CODECHECK certificate 2020-010

https://doi.org/10.5281/zenodo.3865491

Item	Value
Title	Report 9: Impact of non-pharmaceutical interventions (NPIs) to reduce COVID-19 mortality and healthcare demand. March 16, 2020.
Authors	Neil Ferguson , COVID-19 Response Team
Reference	Imperial College Preprint https://doi.org/10.25561/77482
Codechecker	Stephen J. Eglen
Date of check	2020-05-29 12:20:00
Summary	Replication of key findings from Report 9 using CovidSim reimplementation.
Repository	https://github.com/codecheckers/covid-report9

Table 1: CODECHECK summary

Output	Comment	Size (b)
GB_mitigation_release/table3.png	manuscript Table 3 (mitigation strategies)	89964
GB_mitigation_release/tablea1.png	manuscript Table A1 (mitigation strategies)	70155
GB_suppress_release/table4.png	manuscript Table 4 (suppression strategies)	160375
GB_suppress_release/table5.png	manuscript Table 5 (suppression strategies)	45794

Table 2: Summary of output files generated

Summary

I was able to reproduce the results (Tables 3, 4, 5 and A1) from Report 9. Given the large size of each simulation, and the number of simulations, it required significant compute resource (about 24 hours on a departmental HPC server) to reproduce the findings in Report 9. Simulations were repeated using the public CovidSim implementation, first released in April 2020 onto GitHub, rather than the private code used to generate the findings in Report 9. Small variations (mostly under 5%) in the numbers were observed between Report 9 and my runs. By visual comparison of the original and replicated Tables, I observed 3 significant differences:

1. Table A1: R0=2.2, trigger = 3000, PC_CI_HQ_SDOL70, peak beds (in thousands): 40 vs 30, a 25% decrease.
2. Table 5: on trigger = 300, off trigger = 0.75, PC_CI_HQ_SD, total deaths: 39,000 vs 43,000, a 10% increase.
3. Table 5: on trigger = 400, off trigger = 0.75, CI_HQ_SD, total deaths: 100,000 vs 110,000, a 10% increase.

These variations between the original reported values and the reproductions are due to several factors:

1. The CovidSim code base is now deterministic.
2. Slightly different population input files have been used.
3. These results are the average of NR=10 runs, rather than just one simulation as used in Report 9.

However, although the absolute values do not match the initial report, the overall trends are consistent with the original report. Note also that my independent run matches results by the Imperial team as of 2020-05-28.

CODECHECK notes

Installation of CovidSim

The public version of CovidSim was cloned from https://github.com/mrc-ide/covid-sim. For these runs, the master version from commit b125307 (2020-05-27) was used. This version is deterministic across all platforms. This was compiled for local workstations and for a departmental HPC resource.

Input parameter files

Input parameter files and R scripts were provided by Prof Ferguson and are now available from covid-sim in the report9 folder.

Running the model

Powershell scripts to generate the suppression and mitigation results were converted to bash and are provided in the CODECHECK repository. These bash scripts generate a list of jobs that can then be executed on a local machine or submitted as jobs to a cluster. Each job corresponded to running CovidSim ten times with the same parameter settings. More details below.

Initialisation steps

In each of the suppression and mitigation folders, the output from `runonce.sh` was run to generate two further input files, *NetworkGB_8T.bin* and *NoInt_R0=2.4.avNE.severity.xls.* These files were identical in the two folders.

Two folders were then generated to store the results of the batch runs:

```
mkdir GB_suppress_release/mean8
mkdir GB_mitigation_release/MeanT8_NR10a
```

Batch jobs

The list of jobs to run for each scenario was generated from the bash scripts GB_suppress_release/batch.sh and GB_mitigation_release/batch.sh. These generated two job lists: GB_suppress_release/batch-jobs.txt and GB_mitigation_release/batch-jobs.txt

These jobs took about 3 days on a 64-core workstation, and about 1 day on a departmental HPC cluster. To repeat these runs on other computers will depend on your job submission system. However on a linux machine, one simple way to start the jobs (with -j being the number the number of jobs to run in parallel) is:

```
parallel -j8 < batch-jobs.txt
```

Analysis

Each run generated a tab-delimited file (labelled as an .xls) file in the output folder. Two R scripts (both named *summariseSev.r*) provided by Prof Ferguson were used to summarise these runs into two summary files: GB_suppress_release/mean8/stats_contain.csv and GB_mitigation_release/MeanT8_NR10/stats_mitigation.csv.

These files were compared against the values generated by Prof Ferguson and stored in the Excel spreadsheets with *compare_stats.R* scripts in each strategy folder. The results were found to be identical. Inserting my results into his Excel spreadsheet generated the same pivot tables. I took screenshots of these pivot tables to include in this report. The Excel summary spreadsheets are available in the repository.

Acknowledgements

I would like to thank Prof Ferguson and colleagues for promptly answering any queries I had with this reproduction. Dr Kornet (Cambridge) helped with installation of CovidSim and job submission scripts for the HPC cluster. Dr Kronhaus (Cambridge) and Mr Nüst (Münster) provided comments on a draft of this document. CODECHECK is financially supported by the Mozilla foundation.

Citing this document

Eglen, Stephen J. (2020). CODECHECK Certificate 2020-010. Zenodo. https://doi.org/10.5281/zenodo.3865491

DOIs may take a few hours to activate after the certificate is registered. A copy of the certificate is available at https://github.com/codecheckers/covid-report9/blob/master/codecheck/codecheck.pdf.

About CODECHECK

This certificate confirms that the codechecker could independently reproduce the results of a computational analysis given the data and code from a third party. A CODECHECK does not check whether the original computation analysis is correct. However, as all materials required for the reproduction are freely available by following the links in this document, the reader can then study for themselves the code and data.

	Trigger (cumulative ICU cases)	PC	CI	CI_HQ	CI_HQ_SD	CI_SD	_HQ_SDOLT	I_HQ_SDOL70
R0=2.4 Peak beds	100	15%	34%	52%	35%	53%	66%	71%
	300	15%	34%	52%	35%	59%	66%	73%
	1000	15%	34%	52%	41%	66%	66%	79%
	3000	12%	34%	52%	53%	77%	66%	79%
R0=2.2 Peak beds	100	21%	35%	55%	22%	39%	67%	49%
	300	21%	35%	55%	25%	42%	68%	53%
	1000	20%	35%	55%	32%	52%	68%	63%
	3000	14%	35%	55%	45%	68%	68%	80%
R0=2.4 Total deaths	100	2%	18%	30%	13%	20%	48%	29%
	300	2%	18%	30%	13%	23%	48%	30%
	1000	2%	18%	30%	15%	27%	48%	31%
	3000	2%	18%	30%	19%	32%	48%	32%
R0=2.2 Total deaths	100	2%	21%	32%	9%	15%	48%	21%
	300	3%	21%	32%	10%	17%	48%	21%
	1000	4%	21%	32%	11%	21%	49%	23%
	3000	3%	21%	32%	15%	27%	49%	28%

Figure C1: manuscript Table 3 (mitigation strategies)

	Trigger (cumulative ICU cases)	PC	CI	CI_HQ	CI_HQ_SD	CI_SD	CI_HQ_SDOL70	PC_CI_HQ_SDOL70
R0=2.4 Peak beds	100	154	119	87	118	84	62	52
	300	153	119	87	118	75	62	50
	1000	155	119	87	107	61	62	39
	3000	160	119	87	85	41	62	37
R0=2.2 Peak beds	100	121	101	70	119	94	50	78
	300	121	101	70	115	89	50	72
	1000	123	101	70	104	73	50	56
	3000	131	101	70	85	49	50	30
R0=2.4 Total deaths	100	497	417	356	441	403	262	357
	300	495	417	356	438	391	261	357
	1000	495	417	356	428	370	261	350
	3000	495	417	356	412	346	262	342
R0=2.2 Total deaths	100	448	365	311	418	388	238	364
	300	445	365	311	415	379	237	361
	1000	442	365	311	407	361	235	352
	3000	445	365	311	392	335	235	330

Figure C2: manuscript Table A1 (mitigation strategies)

		Total deaths				Peak ICU beds				Proportion of time with SD in place		
R0	Trigger	Do nothing	CI_HQ_SD	PC_CI_SD	PC_CI_HQ_SD	Do nothir	CI_HQ_SD	PC_CI_SD	PC_CI_HQ_SD	CI_HQ_SD	PC_CI_SD	PC_CI_HQ_SD
2	60	410,000	49,000	7,300	6,000	130,000	3,600	1,000	990	96%	73%	61%
	100	410,000	49,000	11,000	8,700	130,000	3,700	1,400	1,400	95%	72%	59%
	200	410,000	48,000	18,000	15,000	130,000	3,900	2,100	2,000	95%	67%	58%
	300	410,000	47,000	24,000	21,000	130,000	4,000	2,600	2,400	94%	64%	56%
	400	410,000	47,000	31,000	27,000	130,000	4,100	3,200	2,900	91%	63%	55%
2.2	60	460,000	65,000	9,800	7,500	150,000	8,100	1,100	1,100	96%	82%	71%
	100	460,000	65,000	15,000	11,000	150,000	8,000	1,700	1,600	90%	80%	69%
	200	460,000	66,000	24,000	19,000	150,000	7,700	2,700	2,500	89%	75%	65%
	300	460,000	69,000	35,000	26,000	150,000	7,500	3,500	3,200	84%	73%	64%
	400	460,000	72,000	44,000	33,000	150,000	7,300	4,200	3,700	82%	72%	62%
2.4	60	510,000	89,000	13,000	9,500	180,000	11,000	1,200	1,100	84%	89%	79%
	100	510,000	90,000	19,000	14,000	180,000	11,000	1,700	1,600	80%	88%	77%
	200	510,000	94,000	32,000	25,000	180,000	10,000	3,200	2,800	73%	82%	75%
	300	510,000	98,000	46,000	35,000	180,000	11,000	4,500	3,800	70%	81%	74%
	400	510,000	100,000	56,000	42,000	180,000	11,000	5,300	4,500	67%	80%	72%
2.6	60	550,000	120,000	23,000	13,000	220,000	16,000	1,700	1,500	68%	94%	86%
	100	550,000	120,000	28,000	19,000	220,000	16,000	2,300	2,100	66%	92%	84%
	200	550,000	120,000	45,000	33,000	220,000	16,000	4,000	3,600	61%	88%	82%
	300	550,000	120,000	58,000	43,000	220,000	16,000	5,400	4,700	58%	85%	78%
	400	550,000	130,000	71,000	53,000	220,000	16,000	6,700	5,700	56%	82%	75%

Figure C3: manuscript Table 4 (suppression strategies)

On trigger	Off trigger as proportion of on trigger	Total deaths		
		CI_HQ_SD	PC_CI_SD	PC_CI_HQ_SD
60	0.25	89,000	13,000	9,500
	0.5	89,000	14,000	11,000
	0.75	89,000	15,000	11,000
100	0.25	90,000	19,000	14,000
	0.5	91,000	21,000	16,000
	0.75	92,000	22,000	17,000
200	0.25	94,000	32,000	25,000
	0.5	96,000	36,000	28,000
	0.75	97,000	40,000	30,000
300	0.25	98,000	46,000	35,000
	0.5	100,000	51,000	39,000
	0.75	100,000	54,000	43,000
400	0.25	100,000	56,000	42,000
	0.5	100,000	62,000	49,000
	0.75	110,000	67,000	52,000

Figure C4: manuscript Table 5 (suppression strategies)

About this document

This document was created using R Markdown using the `codecheck` R package. `make codecheck.pdf` will regenerate the report file.

```r
sessionInfo()
```

```
## R version 4.0.0 (2020-04-24)
## Platform: x86_64-pc-linux-gnu (64-bit)
## Running under: Manjaro Linux
##
## Matrix products: default
## BLAS:   /usr/lib/libopenblasp-r0.3.9.so
## LAPACK: /usr/lib/liblapack.so.3.9.0
##
## locale:
##  [1] LC_CTYPE=en_GB.UTF-8       LC_NUMERIC=C
##  [3] LC_TIME=en_GB.UTF-8        LC_COLLATE=en_GB.UTF-8
##  [5] LC_MONETARY=en_GB.UTF-8    LC_MESSAGES=en_GB.UTF-8
##  [7] LC_PAPER=en_GB.UTF-8       LC_NAME=C
##  [9] LC_ADDRESS=C               LC_TELEPHONE=C
## [11] LC_MEASUREMENT=en_GB.UTF-8 LC_IDENTIFICATION=C
##
## attached base packages:
## [1] stats     graphics  grDevices utils     datasets
## [6] methods   base
##
## other attached packages:
##  [1] readr_1.3.1          tibble_3.0.1
##  [3] rprojroot_1.3-2      codecheck_0.0.0.9003
##  [5] knitr_1.28           rmarkdown_2.1.10
##  [7] parsedate_1.2.0      assertthat_0.2.1
##  [9] R.cache_0.14.0       gh_1.1.0
## [11] stringr_1.4.0        yaml_2.2.1
## [13] xtable_1.8-4         zen4R_0.3-1
##
## loaded via a namespace (and not attached):
##  [1] Rcpp_1.0.4.6      highr_0.8         compiler_4.0.0
##  [4] pillar_1.4.4      R.methodsS3_1.8.0 R.utils_2.9.2
##  [7] tools_4.0.0       digest_0.6.25     jsonlite_1.6.1
## [10] evaluate_0.14     lifecycle_0.2.0   pkgconfig_2.0.3
## [13] rlang_0.4.6       cli_2.0.2         xfun_0.14
## [16] httr_1.4.1        xml2_1.3.2        hms_0.5.3
## [19] vctrs_0.3.0       glue_1.4.1        R6_2.4.1
## [22] fansi_0.4.1       magrittr_1.5      backports_1.1.6
## [25] htmltools_0.4.0   ellipsis_0.3.1    rvest_0.3.5
## [28] stringi_1.4.6     crayon_1.3.4      R.oo_1.23.0
```