Supplementary Materials

Manuscript: healthcare-4593674 | Supplementary Tables S1–S8

Table S1. Missing covariates in the AVO and MM risk sets.

Covariate	AVO: missing n (%) (risk set n = 11,595)	MM: missing n (%) (risk set n = 8,642)
Age	1 (0.0%)	1 (0.0%)
Sex	9 (0.1%)	4 (0.0%)
Marital status	1 (0.0%)	1 (0.0%)
Education	11 (0.1%)	11 (0.1%)
Residence	6 (0.1%)	5 (0.1%)
Smoking	347 (3.0%)	280 (3.2%)
Alcohol use	18 (0.2%)	15 (0.2%)
Night-time sleep	755 (6.5%)	595 (6.9%)
Napping	0 (0.0%)	0 (0.0%)
Physical activity	0 (0.0%)	0 (0.0%)

Notes: Cells are missing n (%). Denominators are the entire AVO risk set (n = 11,595) and MM risk set (n = 8,642), respectively. Each risk set excludes participants meeting that outcome definition at baseline. Percentages are rounded to one decimal place. AVO, articular–visceral organ multimorbidity; MM, overall multimorbidity.

Table S2. Sensitivity analyses allowing nonproportional covariate effects for AVO and MM.

Panel A. AVO HRs allowing nonproportional covariate effects.					
Model	**1 ACE**	**2 ACEs**	**3 ACEs**	**≥4 ACEs**	**Per ACE**
Primary Model 3	1.3253 (1.1360–1.5462)	1.5283 (1.3044–1.7906)	1.8205 (1.5241–2.1747)	2.3492 (1.9219–2.8716)	1.2102 (1.1636–1.2587)
Stratified by sex	1.3254 (1.1361–1.5463)	1.5284 (1.3045–1.7908)	1.8203 (1.5239–2.1745)	2.3466 (1.9197–2.8684)	1.2100 (1.1634–1.2584)
Stratified by alcohol use	1.3257 (1.1364–1.5466)	1.5292 (1.3052–1.7917)	1.8207 (1.5242–2.1749)	2.3475 (1.9205–2.8695)	1.2100 (1.1634–1.2584)
Joint sex and alcohol strata	1.3252 (1.1359–1.5460)	1.5271 (1.3033–1.7894)	1.8187 (1.5225–2.1725)	2.3416 (1.9154–2.8626)	1.2094 (1.1628–1.2578)
Joint time-varying sex and alcohol (linear/log)	1.3257 (1.1364–1.5466)	1.5293 (1.3052–1.7918)	1.8208 (1.5243–2.1750)	2.3469 (1.9200–2.8688)	1.2100 (1.1634–1.2584)

Panel B. MM model with sex and alcohol strata and a log-time age effect.		
ACEs	**Primary Model 3: HR (95% CI)**	**Nonproportional effects: HR (95% CI)**
1	1.0916 (0.9884–1.2057)	1.0921 (0.9888–1.2063)
2	1.2187 (1.0990–1.3514)	1.2202 (1.1002–1.3532)
3	1.3168 (1.1645–1.4890)	1.3173 (1.1649–1.4896)
≥4	1.5363 (1.3263–1.7796)	1.5369 (1.3267–1.7804)

Panel A: all AVO models use 10,822 complete cases, 1,464 events and 89,418 person-years. Schoenfeld-test p-values in the primary AVO model are 0.0265 for sex and 0.0161 for alcohol use (ACE category, 0.9085; global, 0.2800). Time-varying models retain the covariate main effects and add sex × g(t) and alcohol use × g(t), evaluated at risk-set time t. Panel B: both MM models use 8,035 complete cases, 3,042 events and 64,450 person-years. Primary-model Schoenfeld-test p-values are 0.0201 for age, 0.0051 for sex and 0.0387 for alcohol use (ACE category, 0.7266; global, 0.1715). The sensitivity model stratifies jointly by sex and alcohol use, retains age and adds centred age × log(t). Model 3 adjusts for age, sex, marital status, education, residence, smoking, alcohol use, night-time sleep, napping and physical activity; stratification variables enter as strata in the corresponding models. Estimates were refitted using the historical analytic endpoints. ACEs, adverse childhood experiences; AVO, articular–visceral organ multimorbidity; MM, overall multimorbidity; HR, hazard ratio; CI, confidence interval.

Table S3. Recorded event timing, early-event exclusion and sensitivity analysis for follow-up after ACE assessment.

Panel A. First-recorded events by outcome and wave.				
Outcome	**2013**	**2015**	**2018**	**2020**
MM	0	0	2001	1272
AVO	0	0	693	883
CMM	0	0	1367	876
NED	0	0	131	35
RES	0	0	158	213

Panel B. AVO samples before and after the early-event exclusion.						
Specification	**Risk set n**	**Events**	**Person-years**	**Model 3 n**	**Model 3 events**	**Model 3 person-years**
Exclude events coded before 2014; retain 2011 origin	11,595	1,576	95,754	10,822	1,464	89,418

Panel C. AVO hazard ratios for follow-up after the 2014 Life History Survey.		
ACEs	**Primary analysis HR (95% CI)**	**follow-up HR (95% CI)**
0	1.00 (ref.)	1.00 (ref.)
1	1.33 (1.14–1.55)	1.31 (1.13–1.53)
2	1.53 (1.30–1.79)	1.50 (1.28–1.76)
3	1.82 (1.52–2.17)	1.77 (1.48–2.11)
≥4	2.35 (1.92–2.87)	2.25 (1.84–2.75)
Per additional ACE	1.21 (1.16–1.26)	1.20 (1.15–1.25)

Notes: Panel A: first-recorded events in the historical analytic extract. Panel B: early-event exclusion retaining the 2011 origin. Panel C: original author-reported HRs (95% CIs); zero ACEs is the reference. Model 3 adjusts for age, sex, marital status, education, residence, smoking, alcohol use, night-time sleep, napping and physical activity. ACEs, adverse childhood experiences; AVO, articular–visceral organ multimorbidity; MM, overall multimorbidity; CMM, cardiometabolic multimorbidity; NED, neurocognitive and emotional multimorbidity; RES, respiratory multimorbidity; HR, hazard ratio; CI, confidence interval.

Table S4. Complete-case and multiply imputed associations between ACEs and incident AVO.

ACEs	Complete-case HR (95% CI)	Imputed HR (95% CI)	Imputed p-value
1	1.33 (1.14–1.55)	1.31 (1.13–1.52)	<0.001
2	1.53 (1.30–1.79)	1.54 (1.32–1.80)	<0.001
3	1.82 (1.52–2.17)	1.81 (1.52–2.15)	<0.001
≥4	2.35 (1.92–2.87)	2.26 (1.86–2.75)	<0.001
Per ACE	1.21 (1.16–1.26)	1.20 (1.16–1.25)	<0.001

Notes: Cells are Model 3 HRs (95% CIs); zero ACEs is the reference and continuous scores were fitted separately. Complete cases: 10,822 participants, 1,464 events and 89,418 person-years. Multiple imputation: 11,595 participants, 1,576 events and 95,754 person-years. Chained equations generated 20 datasets with 20 iterations per chain (seed 20261001), with estimates pooled using Rubin's rules. Age used predictive mean matching, binary covariates logistic regression, and education and smoking multinomial logistic regression. Predictors included Model 3 covariates, ACE category and score, the event indicator and a Nelson–Aalen cumulative-hazard estimate. Exposure and endpoints were not imputed. Model 3 adjusts for age, sex, marital status, education, residence, smoking, alcohol use, night-time sleep, napping and physical activity. ACEs, adverse childhood experiences; AVO, articular–visceral organ multimorbidity; MM, overall multimorbidity; HR, hazard ratio; CI, confidence interval.

Table S5. Availability of the nine ACE domains in the AVO risk set.

Domain	Observed n	Missing n	Missing %	Exposed n
Parental divorce or separation	11,553	42	0.4%	90
Parental mental-health problems	11,100	495	4.3%	2,374
Parental alcohol or drug-related problems	785	10,810	93.2%	91
Parental arrest or criminal record	11,595	0	0.0%	31
Parental confinement to bed	11,561	34	0.3%	1,976
Domestic violence	10,511	1,084	9.3%	2,111
Physical abuse	11,538	57	0.5%	6,714
Bullying by schoolmates	11,526	69	0.6%	2,833
Unsafe neighbourhood	8,909	2,686	23.2%	949

Notes: Denominator: 11,595 participants in the AVO risk set. Observed n denotes participants with a nonmissing derived domain; exposed n denotes recorded adversity among participants with an observed domain. Missing percentages use the entire risk set. ACEs, adverse childhood experiences; AVO, articular–visceral organ multimorbidity.

Table S6. Sample sizes and AVO associations under two ACE item-completeness rules.

Panel A. Samples under the two item-completeness rules.						
Rule	**Risk set n**	**Events**	**Person-years**	**Model n**	**Model events**	**Model person-years**
Strict nine domains	547	87	4,565	504	82	4,193
Eight observed plus assumed parental alcohol zero	7,747	1,055	64,497	7,237	976	60,257

Panel B. HRs under the two item-completeness rules.		
ACEs	**Strict nine observed: HR (95% CI)**	**Eight observed plus coding assumption: HR (95% CI)**
1	1.62 (0.74–3.54)	1.26 (1.04–1.54)
2	1.40 (0.61–3.22)	1.63 (1.34–1.99)
3	1.36 (0.57–3.27)	1.66 (1.33–2.09)
≥4	2.95 (1.34–6.47)	2.42 (1.90–3.08)
Per ACE	1.22 (1.06–1.40)	1.21 (1.16–1.27)

Notes: Panel A reports the outcome-eligible risk set and complete-case model sample. The strict rule requires all nine domains to be observed. The alternative rule requires the other eight domains to be observed and assigns zero to missing parental alcohol or drug-related responses. Panel B reports Model 3 HRs (95% CIs); zero ACEs is the reference and continuous scores were fitted separately. Model 3 adjusts for age, sex, marital status, education, residence, smoking, alcohol use, night-time sleep, napping and physical activity. ACEs, adverse childhood experiences; AVO, articular–visceral organ multimorbidity; MM, overall multimorbidity; HR, hazard ratio; CI, confidence interval.

Table S7. Ratios of the ≥4-ACE hazard ratios and exploratory comparisons across outcomes.

Comparison	Ratio of HRs (95% CI)	Nominal p-value	Holm-adjusted p-value
AVO vs MM	1.53 (1.25–1.87)	<0.001	<0.001
AVO vs CMM	1.82 (1.43–2.33)	<0.001	<0.001
AVO vs NED	1.66 (0.86–3.22)	0.131	0.263
AVO vs RES	1.08 (0.73–1.60)	0.686	0.686

Notes: Ratios compare the AVO HR with the comparator-outcome HR for ≥4 versus zero ACEs, using outcome-specific Model 3 models. Two-sided Wald tests use a joint community-level covariance to account for overlapping participants and communities. Holm adjustment covers four comparisons. Model 3 adjusts for age, sex, marital status, education, residence, smoking, alcohol use, night-time sleep, napping and physical activity. ACEs, adverse childhood experiences; AVO, articular–visceral organ multimorbidity; MM, overall multimorbidity; HR, hazard ratio; CI, confidence interval. CMM, cardiometabolic multimorbidity; NED, neurocognitive and emotional multimorbidity; RES, respiratory multimorbidity.

Table S8. Associations between ACEs and incident MM stratified by adult social resources.

Resource	Stratum	ACEs	HR (95% CI)	p-value	Interaction p-value
Social participation	No	1	1.08 (0.94–1.25)	0.264	0.855
	No	2	1.22 (1.06–1.42)	0.007	
	No	3	1.37 (1.15–1.63)	<0.001	
	No	≥4	1.62 (1.32–1.97)	<0.001	
	Yes	1	1.11 (0.96–1.27)	0.167	
	Yes	2	1.22 (1.06–1.42)	0.007	
	Yes	3	1.28 (1.07–1.53)	0.006	
	Yes	≥4	1.46 (1.17–1.82)	<0.001	
Education	Primary or below	1	1.12 (0.99–1.27)	0.068	0.643
	Primary or below	2	1.25 (1.11–1.42)	<0.001	
	Primary or below	3	1.35 (1.16–1.56)	<0.001	
	Primary or below	≥4	1.65 (1.38–1.96)	<0.001	
	Junior secondary	1	1.00 (0.81–1.24)	0.969	
	Junior secondary	2	1.18 (0.95–1.46)	0.143	
	Junior secondary	3	1.15 (0.88–1.49)	0.300	
	Junior secondary	≥4	1.46 (1.04–2.05)	0.028	
	Senior secondary or above	1	1.11 (0.83–1.49)	0.486	
	Senior secondary or above	2	1.16 (0.84–1.60)	0.355	
	Senior secondary or above	3	1.58 (1.08–2.31)	0.019	
	Senior secondary or above	≥4	1.14 (0.69–1.89)	0.596	
Selected household expenditure	Low	1	1.08 (0.91–1.29)	0.353	0.678
	Low	2	1.14 (0.95–1.36)	0.170	
	Low	3	1.15 (0.93–1.43)	0.205	
	Low	≥4	1.42 (1.08–1.87)	0.012	
	Middle	1	1.11 (0.93–1.32)	0.256	
	Middle	2	1.30 (1.09–1.55)	0.003	
	Middle	3	1.55 (1.26–1.91)	<0.001	
	Middle	≥4	1.79 (1.40–2.29)	<0.001	
	High	1	1.08 (0.91–1.28)	0.390	
	High	2	1.22 (1.02–1.46)	0.031	
	High	3	1.30 (1.05–1.61)	0.018	
	High	≥4	1.43 (1.11–1.85)	0.005	

Notes: Cells report stratified Model 3 HRs (95% CIs) and nominal p-values for MM; zero ACEs is the reference. Model 3 adjusts for age, sex, marital status, education, residence, smoking, alcohol use, night-time sleep, napping and physical activity. The stratifier is omitted where applicable. Social participation is binary; education has three categories; expenditure comprises selected food, eating-out, tobacco and alcohol spending in tertiles. Stratum sample sizes (n/events): social participation, no 4,029/1,557 and yes 4,002/1,484; education, primary or below 5,261/2,022, junior secondary 1,823/686 and senior secondary or above 951/334; expenditure, low 2,459/942, middle 2,723/1,042 and high 2,800/1,040. Likelihood-ratio interaction tests use common complete cases: social participation, n = 8,031, 3,041 events, p = 0.855; education, n = 8,035, 3,042 events, p = 0.643; expenditure, n = 7,982, 3,024 events, p = 0.678. ACEs, adverse childhood experiences; MM, overall multimorbidity; AVO, articular–visceral organ multimorbidity; HR, hazard ratio; CI, confidence interval.