Health-risk Investigation Among First-grade School Children From Shanghai Chemical Industry Park (SCIP): A Cross-sectional Study

Shuang Xiao
Fudan University
Mingjia Xu
Shanghai Municipal Center for Disease Control and Prevention
Lihua Wang
Jinshan District for Disease Control and Prevention,shanghai
Wei Tu
Georgia Southern University
Lili Yu
Georgia Southern University
Yongqi Sun
Fudan University
Jun Zhang
Fudan University
Wenge Wang
Fudan University
Jian Hu
Fudan University
Yi Hu
Fudan University
Xuesong Zhou
Jinshan District Center for Disease Control and Prevention,shanghai
Qingtao Cai
Jinshan District Center for Disease Control and Prevention,shanghai
Yaning Zhang
Jinshan District Center for Disease Control and Prevention,shanghai
Zhijie Zhang (epistat@gmail.com)
Department of Epidemiology and Biostatistics, School of Public Health, Fudan University, Shanghai, China https://orcid.org/0000-0002-1276-787X

Research

Keywords: chemical industry; children's health; hematological parameters; cross-sectional study; Shanghai, China

Posted Date: November 13th, 2020

DOI: https://doi.org/10.21203/rs.3.rs-102621/v1

Abstract

Background

Shanghai Chemical Industry Park (SCIP), located in Jinshan District, is the largest industrial zone in China. However, the impact on the residents' health has not been assessed. The study aimed to identify the impact of living in chemical industrial areas on the health of first-grade students

Method

A cross-sectional study was conducted among first-graders between May and June 2016 in Jinshan District using experimental examinations and questionnaires. Demographic statistics and hematological parameters were summarized. Geographical distribution and high-risk clusters of prevalence of diseases and birth status were depicted. Multivariate logistic model was used to analyze the differences in the prevalence of diseases and symptoms between chemical and nonchemical industrial areas after adjusting for potential factors.

Result

A total of 4821 first graders were included in the study. Mean age was 7.2 (±0.41) years. The prevalence of respiratory, digestive, and skin diseases was 0.229, 0.042, and 0.168, respectively. We observed one spatial cluster each for respiratory diseases (RD) and skin diseases, respectively. Significant differences in birth defects were not observed. Some significantly different hematological parameters and higher prevalence of RD in nonchemical industrial areas might indicate pollutant exposures in nonchemical industrial areas. The study revealed a possible positive association between environmental factors and RD.

Conclusion

Strong evidence regarding the main impact of SCIP on the health of school children was not observed. Governments and parents might need to pay more attention to indoor and other environmental management. Long-term health effects of chemical industries should be continuously monitored.

Highlights

- The chemical industry park did not affect adverse effects on human health.
- Birth status were considered independent factors of chemical industrial areas.
- Respiratory diseases were associated with indoor environmental exposures.

Introduction

Chemical industries play an important role in the development of the Chinese economy. Up to now, China is the largest chemical-producing country in the world. There have been 22 multimillion-ton refinery and

10 million-ton ethylene petrochemical enterprises in China, clustered into petrochemical industrial parks in the Yangtze River Delta, the Pearl River Delta, and the Bohai Rim Delta. Chemical industries bring huge economic benefits, but simultaneously cause chemical pollution and accidents[1]. The development of chemical industries poses a big challenge to the local environment. Toxic chemicals such as nitrogen oxides[2] and sulfur oxides[3] from the chemical industrial parks have adverse effects on the environment and seriously threaten the surrounding residents' health [4]. Long-term exposure to chemical pollutants (e.g. persistent organic pollutants, heavy metals, particulate matters [PMs]) can lead to acute or chronic symptoms on the human respiratory, digestive, integumentary, nervous, and hematopoietic systems[5]. Maternal exposure to toxic chemicals, particularly to heavy metals, reduces fetal development to a certain extent (e.g., preterm delivery, low birth weight)[5, 6]. Due to the biological vulnerability of children, they are more likely to be affected by the chemical toxicants in the environment than individuals in other age groups [7, 8]. Thus, the health problems of children living near chemical industrial areas (CIA) should pay more attention.

Shanghai Chemical Industry Park (SCIP) is the largest chemical industry park in China, located in the Jinshan District of Shanghai. It is also the first chemical development zone specialized in the development of petrochemical and fine chemistry businesses in China, the leading chemical industry park in the Yangtze River Delta. In the 11th Five-Year Plan (2006–2010), an industrial structure characterized by the gathering of chemical industry was officially formed in the southern part of Jinshan District. In 2008, the three major regions of SCIP, consisting of Shanghai chemical industry zone, Shanghai petrochemical industry zone, and Jinshan second industrial zone, were all completed and put into production. Hence, it is a suitable research site to clarify whether the chemical industries would affect the residents' health. Previous studies from China have mainly focused on the identification of chemical risk sources and individual risk assessment [9-11]. Although both the local government and residents are concerned with the health problems caused by chemical industries, population-based epidemiological studies focusing on the health effects of these chemical industries are insufficient due to potential political issues.

This was a comprehensive school-based cross-sectional study involving all first-grade school children born in 2008 (considering children's vulnerability to chemical pollution, the time the chemical industries initiated their operation, the homogeneity of subjects' characteristics, feasibility of the study and follow-up studies) to investigate the potential influence of the chemical industry on residents' health, especially school children.

Materials And Methods

Study sites

Jinshan District is in the southwest suburb of Shanghai Municipality, with a population of 520,404, nearly half of which are urban population in 2016. The area is 44 km long from east to west and 26 km wide from north to south. It includes 11 townships with a total area of 613 km^2. Jinshan District is the only districts in Shanghai where the economy is dominated primarily by chemical industries and agriculture. Based on the location of the chemical industrial zones (Shanghai chemical industry zone in CJ, Shanghai petrochemical industry zone in SH, and Jinshan second industrial zone in JSW) in Jinshan, the 11 townships were divided into CIA and nonchemical industrial areas (non-CIA) (Figure 1a). CIA include three townships, CJ, JSW, and SH. Non-CIA include eight townships: FJ, LvX, LX, SY, ZY, ZJ, TL, and JSGYQ.

Subjects

General surveys including questionnaires and measurements were conducted on the first-grade school children enrolled in 2015 during the fall semester in all the 28 primary schools within the 11 townships in Jinshan District, Shanghai. Measurements were completed between May and June 2016, while all the questionnaire surveys were finished in September 2016.

Questionnaires

The questionnaires consisted of the following three main parts: (1) general demographic information of first-grade school children, (2) health status of first-graders, and (3) children's environmental exposures including indoor pollution and surrounding potential pollution sources within 300 m of the residence.

The basic demographic information investigated included school, class, townships, sex, date of birth, birth weight, birth outcome, parents' occupations, and parents' educational levels.

The health problems included diseases diagnosed by physicians in the previous year and acute symptoms experienced at least once in the last month. Diseases were defined as follows: (1) respiratory diseases (RD): recurrent respiratory infection, pneumonia, asthma, tracheitis, allergic rhinitis, or other respiratory diseases; (2) digestive diseases: gastritis, peptic ulcer, acute diarrhea, gastroesophageal reflux, or other digestive diseases; and (3) skin diseases: pruritus, eczema, urticaria, conjunctivitis, trachoma, or other skin diseases. Acute symptoms were defined as follows: (1) respiratory symptoms: throat irritation, nasal obstruction, discomfort, cough, expectoration, shortness of breath, or other respiratory symptoms; (2) eye symptoms: eye irritation or other eye symptoms; (3) neurological symptoms: headache, dizziness, weakness, insomnia, memory loss, inattention, abnormal sensation, limb pain, or other neurological symptoms; (4) digestive symptoms: anorexia, nausea and vomiting, stomachache, or other digestive symptoms; and (5) skin symptoms: itch, eczema, alopecia, or other skin symptoms.

Indoor pollution included household smoking, pollutants from indoor decorations, or pollutants after purchasing furniture the previous year, use of air eliminators, and use of heaters during winter. Surrounding sources included traffic trunks, barbecue restaurants, and nonchemical enterprises. The investigators explained the questionnaires consistently to all participants, and the participating students filled out the questionnaire with the help of their parents.

Measurements

Measurements included physical examinations and hematological tests. The subjects were asked to take off their shoes and wear light clothes before measurement, and an ultrasonic height and weight meter was used to measure these parameters. Fasting was also required before obtaining blood samples, and all the blood samples were collected and analyzed by physicians in clinical pathology-accredited laboratories. Complete blood count (CBC) parameters were examined (Table A2).

Data processing

Weight status was classified as underweight (≤13.4 kg/m^2 for girls, ≤13.9 kg/m^2 for boys), normal weight (13.5–17.1 kg/m^2 for girls, 14.0–17.3 kg/m^2 for boys), overweight (17.2–18.8 kg/m^2 for girls, 17.4–19.1 kg/m^2 for boys), and obesity (≥18.9 kg/m^2 for girls, ≥19.2 kg/m^2 for boys) using body mass index (BMI) cutoff points, following the method of the Working Group for Obesity in China (WGOC) for 7-year-old children [12]. Moreover, BMI was calculated.

To eliminate the strong correlation between parents' educational background, we used a new variable, parents' educational level (the higher educational level received by any parent), rather than separately analyzing the father and the mother's educational level. Additionally, because few parents have completed junior high school or below, junior high school or below and senior high school were combined into one variable to avoid extreme values and guarantee the stability of models.

Statistical analysis

We first summarized the demographic statistics and CBC parameters of first-graders. Subsequently, we used *t*-test for continuous variables such as height and χ^2 test for categorical variables such as sex to analyze the differences between non-CIA and CIA. Then, we assessed the geographical distribution and detected high-risk clusters of prevalence of diseases and birth status in first-graders based on school locations using the Kulldorff method of spatial scan statistic based on a discrete Poisson model with maximum spatial cluster size of 30% of population at risk using SaTScan (version 9.6, Martin Kulldorff and Information Management Services Inc). Mapping was performed in QGIS Desktop (version 3.0.3, https://www.qgis.org/).

Finally, the logistic regression model was used to measure the differences in the prevalence of diseases and acute symptoms between CIA and non-CIA. We included all the variables with value p>0.1 under the univariate analysis into the multivariate logistic regression model, and the "backward elimination" method was used to screen the potential risk variables. Potential confounding variables were considered during the modeling process including sex, parents' educational levels and occupations, indoor pollutant exposures, and outdoor environmental exposures within 300 m of the residence. Adjusted odds ratios (ORs) and corresponding 95% confidence intervals (CIs) were calculated. All statistical analyses were performed using R 3.5.3 (R Project for Statistical Computing, http://cran.r-project.org).

Results

3.1 Demographic of first-grade school children in Jinshan District

A total of 4821 first-grade school children were included in the study. Moreover, 4821 questionnaires were distributed, and 4707 were returned (response rate, 97.64%; 52.18% for boys), with weight and height measurement acceptance rate of 97.38% (52.6% for boys) and blood sample measurement acceptance rate of 96.58% (52.6% for boys). All the returned questionnaires and measurements were eligible for inclusion in the analysis.

Among children who completed the questionnaires, 1479 (31.42%) lived in CIA. The mean age was 7.21 years (7.19 for girls and 7.22 for boys; range, 6–10 years). The mean BMI was 16.27 kg/m^2 (16.22 kg/m^2 for girls and 16.34 kg/m^2 for boys). An estimated 24.09% of school children had problems with being overweight and even obesity. The prevalence of overweight and obesity was 13.08% and 14.49% in boys and 12.22% and 8.13% in girls, respectively. No significant difference was observed in age, height, weight, BMI, weight status, birth weight, and birth outcome between first-grade school children living in CIA and non-CIA. Parents of these children were more engaged in the chemical industry in CIA (16.77% for fathers and 5.75% for mothers) than parents in non-CIA (Table 1).

Distribution of diseases' phenotypes in first-grade school children diagnosed by physicians in the previous year is shown in Figure 1. The prevalence of RD (Figure 1b), digestive diseases (Figure 1c), and skin diseases (Figure 1d) was 22.9%, 4.2%, and 16.8%, respectively. Conclusively, tracheitis, allergic rhinitis, pruritus, eczema, conjunctivitis, and acute diarrhea were the common diseases diagnosed in first-grade school children in Jinshan. A higher number of school children diagnosed with diseases were observed in non-CIA than in CIA.

Geographic distribution and high-risk clusters of diseases

Figure 2 shows the geographic distribution and school-based spatial clusters of disease prevalence and abnormality rate of birth weight and birth outcome. In total, disease prevalence (Figure 2a-d) and abnormality rate of birth status (Figure 2e&f) were concentrated in the central region of Jinshan District. The prevalence of all the diseases and abnormality rate of birth status was high in TL. RD (Figure 2b) mainly centered in the northern regions (FJ, ZJ, and TL). The spatial clusters for RD and skin diseases (Figure 2d) were in ZJ and in SY and SH, respectively.

Descriptive statistics of complete blood count parameters

Table 2 summarized the complete hematological parameters of first-grade school children in Jinshan District and partly lists the parameters that were significantly different between CIA and non-CIA, owing that there existed several significantly different parameters. Some CBC parameters were significantly different in school children between CIA and non-CIA. Red blood cell count (RBC), Hemoglobin (Hgb), Hematocrit (HCT), Platelet count (PLT), Percentage of monocytes (% Mo), Percentage of basophils (% Ba), and Absolute monocyte counts (Abs Mo) were slightly lower in non-CIA than in CIA. Moreover, platelet indices, including Platelet distribution width (PDW), Platelet larger cell ratio (P-LCR), Mean platelet volume (MPV), and Absolute lymphocyte counts (Abs Ly), were slightly higher in non-CIA than in CIA.

Multivariate logistic regression analysis

After adjusting the confounding factors, the prevalence of RD in the non-CIA was significantly higher than that in CIA (OR, 0.73; 95% CI, 0.63–0.85; p<0.001) (Table A1). However, the prevalence of other diseases or acute symptoms did not show a significant difference between CIA and non-CIA. Boys were more likely to contract RD than girls (OR, 0.79; 95% CI, 0.69–0.91; p<0.001). Moreover, the children of well-educated parents showed a higher prevalence (OR, 1.86; 95% CI, 1.58–2.20; p<0.0001). Living in 300-m areas around existing outdoor pollution exposures (road trunks [OR, 1.31; 95% CI, 1.07–1.60; p, 0.008]) led to a higher prevalence rate of RD as well. Considering p value close to the critical value, furniture purchasing in the last one year (OR, 1.21; 95% CI, 1.003–1.46; p, 0.044) or household smoking (OR, 1.21; 95% CI, 1.02–1.44; p, 0.029) had marginally higher prevalence of RD. Children who used heaters during the winter were more possibly at risk to respiratory illnesses (OR, 1.25; 95% CI, 1.03–1.53; p, 0.028) than children who did not (Table 3).

Discussion

Significant differences were observed in some CBC parameter levels in school children between CIA and non-CIA. Recent studies have reported the association between air pollution and hematological parameters. To some extent, associations between CBC parameters and pollution exposure could be clarified. Experimental and epidemiological studies indicate that exposure to air pollutants is negatively associated with RBC, HCT, and Hgb [13-15]. An animal experimental study [16] indicated that medium-term exposure to air pollutants decreases RBC and monocytes and increases lymphocytes. A epidemiological study reported that long-term traffic-related air exposure to air pollution had been positively associated with monocyte counts [17]. Platelet indices (PLT, PDW, P-LCR, MPV) are closely associated with thrombosis and hemostasis. PDW is used to evaluate the variability of platelet. High PDW reflects platelet anisocytosis [18]. P-LCR reflects the percentage of larger platelets used to monitor platelet activity [19]. MPV reflects platelet volume. There exists a negative association between platelet number (PLT) and size (MPV), which represents PLT and MPV having significant association [20, 21]. Evidence from previous epidemiological studies reported that the pollutant exposures were positively associated with MPV, PDW, and P-LCR and negatively associated with PLT [22-25]. Compared to CIA, significant differences in CBC parameter levels indicate that pollutant exposure in non-CIA might exist. However, there is a slight difference in the average levels of hematological parameters between CIA and non-CIA. Similarly, average levels are within the normal parameter reference range. Thus, the CBC parameters, specifically platelets, need to be monitored closely and continuously.

Tracheitis, allergic rhinitis, skin pruritus, eczema, conjunctivitis, and acute diarrhea were common diseases diagnosed in first-grade school children in Jinshan District. School children living in non-CIA had higher prevalence of diseases than children living in CIA. From the perspective of the spatial distribution of diseases and birth status, school children living in TL were more likely to have diseases and birth defects than children living in other towns. Larger traffic volume in northern regions, specifically ZJ and TL, was related to the higher prevalence of RD diagnosed. High humidity in southeastern regions (SH and SY) close to the seas causes the high prevalence of skin diseases diagnosed. Considering the sparse school distribution, spatial scanning technology detected one small-scale spatial cluster for respiratory and skin diseases in nonchemical and CIA, respectively.

To examine the association between CIA and the prevalence of diseases, risk factor analysis for diseases was performed after adjusting for confounding factors. Overall, chemical industries have not caused health risk in first-grade school children in Jinshan District. First-grade school children living near non-CIA contracted significantly more RD than the first-grade children living near CIA. From the geographic distribution of RD, the subjects living in northern regions in Jinshan have higher risk of RD than subjects living other part of Jinshan. Northern regions in Jinshan District is more inland and have much higher volume of transportation, which might result in poorer air quality, while the southeastern region in Jinshan is closer to the coast and a previous study found that the relatively better air quality is caused by the unique meteorological condition of the region (the wind causes movement of the air pollutants) [26]. Additionally, previous environmental monitoring in Jinshan showed that respirable PM (PM2.5 and PM10) levels in the northern regions were higher than those in the southern regions. These reasons might lead to a significantly higher respiratory disease prevalence in non-CIA than in CIA.

Boys were at higher risk of RD than girls, which is consistent with the result of the Koch's study [27]. Generally, boys are more active and more involved in outdoor activities so that they generally have more exposure to risk factors than girls. School children with well-educated parents were more likely to experience RD, consistent with the result of Chen's study [28]. Considering diseases were diagnosed by physicians and reported by parents, parents with better educational level might pay more attention to their children's health problems. These diseases and symptoms might be underestimated or ignored by poorly educated parents.

School children who lived in conditions that included household smoking or newly purchased furniture in the previous year had a greater likelihood of having RD than school children who lived without these conditions. Those living within 300 meters of road trunks also had a higher risk of RD than those who did not. These results are consistent with the results of several previous studies [8, 27, 29, 30]. Smoking and road trunks increase the presence of pollutants such as nitrogen dioxide [31, 32]. Children whose household used heating devices during winter had higher prevalence of respiratory illnesses than children whose household did not. One possible explanation is that, there is significant difference between indoor and outdoor temperature, so children living in houses that did not use heating devices during winter might have better resistance to cold and diseases and consequently, are less susceptible to illnesses than children using heating devices.

A higher ratio of boys is overweight and obese than girls, which is consistent with the findings of some previous studies [33, 34]. In Chinese tradition, fat boys are considered healthier than thin boys. Thus, boys enjoy more of the family's resources [35]. As a result, the prevalence of obesity in first-grade school children in Jinshan is 11.5%, which is significantly higher than the data in the previous studies (9.0%) using the WGOC weight status criteria [34]. The local government should intervene in this health problem by disseminating knowledge regarding healthy diet and scientific methods of weight loss.

Our study has some major limitations. First, we divided Jinshan District into CIA and non-CIA based on the location of chemical industries without considering individual chemical exposures. Therefore, the method in determining exposure to chemical pollutions may not be precise. Second, some information (e.g., self-reported diseases, symptoms, and environmental factors) reported by parents were not objective, which might cause recall bias. Additionally, the completed time of measurements and questionnaires were not at the same time and the evaluation of some outcomes especially hematological parameters could be influenced by different timeframes or seasons. Thus, we merely analyzed the difference of hematological parameters between CIA and non-CIA. Moreover, we tried to analyze the relationship of birth outcome and industrial exposures. However, the lack of detailed information of prenatal care may lead to misclassification bias.

Conclusion

Conclusively, industrial industries in Jinshan District are satisfactorily safe at present. Chemical industries have not evidently caused adverse health effects on first-grade school children. However, environmental pollutions from indoor and outdoor exposures have more significantly affected the respiratory health of first-grade school children. The non-CIA should strengthen their control of environmental pollution. Parents should pay more attention to their children's health and reduce the potential chance of indoor exposure for children. In the future, the study can perform point monitoring to analyze individual real exposure. Based on this cross-sectional study, the long-term effect of chemical pollution on children (growth, hematological parameters, diseases, and other parameters) should be continuously monitored.

Declarations

Ethics statement

Ethical approve was acquired from the institutional review board of the School of Public Health of Fudan University.

Fundings:

This research was supported by the National Natural Science Foundation of China (81673239, 81973102, 81773487) and the Medical Key Specialist Construction Project of Jinshan district, Shanghai municipality [JSZK2015H05].

Acknowledgements:

We would like to thank the Jinshan district center for disease control and prevention for assistance in research design and implementation and data collection. We also would like to thank primary school and local health centers for assistance in support of data collection, the views expressed are those of the authors alone.

Contributions：

SX designed the study, analyzed the data and wrote the manuscript. MJX interpreted the data and wrote the manuscript. LHW, XSZ, CQT, JZ helped with research design, data collection. WGW, JH helped with data processing. WT, LLY, and YQS helped with critical revision of manuscript. YH, YNZ and ZJZ supervised all aspects of this study.

Conflicts of interest

We declare that we have no conflicts of interest.

References

1. He G, Zhang L, Lu Y, Mol AP: **Managing major chemical accidents in China: towards effective risk information**. *Journal of hazardous materials* 2011, **187**(1-3):171-181.
2. David F, Mhairi C, Ute S, Sutton MA, J Neil C, Stefan R, Sheppard LJ, Alan J, Bruna G, Galloway JN: **The global nitrogen cycle in the twenty-first century**. *Philosophical Transactions of the Royal Society of London* 2013, **368**(1621):20130164.
3. International C, Jafarinejad S: **Control and treatment of sulfur compounds specially sulfur oxides (SOx) emissions from the petroleum industry: A review**. *Chemistry International* 2016, **2**(4):242-253.
4. Mckone TE, Daniels JI: **Estimating human exposure through multiple pathways from air, water, and soil**. *Regul Toxicol Pharmacol* 1991, **13**(1):36-61.
5. Kampa M, Castanas E: **Human health effects of air pollution**. *Environmental Pollution* 2008, **151**(2):362-367.
6. Currie J, Schmieder JF: **Fetal Exposures to Toxic Releases and Infant Health**. *The American economic review* 2009, **99**(2):177-183.
7. Landrigan PJ, Suk WA, Amler RW: **Chemical wastes, children's health, and the Superfund Basic Research Program**. *Environmental Health Perspectives* 1999, **107**(6):423-427.
8. Padhi BK, Padhy PK, Sahu L, Jain VK, Ghosh R: **Assessment of intra-urban variability in indoor air quality and its impact on children’s health**. *Air Quality Atmosphere & Health* 2010, **3**(3):149-158.
9. Liu C, Lu L, Huang T, Huang Y, Ding L, Zhao W: **The Distribution and Health Risk Assessment of Metals in Soils in the Vicinity of Industrial Sites in Dongguan, China**. *International Journal of Environmental Research & Public Health* 2016, **13**(8):832.
10. Morakinyo OM, Adebowale AS, Mokgobu MI, Mukhola MS: **Health risk of inhalation exposure to sub-10 µm particulate matter and gaseous pollutants in an urban-industrial area in South Africa: an**

ecological study. *Bmj Open* 2017, **7**(3):e013941.

11. Sun G, Li Z, Liu T, Chen J, Wu T, Feng X: **Metal Exposure and Associated Health Risk to Human Beings by Street Dust in a Heavily Industrialized City of Hunan Province, Central China**. *International Journal of Environmental Research & Public Health* 2017, **14**(3):261.
12. Force GOCOT: **Body mass index reference norm for screening overweight and obesity in Chinese children and adolescents**. *Chinese Journal of Epidemiology* 2004, **25**(2):97.
13. Boussetta N, Abedelmalek S, Aloui K, Souissi N: **The effect of air pollution on diurnal variation of performance in anaerobic tests, cardiovascular and hematological parameters, and blood gases on soccer players following the Yo–Yo Intermittent Recovery Test Level-1**. *Chronobiology International* 2017(2):1.
14. Kargarfard M, Shariat A, Shaw BS, Shaw I, Lam ETC, Kheiri A, Eatemadyboroujeni A, Tamrin SBM: **Effects of Polluted Air on Cardiovascular and Hematological Parameters After Progressive Maximal Aerobic Exercise**. *Lung* 2015, **193**(2):275-281.
15. Seaton A, ., Soutar A, ., Crawford V, ., Elton R, ., Mcnerlan S, ., Cherrie J, ., Watt M, ., Agius R, ., Stout R, . **Particulate air pollution and the blood**. *Thorax* 1999, **54**(11):1027.
16. Fauzie AK, Venkataramana GV: **Exposure to organic and inorganic traffic-related air pollutants alters haematological and biochemical indices in albino mice Mus musculus**. *International Journal of Environmental Health Research* 2019(7):1-17.
17. Su TC, Hwang JJ, Yang YR, Chan CC: **Association Between Long-term Exposure to Traffic-related Air Pollution and Inflammatory and Thrombotic Markers in Middle-aged Adults**. *Epidemiology* 2017, **28 Suppl 1**:S74.
18. Vagdatli E, ., Gounari E, ., Lazaridou E, ., Katsibourlia E, ., Tsikopoulou F, ., Labrianou I, . **Platelet distribution width: a simple, practical and specific marker of activation of coagulation**. *Hippokratia* 2010, **14**(1):28-32.
19. Hong H, Wenbin X, Maitta RW: **Steady increment of immature platelet fraction is suppressed by irradiation in single-donor platelet components during storage**. *Plos One* 2014, **9**(1):e85465.
20. Giles C, . **The platelet count and mean platelet volume**. *Br J Haematol* 2010, **48**(1):31-37.
21. Whitfield JB, Martin NG: **Genetic and environmental influences on the size and number of cells in the blood**. *Genetic Epidemiology* 2010, **2**(2):-.
22. Barman T, Kalahasthi R, Rajmohan HR: **Effects of lead exposure on the status of platelet indices in workers involved in a lead-acid battery manufacturing plant**. *J Expo Sci Environ Epidemiol* 2014, **24**(6):629-633.
23. Conterato GM, Bulcão RP, Sobieski R, Moro AM, Charão MF, de Freitas FA, de Almeida FL, Moreira AP, Roehrs M, Tonello R: **Blood thioredoxin reductase activity, oxidative stress and hematological parameters in painters and battery workers: relationship with lead and cadmium levels in blood**. *Journal of Applied Toxicology* 2013, **33**(2):142-150.
24. Knudsen AS, Long M, Pedersen HS, Bonefeld-Jã¸Rgensen EC: **Persistent organic pollutants and haematological markers in Greenlandic pregnant women: the ACCEPT sub-study**. *Int J Circumpolar*

Health 2018, **77**(1):1456303.

25. Zeng Z, Huo X, Zhang Y, Xiao Z, Zhang Y, Xu X: **Lead exposure is associated with risk of impaired coagulation in preschool children from an e-waste recycling area**. *Environmental Science & Pollution Research* 2018:1-10.
26. Xu J, Chang L, Qu Y, Yan F, Wang F, Fu Q: **The meteorological modulation on PM 2.5 interannual oscillation during 2013 to 2015 in Shanghai, China**. *Science of the Total Environment* 2016, **572**:1138-1149.
27. Koch A, Molbak K, Homoe P, Sorensen P, Hjuler T, Olesen ME, Pejl J, Pedersen FK, Olsen OR, Melbye M: **Risk factors for acute respiratory tract infections in young Greenlandic children**. *American journal of epidemiology* 2003, **158**(4):374-384.
28. Chen PC, Lai YM, Wang JD, Yang CY, Hwang JS, Kuo HW, Huang SL, Chan CC: **Adverse effect of air pollution on respiratory health of primary school children in Taiwan**. *Environmental health perspectives* 1998, **106**(6):331-335.
29. Jin-Gui WU, Zhuang ZJ, Niu CJ: **Effect of Indoor Environmental Factors on Respiratory Symptoms in Children and Teenagers Aged 4-17 Years in Urban Area of Shanghai**. *Journal of Environment & Health* 2010, **27**(2):127-130.
30. Zhang Z, Ferm M, Dan N: **Asthmatic Symptoms among Pupils in Relation to Winter Indoor and Outdoor Air Pollution in Schools in Taiyuan, China**. *Environmental Health Perspectives* 2008, **116**(1):90-97.
31. Laumbach RJ, Kipen HM: **Respiratory health effects of air pollution: update on biomass smoke and traffic pollution**. *Journal of Allergy & Clinical Immunology* 2012, **129**(1):3-11.
32. Pilotto LS, Douglas RM, Attewell RG, Wilson SR: **Respiratory effects associated with indoor nitrogen dioxide exposure in children**. *International Journal of Epidemiology* 1997, **26**(4):788.
33. Li H, Zhang Y, Ji C: **Prevalence of overweight and obesity among Chinese children and adolescents, 1985–2010**. *Annals of Human Biology* 2012, **15**(Suppl1):S167-S168.
34. Zhang J, Wang H, Wang Z, Du W, Su C, Zhang J, Jiang H, Jia X, Huang F, Ouyang Y: **Prevalence and stabilizing trends in overweight and obesity among children and adolescents in China, 2011-2015**. *Bmc Public Health* 2018, **18**(1):571.
35. Zhai L, Dong Y, Bai Y, Wei W, Jia L: **Trends in obesity, overweight, and malnutrition among children and adolescents in Shenyang, China in 2010 and 2014: a multiple cross-sectional study**. *Bmc Public Health* 2017, **17**(1):151.

Tables

Table 1. Demographic statistics of first-grade school children in Jinshan District

	Overall	Nonchemical industrial areas	Chemical industrial areas		
	Mean±SD (%)	Mean±SD (%)	Mean±SD (%)	Statistics	*P value*
	4707	3228	1479		
Age (years)	7.34±0.48	7.34±0.482	7.34±0.484	3.24	0.52
6	2 (0.0)	2 (0.1)	0 (0.0)		
7	3093 (65.7)	2115 (65.5)	978 (66.1)		
8	1592 (33.8)	1098 (34.0)	494 (33.4)		
9	7 (0.1)	3 (0.1)	4 (0.3)		
10	3 (0.1)	2 (0.1)	1 (0.1)		
Unknown	10 (0.2)	8 (0.2)	2 (0.1)		
Height (cm)	124.60±5.47	124.55±5.59	124.79±5.20	1.40	0.16
Weight (kg)	25.42±5.15	25.35±4.97	25.60±5.53	1.53	0.13
BMI (kg/m^2)	16.27±2.44	16.24±2.29	16.33±2.74	1.18	0.24
Weight status				1.45	0.70
Normal weight	3283 (69.9)	2286 (70.2)	997 (69.4)		
Overweight	595 (12.7)	418 (12.8)	177 (12.3)		
Obese	539 (11.5)	360 (11.0)	179 (12.5)		
Underweight	278 (5.9)	194 (6.0)	84 (5.8)		
Birth weight				0.057	0.81
2500−4000 g	4049 (86.0)	2765 (85.7)	1284 (86.8)		
<2500 g or >4000 g	582 (12.4)	394 (12.2)	188 (12.7)		
Unknown	76 (1.6)	69 (2.1)	7 (0.5)		
Birth outcomes				1.32	0.25
37−42 wk	3951 (83.9)	2697 (83.6)	1254 (84.8)		
<37 wk or ≧42 wk	482 (10.2)	316 (9.8)	166 (11.2)		
Unknown	274 (5.8)	215 (6.7)	59 (4.0)		
Father’s occupation				104.11	<0.001

General sector	2891 (61.42)	1948 (60.35)	943 (63.76)		
Chemical plants	531 (11.28)	283 (8.77)	248 (16.77)		
Nonchemical plants	1269 (26.96)	981 (30.39)	288 (19.47)		
Unknown	16 (0.34)	16 (0.50)	0		
Mother’s occupation				76.48	<0.001
General sector	3172 (67.39)	2070 (64.13)	1102 (74.51)		
Chemical plants	203 (4.310)	118 (3.66)	85 (5.75)		
Nonchemical plants	1308 (27.79)	1016 (31.47)	292 (19.74)		
Unknown	24 (0.51)	24 (0.74)	0 (0)		

Table 2. Univariate analysis of complete blood count parameters

	Overall	Nonchemical industrial areas	Chemical industrial areas	*t* *value*	*P* *value*
RBC (10^{12}/l)	4.84±0.39	4.82±0.38	4.88±0.40	-5.19	<0.001
Hgb (g/l)	132.38±9.42	131.87±9.24	133.46±9.72	-5.27	<0.001
HCT (%)	39.30±2.71	39.16±2.67	39.60±2.76	-5.14	<0.001
PLT (10^9/l)	284.89±63.41	282.65±62.97	289.70±64.10	-3.51	<0.001
PDW (%)	12.92±2.20	13.02±2.23	12.70±2.12	4.77	<0.001
P-LCR	31.74±7.96	32.05±8.01	31.08±7.82	3.88	<0.001
MPV (fl)	10.88±0.98	10.92±0.99	10.78±0.95	4.79	<0.001
% Mo	5.70±2.07	5.62±2.07	5.86±2.08	-3.67	<0.001
% Ba	0.04±0.03	0.04±0.02	0.04±0.03	-2.68	0.005
Abs Mo (10^9/L)	0.50±0.22	0.49±0.21	0.51±0.23	-2.50	0.01
Abs Ly (10^9/L)	3.42±0.87	3.44±0.87	3.37±0.88	2.49	0.013

Table 3. Prevalence, unadjusted odds ratios, and adjusted odds ratios of respiratory diseases by risk factor variables

Variables	n (%)	*Univariate analysis*			*Multivariate analysis*		
		cOR (95% CI)	*z-score*	*P value*	*aOR (95% CI)*	*z-score*	*P value*
Chemical industrial areas							
No	780 (24.16)						
Yes	297 (20.08)	0.769 (0.66,0.89)	-3.406	<0.001	0.73 (0.63,0.85)	-4.01	<0.001
Sex							
Male	599 (24.39)						
Female	478 (21.24)	0.84 (0.73,0.96)	-2.572	<0.05	0.79 (0.69,0.91)	-3.32	<0.001
Parents' educational level							
Senior high school or below	738 (15.78)						
College or above	333 (7.12)	2.03 (1.74,2.37)	8.967	<0.001	1.86 (1.58,2.20)	7.39	<0.001
Outdoor exposures within 300 m of the residence							
Road trunks							
No	903 (21.89)						
Yes	174 (29.95)	1.48 (1.22,1.80)	4.308	<0.05	1.31 (1.07,1.60)	2.63	0.00847
Indoor exposures							
Household smoking							
No	843 (22.72)						
Yes	230 (24.57)	1.11 (0.94,1.32)	1.10	0.23	1.21 (1.02,1.44)	2.18	0.029
Furniture in the previous year							
No	884						

	(22.3)						
Yes	191 (26.68)	1.27 (1.06,1.52)	2.561	<0.05	1.21 (1.003,1.46)	2.01	0.044
Heating in winter							
No	150 (18.32)						
Yes	925 (23.92)	1.40 (1.16,1.70)	3.454	<0.05	1.25 (1.03,1.53)	2.20	0.028

Figures

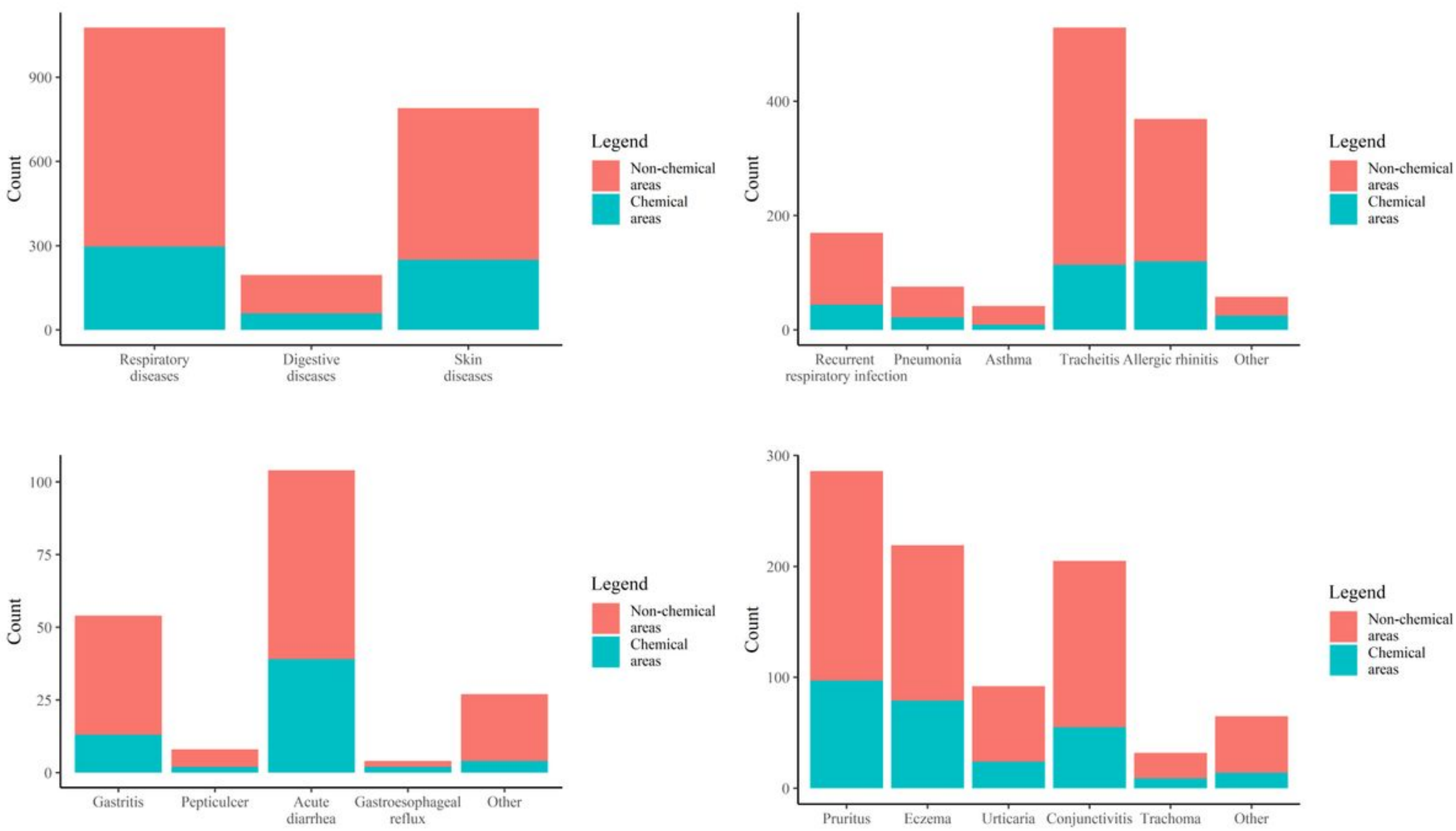

Figure 1

Classification of diseases diagnosed among students. (a) Counts of disease phenotypes; (b) Counts of respiratory disease phenotypes; (c) Counts of digestive disease phenotypes; (d) Counts of skin disease phenotypes

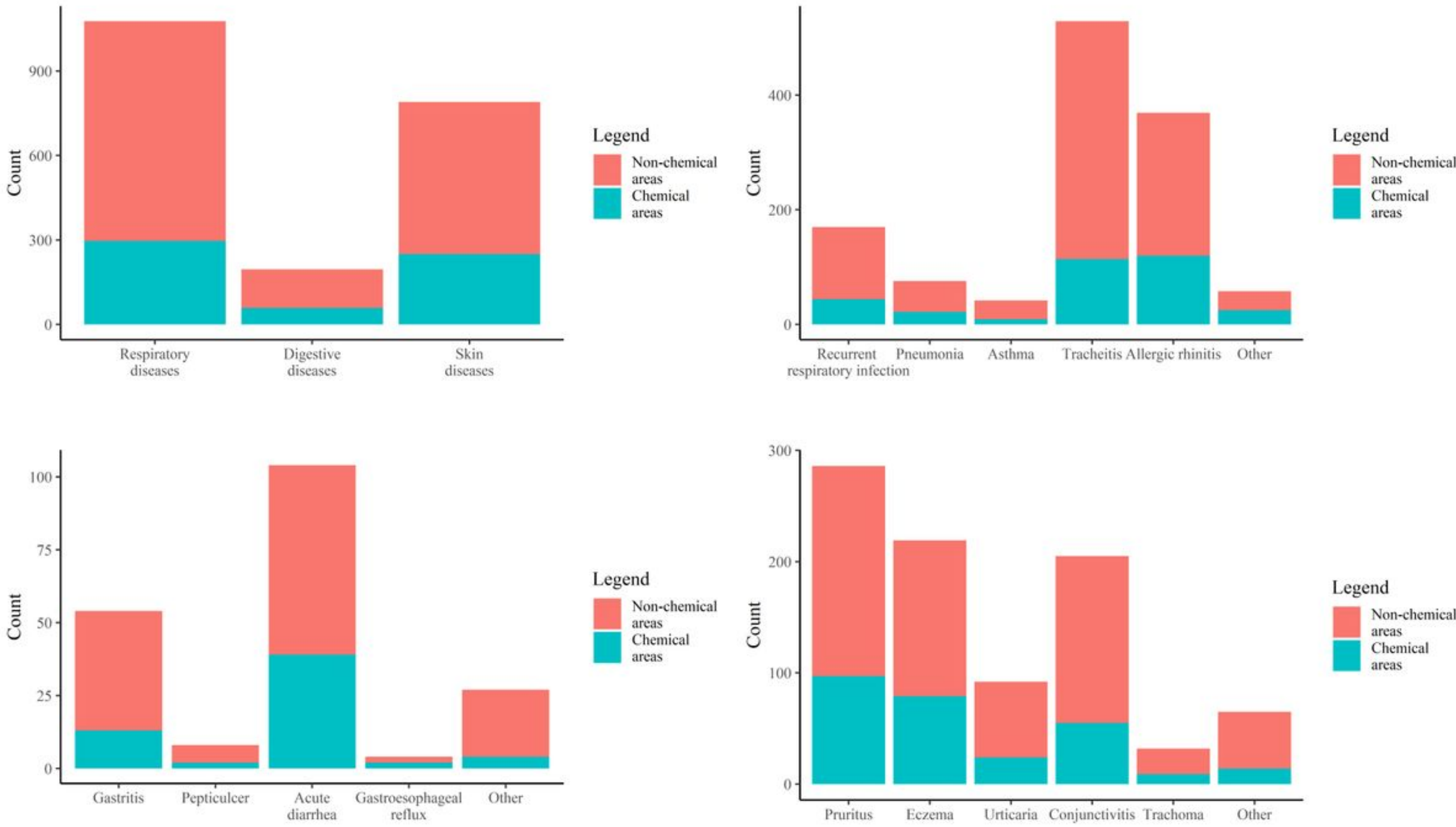

Figure 1

Classification of diseases diagnosed among students. (a) Counts of disease phenotypes; (b) Counts of respiratory disease phenotypes; (c) Counts of digestive disease phenotypes; (d) Counts of skin disease phenotypes

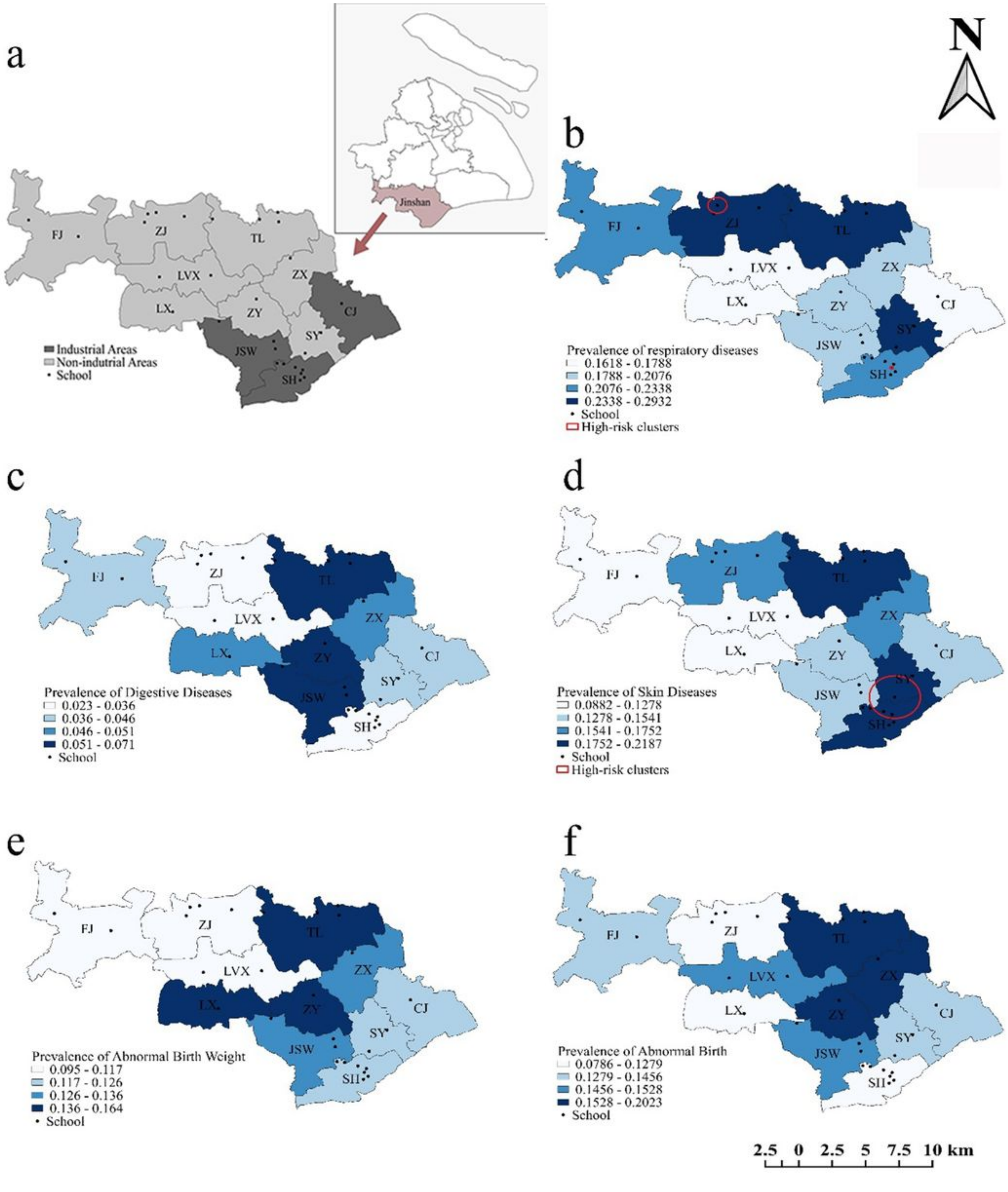

Figure 2

Geographic distribution and spatial clusters of prevalence of diseases and birth status in first-grade school children in Jinshan District. CJ=Caojing, JSW=Jinshanwei, SH=Shihua, TL=Tinglin, JSGYQ=Jinshangongyequ, FJ=Fengjing, LvX=Lvxiang, LX=Langxia, SY=Shanyang, ZY=Zhangyan, ZJ=Zhujing Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

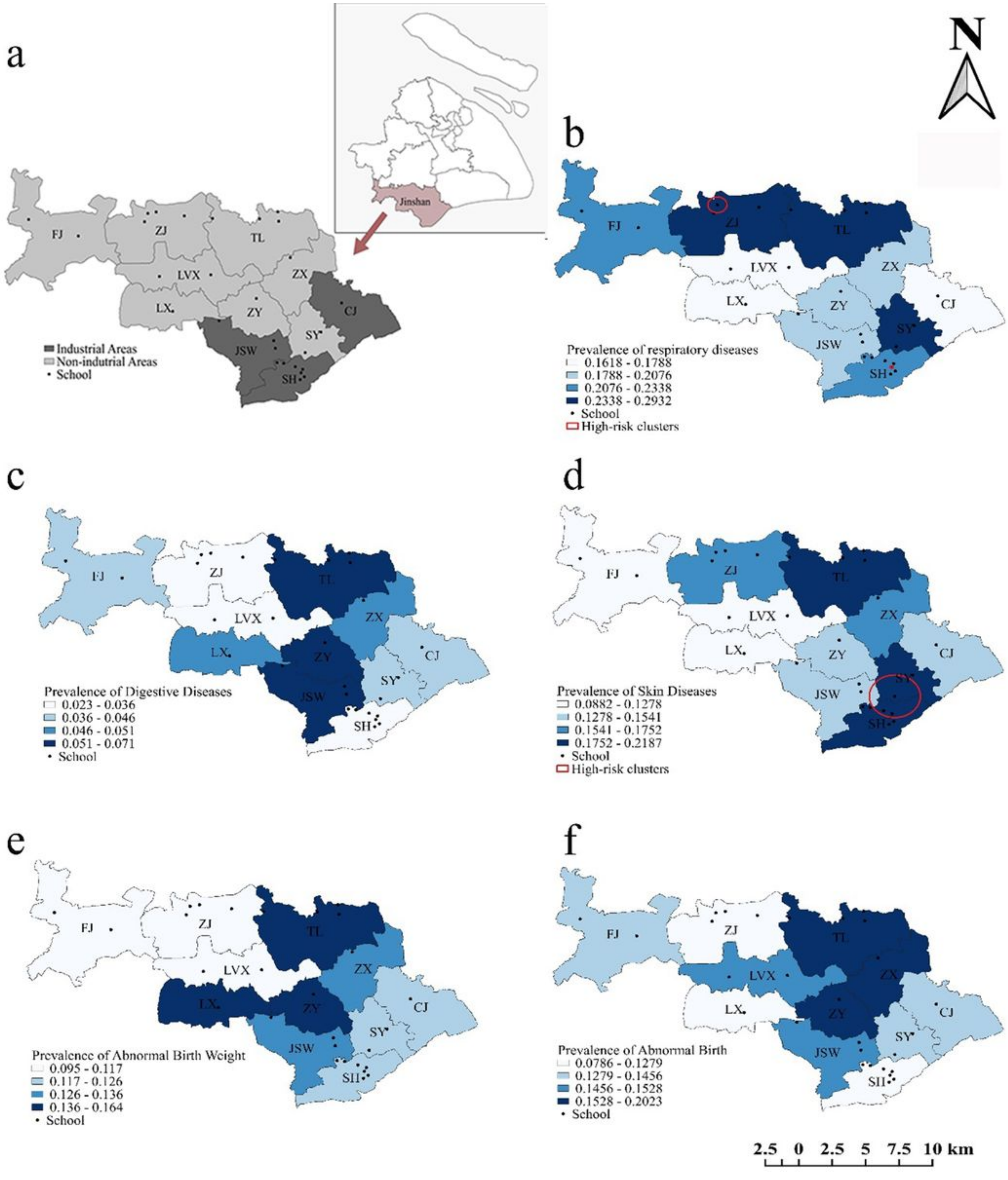

Figure 2

Geographic distribution and spatial clusters of prevalence of diseases and birth status in first-grade school children in Jinshan District. CJ=Caojing, JSW=Jinshanwei, SH=Shihua, TL=Tinglin, JSGYQ=Jinshangongyequ, FJ=Fengjing, LvX=Lvxiang, LX=Langxia, SY=Shanyang, ZY=Zhangyan, ZJ=Zhujing Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- 3Appendixinformation.docx
- 3Appendixinformation.docx