Syllabus
ANTH 504: Anthropological Statistics I

THE UNIVERSITY OF TENNESSEE – KNOXVILLE
FALL 2022

CLASS MEETINGS: TUESDAYS AND THURSDAYS, 8:10 A.M. TO 9:25 A.M.
ROOM 402 STRONG HALL

Instructor: Dr. Benjamin M. Auerbach, Professor

Office: 416 Strong Hall
Office Hours: Tuesdays from 9:30 – 10:30 A.M. or by appointment (e-mail to make appointments)
E-mail: auerbach@utk.edu **(Dr. Auerbach does _not_ read e-mails between 8 PM & 8 AM.)**

Course-at-a-Glance:
- Emphasis is on research design, including skills in programming and critical thinking about the application of quantitative analytical approaches.
- Statistical concepts covered include fundamentals of probability, single sample analysis, two-sample comparisons, correlation and covariance, the general linear model, multivariate comparison, and nonparametric approaches.
- Assessment is based on formal critiques of published papers, independent research paper, and weekly participation.
- Expect to read approximately 50 pages per week and give yourself plenty of time to work through tutorials in R.

Course Objectives:

The goal of this course is to provide you with theoretical knowledge and practical skillset to be literate in statistical reasoning. By the end of the semester you will be able to choose, execute, and interpret a wide range of statistical tests related to the general linear model. Specific objectives are to:
- learn research design for your specific research questions, including identification the kinds of data that you will need to collect to address those questions;
- develop competency for independent research and analysis;
- gain the critical evaluative skills necessary to discern the statistical veracity of your conclusions based on the analytical methods that you choose to use;
- and become familiar with and begin to develop fluency with computer programming, especially within the R environment.

Course Description:

Three fundamentals are universally essential in any good research: 1) you know how to determine the kinds of data necessary to address your research questions (i.e., research design); you know the appropriate methods with which to analyze those data; and, most importantly, you have the skills to

critically interpret the results of the analyses. All three of these, especially the latter two, fall within the realm of statistics.

This is a course about research design and analysis tailored to applications for anthropological research. In this course, we will develop the foundations for statistical analysis, with special emphasis placed on the fundamentals above. We will discuss methods within the context of specific research circumstances. For example, how do you compare two samples? The number of possible approaches will surprise you, but not all are equally valid!

Our focus will be on frequentist methods, especially the parametric general linear model and non-parametric rank statistics. There are Bayesian alternatives for most of these that you may learn if you take ANTH 604. The distinction between these schools of statistical analysis will be explained early in the course. A central focus in the course will be on how to interpret results, and an understanding of statistical significance (including problems with null hypothesis statistical testing, or NHST).

The course uses the R programming environment. Do not worry if you have never had any programming experience; you will gain knowledge and basic competency over the course of the semester. Likewise, some basic mathematical knowledge will be emphasized, though no math beyond linear (matrix) algebra will be used in the course.

Prerequisite:

There are no course prerequisites. However, undergraduates who enroll in the course should be aware that this course is taught exclusively at a graduate level, and that I expect a workload commensurate with that level of advanced training. Anthropological knowledge and a background in linear algebra will be of significant help but are not required.

Course Structure:

Class will meet twice a week as a lecture-based seminar on Tuesdays and a practicum for putting theory into practice on Thursdays. You should bring a laptop computer to use for taking notes as well as the practicum portion of the class. Any computer that is compatible with R 4.1+ (which is downloadable for free from http://cran.r-project.org) is acceptable. Students should also acquire R Studio, which provides a GUI for R. Details about software for the course are provided below. Here is a summary of what to expect for general class structure each week:

Open discussion. The first part of each class consists of a brief open discussion of questions and topics from the previous course meeting. This is meant to be a brief, informal discussion before formal lecture.

Formal lecture. Dr. Auerbach will deliver a formal lecture on Tuesdays. The goal of these lectures is to introduce the formal statistical theory for analyzing specific analytical cases (see the Course Schedule). Frequentist approaches will be emphasized. As noted in the course objectives, it essential for you to understand which statistical solutions to choose for your questions and data; formal lectures will be guided toward helping you develop confidence in determining what analytical approaches to take, and how to interpret the results. Some basic math and equations will be introduced as appropriate.

Practicum. Each Thursday class session will consist of a practicum, in which simulated research questions and real data are introduced for statistical analyses. These are constructed around a set of R tutorial scripts written by Dr. Auerbach. During some weeks, you will be asked to work in small groups,

and others we will work together as a class. Analyses will be performed using R in the classroom. Open discussion is strongly encouraged during this portion of class meetings.

Software:

This course exclusively uses the R programming environment. R allows for flexible statistical computing methods and high quality graphical representation provided by an international community of programmers supported by the R Core Team (the R Comprehensive Network). You should download the most recent versions of both R (through https://cran.r-project.org) and a graphical user interface for it, R Studio (https://www.rstudio.com). Both are free and available for all operating systems.

> ### What is R? Why aren't we using SAS / NCSS / SPSS / etc.?
>
> R is a freely downloadable computer environment that allows for great flexibility in programming, especially for statistical purposes. While other statistical software packages are in widespread use (such as SAS, NCSS, SPSS, STATA, and JMP), and allow for some user flexibility in modifying existing analytical packages, these programs are deficient in that they have idiosyncratic, regimented data handling structures, and generally allow a limited scope of statistical analyses. For most of your research needs, you will likely find that any of these other software packages will be more than adequate. Yet, if you want to use a less common statistical method, a new statistical approach, or most Bayesian approaches, these other software packages often do not offer solutions. R offers a full spectrum of statistical analyses, from Student's *t*-tests to Bayesian generalized linear mixed models, and everything in between.
>
> You are <u>not</u> expected to become an R guru within one semester, but you should expect to develop basic competency in the language. Anyone who has worked extensively with R will tell you that most of the learning for the software is through individual trial and error, so be persistent and don't give up easily! To help you along your first steps, Dr. Auerbach will be providing tutorials. Moreover, there are abundant help resources available:
>
> - R itself has built-in query and help functions. The authors of packages in the software write many of these, so the help may be of varying quality, but it's the first place to look.
> - There are excellent internet resources. A personal favorite is Stack Overflow, a Q&A site for programmers. (Though be aware that you may have to wade through some snarky replies to queries to find an answer!) The people behind CRAN maintain a journal and regularly post manuals and questions.
> - New resources are always appearing as R continues to gain popularity.

Required & Suggested Texts:

All readings for this course are provided to you via Canvas. You should read assigned chapters from Peter Dalgaard's *Introductory Statistics with R* (2nd edition) to get familiar with concepts and coding syntax, though be aware that this book was written in 2008 and so some of the R language has changed substantially since the book was published (hence why we use my tutorial scripts). I also recommend Jerrold Zar's *Biostatistical Analysis* (5th edition) as a principal reference, though it does not make for the best course textbook; some readings are taken from Zar. I also provide PDFs of other resources, including additional books, to help you learn how to use R and apply statistics to a variety of research questions.

Principal Textbooks

Dalgaard P. 2008. *Introductory Statistics with R*. Second edition. New York: Springer.

Zar JH. 2009. *Biostatistical Analysis*. Fifth edition. New York: Prentice Hall.

Additional References

Amrhein V, Greenland S, and McShane B. 2019. Retire statistical significance. *Nature* 567:305-307. (and comments)

Heumann C, Shomaker M, and Shalabh. 2016. *Introduction to Statistics and Data Analysis*. New York: Springer.

Konigsberg LW, and Frankenberg SR. 2013. Bayes in biological anthropology. *American Journal of Physical Anthropology* 57:153-184.

Kruschke JK. 2015. *Doing Bayesian Data Analysis: A Tutorial with R, JAGS, and Stan*. Second edition. New York: Academic Press. (ISBN: 978-0124058880)

Midway SR. 2020. Principles of effective data visualization. *Patterns* 1: patter.2020.100141.

Smith RJ. 2018. The continuing misuse of null hypothesis significance testing in biological anthropology. *American Journal of Physical Anthropology*. DOI: 10.1002/ajpa.23399

Wickham H. 2016. *ggplot2: Elegant Graphics for Data Analysis*. Second edition. New York: Springer.

Course Website: All course materials are on Canvas (utk.instructure.com), including my custom-written tutorials in R. You are strongly advised to access the site often. All course announcements will be posted to Canvas, including any schedule changes.

Copyright: By enrolling in the course, you, as a student, agree that you will not publish, share, or otherwise disseminate any course content to anyone—except for others currently enrolled in the course—without the explicit, written permission of the professor. This includes *not* posting to websites, including Study Blue and CourseHero, that provide shared study materials. Recordings may be shared with any individuals who are currently enrolled this semester in the course. Students who are found to violate this policy are subject to disciplinary action, including the potential to receive a failing grade in the course.

Recording of lectures: You are allowed to make **audio recordings** of lectures while in class. Should you need to miss class, whether for illness or other reasons, please contact Dr. Auerbach before class so he is aware of your situation and can give permission for a planned absence. Please follow the copyright policy above and do not share any recorded materials you produce or receive. You may also wish to coordinate with another student who is attending lecture to obtain notes and an audio recording of the lecture that they make.

Assessment

Some advice: While the deadlines below are absolute deadlines, you should aim at submitting critiques, the term paper abstract, and the term paper <u>before</u> those dates. Your professor would be grateful if all the papers were <u>*not*</u> turned in at the last minute!

PARTICIPATION (10% of grade): This is a graduate level course, and so you are fully responsible for your active presence in the classroom, even as we meet virtually. If you are not attending class (barring legitimate reasons, such as those related to health, family, research, or conferences), then your knowledge will suffer. Learning is a collaborative exercise, and at this advanced level, you will get out of the course what you put into it. At minimum, I expect you to participate in the practica by working on analyses and, when taking part in a small group, contributing to the task at hand. We all look forward to sharing thoughtful conversations about the concepts, limitations, and applications of methods.

CRITIQUES (15% of grade each, totaling 30% of grade): An explanation of critique writing and grading is provided as an appendix to this syllabus. You are required to independently select a peer-reviewed journal paper and critique the research design and the use of statistics by the author(s). Two of these should be produced and <u>submitted via e-mail</u> on **4 October** and **3 November** by 5:00 PM. In each critique, you should briefly summarize the hypotheses and goals of the study, explain the kinds of data collected by the authors, describe the statistical methods used, and argue the efficacy of the approach and analysis. *Remember that constructive criticism involves weighing both the merits and shortcomings of an argument, including the validity of interpretations based on the evidence provided by the analyses performed.* I provide an example of a good critique for you on Canvas.

TERM PAPER (45% of grade): In lieu of a final examination, you should spend the semester developing a simple research question that may be tested using your own data, data available from many online repositories (e.g., Dryad, MorphoSource, or figshare, among others), or data that I can provide. You should write up to a full-length journal manuscript (20-page maximum, 12-point double-spaced) paper outlining your hypothesis, justifying the types of data you choose to utilize in testing the hypothesis and the statistical methods you decide are appropriate. The paper should then provide the results of the statistical analyses and a short interpretation of those results. It is not expected that you perform an extensive amount of background reading for this paper, though a demonstration of relevance to other studies previously performed is necessary. **Detailed guidelines are available on Canvas.**

<u>You must have a research topic and data selected no later than October 11th.</u> Please turn in an abstract (up to 300 words) outlining your question and planned statistical methods by that date to me via e-mail by 5:00 P.M. on that date. **Term papers must be submitted to me via e-mail by 12:00 P.M. on December 12th.** You must also include a copy of all statistical output used in constructing your analysis.

Do not turn in drafts of papers previously submitted for publication, or copies of your Master's thesis; this paper should reflect relatively new work (which includes analyses <u>for</u> a thesis or dissertation). MORE IMPORTANTLY, YOUR PAPER MUST REPRESENT YOUR INDEPENDENT WORK. DO NOT COLLABORATE WITH YOUR CLASSMATES OR OTHERS ON YOUR TERM PAPER. (However, of course, I am always available via e-mail to discuss your paper and address questions or problems you may be encountering.)

TERM PAPER PRESENTATION (15% of grade): In addition to the term paper itself, you will be required to present your term paper results in a professional meeting format talk in class. These presentations should include a PowerPoint or similar slide presentation and should be rehearsed. Each talk will be given a 12-minute presentation period, followed by group Q&A. You will be evaluated on the completeness of your presentation (setting up the question, providing background, explaining methods, and presenting results & conclusions), the appropriate presentation of information on slides, slide legibility, and professional presentation. **Presentations will take place on December 15th from 8:00 A.M. to 10:00 A.M..**

Grading Scale
A: 88-100   B: 76-87   C: 64-76   F: <64
Final grades are not negotiable.

Course Schedule
See the table on the next page. All deadlines for paper submissions in this course are hard, final target dates. Submission of assignments before those deadlines is encouraged!

Important Dates

25 August – First course meeting
4 October – Critique #1 hard deadline
11 October – Term paper abstract hard deadline
3 November – Critique #2 hard deadline
12 December – Term paper hard deadline
15 December – Term paper presentations

Students with Learning Needs
If you require accommodation because of special needs in learning, please contact the Office of Disability Services at 2227 Dunford Hall (974-6087). Please also contact me immediately via e-mail after you register with the Office of Disability Services. Arrangements will be made to adjust the course to fit your needs.

Make-Up Policy
If you become sick (with the novel coronavirus, flu, or any other cause**), with notice, you will be accommodated. Understandably, if you are sick, I do not expect you to attend lectures though you will need to make up any work missed.** Legitimate athletic, religious, legal, or medical reasons all qualify for eligibility to make up assignments or request extensions on course deadlines. If you must miss a lecture or cannot turn in any materials required over the semester, you must contact Dr. Auerbach *__before__* the lecture or deadline.

COURSE SCHEDULE: ANTHROPOLOGICAL STATISTICS I (ANTH 504) – FALL 2022

Read **bolded** chapters before class. Chapters in gray text are noted for additional reference.

Important dates are highlighted in gold. **All assignments should be submitted to Dr. Auerbach via e-mail.**

DATE	TOPIC	PRACTICUM	READINGS
25 August	Introduction to the course Philosophy of science Fundamental statistical concepts	*None*	Zar, Chapter 1 **Kruschke, Ch. 3** (read before next week)
30 Aug. & 1 Sept.	Probability, Data, and Sampling Parameters and distributions	Introduction to R	***An Introduction to Installing & Using R*** **Dalgaard, Ch. 3** **Zar, Ch. 2** (& Chs. 3-6)
6 & 8 September	Descriptive statistics Statistical reporting Best practices in data graphics	Descriptive statistics in R Graphics in R	**Dalgaard, Ch. 4** **Smith 2018** **Midway 2020**
13 & 15 September	One-sample inference	One sample *t*-tests in R	**Dalgaard, Ch. 5**
20 & 22 September	Two-sample inference	Two sample *t*-tests in R	Zar, Chs. 7-9
27 & 29 September	Statistical power & error Assumptions in statistics Data transformations	Manipulating data in R	**Dalgaard, Chs. 9 & 10** **Zar, Chs. 6.3 & 6.4, and 13**
4 October	Odds-ratio and chi-square pivot tables	*None*	**Dalgaard, Ch. 8	Zar, Chs. 22-23**
4 October	**FIRST CRITIQUE DUE BY 5:00 P.M.**		
	No class on 6 October – Work on your term paper!		
11 & 13 October	Correlation, covariance, & causation Introduction to regression	Correlation and covariance in R	**Dalgaard, Ch. 6** Zar, Ch. 19
11 & 13 October	**TERM PAPER ABSTRACT DUE BY 5:00 P.M. ON 11 OCTOBER**		
18 & 20 October	General linear model Regression	Regression in R	**Dalgaard, Chs. 6 & 12** Zar, Ch. 17
25 & 27 October	One-factor ANOVA	ANOVA in R	**Dalgaard, Ch. 7**
1 & 3 November	Multiple factor ANOVA	Multifactor ANOVA in R	Zar, Chs. 10-12
8 & 10 November	Nonparametric sample comparison	Nonparametric tests in R	**Dalgaard, Chs. 5 & 7**
8 & 10 November	**SECOND CRITIQUE DUE BY 5:00 P.M. ON 10 NOVEMBER**		

DATE	TOPIC	PRACTICUM	READINGS
15 & 17 November	MANOVA	MANOVA and DFA in R	**Zar, Ch. 16**
22 November	Resampling methods	*None*	*No readings*
No class on 24 November			
29 Nov. & 1 Dec.	Multiple regression	Multiple regression in R	**Dalgaard, Ch. 11** | Zar, Ch. 20
6 Dec.	Bayes and beyond…	*None*	**Konigsberg & Frankenberg 2013** **Amrhein et al. (2019)**
12 Dec.	**TERM PAPERS DUE BY 12:00 P.M.**		
15 Dec.	**TERM PAPER PRESENTATIONS FROM 8:00 A.M. to 10:00 A.M.**		

Appendix: Guidelines for Writing a Good Critique
ANTH 504 - ANTHROPOLOGICAL STATISTICS I

Dr. Benjamin Auerbach

General advice

We perform critiques of peer-reviewed papers in Anthropological Statistics for two broad reasons:

1. Critiques provide an opportunity for you to think critically about research design, data collection methods, and statistical analysis. It is this practice of critical peer-evaluation that is central to all science. Moreover, your research and communication of results are substantially improved by constantly reading academic literature in your areas of interest. In short, the act of constructive review of research will make you more aware of self-improvement in your own work.

2. Relatedly, if you pursue an academic employment after completing your graduate studies, peer-review of others' research will be a regular practice. A central component to peer-review is the ability to provide constructive feedback. Thus, it is never too early to engage in this activity.

Thus, when you choose a paper to review in this course, it is more important to select a publication that allows you to practice constructive criticism and argumentation. Ideally, this will be in a topic closely related to your research. You do not need to select a paper you have never read before, or a topic with which you are unfamiliar. In fact, the latter is strongly discouraged, given the two goals enumerated above.

I am not looking for complex reviews, but rather seek papers that make clear statements about the research conducted, its merits, and its shortcomings (if any). Most papers that are published in higher tier academic journals are typically well reviewed, but this does not mean that the authors have exhausted all appropriate methods or addressed the full cross-section of questions. Reviewers may have missed important problems as well, so remain vigilant for statistical mistakes and research design oversights. (Even the best anthropologists are still human, after all.)

One crucial piece of general advice is: **<u>do not procrastinate</u>**. You want to give yourself ample time to read through a paper, as well as any related literature (often starting with papers cited in the article under review). Most professional journals give a minimum of three weeks for papers to be reviewed, and some allow as many as six weeks. This policy is adopted to allow sufficient time for reviewers to gather additional information, as necessary, with which to review the paper and provide thoughtful suggestions. Try to mimic this structure, allowing yourself three weeks to consider a paper and write up the critique.

Argumentation

When engaging in the peer review of a paper, your ability to develop a clear, logical argument is important. Always make sure that you support every claim with evidence from the paper or from other sources. This means you should judiciously use citations. Below are two examples to illustrate this:

> **Example One**: "The author's sample is appropriate for the questions asked in the paper. Statistical methods used were adequate, though the authors might have considered additional tests. Specifically, ..."

There are issues with the statement made above concerning the sample, as it not elaborated; it is vague. Are the sample size, sample composition, and source sampled adequate for the specific goals of the study? We can improve this statement with a few simple changes that address those specific points. While this may seem unnecessary, as we think the sample is used appropriately, it is good practice to back up these kinds of claims with some details.

> **Example Two**: "The paper examines a topic that previously was addressed by the research of Smith (2000), though Jones et al. never discuss that study, even though they cite it in passing. Smith's research showed that the factors assumed to be independent by Jones et al. are in fact correlated with each other. Therefore, the study by Jones et al. would be improved had they tested this assumption before proceeding with the analyses, even had they not acknowledged the important contribution by Smith."

This is a good example of constructive criticism. Note that, first, this paragraph brings a specific critique to bear on the paper under review (Jones et al.) that finds support in other sources (Smith, 2000). In addition, it is constructive, in stating that the Jones et al. paper makes an assumption that should be tested based on good statistical & research design practice, as well as because a previous study showed error in that assumption.

Clarity

In general, it is good policy to write the critique well in advance of the deadline (see my comment above). Read back over it a few times with fresh eyes; you'll catch non-sequiturs, typographic errors, and poor argumentation. It should be your goal to constantly improve your writing. To this end, you should ask the following questions when reading over your paper:

- Do I clearly summarize the research goals and major results of the paper succinctly in the first paragraph?
- Am I setting out my overall opinion of the paper and specify major concerns about the paper at the outset?
- Is the argument made for each element of the paper–whether praise or constructive criticism–developed in a logical manner? Am I providing enough evidence from the paper, statistical knowledge, and/or other sources to support my claims?

- Is my critique constructive?
- Would my writing make sense to an informed reader? Do I provide enough detail to achieve this end?

Unclear writing can undermine the best argumentation, so always proofread!

Grading scale

Critiques are scored a maximum of 15 points. The grading scale is, admittedly, somewhat subjective. However, so long as you make an effort to follow the practices outlined above, you will do well. In the end, the act of writing critiques is about the two purposes stated at the beginning of this document. If you use this experience to improve your writing, argumentation, and research reporting skills, then it will serve you for years to come.

Below is the grading rubric. If you receive a score below 10, I will ask you to rewrite the critique for a maximum of 14 points possible.

15 - Excellent critique. All the main points of the paper are addressed (hypotheses, experimental design, statistics, and conclusions). Constructive criticism of deficiencies is made. Attention is given in the critique to whether the paper adequately addressed the bigger theoretical or methodological topics that it set out, or if the authors ever were aware of these. The writing of the critique is clear, concise, organized, and direct.

14.5 - Good critique. All the main points of the paper are addressed. Constructive criticism of deficiencies is made. Discussion of bigger theoretical or methodological topics in the critique are incomplete. Minor erroneous arguments are made in the critique, but a good understanding of the methods and experimental design are exhibited. The writing of the critique could use minor improvements, though it is still clear, organized, and direct.

14 - Good critique. All the main points of the paper are addressed. Alternative solutions and constructive criticism are not consistently put forward. Discussion of bigger theoretical or methodological topics in the critique are lacking or deficient; the critique does not exhibit a clear understanding of the bigger picture, even if the original paper also did not. Some minor erroneous arguments are made in the critique that undermine criticisms. The writing of the critique could use minor improvements, though it is still clear and organized.

13.5 - Okay critique. Main points of the paper are addressed, but incompletely. Most criticism points out errors, but little constructive criticism is offered. Discussion of bigger theoretical or methodological topics in the critique are lacking; the critique does not exhibit an understanding of the bigger picture, even if the original paper also did not. Arguments made about methods are incomplete or incorrect, and detract

from the overall validity of the critique. Writing style needs improvement, though it is still organized and generally clear.

13 - Okay critique. Main points of the paper are addressed, but incompletely. Most criticism points out errors, but no constructive criticism is offered. Bigger theoretical or methodological topics in the critique are missing; the critique does not show understanding of the larger context of the study being reviewed. Arguments made about methods are incorrect, and detract from the validity of the critique. The writing style and organization need improvement, though the critique, overall, is clear.

12 to 12.5 - Critique needs improvement. Some of the main points of the paper are not addressed or are addressed incorrectly. The criticism is not constructive, and the critique overlooks important aspects of the study that need further consideration. Assumptions are made in the critique, and these assumptions then form the basis of arguments made for or against the paper. Critiques graded as 12 tend to be more summary than critique. The organization and style of writing need improvement, and some of the writing is unclear or ambiguous.

11 to 11.5 - Deficient critique. The critique is more of a summary than a systematic discussion of the main points of the paper. Only criticisms are made, and few suggestions for alternative methods are addressed. The critique incorporates erroneous argumentation, does not provide evidence to support arguments, or fails to build an argumentative case. Arguments made may fail to show a clear understanding of the methods being reviewed or make incorrect assumptions about those methods. The organization and style of writing need improvement, and the writing is unclear or ambiguous.

10 to 10.5 - Very deficient critique. The critique is more of a summary than a systematic discussion of the main points of the paper. Only criticisms are made. The paper lacks argumentation, or arguments are opinion rather than supportable comments. Arguments made may fail to show a clear understanding of the methods being reviewed or make incorrect assumptions about those methods. The organization and style of writing need improvement, and the writing is unclear or ambiguous.

Below 10 - Rewrite.