

Wieslaw Jedrychowski\*, Elzbieta Flak\*,  
Elzbieta Mroz\*, Agnieszka Pac\*, Ryszard  
Jacek\*, Elzbieta Sochacka-Tatara \*,  
John Spengler\*\*, Virginia Rauh\*\*\* and  
Frederica Perera\*\*\*

Prenatal exposure to fine particles and respiratory  
symptoms in early childhood. modulating effects of  
fish consumption in pregnancy.  
Krakow Epidemiologic Study

\*/ Chair of Epidemiology and Preventive Medicine, Coll. Med. Jagiellonian University,  
Krakow, Poland

\*\*/ Department of Environmental Health, School of Public Health, Harvard University,  
Boston, USA

\*\*\*/ Columbia Center for Children's Environmental Health, Mailman School Public  
Health, Columbia University, New York, NY, USA

The main purpose of the study was to measure the effect of prenatal exposure to fine particles - assessed with personal dosimeters during pregnancy - on the occurrence of respiratory symptoms in infants, which have systematically been monitored over the first two years of life.

The effect of the exposure was confronted with potential protective effect of breast feeding and maternal diet regarding fish consumption over pregnancy period.

It is believed that fish intake during pregnancy has the favorable effects on fetal development because it is a rich source of proteins and long chain unsaturated fatty acids, which are necessary for healthy fetal growth and postnatal development of babies.

**Exposure**



**Health outcome**



## Prenatal Exposure to FP



**B**

**C**

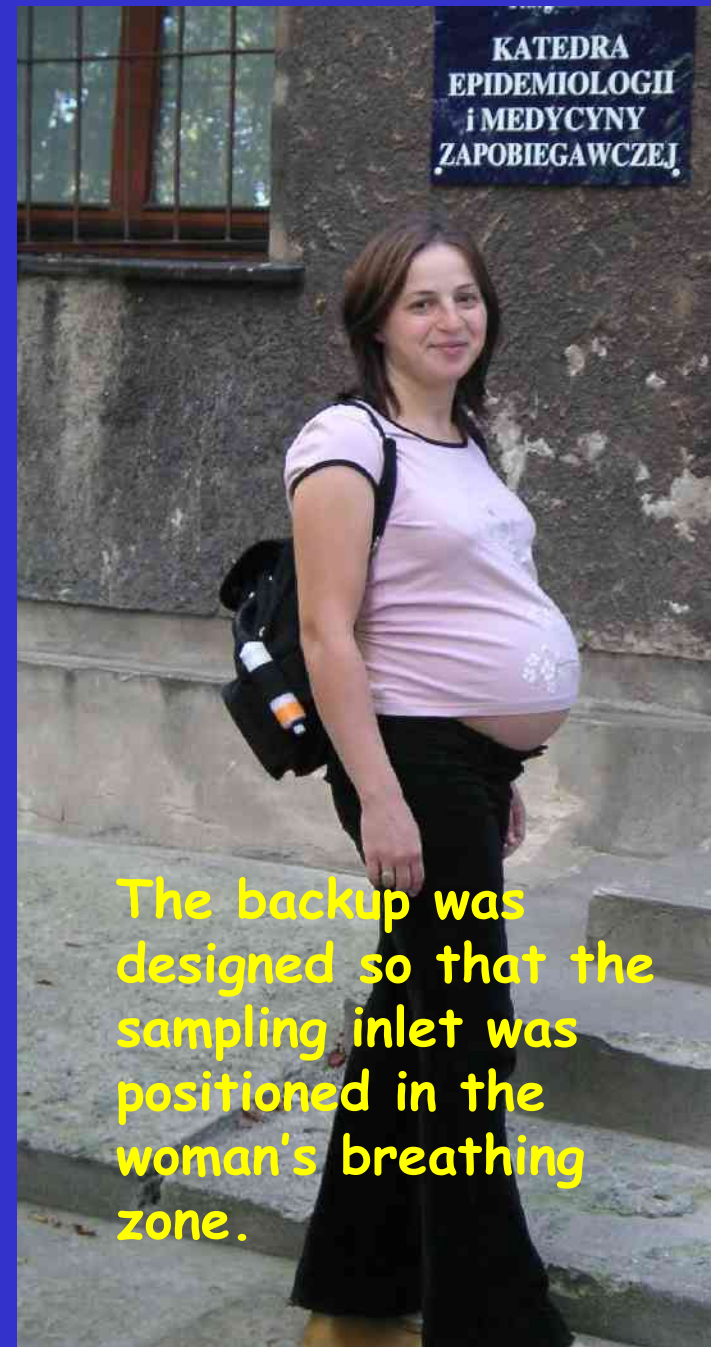
**D**

**Interviews on prenatal nutrition**

## Study Subjects

The cohort consisted of 465 infants who were born at 33-42 weeks of gestation between January 2001 and March 2003 to mothers participating in the cohort study.

Women attending ambulatory prenatal clinics in the first and second trimesters of pregnancy were eligible for the study. The enrollment included only non-smoking women with singleton pregnancies between the ages of 18-35 years, and who were free from chronic diseases such as diabetes and hypertension.



The backup was designed so that the sampling inlet was positioned in the woman's breathing zone.



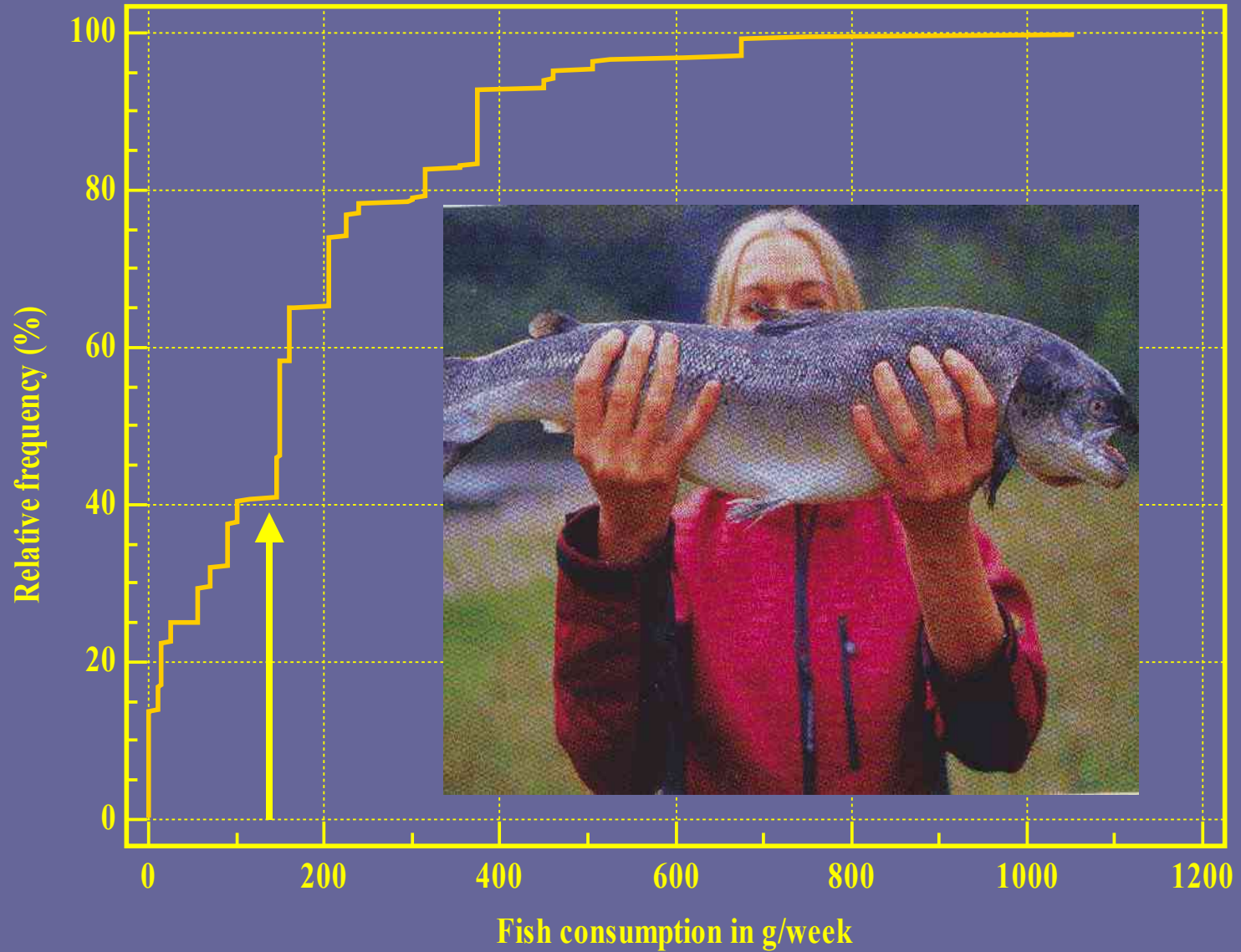
Pumps operated continuously at 2 L/min collecting particles  $\leq 2.5 \mu\text{m}$  in diameter on precleaned quartz microfiber filter, and semivolatile vapours and aerosols on a polyurethane foam (PUF) cartridge backup.

The PUF and filters were once a month shipped to Southwest Research Institute, Texas, USA, where they were analysed for the di-cyclo-hexal phthalate (DCHP).

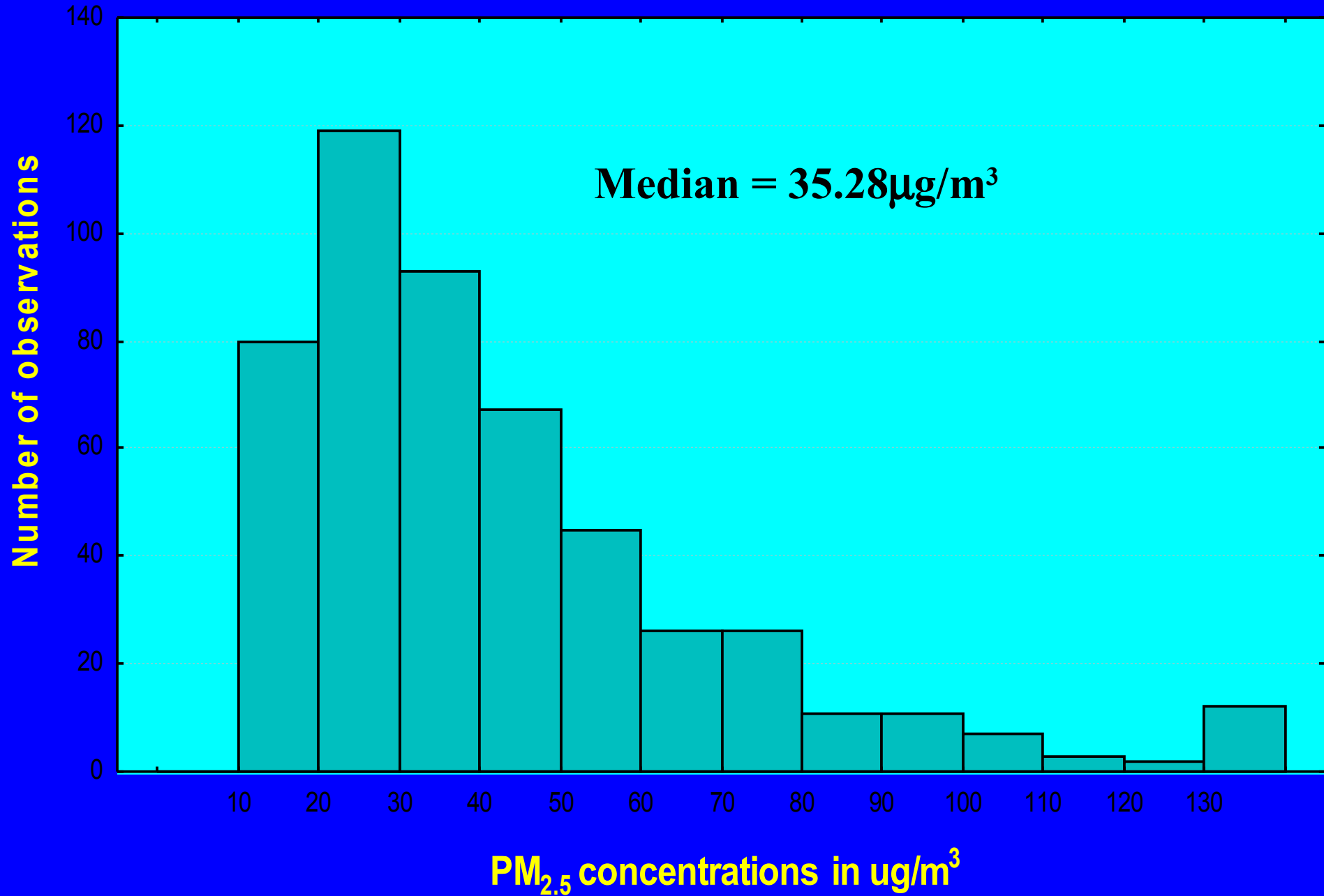
Statistical methods: we used multiple Poisson regression analysis, and applied Generalized Estimating Equations model (GEE) to assess the relationship between maternal exposure to fine particles and nutrition during pregnancy with respiratory symptoms in the follow-up measured at 12 and 24 months of age.

- GEE utilizes data on all respondents, including those with incomplete data and permits simultaneous modelling of the relation (regression) of specific risk factors with health outcomes on all measurements over the follow-up.
- GEE estimates regression coefficients taking into account the correlation between health outcomes at ages 12 and 24 months.

# Cumulative frequency distribution of fish consumption over the third trimester of pregnancy



# Personal exposure to PM<sub>2.5</sub> measured in the second trimester of pregnancy



## Occurrence of respiratory symptoms among children during their first year and second year of life

|                            | Children with symptom | Total sum of days | Mean duration (days) |
|----------------------------|-----------------------|-------------------|----------------------|
| <b>First year (N=465)</b>  |                       |                   |                      |
| Cough                      | 325 (69.9%)           | 6302              | 19.39 (21.99)        |
| Difficult breathing        | 141 (30.3%)           | 1845              | 13.08 (17.10)        |
| Wheezing in the chest      | 83 (17.8%)            | 1205              | 14.52 (20.96)        |
| <b>Second year (N=465)</b> |                       |                   |                      |
| Cough                      | 381 (81.9%)           | 8595              | 22.56 (21.85)        |
| Difficult breathing        | 99 (21.3%)            | 1048              | 10.59 (14.09)        |
| Wheezing in the chest      | 71 (15.3%)            | 844               | 11.89 (12.06)        |
| <b>Total (N=465)</b>       |                       |                   |                      |
| Cough                      | 420 (90.3%)           | 14897             | 35.47 (33.79)        |
| Difficult breathing        | 201 (43.2%)           | 2893              | 14.39 (18.40)        |
| Wheezing in the chest      | 125 (26.9%)           | 2049              | 16.39 (21.99)        |

Occurrence of cough (number of days cough symptom occurred) reported for children over the two-years related to main exposure variables and confounders. (in the GEE population-averaged models).

| Predictor variables              | IRR    | Std. Err. | z     | P>z   | 95% Conf. Interval |        |
|----------------------------------|--------|-----------|-------|-------|--------------------|--------|
| Maternal education               | 0.784  | 0.027     | -6.99 | 0.000 | 0.733              | 0.840  |
| Parity                           | 4.857  | 0.385     | 19.95 | 0.000 | 4.158              | 5.672  |
| Gender of child                  | 0.700  | 0.060     | -4.14 | 0.000 | 0.591              | 0.829  |
| Gestational age                  | 0.940  | 0.027     | -2.15 | 0.032 | 0.889              | 0.995  |
| Postnatal ETS                    | 1.771  | 0.292     | 3.47  | 0.001 | 1.282              | 2.446  |
| Moulds                           | 11.132 | 3.344     | 8.02  | 0.000 | 6.179              | 20.056 |
| Maternal atopy                   | 1.976  | 0.207     | 6.49  | 0.000 | 1.609              | 2.428  |
| Breast feeding                   | 0.999  | 0.002     | -0.91 | 0.364 | 0.996              | 1.002  |
| Prenatal PM <sub>2.5</sub> level | 2.514  | 0.454     | 5.11  | 0.000 | 1.765              | 3.582  |
| Fish consumption                 | 0.845  | 0.032     | -4.41 | 0.000 | 0.785              | 0.911  |

Low PM<sub>2.5</sub> ≤ 35.28µg/m<sup>3</sup>

High PM<sub>2.5</sub> > 35.28µg/m<sup>3</sup>

Occurrence of wheezing in chest (duration in days) in children over the two-year follow-up related to exposure variables and confounders (in the GEE population-averaged models)

| Predictor variables              | IRR   | Std. Err. | z     | P>z   | 95% Conf. Interval |       |
|----------------------------------|-------|-----------|-------|-------|--------------------|-------|
| Parity                           | 1.250 | 0.030     | 9.20  | 0.000 | 1.192              | 1.310 |
| Gender of child                  | 0.864 | 0.021     | -6.10 | 0.000 | 0.824              | 0.905 |
| Gestational age                  | 0.977 | 0.007     | -3.38 | 0.001 | 0.963              | 0.990 |
| Postnatal ETS                    | 1.068 | 0.051     | 1.38  | 0.166 | 0.973              | 1.172 |
| Moulds                           | 2.856 | 0.365     | 8.21  | 0.000 | 2.223              | 3.669 |
| Maternal atopy                   | 1.223 | 0.041     | 6.09  | 0.000 | 1.147              | 1.305 |
| Prenatal PM <sub>2.5</sub> level | 1.356 | 0.038     | 11.02 | 0.000 | 1.285              | 1.432 |
| Fish consumption                 | 0.966 | 0.009     | -3.56 | 0.000 | 0.948              | 0.985 |

**Occurrence of difficult (puffy) breathing (duration in days) in children over the two-year follow-up related to exposure variables and confounders (in the GEE population-averaged models)**

| Predictor variables              | IRR   | Std. Err. | z     | P>z   | 95% Conf. Interval |       |
|----------------------------------|-------|-----------|-------|-------|--------------------|-------|
|                                  |       |           |       |       |                    |       |
| Parity                           | 1.421 | 0.038     | 13.23 | 0.000 | 1.349              | 1.497 |
| Gender of child                  | 0.762 | 0.021     | -9.74 | 0.000 | 0.721              | 0.804 |
| Postnatal ETS                    | 1.072 | 0.052     | 1.42  | 0.155 | 0.974              | 1.179 |
| Moulds                           | 1.977 | 0.215     | 6.27  | 0.000 | 1.598              | 2.447 |
| Maternal atopy                   | 1.537 | 0.059     | 11.17 | 0.000 | 1.425              | 1.657 |
| Breast feeding                   | 0.999 | 0.001     | -2.75 | 0.006 | 0.998              | 0.999 |
| Prenatal PM <sub>2.5</sub> level | 1.180 | 0.034     | 5.83  | 0.000 | 1.116              | 1.248 |
| Fish consumption                 | 0.944 | 0.011     | -4.88 | 0.000 | 0.922              | 0.966 |

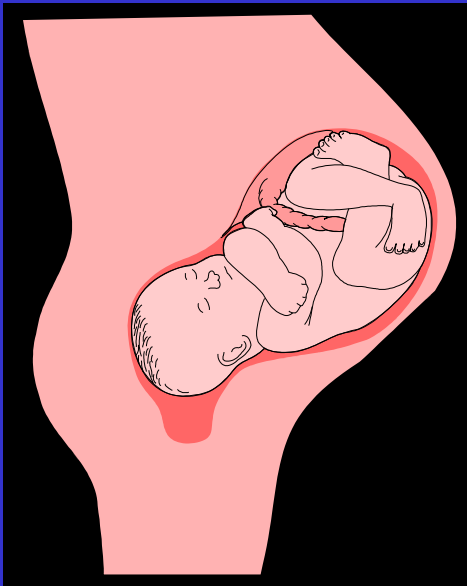
# Effects of the prenatal and postnatal environmental factors on respiratory health of two- year-old infants. Krakow Study

| Predictor variables              | Cough | Wheezing | Puffy breathing |
|----------------------------------|-------|----------|-----------------|
| Parity                           | +     | +        | +               |
| Gender of child (boys)           | +     | +        | +               |
| Postnatal ETS                    | +     | ?        | ?               |
| Moulds                           | +     | +        | +               |
| Maternal atopy                   | +     | +        | +               |
| Prenatal PM <sub>2.5</sub> level | +     | +        | +               |
| Fish consumption                 | —     | —        | —               |
| Breast feeding                   | ?     | ?        | ?               |
| Gestaional age                   | —     | —        | —               |

## Conclusions:

1. the results of our study suggested that prenatal exposure to  $PM_{2.5}$  had an effect on the occurrence of respiratory inflammatory symptoms during early infancy and that this effect was independent of postnatal indoor air quality (environmental tobacco smoke and/or molds in the households)

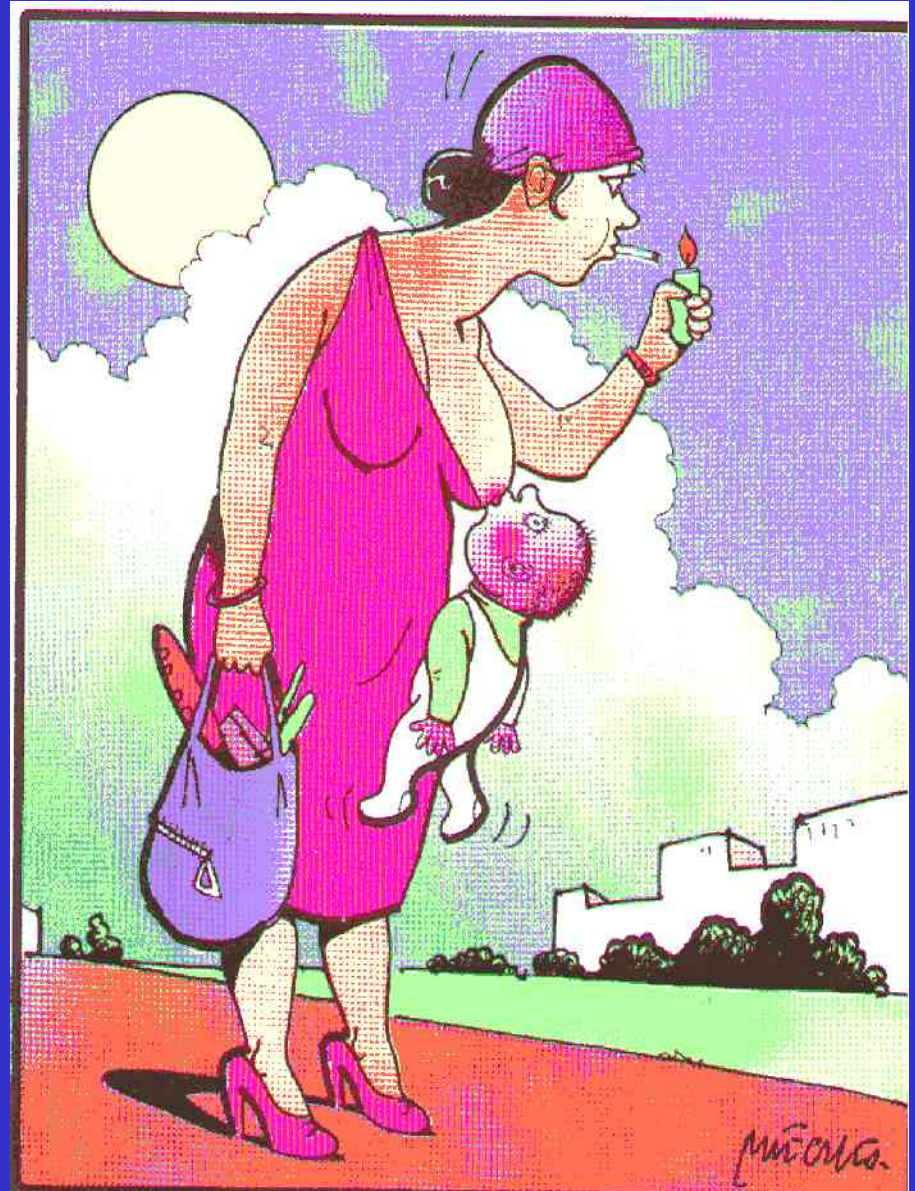
2. Important finding of the study is the protective effect of the fish consumption over the pregnancy period.



In the literature, there is an indication that long-chain polyunsaturated fatty acids (PUFA) supplementation from fish oil is beneficial for fetal development. The protective mechanism may involve antioxidant action of micronutrients and the free-radical scavenging action. It is assumed that increasing omega-3 fatty acids may lead to a reduced inflammatory status.

3. Since it is biologically plausible that the adverse health effects of exposure to  $PM_{2.5}$  compounds may be modulated by nutrients, prevention measures should be focused not only on controlling sources of air pollution, but also must consider healthy nutrition of mothers in pregnancy.

4. Neither the effect of prenatal nor postnatal smoking has been confirmed as the relevant factor for wheezing, but it might be the result of the interrelation between the postnatal ETS and prenatal  $PM_{2.5}$  exposure.

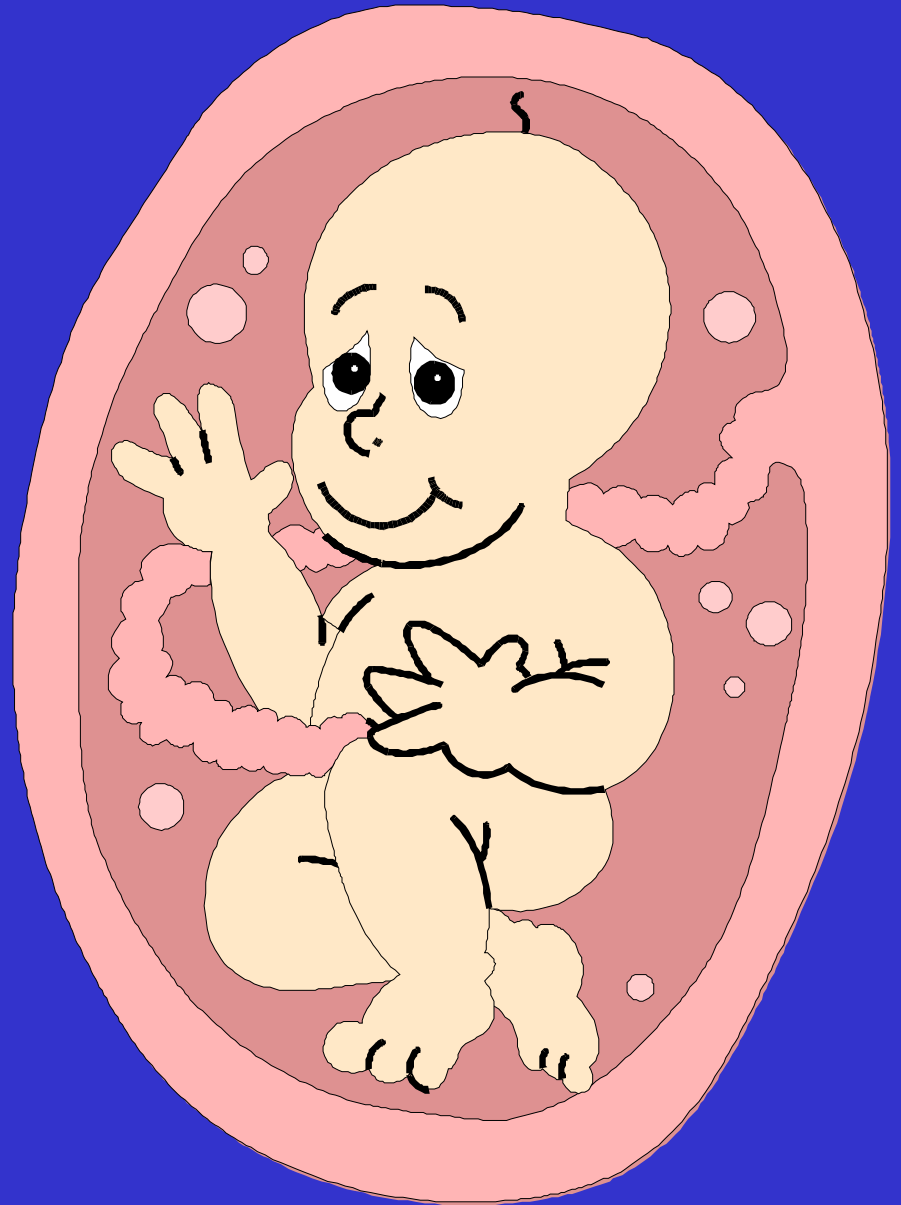


5. The protective effect of breast feeding was insignificant. Breast milk contains many antimicrobial factors (eg, IgG, secretory IgA, complement proteins, lysozyme, and lactoferrin) that coat the GI and upper respiratory tracts and help prevent invasion of mucous membranes by respiratory and enteric pathogens.

The results may be due to the fact that the breastfeeding variable was interrelated with maternal education and parity.



Thanks for  
taking care  
of prenatal  
exposure



The data support an evidence that higher risk of respiratory symptoms may result from biologic effects of prenatal PM<sub>2.5</sub> exposure on developing fetus or in early infancy. The biological mechanisms whereby prenatal PM<sub>2.5</sub> might lead to excessive respiratory outcomes are yet unclear.

It is well established that inhalation of particles with a mass median aerodynamic diameter of 10 µm or less is associated with bronchiolar irritation, and lower tract infections, while exposure to particles 2.5 µm and smaller exhibit a stronger epidemiological link with respiratory inflammatory effects.

Particles even smaller, 0.1 µm or less, are thought to move beyond the respiratory system and may reach the bloodstream and cross placenta. PM<sub>2.5</sub> should be treated as a proxy measure of a whole complex of toxic agents present in the environment because it contains constituents of soots including polycyclic aromatic hydrocarbons, tobacco, wood smoke, organic compounds, sulphates, and metals. Absorbed toxic air pollutants may affect DNA as evidenced by the observations that placental DNA adducts are more common in areas with higher levels of pollution and that altered fetal growth has been associated with PAH- DNA adducts.