Particles in the atmosphere have serious effects on human health, while the mechanism for this remains unclear. Before and during 2008 Beijing Olympics, the air quality was drastically changed. During this period, this study conducted environmental exposure, time series, panel study, and toxicological experiment to investigate the mechanism of the health effects of particles by studying the environment and surface processes. We found: 1) exposure to particles was associated with the increase in numbers of emergency room visits due to cardiovascular disease; the increase in blood pressure and the decrease in heart rate variability were correlated with the increases in concentrations of particles and BC, these findings are consistent with toxicological experimental results; 2) concentrations of particles and BC are associated with respiratory inflammation, BC has the most robust association and causal relationship with respiratory inflammation; 3) exposure to particles can cause birth defects of mice; 4) atmospheric particles can cause oxidative stress, decrease viability, release several pro-inflammation cytokines and chemokines in culture medium and induce related gene expression; 5) iron absorbed on the surface of particles can induce OH radicals, quinones absorbed on airborne particles can induce cellular •OH generation, quartz particles can stimulate a significant increase in calcium in cells and cause cell damage. In summary, this study has found systematic evidences for understanding the mechanism of the health effects of particles.