Automating Health Economic Evaluation with R (+ genAI)

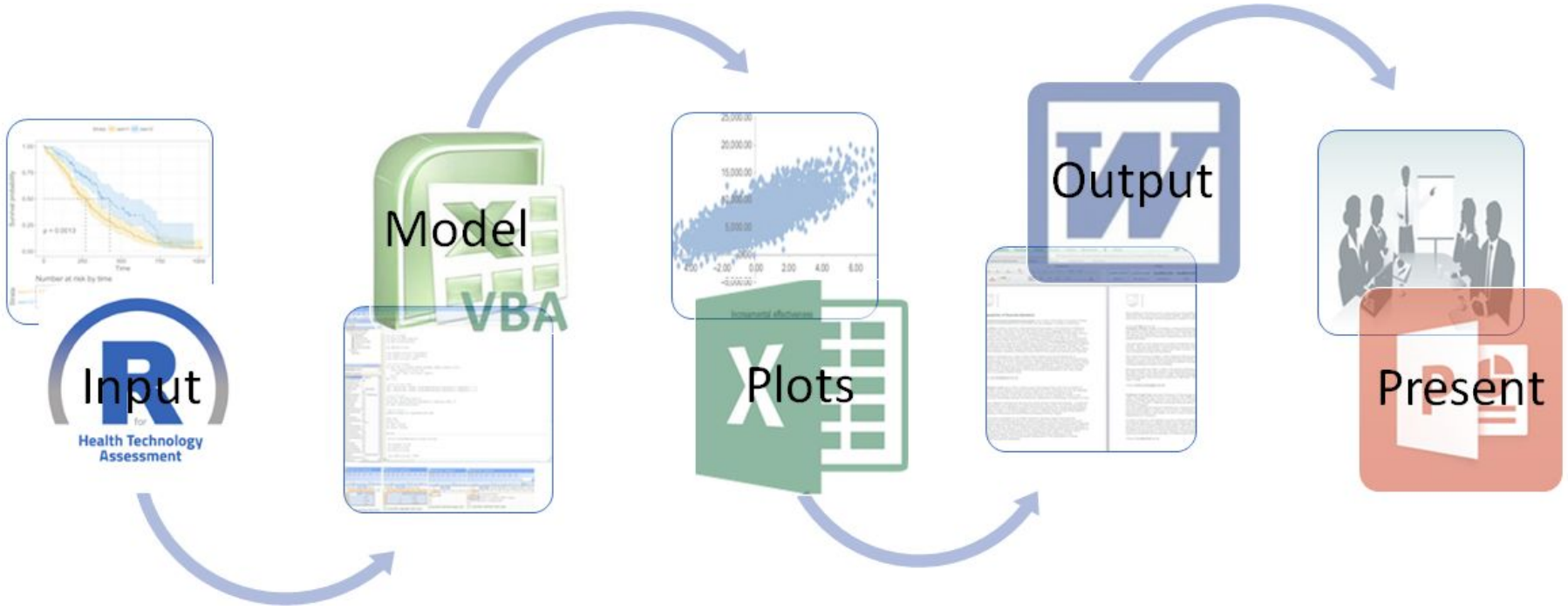
R-HTA 25 | Robert Smith | June 2025

contact@darkpeakanalytics.com

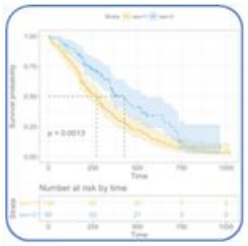
https://github.com/dark-peak-analytics

https://www.linkedin.com/company/dark-peak-analytics

Current process

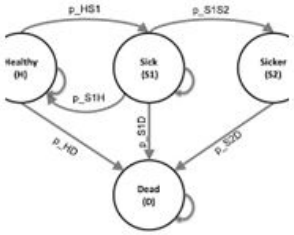


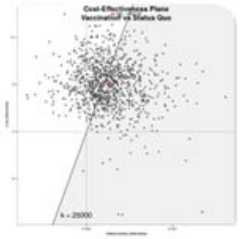
Future process



R for Health Technology Assessment

hesim health economic simulation modeling



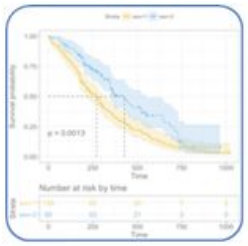


ggplot2

rmarkdown

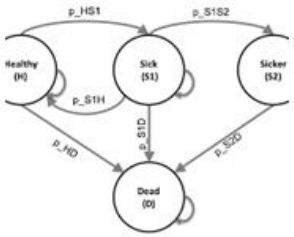
Shiny

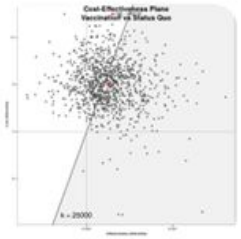
Future process



R for Health Technology Assessment

hesim health economic simulation modeling





ggplot2

rmarkdown

VALUING HEALTH TECHNOLOGIES AT NICE: [COMMENDATIONS FOR IMPROVED INCORPORATIO OF TREATMENT VALUE IN HTA

Shiny

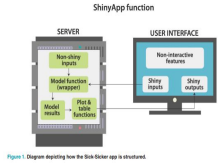
Timeline

Now on CRAN

2021 2022 2023 2024 2025

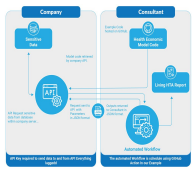
Making Health Economic Models Shiny: A tutorial

Smith & **Schneider.** Making health economic models Shiny: A tutorial. *Wellcome Open Res* 2020, **5**:69 (https://doi.org/10.12688/wellcomeopenres.15807.2)



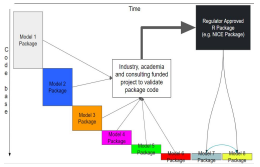
Living HTA: Automating Health Economic Evaluation with R

Smith, Schneider and **Mohammed**. Living HTA: Automating Health Economic Evaluation with R. *Wellcome Open Res* 2022, **7**:194 (https://doi.org/10.12688/wellcomeopenres.17933.2)



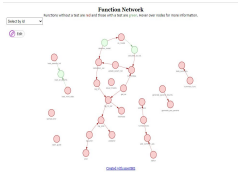
R Packages for health economic evaluation: A tutorial

Smith RA, Mohammed W and **Schneider PP**. R Packages for health economic evaluation: A tutorial. 2023. (https://wellcomeopenresearch.org/articles/8-419)



assertHE: an R package to improve quality assurance of health economic models

Smith, Samyshkin, **Mohammed** et al. assertHE: an R package to improve quality assurance of health economic models. 2024. (https://wellcomeopenresearch.org/articles/9-701)



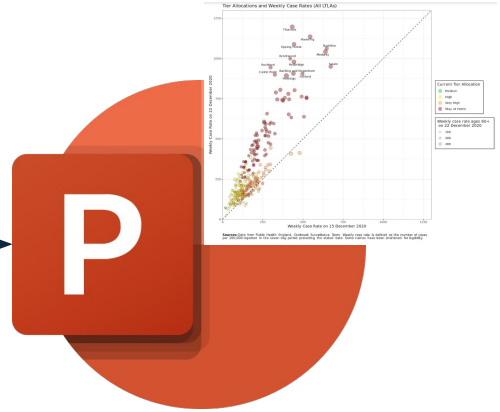
Automating Health Economic Evaluation with R (+genAI)

Smith, Lamrock**, Dolin, Lewis,** McQueen. R we almost there? Applying the advantages of modern software tools to the ICER Severe Asthma Model. In progress

Bibby
Open Source on GitHub

Now a popular short course

Case study: Joint Biosecurity Centre response to COVID-19

NHS Test and Trace → UK Health Security Agency →  →

Each day, huge quantities of data obtained by NHS T&T

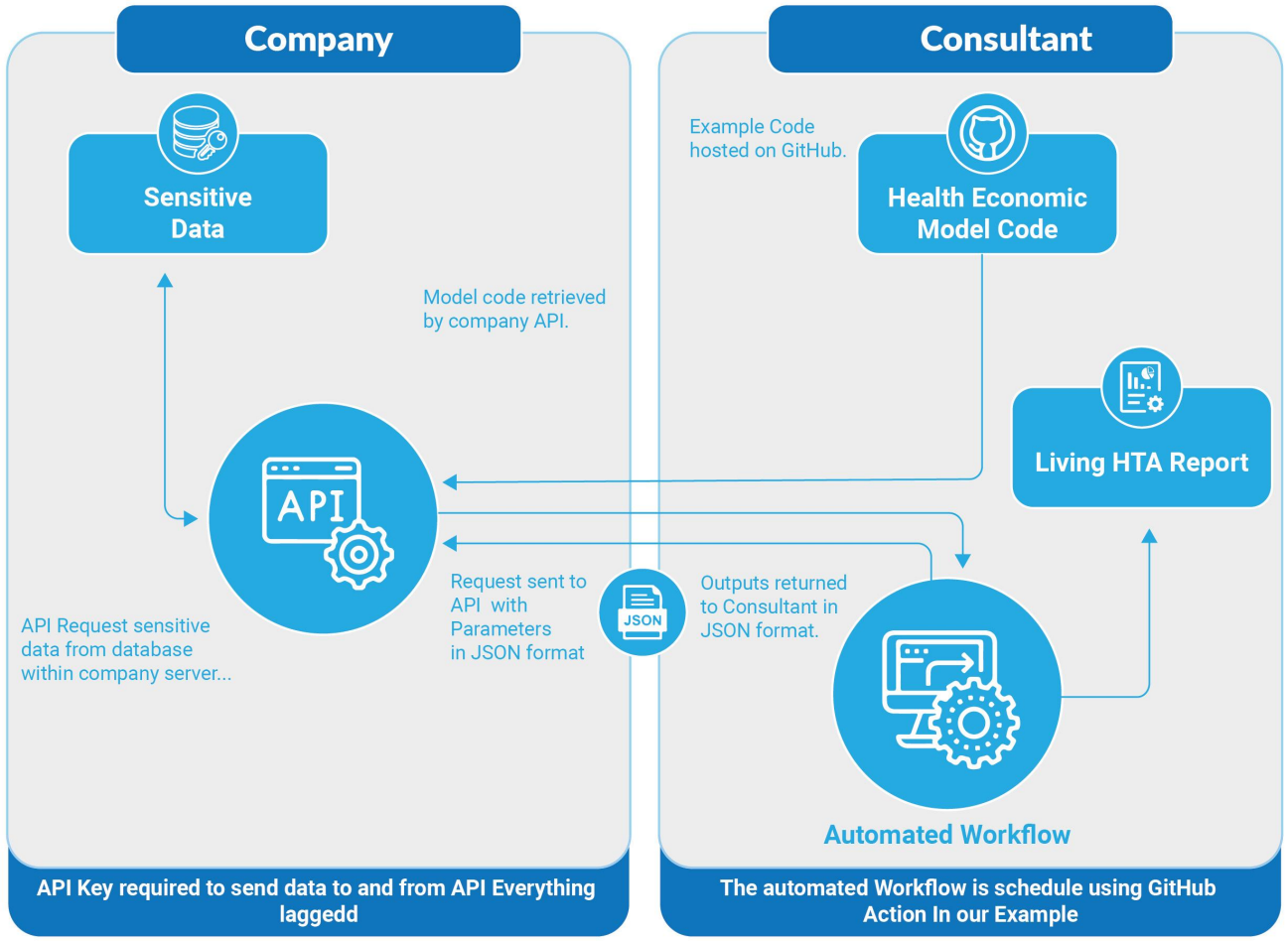
Clever people at JBC (later UKHSA) write code to visualise & describe epi situation

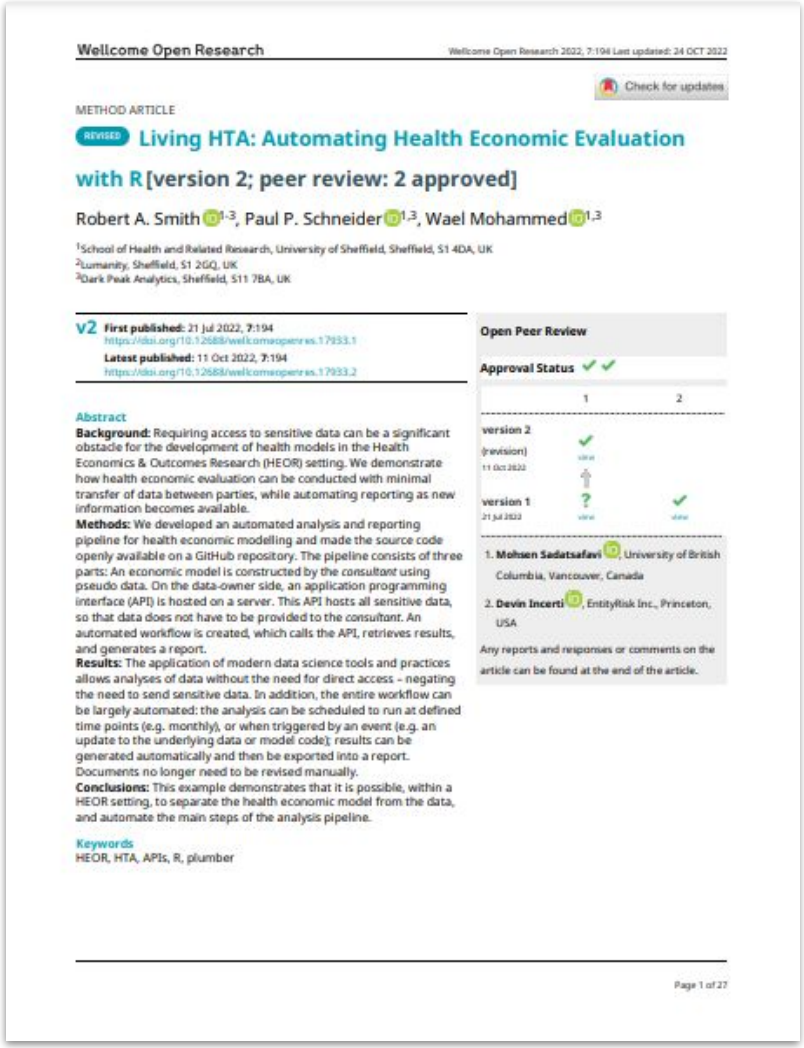
Slides generated, using progressively automated processes, checked, and provided to decision makers

Difficult decisions made

Disclaimer: This is a massively oversimplified and intentionally vague description of the process.

Making Health Economics … hAPpI





Wellcome Open Research

METHOD ARTICLE

REVISED **Living HTA: Automating Health Economic Evaluation with R [version 2; peer review: 2 approved]**

Robert A. Smith [1-3], Paul P. Schneider [1,3], Wael Mohammed [1,3]

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v2 **First published:** 21 Jul 2022, 7:194
https://doi.org/10.12688/wellcomeopenres.17933.1
Latest published: 11 Oct 2022, 7:194
https://doi.org/10.12688/wellcomeopenres.17933.2

Abstract

Background: Requiring access to sensitive data can be a significant obstacle for the development of health models in the Health Economics & Outcomes Research (HEOR) setting. We demonstrate how health economic evaluation can be conducted with minimal transfer of data between parties, while automating reporting as new information becomes available.

Methods: We developed an automated analysis and reporting pipeline for health economic modelling and made the source code openly available on a GitHub repository. The pipeline consists of three parts: An economic model is constructed by the consultant using pseudo data. On the data-owner side, an application programming interface (API) is hosted on a server. This API hosts all sensitive data, so that data does not have to be provided to the consultant. An automated workflow is created, which calls the API, retrieves results, and generates a report.

Results: The application of modern data science tools and practices allows analyses of data without the need for direct access - negating the need to send sensitive data. In addition, the entire workflow can be largely automated: the analysis can be scheduled to run at defined time points (e.g. monthly), or when triggered by an event (e.g. an update to the underlying data or model code); results can be generated automatically and then be exported into a report. Documents no longer need to be revised manually.

Conclusions: This example demonstrates that it is possible, within a HEOR setting, to separate the health economic model from the data, and automate the main steps of the analysis pipeline.

Keywords
HEOR, HTA, APIs, R, plumber

Open Peer Review

Approval Status ✓ ✓

	1	2
version 2 (revision) 11 Oct 2022	✓ view	
version 1 21 Jul 2022	? view	✓ view

1. **Mohsen Sadatsafavi**, University of British Columbia, Vancouver, Canada
2. **Devin Incerti**, Entityrisk Inc., Princeton, USA

Any reports and responses or comments on the article can be found at the end of the article.

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https://wellcomeopenresearch.org/articles/7-194

Aim

Create a system to automatically update models & modelling reports as new information emerges.

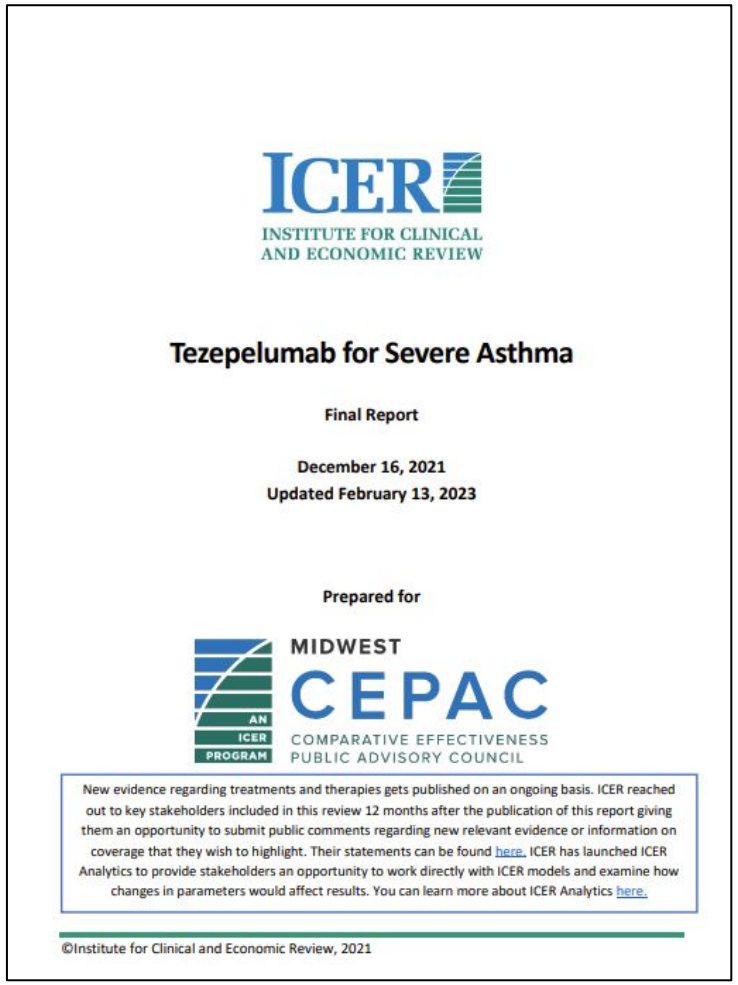
We want this system to:

- Allow users to change input values
- Allow users to change **citations**
- Re-run the model & get new results
- Generate a modeling report in Word.

- … integrate genAI to help us, particularly where:
  - the task is small & self contained.
  - we would just ask chatGPT anyway.

Case study

- ICER model for Severe Asthma originally published in 2021.
- Section 4 contains the Health Economic Model.
- Model developed in Excel & translated to R by Rob & Felicity with colleagues at the University of Colorado.
- Want to allow for automated updates to word format as per Smith, Schneider & Mohammed (2022).
- However, that paper was *waaaaayyyy* too advanced! This one will be simpler.



ICER
INSTITUTE FOR CLINICAL AND ECONOMIC REVIEW

Tezepelumab for Severe Asthma

Final Report

December 16, 2021
Updated February 13, 2023

Prepared for

MIDWEST CEPAC
AN ICER PROGRAM
COMPARATIVE EFFECTIVENESS PUBLIC ADVISORY COUNCIL

New evidence regarding treatments and therapies gets published on an ongoing basis. ICER reached out to key stakeholders included in this review 12 months after the publication of this report giving them an opportunity to submit public comments regarding new relevant evidence or information on coverage that they wish to highlight. Their statements can be found here. ICER has launched ICER Analytics to provide stakeholders an opportunity to work directly with ICER models and examine how changes in parameters would affect results. You can learn more about ICER Analytics here.

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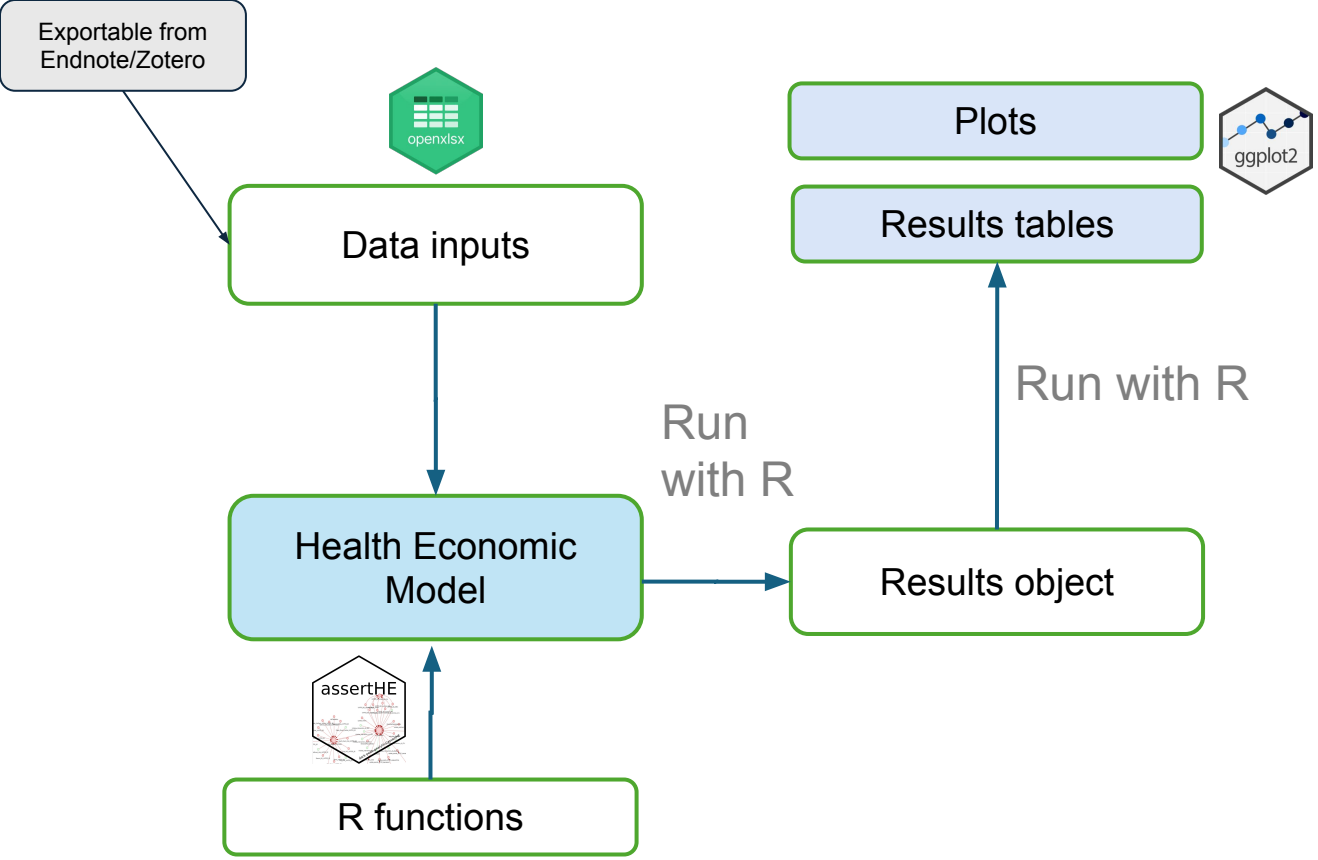
Rind DM, McQueen RB, Herron-Smith S, Herce-Hagiwara B, Gutierrez E, Campbell J, Fluetsch N, Pearson SD. Tezepelumab for Severe Asthma; Final Report. Institute for Clinical and Economic Review, December 16, 2021. https://icer.org/wpcontent/uploads/2021/05/ICER_Severe-Asthma_Final-Evidence-Report_121621.pdf

Smith, R.A., Schneider, P.P. and Mohammed, W., 2022. Living HTA: automating health economic evaluation with R. *Wellcome Open Research*, *7*, p.194.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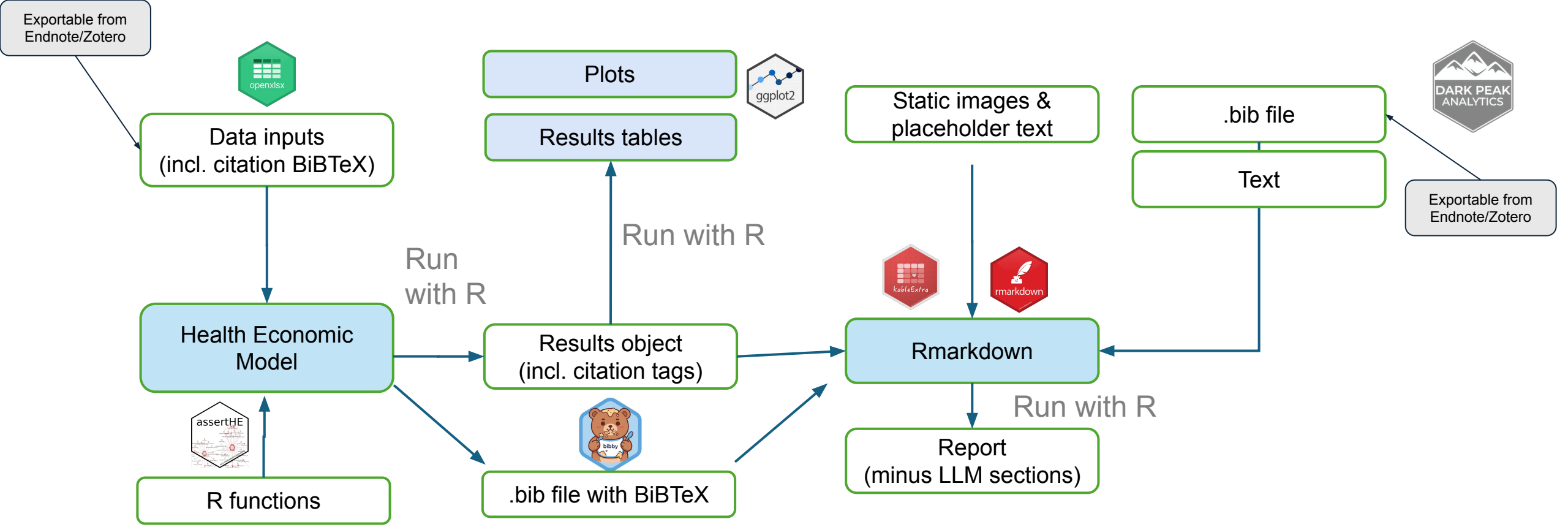
openxlsx
Data inputs
Health Economic Model
assertHE
R functions
Run with R
Results object
Run with R
Results tables
Plots
ggplot2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openxlsx
Data inputs (incl. citation BiBTeX)
Health Economic Model
assertHE
R functions
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Plots
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Results tables
Run with R
Results object (incl. citation tags)
bibby
.bib file with BiBTeX
Static images & placeholder text
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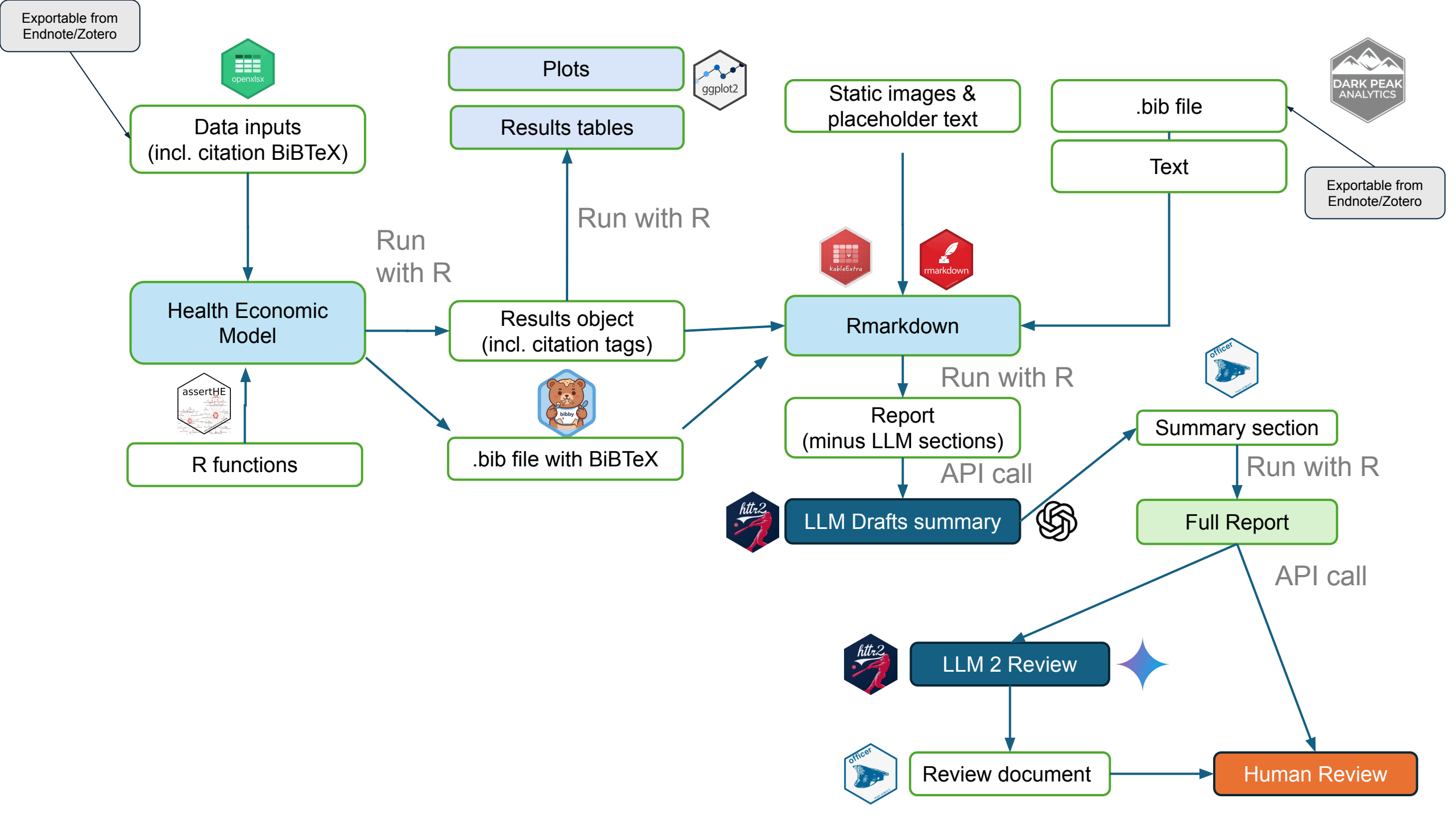
Rmarkdown
Run with R
Report (minus LLM sections)
.bib file
Text
DARK PEAK ANALYTICS
Exportable from Endnote/Zotero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Results tables
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Static images & placeholder text
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Rmarkdown
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Text
DARK PEAK ANALYTICS
Exportable from Endnote/Zotero
Run with R
Report (minus LLM sections)
API call
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LLM Drafts summary
officer
Summary section
Run with R
Full Report
API call
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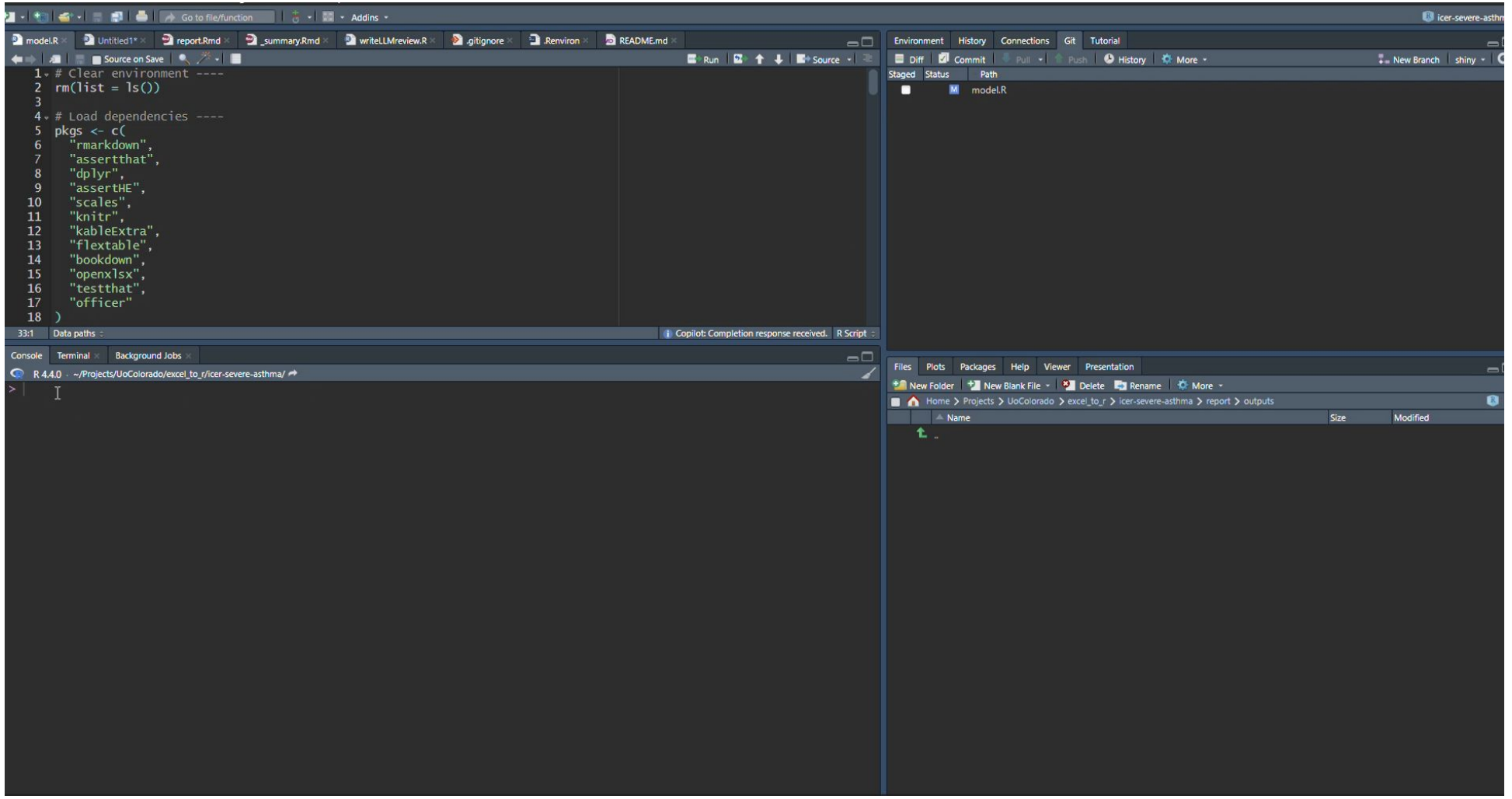
LLM 2 Review
officer
Review document
Human Review

Demonstration



Demonstration

	A	B	C	D	E	F	G	H	I	J	K	L	M	O	P	Q	R	S	T	U
1	v	ca	label	d	value	d	l	u	p	d	d	d	d	Source						
20	e	Eff	Relative risk of exacerbation in standard of care		1									@article{corren2017tezepelumab, title={Tezepelumab in adults with uncontrolled asthma}, author={Corren, Jonathan and Parnes, Jane R and Wang, Liangwei and Mo, May and Roseti, Stephanie L and Griffiths, Janet M and var						
21	rr	Eff	Relative risk of exacerbation in treatment		0.36128					lr#	0			@article{menzies2021tezepelumab, title={Tezepelumab in adults and adolescents with severe, uncontrolled asthma}, author={Menzies-Gow, Andrew and Corren, Jonathan and Bourdin, Arnaud and Chupp, Geoffrey and Israel, E						
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24	rr	Eff	Relative risk of hosp given exacerbation in treatment		0.2									@article{menzies2021tezepelumab, title={Tezepelumab in adults and adolescents with severe, uncontrolled asthma}, author={Menzies-Gow, Andrew and Corren, Jonathan and Bourdin, Arnaud and Chupp, Geoffrey and Israel, E						
25	u	Uti	Utility for non-exacerbation state - SoC alone		0.75									@article{menzies2021tezepelumab, title={Tezepelumab in adults and adolescents with severe, uncontrolled asthma}, author={Menzies-Gow, Andrew and Corren, Jonathan and Bourdin, Arnaud and Chupp, Geoffrey and Israel, E						
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27	d	Uti	Disutility for steroid burst		0.1					b#	#			@article{lloyd2007impact, title={The impact of asthma exacerbations on health-related quality of life in moderate to severe asthma patients in the UK}, author={Lloyd, Andrew and Price, David and Brown, Ruth}, journal={Primary						
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31	p	Uti	Percentage Chronic OCS Users		0.096															
32	u	Uti	Utility of a healthy life year		0.851									@misc{institute2018qaly, title={The QALY: rewarding the care that most improves patients' lives}, author={Institute for Clinical and Economic Review}, year={2018}, publisher={Institute for Clinical and Economic Review Boston,						
33	c	Co	Long-run adverse events costs	C	8326									@article{lefebvre2017burden, title={Burden of systemic glucocorticoid-related complications in severe asthma}, author={Lefebvre, Patrick and Duh, Mei Sheng and Lafeuille, Marie-H{\'e}l{\`e}ne and Gozalo, Laurence and Desai, U						
34	c	Co	Annual cost of SOC		6494					g#	0			@article{whittington2017assessing, title={Assessing the value of mepolizumab for severe eosinophilic asthma: a cost-effectiveness analysis}, author={Whittington, Melanie D and McQueen, R Brett and Ollendorf, Daniel A and T						
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36	c	Co	Cost for an outpatient visit		74															

Demonstration

	v	ca	label	d	value	O
20	e	Eff	Relative risk of exacerbation in standard of care		1	@article{corren2017tezepelumab, title={Tezepelumab in adults with uncontrolled asthma}, author={Corren, Jonathan and Parnes, Jane R and Wang, Liangwei and Mo, May and Roseti, Stephanie L and Griffiths, Janet M and var
21	r	Eff	Relative risk of exacerbation in treatment		0.36128	@article{menzies2021tezepelumab, title={Tezepelumab in adults and adolescents with severe, uncontrolled asthma}, author={Menzies-Gow, Andrew and Corren, Jonathan and Bourdin, Arnaud and Chupp, Geoffrey and Israel, E
22	r	Eff	Relative risk of steroid given exacerbation in treatment		0.41	@article{menzies2021tezepelumab, title={Tezepelumab in adults and adolescents with severe, uncontrolled asthma}, author={Menzies-Gow, Andrew and Corren, Jonathan and Bourdin, Arnaud and Chupp, Geoffrey and Israel, E
23	r	Eff	Relative risk of ED given exacerbation in treatment		0.2	@article{menzies2021tezepelumab, title={Tezepelumab in adults and adolescents with severe, uncontrolled asthma}, author={Menzies-Gow, Andrew and Corren, Jonathan and Bourdin, Arnaud and Chupp, Geoffrey and Israel, E
24	r	Eff	Relative risk of hosp given exacerbation in treatment		0.2	@article{menzies2021tezepelumab, title={Tezepelumab in adults and adolescents with severe, uncontrolled asthma}, author={Menzies-Gow, Andrew and Corren, Jonathan and Bourdin, Arnaud and Chupp, Geoffrey and Israel, E
25	u	Uti	Utility for non-exacerbation state - SoC alone		0.75	@article{menzies2021tezepelumab, title={Tezepelumab in adults and adolescents with severe, uncontrolled asthma}, author={Menzies-Gow, Andrew and Corren, Jonathan and Bourdin, Arnaud and Chupp, Geoffrey and Israel, E
26	u	Uti	Utility for non-exacerbation state - Treatment		0.79	@article{menzies2021tezepelumab, title={Tezepelumab in adults and adolescents with severe, uncontrolled asthma}, author={Menzies-Gow, Andrew and Corren, Jonathan and Bourdin, Arnaud and Chupp, Geoffrey and Israel, E
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30	d	Uti	Disutility for chronic OCS users		0.023	@article{norman2013omalizumab, title={Omalizumab for the treatment of severe persistent allergic asthma: a systematic review and economic evaluation}, author={Norman, Gill and Faria, R and Paton, F and Llewellyn, A and F
31	p	Uti	Percentage Chronic OCS Users		0.096	
32	u	Uti	Utility of a healthy life year		0.851	@misc{institute2018qaly, title={The QALY: rewarding the care that most improves patients' lives}, author={Institute for Clinical and Economic Review}, year={2018}, publisher={Institute for Clinical and Economic Review Boston,
33	c	Co	Long-run adverse events costs	C	8326	@article{lefebvre2017burden, title={Burden of systemic glucocorticoid-related complications in severe asthma}, author={Lefebvre, Patrick and Duh, Mei Sheng and Lafeuille, Marie-H{\'e}l{\`e}ne and Gozalo, Laurence and Desai, U
34	c	Co	Annual cost of SOC		6494	@article{whittington2017assessing, title={Assessing the value of mepolizumab for severe eosinophilic asthma: a cost-effectiveness analysis}, author={Whittington, Melanie D and McQueen, R Brett and Ollendorf, Daniel A and T
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36	c	Co	Cost for an outpatient visit		74	

	v	ca	label	d	value	O
20	e	Eff	Relative risk of exacerbation in standard of care		1	@article{corren2017tezepelumab, title={Tezepelumab in adults with uncontrolled asthma}, author={Corren, Jonathan and Parnes, Jane R and Wang, Liangwei and Mo, May and Roseti, Stephanie L and Griffiths, Janet M and var
21	r	Eff	Relative risk of exacerbation in treatment		0.6	@article{williams2023tezepelumab, title={Long-term efficacy of Tezepelumab in patients with eosinophilic airway inflammation: a multicentre phase 3 trial}, author={Williams, Hannah J and Okafor, Chidi and Tanaka, Mei and Mü
22	r	Eff	Relative risk of steroid given exacerbation in treatment		0.41	@article{menzies2021tezepelumab, title={Tezepelumab in adults and adolescents with severe, uncontrolled asthma}, author={Menzies-Gow, Andrew and Corren, Jonathan and Bourdin, Arnaud and Chupp, Geoffrey and Israel, E
23	r	Eff	Relative risk of ED given exacerbation in treatment		0.2	@article{menzies2021tezepelumab, title={Tezepelumab in adults and adolescents with severe, uncontrolled asthma}, author={Menzies-Gow, Andrew and Corren, Jonathan and Bourdin, Arnaud and Chupp, Geoffrey and Israel, E
24	r	Eff	Relative risk of hosp given exacerbation in treatment		0.2	@article{menzies2021tezepelumab, title={Tezepelumab in adults and adolescents with severe, uncontrolled asthma}, author={Menzies-Gow, Andrew and Corren, Jonathan and Bourdin, Arnaud and Chupp, Geoffrey and Israel, E
25	u	Uti	Utility for non-exacerbation state - SoC alone		0.75	@article{menzies2021tezepelumab, title={Tezepelumab in adults and adolescents with severe, uncontrolled asthma}, author={Menzies-Gow, Andrew and Corren, Jonathan and Bourdin, Arnaud and Chupp, Geoffrey and Israel, E
26	u	Uti	Utility for non-exacerbation state - Treatment		0.79	@article{menzies2021tezepelumab, title={Tezepelumab in adults and adolescents with severe, uncontrolled asthma}, author={Menzies-Gow, Andrew and Corren, Jonathan and Bourdin, Arnaud and Chupp, Geoffrey and Israel, E
27	d	Uti	Disutility for steroid burst		0.1	@article{lloyd2007impact, title={The impact of asthma exacerbations on health-related quality of life in moderate to severe asthma patients in the UK}, author={Lloyd, Andrew and Price, David and Brown, Ruth}, journal={Primar
28	d	Uti	Disutility for ED visit		0.15	@article{lloyd2007impact, title={The impact of asthma exacerbations on health-related quality of life in moderate to severe asthma patients in the UK}, author={Lloyd, Andrew and Price, David and Brown, Ruth}, journal={Primar
29	d	Uti	Disutility for Hospitalisation		0.2	@article{lloyd2007impact, title={The impact of asthma exacerbations on health-related quality of life in moderate to severe asthma patients in the UK}, author={Lloyd, Andrew and Price, David and Brown, Ruth}, journal={Primar
30	d	Uti	Disutility for chronic OCS users		0.023	@article{norman2013omalizumab, title={Omalizumab for the treatment of severe persistent allergic asthma: a systematic review and economic evaluation}, author={Norman, Gill and Faria, R and Paton, F and Llewellyn, A and F
31	p	Uti	Percentage Chronic OCS Users		0.096	
32	u	Uti	Utility of a healthy life year		0.851	@misc{institute2018qaly, title={The QALY: rewarding the care that most improves patients' lives}, author={Institute for Clinical and Economic Review}, year={2018}, publisher={Institute for Clinical and Economic Review Boston
33	c	Co	Long-run adverse events costs	C	8326	@article{lefebvre2017burden, title={Burden of systemic glucocorticoid-related complications in severe asthma}, author={Lefebvre, Patrick and Duh, Mei Sheng and Lafeuille, Marie-H{\'e}l{\`e}ne and Gozalo, Laurence and Desai, U
34	c	Co	Annual cost of SOC		6494	@article{whittington2017assessing, title={Assessing the value of mepolizumab for severe eosinophilic asthma: a cost-effectiveness analysis}, author={Whittington, Melanie D and McQueen, R Brett and Ollendorf, Daniel A and T
35	c	Co	Cost of biologic per year		27859	@article{whittington2017assessing, title={Assessing the value of mepolizumab for severe eosinophilic asthma: a cost-effectiveness analysis}, author={Whittington, Melanie D and McQueen, R Brett and Ollendorf, Daniel A and T
36	c	Co	Cost for an outpatient visit		74	

Demonstration

Table 2.3: Key Model Inputs 2

Parameter	Tezepelumab plus SoC	SoC Alone	Source
Tezepelumab Rate Ratio for Exacerbations	0.361	Reference group	(Menzies-Gow et al., 2021)
Tezepelumab Rate Ratio for Exacerbations Resulting in Steroid Burst (without ED visit or hospitalization)	0.410	Reference group	(Menzies-Gow et al., 2021)
Tezepelumab Rate Ratio for Exacerbations Resulting in ED Visit (without hospitalization)	0.200	Reference group	(Menzies-Gow et al., 2021)
Tezepelumab Rate Ratio for Exacerbations Resulting in Hospitalization	0.200	Reference group	(Menzies-Gow et al., 2021)
Non-Exacerbation Mean Health State Utility for Tezepelumab plus SoC vs SoC Alone (95% CI for tezepelumab mean difference vs. placebo)	0.790	0.75	(Menzies-Gow et al., 2021)

Table 3.1: Results table

Treatment	Cost	QALYs	LY	evLY
Tezepelumab and SOC	$776,355	14.526	29.510	14.551
SoC Alone	$491,215	13.061	28.916	13.061

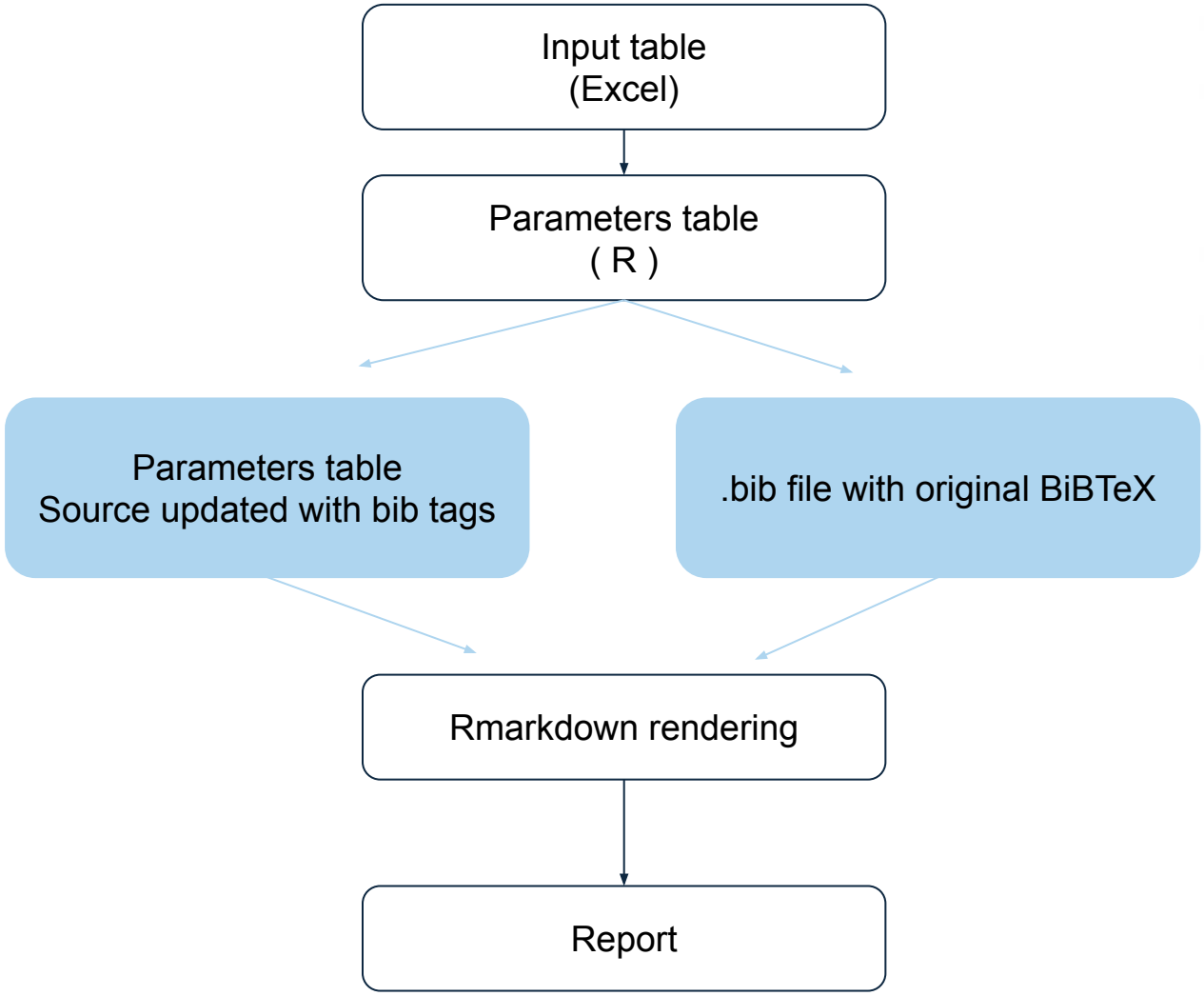
Table 2.3: Key Model Inputs 2

Parameter	Tezepelumab plus SoC	SoC Alone	Source
Tezepelumab Rate Ratio for Exacerbations	0.600	Reference group	(Williams et al., 2023)
Tezepelumab Rate Ratio for Exacerbations Resulting in Steroid Burst (without ED visit or hospitalization)	0.410	Reference group	(Menzies-Gow et al., 2021)
Tezepelumab Rate Ratio for Exacerbations Resulting in ED Visit (without hospitalization)	0.200	Reference group	(Menzies-Gow et al., 2021)
Tezepelumab Rate Ratio for Exacerbations Resulting in Hospitalization	0.200	Reference group	(Menzies-Gow et al., 2021)
Non-Exacerbation Mean Health State Utility for Tezepelumab plus SoC vs SoC Alone (95% CI for tezepelumab mean difference vs. placebo)	0.790	0.75	(Menzies-Gow et al., 2021)

Table 3.1: Results table

Treatment	Cost	QALYs	LY	evLY
Tezepelumab and SOC	$792,049	14.279	29.410	14.303
SoC Alone	$491,215	13.061	28.916	13.061

Managing updates to inputs & citations



https://github.com/dark-peak-analytics/bibby/

Managing updates to inputs & citations

Source column to update

```
report_params$Source <- bibby::update_bib_file_from_vector(
  v_bibtex_entries = report_params$Source,
  path = "table_refs.bib",
  output_type = "markdown_short"
)
```

bib file to update

https://github.com/dark-peak-analytics/bibby/

format

Long: As **Williams et al. (2020)** argue, health policy should be evidence-based.
Short: Health policy should be evidence-based (**Williams et al., 2020**).

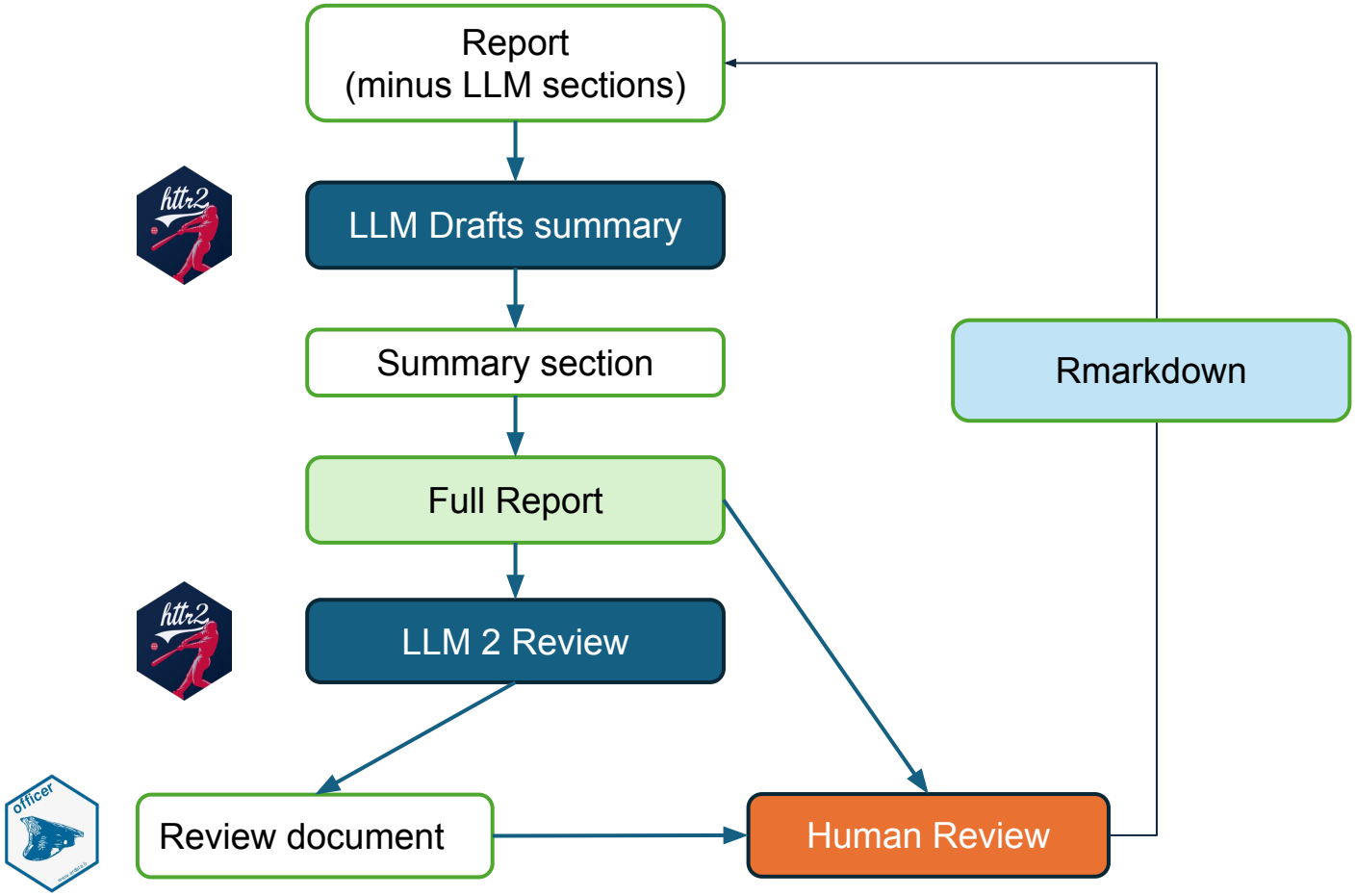
genAI role

- Minimal input – using the LLM via an API request with the httr2 package (Wickham, 2024)
- Small, self contained and quick to validate task - human review essential.
- The genAI output is used to generate a fully reproducible set of outputs – the code that is generated will give the same outputs every time.
- Further edits can be made in an independent process.

R/Python are the most logical languages for a genAI tool to interact with a health economic model – Excel is problematic

Wickham H (2024). httr2: Perform HTTP Requests and Process the Responses_. R package version 1.0.7, http://project.org/package=httr2

genAI role



R/Python are the most logical languages for a genAI tool to interact with a health economic model – Excel is problematic

Wickham H (2024). httr2: Perform HTTP Requests and Process the Responses_. R package version 1.0.7, http://project.org/package=httr2

genAI role

```r
query_llm <- function(text,
                      base_url,
                      model,
                      prompt) {
  full_url <- paste0(base_url, model, ":generateContent")

  body <- jsonlite::toJSON(list(
    contents = list(
      list(
        parts = list(
          list(text = paste0(prompt, ":\n\n", text))
        )
      )
    )
  ), auto_unbox = TRUE)

  response <- httr::POST(
    url = paste0(full_url, "?key=", Sys.getenv("GEMINI_API_KEY")),
    httr::content_type_json(),
    body = body
  )

  result <- httr::content(response, as = "text", encoding = "UTF-8")
  json <- jsonlite::fromJSON(result)
  return(json$candidates$content$parts[[1]]$text)
}
```

R/Python are the most logical languages for a genAI tool to interact with a health economic model – Excel is problematic

Wickham H (2024). httr2: Perform HTTP Requests and Process the Responses_. R package version 1.0.7, http://project.org/package=httr2

Challenges

Higher initial setup time compared to building a single model; efficiency gains typically emerge after ~3–5 value edits or adaptations.

Requires a diverse skillset, including R, R Markdown/Markdown, API calls, prompt engineering, health economic evaluation, BiBTeX referencing, and Excel.

Risk of inconsistency: some changes must be made in multiple locations, increasing the chance of error if not carefully managed.

Potential downsides for team development, including over-reliance on automation and reduced contextual understanding—especially concerning for training junior staff.

Opportunities

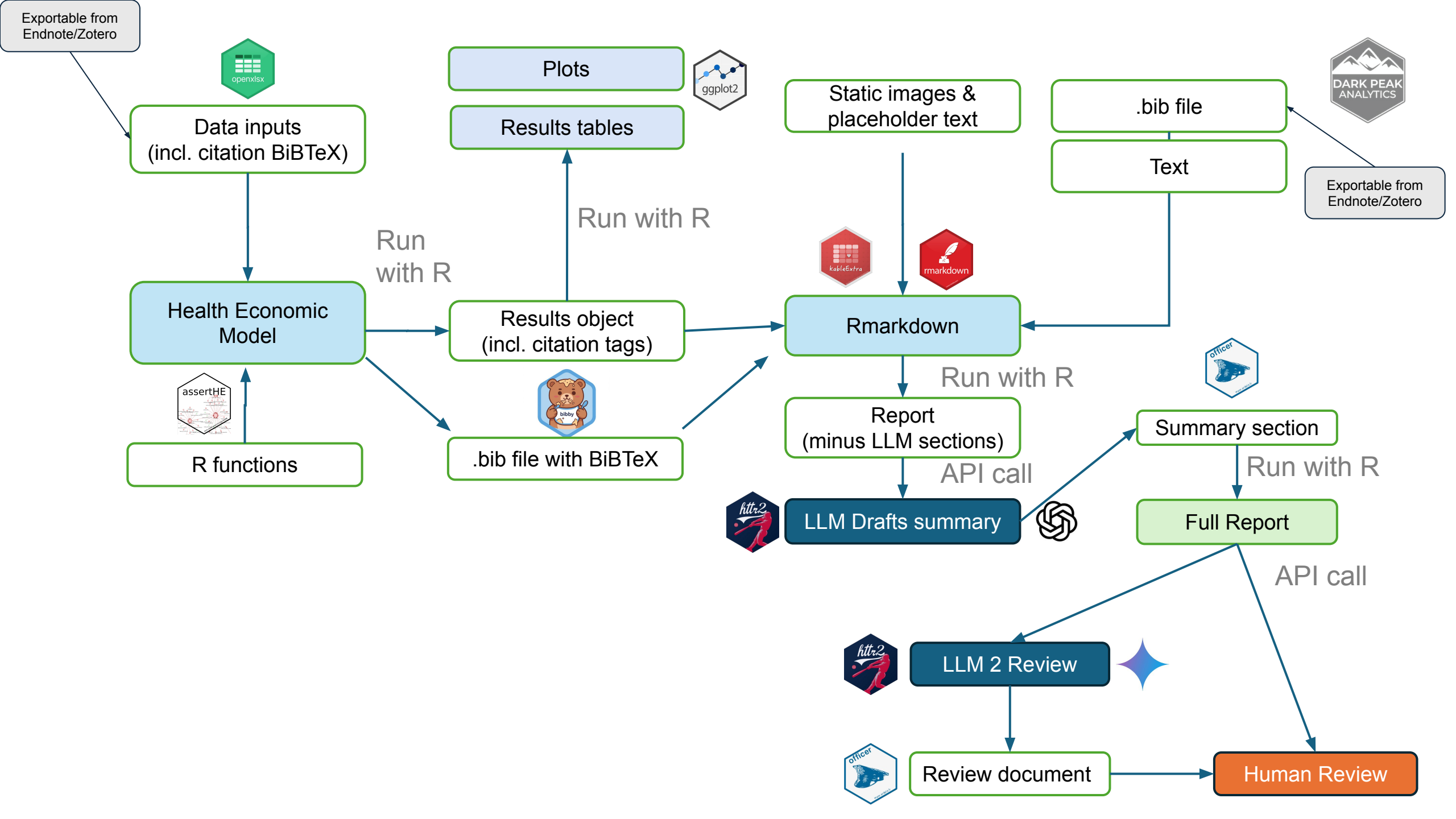
Developing a user interface enables non-programmers to contribute meaningfully to the modelling process.

High value in complex or dynamic contexts, such as models covering multiple countries (3+) or those requiring regular data updates (e.g. early models or living HTAs).

Script-based models align well with LLM capabilities, making them easier to review, validate, and incrementally improve.

LLMs can reduce manual effort, taking on minor edits and supporting model validation, freeing up human time from repetitive tasks like copy-pasting.

Extra Slides


Exportable from Endnote/Zotero
openxlsx
Data inputs (incl. citation BiBTeX)
Health Economic Model
assertHE
R functions
Run with R
Plots
ggplot2
Results tables
Run with R
Results object (incl. citation tags)
bibby
.bib file with BiBTeX
Static images & placeholder text
kableExtra
rmarkdown
Rmarkdown
.bib file
Text
DARK PEAK ANALYTICS
Exportable from Endnote/Zotero
Run with R
Report (minus LLM sections)
API call
httr2
LLM Drafts summary
officer
Summary section
Run with R
Full Report
API call
httr2
LLM 2 Review
officer
Review document
Human Review

The inputs

- Inputs provided in Excel with named ranges & read into a list object in R using openxlsx (Schauberger & Walker, 2023).
- Inputs include:
  - Parameter names
  - Parameter values
  - Parameter strings (for use in text)
  - Parameter citations (in BiBTeX format)
- Decision to use named ranges not obvious but preferred by clients.

Excel inputs sheet

Schauberger P, Walker A (2023). _openxlsx: Read, Write and Edit xlsx Files_. R package version 4.2.5.2, https://CRAN.R-project.org/package=openxlsx

The health economic model

- ICER Severe Asthma Model, translated from Excel -> R.
- Model run on input object & results object generated.
- The model is a Markov model with 4 states: mild, …, dead.
- It runs 1000 PSA iterations in x seconds.
- It is documented in Roxygen & has unit tests for each function as described in Smith, Mohammed & Schneider (2023).

Image showing model structure

Smith, R., Mohammed, W. and Schneider, P., 2023. Packaging cost-effectiveness models in R: A tutorial. *Wellcome Open Research*, *8*.

The report

- R-markdown report (yes we are aware of Quarto!)
- Tables & plots pulled in from R model outputs
- Text input from multiple files (e.g. introduction.txt), allowing non-technical users to provide their own introduction sections.
- Version controlled on GitHub to allow to link to model used.
- References handled in two .bib files. One provided for references in context text, one autogenerated by R.

Image showing citations process