

431 Fall 2026 Syllabus

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1 Welcome to 431!

This is the Fall 2026 syllabus for PQHS / CRSP / MPHP 431: Statistical Methods in Biological & Medical Sciences at Case Western Reserve University with Professor Thomas E. Love.

1.1 Working With This Syllabus

1. This syllabus includes **fifteen** chapters. Use the sidebar on the left side of the screen to navigate between chapters. Make sure you look at each chapter.
2. Click the download icon under the title at the top left to download a PDF version of the syllabus.
3. Click the switch next to the download icon to switch from light to dark mode.
4. The sidebar also lets you search the entire syllabus.
5. The current chapter's table of contents is shown on the right of your screen.
6. The syllabus will be updated occasionally. The date of the current version is listed above under PUBLISHED.

1.2 Who, When and Where?

- The course instructor is Professor Thomas E. Love. Learn more about him in Chapter [7](#).
 - Email him at **Thomas dot Love at case dot edu** if you have any questions before class.
- There are several teaching assistants helping with the course this semester. See Chapter [8](#) for more on them.
- The course is given on Tuesdays and Thursdays from 1:00 to 2:15 PM Eastern Time, in Room E321-323 in Robbins Hall, within CWRU's School of Medicine, starting on 2026-08-25.



2 Getting Started

Your first few steps in this course are to:

1. Register and enroll via the [CWRU Student Information System \(SIS\)](#).
 - Section 100 of PQHS 431, CRSP 431 and MPHP 431 are identical. Be sure to register for PQHS 431 unless you are part of the Clinical Research Scholars Program (in which case, register for CRSP 431) or you are part of the MPH program (in which case, register for MPHP 431.)
2. Visit [this link](#) to record a pronunciation of your full name in the Student Information System so all of your instructors (and fellow students) can hear it.
3. Obtain the texts required for the course. The book you need to purchase is David Spiegelhalter's *The Art of Statistics: How to Learn from Data*, originally published in 2020 and available at all major book retailers for around \$20. All other required texts are free. See Chapter 5 for details.
4. Complete the [Welcome to 431 survey](#) - see below for details.
5. Get started installing the software you'll need for the course. See Chapter 6 and [the Software link on our main website](#) for more details.

2.1 Welcome to 431 Survey

Please fill out the survey at <https://tinyurl.com/431-2026-welcome> to help us get to know you a little better.

- Note that you must **log into Google via your CWRU account** in order to access the survey.
- The survey should take 15-20 minutes to complete, and we encourage you to complete it as soon as you can. The formal deadline for completing this form is found on the [Course Calendar](#).

3 Course Web Site

The main course web site is found at <https://thomaselove.github.io/431-2026/>.

By our first class, this page will house links to everything we will provide, including:

- The [431 Syllabus](#) (this document)
- Professor Love's [Course Book](#), the main textbook for the course
- The [Course Calendar](#), which is the final word for all deadlines and assignments
 - The [Calendar](#) also links to materials for each class, including presentation slides and announcements
- [Data \(and Code\)](#) for the course's assignments, presentations, and notes
- Our [Canvas page](#) for turning in assignments and downloading recordings. (Most classes will be recorded, although 431 requires in-person attendance.)

3.1 Contact Information

Our main website at <https://thomaselove.github.io/431-2026/> includes a [Contact Us page](#) which provides detailed information on the best ways to get help from Professor Love and the Teaching Assistants during the semester.

- The course Teaching Assistants will hold regular office hours over Zoom, and the schedule for these sessions is on the [Contact Us page](#) and the [Course Calendar](#) pages.
- Professor Love will arrive 10 minutes before each class, and stay afterwards, as well, to discuss any student questions and concerns.
 - Professor Love's office at CWRU is on the ground floor of the Wood building (in the WG-82 Suite), specifically WG-82J. Email him if you need an appointment, either in person or via Zoom.
- If you have any unique concerns about the course, need special accommodations or have any other issues you want to discuss with Professor Love specifically, please email him directly (**Thomas dot Love at case dot edu**).

4 Course Description

PQHS 431 (cross-listed as CRSP 431 and MPHP 431) is the first half of a two-semester sequence (with 432) focused on modern data analysis and advanced statistical modeling, with a practical bent and as little theory as possible. We emphasize the key roles of thinking hard, and well, about design and analysis in research.

The course is formally titled *Statistical Methods in Biological & Medical Sciences, Part 1*. A more accurate title is **Data Science for Biological, Medical or Health Research**.

We'll learn about managing and visualizing data, building models and making predictions, and other data science activities. This highly applied course focuses on modern tools for learning from data. We'll learn a lot of R, and we'll use RStudio and Quarto as tools to help make R work better, and help perform our research in rigorous and replicable ways.

4.1 Course Objectives

During the 431-432 sequence, students will:

1. Use modern data science tools to import, tidy/manage, explore (through transformation, visualization and modeling) and communicate about data.
2. Think hard and well about rigorous design and analysis in scientific research.
3. Gain sufficient background in the practical issues regarding linear and generalized linear models to give you a starting place for meaningful applied work, particularly in terms of making comparisons to address general types of statistical and analytic questions (exploratory, predictive, inferential, and causal, in particular.)
4. Learn about the importance of replicable research, and develop facility and practice in open source tools for doing it.
5. Complete a series of assignments (labs, projects and quizzes) designed to help you demonstrate what you've learned.
6. Using R and RStudio to make all of the things above happen; with particular emphasis on doing replicable research and using [Quarto](#) to document the work in a replicable way.

This is **NOT** a course in mathematical statistics or statistical inference. It's far more applied than that.

4.2 Key Topics in 431-432

1. Exploratory Data Analysis: “All graphs are comparisons” including data exploration, statistical graphics and more general visualization of information.
2. Placing biological, medical and health research questions into a statistical framework.
3. Study Development - making choices in designing and executing the collection and aggregation of data.
4. Data Handling - including important issues in importing, tidying and transforming data, as well as methods for dealing with missing data, including imputation.
5. Statistical Comparisons: “All of statistics are comparisons” - including methods for discrete and continuous variables: intervals, assumptions, some thoughts on statistical power, and the bootstrap, design of visualizations and models for rates, proportions and contingency tables.
6. The proper and rigorous use of multi-predictor models for continuous and discrete data, including...
 - Fitting, evaluating, and interpreting linear and generalized linear models with both classical (frequentist) and Bayesian approaches.
 - Prediction and validation.
 - Critical role of graphics, including diagnostics and residual analysis.
 - Model choice, including variable selection, shrinkage and model uncertainty.
 - Dealing with categorical predictors and interactions meaningfully.
 - Adjusting for covariates meaningfully.
7. Using R and RStudio to make all of the things above happen; with particular emphasis on doing replicable research and using [Quarto](#) to document the work in a replicable way.

4.3 Prerequisites and Intended Student Population

What do we expect you to know already before you start the course? **Not much.**

Useful prior experience includes training/experience in statistics, coding/programming and biology/biomedical science. We expect most people will have some experience in one or two of these areas, but very few will have all three.

- Some students have lots of prior training in statistics. But there are many students in the class with no statistical training at all that they use regularly. We assume only that everyone knows what an average is, and has some sense of why statistics might be useful to them in their chosen field.
- Some students have lots of prior coding and programming experience, including experience with R and/or Quarto. Some have never written a line of code in their life. We

assume only that everyone is willing to learn how to do modern work with data, and that means writing computer code, but that some people will be starting from nothing.

- Some students have lots of prior experience with biological and biomedical science, and know a lot of useful things in those areas which relate directly to our work. Others have zero experience in this area, and will learn a lot from their colleagues. We assume only that everyone is willing to learn, and to put in some effort to do so.

People succeed in this course with a wide range of backgrounds and a common interest in using data effectively in research related to biology, health or medicine. There will be multiple people in the class who are years away from their last statistics class. We expect the majority of students will have no prior experience using R, or any meaningful recollection of using statistical software.

The pace can be brisk at times, but all CWRU students who feel up to it are welcome, regardless of their field of study or prior experience. Section 100 (Professor Love's section) is specifically geared towards students in programs under the auspices of the Department of Population & Quantitative Health Sciences, as well as students who intend to continue on and take 432 this Spring. Section 101 (with Professor Zhang) is more appropriate for most other students.

4.4 Motivations for our Approach

Professor Love has a lot of thoughts on this issue and you'll hear about them through the semester, but you may prefer to hear from other people on the subject. So here are a few references that guided our thinking in developing the course.

- [A Guide to Teaching Data Science](#) by Stephanie C. Hicks, Rafael A. Irizarry (pdf)
 - ... our (case-study) approach (in a graduate-level, introductory data science course) teaches students three key skills needed to succeed in data science, which we refer to as creating, connecting, and computing.
- [Data Visualization on Day One: Bringing Big Ideas into Intro Stats Early and Often](#) by Xiaofei Wang, Cynthia Rush, Nicholas Jon Horton (pdf)
- [50 Years of Data Science](#) by David Donoho in the *Journal of Computational and Graphical Statistics*, 2017.
- [Why You Should Master R \(Even if it might eventually become obsolete\)](#) blog post from Sharp Sight, 2016-12-27
- [Teaching R to New Users - From tapply to the Tidyverse](#), A YouTube video by Roger D. Peng
- [Teach the Tidyverse to Beginners](#) and a [related post on teaching ggplot2](#), specifically from David Robinson. There is also [a related video from rstudio::conf 2018](#).
- Video from Hadley Wickham, [You can't do data science in a GUI](#), 2018 in Chicago.

4.5 Is 432 Required?

If I take 431 this semester, do I have to take 432 in the Spring?

It is the natural thing to do, and I assume that almost all of you will do so. The 431 course is part 1 of a two-semester sequence. Frankly, 432 contains some of the most interesting material and is generally regarded by students who take both as the more entertaining course. Every year, some students take only 431, though. The decision is up to you. The 432 course assumes you have completed 431, whether with me or another instructor.

5 Required Texts

5.1 Course Notes

Professor Love maintains a book for the course entitled [Applied Statistics and R Foundations for 431](#).

Although this document shares some of the features of a textbook, it is by no means comprehensive. The main purpose is to give 431 students a set of common materials on which to draw during the course, providing a series of examples using R to work through issues that are likely to come up during the semester, and in later work.

In addition, Professor Love's **slides** and other class materials will be posted for your use throughout the semester. Once class begins, you'll be able to access all materials (including the Course Book) through the main course website at <https://thomaselove.github.io/431-2026/>.

5.2 Buy This Book!

During the course, we will read David Spiegelhalter's **The Art of Statistics**. You can purchase any of the available versions (hard-cover, paperback or e-reader) online or in your local bookstore for about \$20.

- The [Art of Statistics website](#) contains R code, corrections and other materials.
- A reading plan for this text is part of the [Course Calendar](#).

5.3 Other Books to Download

There are three additional **free** books that you will definitely need to obtain during the semester and may be interested in looking at before class begins. Simply visit the links below.

1. [R for Data Science](#) (2nd edition) by Hadley Wickham, Mine Çetinkaya-Rundel and Garrett Grolemund.
- Solutions to the exercises in R4DS can be found [here](#) and may be very helpful to you.

2. [R Graphics Cookbook](#) (2nd edition) by Winston Chang.
 3. [Biostatistics for Biomedical Research](#) by Frank E. Harrell Jr.
- A related set of YouTube videos can be found [here](#).

5.4 Key Articles and Posts

While I will recommend dozens of articles, blog posts and the like to you over the course of the year, these are especially important in 431.

1. Several of the guides prepared by Jeff Leek and his group, including:
 - [Reading academic \(scientific\) papers](#),
 - [Writing your first academic paper](#)
 - [Write papers like a modern scientist](#)
 - [How to Share Data for Collaboration](#) by Shannon E. Ellis and Jeffrey T. Leek in *The American Statistician*, 2018 Special Issue on Data Science, or you can [read the PeerJ preprint version here](#).
2. [Data Organization in Spreadsheets](#) by Karl W. Broman and Kara H. Woo in *The American Statistician*, 2018 Special Issue on Data Science, or you can [read the PeerJ preprint version](#).
 - The Ellis/Leek and Broman/Woo papers are part of the [Practical Data Science for Stats](#) collection, which may be of interest.
3. [Project-oriented workflow](#) at tidyverse.org from Jenny Bryan.
4. From the Ten Simple Rules series at PLOS Computational Biology:
 - [Ten Simple Rules for Effective Statistical Practice](#) by Kass RE et al. 2016
 - [Ten Simple Rules for Graduate Students](#) by Gu J Bourne PE 2007
 - [Ten Simple Rules for Better Figures](#) by Rougier NP Droettboom M Bourne PE 2014
 - [Ten Simple Rules for Creating a Good Data Management Plan](#) by Michener WK 2015
5. [Statistical Inference in the 21st Century: A World Beyond \$p < 0.05\$](#) from 2019 in *The American Statistician*
6. The American Statistical Association's 2016 [Statement on p-Values](#): Context, Process and Purpose.

Professor Love's class-specific READMEs will provide links to these articles and other recommended readings as the semester goes on.

6 Required Software

The course makes heavy use of the R statistical programming language, and several related tools, most especially the RStudio development environment. Every bit of this software is free to use, and open-source.

You will need access to a computer to do your work for this class, not just an iPad or other tablet, but an actual computer. You do not need a state of the art machine, nor should you need any special hardware to run things for this course.

- There will be many people in the course for whom R is a new experience. I assume no prior R work in the course. You will know a fair amount of R (and some other things, too) after taking the course, though.
- We'll be using [Quarto](#) for most of our work, as well, which can be used to generate reproducible reports that appear as .html websites, PDF files or Word documents, among other things.
- For some people, working with R and Quarto is the best part of the class, and the part that they're most excited about.
- For others, it's a real source of anxiety. We understand and encourage patience. There will definitely be some pain, but our experience is that things are much smoother for most people by early October than they appear to be in August.

6.1 R and RStudio

You will do all of your analysis with the open source (and free!) [programming language R](#). You will use [RStudio](#) as the main program to access R. Think of R as an engine and RStudio as a car dashboard. R handles all the calculations and the actual statistics, while RStudio provides a nice interface for running R code.

R is free, but it can sometimes be a pain to install and configure. Information about getting R and RStudio on your computer is provided below, and [also on our main website](#).

Learning R can be difficult at first - it's like learning a new language, just like Spanish, French, or Chinese. Hadley Wickham-the chief scientist at Posit (makers of Rstudio) and the author of some amazing R packages you'll be using like [ggplot2](#) [made this wise observation](#):

It's easy when you start out programming to get really frustrated and think, "Oh it's me, I'm really stupid," or, "I'm not made out to program." But, that is absolutely not the case. Everyone gets frustrated. I still get frustrated occasionally when writing R code. It's just a natural part of programming. So, it happens to everyone and gets less and less over time. Don't blame yourself. Just take a break, do something fun, and then come back and try again later.

If you're finding yourself taking way too long hitting your head against a wall and not understanding, take a break, talk to the teaching assistants, talk to classmates, ask questions, e-mail Professor Love, etc.

I promise you can do this.

Some of this material is also borrowed from Andrew Heiss.

6.2 Getting the Software

Everything is free, but it does require some patience to get control over your computer.

6.2.1 System Requirements

You will need access to a computer to do your work for this class, not just an iPad or other tablet, but an actual computer. Whether or not you want to bring that computer to class is up to you. All of the software we will use in this class is either free and open source, or available to you for free through your affiliation with CWRU, so there is nothing to buy in terms of software.

- We've made some effort in terms of course requirements to set the bar low. You do not need a state of the art machine, nor should you need any special hardware to run things for this course.
- You will need a computer, either PC (running Windows 10 or 11, ideally) or Macintosh (running a reasonably recent OS), but your choice should be determined by your personal preferences and how you believe you will use the machine in your research life. RStudio and R will look and work the same on either a PC or a Macintosh.
- We **do not** recommend the use of a Chromebook for 431 or 432.
- R and RStudio Desktop also run on Linux systems but Professor Love knows essentially nothing about that. Consult the documentation [at CRAN for R](#) and [at the download page for RStudio](#).

6.2.2 What will I need for 431?

Complete instructions for installing R, RStudio, necessary R packages, and 431-specific Data and Code are provided on our course [Software page](https://thomaseelove.github.io/431-2026/), found on our main course website: <https://thomaseelove.github.io/431-2026/>.

6.3 Why do we teach R in 431-432?

Why do we teach using R, rather than SAS or SPSS or Python or whatever?

1. Because it is by far the better choice for what we're trying to do, which is to help you become effective data scientists. And effective scientists, period.
2. Because being a data scientist means writing code and actually doing (not just talking about) replicable research, which R facilitates in an immense variety of ways.
3. Because R is free to you, me and everyone, and its community is a daily delight.

To read comments from other people on the subject, I suggest reading [Why R?](#) from Chester Ismay and Patrick Kennedy.

Also, the question of “Why R and not SPSS?” was nicely addressed by Greg Snow in [this 2010 post at StackOverflow](#)...

When talking about user friendliness of computer software I like the analogy of cars vs. busses: Busses are very easy to use, you just need to know which bus to get on, where to get on, and where to get off (and you need to pay your fare). Cars on the other hand require much more work, you need to have some type of map or directions (even if the map is in your head), you need to put gas in every now and then, you need to know the rules of the road (have some type of drivers licence). The big advantage of the car is that it can take you a bunch of places that the bus does not go and it is quicker for some trips that would require transferring between busses. Using this analogy programs like SPSS are busses, easy to use for the standard things, but very frustrating if you want to do something that is not already preprogrammed. R is a 4-wheel drive SUV (though environmentally friendly) with a bike on the back, a kayak on top, good walking and running shoes in the passenger seat, and mountain climbing and spelunking gear in the back. R can take you anywhere you want to go if you take time to learn how to use the equipment, but that is going to take longer than learning where the bus stops are in SPSS.

6.4 Additional Resources

If you're interested in getting started with the tools you'll be using in 431 before the class gets rolling, the great folks at [RStudio Education](#) provide [these 6 ways to begin learning R](#). Pick the one that appeals to you, and give it a shot.

- Note that if you're having trouble installing things, you can still learn a lot about R, RStudio and Data Science basics with the interactive tutorials at <https://rstudio.cloud/learn/primers>.
- If you're already a strong coder, and have some R experience, there are also [learning pathways for intermediates at RStudio Education](#) which might be appealing to you.

Our goal is to get everyone well into the intermediate level by December. Some people will get there in September, for others it will take longer. But you can do this, and we'll be there to help you.

In addition, there are many, many online resources to help you with working in R and in [Quarto](#), and we'll point you to some of the best of them during the semester.

7 Professor Love



Hi. I have at least three different jobs.

- I am a Professor in the Departments of Medicine and Population & Quantitative Health Sciences at Case Western Reserve University. I teach three courses per year there (PQHS 431, 432 and 500) and also lead the Health Care Analytics track of the MS program in Biostatistics.
- I direct the [Biostatistics and Data Science Division](#) at the [Population Health Research Institute](#) and at the Center for Health Care Research & Policy, which are jointly supported by The MetroHealth System and by CWRU.
- For ten years, I was the (founding) Data Director for [Better Health Partnership](#), an alliance of people who provide, pay for and receive care in Northeast Ohio. I now consult as Chief Data Scientist there.
- I am a Fellow of the American Statistical Association, and have held numerous roles with ASA at the national and local levels.
- I have won numerous awards for my teaching and my research, including the 2018 [John S. Diekhoff Award for Graduate Teaching](#) from CWRU.
- I have been teaching at CWRU since 1994, and have taught every manner of CWRU student over the years, especially students in biostatistics, medicine, and management.

In research, I use statistical methods to look at questions in health policy and in particular the provision of health services. I mostly work with observational data, rather than data that

emerge from randomized clinical trials, and I have a special interest in working with data from electronic health records.

- For example, you may be interested in a [study in Health Affairs](#) showing the impact of a [Medicaid-like expansion plan on care and outcomes of poor patients in Cleveland](#).
- Or you might be interested in our [New England Journal of Medicine](#) study of the effect of electronic health records on the care and outcomes of people with diabetes.
- In 2011, [James O'Malley](#) and I chaired the [Ninth International Conference on Health Policy Statistics](#), here in Cleveland. Here's a [recap](#).
- I've also worked on many projects involving the use of propensity scores to make causal inferences from observational studies, particularly in heart failure.

If you want to see a [fairly complete list of my publications](#), knock yourself out.

I hold degrees from Columbia University in the City of New York and from the University of Pennsylvania. My dissertation adviser was Paul Rosenbaum. I am married to a brilliant woman who is an attorney at Savant Systems, and we have two terrific sons, the older of which holds an MS in Data Analytics for Science at Carnegie Mellon University, while the younger is in his third year of law school at Fordham University. I live in Shaker Heights. I also sing and act occasionally in [community theater](#).

7.1 Email

- **Thomas dot Love at case dot edu** (for matters related to grades or individual concerns)
- I am best reached via email in an emergency.

7.2 Offices

- Wood WG-82J on the ground floor of the Wood building (Tuesday and Thursday afternoons)
- Rammelkamp R-229A at MetroHealth Medical Center (most Friday mornings)

At other times, Professor Love works from his home in Shaker Heights.

Professor Love is available for the 10 minutes before and after each class for drop-in discussions and otherwise by appointment (send email to schedule).

7.3 Name, Pronouns, Social Media

- Professor Love uses he/him/his pronouns, and identifies as male.
 - Most students refer to him either as Professor Love or Doctor Love, and he prefers this in class.
 - He prefers his given name to be written “Thomas” as opposed to “Tom”.
 - Most of his friends and colleagues call him “Tom”. You are welcome to do so, outside of class time, if it makes you comfortable.
- At Github, he is [THOMASELOVE](#).
 - The Github repository [for this syllabus is here](#).

8 Teaching Assistants

All of this year's stellar group of teaching assistants have been in your shoes - they've taken the course in the past, and they enjoyed it enough to come back for more. They are volunteering their precious time and energy to help make the course happen, and we couldn't be more delighted to welcome you to the course. All office hours and all teaching assistant work will be done remotely.

There is a lot to learn in this class. Don't suffer in silence - talk to us!

8.1 TA office hours

TA office hours are held via Zoom. The weekly schedule will appear on our [Contact Us page](#) as well as our [Course Calendar](#).

Our Shared Google Drive (431 Fall 2026 Dr Love and Students) will provide Zoom links for all TA office hours in a document called **431 TA office hours schedule and Zoom links**. No appointment is necessary. Please just drop in.

- Professor Love also holds “drop-in hours” for 10 minutes before and after each class on Tuesdays and Thursdays.

8.2 Getting To Know The TAs

The Fall 2026 Teaching Assistants for 431 include:

TA Name	For more, visit	Current Roles and CWRU Experiences
Marie Masotya	Section 8.2.1	PhD candidate, Clinical Translational Science
Kathryn Menta	Section 8.2.2	PhD Candidate, Epidemiology & Biostatistics
Mahsa Sheikh	Section 8.2.3	PhD candidate, Clinical Translational Science

8.2.1 Marie Masotya



Figure 8.1: Marie Masotya

Marie Masotya, MPH, is a PhD candidate in the Clinical Translational Science program. She is Senior Research Coordinator at University Hospitals (UH) Rainbow Center for Child Health and Policy where she manages research, quality and community-based projects. She is involved in several multi-sectoral community partnerships focused on child health and health equity. These include Better Health Partnership, Lead Safe Cleveland Coalition, and a school-based asthma intervention for elementary school children in Cleveland Metropolitan School District. Marie served as a TA for 431/432 in the past two years and looks forward to assisting again this year. Her best advice: start early and don't hesitate to ask for help. When not doing research, you will find her enjoying live theater, music, and adventures with her spouse and 3 children.

8.2.2 Kathryn Menta



Figure 8.2: Kathryn Menta

Kathryn Menta is a PhD candidate in Epidemiology and Biostatistics within the Department of Population & Quantitative Health Sciences. She worked as a crime scene investigator and forensic DNA technician for about seven years before returning to school to complete a new BS in mathematics and statistics at the University of Missouri, Kansas City. She then completed both a Master's in mathematics and a Master's in statistics at the same institution before coming to CWRU to start her PhD. Her current research is in dynamic treatment regimens focusing on clinical decision making for multiple sclerosis drug treatments. Outside of school, Kathryn enjoys spending time with her husband and two cats, crafting, and binge watching numerous true crime shows and podcasts.

8.2.3 Mahsa Sheikh



Figure 8.3: Mahsa Sheikh

Seyyedeh Mahsa Sheikholeslamian, DDS, MSc, is a PhD student in Clinical Translational Science at the Department of Quantitative and Population Health Sciences, Case Western Reserve University. She has worked with the Evidence Foundation on methodology research, contributing to projects involving critical appraisal, data extraction, interpretation of complex results, and preparing guidelines and evidence summaries for decision-making. Before joining the CTS program, she earned her DDS from Guilan University of Medical Sciences and a master's degree in Restorative Dentistry from Shahid Beheshti University of Medical Sciences. She also has nearly a decade of experience teaching as an assistant professor in dental schools. This semester, she looks forward to supporting students in PQHS/CRSP/MPHP 431 as a teaching assistant. Outside of academics, she enjoys cooking Persian food, visiting museums, and spending time with her daughter and spouse.

9 Getting Help

Data science and statistical programming can be difficult. Computers are stupid and little errors in your code can cause hours of frustration (even if you've been doing this stuff for years!). **You shouldn't spend more than 15 minutes struggling with anything in this class without asking for help.**

We are fully committed to making sure that you learn everything you were hoping to learn from this class. If you tell us you're having trouble, I will not judge you or think less of you. I hope you'll extend me the same grace. You never owe us personal information about your health (mental or physical). If you need extra help, or if you need more time with something, or if you feel like you're behind or not understanding everything, do not suffer in silence! Talk to us! We will work with you.

In general, we don't have a way to diagnose your problem with R, RStudio or Quarto if you don't show us what you're typing that causes an error, or a lack of results. If you wrote a Quarto file, we need to see it, along with a specific question (or series of them) about specific error messages or strange results you are getting. We need to replicate the problem in order to know how to fix your problem, and it also helps if we know what error message you're seeing, or what strange result you are getting.

9.1 Getting One-on-one help over Zoom (TA Office Hours)

You are strongly encouraged to visit our [teaching assistants](#) (TAs) during their Zoom office hours, whenever you need help with the course. This is the best way to get one-on-one help, or try out a new idea. Office Hours are held for your benefit. Our TAs are volunteering their time to help you, and most of them have been in your shoes in previous years. They want to help you!

- The weekly TA office hours schedule appears on our [Contact Us page](#) as well as our [Course Calendar](#). Zoom links are provided on our Shared Google Drive (431 Fall 2026 Dr Love and Students).
- No appointment is necessary. Please just drop in.

9.2 Getting Help over email

Once the semester begins, if you have a question you want to pose via email about the course (especially outside of TA office hour times), please send it to 431-help@case.edu.

- Professor Love *and* the TAs will see this email, and usually respond fairly quickly.

9.3 How We'll Use Canvas

The course's primary listing on [Canvas](#) is PQHS 431, but students in CRSP 431 and MPHP 431 should find the same information. We'll use the Canvas platform for two things:

- turning in most of our lab and project assignments
- providing information about (and maintaining recordings of) our class sessions

Visit <https://canvas.case.edu/> to log in and see what's available there.

9.4 How We'll Use Google Drive

Professor Love will share some data and some other materials (answer sketches for lab assignments, for example) through a Shared Google Drive. You will need to log into Google through your CWRU account in order to view and use these materials.

- To check that you have access to this Shared Google Drive once class begins, [visit this link](#).

9.5 Meeting with Professor Love

Professor Love does not hold regular office hours. He will arrive 10 minutes before each class, and stay afterwards, as well, to address any drop-in student concerns and questions.

- If you have any unique concerns about the course, need special accommodations or have any other issues you want to discuss with Professor Love specifically, please email him (**Thomas dot Love at case dot edu**).
- It's always helpful if Professor Love knows who you are before December, and this can be an especially difficult thing to achieve in a large class like this.

9.6 Other Sources of Help

We provide extensive supplemental resources for 431 on the [Resources page](#) on our website, and in class-specific READMEs and presentations, as linked on the [Course Calendar](#).

In addition, there are many, many online resources to help you learn R beyond those we provide.

- [RStudio Education](#) is a great site with multiple learning paths available.
- Even in the age of generative AI, building internet searches (“googling”) effectively is an important skill that requires practice. Don’t be afraid to use search engines to figure out how to code things in R, for example.
- The [RStudio Community](#) at Posit is a forum specifically designed for people using RStudio and the tidyverse (and that will be you.)

10 Assignments

The primary course assignments for 431 include:

- three projects
- seven labs
- a single quiz
- six check-ins (that you might think of as “mini-quizzes”), and
- eight minute papers

The rest of this section provides some information about each of these assignments. See the [Assignments page](#) on the course website for direct links to instructions and other details. Information on course grades is found in Chapter 11.

10.1 Deadlines for Assignments

All deadlines are posted on the [Course Calendar](#), which is the final word for all deadlines.

- On every assignment, we will be delighted to respond to questions **up to 3 hours before** the assignment is due. After that time, you may wind up on your own. The reason for this is that Professor Love and the teaching assistants will regularly post responses to frequently asked questions about assignments, and we need sufficient time to accomplish this task.

10.2 Using Artificial Intelligence Tools

1. The use of generative AI is **prohibited** for check-ins and for the Quiz.
2. Select use of generative AI is *permitted* (so long as you disclose it appropriately - see the assignment instructions) in developing code and improving communication in course labs and projects.

See Section [12.4.4](#) for additional language and policies on using generative AI software (such as ChatGPT, Claude, or Gemini) at CWRU.

10.3 Projects

You will complete three projects this semester. Project A is smaller than Project B, which is smaller than Project C. The main reason why we have three Projects is that I can't figure out a way to get you to think about all of the things I hope you'll learn from this course in fewer Projects. Another important reason is that I want you to be able to make mistakes during the semester without worrying about it too much, and having three projects spreads out this learning a bit.

1. We set different tasks for each Project, allowing us to touch on a wider fraction of the things I hope you'll learn in 431.
2. The projects use different data sets, types of sources and study designs, and also require varying analyses and use different methods for communicating results.
3. We provide far more guidance (and instruction) for the early projects (A and B) than for Project C.
4. We provide brief written feedback on Project A, more substantial written feedback on B, and oral feedback on Project C.
5. Projects A and B are lower-risk than Project C (and count less towards your grade.)
6. Completing each project makes later assignments (including the other projects) easier for you to do and for us to evaluate.
6. Having a broad range of project activities to evaluate helps reduce the cost of a mistake on any one of them, so that you can build skills from Project to Project.

Links to the instructions for each project can be found on our [Assignments page](#).

10.4 Labs

During the semester, there are **seven** lab assignments.

- Most labs require straightforward demonstrations of mastery for core principles and fundamental skills. Some require deeper dives into more technically sophisticated material.
- Most labs ask you to clean/visualize/analyze some data that we provide to you, and also to react to something we're reading at the same time in the Spiegelhalter book.
- You should anticipate that some coding in R **and** writing at least one essay will be required in most labs.

Lab assignments are submitted through [Canvas](#). The link to post your responses for each Lab will appear in time for you to submit the work, usually just after the deadline for the preceding Lab has passed. After all submissions are in, Dr. Love will provide detailed answer sketches for each Lab.

More information on labs is available [at this link](#).

10.5 Quiz

One consequence of having three Projects instead of two this term is that there is now only one Quiz this term (instead of the two we've done in the past.)

- You will receive this Quiz just before the Thanksgiving break. It is an open-book, end-of-semester assessment of everything we'll do between the start of the course and Class 24.

More information on this Quiz is available [at this link](#).

10.6 Check-ins

Professor Love plans to set six “Check-Ins” these semester. These are brief opportunities for you to demonstrate your understanding and how well you're keeping up with the course. Some might call them “mini-quizzes”.

Each check-in is designed to take somewhere between 15 and 60 minutes of your time. Professor Love may require you to complete and submit work live in class, or he may simply announce the check-in in class, and provide instructions for submission on a short (48 hour) deadline.

More information on check-ins is available [at this link](#).

10.7 Minute Papers

Our Minute Papers are short surveys (completed using a Google Form) where you will answer a few questions about how the course is going for you, express your views and preferences, and comment on relevant concerns.

- You **should** complete the Minute Paper even if you weren't able to attend the most recent class.
- Most Minute Papers take about 5 minutes to complete.
- A good time to do these is right at the end of Tuesday's class, but each Minute Paper is due at noon Wednesday to give you some time to reflect, if you'd like.
- Your first assignment: the [Welcome to 431 Survey](#) uses a similar format, but is more extensive than a typical Minute Paper.

Only Professor Love sees the results of the Minute Papers with identifying information. Generally, he summarizes findings and provides feedback without identifying people as part of that week's Thursday class.

More information on minute papers is available [at this link](#).

11 Grading

Over the past five years, essentially all students taking the course have eventually earned either an “A”, a “B” or an “Incomplete” in 431. This will likely also be the case this year. The course cannot be taken “pass/fail.”

11.1 Grading Philosophy

Grading standards apply in the same way for all students, regardless of whether they are enrolled in PQHS 431, CRSP 431 or MPHP 431. Students in this class are not in competition with each other for grades. I have no set percentage of students who will receive any particular grade. We aim for substantial and timely feedback from the teaching assistants and myself on all elements of the course.

11.2 Building a Course Grade

A student’s grade in 431 is primarily determined by their performance on the following assignments.

Available Points	Assignment	Details
400	Projects	Project A: 80 points Project B: 120 points Project C: 200 points
250	Labs 1-4, 6-7	50 points each; lowest 1 of 6 scores dropped
35	Lab 5	Scored out of 35 points; see Lab 5 for details
120	Quiz	Scored out of 120 points; see Quiz for details
100	Check-ins	25 points each; lowest 2 of 6 scores dropped
70	Minute Papers	10 points each; lowest 1 of 8 scores dropped
25	Welcome to 431	25 points if the survey form is complete and on time
1000	Grand Total	Total available points through the semester

11.3 Bonus Points

Opportunities to earn bonus points this semester include¹:

- If you find **typos** in the materials (code, slides, the Notes, this syllabus) send them to us via email to 431-help@case.edu.
- See a cool visualization online? A nice use of statistical methods or design in a paper? Hear about a resource, event or opportunity that you think other students might benefit from? Share them with us via email, too.
- Timely responses to several individual requests we have hidden in course materials will be rewarded with bonus points.
- We also will reward other contributions to help the course achieve its goals, as perceived by Professor Love and/or the teaching assistants, including asking good questions, helping your fellow students, and numerous other things.

We cannot emphasize enough how much we want to hear from you about things that are relevant to this course. A student can receive as many as 40 bonus points during the semester. We expect most students will receive between 1 and 15 bonus points².

11.4 Requesting an Assignment Regrade

We use a [431 Regrade Request Form](#) to handle almost all grading errors and regrade requests on Labs. The only exception to this policy is when you believe we've made an arithmetic error in summing up your points on a lab. If that happens, just email Dr. Love to get it straightened out.

- If you want Dr. Love to review your grade on one (or more) of Labs 1-7 (or on Projects A or B) you should fill out [the form](#) any time before the December deadline on the [Course Calendar](#).
- Once you submit the form, you'll have the ability to edit it, so you can add to it later in the semester if necessary.
- When all other course work has been graded, Dr. Love will open the form. If you have requested additional points that could change your course grade, he'll review your request. If not, then he won't.

11.5 Turning a Point Total to a Grade

As noted, 1000 points are available to each student.

¹This is not an exhaustive list.

²This strategy differs from what we've used in the past, so we'll see what happens.

- Students with a final point total (including any bonus) of **880-1000** points will receive an A in the course.
- Students with **850-879** points will receive *either an A or B*.
- Students with **725-849** points will receive a B in the course.
- Students with **700-724** points may receive *either a B or C*.
- Students with scores below 700 points have not successfully completed the course. We hope that doesn't happen.

For students in the *discretionary zones* (850-879 points and 700-724 points), the most important factors in Professor Love's decision on a final grade will be demonstrated (1) effort and (2) improvement over the course of the semester. Professor Love will solicit feedback from course teaching assistants about each student to help his assessments.

Students will be able to track their (non-bonus) point status at any time during the semester on the basis of feedback on assignments. If you need more clarification, email Professor Love.

12 General Policies

All Case Western Reserve University policies apply to this class, including those summarized below. To the extent that those policies are unclear, I would regard an appropriate code of conduct as mirroring [this one from the R Consortium](#).

Any concerns or questions regarding these general policies, the teaching assistants or the course itself should be directed to Professor Love, if at all possible.

12.1 Attendance

Things happen, and people occasionally cannot make it to class in person. For 431, we expect all students to attend at least 22 of the 25 sessions in person.

- If you need to miss a class session, or even two, just review the materials and move on, and please feel encouraged to ask for help.
- If you must miss **more than two classes** in a row, then it is your responsibility to email Professor Love as soon as possible to let him know.
 - An appropriate email would read “I am unable to attend class on [specific dates] and I will complete all necessary work while I am away.” No additional explanation is required.

12.2 Auditing

Enrolled students and teaching assistants are the only people permitted to attend the course, without special permission from Professor Love.

- I do not permit anyone to audit the course who has not previously taken it, without exception.

12.3 Recordings

We aim to have video recordings available on [Canvas](#) after several class sessions.

- “Live” Zoom attendance can be a problem, in that remote students will not be able to interact with the class.
- Technical problems may occur during the semester with the recordings.
- You should assume that anything you say in class will be recorded.

12.4 University Required Language

12.4.1 University Enrichment & Engagement

It is the intent that all students regardless of their background and perspective be well-served by this class. Further, we intend to present material whose content is respectful and deliver it in a respectful manner. We expect that all students, instructors and guests will help foster an atmosphere of respect, trust and safety in the classroom.

If you have suggestions for how to make the class content or environment more respectful, or have specific incidents to report, please reach out to the instructor. If you are not comfortable reaching out to the instructor, feel free to reach out to someone else, such as the School of Medicine Graduate Education Office (som-geo@case.edu) or the [Office of Campus Enrichment and Engagement](#). More information on University policy and resources is available [on their website](#).

12.4.2 Disability Accommodations

In accordance with federal law, if you have a documented disability, you may be eligible to request accommodations from Disability Resources. In order to be considered for accommodations you must first register with the Disability Resources office. Please contact their office to register at 216.368.5230 or [follow this link to get more information on how to begin the process](#). Please keep in mind that accommodations are not retroactive.

12.4.3 Academic Integrity

[Click here to obtain the PDF file describing Academic Integrity for Graduate Courses](#)

Here is the official policy of the University on Academic Integrity.

Any violation of the University's Code of Ethics will not be tolerated. All forms of academic dishonesty including cheating, plagiarism, misrepresentation, and obstruction are violations of academic integrity standards and will result in a minimum penalty of receiving a zero for the assignment, the potential for failing the entire course. Cheating includes copying from another's work, falsifying problem solutions or laboratory reports, or using unauthorized sources, notes or computer programs. Plagiarism includes the presentation, without proper attribution, of another's words or ideas from printed or electronic sources. It is also plagiarism to submit, without the instructor's consent, an assignment in one class previously submitted in another. Misrepresentation includes forgery of official academic documents, the presentation of altered or falsified documents or testimony to a university office or official, taking an exam for another student, or lying about personal circumstances to postpone tests or assignments. Obstruction occurs when a student engages in unreasonable conduct that interferes with another's ability to conduct scholarly activity. Destroying a student's computer file, stealing a student's notebook, and stealing a book on reserve in the library are examples of obstruction. In addition, the incident will be reported to the Dean of Undergraduate Studies and Academic Review Board for undergraduates or Senior Associate Dean of Graduate Studies, for Graduate Students.

12.4.4 AI (Artificial Intelligence)

Students at Case Western Reserve University are expected to uphold the highest ethical standards of academic conduct. Academic integrity addresses all forms of academic dishonesty, including cheating, plagiarism, misrepresentation, obstruction, and submitting without permission work to one course that was completed for another course. Please review the complete academic integrity policy for additional information, including an overview of the processes & procedures for reporting academic misconduct.

In addition, we recommend that faculty clearly describe their course-specific expectations for students' use of AI tools.

Note that I have done this on an assignment-level basis.

Students are encouraged to consult with the instructor if they have any questions or concerns regarding the appropriate use of common/basic AI in this course.

Students are expected to use AI responsibly and critically evaluate the outputs of AI tools, ensuring transparency, accountability, and ethical considerations in their utilization.

Students can use basic AI tools for specific tasks approved by the instructor, such as grammar checking or citation formatting. Guidelines for AI usage will be provided to ensure alignment with course objectives and academic standards.

12.4.5 Equity and Title IX

Title IX of Education Amendments of 1972 (“Title IX”) prohibits discrimination based on sex, including sexual harassment, in education programs that receive federal funding. This includes providing support to anyone impacted by sex discrimination or sexual harassment. The Title IX Coordinator is responsible for implementing Title IX and is in CWRU’s Office of Equity. The Title IX Coordinator is also responsible for making sure that the procedures in CWRU’s policy prohibiting sex discrimination and sexual harassment are followed and all persons are treated fairly and with respect. Members of the CWRU community and others should direct questions about the application of Title IX to situations impacting the CWRU community, and its educational programs and activities, to the Title IX Coordinator. Information on the Office of Equity and Title IX is located [on the Office of Equity webpage](#).

12.4.6 CWRU Public Safety

The Case Western Reserve University Division of Public Safety provides quality service, safety, and a positive educational experience for the campus community. Members of the CWRU community – students, faculty, staff, and guests – are encouraged to report all criminal actions, emergencies, or other public safety related incidents to CWRU Division of Public Safety. For an emergency, call 216-368-3333. For a non-emergency, call 216-368-3300. Members of the community are encouraged to [download the Spartan Safe app](#) which offers easy access to critical resources and safety tools.

12.5 Laptop and cell phone use

Here is the official University policy:

“Although having a laptop in class opens up new learning possibilities for students, it can be used in ways that are inappropriate. It is easy for your laptop to become a distraction to you and to those around you. Laptops are to be used only when essential to the task at hand. Please turn off or silence all cell/smart phones, tablets, and other electronic devices for the duration of the course. Inappropriate uses will be noted and may affect the final grade.”

Professor Love adds that, in this class, the use of a laptop or other device is welcomed, and even encouraged, for taking notes on our slides, or following along with the presentation, or trying out ideas in R, but it is inappropriate for you to use such a machine for activities unrelated to the class during our time together. Silence your phone during class. The temptation to look at your phone or Facebook or email during class is nearly irresistible. Resist anyway, if only to avoid distracting your instructor and your fellow students.

Thank you.

13 Movies

Once you have read through this Syllabus, please e-mail Professor Love an image of a poster for your favorite movie. Use the subject line: **431 Favorite Movie**.

If he receives your poster by Noon Eastern time on Wednesday 2026-09-02, he will receive some [bonus credit](#).

Thank you.

14 General Advice

My most important piece of general advice to people is to be kind. That's not always the thing I do as well as I'd like.



The Meanest TA
@MeanestTA

Hell hath no fury like a full professor mildly inconvenienced.

11:32 AM · Jun 12, 2019 · [Twitter for iPhone](#)

My second most important piece of advice is that it's your job while in this course to figure out how to make the time you need to complete the work. That can be a real challenge, and everyone faces it.

14.1 On Graduate School

For graduate students, I urge you to take as much advantage of this learning experience as you can. While I'll refer to some of the pieces below during the course, I've gathered a few favorites here.

1. From matt.might.net...
 - [12 Resolutions for Grad Students](#)
 - [How to get a great letter of recommendation](#)
 - [How to send and reply to email](#). You might also want to look at [Email Etiquette: Guidelines for Writing to Your Professors](#)
2. [Four Things You Should Do When You're Bored, on YouTube](#) (the four things are Exercise / Read / Meditate / Find and Engage a Hobby with Passion). Also, [Get Up and Move. It May Make You Happier](#) by Gretchen Reynolds, in the *New York Times*, 2017-01-25.

3. [Why academics need to focus on structuring their time](#) from *University Affairs*.
4. Most people are really bad at meetings, including Professor Love. In a series of tweets, Greg Wilson argued that “...the single most useful training you can give an adult is how to run a meeting and how to participate in someone else’s.” He then provides [some nice tips in this YouTube video](#).
5. Some people need help taking notes. You might be interested in [Cornell Note Taking](#) or the [5 other methods described here](#).
6. You may be interested in the American Statistical Association, and its extensive [materials for statistics students](#).

14.2 On Seeking a Job

If I have a job or internship to offer, I’ll be noisy about it in class. In the meantime, I’d consider joining the [American Statistical Association as a student member](#) and perhaps joining the [Greater Cleveland R Meetup Group](#).

Here are some gathered thoughts from other folks that you might enjoy:

1. [General Advice on an Academic Career Path](#) (which is filled with useful advice, especially for those studying biostatistics.)
2. [Advice for Applying to Data Science Jobs](#) from [Emily Robinson](#)
3. [Academic job search advice](#) from [matt.might.net](#)
4. [Career Advice for Data Scientists](#) was a panel at [rstudio::conf 2020](#) focused on building a career around R.

15 On Writing

15.1 Writing, Presenting & Communicating

I write all the time. It's my job. It's yours, too. You'll do more of it here than you may be expecting in this class, and in life. So you'll need to take advantage of every opportunity you have to write more effectively tomorrow than you do today.

Here's what I find to be a compelling argument from George Cobb ...

If you want your work with data to make a difference, devote time and effort to choosing the words and pictures you use to present your evidence and conclusions. If you teach or supervise, seek to reward those - they who learn from you, and they who report to you - when they spend time crafting their message.

Think back to the last "report" you were expected to read. Is it easy to recall the main points? The answer, yes or no, depends not so much on the quality of the data, the effort, and the thinking that went into the report, nor on your own dutiful diligence in reading the report, but rather, and mainly, on whether the people who wrote the report had learned and practiced the skills of how to use words and pictures, first, to claim attention, and second, to claim retention: to deliver a message that sticks in the mind.

15.2 Campus Resources

The Department of Population and Quantitative Health Sciences provides a detailed list [on its website in the Resources section](#) of links to several important resources for improving your English and your communication skills. Also helpful is <https://case.edu/student-success/academic-resources>. We strongly encourage you to take advantage of these resources.

15.3 Artificial Intelligence (ChatGPT)

We will discuss some of the flaws and opportunities of AI composition software as part of the Communication goals for this course. Using these tools without my permission puts your

academic integrity at risk. Our Academic Integrity Policy prohibits submitting AI-generated text as one's own, just as it prohibits claiming authorship for text that was originally produced by another person.

More on this course's policies regarding AI and Academic Writing can be found in Section [12.4.4](#).

15.4 Advice from Other People

1. [Preparing Manuscripts for Submission to Medical Journals: The Paper Trail](#) by H. Gilbert Welch, from *Effective Clinical Practice* in 1999.
 - Start early, focus on high-visibility components, develop a systematic approach to the body of the paper, finish strong.
 - Use [thinkchecksubmit](#) and [see this tweet](#) for some related suggestions when selecting a journal or publisher for your work.
2. [Writing a Scientific Paper in Four Easy Steps](#) from Claus Wilke at [The Serial Mentor](#) blog.
3. [Rules to write a good research paper](#) from Daniel Lemire.
4. [Hey-here are some tips on communicating data and statistics!](#) from Andrew Gelman 2017-06-02.
5. [Writing Pet Peeves: Correctness, References, and Style](#) from Tamara Munzner.
6. Frank Harrell's [Checklist for Authors of Statistical Problems to Document and to Avoid](#)

15.5 A Few Tips from Professor Love

1. When writing anything for this course in English, use complete sentences, not just bullet points.
2. Don't leave anything until the last day. Allow time for computer problems and for you to review (and potentially) revise your work.
3. Statistics is a "getting the details right" business - we care deeply about details, and this applies to writing code or complete English sentences. RStudio has a spell-checker. To use it, click F7.
4. Nothing impresses us as much as a clear and concise argument, presented using well-written English sentences, effective and well-labeled figures and tables.
5. Don't parrot back material that Professor Love wrote or said. State ideas in your own words. Stating them in my words is, technically, plagiarism.
6. Edit your more adventurous output; don't present everything you know how to do in R, and don't forget that someone is trying to read both your code and your results.

7. Make your work easy to evaluate. In responding to an assignment, be sure to answer the question that was asked, restating it as necessary.
8. Clearly label everything: graphs, tables, your answer to a specific question. Everything. Again, make your work easy to evaluate.
9. Simplify. Emphasize ideas in plain language. Avoid jargon. Use English well.
10. **Never**, ever refer to anything as statistically significant (or use any synonym for that idea.) **Statistical significance is an actively bad idea**, as we will see in class. Instead, estimate a confidence interval or Bayesian credible interval for the comparison of interest and present that finding.
11. If you must specify a p -value, then:
 - resist with all your might the temptation to identify whether that p -value is larger or smaller than (for example) 0.05.
 - specify most p -values that are less than 0.001 or perhaps less than 0.0001 as $p < 0.001$, rather than, for instance, $p = 0.00000001$ or, worse yet, $p = 0$.
 - In a similar vein, write most p -values that exceed 0.99 as $p > 0.99$ instead of, for instance, $p = 1$.
12. Data are plural. Use “the data **are** ...” rather than “the data *is* ...”
13. A paragraph must contain more than one sentence.
14. Don’t switch tenses. If you want to write in the present tense, stick to it throughout.
15. Don’t write or say random sample unless you used a random number generator. If you used haphazard sampling or convenience sampling, call it what it is, and indicate whether any problems could have cropped up as a result.
16. Similarly, don’t defend a method of data collection because it is random. Most of the time we want to represent some population, and a random sample is just one way to ensure that certain types of biases have a low probability of creeping in.
17. To the extent possible, don’t use **computer-ese** to label variables, plots or tables. R and Quarto allow you to change the labels on graphs and tables to meaningful things – do so. Use meaningful abbreviations, as necessary, explaining what they mean on the first usage.
18. When in doubt, err on the side of clarity. Clear thinking leads to clear writing.