

## Supplementary Materials

Table S1. Air quality regulations in Seoul metropolitan area (SMA) after 2005

| Policy field                         | Regulation                                   | Year | Area  | Contents                                                                                                                                                     |
|--------------------------------------|----------------------------------------------|------|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| On-road mobile sources               | Compulsory supply of low-emission vehicles   | 2005 | SMA   | Required vehicle suppliers in Seoul metropolitan area to supply low-emission vehicles as many as a standard which was set annually                           |
|                                      | Compulsory purchase of low-emission vehicles | 2005 | SMA   | Required administrative agencies of certain size or larger in Seoul metropolitan area to purchase half of new vehicles as low-emission vehicles              |
|                                      | Emission control of old diesel vehicles      | 2005 | SMA   | Financially supported owners of old diesel vehicles to install emission reduction equipment, to retrofit low emission engines, or to scrap their car earlier |
|                                      | Supply of low-emission buses                 | 2005 | SMA   | Replaced diesel buses to compressed natural gas (CNG) buses                                                                                                  |
| Industries                           | Installation of low-NOx burner               | 2006 | SMA   | Financially supported small and medium-sized industries to install low-NOx burner                                                                            |
|                                      | Limits on total emission of air pollutants   | 2007 | SMA   | Allocated the total amount of NOx and SOx emission to certain facilities                                                                                     |
| Protection of susceptible population | PM <sub>10</sub> alert/warning system        | 2005 | Seoul | Issued a warning or an alert when the real-time concentration of PM <sub>10</sub> reached certain level which were set as being harmful to health            |
|                                      | PM <sub>2.5</sub> alert/warning system       | 2013 | Seoul | Issued a warning or an alert when the real-time concentration of PM <sub>2.5</sub> reached certain level which were set as being harmful to health           |

Table S2. Weights of the potential control groups.

|              | Synthetic control for<br>cardiovascular mortality rate<br>in Seoul | Synthetic control for<br>cardiovascular mortality rate<br>in Incheon |
|--------------|--------------------------------------------------------------------|----------------------------------------------------------------------|
|              | Weight                                                             | Weight                                                               |
| Busan        | 0                                                                  | 0.241                                                                |
| Daegu        | 0.165                                                              | 0.175                                                                |
| Gwangju      | 0.408                                                              | 0.004                                                                |
| Daejeon      | 0.161                                                              | 0.27                                                                 |
| Ulsan        | 0                                                                  | 0.093                                                                |
| Gangwon      | 0                                                                  | 0.001                                                                |
| Chungbuk     | 0                                                                  | 0.001                                                                |
| Chungnam     | 0.266                                                              | 0.002                                                                |
| Jeonbuk      | 0                                                                  | 0.002                                                                |
| Jeonnam      | 0                                                                  | 0.002                                                                |
| Gyeongbuk    | 0                                                                  | 0.063                                                                |
| Gyeongnam    | 0                                                                  | 0.144                                                                |
| Jeju         | 0                                                                  | 0                                                                    |
| <b>Total</b> | <b>1.000</b>                                                       | <b>1.000</b>                                                         |

Table S3. Results from sensitivity analyses using direct adjustment of the counterfactual mortality rate.

|         |                                            | Main results                                 | Direct adjustment *                          |
|---------|--------------------------------------------|----------------------------------------------|----------------------------------------------|
|         |                                            | Coefficient (95% CI)                         | Coefficient (95% CI)                         |
| Seoul   | $\beta_0$ (Intercept)                      | -9.0387 (-9.0691, -9.0083) <sup>b</sup>      | -13.0059 (-13.7587, -12.2531) <sup>b</sup>   |
|         | $\beta_1$ (Time trend)                     | -0.0006 (-0.001, -0.0003) <sup>b</sup>       | 0.0069 (0.0049, 0.0089) <sup>b</sup>         |
|         | <b><math>\beta_2</math> (Slope change)</b> | <b>-0.001 (-0.0015, -0.0004)<sup>b</sup></b> | <b>-0.0033 (-0.004, -0.0027)<sup>b</sup></b> |
| Incheon | $\beta_0$ (Intercept)                      | -8.8282 (-8.8618, -8.7946) <sup>a</sup>      | -10.4749 (-11.4589, -9.4909) <sup>b</sup>    |
|         | $\beta_1$ (Time trend)                     | 0 (-0.0004, 0.0003) <sup>a</sup>             | 0.0012 (-0.0015, 0.0038) <sup>b</sup>        |
|         | <b><math>\beta_2</math> (Slope change)</b> | <b>-0.0006 (-0.0012, 0)<sup>a</sup></b>      | <b>-0.002 (-0.0027, -0.0012)<sup>b</sup></b> |

<sup>a</sup> Adjusted for seasonal dummy variable<sup>b</sup> Adjusted for seasonal dummy variable and autoregressive term

\* Direct adjustment of the counterfactual mortality rate with using smoothing spline function

Table S4. Results from sensitivity analyses re-constructing synthetic controls (SC).

|         |                                            | Main results                                  | SC excluding regions<br>having similar regulations <sup>†</sup> | SC excluding<br>neighboring regions <sup>‡</sup> |
|---------|--------------------------------------------|-----------------------------------------------|-----------------------------------------------------------------|--------------------------------------------------|
|         |                                            | Coefficient (95% CI)                          | Coefficient (95% CI)                                            | Coefficient (95% CI)                             |
| Seoul   | $\beta_0$ (Intercept)                      | -9.0387 (-9.0691, -9.0083) <sup>b</sup>       | -9.0473 (-9.0794, -9.0151) <sup>b</sup>                         | -9.0438 (-9.0737, -9.0139) <sup>b</sup>          |
|         | $\beta_1$ (Time trend)                     | -0.0006 (-0.001, -0.0003) <sup>b</sup>        | -0.0005 (-0.0008, -0.0001) <sup>b</sup>                         | -0.0007 (-0.0011, -0.0004) <sup>b</sup>          |
|         | <b><math>\beta_2</math> (Slope change)</b> | <b>-0.001 (-0.0015, -0.0004) <sup>b</sup></b> | <b>-0.0009 (-0.0014, -0.0003) <sup>b</sup></b>                  | <b>-0.0009 (-0.0014, -0.0004) <sup>b</sup></b>   |
| Incheon | $\beta_0$ (Intercept)                      | -8.8282 (-8.8618, -8.7946) <sup>a</sup>       | -8.8718 (-8.9058, -8.8377) <sup>a</sup>                         | -8.8492 (-8.8827, -8.8157) <sup>b</sup>          |
|         | $\beta_1$ (Time trend)                     | 0 (-0.0004, 0.0003) <sup>a</sup>              | 0.0001 (-0.0003, 0.0005) <sup>a</sup>                           | 0.0003 (-0.0001, 0.0006) <sup>b</sup>            |
|         | <b><math>\beta_2</math> (Slope change)</b> | <b>-0.0006 (-0.0012, 0) <sup>a</sup></b>      | <b>-0.0009 (-0.0015, -0.0003) <sup>a</sup></b>                  | <b>-0.0015 (-0.0021, -0.0009) <sup>b</sup></b>   |

<sup>a</sup> Adjusted for seasonal dummy variable<sup>b</sup> Adjusted for seasonal dummy variable and autoregressive term<sup>†</sup> Potential control groups: eleven regions excluding Busan, Daegu, and Jeonnam<sup>‡</sup> Potential control groups: nine regions excluding Daejeon, Gangwon, Chungbuk, and Chungnam

Table S5. Results from sensitivity analyses with different time point of the health effects.

|         |                                            | Main results                                  | 2005 as the time point<br>of interruption      | 2008 as the time point<br>of interruption      |
|---------|--------------------------------------------|-----------------------------------------------|------------------------------------------------|------------------------------------------------|
|         |                                            | Coefficient (95% CI)                          | Coefficient (95% CI)                           | Coefficient (95% CI)                           |
| Seoul   | $\beta_0$ (Intercept)                      | -9.0387 (-9.0691, -9.0083) <sup>b</sup>       | -8.9896 (-9.023, -8.9561) <sup>b</sup>         | -8.9964 (-9.0252, -8.9676) <sup>b</sup>        |
|         | $\beta_1$ (Time trend)                     | -0.0006 (-0.001, -0.0003) <sup>b</sup>        | -0.0006 (-0.0011, -0.0002) <sup>b</sup>        | -0.0005 (-0.0008, -0.0002) <sup>b</sup>        |
|         | <b><math>\beta_2</math> (Slope change)</b> | <b>-0.001 (-0.0015, -0.0004) <sup>b</sup></b> | <b>-0.0008 (-0.0014, -0.0002) <sup>b</sup></b> | <b>-0.0008 (-0.0013, -0.0002) <sup>b</sup></b> |
| Incheon | $\beta_0$ (Intercept)                      | -8.8282 (-8.8618, -8.7946) <sup>a</sup>       | -8.8425 (-8.8791, -8.806) <sup>a</sup>         | -8.83 (-8.8623, -8.7978) <sup>b</sup>          |
|         | $\beta_1$ (Time trend)                     | 0 (-0.0004, 0.0003) <sup>a</sup>              | 0.0001 (-0.0004, 0.0006) <sup>a</sup>          | 0.0001 (-0.0002, 0.0005) <sup>b</sup>          |
|         | <b><math>\beta_2</math> (Slope change)</b> | <b>-0.0006 (-0.0012, 0) <sup>a</sup></b>      | <b>-0.0006 (-0.0013, 0.0001) <sup>a</sup></b>  | <b>-0.0009 (-0.0015, -0.0004) <sup>b</sup></b> |

<sup>a</sup> Adjusted for seasonal dummy variable<sup>b</sup> Adjusted for seasonal dummy variable and autoregressive term