STA305H1/STA1004H: Design and Analysis of Experiments

Classroom sessions: Tue 6-9p, Thu 6-9p in BA 1160 Instructor: Lin Zhang Email: linzhang@utstat.toronto.edu Instructor office hours: Tue 4-5p, Thu 4-5p Teaching Assistants: Bo Chen, Tiffany Fitzpatrick, Jing Zheng (Jimmy) Hu TA office hours: Tue 3-4p (Jimmy), Thu 3-4p (Bo) Office hour location: Sidney Smith Hall 623B (basement) Additional office hours will be announced before midterm and final exam. Course webpage: Can be accessed through the learning Portal

Course Content

This course will provide an introduction to the fundamental concepts of the design of scientific studies including the design of experiments and observational studies. Students will become acquainted with statistical methods used to design and analyze experiments and observational studies. In particular, this course will cover: experiments versus observational studies, clinical trial design, comparing several groups using a completely randomized design, randomized blocks, Latin squares, incomplete block designs, factorial designs, causal inference in randomized and non-randomized studies, and adjusting for selection bias using propensity score methods.

The learning objectives of this course are:

- Understand the ideas, principles, and considerations that are common to the design and analysis of scientific studies including the statistical design of experiments and observational studies.
- Develop a statistical toolbox of methods for the design and analysis of experiments and observational studies.
- Identify appropriate uses and interpretations of experimental designs, and observational studies, including their strengths and limitations.

Topics

Experiments, observational studies, and causal inference

Experiments versus observational studies, and causal inference in randomized experiments.

Selection Bias in Observational Studies

Causal inference in randomized experiments versus observational studies. Introduction to the propensity score and three ways to use the propensity score to adjust for selection bias: matching; sub classification; direct regression adjustment.

Probability and Statistics

Mathematical statistics used in experimental design.

Comparing Several Groups

Comparing several groups in an experimental and observational setting and deciding whether differences that are found are likely to be real or due to chance.

Power and Sample Size

Power and sample size will be introduced for several designs. Applications will include the design and analysis of clinical trials with continuous or binary endpoints.

Blocking techniques

Blocked designs, Latin squares, randomized incomplete block designs.

Factorial Designs

Factorial, blocked factorial, and fractional factorial designs will be discussed.

Split plot designs

Split plot designs will be discussed as an example of restricted randomization in the design of experiments.

Textbooks (Optional)

- 1. Statistics for Experimenters: Design, Innovation, and Discovery. Box, G.E.P., Hunter, J.S., Hunter, W.G. Wiley 2nd Ed. 2005
- 2. Design and Analysis of Experiments. Dean, A., and Voss, D. Springer. 1999. UofT link to electronic copy: <u>http://go.utlib.ca/cat/2573215</u>
- 3. Design of Observational Studies. Rosenbaum, P. R. Springer 2010. UofT link to electronic copy: <u>http://go.utlib.ca/cat/7890274</u>
- Experiments: planning, analysis, and optimization. Wu, C.F.J., Hamada, M.S. Wiley, 2009, 2nd ed.: <u>http://go.utlib.ca/cat/8598479</u>
- 5. Causal inference for statistics, social, and biomedical sciences. Imbens and Rubin. Cambridge University Press, 2015. <u>http://go.utlib.ca/cat/10127748</u>

Note: Textbooks 2-5 are available electronically through the UofT library (i.e., electronic copies of both these textbooks are available at no extra cost)

Course Notes

- The instructor will post in-class lecture notes on Portal
- Online notes by Prof. Nathan Taback is available at http://utstat.toronto.edu/~nathan/designscistudynotes.htm

Evaluation

- In-class closed book midterm (40%), time and location TBA.
- Closed book final exam (60%), during the exam period of August 16-22, 2018

Formula sheet will be provided by the instructor for both exams. You may use a non-programmable and non-communicable calculator.

Homework

There is no hand-in homework for this course. Recommended problems are the exercise questions in the in-class lecture notes and online notes by Prof. Nathan Taback.

Missed Tests

- If a test is missed for a valid reason, you must submit documentation to the course instructor.
- If a test is missed for a valid medical reason, you must submit the University of Toronto Verification of <u>Student Illness or Injury form</u> to your instructor within one week of the test.
- The form will only be accepted as valid if the form is filled out according to the instructions on the form.
- The form must indicate <u>that the degree of incapacitation on academic</u> <u>functioning is moderate</u>, serious, or severe in order to be considered a valid <u>medical reason for missing the term test</u>. If the form indicates that the <u>degree of incapacitation on academic functioning is negligible or mild then</u> <u>this will NOT be considered a valid medical reason</u>.
- If a test is missed for a valid reason, then you will be given a makeup test worth 10% of your final grade and the remaining 30% of the midterm test weight will be shifted to the final exam. This means that the final exam will be worth 90% of your final grade.
- Students must complete the midterm test or the makeup test. If a student misses both the midterm test and the makeup test then a grade of zero will be assigned to the original weight (i.e., 40%) of the midterm test.
- The makeup test will typically occur within two weeks after the date of the midterm test. Students will be contacted by email about the details of the makeup test.
- Other reasons for missing a test will require **prior approval** by your instructor. If prior approval is not received for non-medical reasons, then you will receive a term test grade of zero.

Email policies

• Before you send an e-mail, make sure that you are not asking for information that is already on the course web site, or questions about the course material that are

more appropriately discussed during office hours. If you do not get a response, this may be why.

- Neither I nor the TAs explain course material over email and will NOT respond to emails with such requests. Please come to office hours (or schedule another time to meet if you have irreconcilable conflicts with the office hours).
- Announcements will be posted on Blackboard. Please check there regularly.
- If an urgent matter arises, I may contact the entire class by e-mail. In order to receive these messages, please make sure that your ROSI account has your utoronto.ca e-mail.
- If you wish for your email to make it into my inbox, the subject of your email must contain the text "STA305" or "STA1004". Use your utoronto.ca account to ensure that your message doesn't automatically go to my Junk folder.
- I respond to email regarding the class roughly once a day, and almost never in the evening nor weekend.

Computing

We will use R for all examples. R is freely available for download at <u>http://cran.r-project.org</u> for Windows, Mac, and Linux operating systems. For the test and exam, you will need to know how to interpret output from R.

You may also use R Studio that is an integrated development environment to R. It is freely available at <u>https://www.rstudio.com/products/rstudio/</u>

If you wish to use R at UofT then you will need to sign up for a CQUEST account. To get an account and find out more information about using CQUEST go to <u>http://www.cquest.utoronto.ca</u>

Academic integrity

You are responsible for knowing the content of the University of Toronto's Code of Behaviour on Academic Matters at

<u>http://www.governingcouncil.utoronto.ca/policies/behaveac.htm</u>. If you have any questions about what is or is not permitted in this course, please do not hesitate to contact your instructor.

Accessibility needs

The University of Toronto is committed to accessibility. If you require accommodations for a disability, or have any accessibility concerns about the course, the classroom, or course materials, please contact Accessibility Services as soon as possible: accessibility.services@utoronto.ca or <u>http://accessibility.utoronto.ca</u>.