

Supplementary Materials for

Health Impacts of E-Cigarette and Traditional Tobacco Use in Shanghai Male Railway Workers: A Population-Based Retrospective Cohort Study.

Section S1 Materials and Methods

1.1 Participants and data

All females and individuals who had quit smoking ($n = 5,618$) were excluded as the number of female smokers was very low ($n = 32$), and smoking cessation could confound the effects of current cigarette exposure. Outliers in continuous variables were identified using the interquartile range method and set as missing values. Variables with over 99% missing data (urinary glucose, urine protein, and urine ketones) were excluded. All remaining variables had <20% missing data. Individuals who started smoking before junior high school (age minus accumulated smoking years was greater than 13 years, $n=937$) were eliminated as Chinese primary schools have strict smoking regulations for students, and it was unlikely for them to continue smoking during their primary school years. A total of 30,453 individuals were classified as non-users, 20,428 were classified as cigarette smokers, 671 were classified as e-cigarette users, and 5,983 as dual users. E-cigarettes were invented in China in 2003 and have been around for 20 years until 2022. Thus, e-cigarette users with accumulated smoking years greater than or equal to 20 years were eliminated ($n=147$). To ensure the accumulated smoking years were not different between dual users and e-cigarette users, dual users with accumulated smoking years greater than or equal to 20 were eliminated ($n=1,946$). Non-users with accumulated smoking years greater than 0 were eliminated ($n=7,646$). The individuals with missing values were eliminated for dual users, cigarette smokers, and non-users ($n = 2,880, 14,188, 15,996$, resp.). To address the missing values for e-cigarette users, we performed Little's test and found that the missing values were missing completely at random. Therefore, we imputed these missing values for e-cigarette users by multiple imputations through the chained equations (MICE) method, which followed Rubin's rule. To ensure that there existed no difference for accumulated smoking years among cigarette smokers, e-cigarette users, and dual users, cigarette smokers (dual users, resp.) with accumulated smoking years greater than 15 (greater than 11, resp.) were eliminated ($n=3,845, 362$, resp.). After that, no difference in accumulated smoking years was found among the three subgroups via Games-Howell's test. Similarly, to make sure that there existed no difference for ages, non-users (cigarette smokers, dual users, resp.) with ages ≥ 48 ($\geq 47, \leq 26$, resp.) were eliminated ($n=1,986, 532, 288$, resp.). After that, there existed no difference in ages among the four subgroups via Games-Howell's test. Finally, the final sample size of 7,719 used in this analysis includes non-users (4,825), cigarette smokers (1,863), e-cigarette users (524), and dual users (507), respectively.

1.2 Multinomial logistic regression model concept

A multinomial logistic regression (MNL) was conducted to determine the effects of exposure to different smoking types on male railway workers. Notice that the correlation results were equivalent when swapping the

position of the outcome variable and a certain explanatory variable. For instance, assume that $Y = \{1,2,3,4\}$ represents the four aforementioned subgroups, and $X_j, j = 1,2, \dots, m$ the explanatory variables, from which a MNLR equation and some linear regression equations can be built as follows,

$$\text{logit}[P(Y = i|X)] = \ln \left[\frac{P(Y = i|X)}{P(Y = 1|X)} \right] = \beta_{i0} + \sum_{j=1}^m \beta_{ij}X_j + \varepsilon_1, \quad i = 2,3,4,$$

$$X_l = \beta_{l0} + \sum_{j \neq l} \gamma_{lj}X_j + \sum_{i=2}^4 \alpha_{li}Y_i + \varepsilon_2, \quad l = 1,2, \dots, m.$$

Then, if we want to check the effects on X_l for the exposure $Y = 2$ references to $Y = 1$, the coefficients α_{l2} and β_{2l} enjoy the same sign and hypothesis testing. Therefore, with the outcome variable being set as the four subgroups and other variables as explanatory variables, performing the MNLR operation only once can obtain the impacts of different cigarette-type exposures on all variables.

Table S1 Generalized Variance Inflator Factor (GVIF) values for the multinomial logistic regression analysis

| Variables | GVIF |
|-----------------------------|-------------|
| Age | 2.973726 |
| BMI | 1.253244 |
| Marital status | 1.377646 |
| Education level | 1.160898 |
| Working age | 2.875903 |
| Weekly working hours | 1.018312 |
| Work shift | 1.089348 |
| Income per month | 1.018021 |
| Self-rated sleep quality | 1.240624 |
| Lack of energy last month | 1.249377 |
| Drinking frequency | 1.019771 |
| Smokers in 5 best friends | 1.039912 |
| Cognition of smoking hazard | 1.014899 |
| Self-rated health quality | 1.169023 |
| Systolic blood pressure | 1.51781 |
| Diastolic blood pressure | 1.576722 |
| Heart rate | 1.052388 |
| Fasting blood glucose | 1.090643 |
| Triglyceride | 1.356042 |
| Total cholesterol | 2.413103 |
| High-density lipoprotein | 1.312888 |
| Low-density lipoprotein | 2.163508 |
| Hemoglobin | 1.537169 |
| Red blood cell | 1.519609 |
| White blood cell | 1.127356 |
| Platelet | 1.103089 |
| Alanine aminotransferase | 1.66562 |
| Aspartate aminotransferase | 1.478812 |

| | |
|--------------------------------|----------|
| γ -glutamyl transferase | 1.281952 |
| Total bilirubin | 1.451438 |
| Direct bilirubin | 1.467096 |
| Total protein | 1.176061 |
| Albumin | 1.17137 |
| Urea nitrogen | 1.054667 |
| Uric acid | 1.103105 |
| Creatinine | 1.088525 |
| Alpha-fetoprotein | 1.033856 |
| Carcinoembryonic antigen | 1.02336 |
| Urine pH | 1.032737 |

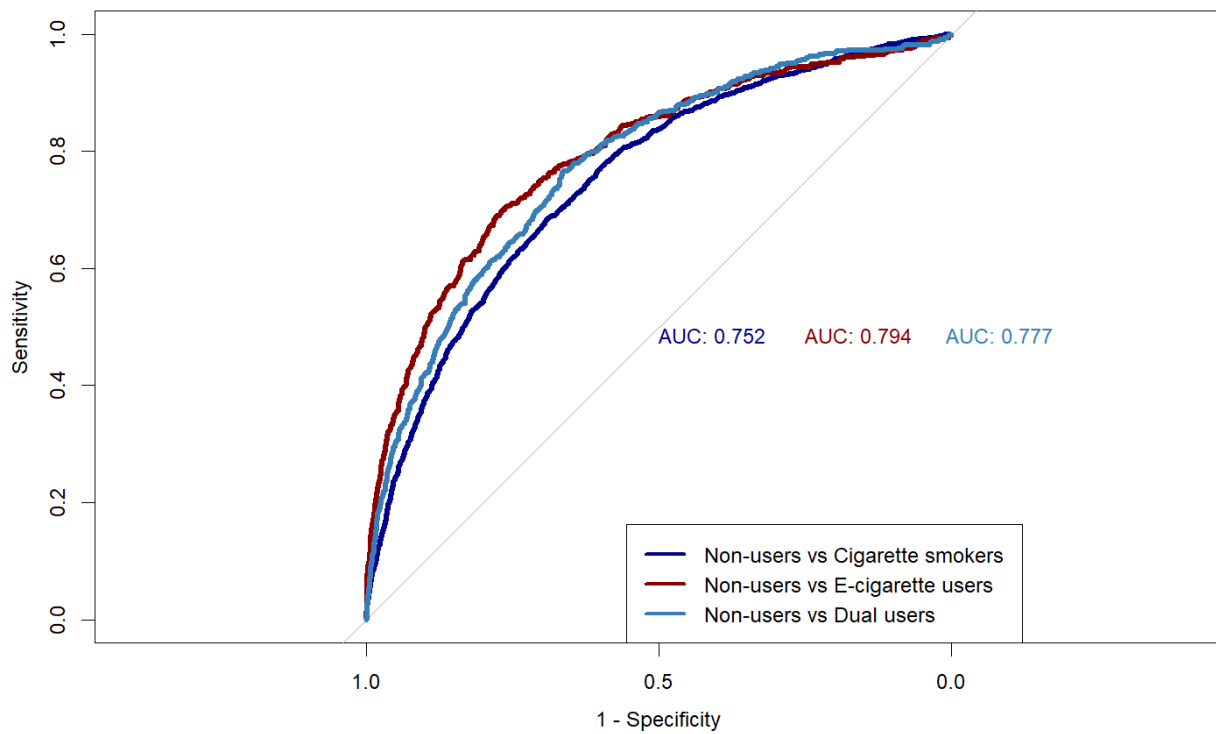


Figure S1 ROC curves of the multinomial logistic regression analysis

Table S2 Multinomial logistic regression results with cigarette smokers and e-cigarette users as references

| Characteristics | Cigarette smokers as a reference | | | | E-cigarette users as a reference | |
|--------------------------------|----------------------------------|------------------|-------------------|------------------|----------------------------------|------------------|
| | E-cigarette users | | Dual users | | Dual users | |
| | OR (95%CI) | P | OR (95%CI) | P | OR (95%CI) | P |
| Age | 1.02 (0.98, 1.06) | 0.274 | 1.05 (1.01, 1.10) | 0.013 | 1.03 (0.98, 1.08) | 0.208 |
| BMI | 0.97 (0.93, 1.01) | 0.123 | 1.02 (0.98, 1.06) | 0.315 | 1.05 (1.00, 1.10) | 0.041 |
| Marital status: Married | 0.59 (0.44, 0.78) | <0.001 | 0.57 (0.44, 0.75) | <0.001 | 0.97 (0.69, 1.38) | 0.881 |
| Education level | 0.44 (0.34, 0.56) | <0.001 | 0.94 (0.72, 1.23) | 0.676 | 2.15 (1.56, 2.95) | <0.001 |
| Working age | 0.97 (0.94, 1.00) | 0.0678 | 0.97 (0.94, 1.00) | 0.074 | 1.00 (0.96, 1.04) | 0.927 |
| Weekly working hours | 0.99 (0.98, 1.00) | 0.169 | 1.00 (0.99, 1.01) | 0.727 | 1.00 (0.99, 1.02) | 0.411 |
| Work shift | 0.98 (0.89, 1.08) | 0.657 | 1.04 (0.94, 1.15) | 0.418 | 1.06 (0.94, 1.20) | 0.317 |
| Income per month | 1.02 (0.95, 1.10) | 0.577 | 1.05 (0.97, 1.13) | 0.195 | 1.03 (0.94, 1.13) | 0.563 |
| Self-rated sleep quality | 0.84 (0.72, 0.98) | 0.023 | 0.95 (0.82, 1.11) | 0.523 | 1.13 (0.94, 1.37) | 0.189 |
| Lack of energy last month | 0.96 (0.85, 1.09) | 0.522 | 1.05 (0.93, 1.19) | 0.400 | 1.10 (0.94, 1.27) | 0.236 |
| Drinking frequency: Occasional | 0.56 (0.44, 0.71) | <0.001 | 0.80 (0.63, 1.01) | 0.059 | 1.42 (1.06, 1.92) | 0.019 |
| Regular | 0.97 (0.74, 1.27) | 0.814 | 0.89 (0.67, 1.18) | 0.430 | 0.92 (0.66, 1.30) | 0.642 |
| Quit | 1.56 (0.70, 3.49) | 0.279 | 0.77 (0.28, 2.12) | 0.613 | 0.49 (0.16, 1.52) | 0.219 |
| Smokers in 5 best friends | 1.03 (0.96, 1.11) | 0.443 | 1.25 (1.16, 1.35) | <0.001 | 1.21 (1.10, 1.33) | <0.001 |
| Cognition of smoking hazard | 0.77 (0.71, 0.84) | <0.001 | 1.01 (0.93, 1.10) | 0.813 | 1.31 (1.18, 1.45) | <0.001 |
| Self-rated health quality | 1.27 (1.13, 1.44) | <0.001 | 1.02 (0.91, 1.16) | 0.709 | 0.80 (0.69, 0.93) | 0.0047 |
| Systolic blood pressure | 1.18 (1.06, 1.31) | 0.002 | 1.01 (0.91, 1.12) | 0.854 | 0.86 (0.75, 0.98) | 0.023 |
| Diastolic blood pressure | 0.98 (0.85, 1.13) | 0.765 | 0.91 (0.79, 1.05) | 0.180 | 0.93 (0.78, 1.11) | 0.40 |
| Heart rate | 1.18 (1.06, 1.33) | 0.004 | 0.96 (0.85, 1.08) | 0.481 | 0.81 (0.70, 0.94) | 0.005 |
| Fasting blood glucose | 1.07 (0.87, 1.30) | 0.518 | 1.02 (0.83, 1.25) | 0.833 | 0.96 (0.74, 1.23) | 0.731 |
| Triglyceride | 0.89 (0.74, 1.06) | 0.200 | 0.91 (0.76, 1.08) | 0.274 | 1.02 (0.81, 1.27) | 0.873 |
| Total cholesterol | 1.19 (0.90, 1.57) | 0.223 | 1.17 (0.88, 1.57) | 0.282 | 0.99 (0.69, 1.41) | 0.942 |
| High-density lipoprotein | 0.76 (0.45, 1.30) | 0.318 | 0.68 (0.40, 1.18) | 0.169 | 0.90 (0.46, 1.76) | 0.753 |
| Low-density lipoprotein | 0.80 (0.59, 1.09) | 0.161 | 0.95 (0.69, 1.30) | 0.735 | 1.18 (0.80, 1.73) | 0.41 |
| Hemoglobin | 1.22 (1.05, 1.42) | 0.010 | 1.15 (0.99, 1.34) | 0.070 | 0.94 (0.78, 1.14) | 0.53 |
| Red blood cell | 0.85 (0.57, 1.28) | 0.445 | 0.63 (0.42, 0.95) | 0.028 | 0.74 (0.45, 1.22) | 0.239 |
| White blood cell | 1.05 (0.97, 1.13) | 0.239 | 0.95 (0.88, 1.03) | 0.252 | 0.91 (0.83, 1.01) | 0.064 |
| Platelet | 1.02 (0.84, 1.23) | 0.846 | 1.06 (0.88, 1.29) | 0.52 | 1.04 (0.82, 1.33) | 0.721 |
| Alanine aminotransferase | 1.01 (0.91, 1.14) | 0.80 | 0.99 (0.88, 1.11) | 0.811 | 0.97 (0.84, 1.12) | 0.694 |
| Aspartate aminotransferase | 1.23 (1.00, 1.51) | 0.054 | 0.98 (0.79, 1.20) | 0.817 | 0.79 (0.61, 1.03) | 0.085 |
| γ-glutamyl transferase | 1.01 (0.93, 1.09) | 0.892 | 1.02 (0.94, 1.11) | 0.588 | 1.02 (0.92, 1.12) | 0.741 |
| Total bilirubin | 1.00 (0.98, 1.04) | 0.748 | 1.00 (0.97, 1.03) | 0.776 | 0.99 (0.95, 1.03) | 0.628 |
| Direct bilirubin | 1.04 (0.95, 1.14) | 0.355 | 1.06 (0.96, 1.16) | 0.258 | 1.01 (0.90, 1.13) | 0.854 |
| Total protein | 1.00 (0.97, 1.03) | 0.93 | 1.00 (0.97, 1.03) | 0.833 | 1.00 (0.97, 1.04) | 0.811 |
| Albumin | 0.95 (0.90, 0.99) | 0.016 | 0.97 (0.92, 1.01) | 0.12 | 1.02 (0.96, 1.08) | 0.478 |
| Urea nitrogen | 0.96 (0.87, 1.05) | 0.375 | 1.00 (0.91, 1.10) | 0.977 | 1.05 (0.93, 1.18) | 0.463 |
| Uric acid | 1.06 (0.92, 1.21) | 0.421 | 1.01 (0.88, 1.16) | 0.849 | 0.96 (0.81, 1.14) | 0.624 |
| Creatinine | 1.02 (0.93, 1.12) | 0.666 | 1.02 (0.93, 1.12) | 0.699 | 1.00 (0.89, 1.12) | 0.97 |
| Alpha-fetoprotein | 0.91 (0.84, 0.97) | 0.006 | 1.00 (0.94, 1.07) | 0.91 | 1.11 (1.02, 1.21) | 0.021 |
| Carcinoembryonic antigen | 1.07 (0.97, 1.19) | 0.183 | 1.00 (0.91, 1.11) | 0.933 | 0.94 (0.83, 1.06) | 0.318 |
| Urine pH | 0.70 (0.56, 0.88) | 0.002 | 1.14 (0.90, 1.43) | 0.282 | 1.63 (1.23, 2.15) | 0.001 |

AOR: adjusted odds ratio. MLNR analysis adjusted for age, body mass index (BMI), education level, monthly income, drinking frequency, self-rated sleep quality, work shift, and marital status.

Bold: p<0.05 is significant.

OR: odds ratio, 95% CI: confidence interval

Table S3 The effects of accumulated smoking years in the three smoking subgroups

| Health indicators | Cigarette smokers | | E-cigarette users | | Dual users | |
|--------------------------------|----------------------------|------------------|----------------------------|------------------|----------------------------|--------------|
| | β (95%CI) | <i>P</i> | β (95%CI) | <i>P</i> | β (95%CI) | <i>P</i> |
| BMI | -0.0104 (-0.0326, 0.0117) | 0.356 | -0.0109 (-0.0437, 0.0219) | 0.516 | 0.0105 (-0.0279, 0.0490) | 0.592 |
| Systolic pressure | -0.1281 (-0.2000, -0.0562) | <0.001 | -0.0424 (-0.1489, 0.0642) | 0.435 | -0.1193 (-0.2441, 0.0055) | 0.061 |
| Diastolic pressure | 0.0538 (-0.0008, 0.1083) | 0.053 | 0.0771 (-0.0036, 0.1578) | 0.061 | -0.0460 (-0.1406, 0.0487) | 0.341 |
| Heart rate | -0.0147 (-0.0864, 0.0570) | 0.688 | 0.0906 (-0.0154, 0.1967) | 0.094 | -0.0425 (-0.1668, 0.0819) | 0.503 |
| Fasting blood glucose | -0.0053 (-0.0094, -0.0012) | 0.011 | -0.006 (-0.0121, 0.0001) | 0.052 | -0.0079 (-0.0150, -0.0008) | 0.029 |
| Triglyceride | -0.0003 (-0.005, 0.0044) | 0.902 | -0.0057 (-0.0127, 0.0013) | 0.108 | -0.0064 (-0.0146, 0.0018) | 0.125 |
| Total cholesterol | 0.0018 (-0.0011, 0.0047) | 0.227 | 0.0075 (0.0032, 0.0117) | 0.001 | 0.0033 (-0.0018, 0.0083) | 0.203 |
| High-density lipoprotein | -0.0019 (-0.0034, -0.0003) | 0.017 | -0.0053 (-0.0076, -0.0030) | <0.001 | -0.0039 (-0.0066, -0.0013) | 0.004 |
| Low-density lipoprotein | 0.0004 (-0.0024, 0.0031) | 0.799 | -0.0049 (-0.0089, -0.0009) | 0.017 | -0.0015 (-0.0062, 0.0032) | 0.539 |
| Hemoglobin | 0.0587 (0.0099, 0.1076) | 0.018 | 0.1018 (0.0296, 0.1740) | 0.006 | 0.1212 (0.0366, 0.2058) | 0.005 |
| Red blood cell | -0.0031 (-0.005, -0.0013) | 0.001 | -0.0039 (-0.0066, -0.0011) | 0.006 | -0.0054 (-0.0086, -0.0022) | 0.001 |
| White blood cell | 0.0278 (0.0174, 0.0382) | <0.001 | 0.0304 (0.0149, 0.0458) | <0.001 | 0.0179 (-0.0002, 0.0360) | 0.053 |
| Platelet | 0.1098 (-0.2543, 0.4739) | 0.554 | 0.0637 (-0.4749, 0.6024) | 0.817 | 0.2922 (-0.3391, 0.9235) | 0.364 |
| Alanine aminotransferase | 0.0244 (-0.0390, 0.0878) | 0.451 | 0.014 (-0.0798, 0.1079) | 0.769 | -0.0243 (-0.1343, 0.0857) | 0.665 |
| Aspartate aminotransferase | -0.0502 (-0.0804, -0.0200) | 0.001 | 0.0179 (-0.027, 0.0627) | 0.435 | -0.0282 (-0.0807, 0.0243) | 0.293 |
| γ -glutamyl transferase | 0.0551 (-0.0427, 0.1528) | 0.269 | 0.1227 (-0.0218, 0.2673) | 0.096 | 0.1272 (-0.0423, 0.2966) | 0.141 |
| Total bilirubin | -0.017 (-0.0447, 0.0107) | 0.229 | -0.0348 (-0.0758, 0.0062) | 0.096 | -0.0261 (-0.0742, 0.0220) | 0.287 |
| Direct bilirubin | -0.0043 (-0.0133, 0.0046) | 0.345 | 0.0076 (-0.0056, 0.0209) | 0.258 | 0.0006 (-0.0150, 0.0161) | 0.942 |
| Total protein | -0.0436 (-0.0709, -0.0164) | 0.002 | -0.0797 (-0.1200, -0.0395) | <0.001 | -0.0295 (-0.0768, 0.0178) | 0.221 |
| Albumin | 0.0067 (-0.0112, 0.0245) | 0.463 | -0.0088 (-0.0352, 0.0175) | 0.511 | -0.0169 (-0.0478, 0.0141) | 0.285 |
| Urea nitrogen | 0.0072 (-0.0016, 0.016) | 0.106 | 0.0092 (-0.0039, 0.0222) | 0.168 | 0.0015 (-0.0138, 0.0167) | 0.849 |
| Uric acid | -0.121 (-0.6832, 0.4412) | 0.673 | 0.1256 (-0.7062, 0.9574) | 0.767 | 0.2937 (-0.6812, 1.2686) | 0.555 |
| Creatinine | -0.0244 (-0.1061, 0.0573) | 0.559 | -0.0899 (-0.2108, 0.0309) | 0.145 | 0.0265 (-0.1152, 0.1681) | 0.714 |
| Alpha-fetoprotein | 0.0217 (0.0098, 0.0335) | <0.001 | -0.003 (-0.0206, 0.0146) | 0.737 | 0.0240 (0.0034, 0.0446) | 0.022 |
| Carcinoembryonic antigen | 0.0056 (-0.0025, 0.0137) | 0.174 | 0.0212 (0.0092, 0.0332) | 0.001 | 0.0109 (-0.0032, 0.0249) | 0.130 |
| Urine pH | 0.0029 (-0.0006, 0.0063) | 0.103 | 0.0001 (-0.005, 0.0052) | 0.980 | 0.0061 (0.0001, 0.0120) | 0.046 |

Bold: $p < 0.05$ is significant.

Table S4 GVIF values for the multiple linear regression analysis

| Variables | GVIF |
|--|-------------|
| Age | 2.686239 |
| Marital status | 1.299388 |
| Education level | 1.162788 |
| Working age | 2.585523 |
| Weekly working hours | 1.026122 |
| Work shift | 1.085288 |
| Income per month | 1.023988 |
| Self-rated sleep quality | 1.222010 |
| Lack of energy last month | 1.224724 |
| Drinking frequency | 1.030056 |
| Smokers in 5 best friends | 1.065766 |
| Cognition of smoking hazard | 1.017952 |
| Self-rated health quality | 1.147149 |
| Systolic blood pressure | 1.503574 |
| Diastolic blood pressure | 1.568409 |
| Heart rate | 1.051065 |
| Fasting blood glucose | 1.104845 |
| Triglyceride | 1.364499 |
| Total cholesterol | 2.295366 |
| High-density lipoprotein | 1.308371 |
| Low-density lipoprotein | 2.051424 |
| Hemoglobin | 1.533625 |
| Red blood cell | 1.515775 |
| White blood cell | 1.143653 |
| Platelet | 1.104655 |
| Alanine aminotransferase | 1.641110 |
| Aspartate aminotransferase | 1.488153 |
| γ -glutamyl transferase | 1.289997 |
| Total bilirubin | 1.440944 |
| Direct bilirubin | 1.457369 |
| Total protein | 1.158738 |
| Albumin | 1.159436 |
| Urea nitrogen | 1.051666 |
| Uric acid | 1.086714 |
| Creatinine | 1.093751 |
| Alpha-fetoprotein | 1.043419 |
| Carcinoembryonic antigen | 1.028781 |
| Urine pH | 1.037622 |
| Accumulated smoking years: Three smoking subgroups | 1.047192 |