Appendix 1 Supplementary methods

Definition of covariates

Smoking history (never, former, and current)

Definition and measurement of variables, like usual smoking habits, were obtained by questionnaire in the health examination program. Smoking status was used to categorize participants into three groups: none, former smoker, and current smoker. Current smoker was classified according to the WHO definition as a person who has smoked more than five packs (100 cigarettes) in a lifetime and smoked daily or occasionally for the last 28 days. Former smoker was defined as a person who had smoked more than 100 cigarettes in a lifetime and had not smoked in the last 28 days (52).

Alcohol consumption (none, moderate, and heavy)

Definition and measurement of variables, like usual alcohol consumption, were obtained by questionnaire in the health examination program. Alcohol consumption was categorized into three groups: none, moderate drinker, and heavy drinker. Differentiation between moderate and heavy drinkers was based on whether a patient usually takes more than 14 drinks/7 drinks per week for men/women. The drinks were calculated by multiplying the average drinking frequency per week by the number of drinks per occasion (53).

Physical activity (low, moderate)

Physical activity was assessed using the Korean version of the International Physical Activity Questionnaire-short form. We created composite physical activity based on Metabolic Equivalent Task (MET)-minutes/week (walking: 3.3 METs; moderate physical activity: 4.0 METs; vigorous physical activity: 8.0 METs), which was categorized as follows based on total physical activity metabolic equivalents: low (<600 METs), moderate (600–2,999 METs), and vigorous (≥3,000 METs) (54,55).

Comorbidities

Hypertension

Hypertension was defined as using at least one claim of ICD-10 code(I10-15) with the prescription of an anti-hypertensive agent, claims of ICD-10 code(I10-15) more than two times, a systolic blood pressure of ≥140 mmHg and a diastolic blood pressure of ≥90 mmHg or positive checking in self-report questionnaire on hypertension in the health examination program (56).

Diabetes mellitus

Diabetes mellitus was as defined using at least one claim of ICD-10 code(E11-14) with the prescription of an anti-diabetic agent, claims of ICD-10 code(E11-14) more than two times, fasting serum glucose concentration of ≥7.0 mmol/L or positive checking in self-report questionnaire on diabetes mellitus in the health examination program (56).

Dyslipidemia

Dyslipidemia was defined as using at least one claim of ICD-10 code(E78) with the prescription of an anti-dyslipidemic agent, claims of ICD-10 code(E78) more than two times or total cholesterol level of ≥240 mg/dL (56).

Stroke

Stroke was defined as using claims of ICD-10 codes (I60–I63) with primary diagnosis, admission ≥1 time (≥3 days) and brain imaging (CT or MRI) ≥1 time (56).

Myocardial infarction

Myocardial infarction was defined as using claims of ICD-10 codes (I21, I22) with primary diagnosis with admission of one and more times (56).

Chronic obstructive pulmonary disease

Chronic obstructive pulmonary disease was defined as using claims of ICD-10 codes (J42, J43 (except J43.0), J44) with more than two times of admission or outpatient department (57).

Renal disease

Renal disease was defined as using claims of ICD-10 codes (N17-19, I12-13, E08.2, E10.2, E11.2, E13.2) more than two times or estimated glomerular filtration rate (eGFR) of <60 mL/min/1.73 m² (58).

Liver disease

Liver disease was defined as using claims of ICD-10 codes (B18, K70, K71, K72, K73, K74, K76.1) with more than

two times of admission or outpatient department (59).

Cancer

Cancer was defined as using claims of ICD-10 code (C00–C97) more than two times with cancer-specific deductible code (V027, V193-4) from the Health Insurance Review and Assessment Service (60).

Charlson comorbidity index (0, 1, or ≥2)

The Charlson comorbidity index score was calculated for each subject based on diseases diagnosed before index date and divided into three groups (0, 1, and ≥2 scores) (61).

Metabolic syndrome

Metabolic syndrome was defined based on the presence of at least three of the following five criteria: (I) waist circumference ≥90 cm for men or ≥80 cm for women, (II) triglyceride (TG) level ≥150 mg/dL, (III) high-density lipoprotein (HDL) cholesterol <40 mg/dL for men or <50 mg/dL for women, (IV) systolic/diastolic blood pressure ≥130/85 mmHg or use of antihypertensive medication, (V) fasting glucose level ≥100 mg/dL or use of antidiabetic medication (62).

References

52. Lee KH, Lee CM, Kwon HT, et al. Relationship between Obesity and Smoking in Korean Men: Data Analyses from the Third and Fourth Korea National Health and Nutrition Examination Surveys (KNHANES). JKSRNT 2010;1(2):115-23.
53. Yang JH, Choi CK, Kim HY, et al. Association between Alcohol Drinking Status and Depressive Symptoms in Korean Adults. Chonnam Med J 2021;57:68-75.
54. Do-Hyun K, Eun-Joon L, Ji-Yeon L, Duk-Chul L. The association and the characteristics of the smoking status and differences in physical activity level in Korean adults: The Sixth Korea National Health and Nutrition Examination Survey (KNHANES VI-1), 2013. Korean J Fam Pract 2015;5:S510-6.
55. Chun MY. Validity and reliability of korean version of international physical activity questionnaire short form in the elderly. Korean J Fam Med 2012;33:144-51.
56. Choi EK. Cardiovascular Research Using the Korean National Health Information Database. Korean Circ J 2020;50:754-72.
57. Park SC, Kim YS, Kang YA, et al. Hemoglobin and mortality in patients with COPD: a nationwide population-based cohort study. Int J Chron Obstruct Pulmon Dis 2018;13:1599-605.
58. Kim J, Jeon J, Lee HS, et al. Association Between the Risk for Cardiovascular Events and Antiviral Treatment for Herpes Zoster. Clin Infect Dis 2021;73:758-64.
59. Global, regional, and national age-sex specific mortality for 264 causes of death, 1980-2016: a systematic analysis for the Global Burden of Disease Study 2016. Lancet 2017;390:1151-210.
60. Lim H, Lee YH, Bae S, et al. Cancer cluster among small village residents near the fertilizer plant in Korea. PLoS One 2021;16:e0247661.
61. Kwon HS, Suh J, Kim MH, et al. Five-Year Community Management Rate for Dementia Patients: A Proposed Indicator for Dementia Policies. J Clin Neurol 2022;18:24-32.
62. Alberti KG, Zimmet P, Shaw J. Metabolic syndrome--a new world-wide definition. A Consensus Statement from the International Diabetes Federation. Diabet Med 2006;23:469-80.

Table S1 Results of univariate Cox regression analysis for the association of hemorrhoids with incidence risk of heart failure

Variables	Before PSM (N=356,033)	After PSM 1:5 (N=137,790)
Without hemorrhoids	Reference	Reference
With hemorrhoids	1.073 (1.028–1.121)	1.073 (1.018–1.131)
Age (years)	1.077 (1.076–1.079)	1.078 (1.076–1.080)
Sex		
Male	Reference	Reference
Female	0.935 (0.910–0.961)	0.936 (0.897–0.977)
Body mass index (kg/m^2)	1.049 (1.046–1.052)	1.050 (1.044–1.056)
Household income		
Low	Reference	Reference
Middle	0.964 (0.940–0.989)	0.993 (0.952–1.036)
High	0.858 (0.835–0.881)	0.857 (0.820–0.836)
Smoking status		
Never	Reference	Reference
Former	1.087 (1.041–1.136)	1.118 (1.050–1.190)
Current	1.270 (1.230–1.311)	1.280 (1.215–1.348)
Alcohol consumption (days/week)		
None	Reference	Reference
1–2 times	0.888 (0.862–0.914)	0.800 (0.860–0.941)
3–4 times	0.923 (0.879–0.969)	0.960 (0.908–1.058)
≥5 times	0.942 (0.894–0.992)	0.966 (0.883–1.058)
Regular physical activity (days/week)		
None	Reference	Reference
1–4 days	0.870 (0.848–0.893)	0.874 (0.840–0.910)
≥5 days	0.897 (0.866–0.928)	0.940 (0.881–0.982)
Comorbidities		
Hypertension	1.361 (1.331–1.393)	1.346 (1.297–1.398)
Diabetes mellitus	1.212 (1.176–1.249)	1.185 (1.103–1.230)
Dyslipidemia	1.291 (1.255–1.328)	1.300 (1.247–1.354)
Stroke	1.174 (0.999–1.380)	1.276 (1.080–1.581)
Myocardial infarction	3.079 (2.592–3.656)	2.881 (2.222–3.735)
COPD	1.287 (1.255–1.319)	1.281 (1.244–1.340)
Renal disease	1.273 (1.204–1.346)	1.258 (1.161–1.366)
Liver disease	1.083 (1.050–1.117)	1.078 (1.083–1.125)
Cancer	1.112 (1.054–1.174)	1.185 (1.103–1.274)
Metabolic syndrome	1.108 (1.082–1.135)	1.115 (1.073–1.158)
Charlson comorbidity index		
0	Reference	Reference
1	1.102 (1.058–1.147)	1.105 (1.086–1.178)
≥2	1.206 (1.080–1.345)	1.325 (1.099–1.597)

Data are presented as adjusted HR (95% CI).

Table S2 Results of multivariate Cox regression analysis for the association of hemorrhoids with incidence risk of heart failure: a 1-year landmark analysis

Variable	Before PSM (N=354,109)			After PSM 1:5 (N=138,048)		
	Incidence rate (per 100,000 person-years)	Crude HR (95% CI)	Adjusted HR (95% CI)	Incidence rate (per 100,000 person-years)	Crude HR (95% CI)	Adjusted HR (95% CI)
Without hemorrhoids	670.386	Reference	Reference	642.869	Reference	Reference
With hemorrhoids		1.056 (1.012–1.103)	1.091 (1.044–1.140)		1.098 (1.046–1.154)	1.112 (1.055–1.172)

Values from multivariate Cox regression models adjusted for age, sex, body mass index, household income, smoking status, alcohol consumption, regular physical activity, comorbidities, and Charlson comorbidity index.

Table S3 Frequency table of procedure code for population who received procedure/treatment for hemorrhoids

Hemorrhoids treatment group (N=14,544)							
Number of treatment = 1		Number of treatment = 2		Number of treatment = 3		Number of treatment = 4	
Procedure code	N (%)	Procedure code	N (%)	Procedure code	N (%)	Procedure code	N (%)
Q3012	856 (5.9%)	Q3012 & Q3013	300 (2.1%)	Q3012 & Q3013 & Q3014	0 (0.0%)	Q3014 & Q3015 & Q3016 & Q3017	0 (0.0%)
Q3013	11,553 (79.4%)	Q3012 & Q3014	1 (0.0%)	Q3012 & Q3013 & Q3015	15 (0.1%)	Q3013 & Q3015 & Q3016 & Q3017	0 (0.0%)
Q3014	206 (1.4%)	Q3012 & Q3015	27 (0.2%)	Q3012 & Q3013 & Q3016	7 (0.0%)	Q3013 & Q3014 & Q3016 & Q3017	0 (0.0%)
Q3015	258 (1.8%)	Q3012 & Q3016	20 (0.1%)	Q3012 & Q3013 & Q3017	11 (0.1%)	Q3013 & Q3014 & Q3015 & Q3017	0 (0.0%)
Q3016	235 (1.6%)	Q3012 & Q3017	10 (0.1%)	Q3012 & Q3014 & Q3015	0 (0.0%)	Q3013 & Q3014 & Q3015 & Q3016	0 (0.0%)
Q3017	201 (1.4%)	Q3013 & Q3014	19 (0.1%)	Q3012 & Q3014 & Q3016	0 (0.0%)	Q3012 & Q3015 & Q3016 & Q3017	0 (0.0%)
		Q3013 & Q3015	515 (3.5%)	Q3012 & Q3014 & Q3017	0 (0.0%)	Q3012 & Q3014 & Q3016 & Q3017	0 (0.0%)
		Q3013 & Q3016	166 (1.1%)	Q3012 & Q3015 & Q3016	1 (0.0%)	Q3012 & Q3014 & Q3015 & Q3017	0 (0.0%)
		Q3013 & Q3017	75 (0.5%)	Q3012 & Q3015 & Q3017	0 (0.0%)	Q3012 & Q3014 & Q3015 & Q3016	0 (0.0%)
		Q3014 & Q3015	9 (0.1%)	Q3012 & Q3016 & Q3017	2 (0.0%)	Q3012 & Q3013 & Q3016 & Q3017	2 (0.0%)
		Q3014 & Q3016	2 (0.0%)	Q3013 & Q3014 & Q3015	3 (0.0%)	Q3012 & Q3013 & Q3015 & Q3017	0 (0.0%)
		Q3014 & Q3017	0 (0.0%)	Q3013 & Q3014 & Q3016	0 (0.0%)	Q3012 & Q3013 & Q3015 & Q3016	2 (0.0%)
		Q3015 & Q3016	8 (0.1%)	Q3013 & Q3014 & Q3017	0 (0.0%)	Q3012 & Q3013 & Q3014 & Q3017	0 (0.0%)
		Q3015 & Q3017	8 (0.1%)	Q3013 & Q3015 & Q3016	10 (0.1%)	Q3012 & Q3013 & Q3014 & Q3016	0 (0.0%)
		Q3016 & Q3017	6 (0.0%)	Q3013 & Q3015 & Q3017	6 (0.0%)	Q3012 & Q3013 & Q3014 & Q3015	0 (0.0%)
				Q3013 & Q3016 & Q3017	2 (0.0%)		
				Q3014 & Q3015 & Q3016	2 (0.0%)		
				Q3014 & Q3015 & Q3017	1 (0.0%)		
				Q3014 & Q3016 & Q3017	1 (0.0%)		
				Q3015 & Q3016 & Q3017	0 (0.0%)		

The procedure code names of the treatment corresponding to each codes are as follows: thrombectomy and excision of the skin tag (Q3015); surgery for strangulated circumferential hemorrhoids (Q3014); thrombosed hemorrhoid surgery (Q3012); coagulation, cauterization, sclerotherapy, and rubber band ligation (Q3016); circular stapled hemorrhoidectomy (Q3017); hemorrhoidectomy (Q3013).

Table S4 Results of univariate Cox regression analysis for the association of procedure/treatment for hemorrhoids with incidence risk of heart failure

Variables	Before PSM (N=24,363)	After PSM 1:1 (N=18,238)
Without treatment	Reference	Reference
With treatment	0.919 (0.845–1.001)	0.941 (0.880–1.001)
Age (years)	1.076 (1.071–1.082)	1.075 (1.070–1.081)
Sex		
Male	Reference	Reference
Female	0.938 (0.847–1.039)	0.927 (0.829–1.036)
Body mass index (kg/m²)	1.062 (1.047–1.078)	1.061 (1.044–1.078)
Household income		
Low	Reference	Reference
Middle	1.061 (0.956–1.177)	1.077 (0.961–1.207)
High	0.900 (0.808–1.003)	0.906 (0.804–1.020)
Smoking status		
Never	Reference	Reference
Former	1.141 (0.986–1.321)	1.100 (0.936–1.294)
Current	1.365 (1.207–1.542)	1.340 (1.170–1.534)
Alcohol consumption (days/week)		
None	Reference	Reference
1–2 times	0.910 (0.818–1.013)	0.910 (0.818–1.013)
3–4 times	0.837 (0.693–1.012)	0.817 (0.683–1.012)
≥5 times	0.812 (0.644–1.025)	0.772 (0.595–1.002)
Regular physical activity (days/week)		
None	Reference	Reference
1–4 days	0.883 (0.803–0.971)	0.894 (0.806–0.992)
≥5 days	1.044 (0.921–1.184)	1.065 (0.929–1.221)
Comorbidities		
Hypertension	1.398 (1.277–1.531)	1.417 (1.284–1.563)
Diabetes mellitus	1.184 (1.041–1.347)	1.200 (1.042–1.382)
Dyslipidemia	1.250 (1.133–1.379)	1.271 (1.142–1.413)
Stroke	1.456 (0.912–2.323)	1.799 (1.080–2.997)
Myocardial infarction	2.471 (1.173–5.207)	2.554 (1.140–5.720)
COPD	1.420 (1.300–1.551)	1.442 (1.310–1.586)
Renal disease	1.307 (1.086–1.572)	1.261 (1.022–1.557)
Liver disease	1.065 (0.862–1.179)	1.022 (0.915–1.142)
Cancer	1.087 (0.906–1.258)	1.151 (0.961–1.378)
Metabolic syndrome	1.151 (1.051–1.260)	1.186 (1.056–1.287)
Charlson comorbidity index		
0	Reference	Reference
1	0.991 (0.856–1.179)	1.037 (0.873–1.231)
≥2	1.325 (1.099–1.597)	1.482 (0.971–2.294)

Data are presented as adjusted HR (95% CI).

Table S5 Results of sensitivity analysis using Cox regression analysis for the association of hemorrhoids with incidence risk of heart failure

Variables	Before PSM (N=347,806)	After PSM 1:5 (N=94,386)
Without hemorrhoids	Reference	Reference
With hemorrhoids	1.051 (1.010–1.094)	1.055 (1.012–1.100)
Age (years)	1.077 (1.076–1.079)	1.078 (1.075–1.080)
Sex		
Male	Reference	Reference
Female	0.936 (0.910–0.962)	0.921 (0.875–0.969)
Body mass index (kg/m^2)	1.049 (1.045–1.052)	1.054 (1.047–1.061)
Household income		
Low	Reference	Reference
Middle	0.962 (0.938–0.987)	0.972 (0.923–1.024)
High	0.855 (0.832–0.879)	0.845 (0.801–0.892)
Smoking status		
Never	Reference	Reference
Former	1.091 (1.044–1.140)	1.066 (0.987–1.150)
Current	1.268 (1.228–1.310)	1.167 (1.094–1.245)
Alcohol consumption (days/week)		
None	Reference	Reference
1–2 times	0.884 (0.858–0.910)	0.883 (0.836–0.933)
3–4 times	0.924 (0.879–0.971)	0.985 (0.896–1.082)
≥5 times	0.948 (0.899–0.999)	0.975 (0.871–1.031)
Regular physical activity (days/week)		
None	Reference	Reference
1–4 days	0.871 (0.849–0.894)	0.887 (0.846–0.931)
≥5 days	0.891 (0.860–0.922)	0.911 (0.862–0.973)
Comorbidities		
Hypertension	1.364 (1.332–1.395)	1.402 (1.340–1.468)
Diabetes mellitus	1.207 (1.171–1.244)	1.170 (1.093–1.252)
Dyslipidemia	1.293 (1.256–1.330)	1.299 (1.236–1.366)
Stroke	1.171 (0.999–1.382)	1.287 (0.991–1.671)
Myocardial infarction	3.136 (2.639–3.727)	3.698 (2.808–4.870)
COPD	1.286 (1.254–1.318)	1.308 (1.246–1.363)
Renal disease	1.272 (1.202–1.346)	1.227 (1.113–1.353)
Liver disease	1.086 (1.052–1.121)	1.057 (1.004–1.113)
Cancer	1.123 (1.063–1.187)	1.189 (1.090–1.296)
Metabolic syndrome	1.103 (1.077–1.130)	1.088 (1.037–1.141)
Charlson comorbidity index		
0	Reference	Reference
1	1.106 (1.061–1.152)	1.111 (1.027–1.202)
≥2	1.202 (1.076–1.343)	1.241 (0.986–1.563)

Data are presented as adjusted HR (95% CI). The hemorrhoids were defined excluding ICD-10 codes I84.2 (internal hemorrhoids without complication), I84.6 (residual hemorrhoidal skin tags), and I84.9 (unspecified hemorrhoids without complication).

Table S6 Results of sensitivity analysis using multivariate Cox regression analysis for the association of hemorrhoids with incidence risk of heart failure

Variable	Before PSM (N=347,806)			After PSM 1:5 (N=94,386)		
	Incidence rate (per 100,000 person-years)	Crude HR (95% CI)	Adjusted HR (95% CI)	Incidence rate (per 100,000 person-years)	Crude HR (95% CI)	Adjusted HR (95% CI)
Without hemorrhoids	696.204	Reference	Reference	658.971	Reference	Reference
With hemorrhoids		1.052 (1.003–1.102)	1.051 (1.010–1.094)		1.050 (1.017–1.084)	1.055 (1.012–1.100)

Values from multivariate Cox regression models adjusted for age, sex, body mass index, household income, smoking status, alcohol consumption, regular physical activity, comorbidities, and Charlson comorbidity index. The hemorrhoids were defined excluding ICD-10 codes I84.2 (internal hemorrhoids without complication), I84.6 (residual hemorrhoidal skin tags), and I84.9 (unspecified hemorrhoids without complication).

Table S7 Results of sensitivity analysis using Cox regression analysis for the association of procedure/treatment for hemorrhoids with incidence risk of heart failure.

Variables	Before PSM (N=16,136)	After PSM 1:1 (N=9,940)
Without treatment	Reference	Reference
With treatment	0.920 (0.845–1.000)	0.921 (0.841–1.001)
Age (years)	1.075 (1.068–1.082)	1.076 (1.068–1.084)
Sex		
Male	Reference	Reference
Female	0.947 (0.832–1.079)	0.942 (0.808–1.098)
Body mass index (kg/m^2)	1.062 (1.043–1.082)	1.057 (1.035–1.080)
Household income		
Low	Reference	Reference
Middle	1.054 (0.924–1.203)	1.057 (0.801–1.239)
High	0.865 (0.754–0.982)	0.933 (0.795–1.095)
Smoking status		
Never	Reference	Reference
Former	1.230 (1.025–1.477)	1.319 (1.074–1.620)
Current	1.342 (1.147–1.571)	1.396 (1.157–1.684)
Alcohol consumption (days/week)		
None	Reference	Reference
1–2 times	0.840 (0.733–0.963)	0.871 (0.742–1.024)
3–4 times	0.801 (0.631–1.018)	0.726 (0.541–0.976)
≥5 times	0.892 (0.670–1.188)	0.889 (0.637–1.240)
Regular physical activity (days/week)		
None	Reference	Reference
1–4 days	0.902 (0.801–1.016)	0.890 (0.773–1.024)
≥5 days	0.991 (0.843–1.165)	0.949 (0.785–1.149)
Comorbidities		
Hypertension	1.488 (1.327–1.668)	1.428 (1.250–1.632)
Diabetes mellitus	1.034 (0.872–1.227)	1.080 (0.875–1.284)
Dyslipidemia	1.267 (1.120–1.435)	1.208 (1.087–1.394)
Stroke	1.553 (0.854–2.823)	0.976 (0.435–2.187)
Myocardial infarction	3.824 (1.700–8.600)	2.711 (1.004–7.320)
COPD	1.493 (1.395–1.668)	1.498 (1.317–1.704)
Renal disease	1.312 (1.041–1.653)	1.398 (1.083–1.808)
Liver disease	1.031 (0.960–1.241)	1.114 (0.861–1.290)
Cancer	1.226 (1.000–1.503)	1.214 (0.967–1.523)
Metabolic syndrome	1.175 (1.087–1.319)	1.131 (0.988–1.294)
Charlson comorbidity index		
0	Reference	Reference
1	1.038 (0.851–1.268)	1.012 (0.799–1.282)
≥2	1.602 (0.594–2.581)	1.780 (1.085–2.919)

Data are presented as adjusted HR (95% CI). The hemorrhoids were defined excluding ICD-10 codes I84.2 (internal hemorrhoids without complication), I84.6 (residual hemorrhoidal skin tags), and I84.9 (unspecified hemorrhoids without complication).

Table S8 Results of sensitivity analysis using multivariate Cox regression for the association of procedure/treatment for hemorrhoids with incidence risk of heart failure

Variable	Before PSM (N=347,806			After PSM 1:5 (N=94,386		
	Incidence rate (per 100,000 person-years)	Crude HR (95% CI)	Adjusted HR (95% CI)	Incidence rate (per 100,000 person-years)	Crude HR (95% CI)	Adjusted HR (95% CI)
Without hemorrhoids	696.204	Reference	Reference	658.971	Reference	Reference
With hemorrhoids		0.921 (0.840–1.000)	0.920 (0.845–1.000)		0.912 (0.823–1.000)	0.921 (0.841–1.001)

Values from multivariate Cox regression models adjusted for age, sex, body mass index, household income, smoking status, alcohol consumption, regular physical activity, comorbidities, and Charlson comorbidity index. The hemorrhoids were defined excluding ICD-10 codes I84.2 (internal hemorrhoids without complication), I84.6 (residual hemorrhoidal skin tags), and I84.9 (unspecified hemorrhoids without complication).