Supplementary Table S1. Number of deaths by sex and age

Area	Total	Male	Female	0–64 yrs	⩾ 65 yrs
Xining	11107	6678	4429	2830	8277
Qingdao	9638	5306	4332	2287	7351
Yancheng	15101	8392	6709	2836	12265
Wuxi	7324	3986	3338	1236	6088
Feixi	12516	7477	5039	2582	9934
Xiangtan	20306	11913	8393	4230	16076
Ningbo	109355	60844	48511	19292	90063
Wuhan	39461	22949	16512	8362	31099
Yunxi	8499	5074	3425	2385	6114
Yichang	11117	6502	4615	2525	8592
Shenzhen	3635	2205	1430	1382	2253
Korla	3641	2276	1365	1376	2265
Binyang	15357	9120	6237	4709	10648
Chengdu	9666	5503	4163	1649	8017
Mengzi	6666	3947	2719	2460	4206
Lhasa	770	459	311	316	454
Nyingchi	784	471	313	385	399
Huairou	5275	3044	2231	1196	4079
Zhengding	7338	4153	3185	1995	5343
Horinger	2049	1313	736	479	1570
Hailar	4981	2887	2094	1510	3471
Liaoyang	9463	5610	3853	2636	6827
Harbin	15839	8940	6899	4577	11262
Shanghe	12381	6742	5639	2637	9744
Total	342269	195791	146478	75872	266397

Supplementary Table S2. Relative risk associated with cold spells for each group

Cold spells	***RR* (95% *CI*)**												
	Total	Male	Female	0–64	⩾ 65	TMC	SMC	North	South	Urban	Rural	Respiratory diseases	Circulatory diseases
C10P_2D	1.07 (0.98, 1.17)	1.04 (0.93, 1.17)	1.14 (1.05, 1.23)	1.02 (0.91, 1.15)	1.13 (1.04, 1.22)	1.03 (0.94, 1.13)	1.16 (1.03, 1.31)	0.98 (0.89, 1.08)	1.15 (1.02, 1.29)	1.03 (0.94, 1.12)	1.18 (0.99, 1.42)	1.13 (0.99, 1.29)	1.15 (1.06, 1.25)
C10P_3D	1.07 (0.99, 1.17)	1.04 (0.94, 1.16)	1.14 (1.06, 1.22)	1.02 (0.91, 1.14)	1.14 (1.06, 1.22)	1.03 (0.94, 1.13)	1.16 (1.04, 1.29)	0.98 (0.89, 1.08)	1.15 (1.04, 1.28)	1.05 (0.97, 1.14)	1.15 (0.97, 1.36)	1.14 (1.02, 1.27)	1.16 (1.06, 1.26)
C10P_4D	1.05 (0.98, 1.12)	1.02 (0.94, 1.10)	1.10 (1.00, 1.20)	0.99 (0.88, 1.10)	1.12 (1.06, 1.17)	0.99 (0.90, 1.08)	1.12 (1.03, 1.21)	0.95 (0.87, 1.03)	1.12 (1.03, 1.21)	1.04 (0.97, 1.12)	1.07 (0.92, 1.23)	1.10 (0.98, 1.22)	1.15 (1.07, 1.25)
C5P_2D	1.10 (1.00, 1.20)	1.07 (0.96, 1.20)	1.17 (1.06, 1.28)	1.01 (0.87, 1.18)	1.20 (1.13, 1.27)	1.01 (0.90, 1.14)	1.21 (1.09, 1.33)	0.97 (0.87, 1.09)	1.21 (1.09, 1.33)	1.09 (0.98, 1.22)	1.11 (0.95, 1.30)	1.18 (1.02, 1.36)	1.26 (1.14, 1.40)
C5P_3D	1.09 (1.00, 1.19)	1.08 (0.97, 1.21)	1.12 (1.02, 1.24)	1.01 (0.88, 1.16)	1.19 (1.12, 1.27)	0.99 (0.87, 1.12)	1.18 (1.09, 1.28)	0.96 (0.86, 1.08)	1.19 (1.09, 1.29)	1.12 (1.03, 1.21)	1.12 (0.93, 1.34)	1.24 (1.06, 1.45)	1.22 (1.09, 1.37)
C5P_4D	1.10 (1.01, 1.19)	1.09 (0.97, 1.21)	1.12 (1.01, 1.23)	1.06 (0.93, 1.20)	1.15 (1.08, 1.23)	1.04 (0.88, 1.22)	1.14 (1.05, 1.24)	1.01 (0.87, 1.16)	1.14 (1.06, 1.24)	1.10 (1.02, 1.19)	1.14 (0.93, 1.39)	1.16 (0.99, 1.36)	1.20 (1.07, 1.34)
C2.5P_2D	1.12 (1.01, 1.25)	1.13 (0.99, 1.29)	1.13 (0.99, 1.29)	1.05 (0.90, 1.24)	1.21 (1.11, 1.32)	1.05 (0.90, 1.24)	1.20 (1.03, 1.40)	1.02 (0.88, 1.18)	1.20 (1.03, 1.39)	1.09 (0.98, 1.21)	1.23 (0.99, 1.53)	1.12 (1.01, 1.25)	1.29 (1.14, 1.46)
C2.5P_3D	1.13 (1.00, 1.28)	1.12 (0.96, 1.32)	1.16 (1.01, 1.33)	1.07 (0.92, 1.25)	1.21 (1.07, 1.37)	1.09 (0.88, 1.34)	1.20 (1.01, 1.42)	1.04 (0.87, 1.25)	1.20 (1.01, 1.42)	1.07 (0.96, 1.19)	1.32 (0.99, 1.77)	1.07 (0.82, 1.40)	1.26 (1.08, 1.47)
C2.5P_4D	1.16 (1.01, 1.33)	1.18 (0.98, 1.43)	1.12 (0.94, 1.33)	1.14 (0.92, 1.41)	1.19 (1.07, 1.34)	1.09 (0.87, 1.36)	1.24 (1.01, 1.52)	1.05 (0.88, 1.27)	1.25 (1.02, 1.53)	1.06 (0.94, 1.21)	1.38 (1.02, 1.85)	1.06 (0.78, 1.44)	1.27 (1.09, 1.47)
C1P_2D	1.15 (0.95, 1.39)	1.09 (0.85, 1.39)	1.27 (1.03, 1.57)	1.06 (0.82, 1.38)	1.27 (1.07, 1.50)	1.04 (0.76, 1.43)	1.32 (1.09, 1.59)	0.98 (0.76, 1.28)	1.32 (1.09, 1.59)	1.12 (0.94, 1.35)	1.35 (0.90, 2.02)	1.15 (0.95, 1.39)	1.39 (1.06, 1.82)
C1P_3D	1.16 (0.95, 1.42)	1.10 (0.86, 1.42)	1.28 (1.01, 1.64)	1.07 (0.80, 1.44)	1.28 (1.06, 1.53)	1.04 (0.79, 1.38)	1.29 (0.97, 1.72)	0.99 (0.76, 1.30)	1.29 (0.97, 1.72)	1.03 (0.84, 1.26)	1.51 (1.01, 2.27)	0.87 (0.55, 1.39)	1.44 (1.08, 1.93)
C1P_4D	1.13 (0.87, 1.47)	1.04 (0.75, 1.44)	1.37 (1.04, 1.81)	1.11 (0.77, 1.61)	1.14 (0.89, 1.48)	1.00 (0.71, 1.42)	1.31 (0.89, 1.93)	0.95 (0.72, 1.26)	1.31 (0.89, 1.93)	0.94 (0.74, 1.19)	1.62 (1.01, 2.59)	0.83 (0.46, 1.49)	1.36 (0.98, 1.87)

Note. RR represents for relative risk; TMC represents for temperate monsoon climate zone; SMC represents for subtropical monsoon climate zone.

Supplementary Table S3. Results of sensitivity analysis for controlling meteorological factors

Cold spells	Basic model*	Changing exposure factor	Adjusting *df* of relative humidity		Adjusting *df* of atmospheric pressure	
		T_min	2	4	2	4
C10P_2D	1.07 (0.98, 1.17)	1.07 (1.01, 1.13)	1.07 (0.98, 1.17)	1.07 (0.98, 1.17)	1.07 (0.98, 1.17)	1.07 (0.98, 1.17)
C10P_3D	1.07 (0.99, 1.17)	1.05 (0.99, 1.12)	1.07 (0.99, 1.16)	1.07 (0.99, 1.17)	1.07 (0.99, 1.17)	1.07 (0.98, 1.16)
C10P_4D	1.05 (0.98, 1.12)	1.05 (0.98, 1.11)	1.04 (0.97, 1.12)	1.05 (0.97, 1.12)	1.04 (0.98, 1.12)	1.04 (0.97, 1.11)
C5P_2D	1.10 (1.00, 1.20)	1.09 (1.00, 1.18)	1.09 (1.00, 1.19)	1.10 (1.00, 1.20)	1.09 (1.00, 1.19)	1.09 (1.00, 1.19)
C5P_3D	1.09 (1.00, 1.19)	1.06 (0.96, 1.17)	1.09 (1.00, 1.18)	1.09 (1.01, 1.19)	1.09 (1.00, 1.19)	1.09 (1.00, 1.18)
C5P_4D	1.10 (1.01, 1.19)	1.08 (0.96, 1.22)	1.09 (1.01, 1.18)	1.10 (1.01, 1.19)	1.09 (1.01, 1.19)	1.09 (1.01, 1.18)
C2.5P_2D	1.12 (1.01, 1.25)	1.20 (1.07, 1.35)	1.12 (1.01, 1.24)	1.12 (1.01, 1.25)	1.12 (1.01, 1.25)	1.12 (1.01, 1.24)
C2.5P_3D	1.13 (1.00, 1.28)	1.16 (1.04, 1.31)	1.13 (1.00, 1.27)	1.13 (1.00, 1.27)	1.13 (1.00, 1.28)	1.12 (0.99, 1.27)
C2.5P_4D	1.16 (1.01, 1.33)	1.19 (1.02, 1.39)	1.15 (1.01, 1.32)	1.16 (1.01, 1.33)	1.16 (1.00, 1.33)	1.15 (1.00, 1.32)
C1P_2D	1.15 (0.95, 1.39)	1.15 (0.93, 1.41)	1.15 (0.96, 1.37)	1.15 (0.96, 1.38)	1.15 (0.95, 1.38)	1.14 (0.95, 1.38)
C1P_3D	1.16 (0.95, 1.42)	1.15 (0.91, 1.45)	1.15 (0.95, 1.40)	1.15 (0.95, 1.41)	1.16 (0.95, 1.41)	1.15 (0.94, 1.41)

C1P_4D	1.13 (0.87, 1.47)	1.10 (0.82, 1.48)	1.13 (0.88, 1.44)	1.13 (0.88, 1.45)	1.13 (0.88, 1.47)	1.12 (0.87, 1.46)

Note. *: *T_min* stands for daily minimum temperature; *df* stands for degrees of freedom. In the basic model, exposure factor is daily mean temperature, *df* of relative humidity and atmospheric pressure is 3.

Supplementary Table S4. Results of sensitivity analysis of different lag days

Cold spells	**Basic model***	**Adjusting *lag* days for daily mean temperature**	
		14	28
C10P_2D	1.07 (0.98, 1.17)	1.08 (1.02, 1.14)	1.09 (1.00, 1.19)
C10P_3D	1.07 (0.99, 1.17)	1.09 (1.05, 1.13)	1.10 (1.01, 1.20)
C10P_4D	1.05 (0.98, 1.12)	1.05 (1.00, 1.11)	1.09 (1.01, 1.18)
C5P_2D	1.10 (1.00, 1.20)	1.08 (1.01, 1.15)	1.16 (1.03, 1.31)
C5P_3D	1.09 (1.00, 1.19)	1.08 (1.00, 1.15)	1.16 (1.03, 1.31)
C5P_4D	1.10 (1.01, 1.19)	1.08 (1.01, 1.15)	1.17 (1.02, 1.36)
C2.5P_2D	1.12 (1.01, 1.25)	1.05 (0.98, 1.12)	1.16 (1.00, 1.35)
C2.5P_3D	1.13 (1.00, 1.28)	1.04 (0.97, 1.12)	1.18 (0.96, 1.46)
C2.5P_4D	1.16 (1.01, 1.33)	1.07 (0.95, 1.21)	1.17 (0.97, 1.43)
C1P_2D	1.15 (0.95, 1.39)	1.05 (0.94, 1.17)	1.23 (0.97, 1.56)
C1P_3D	1.16 (0.95, 1.42)	1.02 (0.91, 1.15)	1.18 (0.88, 1.58)
C1P_4D	1.13 (0.87, 1.47)	1.04 (0.89, 1.21)	1.11 (0.78, 1.57)

Note. *: In the basic model, *lag*=0-3 days. Bold values of RR were statistically significant.

Supplementary Table S5. Results of sensitivity analysis for adjusting *df* of air pollutants

Cold spells	**Basic model***	**Adjusting *df* of O_3**		**Adjusting *df* of $PM_{2.5}$**	
		2	4	2	4
C10P_2D	1.07 (0.98, 1.17)	1.08 (0.99, 1.17)	1.07 (0.98, 1.17)	1.07 (0.98, 1.17)	1.08 (0.99, 1.17)
C10P_3D	1.07 (0.99, 1.17)	1.08 (0.99, 1.17)	1.07 (0.99, 1.17)	1.07 (0.99, 1.16)	1.08 (0.99, 1.17)
C10P_4D	1.05 (0.98, 1.12)	1.05 (0.98, 1.12)	1.05 (0.98, 1.12)	1.04 (0.97, 1.12)	1.05 (0.98, 1.12)
C5P_2D	1.10 (1.00, 1.20)	1.10 (1.01, 1.20)	1.09 (1.00, 1.20)	1.09 (1.00, 1.19)	1.10 (1.01, 1.20)
C5P_3D	1.09 (1.00, 1.19)	1.10 (1.01, 1.19)	1.09 (1.00, 1.19)	1.09 (1.00, 1.19)	1.10 (1.01, 1.20)
C5P_4D	1.10 (1.01, 1.19)	1.10 (1.02, 1.19)	1.10 (1.01, 1.19)	1.10 (1.01, 1.19)	1.10 (1.02, 1.19)
C2.5P_2D	1.12 (1.01, 1.25)	1.13 (1.02, 1.25)	1.12 (1.01, 1.24)	1.12 (1.01, 1.24)	1.13 (1.03, 1.25)
C2.5P_3D	1.13 (1.00, 1.28)	1.13 (1.01, 1.28)	1.13 (1.00, 1.28)	1.13 (1.00, 1.28)	1.14 (1.01, 1.29)
C2.5P_4D	1.16 (1.01, 1.33)	1.16 (1.01, 1.33)	1.15 (1.00, 1.33)	1.16 (1.01, 1.33)	1.17 (1.01, 1.34)
C1P_2D	1.15 (0.95, 1.39)	1.15 (0.95, 1.38)	1.14 (0.95, 1.38)	1.15 (0.95, 1.38)	1.17 (0.97, 1.40)
C1P_3D	1.16 (0.95, 1.42)	1.15 (0.95, 1.40)	1.15 (0.94, 1.40)	1.16 (0.95, 1.41)	1.17 (0.96, 1.43)
C1P_4D	1.13 (0.87, 1.47)	1.13 (0.87, 1.45)	1.12 (0.87, 1.45)	1.13 (0.88, 1.46)	1.14 (0.88, 1.48)

Note. *: *df* stands for degrees of freedom. In the basic model, the *df* of O_3 and $PM_{2.5}$ is 3.

Supplementary Table S6. Results of sensitivity analysis for controlling air pollutants

Cold spells	Basic model*	Replacing air pollutant	Changing air pollutants	
		PM_{10}	*P*	*NO_2*
C10P_2D	1.07 (0.98, 1.17)	1.07 (0.98, 1.16)	1.08 (0.99, 1.17)	1.08 (0.99, 1.17)
C10P_3D	1.07 (0.99, 1.17)	1.07 (0.99, 1.16)	1.08 (1.00, 1.17)	1.08 (0.99, 1.17)
C10P_4D	1.05 (0.98, 1.12)	1.04 (0.97, 1.11)	1.05 (0.98, 1.12)	1.05 (0.98, 1.12)
C5P_2D	1.10 (1.00, 1.20)	1.09 (1.00, 1.19)	1.10 (1.01, 1.20)	1.10 (1.01, 1.20)
C5P_3D	1.09 (1.00, 1.19)	1.09 (1.00, 1.19)	1.09 (1.00, 1.19)	1.10 (1.01, 1.19)
C5P_4D	1.10 (1.01, 1.19)	1.09 (1.00, 1.19)	1.10 (1.01, 1.19)	1.10 (1.02, 1.18)
C2.5P_2D	1.12 (1.01, 1.25)	1.12 (1.01, 1.24)	1.13 (1.02, 1.25)	1.12 (1.02, 1.24)
C2.5P_3D	1.13 (1.00, 1.28)	1.13 (0.99, 1.28)	1.13 (1.00, 1.27)	1.13 (1.00, 1.27)
C2.5P_4D	1.16 (1.01, 1.33)	1.16 (1.00, 1.34)	1.16 (1.01, 1.33)	1.15 (1.01, 1.32)
C1P_2D	1.15 (0.95, 1.39)	1.14 (0.95, 1.37)	1.15 (0.96, 1.39)	1.16 (0.97, 1.38)
C1P_3D	1.16 (0.95, 1.42)	1.15 (0.94, 1.40)	1.16 (0.95, 1.42)	1.17 (0.97, 1.42)
C1P_4D	1.13 (0.87, 1.47)	1.13 (0.87, 1.46)	1.13 (0.88, 1.46)	1.15 (0.90, 1.47)

Note. *: In the basic model, air pollution factors include *$PM_{2.5}$*; *P* means air pressure.

An example demonstrating the calculation of *VSL* and *V*SLY.

Site, Yichang;

Year, 2014.

Step 1，Calculating $VSL_{\text{Yichang,2014}}$.

VSL_{base}= 5.54 million CNY;

$GDP_{\text{Yichang,2014}}$ = 284.62 billion CNY；

$GDP_{\text{Yichang,2016}}$ = 338.36 billion CNY.

Equation:

$$VSL_{\text{Yichang,2014}} = VSL_{base} \times \left(\frac{GDP_{\text{Yichang,2014}}}{GDP_{\text{Yichang,2016}}}\right)^{0.5}$$

Step 2，Calculating $VSLY_{\text{Yichang, 2014, female}}$ and $VSLY_{\text{Yichang,2014, male}}$.

$LE_{2014,40,female}$ = 41.4 years;

$LE_{2014,40,male}$ = 36.5 years;

r = 3%.

Equations:

$$VSLY_{\text{Yichang,2014, female}} = VSL_{\text{Yichang,2014}} \times r \times \left[1 - (1+r)^{-LE_{2014,40_{\text{female}}}}\right]^{-1}$$

$$VSLY_{\text{Yichang,2014, male}} = VSL_{\text{Yichang,2014}} \times r \times \left[1 - (1+r)^{-LE_{2014,40_{\text{male}}}}\right]^{-1}$$

Step 3，Calculating *VSL* for age-specific sexes in Yichang.

Calculating $VSL_{age,site,year,sex}$ for a 65-year-old population, i.e., $VSL_{\text{65,Yichang,2014,female}}$ and $VSL_{\text{65,Yichang,2014,male}}$.

$LE_{\text{65,2014,female}}$ = 18.7 years;

$LE_{\text{65,2014,male}}$ = 15.4 years.

Equations:

$$VSL_{\text{65,Yichang,2014, female}} = VSLY_{\text{Yichang,2014,female}} \times LE_{\text{65,female,2014}}$$

$$VSL_{65,\text{Yichang},2014,\ \text{male}} = VSL_{\text{Yichang},2014,\text{male}} \times LE_{65,\text{male},2014}$$

Step 4， The sum of the $VSL_{age,site,year,sex}$ for each age-sex group is the economic burden from 2014 due to premature death in Yichang.