

# Case study - Screening CKD CEA

Xavier G.L.V. Pouwels

## Introduction

This vignette showcases how to use the functionalities of **pacheck** on a health economic model developed in Python focusing on the health economic impact on screening for Chronic Kidney Disease (Cusick et al. 2023).

## Loading packages and data

```
#library(pacheck)
devtools::load_all()
```

i Loading pacheck

Warning: replacing previous import 'glmnet::na.replace' by 'gtools::na.replace' when loading 'pacheck'

Warning: replacing previous import 'boot::logit' by 'gtools::logit' when loading 'pacheck'

Warning: replacing previous import 'boot::inv.logit' by 'gtools::inv.logit' when loading 'pacheck'

Warning: replacing previous import 'magrittr::is\_less\_than' by 'testthat::is\_less\_than' when loading 'pacheck'

Warning: replacing previous import 'magrittr::not' by 'testthat::not' when loading 'pacheck'

Warning: replacing previous import 'magrittr::equals' by 'testthat::equals' when loading 'pacheck'

Warning: replacing previous import 'dplyr::matches' by 'testthat::matches' when loading 'pacheck'

Warning: replacing previous import 'assertthat::has\_name' by 'tibble::has\_name' when loading 'pacheck'

Warning: replacing previous import 'magrittr::extract' by 'tidyr::extract' when loading 'pacheck'

Warning: replacing previous import 'testthat::matches' by 'tidyr::matches' when loading 'pacheck'

```
set.seed(1234)
data("df_ckd_inputs")
data("df_ckd_results")
```

## Preparing dataset for use in pacheck

The following code chunk prepares the inputs and outputs list of the CKD Screening CEA to use the `pacheck` tests. In this example, only a subset of all inputs is used for convenience.

```
df_ckd_results_wide <- df_ckd_results |>
  mutate(intervention = ifelse(intervention == "[0, 10, 20, 30, 40]", "Screening", intervention))
  select(!c(full_index, Starting.age, dapa.costs, avg.on.dapa)) |>
  pivot_wider(names_from = intervention,
              names_sep = "_",
              values_from = !intervention
              )
df_ckd_results_wide <- data.frame(apply(df_ckd_results_wide, 2, unlist))
df_ckd <- cbind(df_ckd_inputs,
               df_ckd_results_wide)
df_ckd$Unnamed..0 <- df_ckd$iteration <- NULL

# Add utility values defined in model script
## General population utility values
df_ckd$male_35_QALY <- 0.925
```

```
df_ckd$male_45_QALY <- 0.894
df_ckd$male_55_QALY <- 0.870
df_ckd$male_65_QALY <- 0.852
df_ckd$male_75_QALY <- 0.816
df_ckd$male_85_QALY <- 0.807

df_ckd$female_35_QALY <- 0.900
df_ckd$female_45_QALY <- 0.871
df_ckd$female_55_QALY <- 0.846
df_ckd$female_65_QALY <- 0.822
df_ckd$female_75_QALY <- 0.784
df_ckd$female_85_QALY <- 0.747
```

## Testing plausibility of model inputs and outputs

One way to test the plausibility of model inputs and outputs is simply to inspect the summary statistics of each variable. This can be done with the `pacheck` package using the `generate_sum_stats` function. The correlation between (specific) inputs and outputs of the health economic model can be generated using the `generate_cor` function. This allows to investigate whether the relation between inputs and outputs.

In addition, one can check whether the mean quality of life of individuals within the model (total undiscounted quality adjusted life years divided by total undiscounted life years) lies within the minimal and maximal utility value in each iteration (using the `check_mean_qol` function).

```
# Summary stats
generate_sum_stats(df = df_ckd[, c(grep("Screening", names(df_ckd)),
                                   grep("Placebo", names(df_ckd)))])
```

	Parameter	Mean	SD	Percentile_2.5th
1	LY.disc_Screening	23.839	0.050	23.739
2	LY_Screening	43.925	0.213	43.501
3	QALY.disc_Screening	19.148	0.604	17.817
4	QALY_Screening	33.918	1.344	30.975
5	cost.disc_Screening	261051.986	33438.786	199122.533
6	costs_Screening	587064.127	74317.644	449964.540
7	kf_incidence_Screening	2.049	1.081	0.538
8	ace.costs_Screening	2382.605	520.850	1451.878
9	screening.costs_Screening	170.428	23.700	123.628

10	discounted.screening.costs_Screening	117.816	15.955	86.244		
11	diagnosis.costs_Screening	179.832	31.508	125.202		
12	PSA.screening...office_Screening	52.360	6.913	38.499		
13	dis_LY_detected_Screening	8.070	0.920	6.353		
14	dis_QALY_detected_Screening	6.229	0.766	4.821		
15	dis_cost_detected_Screening	111076.481	17999.440	79798.658		
16	detected_total_Screening	0.601	0.049	0.507		
17	original.treated_Screening	0.001	0.000	0.001		
18	LY.disc_Placebo	23.823	0.049	23.717		
19	LY_Placebo	43.857	0.211	43.408		
20	QALY.disc_Placebo	19.129	0.605	17.795		
21	QALY_Placebo	33.855	1.342	30.934		
22	cost.disc_Placebo	258120.136	33370.902	196189.082		
23	costs_Placebo	579781.217	74070.352	443079.013		
24	kf_incidence_Placebo	2.316	1.138	0.682		
25	ace.costs_Placebo	127.389	28.565	77.016		
26	screening.costs_Placebo	0.000	0.000	0.000		
27	discounted.screening.costs_Placebo	0.000	0.000	0.000		
28	diagnosis.costs_Placebo	0.000	0.000	0.000		
29	PSA.screening...office_Placebo	52.360	6.913	38.499		
30	dis_LY_detected_Placebo	0.464	0.063	0.341		
31	dis_QALY_detected_Placebo	0.299	0.045	0.213		
32	dis_cost_detected_Placebo	13816.880	3231.202	8558.803		
33	detected_total_Placebo	0.143	0.025	0.100		
34	original.treated_Placebo	0.001	0.000	0.001		
	Percentile_97.5th	Minimum	Maximum	Median	Skewness	Kurtosis
1	23.925	23.658	23.994	23.843	-0.345	2.930
2	44.284	43.143	44.563	43.943	-0.360	2.865
3	20.097	16.212	20.412	19.229	-0.791	4.135
4	36.069	27.391	36.779	34.049	-0.762	4.073
5	326689.961	163575.058	357513.425	259162.244	0.058	2.538
6	731880.360	369210.041	803231.321	583185.348	0.061	2.546
7	4.561	0.199	8.016	1.834	1.044	4.723
8	3458.341	1056.600	4457.220	2371.065	0.287	3.022
9	218.491	103.631	240.621	169.819	0.035	2.784
10	150.069	73.005	162.031	117.797	-0.001	2.774
11	243.959	96.650	295.137	178.127	0.346	3.024
12	65.929	33.104	70.924	52.576	-0.047	2.767
13	9.930	5.901	11.887	8.048	0.287	3.313
14	7.792	4.219	9.453	6.219	0.242	3.320
15	148147.897	66851.373	177291.203	110010.570	0.288	2.880
16	0.697	0.459	0.782	0.603	0.037	2.941
17	0.002	0.000	0.002	0.001	0.461	2.570

18	23.908	23.655	23.982	23.826	-0.327	2.953
19	44.215	43.102	44.508	43.870	-0.353	2.878
20	20.080	16.212	20.404	19.211	-0.786	4.109
21	36.006	27.391	36.750	34.010	-0.756	4.044
22	323972.491	161526.128	354012.767	256113.989	0.057	2.539
23	724751.751	364489.994	794992.643	575199.901	0.061	2.546
24	4.989	0.257	8.016	2.115	0.885	4.150
25	188.832	49.189	233.590	125.515	0.471	3.369
26	0.000	0.000	0.000	0.000	NaN	NaN
27	0.000	0.000	0.000	0.000	NaN	NaN
28	0.000	0.000	0.000	0.000	NaN	NaN
29	65.929	33.104	70.924	52.576	-0.047	2.767
30	0.590	0.294	0.688	0.463	0.070	2.845
31	0.393	0.154	0.455	0.299	0.108	3.065
32	21086.041	6047.245	26401.459	13736.850	0.577	3.640
33	0.192	0.078	0.248	0.144	0.181	2.897
34	0.002	0.000	0.002	0.001	0.461	2.570

```
## only for the outcomes for the sake of brevity
```

```
# Check correlations between inputs and outputs
```

```
##e.g. screening costs and higher ACE.costs should lead to higher screening costs and total costs
```

```
generate_cor(df = df_ckd,
```

```
vars = c("screening_cost", "ACE.cost", "ace.costs_Screening", "ace.costs_Placebo", "costs_Screening", "costs_Placebo"))
```

	screening_cost	ACE.cost	ace.costs_Screening
screening_cost	1.000000000	-0.003174668	0.01589675
ACE.cost	-0.003174668	1.000000000	0.02133284
ace.costs_Screening	0.015896751	0.021332839	1.000000000
ace.costs_Placebo	0.012761751	0.031060510	0.57009617
costs_Screening	-0.015980451	-0.043940540	0.04000416
costs_Placebo	-0.015715541	-0.043832696	0.02417731

  

	ace.costs_Placebo	costs_Screening	costs_Placebo
screening_cost	0.01276175	-0.01598045	-0.01571554
ACE.cost	0.03106051	-0.04394054	-0.04383270
ace.costs_Screening	0.57009617	0.04000416	0.02417731
ace.costs_Placebo	1.00000000	0.03882038	0.03066481
costs_Screening	0.03882038	1.00000000	0.99976612
costs_Placebo	0.03066481	0.99976612	1.00000000

```
## negative correlation between screening_cost and costs_Screening,
## weak positive correlation between ACE.cost and total ACE costs
## weak negative correlation with total costs of strategies

# Specific checks
## mean quality of life between minimal and maximal utility values
v_vars_u <- grep("_QALY", names(df_ckd), value = TRUE)
v_vars_u <- v_vars_u[-grep("dis", v_vars_u)]

check_mean_qol(df = df_ckd,
               t_qaly = "QALY_Screening",
               t_ly = "LY_Screening",
               u_values = v_vars_u)
```

```
Mean_QoL_below_min Mean_QoL_above_max
"None"              "None"
```

```
check_mean_qol(df = df_ckd,
               t_qaly = "QALY_Placebo",
               t_ly = "LY_Placebo",
               u_values = v_vars_u)
```

```
Mean_QoL_below_min Mean_QoL_above_max
"None"              "None"
```

```
## Costs, prevalence, HR are positive
v_vars_prev <- grep("prev", names(df_ckd), value = TRUE)
v_vars_c <- grep("_cost", names(df_ckd), value = TRUE)
v_vars_hr <- grep(".HR", names(df_ckd), value = TRUE)
# v_vars_c <- v_vars_c[-grep("inc", v_vars_c)]
check_positive(c(v_vars_prev, v_vars_c, v_vars_hr), df = df_ckd)
```

	Input	Negative_values
1	diabetic_prevalence_30_39	None
2	diabetic_prevalence_40_49	None
3	diabetic_prevalence_50_59	None
4	diabetic_prevalence_60_69	None
5	diabetic_prevalence_70_79	None
6	DM_prev_30_39	None
7	DM_prev_40_49	None

8	DM_prev_50_59	None
9	DM_prev_60_69	None
10	DM_prev_70	None
11	screening_cost	None
12	provider_cost	None
13	eGFR_cost	None
14	ultrasound_cost	None
15	disutility_medication_cost	None
16	UTI_event_cost	None
17	DKA_event_cost	None
18	Stage3a_overall_cost	None
19	Stage3b_overall_cost	None
20	Stage4_overall_cost	None
21	Stage5_overall_cost	None
22	Stage3a_DM_overall_cost	None
23	Stage3b_DM_overall_cost	None
24	Stage4_DM_overall_cost	None
25	Stage3a_NDM_cost	None
26	Stage3b_NDM_cost	None
27	Stage4_NDM_cost	None
28	Stage5_NDM_cost	None
29	Stage3a_DM_cost	None
30	Stage3b_DM_cost	None
31	Stage4_DM_cost	None
32	Stage5_DM_cost	None
33	baseline_costs	None
34	dis_cost_detected_Placebo	None
35	dis_cost_detected_Screening	None
36	DM_NDM_HR	None
37	diabetic.ACM.HR	None
38	diabetic.kidney.HR	None
39	non.diabetic.ACM.HR	None
40	non.diabetic.kidney.HR	None

## Reference

Cusick, Marika M., Rebecca L. Tisdale, Glenn M. Chertow, Douglas K. Owens, and Jeremy D. Goldhaber-Fiebert. 2023. "Population-Wide Screening for Chronic Kidney Disease: A Cost-Effectiveness Analysis." *Annals of Internal Medicine* 176 (6): 788–97. <https://doi.org/10.7326/M22-3228>.