

# Week 1, Class 2

## Introduction to R and Data Frames

Sean Westwood

### In Today's Class

- Basic R operations with variables and vectors
- Creating and examining data frames
- Loading CSV files using `read_csv()`
- Essential tidyverse functions for data exploration
- Applying AI assistance effectively for R programming

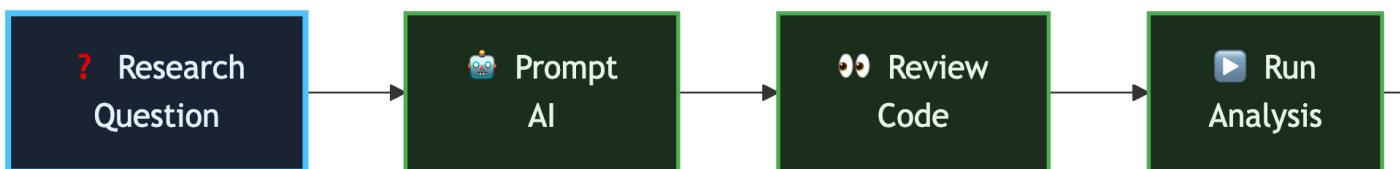
## The AI Revolution in Data Analysis

### What's Changed Recently

Traditional Workflow:



AI-Assisted Approach:



## Key Difference

- We focus on understanding and interpretation, not memorizing syntax
- AI handles the programming details
- You verify the logic and meaning

## Working with Objects in R

### Basic Variable Assignment

R stores information as **objects**. We create objects using the assignment operator <-:

```
# Store a number
electoral_votes_to_win <- 270
electoral_votes_to_win
```

```
[1] 270
```

```
# Store text
candidate_name <- "Biden"
candidate_name
```

```
[1] "Biden"
```

```
# Store the result of a calculation
margin_2020 <- (81283501 - 74223975) / 155507476
margin_2020
```

```
[1] 0.0453967
```

### Variable Types

R automatically determines the type of data you're storing:

- **Numeric:** Numbers for calculations (270, 3.14, -5.2)
  - Used for vote counts, percentages, ages, income data
- **Character:** Text enclosed in quotes ("Biden", "Democratic", "2024")

- Used for names, party affiliations, state labels, survey responses
- **Logical:** True/false values (TRUE, FALSE)
  - Used for yes/no questions, whether conditions are met

```
# These are different!
number_value <- 270
number_value
```

```
[1] 270
```

```
text_value <- "270"
text_value
```

```
[1] "270"
```

## Working with Vectors

### Creating Vectors

We often want to store multiple values in a single variable. For example, we might want to store the electoral votes for swing states in 2020. We can do this by creating a vector.

Think of them as lists of values.

**Vectors** are one-dimensional collections of related values.

```
# Electoral votes for swing states in 2020
swing_states <- c("Pennsylvania", "Michigan", "Wisconsin",
                  "Arizona", "Georgia", "Nevada")

electoral_votes <- c(20, 16, 10, 11, 16, 6)
```

## Understanding the `c()` Function

The `c()` function stands for “combine” or “concatenate”. It’s how we create vectors in R.

**Key points about `c()`:**

- Combines multiple values into a single vector
- All values must be the same type (all numbers or all text)
- Separate values with commas
- Can combine single values or other vectors

```
# Combining individual values
approval_ratings <- c(45, 48, 42, 50, 47)

# Combining text values
parties <- c("Democratic", "Republican", "Independent")

# R converts everything to the same type
mixed <- c(1, 2, "three", 4) # All become text!
mixed

[1] "1"      "2"      "three"  "4"
```

## Adding to Existing Vectors

You can expand vectors by combining them with new values using `c()`:

```
# Start with core swing states
key_states <- c("Pennsylvania", "Michigan", "Wisconsin")

# Add more states to our analysis
key_states <- c(key_states, "Arizona", "Georgia")
key_states

[1] "Pennsylvania" "Michigan"      "Wisconsin"     "Arizona"       "Georgia"

# Add even more states
all_competitive <- c(key_states, "Nevada", "North Carolina")
all_competitive
```

```
[1] "Pennsylvania"   "Michigan"        "Wisconsin"       "Arizona"  
[5] "Georgia"        "Nevada"          "North Carolina"
```

```
# Combine multiple vectors  
rust_belt <- c("Pennsylvania", "Michigan", "Wisconsin", "Ohio")  
sun_belt <- c("Arizona", "Georgia", "Nevada", "North Carolina")  
all_battlegrounds <- c(rust_belt, sun_belt)  
all_battlegrounds
```

```
[1] "Pennsylvania"   "Michigan"        "Wisconsin"       "Ohio"  
[5] "Arizona"         "Georgia"         "Nevada"          "North Carolina"
```

## Basic Vector Operations

How many swing states?

```
length(swing_states)
```

```
[1] 6
```

Total electoral votes in swing states?

```
sum(electoral_votes)
```

```
[1] 79
```

What is the maximum number of electoral votes in a swing state?

```
max(electoral_votes)
```

```
[1] 20
```

## Mathematical Operations

Vectors make calculations across multiple values easy:

What if we want to increase the electoral votes in each swing state by 5%?

```
# If turnout increased by 5% in each state  
new_turnout <- electoral_votes * 1.05  
  
new_turnout
```

```
[1] 21.00 16.80 10.50 11.55 16.80 6.30
```

## Essential Functions for Working with Data

### Basic Summary Functions

```
# Presidential approval ratings (simulated)  
approval_ratings <- c(45, 42, 48, 51, 44, 47, 43, 49, 46, 50)  
  
# Central tendency  
mean(approval_ratings)      # Average approval
```

```
[1] 46.5
```

```
median(approval_ratings)    # Middle value
```

```
[1] 46.5
```

```
# Spread  
range(approval_ratings)    # Min and max
```

```
[1] 42 51
```

```
length(approval_ratings)    # Number of observations
```

```
[1] 10
```

### The round() Function

Make numbers readable:

```
# Calculate Biden's 2020 vote percentage  
biden_percentage <- 81283501 / 155507476  
  
# Round to 2 decimal places  
round(biden_percentage, 2)
```

```
[1] 0.52
```

```
# Round mean approval to 1 decimal place  
round(mean(approval_ratings), 1)
```

```
[1] 46.5
```

## Introduction to Data Frames

### What Are Data Frames?

**Data frames** are like spreadsheets that store data in rows and columns.

Key features:

- **Rows:** Observations (countries, voters, elections)
- **Columns:** Variables (population, party, vote share)
- **Names:** Each column has a descriptive name

## Loading Data with Tidyverse

### Setting Up: Why Tidyverse?

The **tidyverse** is a collection of R packages designed for data science that share a common philosophy and grammar.

### Why use tidyverse over base R?

- **Consistent syntax:** Functions work similarly across packages
- **Readable code:** Operations read like English sentences
- **Better error messages:** More helpful when things go wrong
- **Modern approach:** Designed for contemporary data analysis workflows

First, we load the tidyverse package:

```
library(tidyverse)
```

## Loading CSV Files

### What is a CSV file?

CSV stands for “Comma-Separated Values” - it’s a simple text format where:

- Each row represents one observation
- Columns are separated by commas
- First row usually contains variable names

**Other file formats:** R can load Excel files (.xlsx), SPSS files (.sav), Stata files (.dta), and many others, but for this course, all our data will be in CSV format.

To load CSV files, we use `read_csv()`. This is a function from the tidyverse package that reads in a CSV file and returns a data frame.

```
# Load UN population data  
UNpop <- read_csv("../data/UNpop.csv")
```

```
Rows: 7 Columns: 2  
-- Column specification -----  
Delimiter: ","  
dbl (2): year, world.pop  
  
i Use `spec()` to retrieve the full column specification for this data.  
i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

## Examining Data Frames

### Essential Exploration Functions

```
# Quick overview of structure (what you will send to AI to help you)  
glimpse(UNpop)
```

```
Rows: 7
Columns: 2
$ year      <dbl> 1950, 1960, 1970, 1980, 1990, 2000, 2010
$ world.pop <dbl> 2525779, 3026003, 3691173, 4449049, 5320817, 6127700, 6916183
```

## Understanding the Output

`glimpse()` shows:

- Number of rows and columns
- Column names and types
- First few values in each column

This gives you a complete picture of your data structure.

## Understanding Data Types

When we use `glimpse()`, we see information about each column's data type. Some common data types:

- `<dbl>` means “double precision floating point number” (a decimal number)
  - Examples: population counts, vote shares, income amounts
- `<chr>` means “character” (text data)
  - Used for text
  - Examples: candidate names, party affiliations, state names
- `<int>` means “integer” (whole numbers)
  - Examples: number of votes, year, district numbers
- `<lgl>` means “logical” (TRUE/FALSE values)
  - Examples: incumbent status, ballot measure results
- `<date>` means date values (a date)
  - Examples: election dates, survey dates

## More Essential Exploration Functions: Head

The `head()` function shows the first few rows of your data frame, which is useful for:

- Seeing what your actual data looks like (not just the structure)
- Checking if data loaded correctly
- Understanding the format and content of each column
- Getting a quick preview before doing analysis

**Note:** There's also a `tail()` function that shows the last few rows, which can be helpful for checking if your data is complete or seeing the most recent observations.

```
head(UNpop)
```

```
# A tibble: 6 x 2
  year   world.pop
  <dbl>     <dbl>
1 1950    2525779
2 1960    3026003
3 1970    3691173
4 1980    4449049
5 1990    5320817
6 2000    6127700
```

## More Essential Exploration Functions: Summary

The `summary()` function provides descriptive statistics for each column in your data frame:

- For **numeric columns** (like population counts):
  - **Min.:** Minimum value
  - **1st Qu.:** First quartile (25th percentile)
  - **Median:** Middle value (50th percentile)
  - **Mean:** Average value
  - **3rd Qu.:** Third quartile (75th percentile)
  - **Max.:** Maximum value

```
# Summary statistics
summary(UNpop)
```

```

year      world.pop
Min.    :1950   Min.    :2525779
1st Qu.:1965   1st Qu.:3358588
Median  :1980   Median  :4449049
Mean    :1980   Mean    :4579529
3rd Qu.:1995   3rd Qu.:5724258
Max.    :2010   Max.    :6916183

```

## More Essential Exploration Functions: Names

The `names()` function shows the names of the columns in your data frame:

- Useful for:
  - Checking column names
  - Understanding variable labels

```
# Column names
names(UNpop)
```

```
[1] "year"      "world.pop"
```

## Working with Real Data: UN Population

### The UNpop Dataset

**Source:** United Nations population estimates

**Time period:** 1950-2010 (10-year intervals)

**Variables:**

- `year`: Year of measurement
- `world.pop`: World population (in thousands)

## Simple Calculations

### Population growth over time

```
UNpop$world.pop[7] - UNpop$world.pop[1] # Growth from 1950 to 2010
```

```
[1] 4390404
```

### Average population across all years

```
# Average population across all years  
mean(UNpop$world.pop)
```

```
[1] 4579529
```

### Convert from thousands to billions

```
# Convert from thousands to billions  
UNpop$world.pop / 1000000
```

```
[1] 2.525779 3.026003 3.691173 4.449049 5.320817 6.127700 6.916183
```

## AI Integration for R Programming

### Effective AI Prompts

#### For syntax help:

"I have a data frame called 'leaders' with columns 'name', 'party', and 'years\_served'. How do I calculate the average years served using tidyverse functions? I want a simple response—don't give me more than I asked for. I am learning R, so explain each step."

#### For error messages:

"I got this error: 'Error: could not find function “read\_csv”’. What does this mean and how do I fix it? I am using Positron"

## Exercise: Congressional Leadership Data

### Create and Analyze

Run this code:

```
# Create the data frame
congressional_leaders <- data.frame(
  name = c("Pelosi", "Schumer", "McConnell", "McCarthy"),
  party = c("Democratic", "Democratic", "Republican", "Republican"),
  chamber = c("House", "Senate", "Senate", "House"),
  years_served = c(36, 24, 38, 16),
  age = c(82, 72, 80, 58)
)
```

#### Your tasks:

1. Calculate average years of service
2. Find the oldest leader
3. Count Democrats vs Republicans
4. Which chamber has more experienced leaders on average?

### With AI Assistance

Try this prompt:

"I am working in R with the tidyverse. I have a data frame called congressional\_leaders. The column names are name, party, chamber, years\_served, and age. Help me calculate summary statistics for years served by party and chamber. I want a simple response—don't give me more than I asked for. I am learning R, so explain each step."

### What you should get back

Something like this:

**SW** "I am working in R with the tidyverse. I have a data frame called congressional\_leaders. The column names are name, party, chamber, years\_served, and age. Help me calculate summary statistics for years served by party and chamber. I am learning R, so explain each step."

I'll help you calculate summary statistics for years served by party and chamber using the tidyverse in R. Here's how to do it step by step:

Summary Statistics for Congressional Leaders  
Code



Let me explain each step of this code:

### Step-by-Step Explanation:

#### 1. Loading tidyverse

```
r
library(tidyverse)
```

This loads all the tidyverse packages, including `dplyr` (for data manipulation) and `ggplot2` (for visualization).

**2. The pipe operator (`%>%`)** This passes the result from one function to the next. Think of it as "and then do this." It makes code more readable by flowing from left to right.

**3. `group_by(party, chamber)`** This groups your data by unique combinations of party and chamber (e.g., Republican House, Democratic

Reply to Claude...

+ ⌂ Research

Claude Sonnet 4

```
# Load the tidyverse package
library(tidyverse)

# Method 1: Basic summary statistics by party and chamber
summary_stats <- congressional_leaders %>%
  group_by(party, chamber) %>%
  summarise(
    count = n(),                                     # Number of leaders in each group
    mean_years = mean(years_served),                 # Average years served
    median_years = median(years_served),              # Median years served
    min_years = min(years_served),                    # Minimum years served
    max_years = max(years_served),                    # Maximum years served
    sd_years = sd(years_served),                      # Standard deviation
    .groups = "drop"                                  # Remove grouping after summarise
  )

# Display the results
print(summary_stats)

# Method 2: More detailed summary with quartiles
detailed_stats <- congressional_leaders %>%
  group_by(party, chamber) %>%
  summarise(
    count = n(),
    mean_years = round(mean(years_served), 2),
    median_years = median(years_served),
    q1_years = quantile(years_served, 0.25),        # First quartile (25th percentile)
    q3_years = quantile(years_served, 0.75),        # Third quartile (75th percentile)
    iqr_years = IQR(years_served),                   # Interquartile range
    min_years = min(years_served),
    max_years = max(years_served),
    sd_years = round(sd(years_served), 2),
    .groups = "drop"
  )

print(detailed_stats)
```

## When we run the code

```
congress_summary <- congressional_leaders %>%
  group_by(party, chamber) %>%
  summarise(
    n = n(),
    mean_years = mean(years_served, na.rm = TRUE),
    median_years = median(years_served, na.rm = TRUE),
    sd_years = sd(years_served, na.rm = TRUE),
    min_years = min(years_served, na.rm = TRUE),
    max_years = max(years_served, na.rm = TRUE),
    .groups = "drop"
  )
```

```
congress_summary
```

```
# A tibble: 4 x 8
  party      chamber     n mean_years median_years sd_years min_years max_years
  <fct>      <fct>   <dbl>      <dbl>       <dbl>     <dbl>      <dbl>      <dbl>
1 Rep       House     100  10.0        10.0      10.0      10.0      10.0
2 Rep       Senate    100  10.0        10.0      10.0      10.0      10.0
3 Dem       House     100  10.0        10.0      10.0      10.0      10.0
4 Dem       Senate    100  10.0        10.0      10.0      10.0      10.0
```

	<chr>	<chr>	<int>	<dbl>	<dbl>	<dbl>	<dbl>
1	Democratic	House	1	36	36	NA	36
2	Democratic	Senate	1	24	24	NA	24
3	Republican	House	1	16	16	NA	16
4	Republican	Senate	1	38	38	NA	38

## Common Mistakes and Solutions

### Error: Object Not Found

Error: object 'data' not found

**Cause:** Variable name misspelled or not created yet

**Solution:** Check spelling! Make sure you are using the correct case.

### Error: Could Not Find Function

Error: could not find function "read\_csv"

**Cause:** Package not loaded

**Solution:** Run `library(tidyverse)` first

### Error: Wrong Data Type

**The Problem:** When data looks like numbers but is stored as text (character strings), mathematical functions won't work.

```
# This won't work as expected
numbers <- c("1", "2", "3")
mean(numbers) # Error!

# Instead:
numbers <- c(1, 2, 3)
mean(numbers) # Works!
```

## Best Practices

### Variable Naming

Good names:

- electoral\_votes
- swing\_states
- approval\_ratings

Poor names:

- x, data, stuff
- electoralVotes (inconsistent style)

### A full script

```
# Load packages first
library(tidyverse)
```

```
# Load data
UNpop <- read_csv("../data/UNpop.csv")
```

```
Rows: 7 Columns: 2
-- Column specification -----
Delimiter: ","
dbl (2): year, world.pop

i Use `spec()` to retrieve the full column specification for this data.
i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
# Examine data
glimpse(UNpop)
```

```
Rows: 7
Columns: 2
$ year      <dbl> 1950, 1960, 1970, 1980, 1990, 2000, 2010
$ world.pop <dbl> 2525779, 3026003, 3691173, 4449049, 5320817, 6127700, 6916183
```

```
# Analyze  
mean(UNpop$world.pop)
```

```
[1] 4579529
```

## Comments

**Comments** are lines that start with # and are ignored by R. They are useful for:

- Explaining what the code does
- Adding notes to yourself
- Making the code more readable

```
# Calculate population growth rate  
  
growth_summary <- UNpop %>%  
  slice(c(1, 7)) %>%  
  summarise(  
    growth_rate = (last(world.pop) - first(world.pop)) / first(world.pop) * 100  
  )  
  
growth_summary  
  
# A tibble: 1 x 1  
  growth_rate  
  <dbl>  
1        174.
```

## Looking Ahead

### In Our Next Class

#### Working with Real Data

- Loading and exploring real political datasets
- Master essential data manipulation: `filter()`, `select()`, `arrange()`
- Using the pipe operator `%>%` to chain operations
- Handling missing values (NA) properly

## **Key Concepts to Remember**

- R stores information as objects
- Vectors hold multiple related values
- Data frames organize data in rows and columns
- `read_csv()` loads external data files
- AI helps with syntax; you provide the thinking

## **Questions?**

**Key takeaway:** You don't need to memorize R syntax. You need to understand data concepts and how to work with AI to implement your ideas.