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EPI202: Fall 2022
Homework 4
To be uploaded as PDF to course website by 9:30 am on December 8, 2022

Please provide brief but precise answers.

We encourage collaborative learning in this course. You may discuss homework assignments with other students. However, all written work that you submit for grading must be your own, in your own words, reflecting your understanding of the homework assignment. Homework assignments should not be prepared by copying, paraphrasing, or summarizing someone else's work.

Proper notation should be used throughout the assignment and relevant calculations should be shown.

NAME: ____Diego Liang______

Part I. Exploring the association between sedentary lifestyle and all-cause mortality using logistic regression models.

In this section, you will use data from a prospective cohort study based upon the first 10 years of follow-up of participants in the Myocardial Infarction Onset Study to examine the relationship between sedentary lifestyle defined as physical activity less than once per week compared to one or more times per week (at baseline) and the cumulative incidence of death from any cause within the first 10 years. The variables in this dataset are described below. [Note: In this study, conducted in the late 1980s, sex was recorded and categorized as female or male based on NIH reporting requirements in place at the time. No data on gender was recorded]:

Variable Name	**Description**
Id	ID number
Age	Age (continuous, years)
age_cat	Age Category (1: <50yrs, 2: 50-64 yrs, 3: 65+ yrs)
Female	Female (1: female, 0: male)
Married	Married (1: yes, 0:no)
Educ	Educational Attainment (1: <HS, 2: HS, 3: >HS)
Dm	Diabetes (1: yes, 0:no)
Htn	Hypertension (1: yes, 0:no)
phys_activity	Frequency of Physical Activity (0: <1/wk, 1: 1-3/wk, 2: 4+/wk)
follow_up	Duration of follow-up (years)
Dead	Death from any cause in the first 10 years (0: Alive, 1: Died)

In homework 4, you will continue your analysis of the association between sedentary lifetyle at baseline and the outcome of all-cause mortality by ten years that you began with tabular methods last week in homework 3.

You may use SAS, STATA, R or any other statistical analysis software package of your choosing. Include relevant lines of code. If you do any calculations by hand or using the Epi 202 calculator, identify the formulas you used and the values you included in the formulas, as in previous homework assignments.

1. In the last question of Homework 3, you evaluated the association between sedentary lifestyle (physical activity < 1 time per week versus ≥ 1 time per week) and all-cause mortality after adjusting for age using tabular analysis (i.e., Mantel-Hanszel estimator). However, the association might be confounded by many other variables. Here, you will analyze the association between sedentary lifestyle at baseline and 10-year all-cause mortality using logistic regression models and adjusting for other potential confounders**.**

    a. **Write out and interpret the algebraic form** of the logistic regression model that includes as covariates: sedentary lifestyle (exposure), diabetes, hypertension, sex (female), and age (as a continuous variable).

        i. Write out the model

$$\text{logit(10-year all-cause mortality)} = \beta_0 + \beta_1 \times \text{sedentary lifestyle} + \beta_2 \times \text{diabetes} + \beta_3 \times \text{hypertension} + \beta_4 \times \text{sex (female)} + \beta_5 \times \text{age} + \varepsilon$$

```
> (log_1 %>% tidy(conf.int = T))
# A tibble: 6 × 7
  term         estimate std.error statistic   p.value conf.low conf.high
  <chr>           <dbl>     <dbl>     <dbl>     <dbl>    <dbl>     <dbl>
1 (Intercept)   -5.76     0.257      -22.4  7.63e-111  -6.27     -5.26
2 sedentaryyes   0.586    0.141        4.16 3.18e-  5   0.316     0.869
3 dm_catyes      0.850    0.0900       9.45 3.44e- 21   0.674     1.03
4 htn_catyes     0.341    0.0797       4.28 1.87e-  5   0.185     0.497
5 female_catF   -0.195    0.0856      -2.28 2.25e-  2  -0.364    -0.0283
6 age            0.0638   0.00367     17.4  1.14e- 67   0.0566    0.0710
```

$$\text{logit(10-year all-cause mortality)} = -5.76 + 0.586 \times \text{sedentary lifestyle} + 0.850 \times \text{diabetes} + 0.341 \times \text{hypertension} - 0.195 \times \text{sex (female)} + 0.064 \times \text{age} + \varepsilon$$

        ii. Interpret in words each coefficient term in your model.

$$\beta_0 = -5.76$$

The log odds of 10-year all-cause mortality is −5.76 among those who did not have a sedentary lifestyle, diabetes, hypertension, and aged 0, assuming no selection bias or information bias.

$$\beta_1 = 0.586$$

The log odds of 10-year all-cause mortality is 0.586 higher among those who had a sedentary lifestyle, adjusted for diabetes, hypertension, sex and age, assuming no confounding, selection bias, or information bias.

$$\beta_2 = 0.850$$

The log odds of 10-year all-cause mortality is 0.850 higher among those who had diabetes, adjusted for sedentary lifestyle, hypertension, sex, and age, assuming no confounding, selection bias, or information bias.

$$\beta_3 = 0.341$$

The log odds of 10-year all-cause mortality is 0.341 higher among those who had hypertension, adjusted for sedentary lifestyle, diabetes, sex, and age, assuming no confounding, selection bias, or information bias.

$$\beta_4 = -0.195$$

The log odds of 10-year all-cause mortality is 0.195 lower among those who were female, adjusted for sedentary lifestyle, diabetes, hypertension, and age, assuming no confounding, selection bias, or information bias.

$$\beta_5 = 0.064$$

The log odds of 10-year all-cause mortality will increase 0.064 per 1 year increase in age, adjusted for sedentary lifestyle, diabetes, hypertension, and sex, assuming no confounding, selection bias, or information bias.

b. **Expand your written model from (a)** to also include the interaction between a sedentary lifestyle and diabetes at baseline.

```
> (log_2 %>% tidy(conf.int = T))
# A tibble: 7 × 7
  term                  estimate std.error statistic   p.value conf.low conf.high
  <chr>                    <dbl>     <dbl>     <dbl>     <dbl>    <dbl>     <dbl>
1 (Intercept)            -5.73     0.266     -21.6   2.26e-103  -6.26    -5.22
2 sedentaryyes            0.562    0.158       3.55  3.78e-  4   0.260    0.881
3 dm_catyes               0.747    0.327       2.29  2.23e-  2   0.0862   1.37
4 htn_catyes              0.341    0.0797      4.27  1.92e-  5   0.184    0.497
5 female_catF            -0.195    0.0856     -2.28  2.26e-  2  -0.364   -0.0281
6 age                     0.0638   0.00367    17.4   1.15e- 67   0.0566   0.0710
7 sedentaryyes:dm_catyes  0.111    0.340       0.328 7.43e-  1  -0.541    0.796
```

i. Write out the model

$$\text{logit}(\text{10-year all-cause mortality}) = \beta_0 + \beta_1 \times \text{sedentary lifestyle} + \beta_2 \times \text{diabetes} + \beta_3 \times \text{hypertension} + \beta_4 \times \text{sex (female)} + \beta_5 \times \text{age} + \beta_6 \times \text{sedentary lifestyle} \times \text{diabetes} + \varepsilon$$

$$\text{logit}(\text{10-year all-cause mortality}) = -5.73 + 0.562 \times \text{sedentary lifestyle} + 0.747 \times \text{diabetes} + 0.341 \times \text{hypertension} - 0.195 \times \text{sex (female)} + 0.064 \times \text{age} + 0.111 \times \text{sedentary lifestyle} \times \text{diabetes} + \varepsilon$$

ii. Interpret the coefficient terms for: (a) sedentary lifestyle, (b) diabetes, and (c) the sedentary*diabetes interaction term.

$$\beta_1 = 0.562$$

The log odds of 10-year all-cause mortality is 0.562 higher among those who did not have diabetes comparing having a sedentary lifestyle at baseline to not having a sedentary lifestyle at baseline, holding hypertension, sex, and age constant, assuming no confounding, selection bias, or information bias.

$$\beta_2 = 0.747$$

The log odds of 10-year all-cause mortality is 0.747 higher among those who did not have a sedentary lifestyle at baseline comparing having diabetes to not having diabetes, holding hypertension, sex, and age constant, assuming no confounding, selection bias, or information bias.

$$\beta_6 = 0.111$$

The difference between having diabetes and not having diabetes in log odds ratios for sedentary lifestyle at baseline and 10-year all-cause is 0.111, holding hypertension, sex, and age constant, assuming no confounding, selection bias, or information bias.

iii. What is the association between sedentary lifestyle and death during the follow-up period among those with and without diabetes separately? Answer this question only using model coefficients. Report associations as odds ratios. **There is no need to interpret the results.**

Among those having diabetes,

$$\ln\left(OR_{\text{sedentary|diabetes}}\right) = \ln\left(Odds_{\text{sedentary|diabetes}}\right) - \ln\left(Odds_{\text{no sedentary|diabetes}}\right) = \beta_1 + \beta_6$$
$$= 0.562 + 0.111 = 0.673$$

$$OR_{\text{sedentary|diabetes}} = e^{(0.673)} = 1.962$$

Among those having no diabetes,

$$\ln\left(OR_{\text{sedentary|no diabetes}}\right) = \ln\left(Odds_{\text{sedentary|no diabetes}}\right) - \ln\left(Odds_{\text{no sedentary|no diabetes}}\right) = \beta_1$$
$$= 0.562$$

$$OR_{\text{sedentary|no diabetes}} = e^{(0.562)} = 1.75$$

```
> (log_2 %>% tidy(conf.int = T))
# A tibble: 7 × 7
  term                  estimate std.error statistic   p.value conf.low conf.high
  <chr>                    <dbl>     <dbl>     <dbl>     <dbl>    <dbl>     <dbl>
1 (Intercept)            -5.73     0.266     -21.6   2.26e-103  -6.26     -5.22  
2 sedentaryyes            0.562    0.158       3.55  3.78e-  4   0.260     0.881 
3 dm_catyes               0.747    0.327       2.29  2.23e-  2   0.0862    1.37  
4 htn_catyes              0.341    0.0797      4.27  1.92e-  5   0.184     0.497 
5 female_catF            -0.195    0.0856     -2.28  2.26e-  2  -0.364    -0.0281
6 age                     0.0638   0.00367    17.4   1.15e- 67   0.0566    0.0710
7 sedentaryyes:dm_catyes  0.111    0.340       0.328 7.43e-  1  -0.541     0.796 
> exp((log_2 %>% tidy(conf.int = T))[2,2]+(log_2 %>% tidy(conf.int = T))[7,2])
  estimate
1 1.961711
> exp((log_2 %>% tidy(conf.int = T))[2,2])
# A tibble: 1 × 1
  estimate
     <dbl>
1     1.75
```

2. Next, you will fit the models you described above using statistical software. [Hint: you can find useful code and examples in the regression guides posted on canvas]

   a. Prepare Table 3 for your publication as follows.

Association between sedentary lifestyle and all-cause mortality	OR (95% CI)
Crude	2.871 (2.228, 3.751)
Age and sex adjusted	1.919 (1.468, 2.538)
Fully adjusted*	1.798 (1.371, 2.385)

*adjusted for diabetes, hypertension, sex (female) and age.

	Model 1	Model 2	Model 3
(Intercept)	0.163 (0.126, 0.208)	0.004 (0.002, 0.006)	0.003 (0.002, 0.005)
sedentaryyes	2.871 (2.228, 3.751)	1.919 (1.468, 2.538)	1.798 (1.371, 2.385)
age		1.068 (1.061, 1.076)	1.066 (1.058, 1.074)
female_catF		0.912 (0.774, 1.074)	0.823 (0.695, 0.972)
dm_catyes			2.340 (1.962, 2.792)
htn_catyes			1.406 (1.203, 1.644)
Num.Obs.	3712	3712	3712
AIC	4426.8	4016.2	3900.1
BIC	4439.2	4041.1	3937.4
Log.Lik.	-2211.403	-2004.093	-1944.043
RMSE	0.45	0.42	0.42

b. From the fully adjusted model, estimate and interpret the odds ratio and 95% confidence interval for the association between a **5-year** increment in age and death during the follow-up period.

$$\ln(\text{OR}) = \ln\left(\text{odds}_{\text{age } x+n}\right) - \ln\left(\text{odds}_{\text{age } x}\right) = 0.064 \times 5 = 0.32$$

$$\text{OR} = e^{\ln(\text{OR})} = e^{0.32} = 1.375$$

After adjusting for diabetes, hypertension, sex (female) and sedentary lifestyle, the odds of 10-year all-cause mortality is 1.377 times higher for every five-year increase in age, assuming no other sources of bias.

The 95% confidence interval for the association between a 5-year increment in age and death during the follow-up period is:

$$e^{5\times(0.064)\pm1.96\times0.004} = (1.327, 1.426)$$

With 95% confidence, these data are consistent with odds ratios ranging from 1.327 to 1.426 for the association between a 5-year increment in age and 10-year all-cause mortality, assuming no bias.

```
> (log_full %>% tidy(conf.int = T))
# A tibble: 6 × 7
  term         estimate std.error statistic   p.value conf.low conf.high
  <chr>           <dbl>     <dbl>     <dbl>     <dbl>    <dbl>     <dbl>
1 (Intercept)    -5.76     0.257     -22.4  7.63e-111  -6.27     -5.26
2 sedentaryyes    0.586    0.141       4.16 3.18e-  5   0.316     0.869
3 age             0.0638   0.00367    17.4  1.14e- 67   0.0566    0.0710
4 female_catF    -0.195    0.0856     -2.28 2.25e-  2  -0.364    -0.0283
5 dm_catyes       0.850    0.0900      9.45 3.44e- 21   0.674     1.03
6 htn_catyes      0.341    0.0797      4.28 1.87e-  5   0.185     0.497
> exp(5*(log_full %>% tidy(conf.int = T))[3,2])
  estimate
1 1.375466
> exp(5*(log_full %>% tidy(conf.int = T))[3,6])
  conf.low
1 1.327365
> exp(5*(log_full %>% tidy(conf.int = T))[3,7])
  conf.high
1  1.426341
```

c. Include an interaction term between sedentary lifestyle and **diabetes in your fully adjusted model.**

i. Provide the adjusted odds ratio and 95% confidence interval for the association between sedentary lifestyle at baseline and death from any cause **among those with diabetes. Interpret your numerical result in words.**

```
> (log_interaction %>% tidy(exponentiate = T, conf.int = T))
# A tibble: 7 × 7
  term                 estimate std.error statistic   p.value conf.low conf.…¹
  <chr>                   <dbl>     <dbl>     <dbl>     <dbl>    <dbl>   <dbl>
1 (Intercept)           0.00323   0.266     -21.6   2.26e-103  0.00191 0.00540
2 sedentaryyes          1.75      0.158       3.55  3.78e-  4  1.30    2.41
3 dm_catyes             2.11      0.327       2.29  2.23e-  2  1.09    3.95
4 age                   1.07      0.00367    17.4   1.15e- 67  1.06    1.07
5 female_catF           0.823     0.0856     -2.28  2.26e-  2  0.695   0.972
6 htn_catyes            1.41      0.0797      4.27  1.92e-  5  1.20    1.64
7 sedentaryyes:dm_catyes 1.12     0.340       0.328 7.43e-  1  0.582   2.22
# … with abbreviated variable name ¹conf.high
> (log_interaction %>% tidy(exponentiate = T, conf.int = T))[2,2]*
+   (log_interaction %>% tidy(exponentiate = T, conf.int = T))[7,2]
  estimate
1 1.961711
```

```
> exp(rbind(beta_sen_dm, CI_LB_sen_dm, CI_UB_sen_dm))
             sedentaryyes
beta_sen_dm      1.961711
CI_LB_sen_dm     1.085179
CI_UB_sen_dm     3.546244
```

$$\ln(\mathrm{OR}_{\mathrm{sedentary|diabetes}}) = \ln(\mathrm{Odds}_{\mathrm{sedentary|diabetes}}) - \ln(\mathrm{Odds}_{\mathrm{no\ sedentary|diabetes}}) = 0.562 + 0.111 = 0.673$$

$$OR_{sedentary|diabetes} = e^{0.673} = 1.962$$

Adjusting for hypertension, sex (female) and age, among those with diabetes, the odds of 10-year all-cause mortality for those who had a sedentary lifestyle is 1.960 times the odds of 10-year all-cause mortality for those who did not have a sedentary lifestyle, assuming no other bias.

The 95% confidence interval for the association between sedentary lifestyle at baseline and 10-year all-cause mortality among those with diabetes is $(1.085, 3.546)$.

With 95% confidence, these data are consistent with the odds ratios ranging from 1.085 to 3.546 for the association between sedentary lifestyle at baseline and 10-year all-cause mortality among those with diabetes, assuming no bias.

ii. Provide the adjusted odds ratio and 95% confidence interval for the association between sedentary lifestyle at baseline and death from any cause **among those without diabetes. Interpret your numerical result in words.**

```
> (log_interaction %>% tidy(exponentiate = T, conf.int = T))
# A tibble: 7 × 7
  term                  estimate std.error statistic   p.value conf.low conf.high
  <chr>                    <dbl>     <dbl>     <dbl>     <dbl>    <dbl>     <dbl>
1 (Intercept)            0.00323   0.266      -21.6  2.26e-103  0.00191   0.00540
2 sedentaryyes           1.75      0.158        3.55 3.78e-  4  1.30      2.41
3 dm_catyes              2.11      0.327        2.29 2.23e-  2  1.09      3.95
4 age                    1.07      0.00367     17.4  1.15e- 67  1.06      1.07
5 female_catF            0.823     0.0856      -2.28 2.26e-  2  0.695     0.972
6 htn_catyes             1.41      0.0797       4.27 1.92e-  5  1.20      1.64
7 sedentaryyes:dm_catyes 1.12      0.340        0.328 7.43e-  1  0.582     2.22
```

$$\ln(\mathrm{OR}_{\text{sedentary|no diabetes}}) = \ln(\mathrm{Odds}_{\text{sedentary|no diabetes}}) - \ln(\mathrm{Odds}_{\text{no sedentary|no diabetes}}) = 0.562$$

$$OR_{sedentary|diabetes} = e^{0.562} = 1.750$$

Adjusting for hypertension, sex (female) and age, among those without diabetes, the odds of 10-year all-cause mortality for those who had a sedentary lifestyle is 1.760 times the odds of 10-year all-cause mortality for those who did not have a sedentary lifestyle, assuming no other bias.

The 95% confidence interval for the association between sedentary lifestyle at baseline and 10-year all-cause mortality among those with diabetes is:

$$e^{(0.260, 0.881)} = (1.300, 2.410)$$

With 95% confidence, these data are consistent with the odds ratios ranging from 1.300 to 2.410 for the association between sedentary lifestyle at baseline and 10-year all-cause mortality among those without diabetes, assuming no bias.

d. Is there evidence for effect measure modification for the association between sedentary lifestyle by diabetes **on the multiplicative** scale in these data? Provide the p-value for the test of homogeneity and interpret it (i) directly and (ii) in the context of a Neyman-Pearson hypothesis test.

H_0: There is no effect measure modification by diabetes on the multiplicative scale for the association between sedentary lifestyle and 10-year all-cause mortality, after adjusting for hypertension, sex (female) and age.
H_A: There is effect measure modification by diabetes on the multiplicative scale for the association between sedentary lifestyle and 10-year all-cause mortality, after adjusting for hypertension, sex (female) and age.
$Z^2 = 0.328$ under the null
P-homogeneity $= 0.743$ from Wald test

The probability of observing odds ratios as or more different than the observed odds ratios for those with diabetes and those without diabetes is 0.743, if the null is true, assuming no other bias.
We fail to reject the null hypothesis at a 0.05 level of significance. There is sufficient evidence to conclude that there is no effect measure modification by diabetes on the multiplicative scale for the association between sedentary lifestyle and 10-year all-cause mortality, after adjusting for hypertension, sex (female) and age, assuming no other bias.

e. After adjusting for diabetes, hypertension, sex (female), and age (as a continuous variable), is there evidence that the association between sedentary lifestyle at baseline and death from any cause is modified by diabetes **on the additive scale**? (**HINT**: create a model recoding sedentary lifestyle and diabetes into a single four-level categorical variable and use the model output to calculate the relative excess risk due to interaction). → RERI = OR (sedentary=1, diabetes=1) – OR(sedentary =1, diabetes =0) – OR(sedentary =0, diabetes =1) + 1

```
> (log_model_add_emm <-  glm(dead~sedendm_cat+htn_cat+female_cat+age,
+                            data = mi_onset_10_cat,
+                            family = binomial(link = "logit")) %>%
+     tidy(exponentiate=T,
+          conf.int=T) %>%
+     mutate(across(where(is.numeric),round,digits=3)))
# A tibble: 7 × 7
  term                                estimate std.error statistic p.value conf.low conf.high
  <chr>                                  <dbl>     <dbl>     <dbl>   <dbl>    <dbl>     <dbl>
1 (Intercept)                            0.003     0.266    -21.6    0        0.002     0.005
2 sedendm_catsedentary and no diabetes   1.76      0.158      3.56   0        1.30      2.41
3 sedendm_catno sedentary and diabetes   2.11      0.327      2.29   0.022    1.09      3.95
4 sedendm_catsedentary and diabetes      4.14      0.171      8.29   0        2.98      5.84
5 htn_catyes                             1.41      0.08       4.27   0        1.20      1.64
6 female_catF                            0.823     0.086     -2.28   0.023    0.695     0.972
7 age                                    1.07      0.004     17.4    0        1.06      1.07
```

$$RERI = OR_{\text{sedentary and diabetes}} - OR_{\text{sedentary and no diabetes}} - OR_{\text{no sedentary and diabetes}} + 1$$
$$= 4.140 - 1.760 - 2.110 + 1 = 1.270$$

There is an effect modification by diabetes on the additive scale for the association between sedentary lifestyle at baseline and 10-year all-cause mortality, after adjusting for diabetes, hypertension, sex (female) and age. Sedentary lifestyle at baseline is more harmful among those with diabetes than those without diabetes, after adjusting for diabetes, hypertension, sex (female) and age.

```
> epi.interaction(model = log_interaction,
+                 param = "product",
+                 coef = c(2,3,7),
+                 conf.level = 0.95)$reri
       est      lower    upper
1 1.275485 -0.1069122 2.657883
```

3. Start to write the results section of a paper describing the relationship between sedentary lifestyle at baseline and death in the subsequent 10 years. Start by describing the study population. Describe the key findings from Table 1 (created as a part of homework 3), highlighting important differences between participants who were and were not sedentary at baseline, but don't repeat every number from the table. Rather, you should describe the results to give the reader insight into the study population and major differences between those with and without sedentary lifestyle at baseline. (**HINT**: You might want to look at some of the papers that you read for EPI201

and EPI202 throughout the semester for guidance as to the style of the first paragraph of the results section of an epidemiologic research paper.) For the next paragraph, describe the results from Table 2 (also created as part of homework 3). You should include information regarding the crude association and whether there appears to be confounding and/or effect modification by diabetes in the study data. In the third paragraph, summarize the findings from Table 3 (created as part of homework 4). Now describe the results of your evaluation of whether there is evidence for effect measure modification by diabetes on the multiplicative and additive scales in the fully adjusted model. Finally, conclude with a brief summary (two or three sentences) describing your conclusions based on these results.

3712 participants were followed during the 10 years in the prospective cohort (MI onset cohort), including 3199 with a sedentary lifestyle at baseline and 513 without a sedentary lifestyle at baseline, investigating the association between sedentary lifestyle and 10-year all-cause mortality by cumulative incidence ratio (CIR) and odds ratio (OR). Participants who had a sedentary lifestyle at baseline tend to be older, female, non-married, less education attainment, with diabetes and with hypertension at baseline.

We found there is a crude positive relationship between sedentary lifestyle at baseline and the 10-year all-cause mortality (crude CIR=2.274 [95% CI: 1.8248, 2.8338]). The magnitude of this association is similar stratified by diabetes at baseline (2.0182 [95% CI: 1.3272, 3.0689] for diabetes vs 2.1560 [95% CI: 1.6693, 2.7846]), and there is no multiplicative effect modification by diabetes (p=0.7917 for the test of homogeneity of the association). We conducted the Mantel-Haenszel method to investigate the association for diabetes, as proportion of participants with diabetes is significant different among those who have sedentary lifestyle and those who have not (p<0.001). After stratifying for the diabetes at baseline, there is an association between sedentary lifestyle at baseline and 10-year all-cause mortality (Mantel-Haenszel CIR=2.1216 [95% CI: 1.7047, 2.6404]).

The association between sedentary lifestyle at baseline and 10-year all-cause mortality is positively significant, but the magnitude of this association gets smaller (age and sex adjusted OR=1.919 [95% CI: 1.468, 2.538]) after adjusted for age and sex and becomes further smaller (fully adjusted OR=1.798 [95% CI: 1.371, 2.385]). after adjusted for two more confounders (diabetes and hypertension status at baseline), compared to the crude model. We found strong evidence suggesting there is the additive effect modification by diabetes (RERI=1.270>0) for the association between sedentary lifestyle at baseline and 10-year all-cause mortality, but there is no effect modification by diabetes on the multiplicative scale (diabetes by sedentary lifestyle interaction term $p = 0.743$) in the fully adjusted model.

Overall, there is evidence indicating the positive relationship between sedentary lifestyle at baseline and 10-year all-cause mortality after adjusted for age, sex, diabetes, and hypertension, and it gets stronger for those with diabetes at baseline on the additive scale.