Report for the Markov model (cohort state-transition model)

Data and parameters

```
rate_data <- read_csv("data/ghdx_data.csv")
print(xtable(data.frame(rate_data),digits=c(0,0,0,6,6,6),
      caption = "Data from Global Health Data Exchange"),
      caption.placement="top",comment=FALSE)
```

Table 1: Data from Global Health Data Exchange

	index	sex	incidence	death_CVD	death_nonCVD
1	40	male	0.003888	0.000819	0.002494
2	45	male	0.006729	0.001340	0.003399
3	50	male	0.010564	0.002302	0.004951
4	55	male	0.015291	0.003665	0.007282
5	60	male	0.022078	0.006404	0.011159
6	65	male	0.030980	0.011155	0.016946
7	70	male	0.043589	0.019978	0.026305
8	40	female	0.004545	0.000351	0.001137
9	45	female	0.007094	0.000643	0.001620
10	50	female	0.010133	0.001206	0.002475
11	55	female	0.013734	0.002014	0.003705
12	60	female	0.018272	0.003872	0.005850
13	65	female	0.023744	0.006996	0.009060
14	70	female	0.033907	0.013398	0.014907

```
population_data <- read_csv("data/Normal3Stra_data.csv")
population_data <- data.frame(population_data)
```

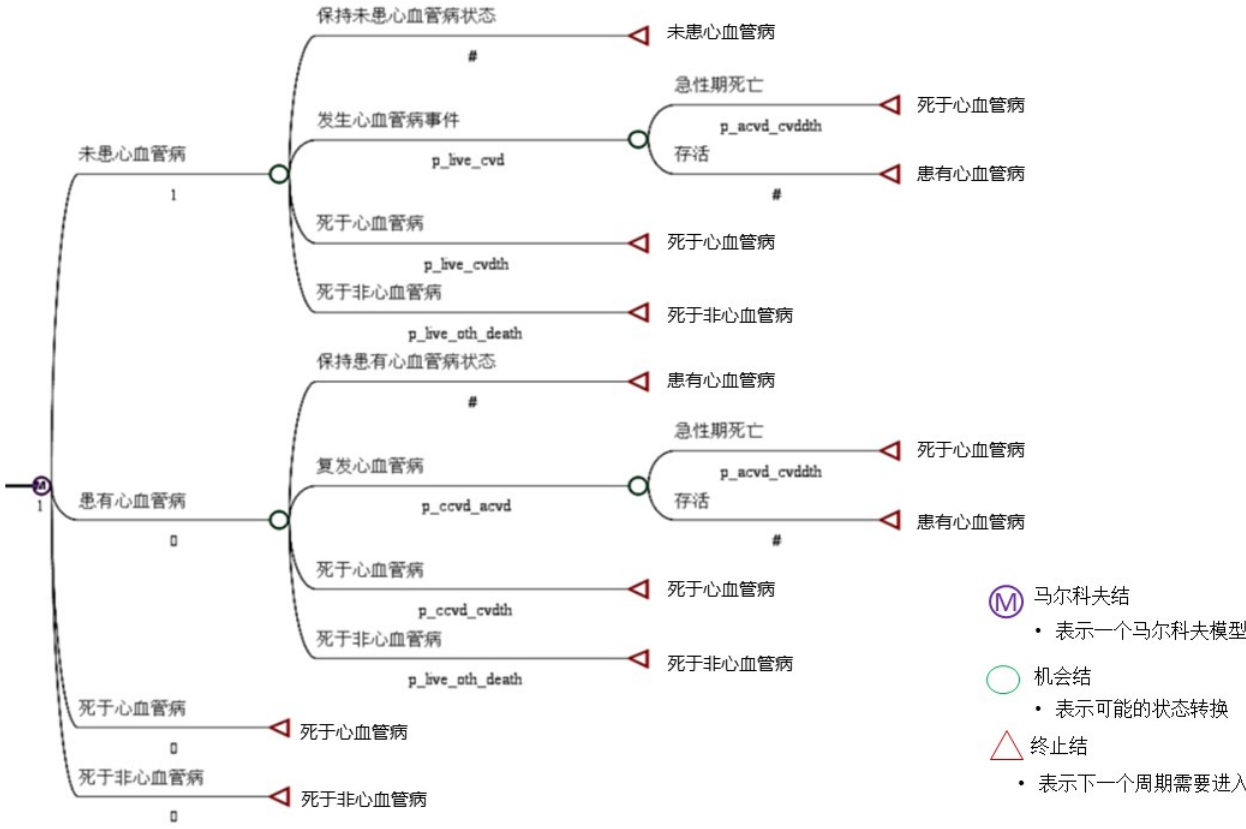
```
n_t <- 10   # time horizon, number of cycles
v_names_states <- c("S1", "S2", "S3", "S4") # S1: live; S2: cvd; S3: cvdth; S4: oth_death
n_states    <- length(v_names_states)   # number of health states
v_names_str <- c("Strategy0","Strategy1", "Strategy2", "Strategy3") # store the strategy names
n_str       <- length(v_names_str)      # number of strategies
names_population <- c("m40","m45","m50","m55","m60","m65","m70",
                      "f40","f45","f50","f55","f60","f65","f70")
# Health utilities
out_cvd_free <- 1   # utility when being S1
out_cvd <- 0.9   # utility when being S2
out_dth <-  0   # utility when being S3 and S4 together
out_trans_to_cvd <- -0.038

uti_values <- c(out_cvd_free, out_cvd, out_dth, out_dth)
```

```
year <- c(1,1,0,0)
HR_cvdhistory_cvd <-    1.37
HR_cvdhistory_cvdth <- 3.12
HR_high_live_cvdth <-   1.17

p_live_oth_death <- rate_to_prob(r=rate_data$death_nonCVD, t = 1)
p_live_cvd <- rate_to_prob(r=rate_data$incidence, t=1)
p_live_cvdth <- rate_to_prob(r=rate_data$death_CVD, t=1)
p_ccvd_acvd <- rate_to_prob(rate_data$incidence*HR_cvdhistory_cvd, t=1)
p_ccvd_cvdth <- rate_to_prob(rate_data$death_CVD*HR_cvdhistory_cvdth, t=1)
# p_acvd_cvddth
```

A transition probability matrix P_t



状态转换概率矩阵

状态	未患心血管病	患有心血管病	死于心血管病	死于非心血管病
未患心血管病	P4	P1	P2	P3
患有心血管病		P6	P5	P3

$$P_t = \begin{Bmatrix} p_{[1,1,t]} & p_{[1,2,t]} & p_{[1,3,t]} & p_{[1,4,t]} \\ p_{[2,1,t]} & p_{[2,2,t]} & p_{[2,3,t]} & p_{[2,4,t]} \\ p_{[3,1,t]} & p_{[3,2,t]} & p_{[3,3,t]} & p_{[3,4,t]} \\ p_{[4,1,t]} & p_{[4,2,t]} & p_{[4,3,t]} & p_{[4,4,t]} \end{Bmatrix}$$

Thus,

$P4 = 1 - P1 - P2 - P3$

$P1 = p\_live\_cvd * (1 - p\_acvd\_cvdth)$

$P2 = p\_live\_cvdth + p\_live\_cvd * p\_acvd\_cvdth$

$P3 = p\_live\_oth\_death$

$P6 = 1 - (p\_ccvd\_cvdth + p\_ccvd\_acvd * p\_acvd\_cvdth) - p\_live\_oth\_death$

$P5 = p\_ccvd\_cvdth + p\_ccvd\_acvd * p\_acvd\_cvdth$

Strategy0

```
noStrategy_data <- read_csv("data/Normal_data.csv")
print(xtable(data.frame(noStrategy_data),digits=c(0,0,0,0),
      caption = "Distribution of the population"),
      caption.placement="top",comment=FALSE)
```

Table 2: Distribution of the population

	index	sex	num
1	40	male	229
2	45	male	444
3	50	male	422
4	55	male	410
5	60	male	322
6	65	male	160
7	70	male	116
8	40	female	498
9	45	female	856
10	50	female	822
11	55	female	842
12	60	female	519
13	65	female	394
14	70	female	187

```
####################### Construct state-transition models for Strategy1 ######################
patient_group <- matrix(noStrategy_data$num, ncol=1,
                        dimnames=list(names_population))
result_m_M <- array(0, dim = c(10, 4, 14),
                    dimnames = list(paste0("t",0:9), v_names_states, names_population))
# p_acvd_cvddth
p8 <-array(runif(140,min=0.02,max=0.1),dim=c(10,14),dimnames=list(1:10,names_population))
p9 <- array(NA, dim=c(10,14),dimnames=list(1:10,names_population))
p10 <- array(NA, dim=c(10,14), dimnames=list(1:10,names_population))
```

```
prob_CVD_group0 <- matrix(0, ncol=14, nrow=10,
                    dimnames=list(paste0("t",0:9),names_population))
prob_CVDlive_group0 <- matrix(0, ncol=14, nrow=10,
                    dimnames=list(paste0("t",0:9),names_population))

result_CVD <- matrix(0, ncol = 1, nrow = 14,
                    dimnames=list(names_population, ""))
result_CVDlive <- matrix(0, ncol = 1, nrow = 14,
                    dimnames=list(names_population, ""))
result_QALY <- matrix(0, ncol = 1, nrow = 14,
                    dimnames=list(names_population, ""))
result_Lifeyear <- matrix(0, ncol = 1, nrow = 14,
                    dimnames=list(names_population, ""))
result_CVDeath <- matrix(0, ncol = 1, nrow = 14,
                    dimnames=list(names_population, ""))
result_nonCVDeath <- matrix(0, ncol = 1, nrow = 14,
                    dimnames=list(names_population, ""))
# create a matrix for p_acvd_cvdth
for(i in 1:14){
  # construct a_P
  if(i == 7 | i == 14){
    a_P <- array(0, dim = c(n_states, n_states, 10),
                 dimnames = list(v_names_states, v_names_states, 1:10))
    a_P["S1", "S1", 1:10] <- 1-(p_live_cvd[i]*(1-p8[1:10,i]) +
                                p_live_cvdth[i]*p_live_cvd[i]*p8[1:10,i] +
                                p_live_oth_death[i])
    a_P["S1", "S2", 1:10] <- p_live_cvd[i]*(1-p8[1:10,i])
    a_P["S1", "S3", 1:10] <- p_live_cvdth[i]*p_live_cvd[i]*p8[1:10,i]
    a_P["S1", "S4", 1:10] <- p_live_oth_death[i]
    a_P["S2", "S1", 1:10] <- 0
    a_P["S2", "S2", 1:10] <- 1-p_live_oth_death[i]-
      (p_ccvd_cvdth[i]+p_ccvd_acvd[i]*p8[1:10,i])
    a_P["S2", "S3", 1:10] <- p_ccvd_cvdth[i]+
      p_ccvd_acvd[i]*p8[1:10,i]
    a_P["S2", "S4", 1:10] <- p_live_oth_death[i]
    a_P["S3", "S3", 1:10] <- 1
    a_P["S4", "S4", 1:10] <- 1
    p9[1:10,i] <- p_ccvd_acvd[i]*(1-p8[1:10,i])
    p10[1:10,i] <- p_live_cvd[i]
  }

  if(i != 7 && i != 14){
    a_P <- array(0, dim = c(n_states, n_states, 10),
                 dimnames = list(v_names_states, v_names_states, 1:10))
    a_P["S1", "S1", 1:5] <- 1-(p_live_cvd[i]*(1-p8[1:5,i]) +
                                p_live_cvdth[i]*p_live_cvd[i]*p8[1:5,i] +
                                p_live_oth_death[i])
    a_P["S1", "S2", 1:5] <- p_live_cvd[i]*(1-p8[1:5,i])
    a_P["S1", "S3", 1:5] <- p_live_cvdth[i]*p_live_cvd[i]*p8[1:5,i]
    a_P["S1", "S4", 1:5] <- p_live_oth_death[i]
    a_P["S2", "S1", 1:5] <- 0
    a_P["S2", "S2", 1:5] <- 1-p_live_oth_death[i]-
      (p_ccvd_cvdth[i]+p_ccvd_acvd[i]*p8[1:5,i])
```

```
    a_P["S2", "S3", 1:5] <- p_ccvd_cvdth[i]+
      p_ccvd_acvd[i]*p8[1:5,i]
    a_P["S2", "S4", 1:5] <- p_live_oth_death[i]
    a_P["S3", "S3", 1:5] <- 1
    a_P["S4", "S4", 1:5] <- 1
    a_P["S1", "S1", 6:10] <-  1-(p_live_cvd[i+1]*(1-p8[6:10,i+1])+
                               p_live_cvdth[i+1]*p_live_cvd[i+1]*p8[6:10,i+1]
                               +p_live_oth_death[i+1])
    a_P["S1", "S2", 6:10] <- p_live_cvd[i+1]*(1-p8[6:10,i+1])
    a_P["S1", "S3", 6:10] <- p_live_cvdth[i+1]*p_live_cvd[i+1]*p8[6:10,i+1]
    a_P["S1", "S4", 6:10] <- p_live_oth_death[i+1]
    a_P["S2", "S1", 6:10] <- 0
    a_P["S2", "S2", 6:10] <- 1-p_live_oth_death[i+1]-
       (p_ccvd_cvdth[i+1]+p_ccvd_acvd[i+1]*p8[6:10,i+1])
    a_P["S2", "S3", 6:10] <- p_ccvd_cvdth[i+1]+p_ccvd_acvd[i+1]*p8[6:10,i+1]
    a_P["S2", "S4", 6:10] <-  p_live_oth_death[i+1]
    a_P["S3", "S3", 6:10] <- 1
    a_P["S4", "S4", 6:10] <- 1
    p9[1:5,i] <- p_ccvd_acvd[i]*(1-p8[1:5,i])
    p9[6:10,i] <- p_ccvd_acvd[i+1]*(1-p8[6:10,i])
    p10[1:5,i] <- p_live_cvd[i]
    p10[6:10,i] <- p_live_cvd[i+1]
  }
  # construct m_M
    v_s_init <- c(state0 = 1, state1 = 0, state2 = 0, state3 = 0)
    m_M <- matrix(0,nrow     = (n_t), ncol = n_states,
                  dimnames = list(0:(n_t-1), v_names_states))
    m_M[1, ] <- v_s_init
    for(t in 1:9){
      m_M[t + 1, ] <- m_M[t, ] %*% a_P[, , t]
    }
  # calculate result
    prob_CVD_group0[ ,i] <- m_M[ ,1] * p10[ ,i]  # new occurence = S1*p10
    # new occurence = s1*p1+s2*p9
    prob_CVDlive_group0[ ,i] <- m_M[ ,1]*(a_P["S1", "S2", 1:10]) + m_M[ ,2]*p9[ ,i]
    result_m_M[ , , i] <- m_M
  result_CVD[i] <- sum(prob_CVD_group0[, i] * patient_group[i])
  result_CVDlive[i] <- sum(prob_CVDlive_group0[, i] * patient_group[i])
  result_Lifeyear[i] <- sum(t(t(m_M) * year) * patient_group[i])
  result_QALY[i] <- sum(t(t(m_M) * uti_values)*patient_group[i] +
                          prob_CVDlive_group0[, i]*out_trans_to_cvd*patient_group[i])
  result_CVDeath[i] <- m_M[10, 3] * patient_group[i]
  result_nonCVDeath[i] <- m_M[10, 4] * patient_group[i]
}
result_m_M[ , ,1] # an example for the patient group 40-45, male
```

```
##           S1          S2           S3          S4
## t0 1.0000000 0.000000000 0.000000e+00 0.000000000
## t1 0.9937886 0.003720419 1.310130e-07 0.002490893
## t2 0.9876486 0.007365092 1.076639e-05 0.004975580
## t3 0.9816080 0.010905609 3.234439e-05 0.007454052
## t4 0.9757065 0.014301390 6.583269e-05 0.009926297
## t5 0.9696266 0.017875894 1.051874e-04 0.012392300
```

```
## t6 0.9602222 0.023844594 1.900998e-04 0.015743123
## t7 0.9510221 0.029588420 3.071864e-04 0.019082288
## t8 0.9420499 0.035081879 4.584556e-04 0.022409725
## t9 0.9328536 0.040799589 6.214720e-04 0.025725358
```

Result for Strategy0

```
result_CVD_stg0 <- sum(result_CVD)
print(xtable(data.frame(rbind(result_CVD,"sum" = result_CVD_stg0)),
             caption = "New CVD events for patients under Strategy0"),
      caption.placement="top",comment=FALSE)
```

Table 3: New CVD events for patients under Strategy0

	V1
m40	11.69
m45	36.16
m50	49.99
m55	67.49
m60	71.23
m65	45.94
m70	37.09
f40	28.02
f45	70.19
f50	91.50
f55	122.55
f60	95.88
f65	94.67
f70	50.84
sum	873.24

```
print(xtable(data.frame(matrix(c(sum(result_CVD),sum(result_CVDeath),sum(result_nonCVDeath),
                                 sum(result_QALY),sum(result_Lifeyear)),nrow = 1, ncol=5,
                                 dimnames = list("", c("CVD events","CVD Death","non-CVD Death",
                                                       "QALY", "Life Year")))),
             caption = "Result for Strategy0"), caption.placement="top",comment=FALSE)
```

Table 4: Result for Strategy0

	CVD.events	CVD.Death	non.CVD.Death	QALY	Life.Year
1	873.24	59.76	337.15	59978.71	60447.68

Table 5: Incidence rate

Item		CVD incidence(HR)	CVD cause-specific mortality (HR)
Strategy 1	Low risk	0.63	1
	Medium risk	1.56	1
	High risk	1.6	1.7
Strategy 2	Low risk	0.43	1
	Medium risk	0.97	1
	High risk	2.06	1.7
Strategy 3	Low risk	0.45	1
	Medium risk	1.09	1
	High risk	2.11	1.7
Intervention	Weight control	0.93	0.93
	Smoke cession	0.85	0.72
	Salt reduction	0.81	0.66
Medication	Statin and antihypertensive	0.7	0.82

```
HR_l_stg1   <- 0.63
HR_m_stg1   <- 1.56
HR_h_stg1   <- 1.6

HR_l_stg2   <- 0.43
HR_m_stg2   <- 0.97
HR_h_stg2   <- 2.06

HR_l_stg3   <- 0.45
HR_m_stg3   <- 1.09
HR_h_stg3   <- 2.11
# lifestyle intervention for medium risk and above
HR_smk_cvd  <-  0.85
HR_smk_cvdth    <-  0.72
HR_salt_cvd <-  0.81
HR_salt_cvdth   <-  0.66
HR_wtc_cvd  <-  0.93
HR_wtc_dth  <-  0.93
# treatment intervention for high risk (additional)
HR_hpt_lip_cvd  <-  0.7
HR_hpt_lip_cvdth <- 0.82
```

Strategy 1

```
print(xtable(data.frame(population_data[which(population_data$strategy == "strategy1"),]),digits=c(0,0,
      caption = "Distribution of the population under different strategies"),
      caption.placement="top",comment=FALSE)
```

```
p_live_cvd_l <- ProbFactor(p_live_cvd,HR_l_stg1)
p_live_cvd_m <- ProbFactor(p_live_cvd,HR_m_stg1*
```

Table 6: Distribution of the population under different strategies

	index	sex	strategy	low	medium	high
1	40	male	strategy1	159	8	62
2	45	male	strategy1	173	64	207
3	50	male	strategy1	188	63	171
4	55	male	strategy1	200	89	121
5	60	male	strategy1	129	89	104
6	65	male	strategy1	71	42	47
7	70	male	strategy1	48	28	40
8	40	female	strategy1	444	6	48
9	45	female	strategy1	738	18	100
10	50	female	strategy1	677	20	125
11	55	female	strategy1	440	217	185
12	60	female	strategy1	216	164	139
13	65	female	strategy1	128	136	130
14	70	female	strategy1	65	55	67

```
                            HR_smk_cvd*HR_salt_cvd*HR_wtc_cvd)  # lifestyle intervention
p_live_cvd_h <- ProbFactor(p_live_cvd,HR_h_stg1*
                            HR_smk_cvdth*HR_salt_cvdth*HR_wtc_dth*    # lifestyle intervention
                            HR_hpt_lip_cvdth)   # treatment intervention
p_live_cvdth_l <- ProbFactor(p_live_cvdth,1)    # equal
p_live_cvdth_m <- ProbFactor(p_live_cvdth,1*
                              HR_smk_cvd*HR_salt_cvd*HR_wtc_cvd)  # lifestyle intervention
p_live_cvdth_h <- ProbFactor(p_live_cvdth,1.7*
                              HR_smk_cvdth*HR_salt_cvdth*HR_wtc_dth* # lifestyle intervention
                              HR_hpt_lip_cvdth) # treatment intervention
```

```
risk_levels <- c("low","medium","high")
result_CVD_lmh <- matrix(0,  nrow = 14,ncol = 3,
                         dimnames = list(names_population, risk_levels))
p_live_cvd_lmh <- matrix(cbind(p_live_cvd_l,p_live_cvd_m,p_live_cvd_h), ncol=3,
                         dimnames = list(names_population,risk_levels))
p_live_cvdth_lmh <- matrix(cbind(p_live_cvdth_l,p_live_cvdth_m,p_live_cvdth_h), ncol=3,
                           dimnames = list(names_population,risk_levels))
patient_group <- matrix(cbind(population_data[which(population_data$strategy=="strategy1"),]$low,
                              population_data[which(population_data$strategy=="strategy1"),]$medium,
                              population_data[which(population_data$strategy=="strategy1"),]$high),
       ncol = 3, nrow=14,dimnames = list(names_population,risk_levels))
prob_CVD_group1 <- matrix(0, ncol=14, nrow=10,
                      dimnames=list(paste0("t",0:9),names_population))
prob_CVDlive_group1 <- matrix(0, ncol=14, nrow=10,
                      dimnames=list(paste0("t",0:9),names_population))
result_CVD_stg1 <- matrix(0, ncol = 3, nrow = 14,
                      dimnames=list(names_population, risk_levels))
result_CVDlive_stg1 <- matrix(0, ncol = 3, nrow = 14,
                      dimnames=list(names_population, risk_levels))
result_QALY_stg1 <- matrix(0, ncol = 3, nrow = 14,
                      dimnames=list(names_population, risk_levels))
result_Lifeyear_stg1 <- matrix(0, ncol = 3, nrow = 14,
                      dimnames=list(names_population, risk_levels))
result_CVDeath_stg1 <- matrix(0, ncol = 3, nrow = 14,
```

```
                    dimnames=list(names_population, risk_levels))
result_nonCVDeath_stg1 <- matrix(0, ncol = 3, nrow = 14,
                    dimnames=list(names_population, risk_levels))

p8 <-array(runif(140,min=0.02,max=0.1),dim=c(10,14),dimnames=list(1:10,names_population))
p9 <- array(NA, dim=c(10,14),dimnames=list(1:10,names_population))
p10 <- array(NA, dim=c(10,14), dimnames=list(1:10,names_population))

for(r in 1:3){  # three rish groups
  # create a matrix for p_acvd_cvdth
  for(i in 1:14){
  # construct a_P
 if(i == 7 | i == 14){
    a_P <- array(0, dim = c(n_states, n_states, 10),
                dimnames = list(v_names_states, v_names_states, 1:10))
    a_P["S1", "S1", 1:10] <- 1-(p_live_cvd_lmh[i,r]*(1-p8[1:10,i]) +
                                p_live_cvdth_lmh[i,r]*p_live_cvd_lmh[i,r]*(1-p8[1:10,i]) +
                                p_live_oth_death[i])
    a_P["S1", "S2", 1:10] <- p_live_cvd_lmh[i,r]*(1-(1-p8[1:10,i]))
    a_P["S1", "S3", 1:10] <- p_live_cvdth_lmh[i,r]*p_live_cvd_lmh[i,r]*(1-p8[1:10,i])
    a_P["S1", "S4", 1:10] <- p_live_oth_death[i]
    a_P["S2", "S1", 1:10] <- 0
    a_P["S2", "S2", 1:10] <- 1-p_live_oth_death[i]-
      (p_ccvd_cvdth[i]+p_ccvd_acvd[i]*(1-p8[1:10,i]))
    a_P["S2", "S3", 1:10] <- p_ccvd_cvdth[i]+
      p_ccvd_acvd[i]*(1-p8[1:10,i])
    a_P["S2", "S4", 1:10] <- p_live_oth_death[i]
    a_P["S3", "S3", 1:10] <- 1
    a_P["S4", "S4", 1:10] <- 1
    p9[1:10,i] <- p_ccvd_acvd[i]*(1-p8[1:10,i])
    p10[1:10,i] <- p_live_cvd[i]
  }
  if(i != 7 && i != 14){
    a_P <- array(0, dim = c(n_states, n_states, 10),
                dimnames = list(v_names_states, v_names_states, 1:10))
    a_P["S1", "S1", 1:5] <- 1-(p_live_cvd_lmh[i,r]*(1-p8[1:5,i]) +
                                p_live_cvdth_lmh[i,r]*p_live_cvd_lmh[i,r]*p8[1:5,i] +
                                p_live_oth_death[i])
    a_P["S1", "S2", 1:5] <- p_live_cvd_lmh[i,r]*(1-p8[1:5,i])
    a_P["S1", "S3", 1:5] <- p_live_cvdth_lmh[i,r]*p_live_cvd_lmh[i,r]*p8[1:5,i]
    a_P["S1", "S4", 1:5] <- p_live_oth_death[i]
    a_P["S2", "S1", 1:5] <- 0
    a_P["S2", "S2", 1:5] <- 1-p_live_oth_death[i]-
      (p_ccvd_cvdth[i]+p_ccvd_acvd[i]*p8[1:5,i])
    a_P["S2", "S3", 1:5] <- p_ccvd_cvdth[i]+
      p_ccvd_acvd[i]*p8[1:5,i]
    a_P["S2", "S4", 1:5] <- p_live_oth_death[i]
    a_P["S3", "S3", 1:5] <- 1
    a_P["S4", "S4", 1:5] <- 1
    a_P["S1", "S1", 6:10] <-  1-(p_live_cvd_lmh[i+1,r]*(1-p8[1:5,i+1])+
                               p_live_cvdth_lmh[i+1,r]*p_live_cvd_lmh[i+1,r]*p8[1:5,i+1]
                               +p_live_oth_death[i+1])
    a_P["S1", "S2", 6:10] <- p_live_cvd_lmh[i+1,r]*(1-p8[1:5,i+1])
```

```
    a_P["S1", "S3", 6:10] <- p_live_cvdth_lmh[i+1,r]*p_live_cvd_lmh[i+1,r]*p8[1:5,i+1]
    a_P["S1", "S4", 6:10] <- p_live_oth_death[i+1]
    a_P["S2", "S1", 6:10] <- 0
    a_P["S2", "S2", 6:10] <- 1-p_live_oth_death[i+1]-
       (p_ccvd_cvdth[i+1]+p_ccvd_acvd[i+1] * p8[1:5,i+1])
    a_P["S2", "S3", 6:10] <- p_ccvd_cvdth[i+1]+p_ccvd_acvd[i+1]*p8[1:5,i+1]
    a_P["S2", "S4", 6:10] <-  p_live_oth_death[i+1]
    a_P["S3", "S3", 6:10] <- 1
    a_P["S4", "S4", 6:10] <- 1
    p9[1:5,i] <- p_ccvd_acvd[i]*(1-p8[1:5,i])
    p9[6:10,i] <- p_ccvd_acvd[i+1]*(1-p8[6:10,i])
    p10[1:5,i] <- p_live_cvd[i]
    p10[6:10,i] <- p_live_cvd[i+1]
  }
     # construct m_M
    v_s_init <- c(state0 = 1, state1 = 0, state2 = 0, state3 = 0)
    m_M <- matrix(0,nrow     = (n_t), ncol = n_states,
                  dimnames = list(0:(n_t-1), v_names_states))
    m_M[1, ] <- v_s_init
    for(t in 1:9){
      m_M[t + 1, ] <- m_M[t, ] %*% a_P[, , t]
    }
    # calculate result
    prob_CVD_group1[ ,i] <- m_M[ ,1]* p10[ ,i]  # new occurence = S1*p9
    prob_CVDlive_group1[ ,i] <- m_M[ ,1]*(a_P["S1", "S2", 1:10]) + m_M[ ,2]*p9[ ,i] # new occurence = s

  result_CVD_stg1[i,r] <- sum(prob_CVD_group1[,i]*patient_group[i,r])
  result_CVDlive_stg1[i,r] <- sum(prob_CVDlive_group1[,i]*patient_group[i,r])
  result_Lifeyear_stg1[i,r] <- sum(t( t(m_M) * year )*patient_group[i,r])

  result_QALY_stg1[i,r] <- sum(t(t(m_M) * uti_values)*patient_group[i,r] +
                          prob_CVDlive_group1[, i]*out_trans_to_cvd*patient_group[i,r])
  result_CVDeath_stg1[i,r] <- m_M[10,3]*patient_group[i,r]
  result_nonCVDeath_stg1[i,r] <- m_M[10,4]*patient_group[i,r]
}
}
```

Result for Strategy1

```
print(xtable((rbind(result_CVD_stg1, "sum" = colSums(result_CVD_stg1))),
      caption = "New CVD events for patients under Strategy1"),
      caption.placement="top",comment=FALSE)
```

```
result_tab <- data.frame(matrix(c(sum(result_CVD_stg1),sum(result_CVDeath_stg1),
                                  sum(result_nonCVDeath_stg1), sum(result_QALY_stg1),
                                  sum(result_Lifeyear_stg1)),nrow = 1, ncol=5,
                    dimnames = list("", c("CVD events","CVD Death","non-CVD Death",
                                          "QALY", "Life Year"))))
print(xtable(data.frame(result_tab),
      caption = "Result for Strategy1"),
      caption.placement="top",comment=FALSE)
```

Table 7: New CVD events for patients under Strategy1

	low	medium	high
m40	8.18	0.41	3.19
m45	14.28	5.21	17.12
m50	22.72	7.47	20.72
m55	33.86	14.66	20.57
m60	29.66	19.68	24.04
m65	21.51	12.06	14.34
m70	16.25	8.91	13.68
f40	25.21	0.34	2.73
f45	61.29	1.48	8.32
f50	76.75	2.23	14.21
f55	65.63	31.60	27.68
f60	41.19	30.32	26.62
f65	32.03	32.62	32.73
f70	18.51	14.89	19.22
sum	467.08	181.87	245.17

Table 8: Result for Strategy1

	CVD.events	CVD.Death	non.CVD.Death	QALY	Life.Year
1	894.12	34.14	333.70	59952.71	60249.97

Strategy 2

```
print(xtable(data.frame(population_data[which(population_data$strategy == "strategy2"),]),digits=c(0,0,
      caption = "Distribution of the population under different strategies"),
      caption.placement="top",comment=FALSE)
```

Table 9: Distribution of the population under different strategies

	index	sex	strategy	low	medium	high
15	40	male	strategy2	163	50	16
16	45	male	strategy2	212	168	64
17	50	male	strategy2	106	231	85
18	55	male	strategy2	35	210	165
19	60	male	strategy2	5	81	236
20	65	male	strategy2	1	15	144
21	70	male	strategy2	0	3	113
22	40	female	strategy2	478	17	3
23	45	female	strategy2	734	108	14
24	50	female	strategy2	537	238	47
25	55	female	strategy2	277	433	132
26	60	female	strategy2	44	282	193
27	65	female	strategy2	4	104	286
28	70	female	strategy2	0	23	164

```
p_live_cvd_l <- ProbFactor(p_live_cvd,HR_l_stg2)
p_live_cvd_m <- ProbFactor(p_live_cvd,HR_m_stg2*
                           HR_smk_cvd*HR_salt_cvd*HR_wtc_cvd)  # lifestyle intervention
p_live_cvd_h <- ProbFactor(p_live_cvd,HR_h_stg2*
                           HR_smk_cvdth*HR_salt_cvdth*HR_wtc_dth*    # lifestyle intervention
                           HR_hpt_lip_cvdth)   # treatment intervention
p_live_cvdth_l <- ProbFactor(p_live_cvdth,1)    # equal
p_live_cvdth_m <- ProbFactor(p_live_cvdth,1*
                             HR_smk_cvd*HR_salt_cvd*HR_wtc_cvd)  # lifestyle intervention
p_live_cvdth_h <- ProbFactor(p_live_cvdth,1.7*
                             HR_smk_cvdth*HR_salt_cvdth*HR_wtc_dth* # lifestyle intervention
                             HR_hpt_lip_cvdth) # treatment intervention
```

```
risk_levels <- c("low","medium","high")
result_CVD_lmh <- matrix(0,  nrow = 14,ncol = 3,
                         dimnames = list(names_population, risk_levels))
p_live_cvd_lmh <- matrix(cbind(p_live_cvd_l,p_live_cvd_m,p_live_cvd_h), ncol=3,
                         dimnames = list(names_population,risk_levels))
p_live_cvdth_lmh <- matrix(cbind(p_live_cvdth_l,p_live_cvdth_m,p_live_cvdth_h), ncol=3,
                           dimnames = list(names_population,risk_levels))
patient_group <- matrix(cbind(population_data[which(population_data$strategy=="strategy2"),]$low,
                              population_data[which(population_data$strategy=="strategy2"),]$medium,
                              population_data[which(population_data$strategy=="strategy2"),]$high),
       ncol = 3, nrow=14,dimnames = list(names_population,risk_levels))
prob_CVD_group2 <- matrix(0, ncol=14, nrow=10,
                     dimnames=list(paste0("t",0:9),names_population))
prob_CVDlive_group2 <- matrix(0, ncol=14, nrow=10,
```

```
                    dimnames=list(paste0("t",0:9),names_population))
result_CVD_stg2 <- matrix(0, ncol = 3, nrow = 14,
                    dimnames=list(names_population, risk_levels))
result_CVDlive_stg2 <- matrix(0, ncol = 3, nrow = 14,
                    dimnames=list(names_population, risk_levels))
result_QALY_stg2 <- matrix(0, ncol = 3, nrow = 14,
                    dimnames=list(names_population, risk_levels))
result_Lifeyear_stg2 <- matrix(0, ncol = 3, nrow = 14,
                    dimnames=list(names_population, risk_levels))
result_CVDeath_stg2 <- matrix(0, ncol = 3, nrow = 14,
                    dimnames=list(names_population, risk_levels))
result_nonCVDeath_stg2 <- matrix(0, ncol = 3, nrow = 14,
                    dimnames=list(names_population, risk_levels))
p8 <-array(runif(140,min=0.02,max=0.1),dim=c(10,14),dimnames=list(1:10,names_population))
p9 <- array(NA, dim=c(10,14),dimnames=list(1:10,names_population))
p10 <- array(NA, dim=c(10,14), dimnames=list(1:10,names_population))
for(r in 1:3){  # three rish groups
  # create a matrix for p_acvd_cvdth
  for(i in 1:14){
  # construct a_P
  if(i == 7 | i == 14){
    a_P <- array(0, dim = c(n_states, n_states, 10),
                dimnames = list(v_names_states, v_names_states, 1:10))
    a_P["S1", "S1", 1:10] <- 1-(p_live_cvd_lmh[i,r]*(1-p8[1:10,i]) +
                                p_live_cvdth_lmh[i,r]*p_live_cvd_lmh[i,r]*(1-p8[1:10,i]) +
                                p_live_oth_death[i])
    a_P["S1", "S2", 1:10] <- p_live_cvd_lmh[i,r]*(1-(1-p8[1:10,i]))
    a_P["S1", "S3", 1:10] <- p_live_cvdth_lmh[i,r]*p_live_cvd_lmh[i,r]*(1-p8[1:10,i])
    a_P["S1", "S4", 1:10] <- p_live_oth_death[i]
    a_P["S2", "S1", 1:10] <- 0
    a_P["S2", "S2", 1:10] <- 1-p_live_oth_death[i]-
      (p_ccvd_cvdth[i]+p_ccvd_acvd[i]*(1-p8[1:10,i]))
    a_P["S2", "S3", 1:10] <- p_ccvd_cvdth[i]+
      p_ccvd_acvd[i]*(1-p8[1:10,i])
    a_P["S2", "S4", 1:10] <- p_live_oth_death[i]
    a_P["S3", "S3", 1:10] <- 1
    a_P["S4", "S4", 1:10] <- 1
    p9[1:10,i] <- p_ccvd_acvd[i]*(1-p8[1:10,i])
    p10[1:10,i] <- p_live_cvd[i]
  }
  if(i != 7 && i != 14){
    a_P <- array(0, dim = c(n_states, n_states, 10),
                dimnames = list(v_names_states, v_names_states, 1:10))
    a_P["S1", "S1", 1:5] <- 1-(p_live_cvd_lmh[i,r]*(1-p8[1:5,i]) +
                                p_live_cvdth_lmh[i,r]*p_live_cvd_lmh[i,r]*p8[1:5,i] +
                                p_live_oth_death[i])
    a_P["S1", "S2", 1:5] <- p_live_cvd_lmh[i,r]*(1-p8[1:5,i])
    a_P["S1", "S3", 1:5] <- p_live_cvdth_lmh[i,r]*p_live_cvd_lmh[i,r]*p8[1:5,i]
    a_P["S1", "S4", 1:5] <- p_live_oth_death[i]
    a_P["S2", "S1", 1:5] <- 0
    a_P["S2", "S2", 1:5] <- 1-p_live_oth_death[i]-
      (p_ccvd_cvdth[i]+p_ccvd_acvd[i]*p8[1:5,i])
    a_P["S2", "S3", 1:5] <- p_ccvd_cvdth[i]+
```

```
      p_ccvd_acvd[i]*p8[1:5,i]
    a_P["S2", "S4", 1:5] <- p_live_oth_death[i]
    a_P["S3", "S3", 1:5] <- 1
    a_P["S4", "S4", 1:5] <- 1
    a_P["S1", "S1", 6:10] <-  1-(p_live_cvd_lmh[i+1,r]*(1-p8[1:5,i+1])+
                              p_live_cvdth_lmh[i+1,r]*p_live_cvd_lmh[i+1,r]*p8[1:5,i+1]
                              +p_live_oth_death[i+1])
    a_P["S1", "S2", 6:10] <- p_live_cvd_lmh[i+1,r]*(1-p8[1:5,i+1])
    a_P["S1", "S3", 6:10] <- p_live_cvdth_lmh[i+1,r]*p_live_cvd_lmh[i+1,r]*p8[1:5,i+1]
    a_P["S1", "S4", 6:10] <- p_live_oth_death[i+1]
    a_P["S2", "S1", 6:10] <- 0
    a_P["S2", "S2", 6:10] <- 1-p_live_oth_death[i+1]-
       (p_ccvd_cvdth[i+1]+p_ccvd_acvd[i+1]*p8[1:5,i+1])
    a_P["S2", "S3", 6:10] <- p_ccvd_cvdth[i+1]+p_ccvd_acvd[i+1]*p8[1:5,i+1]
    a_P["S2", "S4", 6:10] <-  p_live_oth_death[i+1]
    a_P["S3", "S3", 6:10] <- 1
    a_P["S4", "S4", 6:10] <- 1
    p9[1:5,i] <- p_ccvd_acvd[i]*(1-p8[1:5,i])
    p9[6:10,i] <- p_ccvd_acvd[i+1]*(1-p8[6:10,i])
    p10[1:5,i] <- p_live_cvd[i]
    p10[6:10,i] <- p_live_cvd[i+1]
  }
     # construct m_M
    v_s_init <- c(state0 = 1, state1 = 0, state2 = 0, state3 = 0)
    m_M <- matrix(0,nrow     = (n_t), ncol = n_states,
                  dimnames = list(0:(n_t-1), v_names_states))
    m_M[1, ] <- v_s_init
    for(t in 1:9){
      m_M[t + 1, ] <- m_M[t, ] %*% a_P[, , t]
    }
    # calculate result
    prob_CVD_group2[ ,i] <- m_M[ ,1]* p10[ ,i]  # new occurence = S1*p9
    prob_CVDlive_group2[ ,i] <- m_M[ ,1]*(a_P["S1", "S2", 1:10]) + m_M[ ,2]*p9[ ,i]
  result_CVD_stg2[i,r] <- sum(prob_CVD_group2[,i]*patient_group[i,r])
  result_CVDlive_stg2[i,r] <- sum(prob_CVDlive_group2[,i]*patient_group[i,r])
  result_Lifeyear_stg2[i,r] <- sum(t( t(m_M) * year )*patient_group[i,r])

  result_QALY_stg2[i,r] <- sum(t(t(m_M) * uti_values)*patient_group[i,r] +
                           prob_CVDlive_group2[, i]*out_trans_to_cvd*patient_group[i,r])
  result_CVDeath_stg2[i,r] <- m_M[10,3]*patient_group[i,r]
  result_nonCVDeath_stg2[i,r] <- m_M[10,4]*patient_group[i,r]
}}
```

Result for Strategy2

```
print(xtable((rbind(result_CVD_stg2, "sum" = colSums(result_CVD_stg2))),
      caption = "New CVD events for patients under Strategy1"),
      caption.placement="top",comment=FALSE)
```

Table 10: New CVD events for patients under Strategy1

	low	medium	high
m40	8.43	2.57	0.82
m45	17.63	13.87	5.26
m50	12.94	27.91	10.20
m55	6.02	35.56	27.68
m60	1.17	18.65	53.63
m65	0.31	4.55	42.93
m70	0.00	1.02	37.61
f40	27.27	0.97	0.17
f45	61.41	8.97	1.16
f50	61.50	27.00	5.30
f55	41.86	64.61	19.53
f60	8.53	53.77	36.41
f65	1.03	26.10	70.77
f70	0.00	6.58	46.17
sum	248.10	292.16	357.64

```
result_tab <- data.frame(matrix(c(sum(result_CVD_stg2),sum(result_CVDeath_stg2),
                                  sum(result_nonCVDeath_stg2),sum(result_QALY_stg2),
                                  sum(result_Lifeyear_stg2)), nrow = 1, ncol=5,
                    dimnames = list("", c("CVD events","CVD Death","non-CVD Death",
                                          "QALY", "Life Year"))))
print(xtable(data.frame(result_tab),caption = "Result for Strategy2"),
      caption.placement="top",comment=FALSE)
```

Table 11: Result for Strategy2

	CVD.events	CVD.Death	non.CVD.Death	QALY	Life.Year
1	897.89	32.83	333.78	59998.92	60261.35

Strategy 3

```
print(xtable(data.frame(population_data[which(population_data$strategy == "strategy3"),]),digits=c(0,0,0
      caption = "Distribution of the population under different strategies"),
      caption.placement="top",comment=FALSE)
```

Table 12: Distribution of the population under different strategies

	index	sex	strategy	low	medium	high
29	40	male	strategy3	0	0	0
30	45	male	strategy3	0	0	0
31	50	male	strategy3	106	231	85
32	55	male	strategy3	35	210	165
33	60	male	strategy3	5	81	236
34	65	male	strategy3	1	15	144
35	70	male	strategy3	0	3	113
36	40	female	strategy3	0	0	0
37	45	female	strategy3	0	0	0
38	50	female	strategy3	537	238	47
39	55	female	strategy3	277	433	132
40	60	female	strategy3	44	282	193
41	65	female	strategy3	4	104	286
42	70	female	strategy3	0	23	164

```
p_live_cvd_l <- ProbFactor(p_live_cvd,HR_l_stg3)
p_live_cvd_m <- ProbFactor(p_live_cvd,HR_m_stg3*
                           HR_smk_cvd*HR_salt_cvd*HR_wtc_cvd)  # lifestyle intervention
p_live_cvd_h <- ProbFactor(p_live_cvd,HR_h_stg3*
                           HR_smk_cvdth*HR_salt_cvdth*HR_wtc_dth*    # lifestyle intervention
                           HR_hpt_lip_cvdth)   # treatment intervention
p_live_cvdth_l <- ProbFactor(p_live_cvdth,1)    # equal
p_live_cvdth_m <- ProbFactor(p_live_cvdth,1*
                             HR_smk_cvd*HR_salt_cvd*HR_wtc_cvd)  # lifestyle intervention
p_live_cvdth_h <- ProbFactor(p_live_cvdth,1.7*
                             HR_smk_cvdth*HR_salt_cvdth*HR_wtc_dth* # lifestyle intervention
                             HR_hpt_lip_cvdth) # treatment intervention
```

```
risk_levels <- c("low","medium","high")
result_CVD_lmh <- matrix(0,  nrow = 14,ncol = 3,
                         dimnames = list(names_population, risk_levels))
p_live_cvd_lmh <- matrix(cbind(p_live_cvd_l,p_live_cvd_m,p_live_cvd_h), ncol=3,
                         dimnames = list(names_population,risk_levels))
p_live_cvdth_lmh <- matrix(cbind(p_live_cvdth_l,p_live_cvdth_m,p_live_cvdth_h), ncol=3,
                           dimnames = list(names_population,risk_levels))
patient_group <- matrix(cbind(population_data[which(population_data$strategy=="strategy3"),]$low,
                              population_data[which(population_data$strategy=="strategy3"),]$medium,
                              population_data[which(population_data$strategy=="strategy3"),]$high),
       ncol = 3, nrow=14,dimnames = list(names_population,risk_levels))
prob_CVD_group3 <- matrix(0, ncol=14, nrow=10,
                    dimnames=list(paste0("t",0:9),names_population))
prob_CVDlive_group3 <- matrix(0, ncol=14, nrow=10,
```

```
                    dimnames=list(paste0("t",0:9),names_population))
result_CVD_stg3 <- matrix(0, ncol = 3, nrow = 14,
                    dimnames=list(names_population, risk_levels))
result_CVDlive_stg3 <- matrix(0, ncol = 3, nrow = 14,
                    dimnames=list(names_population, risk_levels))
result_QALY_stg3 <- matrix(0, ncol = 3, nrow = 14,
                    dimnames=list(names_population, risk_levels))
result_Lifeyear_stg3 <- matrix(0, ncol = 3, nrow = 14,
                    dimnames=list(names_population, risk_levels))
result_CVDeath_stg3 <- matrix(0, ncol = 3, nrow = 14,
                    dimnames=list(names_population, risk_levels))
result_nonCVDeath_stg3 <- matrix(0, ncol = 3, nrow = 14,
                    dimnames=list(names_population, risk_levels))

p8 <-array(runif(140,min=0.02,max=0.1),dim=c(10,14),dimnames=list(1:10,names_population))
p9 <- array(NA, dim=c(10,14),dimnames=list(1:10,names_population))
p10 <- array(NA, dim=c(10,14), dimnames=list(1:10,names_population))
for(r in 1:3){  # three rish groups
  # create a matrix for p_acvd_cvdth
  for(i in 1:14){
  # construct a_P
 if(i == 7 | i == 14){
    a_P <- array(0, dim = c(n_states, n_states, 10),
                 dimnames = list(v_names_states, v_names_states, 1:10))
    a_P["S1", "S1", 1:10] <- 1-(p_live_cvd_lmh[i,r]*(1-p8[1:10,i]) +
                                p_live_cvdth_lmh[i,r]*p_live_cvd_lmh[i,r]*(1-p8[1:10,i]) +
                                p_live_oth_death[i])
    a_P["S1", "S2", 1:10] <- p_live_cvd_lmh[i,r]*(1-(1-p8[1:10,i]))
    a_P["S1", "S3", 1:10] <- p_live_cvdth_lmh[i,r]*p_live_cvd_lmh[i,r]*(1-p8[1:10,i])
    a_P["S1", "S4", 1:10] <- p_live_oth_death[i]
    a_P["S2", "S1", 1:10] <- 0
    a_P["S2", "S2", 1:10] <- 1-p_live_oth_death[i]-
      (p_ccvd_cvdth[i]+p_ccvd_acvd[i]*(1-p8[1:10,i]))
    a_P["S2", "S3", 1:10] <- p_ccvd_cvdth[i]+
      p_ccvd_acvd[i]*(1-p8[1:10,i])
    a_P["S2", "S4", 1:10] <- p_live_oth_death[i]
    a_P["S3", "S3", 1:10] <- 1
    a_P["S4", "S4", 1:10] <- 1
    p9[1:10,i] <- p_ccvd_acvd[i]*(1-p8[1:10,i])
    p10[1:10,i] <- p_live_cvd[i]
  }
  if(i != 7 && i != 14){
    a_P <- array(0, dim = c(n_states, n_states, 10),
                 dimnames = list(v_names_states, v_names_states, 1:10))
    a_P["S1", "S1", 1:5] <- 1-(p_live_cvd_lmh[i,r]*(1-p8[1:5,i]) +
                                p_live_cvdth_lmh[i,r]*p_live_cvd_lmh[i,r]*p8[1:5,i] +
                                p_live_oth_death[i])
    a_P["S1", "S2", 1:5] <- p_live_cvd_lmh[i,r]*(1-p8[1:5,i])
    a_P["S1", "S3", 1:5] <- p_live_cvdth_lmh[i,r]*p_live_cvd_lmh[i,r]*p8[1:5,i]
    a_P["S1", "S4", 1:5] <- p_live_oth_death[i]
    a_P["S2", "S1", 1:5] <- 0
    a_P["S2", "S2", 1:5] <- 1-p_live_oth_death[i]-
      (p_ccvd_cvdth[i]+p_ccvd_acvd[i]*p8[1:5,i])
```

```
    a_P["S2", "S3", 1:5] <- p_ccvd_cvdth[i]+
      p_ccvd_acvd[i]*p8[1:5,i]
    a_P["S2", "S4", 1:5] <- p_live_oth_death[i]
    a_P["S3", "S3", 1:5] <- 1
    a_P["S4", "S4", 1:5] <- 1
    a_P["S1", "S1", 6:10] <-  1-(p_live_cvd_lmh[i+1,r]*(1-p8[1:5,i+1])+
                               p_live_cvdth_lmh[i+1,r]*p_live_cvd_lmh[i+1,r]*p8[1:5,i+1]
                               +p_live_oth_death[i+1])
    a_P["S1", "S2", 6:10] <- p_live_cvd_lmh[i+1,r]*(1-p8[1:5,i+1])
    a_P["S1", "S3", 6:10] <- p_live_cvdth_lmh[i+1,r]*p_live_cvd_lmh[i+1,r]*p8[1:5,i+1]
    a_P["S1", "S4", 6:10] <- p_live_oth_death[i+1]
    a_P["S2", "S1", 6:10] <- 0
    a_P["S2", "S2", 6:10] <- 1-p_live_oth_death[i+1]-
       (p_ccvd_cvdth[i+1]+p_ccvd_acvd[i+1]*p8[1:5,i+1])
    a_P["S2", "S3", 6:10] <- p_ccvd_cvdth[i+1]+p_ccvd_acvd[i+1]*p8[1:5,i+1]
    a_P["S2", "S4", 6:10] <-  p_live_oth_death[i+1]
    a_P["S3", "S3", 6:10] <- 1
    a_P["S4", "S4", 6:10] <- 1
    p9[1:5,i] <- p_ccvd_acvd[i]*(1-p8[1:5,i])
    p9[6:10,i] <- p_ccvd_acvd[i+1]*(1-p8[6:10,i])
    p10[1:5,i] <- p_live_cvd[i]
    p10[6:10,i] <- p_live_cvd[i+1]
  }
     # construct m_M
    v_s_init <- c(state0 = 1, state1 = 0, state2 = 0, state3 = 0)
    m_M <- matrix(0,nrow     = (n_t), ncol = n_states,
                  dimnames = list(0:(n_t-1), v_names_states))
    m_M[1, ] <- v_s_init
    for(t in 1:9){
      m_M[t + 1, ] <- m_M[t, ] %*% a_P[, , t]
    }
     # calculate result
    prob_CVD_group3[ ,i] <- m_M[ ,1]* p10[ ,i]  # new occurence = S1*p9
    prob_CVDlive_group3[ ,i] <- m_M[ ,1]*(a_P["S1", "S2", 1:10]) + m_M[ ,2]*p9[ ,i]
  result_CVD_stg3[i,r] <- sum(prob_CVD_group3[,i]*patient_group[i,r])
  result_CVDlive_stg3[i,r] <- sum(prob_CVDlive_group3[,i]*patient_group[i,r])
  result_Lifeyear_stg3[i,r] <- sum(t( t(m_M) * year )*patient_group[i,r])

  result_QALY_stg3[i,r] <- sum(t(t(m_M) * uti_values)*patient_group[i,r] +
                           prob_CVDlive_group3[, i]*out_trans_to_cvd*patient_group[i,r])
  result_CVDeath_stg3[i,r] <- m_M[10,3]*patient_group[i,r]
  result_nonCVDeath_stg3[i,r] <- m_M[10,4]*patient_group[i,r]
}
}
```

```
# There is another group for Strategy3
noncreen_names <- c("m40","m45","f40","f45")
noscreen_group <- matrix(c(229,498,444,856),ncol = 1, nrow = 4,
                         dimnames = list(noncreen_names,""))
noscreen_group_CVD <- matrix(NA,ncol = 1, nrow = 4,
                             dimnames = list(noncreen_names,""))
noscreen_group_CVDlive <- matrix(NA,ncol = 1, nrow = 4,
                             dimnames = list(noncreen_names,""))
```

```
noscreen_group_Lifeyear <- matrix(NA,ncol = 1, nrow = 4,
                            dimnames = list(noncreen_names,""))
noscreen_group_QALY <- matrix(NA,ncol = 1, nrow = 4,
                            dimnames = list(noncreen_names,""))
noscreen_group_CVDeath <- matrix(NA,ncol = 1, nrow = 4,
                            dimnames = list(noncreen_names,""))
noscreen_group_nonCVDeath <- matrix(NA,ncol = 1, nrow = 4,
                            dimnames = list(noncreen_names,""))
m_M1 <- result_m_M[ , , 1]
m_M2 <- result_m_M[ , , 2]
m_M3 <- result_m_M[ , , 7]
m_M4 <- result_m_M[ , , 8]
noscreen_m_M <- list(m_M1, m_M2, m_M3, m_M4)

for(i in 1:4){
  name <- noncreen_names[i]
  noscreen_group_CVD[i] <- sum(prob_CVD_group0[,noncreen_names][,i] * noscreen_group[i])
  noscreen_group_Lifeyear[i] <- sum(t(t(result_m_M[,,name]) * year)  * noscreen_group[i])
  noscreen_group_QALY[i] <- sum(t(t(result_m_M[,,name]) * uti_values)*noscreen_group[i] +
                          prob_CVDlive_group0[, i]*out_trans_to_cvd*noscreen_group[i])
  noscreen_group_CVDeath[i] <- sum(data.frame(noscreen_m_M[i])[10,3]*noscreen_group[i])
  noscreen_group_nonCVDeath[i] <-  sum(data.frame(noscreen_m_M[i])[10,4]*noscreen_group[i])
}
```

Result for Strategy3

```
print(xtable((rbind(result_CVD_stg3, "sum" = colSums(result_CVD_stg3))),
      caption = "New CVD events for patients under Strategy1"),
      caption.placement="top",comment=FALSE)
```

Table 13: New CVD events for patients under Strategy1

	low	medium	high
m40	0.00	0.00	0.00
m45	0.00	0.00	0.00
m50	12.93	27.80	10.19
m55	6.00	35.35	27.63
m60	1.17	18.47	53.43
m65	0.31	4.50	42.83
m70	0.00	1.01	37.53
f40	0.00	0.00	0.00
f45	0.00	0.00	0.00
f50	61.45	26.90	5.30
f55	41.80	64.27	19.51
f60	8.51	53.40	36.34
f65	1.02	25.85	70.55
f70	0.00	6.51	46.00
sum	133.20	264.07	349.30

```
result_CVD_stg3 <- sum(result_CVD_stg3, noscreen_group_CVD)

result_CVDlive_stg3 <- sum(result_CVDlive_stg3, noscreen_group_CVDlive)
result_Lifeyear_stg3 <- sum(result_Lifeyear_stg3, noscreen_group_Lifeyear)
result_QALY_stg3 <- sum(result_QALY_stg3, noscreen_group_QALY)
result_CVDeath_stg3 <- sum(result_CVDeath_stg3, noscreen_group_CVDeath)
result_nonCVDeath_stg3 <- sum(result_nonCVDeath_stg3, noscreen_group_nonCVDeath)

result_tab <- data.frame(matrix(c(sum(result_CVD_stg3),sum(result_CVDeath_stg3),
                                  sum(result_nonCVDeath_stg3),
                                  sum(result_QALY_stg3),
                                  sum(result_Lifeyear_stg3)), nrow = 1, ncol=5,
                    dimnames = list("", c("CVD events","CVD Death","non-CVD Death",
                                          "QALY", "Life Year"))))
print(xtable(data.frame(result_tab),
      caption = "Result for Strategy3"),
      caption.placement="top",comment=FALSE)
```

Table 14: Result for Strategy3

	CVD.events	CVD.Death	non.CVD.Death	QALY	Life.Year
1	893.99	62.97	416.32	59904.48	60238.40

Conclusion

```
print(xtable((matrix(cbind(sum(result_CVD),sum(result_CVD_stg1),
                           sum(result_CVD_stg2),sum(result_CVD_stg3)),nrow = 1, ncol = 4,
      dimnames = list("",v_names_str))),
      caption = "CVD events for patients under 3 strategies"),
      caption.placement="top",comment=FALSE)
```

Table 15: CVD events for patients under 3 strategies

	Strategy0	Strategy1	Strategy2	Strategy3
1	873.24	894.12	897.89	893.99

```
print(xtable((matrix(cbind(sum(result_QALY),sum(result_QALY_stg1),
                           sum(result_QALY_stg2),sum(result_QALY_stg3)),nrow = 1, ncol = 4,
      dimnames = list("",v_names_str))),
      caption = "QALY for patients under 3 strategies"),
      caption.placement="top",comment=FALSE)
```

Table 16: QALY for patients under 3 strategies

	Strategy0	Strategy1	Strategy2	Strategy3
1	59978.71	59952.71	59998.92	59904.48

```
print(xtable((matrix(cbind(sum(result_Lifeyear),sum(result_Lifeyear_stg1),
                           sum(result_Lifeyear_stg2),sum(result_Lifeyear_stg3)),nrow = 1, ncol = 4,
      dimnames = list("",v_names_str))),
      caption = "Life year for patients under 3 strategies"),
      caption.placement="top",comment=FALSE)
```

Table 17: Life year for patients under 3 strategies

	Strategy0	Strategy1	Strategy2	Strategy3
1	60447.68	60249.97	60261.35	60238.40