Practical assignment discounting - Solution

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Assignment and solutions

1. Define a new object `r_disc`, which is the discount rate that will be used in the current assignment, and set its value to `0.05` (meaning 5% discount annualy)

```
rm(list  = ls()) # clear environment
df_thx <- readRDS("data_discount.rds") # Load data

# Define discount rates
r_disc <- 0.05

# Show data frame
kable(df_thx)
```

Year	Inc_cost_A	Inc_QALY_A	Inc_cost_B	Inc_QALY_B	Inc_cost_C	Inc_QALY_C
0	20000	0	20000	0	10000	0.0
1	20000	1	20000	0	10000	0.5
2	20000	1	20000	0	10000	0.5
3	0	1	0	0	10000	0.5
4	0	1	0	0	10000	0.5
5	0	0	0	0	10000	0.5
6	0	0	0	0	0	0.5
7	0	0	0	0	0	0.5
8	0	0	0	0	0	0.5
9	0	0	0	1	0	0.0
10	0	0	0	1	0	0.0
11	0	0	0	1	0	0.0
12	0	0	0	1	0	0.0

2. Calculate the total undiscounted incremental costs and effects for each intervention

```
v_res_undisc <- colSums(df_thx[, c(2:ncol(df_thx))]) # Calculate total undiscounted costs
kable(v_res_undisc)
```

	x
Inc_cost_A	60000
Inc_QALY_A	4

	x
Inc_cost_B	60000
Inc_QALY_B	4
Inc_cost_C	60000
Inc_QALY_C	4

3. Calculate the **undiscounted** ICERS for each of these interventions using the total incremental costs and effects you calculated under step 2

```
v_res_undisc <- unname(v_res_undisc) # remove names for clarity

v_icer_undisc <- c(ICER_A = v_res_undisc[1]/v_res_undisc[2],
                   ICER_B = v_res_undisc[3]/v_res_undisc[4],
                   ICER_C = v_res_undisc[5]/v_res_undisc[6]
) # calculate undiscounted ICERs

kable(v_icer_undisc)
```

	x
ICER_A	15000
ICER_B	15000
ICER_C	15000

3.a. Question: what are the total incremental costs and effects for each intervention? Which intervention provides the highest **undiscounted** incremental costs and effects?
3.a. **Answer:** There are no differences concerning the UNDISCOUNTED incremental costs and effect between the different interventions.
3.b. Question: what are the ICERs for each intervention? Which intervention provides the best value for money (most favourable ICER) based on these **undiscounted** incremental costs and effects?
3.b. **Answer:** There are no differences concerning the UNDISCOUNTED ICERs costs and effect between the different interventions.

4. Create a vector of discount weights for Years 0 to 12.

```
v_disc <- 1/(1+r_disc)^df_thx$Year # create vector of discount weights
kable(v_disc,
      digits = 3) # show
```

x
1.000
0.952
0.907
0.864
0.823
0.784
0.746
0.711
0.677
0.645
0.614
0.585
0.557

5. Apply discounting on the incremental effects and costs (by multiplying each column by the vector of discount weights fo instance) to convert these to their present value. Report the discounted effects and costs in new columns called Inc_cost_A_d, Inc_QALY_A_d, Inc_cost_B_d, Inc_QALY_B_d, Inc_cost_C_d, Inc_QALY_C_d.

```
# Calculate discounted incremental effects and costs
df_thx$Inc_cost_A_d <- df_thx$Inc_cost_A * v_disc
df_thx$Inc_QALY_A_d <- df_thx$Inc_QALY_A * v_disc
df_thx$Inc_cost_B_d <- df_thx$Inc_cost_B * v_disc
df_thx$Inc_QALY_B_d <- df_thx$Inc_QALY_B * v_disc
df_thx$Inc_cost_C_d <- df_thx$Inc_cost_C * v_disc
df_thx$Inc_QALY_C_d <- df_thx$Inc_QALY_C * v_disc

kable(df_thx[,c("Year", "Inc_cost_A", "Inc_QALY_A",
                "Inc_cost_A_d", "Inc_QALY_A_d")],
      digits = 3) # show difference for intervention A
```

Year	Inc_cost_A	Inc_QALY_A	Inc_cost_A_d	Inc_QALY_A_d
0	20000	0	20000.00	0.000
1	20000	1	19047.62	0.952
2	20000	1	18140.59	0.907
3	0	1	0.00	0.864
4	0	1	0.00	0.823
5	0	0	0.00	0.000
6	0	0	0.00	0.000
7	0	0	0.00	0.000
8	0	0	0.00	0.000
9	0	0	0.00	0.000
10	0	0	0.00	0.000

Year	Inc_cost_A	Inc_QALY_A	Inc_cost_A_d	Inc_QALY_A_d
11	0	0	0.00	0.000
12	0	0	0.00	0.000

6. Calculate the total **discounted** incremental costs and effects, and ICERs for each intervention.

```
v_res_disc <- colSums(df_thx[, c("Inc_cost_A_d", "Inc_QALY_A_d",
                                 "Inc_cost_B_d", "Inc_QALY_B_d",
                                 "Inc_cost_C_d", "Inc_QALY_C_d")]) # calculate totals - discounted
kable(v_res_disc,
      digits = 3)
```

	x
Inc_cost_A_d	57188.209
Inc_QALY_A_d	3.546
Inc_cost_B_d	57188.209
Inc_QALY_B_d	2.400
Inc_cost_C_d	53294.767
Inc_QALY_C_d	3.232

```
v_res_disc <- unname(v_res_disc)

v_icer_disc <- c(ICER_A = v_res_disc[1]/v_res_disc[2],
                 ICER_B = v_res_disc[3]/v_res_disc[4],
                 ICER_C = v_res_disc[5]/v_res_disc[6]
) # calculate discounted ICERs

kable(v_icer_disc,
      digits = 3)
```

	x
ICER_A	16127.75
ICER_B	23828.03
ICER_C	16491.73

6.a. Question: what are the total **discounted** incremental costs and effects for each intervention? Which intervention provides the highest **discounted** incremental costs and effects?
6.a. **Answer:** Discounted incremental costs of A and B are equal and remain higher than discounted incremental costs of C. Intervention A provides the highest discounted incremental effects followed by C and B.
6.b. Question: what are the **discounted** ICERs for each intervention? Which intervention provides the best value for money (most favourable ICER) based on these **discounted** incremental costs and effects?
6.b. **Answer:** The discounted ICER of intervention A is the lowest (best value for money), followed by C and then B.
6.c. Can you explain the difference between the results obtained under step 6 and steps 2 and 3?
6.c. **Answer:** All ICERs increase because the health effects of all interventions are more heavily discounted than the costs because the incremental effects occurs later in the future than the costs. Hence, their present value is more heavily discounted than the incremental costs, and the ICERs increase.
7. Now apply a discount rate of **10%** and calculate the **discounted** incremental costs and effects, and

ICERs for each intervention again. Which intervention provides the most and least value for money? Can you explain these results? Are these comparable with results obtained in step 6?

7. **Answer:** The effect observed under step 6 is only reinforced due to the higher yearly discount rate. Changing the discount rate does not change the order (in terms of ICER) of the interventions.

8. Can you explain why, even with a small discount rate (for example 0.1%) cost-effectiveness with discounting is always worse than cost-effectiveness without discounting?

8. **Answer:** For all three programmes, costs are incurred earlier (in earlier years) than health benefits are gained. Consequently, when future costs and future effects are discounted, the present value of health effects decreases more than the present value of costs. Given that health benefits are discounted more heavily than than costs, the cost-effectiveness deteriorates (the ICERs go up) whenever any discount rate >0 % is applied.

```
r_disc_2 <- 0.10
v_disc_2 <- 1/(1+r_disc_2)^df_thx$Year # create vector of discount rates
v_res_disc10 <- apply(df_thx[, c("Inc_cost_A", "Inc_QALY_A",
                                 "Inc_cost_B", "Inc_QALY_B",
                                 "Inc_cost_C", "Inc_QALY_C")], 2, function(x) x %*% v_disc_2) # matrix 
v_icer_disc10 <- c(ICER_A = v_res_disc10[1]/v_res_disc10[2],
                   ICER_B = v_res_disc10[3]/v_res_disc10[4],
                   ICER_C = v_res_disc10[5]/v_res_disc10[6]
) # calculate discounted ICERs, with 10% discount rate

# Comparison all results
m_res_total <- rbind(v_icer_undisc,
                     v_icer_disc,
                     v_icer_disc10)
kable(rbind(v_res_undisc,
        v_res_disc,
        v_res_disc10),
      caption = "Totals using the different discount rates",
      digits = 3)
```

Table 8: Totals using the different discount rates

	Inc_cost_A	Inc_QALY_A	Inc_cost_B	Inc_QALY_B	Inc_cost_C	Inc_QALY_C
v_res_undisc	60000.00	4.000	60000.00	4.000	60000.00	4.000
v_res_disc	57188.21	3.546	57188.21	2.400	53294.77	3.232
v_res_disc10	54710.74	3.170	54710.74	1.479	47907.87	2.667

```
kable(m_res_total,
      caption = "ICERs using the different discount rates",
      digits = 3) #  show results
```

Table 9: ICERs using the different discount rates

	ICER_A	ICER_B	ICER_C
v_icer_undisc	15000.00	15000.00	15000.00
v_icer_disc	16127.75	23828.03	16491.73
v_icer_disc10	17259.64	36997.58	17960.09

```
df_res <- data.frame(cbind(Analysis = c("Undiscounted", "5% discount", "10% discount")),
                     m_res_total)
df_plot <- df_res %>%
    pivot_longer(c(ICER_A, ICER_B, ICER_C), names_to = "Intervention", values_to = "ICER")

 ggplot(data = df_plot, aes(x = Intervention, y = ICER, fill = Analysis)) +
      geom_bar(stat = "identity", position = position_dodge())  +
      theme_bw()
```