges is academic, students are encouraged to discuss these challenges and circumstances with their instructor, if they feel they may need additional support or temporary accommodations at the beginning or during this course. The course instructor may consider making reasonable temporary adjustments depending on the student's situation. For personal concerns or if additional support is needed, students may reach out to the Office of Student Affairs or any of the appropriate referral resources listed on the SPH Student Connect Canvas page.

Reporting Discrimination or Harassment: If you experience any form of gender or sex-based discrimination or harassment, including sexual assault, sexual harassment, relationship violence, or stalking, know that help and support are available. You may report such incidents to the RBHS Title IX Office or to the School of Public Health's Office of Student Affairs. Rutgers University has staff members trained to support survivors in navigating campus life, accessing health and counseling services,

providing academic and housing accommodations, and more. If you experience any other form of discrimination or harassment, including racial, ethnic, religious, political, or academic, please report any such incidents to the School's Office of Student Affairs. The School strongly encourages all students to report any incidents of discrimination or harassment to the School. Please be aware that all Rutgers employees (other than those designated as confidential resources such as advocates, counselors, clergy and healthcare providers as listed in Appendix A to Policy 10.3.12) are required to report information about such discrimination and harassment to the School and potentially the University. For example, if you tell a faculty or staff member about a situation of sexual harassment or sexual violence, or other related misconduct, the faculty or staff member must share that information with the RBHS Title IX Coordinator. If you wish to speak to a confidential employee who does not have this reporting responsibility, you can find a list of resources in Appendix A to University Policy 10.3.12. For more information about your options at Rutgers, please visit Rutgers Violence Prevention and Victim Assistance.

Overview of School Policies: Academic and non-academic policies and procedures, such as Auditing a Course, Retaking Courses, Grade Grievance and others that cover registration, courses and grading, academic standing and progress, student rights and responsibilities, graduation and more may be found under Policies on the School of Public Health website. Below are select specific policies; however, students are responsible for keeping informed about academic and non-academic policies and procedures beyond those noted on this syllabus.

Graduate Student Computer Policy: Students are required to possess a personal laptop, no older than approximately two years, that must meet minimum requirements which may be found online at: sph.rutgers.edu/student-life/computer-support.html

Policy Concerning Use of Recording Devices and Other Electronic Communications Systems: When personally owned communication/recording devices are used by students to record lectures and/or classroom lessons, such use must be authorized by the faculty member or instructor who must give either oral or written permission prior to the start of the semester and identify restrictions, if any, on the use of mobile communications or recording devices.

Policy Concerning Use of Turnitin: Students agree that by taking this course all required papers may be subject to submission for textual similarity review to Turnitin.com (directly or via learning management system, i.e. Canvas) for the detection of plagiarism. All submitted papers will be included as source documents in the Turnitin.com reference database solely for the purpose of detecting plagiarism of such papers. Use of the Turnitin.com service is subject to the Usage Policy posted on the Turnitin.com site. Students who do not agree should contact the course instructor immediately.

Withdrawal/Refund Schedule: Students who stop attending their course(s) without submitting a completed Add/Drop Course form will receive a failing grade. Furthermore, students dropping to zero credits for the semester are considered withdrawn and must submit a completed Leave of Absence form from the School of Public Health's Office of Student Affairs. The School of Public Health refunds tuition only. Administrative and technology fees are non-refundable. You may find the Withdrawal/Refund Schedule on the School of Public Health website at: sph.rutgers.edu/academics/academic-calendar.html