Colorado State University

STAT 331

INTERMEDIATE APPLIED STATISTICAL METHODS

INSTRUCTOR INFORMATION

Instructor: Gray Stanton
Email: gstanton@colostate.edu
Teaching assistant (TA): Lauren Quesada
TA email: lauren.quesada@colostate.edu
Communication Policy: **Email** is the preferred method of digital communication, **please send to the above address** rather than messaging on Canvas. For questions about course content or homework problems, face-to-face discussions (either during/after class or at office hours) are preferable if possible. For grading-specific questions, please contact the TA. For all other questions, please contact the instructor.

PREREQUISITES FOR COURSE

STAT 301 or STAT 307 or STAT 311 or STAT 315 or permission of instructor

Some previous classroom experience in statistics is expected, and an introductory statistics course designed for students in the sciences would provide a sufficient foundation. In particular, students are expected to have previously encountered confidence intervals, hypothesis testing, and linear regression.

LOGISTICS

Classroom: Military Sciences Building, Room 115

Class Times: Mon, Wed, Fri from 1:00PM – 1:50 PM.

Office Hours: Wed 2pm – 4pm Stats Building 3rd Floor Room 315,

Final Exam Time: Friday (12/15) 7:30 – 9:30 AM

COURSE DESCRIPTION & OBJECTIVES

STAT 331 is an applied statistics course with strong emphasis on **practical use** and **interpretation** of popular methods, with lesser emphasis on mathematics. Topics covered include linear regression, covariate interactions, model assumptions and diagnostics, model selection and validation, GLMs, mixed models, factorial ANOVA, ANCOVA. Also covers basic categorical data analysis and contemporary data analysis debates. Assignments involve reproducing analyses in published scientific papers and open-ended data analysis projects. Data analyses are performed using jamovi software.
A more detailed tentative course outline is given below.

Upon completing this course, you should be able to

- **Use jamovi software** to execute a variety of popular data analysis methods.
- Given a specific research question, **formulate** an appropriate data collection and analysis plan.
- **Interpret summary output** from a statistical analysis with respect to a research question of interest.
- **Detect potential problems** stemming from model fit or data quality and assess their impact on how statistical results are interpreted.
- Read a research paper and **describe** the way in which statistical methods are used to **answer questions of interest**.
- Read a research paper and **evaluate** the **appropriateness of statistical methods** used. Suggest alternatives if appropriate.
- **Describe**, using language accessible to non-experts, **the properties** of popular statistical models.

PEDAGOGICAL APPROACH

The emphasis of this course is on how **standard statistical tools** can be applied to **real-world research** problems. To that end, background knowledge of probability is helpful, but the course will cover the **mathematical intuition** that is needed to competently apply the relevant statistical methods. Other than a previous statistics class, no mathematics other than a course in college algebra is assumed.

The course is intended for students who want to learn about the most popular statistical methods and to gain **practical experience** in how these methods are used in real research. The techniques of model building, linear regression, ANOVA, and GLMs are part of the **core toolkit** for a quantitative researcher. To sharpen our proficiency with these techniques, the examples and assignments in this class will be predominately taken from published quantitative research. Many homework assignments will involve both **reproducing published results** as well as providing new perspectives on what exactly the data are saying.

The software used for this course is **jamovi**. Jamovi is an open-source "third generation statistical spreadsheet", meaning that it provides a graphical interface dedicated to statistical analysis and is also free, both now and in the future. This is an advantage that jamovi has over comparable popular proprietary software, such as SPSS, SAS, or Stata. Further, jamovi is built on top of R, which is an extremely popular statistical programming language. So, skills gained from using jamovi can either transfer to R or to one of the proprietary software packages, while avoiding locking you into programs which cost hundreds of dollars a year.

Textbook / Course Readings

Your primary resources will be course notes and links to additional readings, provided on Canvas. The notes are available in web format as Introduction to STAT 331: Intermediate Applied Statistical Methods by Ben Prytherch. We will also reference three free OER textbooks: learning statistics with jamovi, by Danielle Navarro and David Foxcroft, Answering questions with data by Matthew Crump, Danielle Navarro, and Jeffrey Suzuki, and Statistical Analysis with The General Linear Model, by Jeff Miller and Patricia Haden.

Course Materials & Equipment

The analyses conducted in STAT 331 will utilize **jamovi**. Jamovi is a GUI-based (Graphical User Interface, i.e. point and click rather than writing code) data analysis software. It's open source, free, and sufficiently powerful for all methods covered in this course. If you are also learning R, jamovi is a great stepping-stone, as it is R-based and can produce prewritten R code that you can copy/paste. The main skill needed in data analysis is knowing how to make sense of the output that your software provides you, and what you learn from jamovi are fully transferrable to any other statistical software. You can download a copy of jamovi from https://jamovi.org (I recommend using the stable branch of **jamovi desktop**, which is currently 2.3.28). Accessibility information related to Jamovi can be found by visiting the Jamovi Accessibility Conformance Report.

Credit Hours and Workload

STAT 331 is a 3 credit hour course, developed along the guideline that students should expect to spend **2 hours of outside work (e.g. studying, working on homework) for each hour in class**. This is only a guideline; the actual time commitment needed will vary from week to week and from person to person. If you find you are spending significantly more than 5 hours per week outside class on a regular basis, please come and talk to me!

Course Policies

Late assignments are assessed a 10% penalty per day after the due date. Please contact me or the course TA if you will not be able to take an exam during the scheduled window, or if something happens that prevents you from being able to complete course assignments on time.

Grading Policy And Philosophy

In this course and in the real world, getting the "right" numbers is necessary but not sufficient for a good data analysis. What is far more important is giving a **statistically sound interpretation**

of what the results show and being able to relate the output of the calculations back to the research question. To that end, although some calculation problems may be present in the homework and on the exams, there won't be very many. This isn't to say that calculations aren't important, but rather that it is assumed that you can use your tools well enough to get the "right" numbers.

Accordingly, the goal of the exams and the data analysis assignments are to assess your ability to apply what you have learned **to problems you haven't seen before**, to **explain what the numbers you calculate mean**, and to **reason about the overall conceptual architecture** that undergirds the statistical methods we use.

STAT 331 uses plus/minus grading. The reason for this is that letter grade cutoffs are arbitrary, and using plus/minus grades lowers the stakes at each cutoff from 1 grade point to 1/3rd of a grade point. For example, under traditional grading, a 91% converts to 4 grade points and an 89% converts to 3 grade points. Under plus/minus grading, the grade points are 3.67 and 3.33, respectively.

Depending on the overall performance of the class, it is possible that some adjustments to grading cutoffs may be made. This is equivalent to a "curve". Numeric grades are supposed to quantify some combination of your understanding, ability, and effort in a course. But they are imperfect, to say the least. So, it is possible (not guaranteed!) that a student scoring below the lower bound of a grade range below will nonetheless receive that higher grade. All potential adjustment to cutoffs will only be in the direction of increasing grades. The default cutoffs are:

Grade	Range
A+	100% to 97%
A	<97% to 92%
A-	<92% to 90%
B+	<90% to 88%
B	<88% to 82%
B-	<82% to 80%
C+	<80% to 78%
C	<78% to 70%
D	<70% to 60%
F	<60%

As a student enrolled in this course, one of your responsibilities is to submit course work by the due dates listed in Canvas. With that said, I take my role as your instructor very seriously, and, in fact, I care about how well you do in this course and that you have a satisfying, rewarding

experience. We are all human beings doing the best we can, and so do not hesitate to reach out if you experience outside issues which affect your ability to complete your coursework.

Additionally, it is my commitment to you to respond individually to the work you submit in this class and to return your work in a timely manner. Data analysis assignments and exams will be graded within 7 days of being submitted, excepting unforeseen circumstances.

ASSIGNMENT	GRADE PERCENTAGE
Data analysis assignments	40%
Canvas quizzes	5%
Exams (3 mid-terms and one final)	40%
Project 1	5%
Project 2	10%
Total:	**100 %**

*Keep a copy of all work created for the course, including work submitted through Canvas course learning management system.

ASSIGNMENT DETAILS

Data analysis assignments will require you to analyze data using jamovi and write up results in a document that you submit to Canvas. Most of these assignments are based on existing published research papers for which the data are publicly available. At minimum, you will read the methods and results sections of these papers and attempt to reproduce the reported results. Sometimes you will conduct additional analyses.

These data analysis assignments are a regular feature of STAT 331, with an average of slightly less than one assignment per week. Unless otherwise noted, the week's **homework is due at midnight on Friday.**

Feel free to discuss or work on the homework together with your classmates, but **do not directly copy** the solutions of others. The homework questions are frequently about interpretation, and there is room for significant subjectivity and flexibility in the "correct" answers. Your solutions should be written in your own words and based on your own work.

Canvas quizzes are multiple-choice, and you will be able to earn back any points you lose by submitting corrections (with explanations) after the answers are revealed. These are meant to give you frequent practice and feedback, and they are low stakes insofar as you can earn back all points missed.

Exams which are designed to assess how well you understand what has been covered in class. You will take four exams during STAT 331 (three mid-terms and a final), each equally weighted. These exams will be challenging; on the other hand, they will only worth 40% of your overall grade. You will also be able to turn in exam corrections for half credit back on any points you lose.

Projects will be done in small groups. For the first project, you'll be given a dataset and a broad research question, and you will need to decide what analyses to perform, what results to report, and how they should be interpreted. For the second project, you will choose any topic you like and submit a research plan, subject to approval. You will present initial results, get feedback from me and from your classmates, and any requested revisions will be due by the last day of classes.

COURSE OUTLINE

1. Module 1: Review of Classical Inference
    1.1. Sampling Distributions
    1.2. Confidence Intervals
    1.3. Hypothesis Testing
2. Module 2: Model Building with linear regression
    2.1. Review of Simple and Multivariate Regression
    2.2. Interactions between Predictor Variables
    2.3. Elementary Data Transformations
3. Module 3: Assessing and Improving Model Fit
    3.1. Checking Assumptions of the General Linear Model
    3.2. Advanced Data Transformations and the Model's Functional Form
    3.3. Multicollinearity
    3.4. Theoretical/Philosophical Questions in Modeling
4. Module 4: ANOVA-based Methods
    4.1. ANOVA as a special case of regression
    4.2. ANOVA-specific considerations
    4.3. ANCOVA
5. Module 5: Categorical Data Analysis
    5.1. Inference for Proportions
    5.2. Relative Risk and Odds-Ratios
    5.3. Chi-Squared Tests
6. Module 6: Generalized Linear Model
    6.1. Link functions
    6.2. Logistic Regression
    6.3. Ordinal Regression
    6.4. Poisson and Zero-Inflated Poisson

7. Module 7: Mixed Models
   7.1. Repeated Measures
   7.2. Fixed vs Random Effects and Coefficients
   7.3. Interpretations of Mixed Effect Models
8. Module 2: Contemporary Issues in Applied Data Analysis
   8.1. The Replication Crisis
   8.2. Assessing Bias with Meta-Analysis
   8.3. Debates about "statistically significant"
   8.4. Proposed Reforms

ADVICE FOR SUCCEEDING IN STAT 301

- If you feel confused in STAT 301, you will not be alone. Understanding statistics is challenging. If you hear something that you don't understand in class, it is a safe bet that many of your classmates also didn't understand. **Please ask questions when you have them.** It doesn't matter if you think the question is too simple, or if you feel like everyone else understands it but you. They don't. And they'll be happy you asked it!
- All of the course material was developed with the goal of helping you understand statistics. The course notes, homework assignments, and group projects were all created to complement one another. If you have trouble seeing the purpose of what's in the notes, check to see what kinds of questions are being asked in the homework, especially the wordy ones. If you read a homework question that confuses you, see if there's a worked example or video on the same topic, or scan the notes for examples and definitions.
- It is not likely that you will fully absorb the course materials by listening to lecture alone. A good practice is to **read through the course notes after attending lecture**. A better practice is to read them before lecture, too.

CANVAS INFORMATION & TECHNICAL SUPPORT

Canvas is where course content, grades, and communication will reside for this course.

- Login for Canvas
- Canvas Support

For passwords or any other computer-related technical support, contact the Central IT Technical Support Help Desk by calling (970) 491-7276 or emailing help@colostate.edu.

The Technical Support and Requirements page identifies the browsers, operating systems, and plugins that work best with Canvas. If you are new to Canvas, review the CSU Passport to Canvas course.

Academic Integrity & CSU Honor Pledge

This course will adhere to the CSU Academic Integrity/Misconduct policy as found in the General Catalog and the Student Conduct Code.

Academic integrity lies at the core of our common goal: to create an intellectually honest and rigorous community. Because academic integrity, and the personal and social integrity of which academic integrity is an integral part, is so central to our mission as students, teachers, scholars, and citizens, I will ask that you affirm the CSU Honor Pledge as part of completing your work in this course.

Further information about Academic Integrity is available at CSU's Academic Integrity - Student Resources.

Universal Design for Learning/Accommodation of Needs

I am committed to the principle of universal learning. This means that our classroom, our virtual spaces, our practices, and our interactions be as inclusive as possible. Mutual respect, civility, and the ability to listen and observe others carefully are crucial to universal learning.

If you are a student who will need accommodations in this class, please contact me to discuss your individual needs. Any accommodation must be discussed in a timely manner. A verifying memo from the Student Disability Center (SDC) may be required before any accommodation is provided.

The SDC has the authority to verify and confirm the eligibility of students with disabilities for the majority of accommodations. While some accommodations may be provided by other departments, a student is not automatically eligible for those accommodations unless their disability can be verified and the need for the accommodation confirmed, either through SDC or through acceptable means defined by the particular department. Faculty and staff may consult with the SDC staff whenever there is doubt as to the appropriateness of an accommodative request by a student with a disability.

The goal of SDC is to normalize disability as part of the culture of diversity at Colorado State University. The characteristic of having a disability simply provides the basis of the support that is available to students. The goal is to ensure students with disabilities have the opportunity to be as successful as they have the capability to be.

Support and services are offered to student with functional limitations due to visual, hearing, learning, or mobility disabilities as well as to students who have specific physical or mental health conditions due to epilepsy, diabetes, asthma, AIDS, psychiatric diagnoses, etc. Students who are temporarily disabled are also eligible for support and assistance.

Any student who is enrolled at CSU, and who self-identifies with SDC as having a disability, is eligible for support from SDC. Specific accommodatiohns are determined individually for each student and must be supported by appropriate documentation and/or evaluation of needs consistent with a particular type of disability. SDC reserves the right to ask for any appropriate documentation of disability in order to determine a student's eligibility for accommodations as well as in support for specific accommodative requests. The accommodative process begins once a student meets with an accommodations specialist in the SDC.

Third-party Tools/Privacy

Please note that this course may require you to use third-party tools (tools outside of the Canvas learning management system), such as Skype and others. Some of these tools may collect and share information about their users. Because your privacy is important, you are encouraged to consult the privacy policies for any third-party tools in this course so that you are aware of how your personal information is collected, used, and shared.

Undocumented Student Support

Any CSU student who faces challenges or hardships due to their legal status in the United States and believes that it may impact their academic performance in this course is encouraged to visit Student Support Services for Undocumented, DACA & ASSET for resources and support. Additionally, only if you feel comfortable, please notify your professor so they may pass along any additional resources they may possess.

Title IX/Interpersonal Violence

For the full statement regarding role and responsibilities about reporting harassment, sexual harassment, sexual misconduct, domestic violence, dating violence, stalking, and the retaliation policy, visit CSU Policy: Title IX Sexual Harassment.

If you feel that your rights have been compromised at CSU, several resources are available to assist:

- Student Resolution Center, 200 Lory Student Center, (970) 491-7165
- Office of Equal Opportunity, Student Services Building, Room 101, (970) 491-5836

A note about interpersonal violence: If you or someone you know has experienced sexual assault, relationship violence and/or stalking, know that you are not alone. As instructors, we are required by law to notify university officials about disclosures related to interpersonal violence. Confidential victim advocates are available 24 hours a day, 365 days a year to provide support related to the emotional, physical, physiological, and legal aftermath of interpersonal violence. Contact the Victim Assistance Team at 970-492-4242.

Religious Observances

CSU does not discriminate on the basis of religion. Reasonable accommodation should be made to allow individuals to observe their established religious holidays. Students seeking an exemption from attending class or completing assigned course work for a religious holiday will need to complete the Request Form at least one full week prior to the event.

Once turned in, the Division of Student Affairs will review the request and contact the student accordingly. If approved, the student will receive a memo from the Dean of Students to give to their professor or course instructor.

Students are asked to turn in the request forms as soon as the conflict is noticed. Similarly, unanticipated conflicts requiring a religious observance, such as a death in the family, can also be reviewed.

CSU Principles of Community

Inclusion: We create and nurture inclusive environments and welcome, value and affirm all members of our community, including their various identities, skills, ideas, talents, and contributions.

Integrity: We are accountable for our actions and will act ethically and honestly in all our interactions.

Respect: We honor the inherent dignity of all people within an environment where we are committed to freedom of expression, critical discourse, and the advancement of knowledge.

Service: We are responsible, individually and collectively, to give of our time, talents, and resources to promote the well-being of each other and the development of our local, regional, and global communities.

Social Justice: We have the right to be treated and the responsibility to treat others with fairness and equity, the duty to challenge prejudice, and to uphold the laws, policies and procedures that promote justice in all respects.

Diversity and Inclusion

The Office of Inclusive Excellence website includes a comprehensive statement of CSU's commitment to diversity and inclusion.