

Expanding R use in applied epidemiology and public health

Neale Batra, President, Applied Epi

R Medicine Conference, 8 June 2023

www.AppliedEpi.org | Applied Epi is a nonprofit organization

Epidemiologists are under-equipped

Most epidemiologists around the world use **sub-standard or expensive analytical tools.**

They want free, advanced statistical software like **R** but **lack relevant training and support.**

Differences in R use within epidemiology

Academic epidemiology

- Objective is to advance knowledge base
- Analyses often involve complex math modeling
- ✓ R widely accepted and resources are available

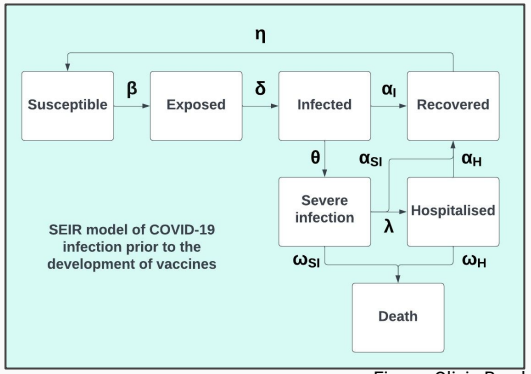


Figure: Olivia Boyd

Applied and “field” epidemiology

- Objective is operational insights for disease control
- Analyses are most often descriptive
- ✗ R adoption low, reproducible workflows less common



Image: Temuulen Enebish





Dr. Chukwuma D. Umeokonkwo
Medical Epidemiologist and Scientific Writer, Field Epidemiology Training Program (FETP), Liberia

Lack of context-specific materials and support

"Many times I go to **online courses** to learn… but because they are not epidemiologists, they **don't understand the variables we work with, the way we think, and the type of outputs we want.**"

"So having an epi who has **experience in the field**, who has **passed through those challenges**, to sit down and write the code with you … it makes learning R simple."



Dr. Chukwuma D. Umeokonkwo
Medical Epidemiologist and Scientific Writer, Field Epidemiology Training Program (FETP), Liberia

The impact of R is “game-changing”

A Haitian epidemiologist used our **Epidemiologist R Handbook** to transition weekly disease surveillance analyses to R.

Before

30 *hours each week* of **tedious**, **manual**, and **error-prone Excel workflows**

After

30 *minutes* of **agile**, **robust**, and **reproducible** analytics

"With R **I can do anything**. What took 10 hours in Excel, I **do in less** than 1 hour… and it is easier to **detect if there is a mistake**"



Photo: US CDC





Dr. Chukwuma D. Umeokonkwo
Medical Epidemiologist and Scientific Writer, Field Epidemiology Training Program (FETP), Liberia

Repetitive tasks & unrecognized errors

"So you have a **prolonged outbreak**, and the data collection process is not under your control - **you have to clean the data over and over** to update your reports…

…it takes away a large amount of **time that could be invested in thinking** or other aspects of the epidemiological investigation."



Dr. Chukwuma D. Umeokonkwo
Medical Epidemiologist and Scientific Writer, Field Epidemiology Training Program (FETP), Liberia

The need for R training is clear

A recent survey of field epidemiologists in low-income countries:

- **91%** felt constrained by their point-and-click analytic tools
- **96%** said R training should be a “high” priority
- Only **12%** said their agency has sufficient R training capacity

“R is the gold standard in infectious disease epidemiology”

- Field epidemiologist in Nigeria

[1]*A 2022 survey of 159 field epidemiologists in 50 countries, conducted by TEPHINET and Applied Epi*

R is not just a new tool, but a new culture

Users trusted with agency to be creators

Decentralised innovation and local problem-solving

More competitively-skilled epis from the global south

R adoption advances equity in global health practice

Applied Epi™

Elevating
Frontline
Epidemiology



A grassroots movement by epidemiologists, for epidemiologists

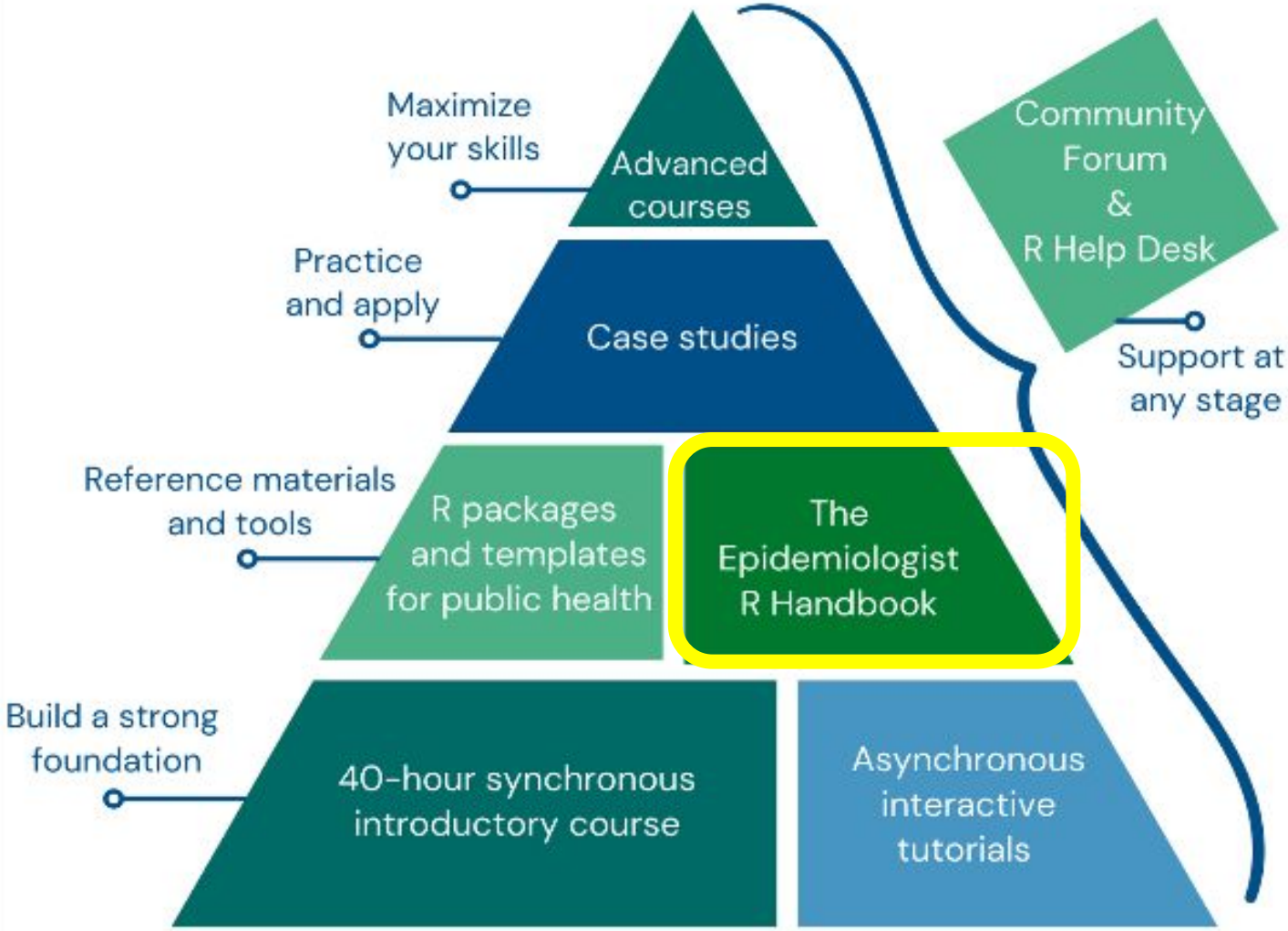
- Global team of 170 members
- Ground-level experience
- Technical expertise
- Local and global partnerships

Applied Epi is a nonprofit organization, 501(c)(3)
www.AppliedEpi.org

Strengthen the foundation

We focus on *frontline epidemiology and public health*

1) **Training** that is relevant to local practice
2) **Tools** for accessible and agile analytics
3) **Support** for sustained capacity-building
4) **Standards** for practical and robust methodologies


Maximize your skills
Advanced courses
Practice and apply
Case studies
Reference materials and tools
R packages and templates for public health
The Epidemiologist R Handbook
Build a strong foundation
40-hour synchronous introductory course
Asynchronous interactive tutorials
Community Forum & R Help Desk
Support at any stage

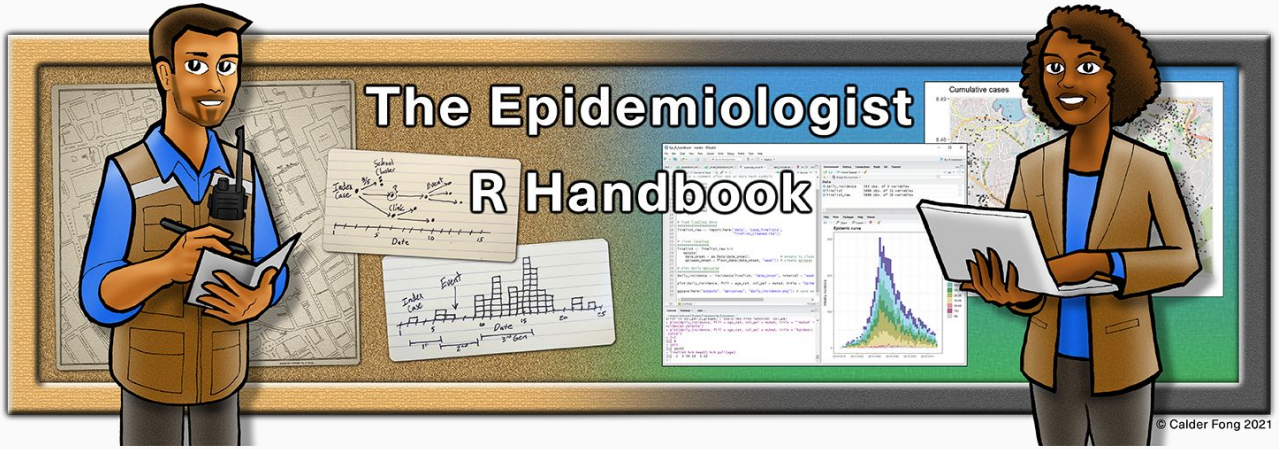
The Epidemiologist R Handbook

www.epiRhandbook.com

"An open-source unicorn"
- Github senior solutions architect

"Boom! Holy smokes!!!
I can't get enough of it!"
- WHO Brazzaville epidemiologist

"An epi's greatest companion."
- Nigeria CDC epidemiologist



- **1.6 million views (18,000 weekly) from 450,000 users**
- **Free R manual, online or offline, 11 languages**
- **50 chapters** of code examples and tutorials
- Written by 120+ contributors in their spare time

The Epidemiologist R Handbook

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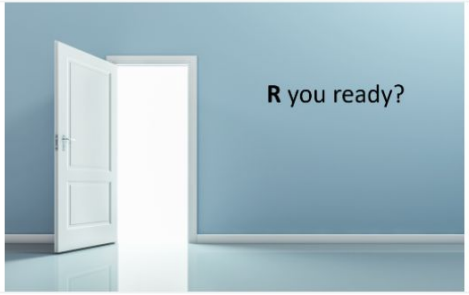
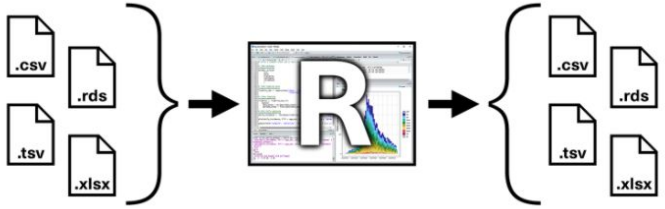
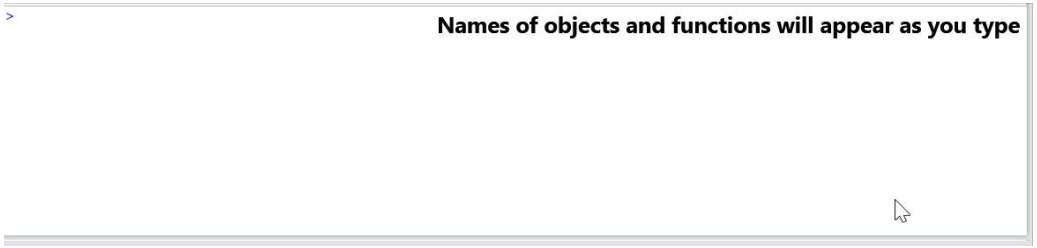
Do not be intimidated - come discover the world of R!

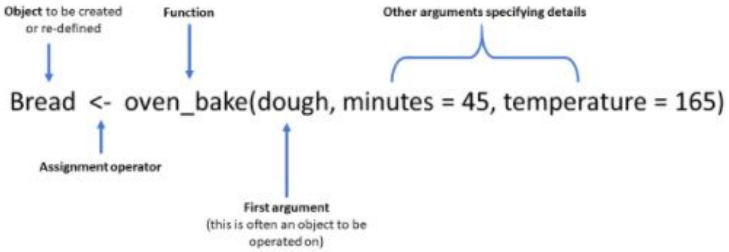


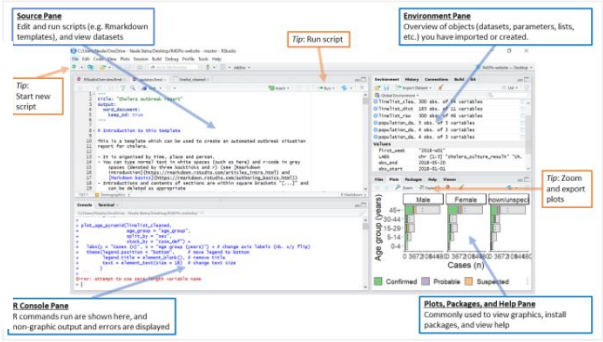
7 Import and export





Names of objects and functions will appear as you type





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16 Iteration, loops, and lists

8 Cleaning data and core functions

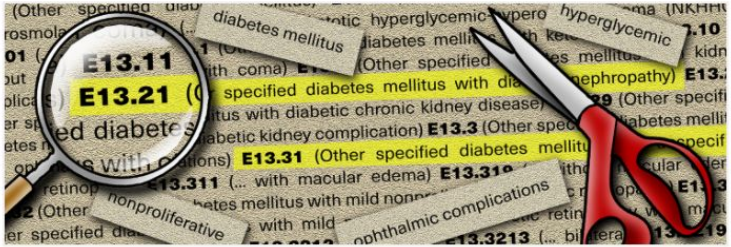
Date of Onset	Sex	Age
1/1/1965	M	24 years
15 March 1994	*NA*	16 months
13 Dec. 1989	Fem	29
25/6/2001	F	3

date_onset	sex	age_years
1965-01-01	Male	24.00
1994-03-15	Missing	1.33
1989-12-13	Female	29.00
2001-06-25	Female	3.00

12 Pivoting data

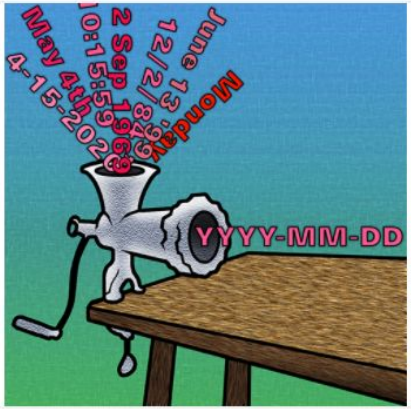


10 Characters and strings



This page demonstrates use of the **stringr** package to evaluate and handle character values ("strings").

9 Working with dates



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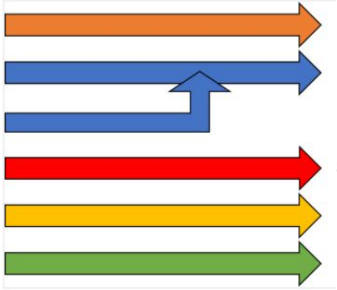
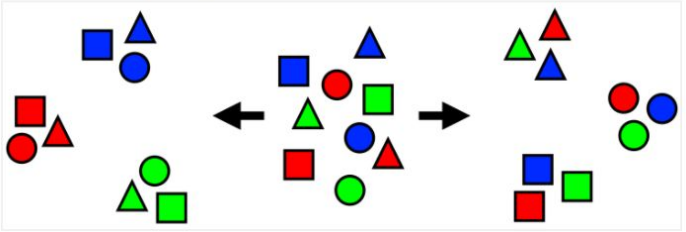


13 Grouping data



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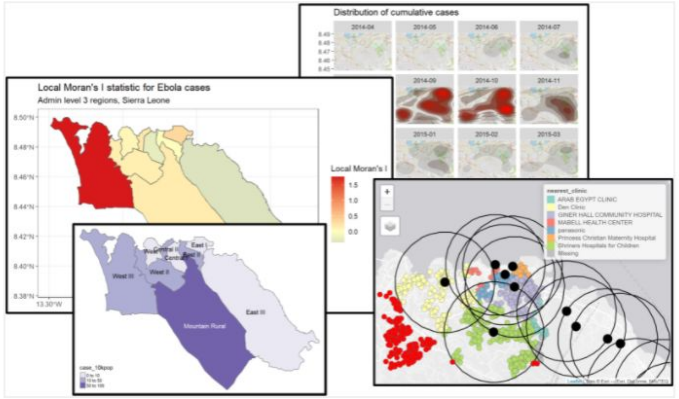
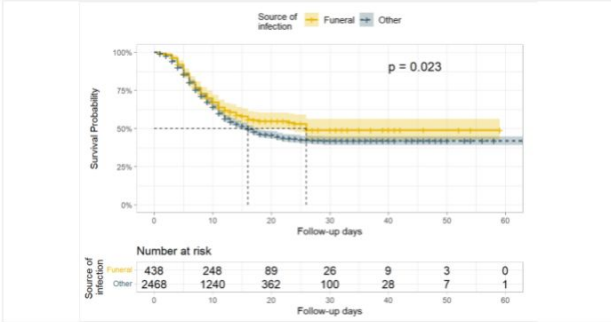
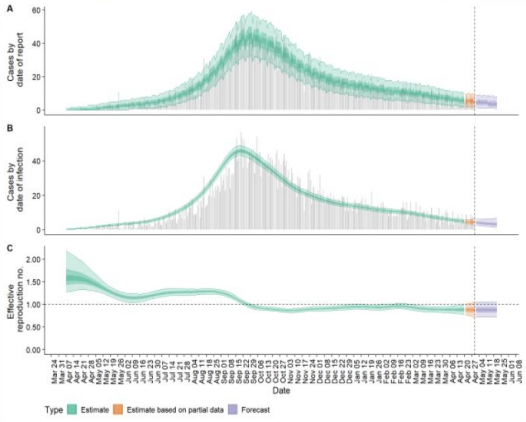
28 GIS basics



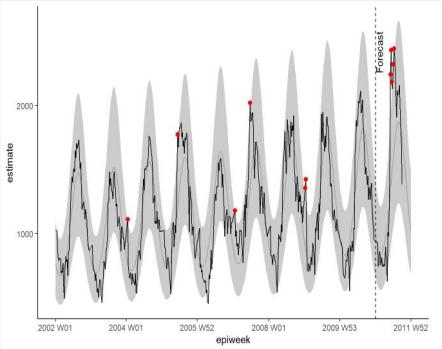
27 Survival analysis



24 Epidemic modeling

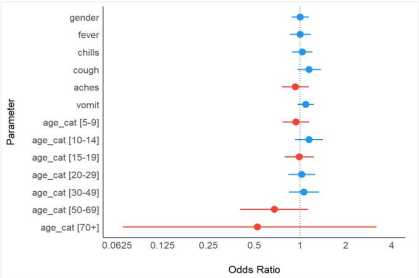


23 Time series and outbreak detection



19 Univariate and multivariable regression

```
## remove the intercept term from your multivariable results
final_mv_reg %>%
  model_parameters(exponentiate = TRUE) %>%
  plot()
```



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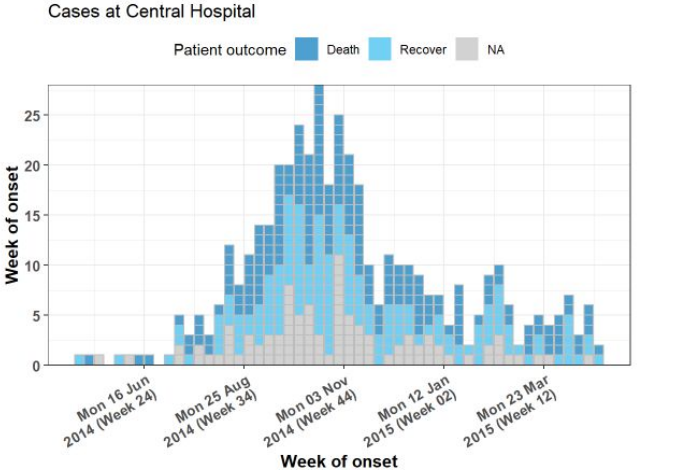
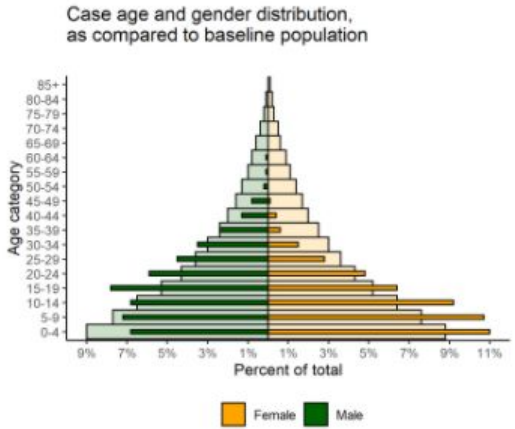
29 Tables for presentation

Hospital	Total cases with known outcome	Recovered			Died		
		Total	% of cases	Median CT values	Total	% of cases	Median CT values
St. Mark's Maternity Hospital (SMMH)	325	126	38.8%	22	199	61.2%	22
Central Hospital	358	165	46.1%	22	193	53.9%	22
Other	685	290	42.3%	21	395	57.7%	22
Military Hospital	708	309	43.6%	22	399	56.4%	21
Missing	1,125	514	45.7%	21	611	54.3%	21
Port Hospital	1,364	579	42.4%	21	785	57.6%	22
Total	**3,440**	**1,469**	**42.7%**	**22**	**1,971**	**57.3%**	**22**







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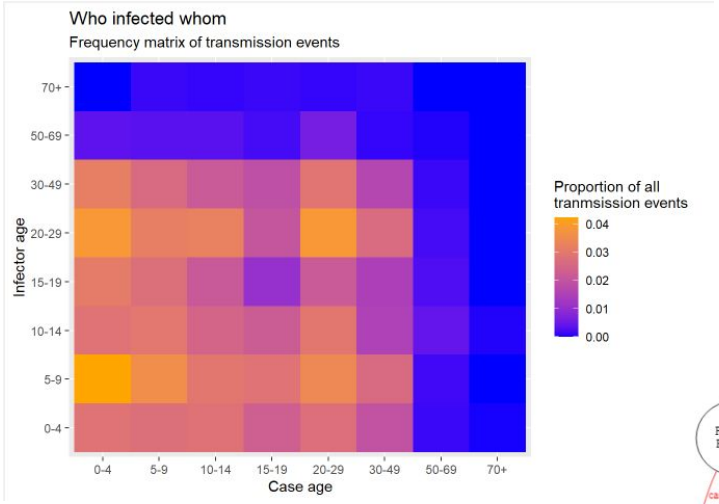

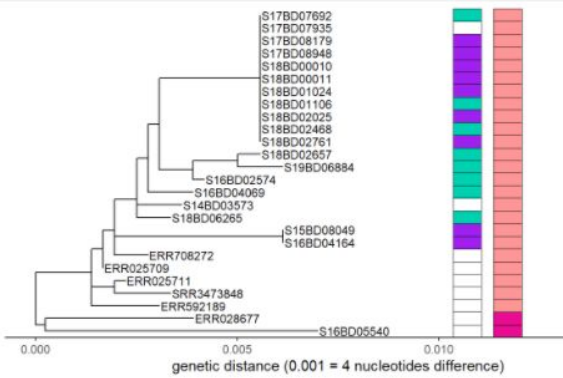

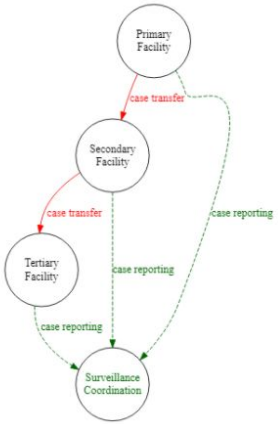

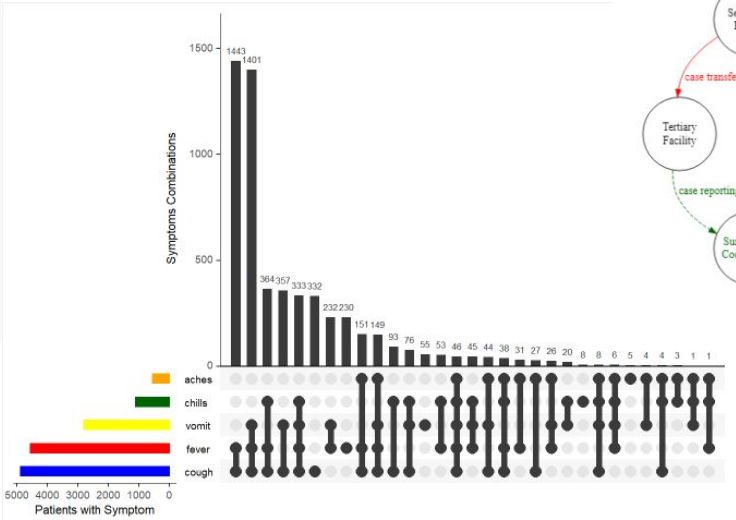

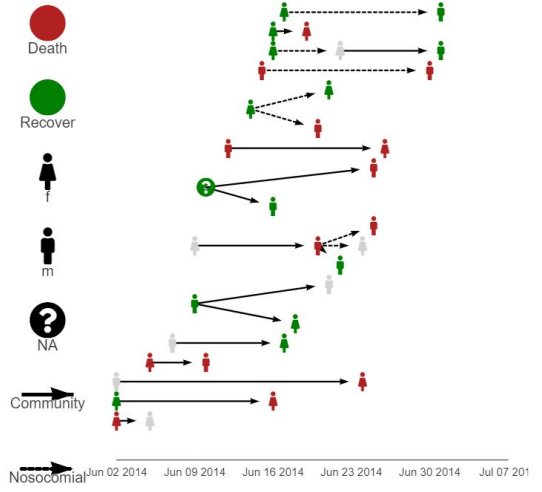

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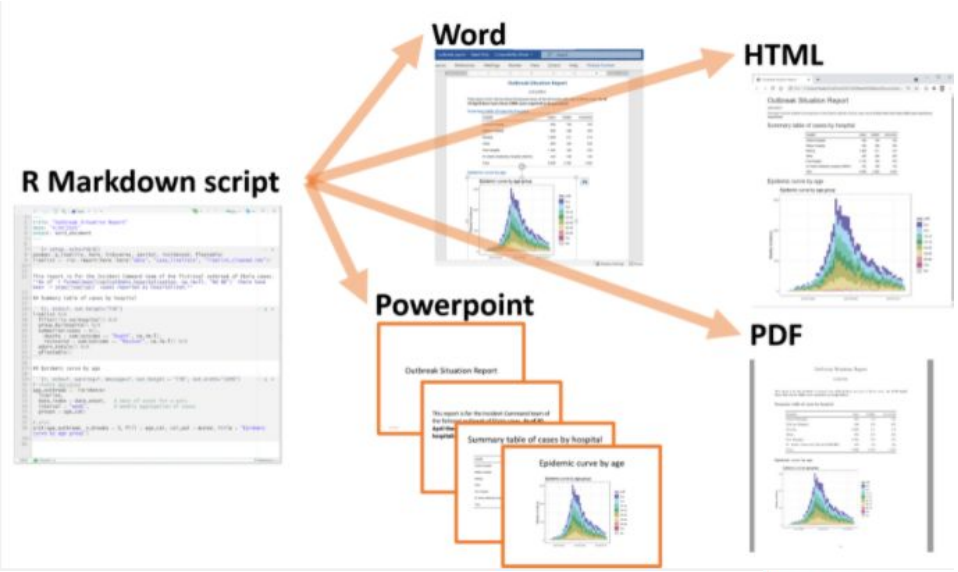

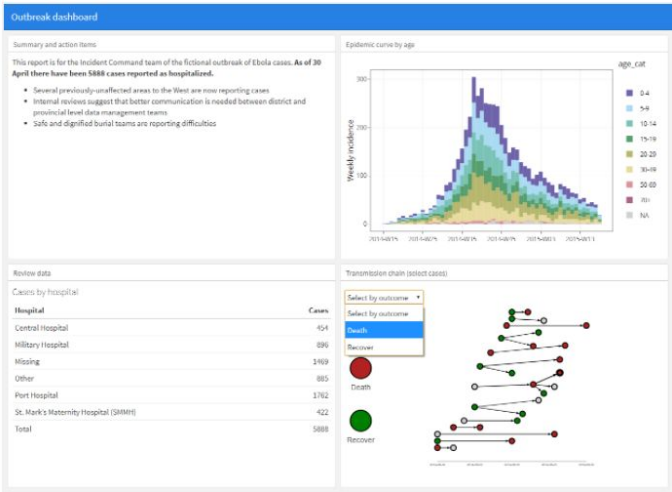



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Field Epidemiologist & Mentor,
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Nigeria

Le Epi R Handbook

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Gestion des données



R pour l'épidémiologie appliquée et la santé publique

Utilisation : Ce manuel a été utilisé **plus d'un million de fois par 400 000 personnes** dans le monde entier.

Objectif: Servir de manuel de référence rapide du code R (en ligne et **hors line**) avec des exemples centrés sur la tâche qui traitent des problèmes épidémiologiques courants.

Essayez nos tutoriels interactifs gratuits ou notre **cours d'introduction** synchrone et virtuel utilisé par

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R pour l'épidémiologie appliquée et la santé publique

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Gestión de datos



R para epidemiología aplicada y salud pública

Utilización: Este manual ha sido utilizado más de **1 millón de veces por 300.000 personas** en todo el mundo.

Objetivo: Servir como breve guía de referencia para escribir código en R (en línea y **versión sin conexión**) con ejemplos detallados que aborden problemas epidemiológicos.

¿Estás empezando con R? Prueba nuestros **tutoriales interactivos gratuitos** o **el curso de**

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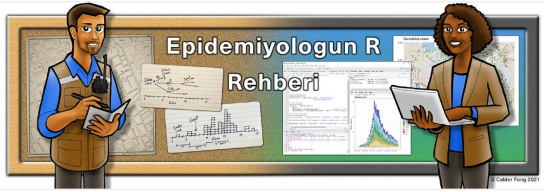

Uygulamalı epidemiyoloji ve halk sağlığı için R

Kullanımı: Bu çevrimiçi kitap, dünya çapında **300.000 kişi tarafından 1 milyondan fazla kez** kullanılmıştır.

Hedef: Yaygın epidemiyolojik sorunlara çözümler üreten, pratik, hedef odaklı ve hızlı bir (çevrimiçi ve **çevrimdışı**) referans kılavuz olarak rol oynamak.

R'a yeni mi başlıyorsun? Ücretsiz **interaktif eğitimlerimiz** ya da senkronize, sanal **kurslarımız** Amerika CDC, Dünya Sağlık Örgütü dahil olmak üzere 75'ten fazla sağlık örgütü ve saha eğitim programlarında

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疫学や公衆衛生に関わる業務のための R

利用実績: 本ハンドブックは、世界中 **30 万人**に **100 万回以上** 利用されています。

目的: 疫学業務や研究で頻繁に直面する課題に対する対処法の実例を扱い、素早く使用できる R のリファレンスマニュアルとしてオンラインでも**オフライン**でも機能する

R を始めたばかりですか？ アメリカ CDC、WHO、その他 75 以上の保健機関および世界中のフィールドエピトレーニングプログラムで使用されている **無料の自己学習型チュートリアル** または、、ライブリモート型の **intro course** を試してください

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コントリビューション

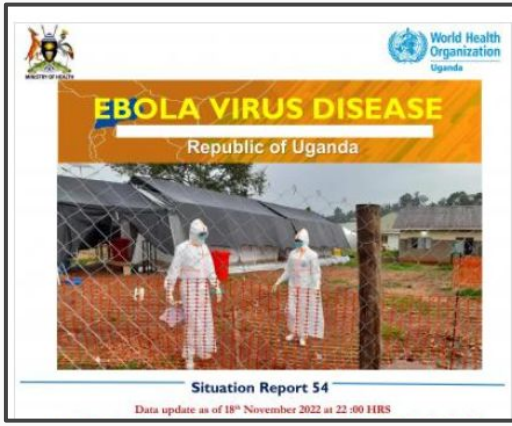
The Epi R Handbook in a recent Ebola response

August 2022 - Uganda Ministry of Health begins review of Epi R Handbook

September 2022 - Uganda declares an **Ebola disease outbreak** caused by the Sudan ebolavirus species.

October 2022 - MoH outbreak analytics conducted with R using Epi R Handbook code examples

November 2022 - Applied Epi enlisted by Uganda MoH and WHO to support the with synchronous R training and R Help Desk

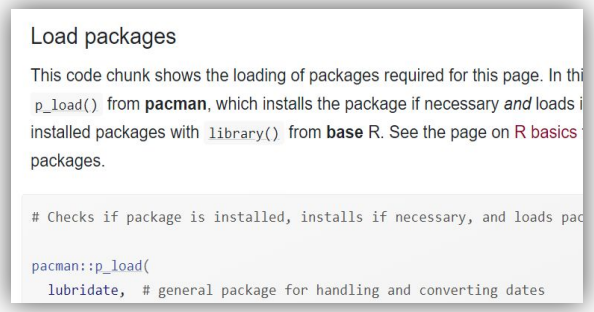


"To have everything in one place - which you can carry with you to the field… now every day I wake up more ready, more happy."

- Daniel Eurien, Uganda Ministry of Health,
Ebola data & analytics lead

Epi R Handbook challenges

- Independence from major institutions
- Editorial decisions:
    - How much to write?
    - Which packages and functions?
    - How many solutions to show?
- {bookdown} with 50 chapters and 40,000 lines
- Maintenance & version control across 11 translations
- Transition to Quarto
- Lack of financial support

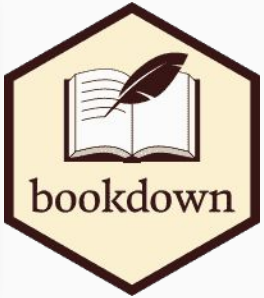


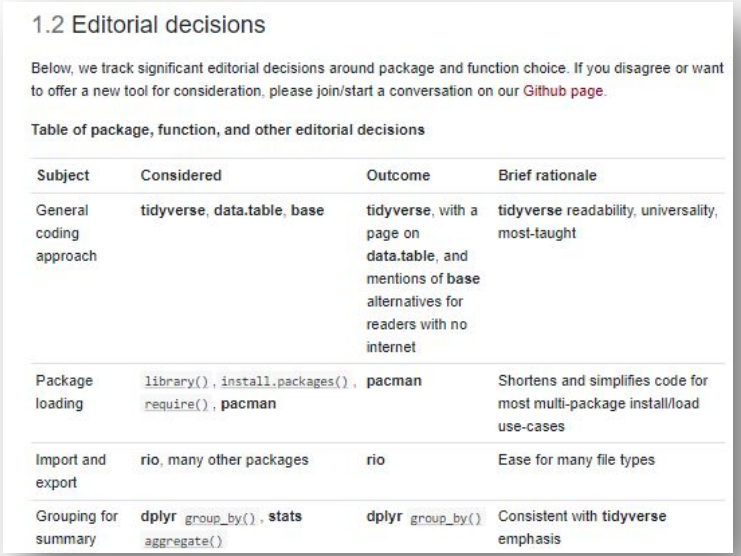
Load packages

This code chunk shows the loading of packages required for this page. In thi
`p_load()` from **pacman**, which installs the package if necessary *and* loads i
installed packages with `library()` from **base** R. See the page on R basics
packages.

```
# Checks if package is installed, installs if necessary, and loads pac

pacman::p_load(
  lubridate,  # general package for handling and converting dates
```



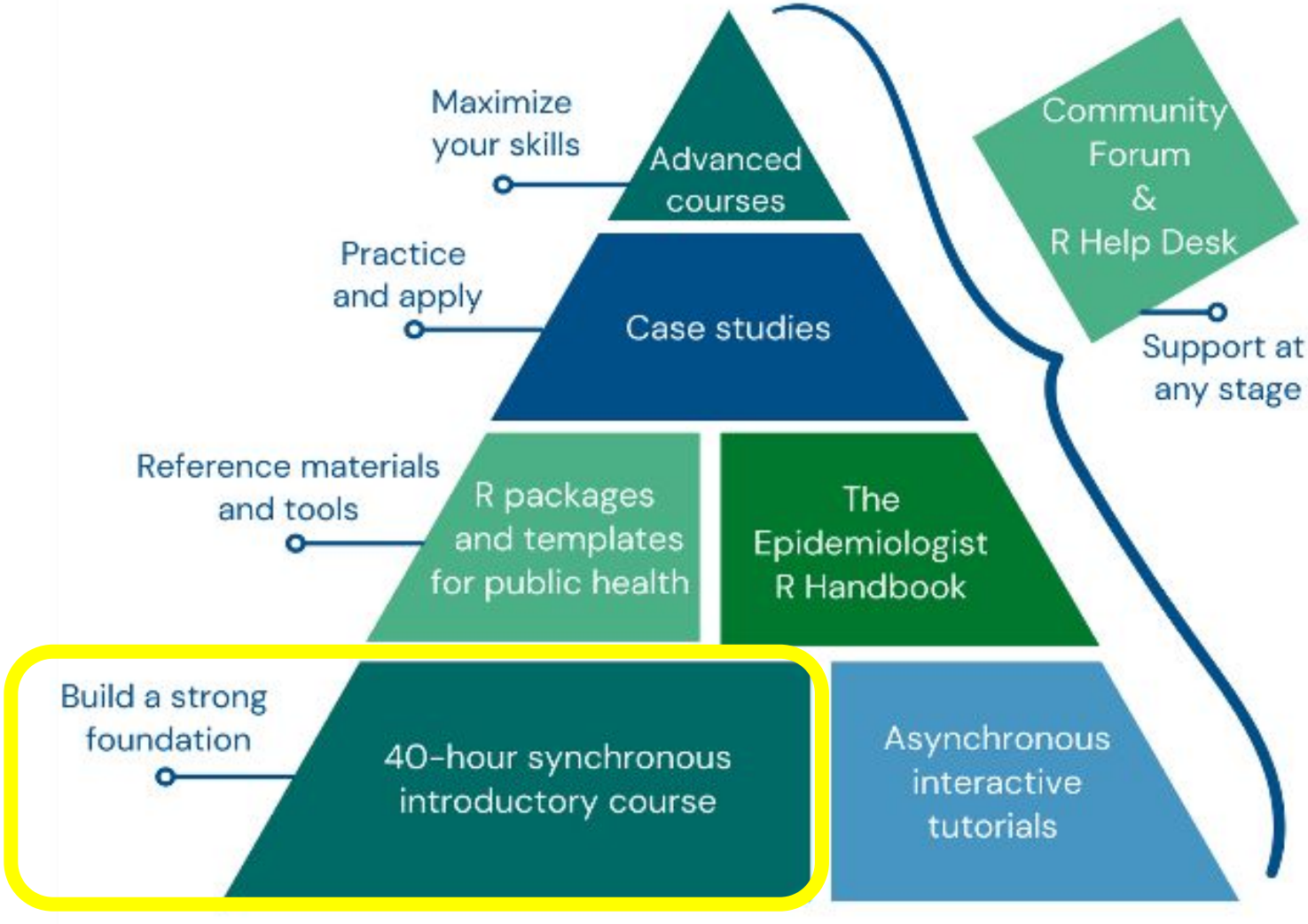


1.2 Editorial decisions

Below, we track significant editorial decisions around package and function choice. If you disagree or want to offer a new tool for consideration, please join/start a conversation on our Github page.

Table of package, function, and other editorial decisions

Subject	Considered	Outcome	Brief rationale
General coding approach	**tidyverse**, **data.table**, **base**	**tidyverse**, with a page on **data.table**, and mentions of **base** alternatives for readers with no internet	**tidyverse** readability, universality, most-taught
Package loading	`library()`, `install.packages()`, `require()`, **pacman**	**pacman**	Shortens and simplifies code for most multi-package install/load use-cases
Import and export	**rio**, many other packages	**rio**	Ease for many file types
Grouping for summary	**dplyr** `group_by()`, **stats** `aggregate()`	**dplyr** `group_by()`	Consistent with **tidyverse** emphasis


Maximize your skills
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The Epidemiologist R Handbook
Build a strong foundation
40-hour synchronous introductory course
Asynchronous interactive tutorials
Community Forum & R Help Desk
Support at any stage

Our educational approach

We are frontline practitioners ourselves

Equip to actually use R on local computer

Synchronous (protected learning time)

1-on-1 coaching

Intentional vocabulary and package selection to reduce mental load

Building confidence to “tinker”

1-on-1 support after finishing the class



Intro to R for applied epidemiology - live course

Comprehensive: 40 hours, synchronous course

Relevant topics: Data cleaning, summary tables, ggplot2, GIS demo, R Markdown reports

Interactive: live demos, 1-on-1 meetings, exercises with {learnr}, {gradethis} quizes, multi screen share

Post-course support: R Help Desk video calls

Multilingual delivery: English, French, Spanish

Curriculum choices:

- When to introduce Rmd?
- How much base?
- Projects, here(), {pacman},
- {janitor}, {gtsummary}, how much GIS?


Photo: Neale Batra

"I've taken several R trainings - **this is the BEST**!"
- US CDC Epidemic Intelligence Service (EIS) Officer

"Superbly **structured**, **focused**, delivered by **experienced epidemiologists** to provide **context** to the code"
- Epi team manager, Public Health Wales (UK)

Intro to R for applied epidemiology: 40-hour live course

700 graduates in 16 months, from 130 agencies

World Health Organization (WHO) offices:
Ukraine, Uganda, Somalia, Belize, & Eastern Mediterranean

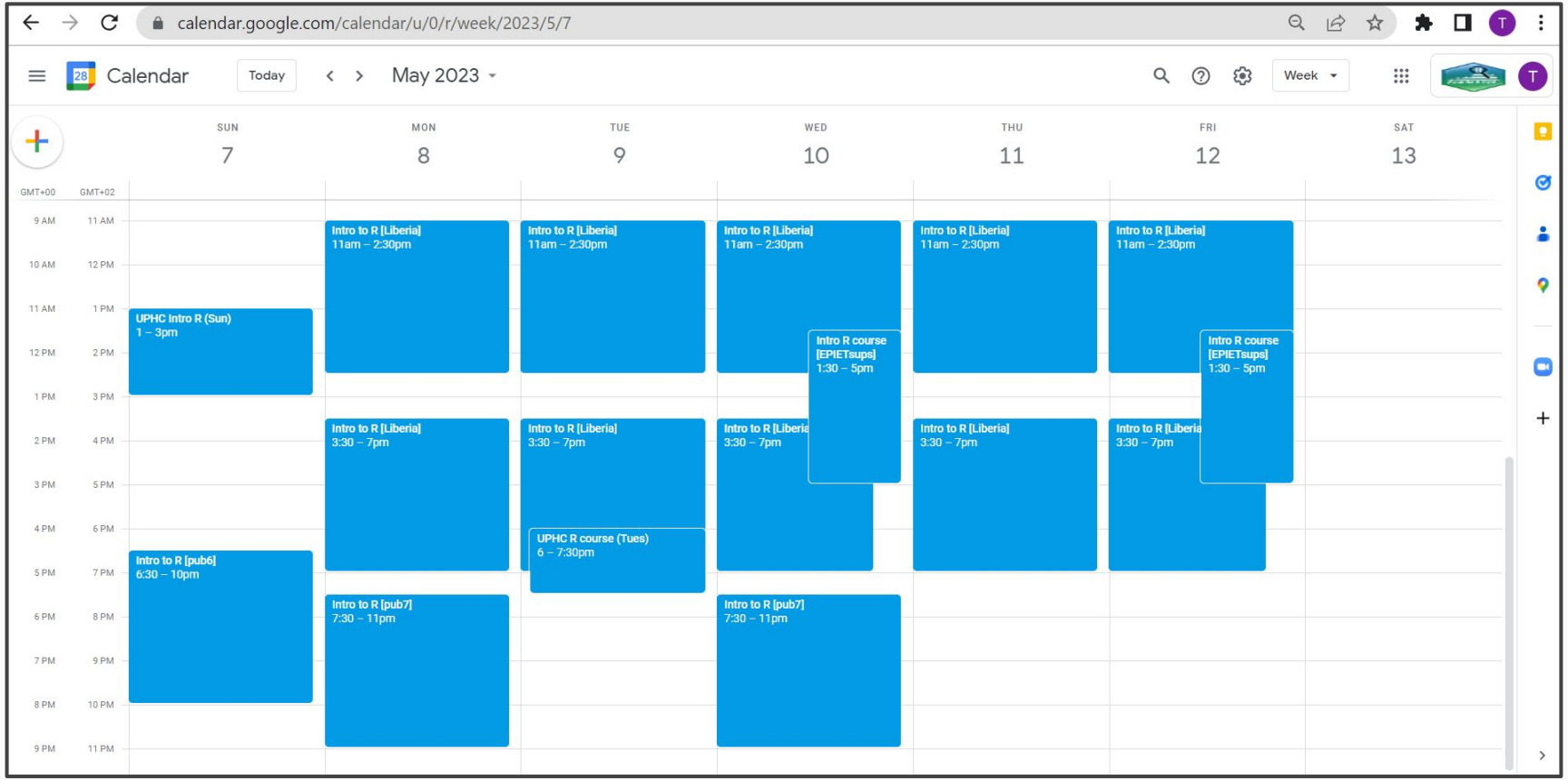
Doctors without Borders (MSF) operational centres:
Amsterdam (OCA), Belgium (OCB), & Barcelona (OCBA)

NGOs and multi-national organisations:
European CDC, Africa CDC, TEPHINET, AFENET, UNICEF, Vital Strategies, Save the Children, Resolve to Save Lives, CDC Foundation

National and local public health agencies and Field Epi Training Programs (FETPs):
United States (CDC), Canada (PHAC), Ukraine, Nigeria, DR Congo, Uganda, Libya, Togo, Rwanda, Tanzania, South Africa, Liberia, Gambia, Namibia, Cambodia, Malaysia, Philippines, Taiwan, Australia, New Zealand, Lebanon, Saudi Arabia, Peru, Belize, Guatemala, Mexico, Kazakhstan, Tajikistan, Georgia, Kyrgyzstan, Uzbekistan, Pakistan, Moldova, Finland, Serbia, Kosovo, Albania, Norway, Sweden, Netherlands, Malta, Wales, Scotland, Ireland, Norway, Romania, Denmark (Statens Serum Institut), France, Belgium (Sciensano), Netherlands (RIVM), Germany (Robert Koch Institute)

Within North America:
California DPH, New York DOH, Colorado DPHE, Arizona DOH, Oregon Health Authority, Kansas DHE, Kentucky DPH, Maryland DOH, US Virgin Islands DOH, Virginia DOH, Tennessee DOH, Massachusetts DPH, New Jersey DOH, Wisconsin DHS, Sonoma County (CA), Santa Cruz County (CA), Riverside County (CA), San Mateo County (CA), Solano County (CA), Long Beach (CA), Tarrant County (TX), Maricopa County (AZ), Southern Nevada Health District (NV), East Shore District (MD), El Dorado County (CO), Madison & Dane County (WI), Genesee County (MI), Grand Traverse County (MI), Ottawa County (MI), Ingham County (MI), Barry-Eaton District (MI), Jackson County (MI), Gratiot County (MI), Johnson County (KS), Salt Lake County (UT), DC DOH, Navajo Area Indian Health Service, Southern Plains Tribal Epi Center (SPTHB), Island Health (Vancouver Island), Indigenous Services Canada, Public Health Services of Mexico City (Mexico)

Around-the-clock courses



50+ instructors who are seasoned epidemiologists



Deepak Varughese
Epi & primary care
Rural and tribal India

"Knowing that I played a small part in helping people from Uganda to Ukraine to the United States to unlock some of the power of R is a gratifying experience."



Paula Blomquist
Principal Epid.
UK Health Security Agency

"I enjoy the moment when something clicks, and they realise they've just figured out how to save hours and hours of their lives!"



Leonel Lerebours Nadal
Field Epidemiologist, Dominican Republic

"The mix of training+ field epi+ all the time zones … is an actual movement to make data analysis for taking action true"



Mumbua Mutunga
Epid. & statistician
Kenya

"It's always the fulfilment that I get when I know that I have helped someone believe in the versatility of R."



Putting in the effort - local computer install issues

- 400+ video calls (1-on-1) to troubleshoot computer setup
  - Resolve VPN issues
  - OneDrive and syncing issues
  - Resolve R package installation and version issues
  - Very old computers
  - Offline backup options
  - …



```
Error: package or namespace load failed for ‘tidyverse’:
 .onAttach failed in attachNamespace() for 'tidyverse', details:
  call: NULL
  error: package or namespace load failed for ‘ggplot2’ in loadNamespace(i, c(lib.loc, .libPaths()), v
ersionCheck = vI[[i]]):
 there is no package called ‘rlang’
In addition: Warning messages:
1: package ‘tidyverse’ was built under R version 4.2.3
2: package ‘ggplot2’ was built under R version 4.2.3
```

With simultaneous translation into Khmer

Instructors located around the world



Statisticians and epidemiologists in Cambodia

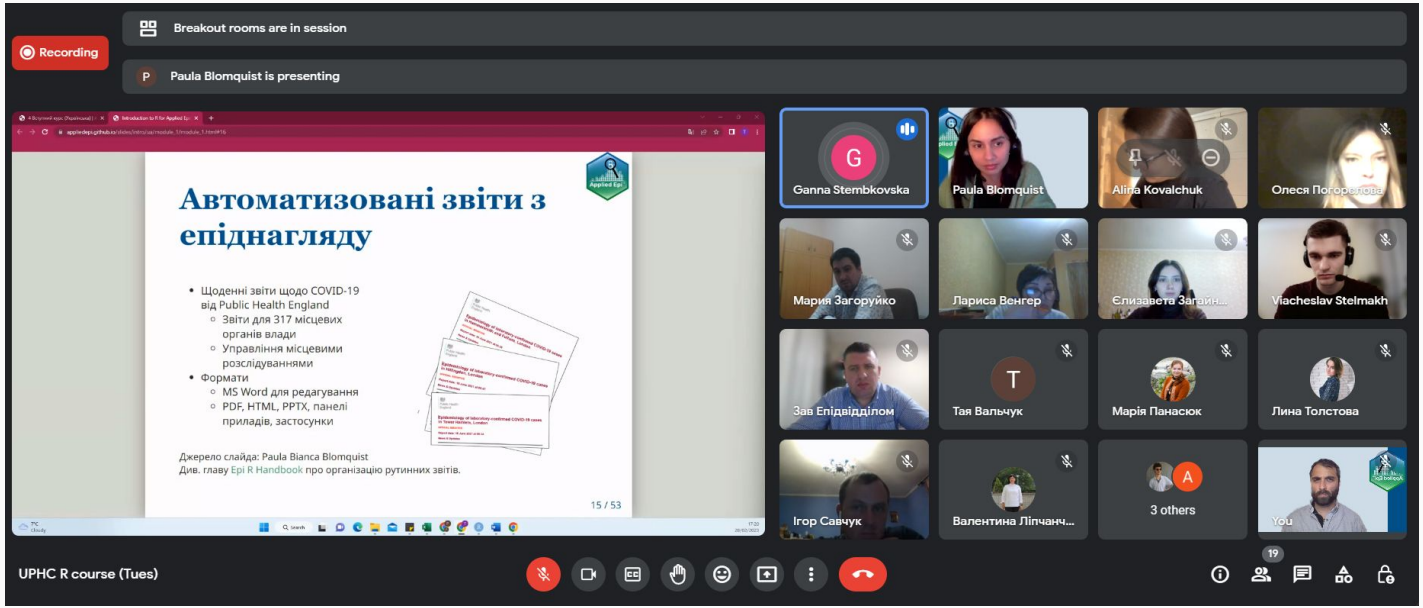


With consecutive translation into Ukrainian

14 local epidemiologists across Ukraine

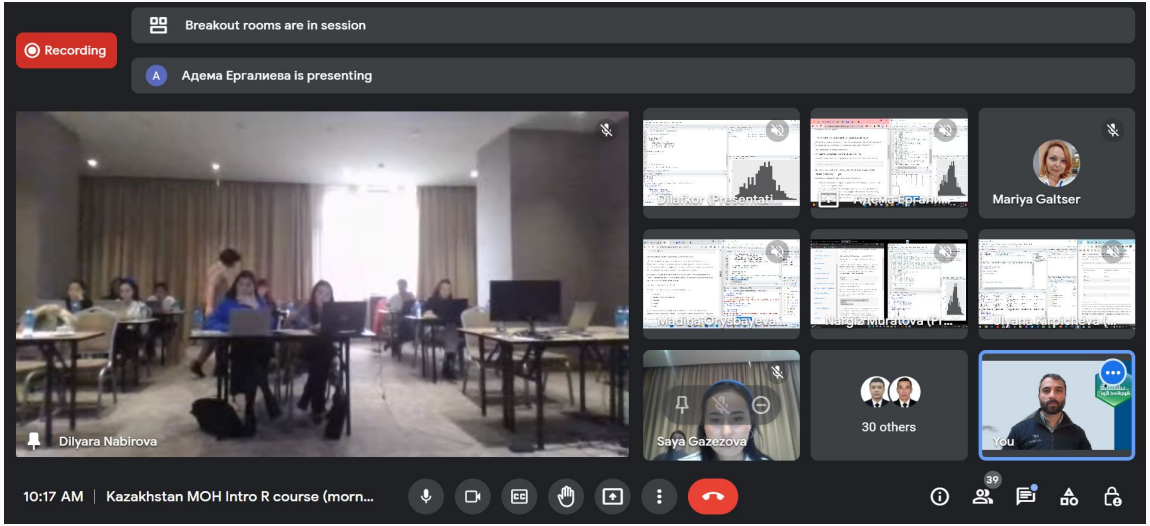
“It is a pity that I did not learn R before, because I see how my previous work would be performed more efficiently!”

- Denis, Epidemiologist, Ukraine



With consecutive translation into Russian

- 24 field epidemiologists across central Asia: Kazakhstan, Tajikistan, Kyrgyzstan, Uzbekistan
- 6 months later, 21/24 participants are using R routinely



"All our participants are so impressed with your course; the MoH guys said it is the best class they ever had."

- Dilyara, course coordinator, Central Asia Field Epi Training Program (FETP)

Improvement

Observed: Improvement in self-assessed proficiency

Future: Objective assessment of R code skill

Future: Assess factors impacting long-term adoption, including:

- Use of R Help Desk
- Transition of entire teams
- Session schedule/pace
- Asych vs. synch delivery

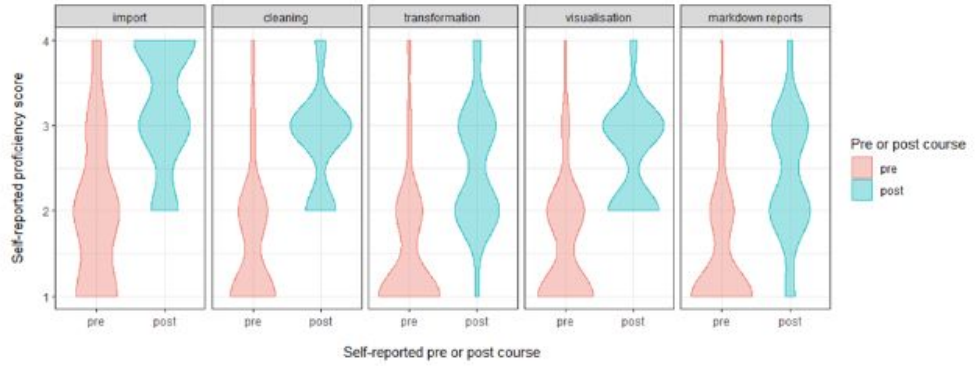
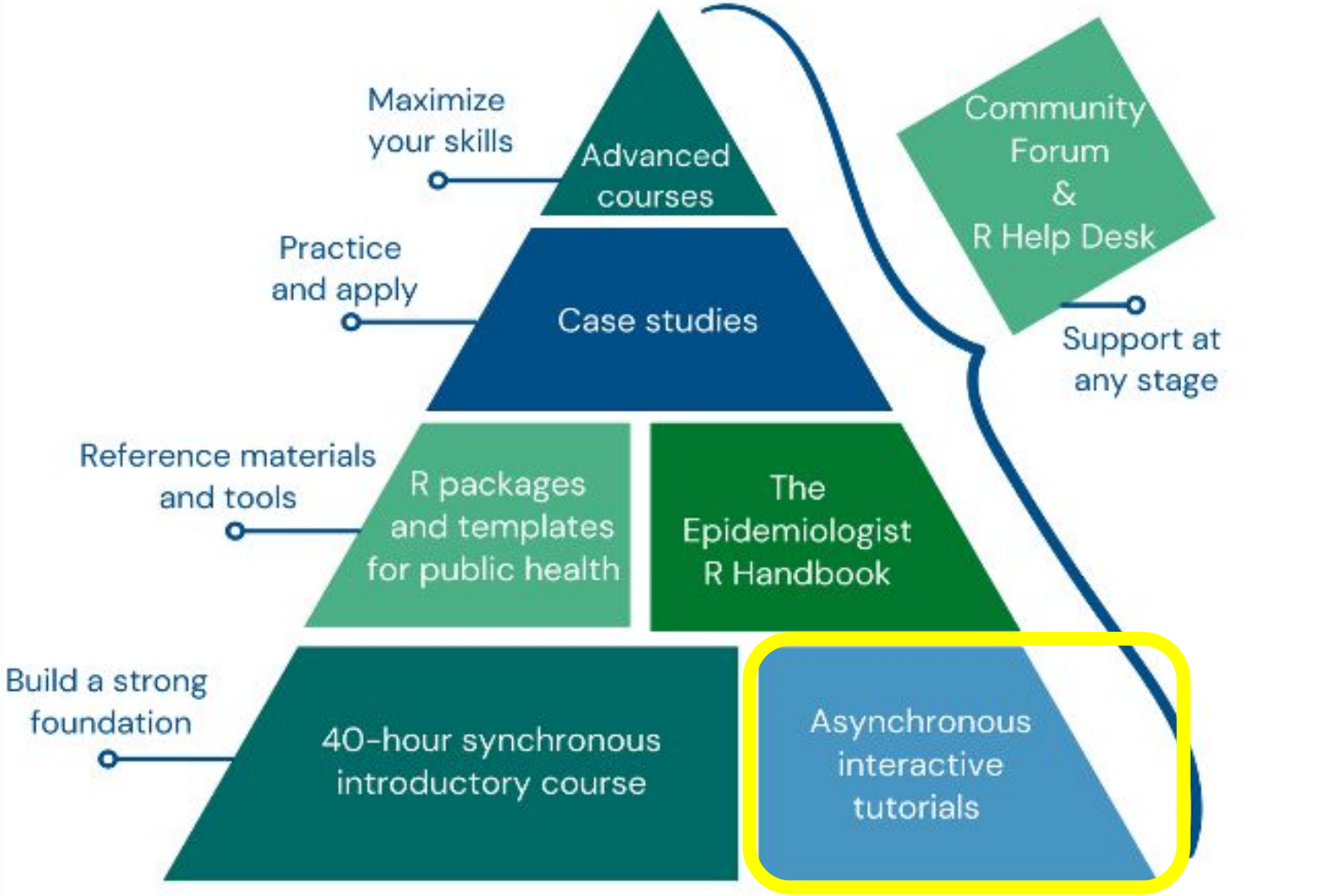


Figure 1. Reported R proficiency distributions (pre and post course comparison). Participants rated their proficiency in R across areas of data manipulation pre and post course on a scale of 1-4, with 1 being no proficiency and 4 being fully proficient. Results show violin plots for N = 340 participants. In all cases, the Kruskal-Wallis test found a significant difference between distributions pre and post course ($p < 0.05$).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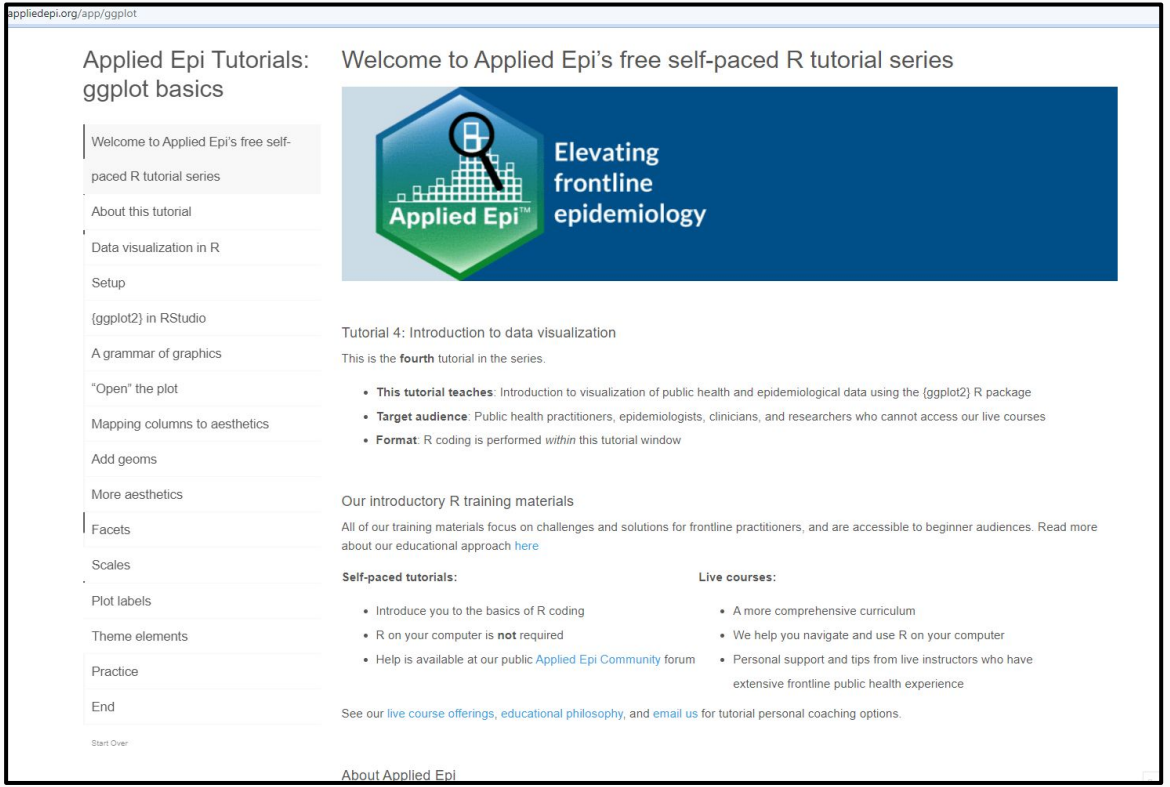
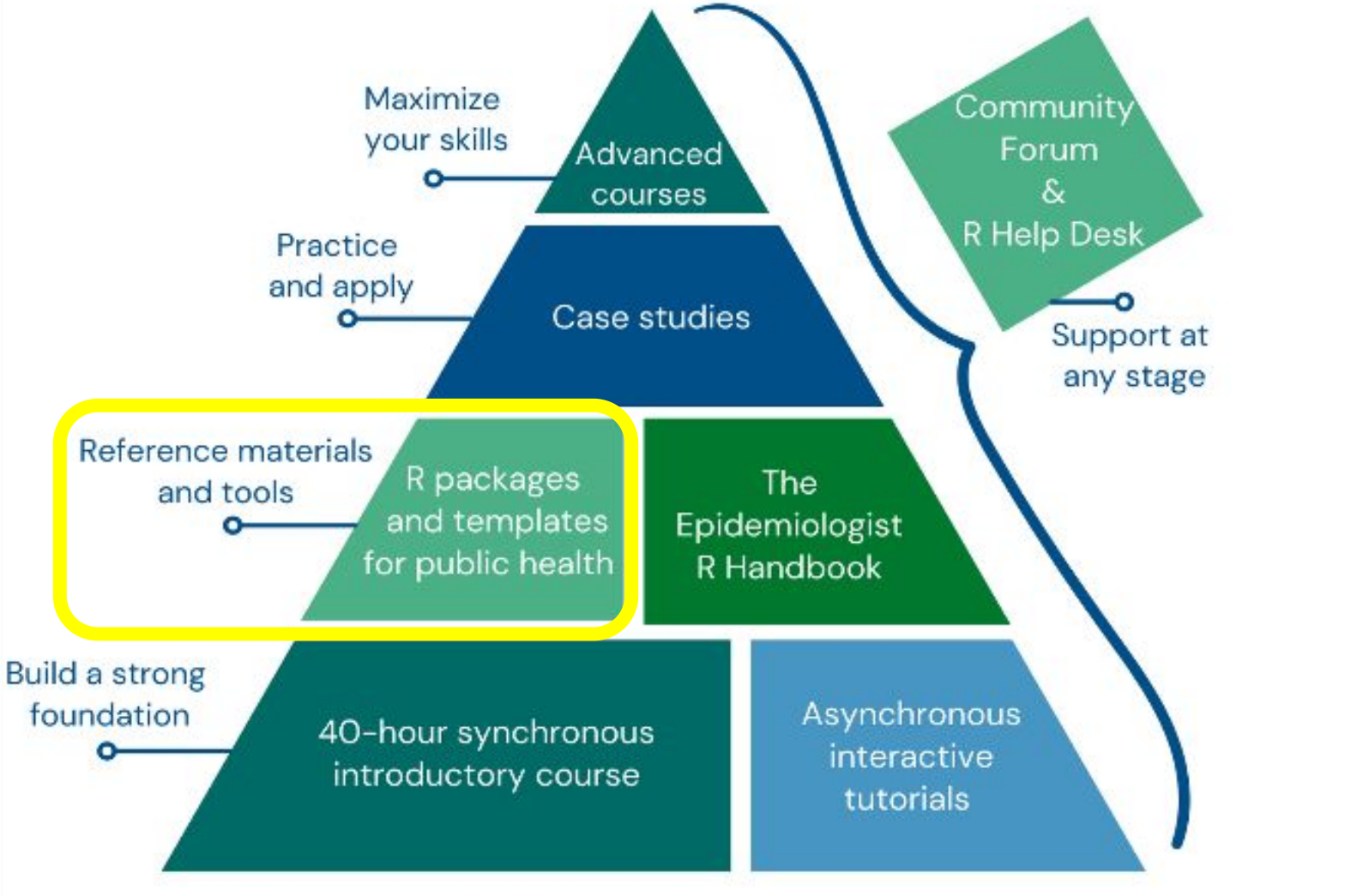
Asynchronous interactive tutorials
Community Forum & R Help Desk
Support at any stage

Free interactive {learnr} R tutorials

- Free access: www.appliedepi.org/tutorial
- Write code in browser
- Topics
  - Basic R coding
  - Tidy data
  - Data cleaning
  - Descriptive tables
  - Data visualization
- 1000+ users worldwide
- Partners:
  - Doctors without Borders (MSF)
  - TEPHINET (global network of Field Epi Training Programs)

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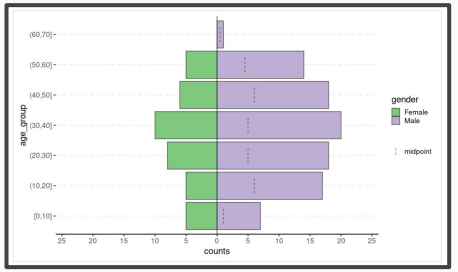
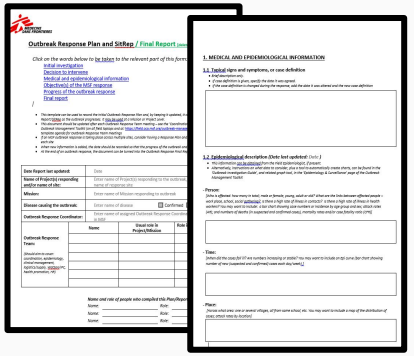
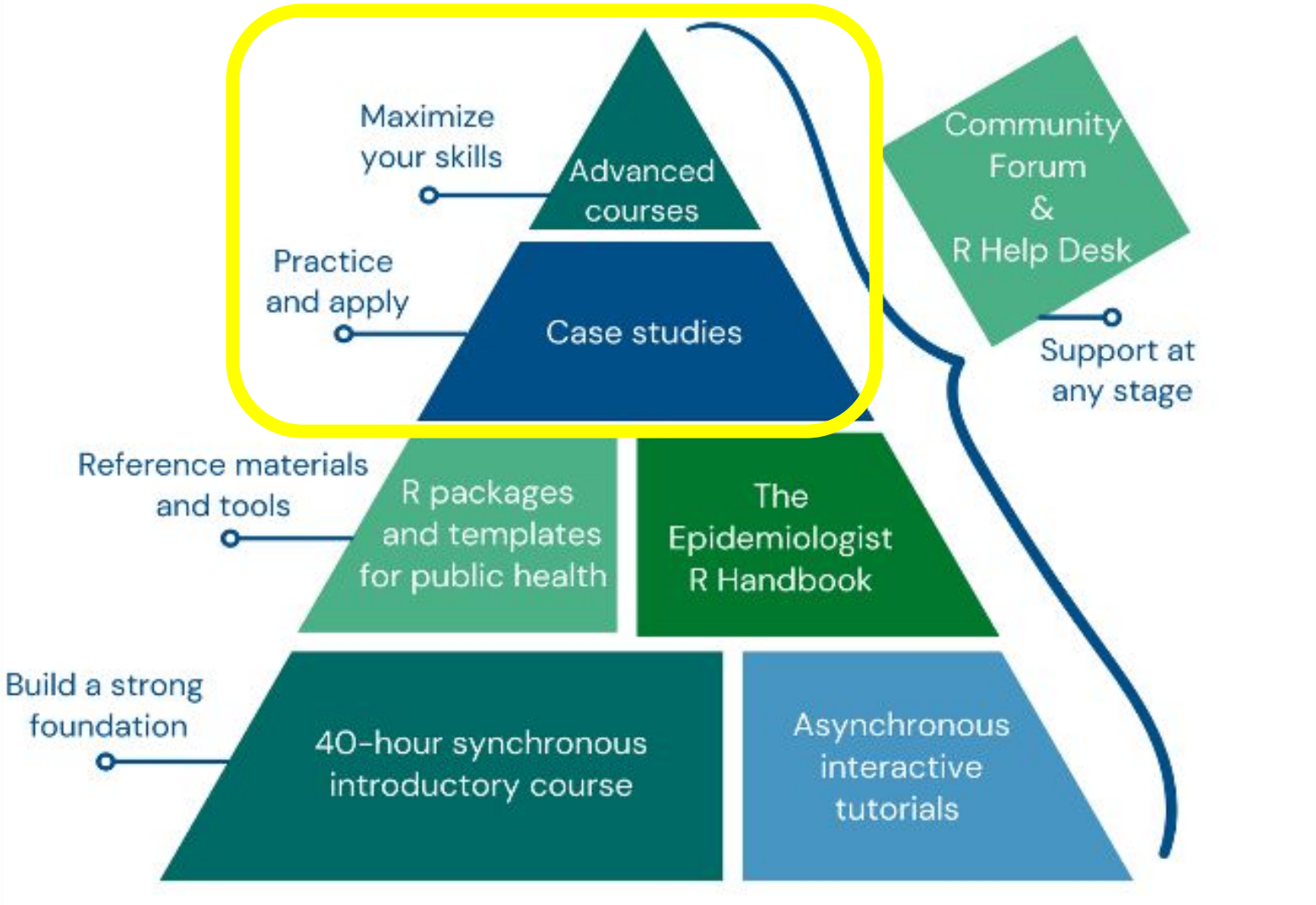
{sitrep}, {epikit}, {apyramid} packages

- **Helper functions for epidemiological analysis**
  - **age_categories()**
  - **age_pyramid()**
  - **fmt_count()**
  - **CFR, AR, MR…**



- **R Markdown templates for "situation reports"**
  - Import your data and make small code adjustments
  - Outbreaks: Cholera/AWD, Meningitis, Measles/Rubella, Acute Jaundice Syndrome
  - Surveys (various study designs, inclusion criteria): Mortality, Vaccination coverage, Nutrition

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Advanced courses and case studies

Advanced R workshops

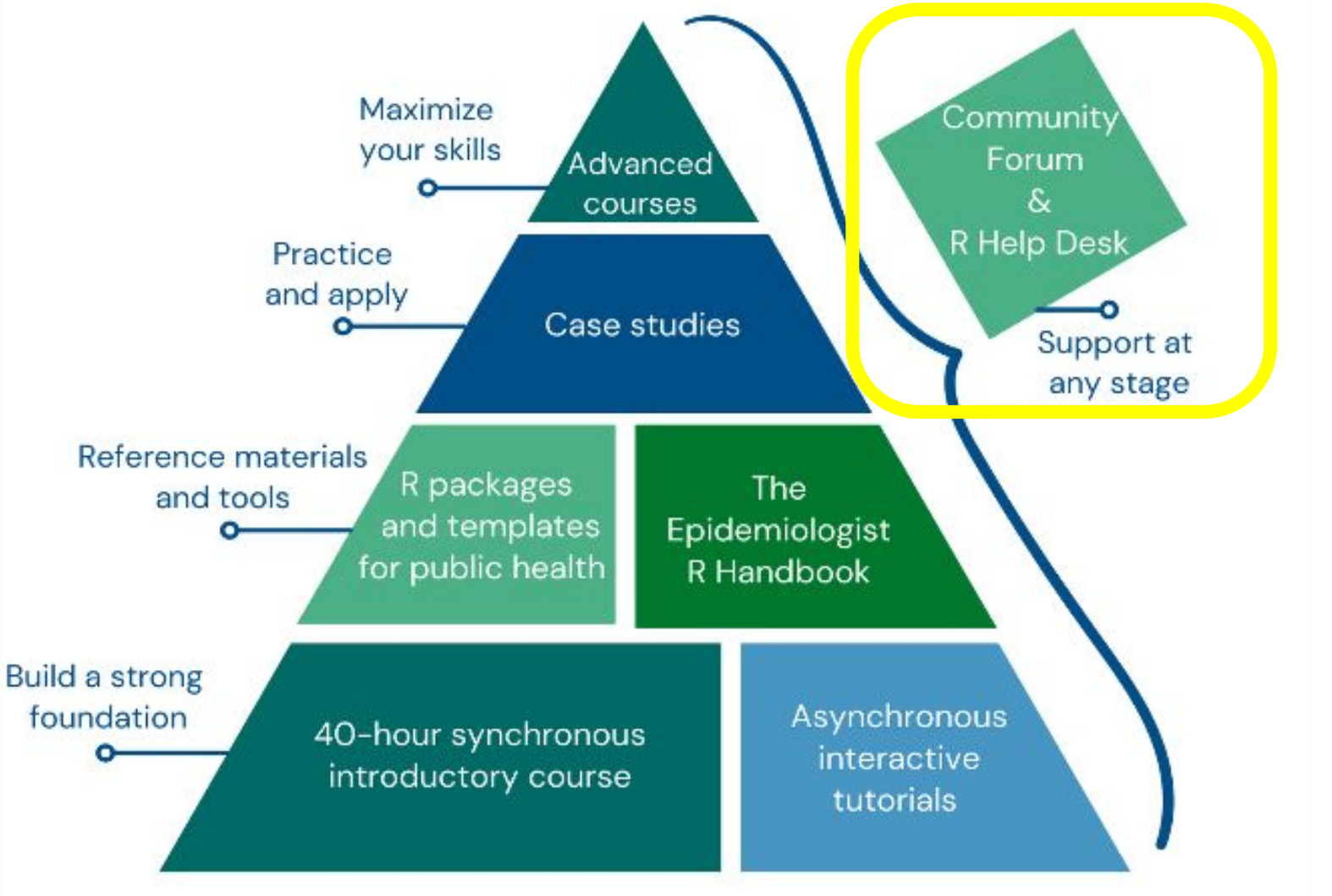
- Statistics and regression
- GIS
- Dashboards (shiny, flexdashboard)
- Git & Github
- Survey analysis
- Relational databases
- Iteration and functional programming

Case study repository

"Where can I go to get extra practice?"

- Course participant

- A repository of free, open-source case studies
- Collaboration with Field Epi Training Programs (FETPs)
- Translate existing case studies to R, from Excel, EpiInfo, SPSS, Stata, and SAS
- Offer walk-through demonstrations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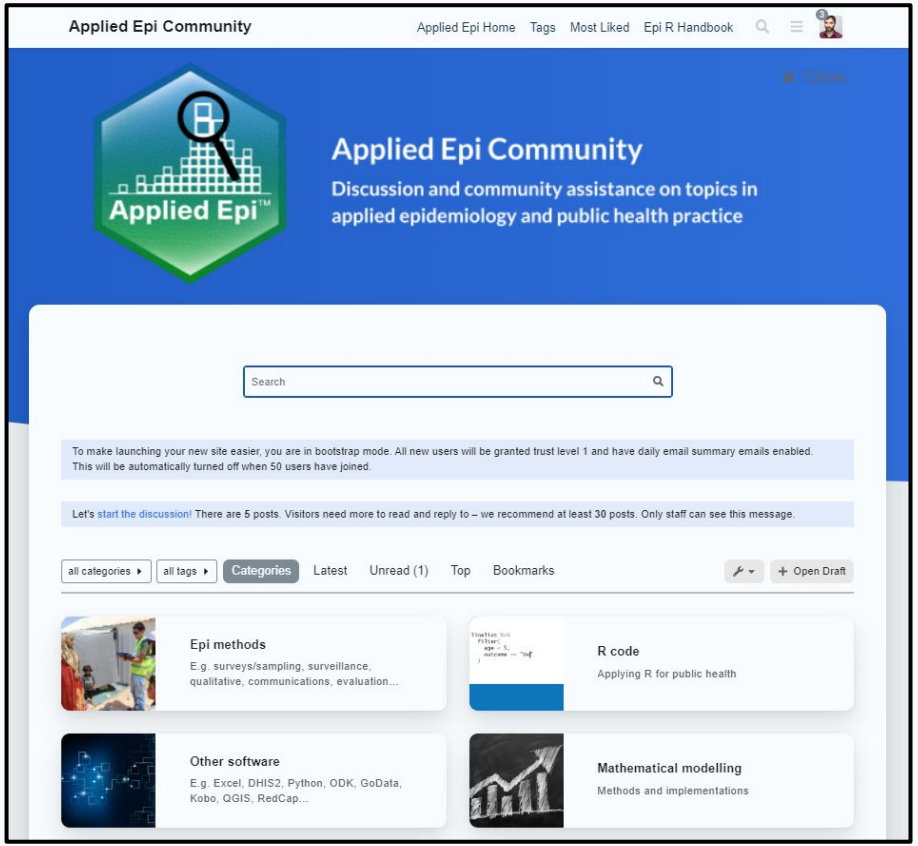
Applied Epi Community

Free access: community.appliedepi.org

Q&A and discussion forum on topics in applied epidemiology and public health:

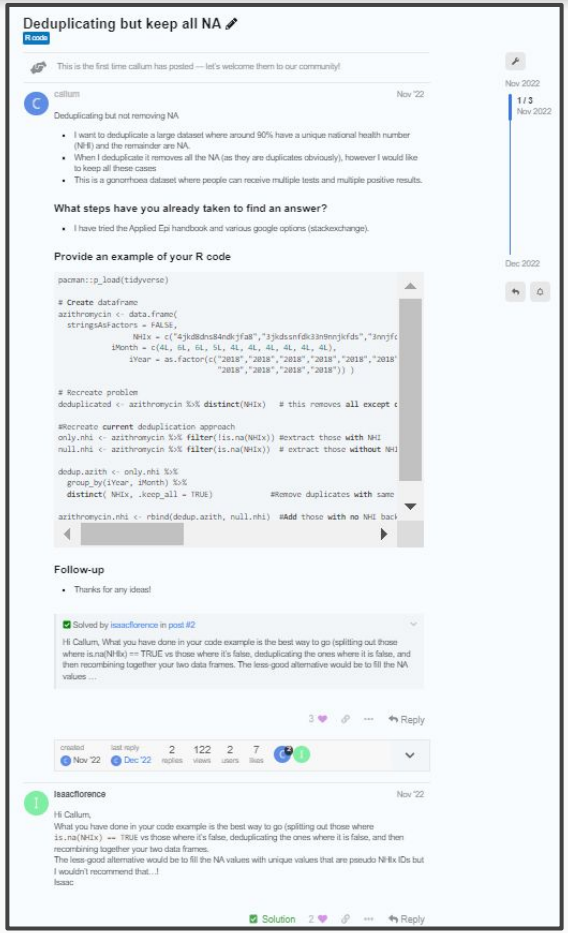
- Welcoming of beginners
- Embrace public health context
- Q&A on R code & epi methods
- Share tips, templates, and code



Applied Epi Community

Free access: community.appliedepi.org

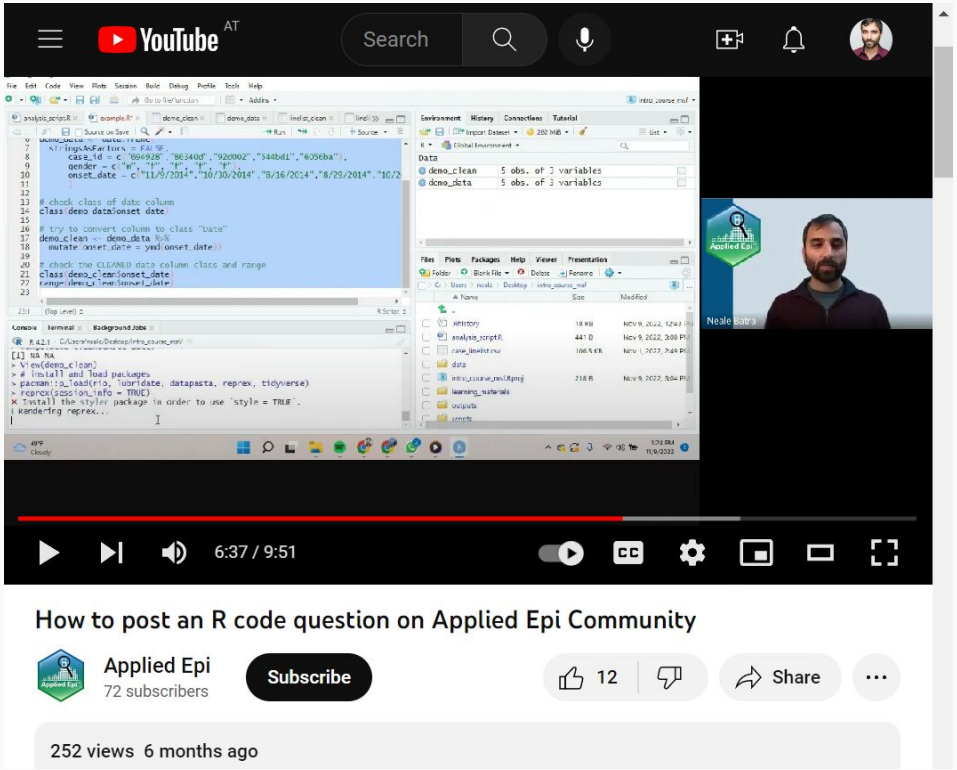
- ☑ Deduplicating but keep all NA
- ☑ Package for capture-recapture study to estimate the sensitivity of a surveillance system
  - r
  - code
  - surveillance
- ☑ How can I rename 0s and 1s to show “Yes” and “No” in my table?
  - r
  - cleaning-data
- ☑ Creating an epi curve based on a unique date range and adding trend lines
- ☑ La fonction pivot_longer ne fonctionne pas
- ☑ Transmission chain using epicontacts
- ☑ Calculating Relative Risk / Odds Ratio in gtsummary. Adding adjusted OR in same table
- ☑ Importing data from Kobo Toolbox
- ☑ Calculating person-days 1
  - code



De-mystifying the “reprex”

The “minimal, reproducible example”

- Simple video and written tutorials
- Incorporate practice into courses
- Webinars and live support sessions planned



R Help Desk for public health

- 1-on-1 calls with R experts who know public health

- Support for:
  - Error troubleshooting
  - Code review
  - Emergency response data pipelines

- Languages: English, French, & Spanish
- Global time zone coverage
- 30min, 1 hour, or 2 hours call duration

- Zoom to enable screen control
- No data file sharing



R Help Desk - Uganda Ebola response

*"The R Help Desk's **timely assistance** and guidance empowered us to navigate complex data analysis challenges and **provide decision-makers with the relevant information in a timely manner**"*



Daniel Eurien

Ebola Response Epidemiologist & Data Manager, Uganda Ministry of Health

- November 2022 - March 2023, **60 hours** of R Help Desk funded by WHO
- Analysis of Ebola linelist data based on requests of the Ebola task force
- 92 R Markdown (HTML) reports generated, also {flexdashboard}

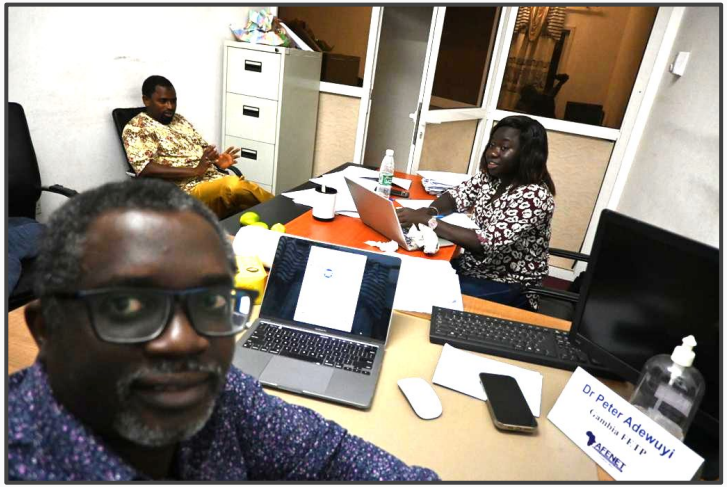


"I helped Daniel with the requests of the Ebola task force for decision making, and control of the outbreak. And lately, to analyse the DHIS2 data to see the impact of the Ebola outbreak on the routine health care."

- *Berhe Etsay, R Help Desk Technician, Applied Epi*

R Help Desk - The Gambia

- The Gambia, 2022 - a large cluster of acute kidney injuries among children was associated with case fatality rates >80%[1]
- *"The Applied Epi team help desk assigned an experienced tutor, who worked me through the process within 2-4 hours of my request."*
- Dr. Peter Adewuyi with The Gambian Field Epidemiology Training Program requested assistance performing **logistic regression for operational research**.



[1]Bastani P, Jammeh A, Lamar F, et al. Acute Kidney Injury Among Children Likely Associated with Diethylene Glycol–Contaminated Medications — The Gambia, June–September 2022. MMWR Morb Mortal Wkly Rep 2023;72:217–222. DOI: http://dx.doi.org/10.15585/mmwr.mm7209a1

R Help Desk - Doctors without Borders (MSF)

Analysis of vaccination coverage survey in eastern DRC

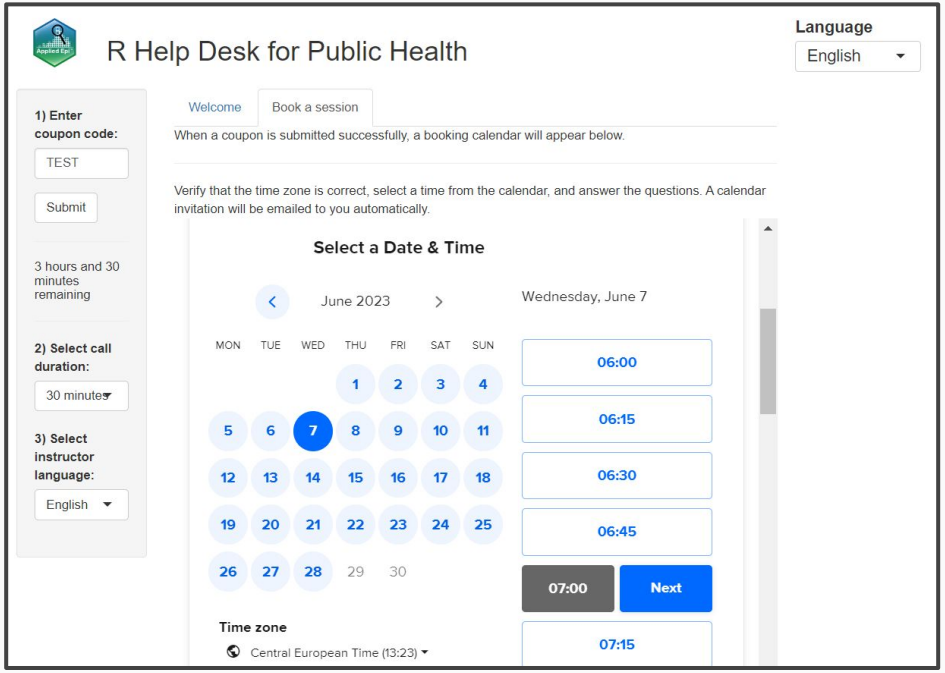
- Data collected with Kobo questionnaire, two-stage cluster sampling
- Rmd templates used to generate complete report
- Reviewed by on-site epidemiologist

Analysis of nutrition survey in Pakistan

- R support for calculation of key metrics (ICC and Design Effect)
- Comparison to Stata results

R Help Desk - looking forward

- Greater availability to the general public
- More technicians with specialised skills (e.g. GIS, time series analysis, survey analysis, shiny, forecasting, etc.)
- Rapid-determination scholarship application
- With demand, increase to a 24/7 staffing model



Beyond R: the Applied Epidemiology Manual

Under development: A manual for practical implementation of epidemiological methods

- Requested by many of our partners
- Worldwide network of 80 authors, reviewers, and advisors
- Addresses need for a task-oriented, “one-stop” practical guide
  - Free and open-source
  - Links to existing resources and Epi R Handbook/tool-agnostic case studies
  - Multi-lingual, available online/offline
- Topics: disease surveillance, outbreak response, surveys, data management & collection, qualitative methods, statistical analysis, time series, GIS, etc.



Closing remarks

How to ensure that R is also led by *practitioners* and not only academic early-adopters?

**"Earlier, I thought R is for senior analysts.
Now that fear is gone. I now know that R is for everyone."**

Simon Boakye, Disease Control Officer, Ghana

In which fields (like public health) will R adoption result in tremendous real-world impact?

How do we create channels between developers/programmers and front-end users?

How do we create beginner-friendly Q&A spaces?

What is R's role in a more language-agnostic support ecosystem?
(with Excel, EpiInfo, Julia, etc)



contact@appliedepi.org

www.appliedepi.org

www.appliedepi.org/join (part-time instructor pool)

@appliedepi @epiRhandbook