

Data Cleaning

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1 Introduction

This document outlines the methodology for data cleaning, exploration, and visualization. It is structured to ensure transparency and reproducibility of all analyses.

1.1 Methodology

Briefly describe the methods used in the project, including data sources, cleaning steps, and techniques applied to handle missing or inconsistent data.

1.2 Loading Data

The first step in any data analysis is to load the data. This section outlines the process of importing the data into R, including any necessary transformations or adjustments to ensure compatibility with the analysis.

```
# Example of loading data from a CSV file
# raw_data <- read_csv(here("Data", "Raw", "data_file.csv"))
# raw_data <- read_excel(here("Data", "Raw", "data_file.xlsx"))
```

1.3 Cleaning Data

The data cleaning process involves several steps to ensure the data is in a suitable format for analysis. This includes handling missing values, correcting data types, and removing duplicates.

```
# Example of cleaning data
# - Removing duplicates
# - Handling missing values
# - Converting data types and cleaning white space
# - Renaming columns, etc.

# cleaned_data <- raw_data %>%
#   clean_names() %>%
```

```
# mutate(column_name = as_factor(column_name)) %>%
# mutate(date_column = as.Date(date_column, format = "%Y-%m-%d")) %>% # convert to date
# mutate(numeric_column = as.numeric(numeric_column)) %>% # convert to numeric
# mutate(accross(everything(), ~str_squish(.))) %>% # clean whitespace
# drop_na()
```

1.4 Data Exploration

Data exploration is a crucial step in understanding the dataset and identifying patterns or anomalies. This section includes summary statistics, visualizations, and any other relevant analyses to gain insights into the data.

```
# Explore the cleaned data using basic summaries:
# glimpse(cleaned_data)
# summary(cleaned_data)
# str(cleaned_data)
```

1.5 Data Visualization

Data visualization is an essential part of data analysis, allowing for the communication of findings in a clear and effective manner. This section includes various plots and charts to illustrate key insights from the data.

```
# Example of creating a summary table
# summary_table <- cleaned_data %>%
#   group_by(group_var) %>%
#   summarise(mean_value = mean(value_var, na.rm = TRUE)) %>%
#   ungroup() %>%
#   kable() %>%
#   kable_styling(full_width = F, position = "left")

# save_kable(summary_table, file = here(output_path_tables, "summary_table.html"),
#   bootstrap_options = c("striped", "hover", "condensed"),
#   full_width = F, position = "left")

# Example of visualization plot
# ggplot(cleaned_data, aes(x = var1, y = var2)) +
#   geom_point() +
#   theme_minimal()

# Example of saving a plot
# ggsave(filename = here(output_path_images, "plot_name.png"), plot = last_plot(), width = 6, height = 6)
```

2 Literature Cited

Citing the packages and data used in the analysis is important for reproducibility and transparency. The following code generates a bibliography of all loaded packages. Items can be cited directly within the documentation using the syntax **(key?)** where key is the citation key in the first line of the entry, e.g., R Core Team (2024). To put citations in parentheses, use **(key?)** instead.

```
@Manual{R-base,
  title = {R: A Language and Environment for Statistical Computing},
  author = {{R Core Team}},
  organization = {R Foundation for Statistical Computing},
  address = {Vienna, Austria},
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    year = {2024},
    url = {https://www.R-project.org/},
  }

@Manual{R-cowplot,
  title = {cowplot: Streamlined Plot Theme and Plot Annotations for ggplot2},
  author = {Claus O. Wilke},
  year = {2024},
  note = {R package version 1.1.3},
  url = {https://wilkelab.org/cowplot/},
}

@Manual{R-devtools,
  title = {devtools: Tools to Make Developing R Packages Easier},
  author = {Hadley Wickham and Jim Hester and Winston Chang and Jennifer Bryan},
  year = {2022},
  note = {R package version 2.4.5},
  url = {https://devtools.r-lib.org/},
}

@Manual{R-dplyr,
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  year = {2023},
  note = {R package version 1.1.4},
  url = {https://dplyr.tidyverse.org},
}

@Manual{R-forcats,
  title = {forcats: Tools for Working with Categorical Variables (Factors)},
  author = {Hadley Wickham},
  year = {2023},
  note = {R package version 1.0.0},
  url = {https://forcats.tidyverse.org/},
}

@Manual{R-gganimate,
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  url = {https://gganimate.com},
}

@Manual{R-ggmap,
  title = {ggmap: Spatial Visualization with ggplot2},
  author = {David Kahle and Hadley Wickham and Scott Jackson},
  year = {2023},
  note = {R package version 4.0.0},
  url = {https://github.com/dkahle/ggmap},
}

@Manual{R-ggplot2,

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  title = {ggplot2: Create Elegant Data Visualisations Using the Grammar of Graphics},
  author = {Hadley Wickham and Winston Chang and Lionel Henry and Thomas Lin Pedersen and Kokske Takahashi},
  year = {2024},
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  url = {https://ggplot2.tidyverse.org/},
}

@Manual{R-ggrepel,
  title = {ggrepel: Automatically Position Non-Overlapping Text Labels with ggplot2},
  author = {Kamil Slowikowski},
  year = {2024},
  note = {R package version 0.9.6},
  url = {https://ggrepel.slowkow.com/},
}

@Manual{R-ggtext,
  title = {ggtext: Improved Text Rendering Support for ggplot2},
  author = {Claus O. Wilke and Brenton M. Wiernik},
  year = {2022},
  note = {R package version 0.1.2},
  url = {https://wilkelab.org/ggtext/},
}

@Manual{R-glue,
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  author = {Jim Hester and Jennifer Bryan},
  year = {2024},
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  url = {https://glue.tidyverse.org/},
}

@Manual{R-here,
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  author = {Kirill Müller},
  year = {2020},
  note = {R package version 1.0.1},
  url = {https://here.r-lib.org/},
}

@Manual{R-janitor,
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  author = {Sam Firke},
  year = {2024},
  note = {R package version 2.2.1},
  url = {https://github.com/sfirke/janitor},
}

@Manual{R-kableExtra,
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  year = {2024},
  note = {R package version 1.4.0},
}

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    url = {http://haozhu233.github.io/kableExtra/},
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@Manual{R-knitcitations,
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  year = {2021},
  note = {R package version 1.0.12},
  url = {https://github.com/cboettig/knitcitations},
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@Manual{R-knitr,
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  author = {Yihui Xie},
  year = {2025},
  note = {R package version 1.50},
  url = {https://yihui.org/knitr/},
}

@Manual{R-lubridate,
  title = {lubridate: Make Dealing with Dates a Little Easier},
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  year = {2024},
  note = {R package version 1.9.4},
  url = {https://lubridate.tidyverse.org},
}

@Manual{R-pacman,
  title = {pacman: Package Management Tool},
  author = {Tyler Rinker and Dason Kurkiewicz},
  year = {2019},
  note = {R package version 0.5.1},
  url = {https://github.com/trinker/pacman},
}

@Manual{R-patchwork,
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  author = {Thomas Lin Pedersen},
  year = {2024},
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  url = {https://patchwork.data-imaginist.com},
}

@Manual{R-plotly,
  title = {plotly: Create Interactive Web Graphics via plotly.js},
  author = {Carson Sievert and Chris Parmer and Toby Hocking and Scott Chamberlain and Karthik Ram and I
  year = {2024},
  note = {R package version 4.10.4},
  url = {https://plotly-r.com},
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@Manual{R-purrr,
  title = {purrr: Functional Programming Tools},

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  author = {Hadley Wickham and Lionel Henry},
  year = {2025},
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  url = {https://purrr.tidyverse.org/},
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@Manual{R-raster,
  title = {raster: Geographic Data Analysis and Modeling},
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  year = {2025},
  note = {R package version 3.6-32},
  url = {https://rspatial.org/raster},
}

@Manual{R-readr,
  title = {readr: Read Rectangular Text Data},
  author = {Hadley Wickham and Jim Hester and Jennifer Bryan},
  year = {2024},
  note = {R package version 2.1.5},
  url = {https://readr.tidyverse.org},
}

@Manual{R-readxl,
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  year = {2025},
  note = {R package version 1.4.5},
  url = {https://readxl.tidyverse.org},
}

@Manual{R-remotes,
  title = {remotes: R Package Installation from Remote Repositories, Including
GitHub},
  author = {Gábor Csárdi and Jim Hester and Hadley Wickham and Winston Chang and Martin Morgan and Dan },
  year = {2024},
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  url = {https://remotes.r-lib.org},
}

@Manual{R-rmarkdown,
  title = {rmarkdown: Dynamic Documents for R},
  author = {JJ Allaire and Yihui Xie and Christophe Dervieux and Jonathan McPherson and Javier Luraschi},
  year = {2024},
  note = {R package version 2.29},
  url = {https://github.com/rstudio/rmarkdown},
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@Manual{R-scales,
  title = {scales: Scale Functions for Visualization},
  author = {Hadley Wickham and Thomas Lin Pedersen and Dana Seidel},
  year = {2023},
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  url = {https://scales.r-lib.org},
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  url = {https://github.com/r-lib/sessioninfo#readme},
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@Manual{R-sf,
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  author = {Edzer Pebesma},
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  note = {R package version 1.0-20},
  url = {https://r-spatial.github.io/sf/},
}

@Manual{R-sp,
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  year = {2025},
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  url = {https://github.com/edzer/sp/},
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@Manual{R-stringr,
  title = {stringr: Simple, Consistent Wrappers for Common String Operations},
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  year = {2023},
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  url = {https://stringr.tidyverse.org},
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@Manual{R-tibble,
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  year = {2023},
  note = {R package version 3.2.1},
  url = {https://tibble.tidyverse.org/},
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@Manual{R-tidyr,
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  url = {https://tidyr.tidyverse.org},
}

@Manual{R-tidyverse,
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  author = {Hadley Wickham},

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url = {https://tidyverse.tidyverse.org},
}

@Manual{R-tigris,
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  year = {2024},
  note = {R package version 2.1},
  url = {https://github.com/walkerke/tigris},
}

@Manual{R-usethis,
  title = {usethis: Automate Package and Project Setup},
  author = {Hadley Wickham and Jennifer Bryan and Malcolm Barrett and Andy Teucher},
  year = {2024},
  note = {R package version 3.1.0},
  url = {https://usethis.r-lib.org},
}

@Article{ggmap2013,
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  title = {ggmap: Spatial Visualization with ggplot2},
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  year = {2013},
  volume = {5},
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  url = {https://journal.r-project.org/archive/2013-1/kahle-wickham.pdf},
}

@Book{ggplot22016,
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  title = {ggplot2: Elegant Graphics for Data Analysis},
  publisher = {Springer-Verlag New York},
  year = {2016},
  isbn = {978-3-319-24277-4},
  url = {https://ggplot2.tidyverse.org},
}

@Book{knitr2015,
  title = {Dynamic Documents with {R} and knitr},
  author = {Yihui Xie},
  publisher = {Chapman and Hall/CRC},
  address = {Boca Raton, Florida},
  year = {2015},
  edition = {2nd},
  note = {ISBN 978-1498716963},
  url = {https://yihui.org/knitr/},
}

@InCollection{knitr2014,

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booktitle = {Implementing Reproducible Computational Research},
editor = {Victoria Stodden and Friedrich Leisch and Roger D. Peng},
title = {knitr: A Comprehensive Tool for Reproducible Research in {R}},
author = {Yihui Xie},
publisher = {Chapman and Hall/CRC},
year = {2014},
note = {ISBN 978-1466561595},
}

@Article{lubridate2011,
  title = {Dates and Times Made Easy with {lubridate}},
  author = {Garrett Golemund and Hadley Wickham},
  journal = {Journal of Statistical Software},
  year = {2011},
  volume = {40},
  number = {3},
  pages = {1--25},
  url = {https://www.jstatsoft.org/v40/i03/},
}

@Manual{pacman2018,
  title = {{pacman}: {P}ackage Management for {R}},
  author = {Tyler W. Rinker and Dason Kurkiewicz},
  address = {Buffalo, New York},
  note = {version 0.5.0},
  year = {2018},
  url = {http://github.com/trinker/pacman},
}

@Book{plotly2020,
  author = {Carson Sievert},
  title = {Interactive Web-Based Data Visualization with R, plotly, and shiny},
  publisher = {Chapman and Hall/CRC},
  year = {2020},
  isbn = {9781138331457},
  url = {https://plotly-r.com},
}

@Book{rmarkdown2018,
  title = {R Markdown: The Definitive Guide},
  author = {Yihui Xie and J.J. Allaire and Garrett Golemund},
  publisher = {Chapman and Hall/CRC},
  address = {Boca Raton, Florida},
  year = {2018},
  isbn = {9781138359338},
  url = {https://bookdown.org/yihui/rmarkdown},
}

@Book{rmarkdown2020,
  title = {R Markdown Cookbook},
  author = {Yihui Xie and Christophe Dervieux and Emily Riederer},
  publisher = {Chapman and Hall/CRC},
  address = {Boca Raton, Florida},

```

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    year = {2020},
    isbn = {9780367563837},
    url = {https://bookdown.org/yihui/rmarkdown-cookbook},
  }

@Book{sf2023,
  author = {Edzer Pebesma and Roger Bivand},
  title = {{Spatial Data Science: With applications in R}},
  year = {2023},
  publisher = {{Chapman and Hall/CRC}},
  url = {https://r-spatial.org/book/},
  doi = {10.1201/9780429459016},
}

@Article{sf2018,
  author = {Edzer Pebesma},
  title = {{Simple Features for R: Standardized Support for Spatial Vector Data}},
  year = {2018},
  journal = {{The R Journal}},
  doi = {10.32614/RJ-2018-009},
  url = {https://doi.org/10.32614/RJ-2018-009},
  pages = {439--446},
  volume = {10},
  number = {1},
}

@Article{sp2005,
  author = {Edzer J. Pebesma and Roger Bivand},
  title = {Classes and methods for spatial data in {R}},
  journal = {R News},
  year = {2005},
  volume = {5},
  number = {2},
  pages = {9--13},
  month = {November},
  url = {https://CRAN.R-project.org/doc/Rnews/},
}

@Book{sp2013,
  author = {Roger S. Bivand and Edzer Pebesma and Virgilio Gomez-Rubio},
  title = {Applied spatial data analysis with {R}, Second edition},
  year = {2013},
  publisher = {Springer, NY},
  url = {https://asdar-book.org/},
}

@Article{tidyverse2019,
  title = {Welcome to the {tidyverse}},
  author = {Hadley Wickham and Mara Averick and Jennifer Bryan and Winston Chang and Lucy D'Agostino Mc
  year = {2019},
  journal = {Journal of Open Source Software},
  volume = {4},
  number = {43},

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pages = {1686},
doi = {10.21105/joss.01686},
}
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2.0.1 Data Sources

- Data source 1: [Name of Dataset or Study], [DOI/Link]
- Data source 2: [Name of Dataset or Study], [DOI/Link] # A tibble: 1 x 11 version os system ui language collate ctype tz date pandoc quarto 1 R version~ macO~ aarch~ X11 (EN) en_US~ en_U~ Amer~ 2025~ 3.2 @~ 1.5.5~ nocite: ‘

Allaire, JJ, Yihui Xie, Christophe Dervieux, Jonathan McPherson, Javier Luraschi, Kevin Ushey, Aron Atkins, et al. 2024. *Rmarkdown: Dynamic Documents for r*. <https://github.com/rstudio/rmarkdown>.

Bivand, Roger S., Edzer Pebesma, and Virgilio Gomez-Rubio. 2013. *Applied Spatial Data Analysis with R, Second Edition*. Springer, NY. <https://asdar-book.org/>.

Boettiger, Carl. 2021. *Knitcitations: Citations for Knitr Markdown Files*. <https://github.com/cboettig/knitcitations>.

Csárdi, Gábor, Jim Hester, Hadley Wickham, Winston Chang, Martin Morgan, and Dan Tenenbaum. 2024. *Remotes: R Package Installation from Remote Repositories, Including GitHub*. <https://remotes.r-lib.org>.

Firke, Sam. 2024. *Janitor: Simple Tools for Examining and Cleaning Dirty Data*. <https://github.com/sfirke/janitor>.

Grolemund, Garrett, and Hadley Wickham. 2011. “Dates and Times Made Easy with lubridate.” *Journal of Statistical Software* 40 (3): 1–25. <https://www.jstatsoft.org/v40/i03/>.

Hester, Jim, and Jennifer Bryan. 2024. *Glue: Interpreted String Literals*. <https://glue.tidyverse.org/>.

Hijmans, Robert J. 2025. *Raster: Geographic Data Analysis and Modeling*. <https://rspatial.org/raster>.

Kahle, David, and Hadley Wickham. 2013. “Ggmap: Spatial Visualization with Ggplot2.” *The R Journal* 5 (1): 144–61. <https://journal.r-project.org/archive/2013-1/kahle-wickham.pdf>.

Kahle, David, Hadley Wickham, and Scott Jackson. 2023. *Ggmap: Spatial Visualization with Ggplot2*. <https://github.com/dkahle/ggmap>.

Müller, Kirill. 2020. *Here: A Simpler Way to Find Your Files*. <https://here.r-lib.org/>.

Müller, Kirill, and Hadley Wickham. 2023. *Tibble: Simple Data Frames*. <https://tibble.tidyverse.org/>.

Pebesma, Edzer. 2018. “Simple Features for R: Standardized Support for Spatial Vector Data.” *The R Journal* 10 (1): 439–46. <https://doi.org/10.32614/RJ-2018-009>.

———. 2025. *Sf: Simple Features for r*. <https://r-spatial.github.io/sf/>.

Pebesma, Edzer J., and Roger Bivand. 2005. “Classes and Methods for Spatial Data in R.” *R News* 5 (2): 9–13. <https://CRAN.R-project.org/doc/Rnews/>.

Pebesma, Edzer, and Roger Bivand. 2023. *Spatial Data Science: With applications in R*. Chapman and Hall/CRC. <https://doi.org/10.1201/9780429459016>.

———. 2025. *Sp: Classes and Methods for Spatial Data*. <https://github.com/edzer/sp/>.

Pedersen, Thomas Lin. 2024. *Patchwork: The Composer of Plots*. <https://patchwork.data-imaginist.com>.

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R Core Team. 2024. *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing. <https://www.R-project.org/>.

Rinker, Tyler W., and Dason Kurkiewicz. 2018. *pacman: Package Management for R*. Buffalo, New York. <http://github.com/trinker/pacman>.

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Sievert, Carson. 2020. *Interactive Web-Based Data Visualization with r, Plotly, and Shiny*. Chapman; Hall/CRC. <https://plotly-r.com>.

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Slowikowski, Kamil. 2024. *Ggrepel: Automatically Position Non-Overlapping Text Labels with Ggplot2*. <https://ggrepel.slowkow.com/>.

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- . 2023a. *Forcats: Tools for Working with Categorical Variables (Factors)*. <https://forcats.tidyverse.org/>.
- . 2023b. *Stringr: Simple, Consistent Wrappers for Common String Operations*. <https://stringr.tidyverse.org>.
- . 2023c. *Tidyverse: Easily Install and Load the Tidyverse*. <https://tidyverse.tidyverse.org>.
- Wickham, Hadley, Mara Averick, Jennifer Bryan, Winston Chang, Lucy D’Agostino McGowan, Romain François, Garrett Golemund, et al. 2019. “Welcome to the tidyverse.” *Journal of Open Source Software* 4 (43): 1686. <https://doi.org/10.21105/joss.01686>.
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- Wickham, Hadley, Jennifer Bryan, Malcolm Barrett, and Andy Teucher. 2024. *Usethis: Automate Package and Project Setup*. <https://usethis.r-lib.org>.
- Wickham, Hadley, Winston Chang, Robert Flight, Kirill Müller, and Jim Hester. 2025. *Sessioninfo: R Session Information*. <https://github.com/r-lib/sessioninfo#readme>.
- Wickham, Hadley, Winston Chang, Lionel Henry, Thomas Lin Pedersen, Kohske Takahashi, Claus Wilke, Kara Woo, Hiroaki Yutani, Dewey Dunnington, and Teun van den Brand. 2024. *Ggplot2: Create Elegant Data Visualisations Using the Grammar of Graphics*. <https://ggplot2.tidyverse.org>.
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- Wickham, Hadley, Jim Hester, Winston Chang, and Jennifer Bryan. 2022. *Devtools: Tools to Make Developing r Packages Easier*. <https://devtools.r-lib.org/>.
- Wickham, Hadley, Thomas Lin Pedersen, and Dana Seidel. 2023. *Scales: Scale Functions for Visualization*. <https://scales.r-lib.org>.
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