

# VENTILATION of HOMES and HEALTH

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Me?, Master in HVAC, writing the energy (saving) building code in Sweden (1975), MD in Environmental Medicine, Karolinska Institute (1994)

The Allergy inquiry 1987-9

Natl. Inst of Public Health,  
The Allergy program 1991-1998

National Board of Urban Planning and Building (The Energy Building Code 1975)  
Occupational Safety and Health Administration... UN

- ▶ Prof at DTU, UT Tyler, Tsinghua, USST, Chongqing U, Central South U, South East U, + 6 more



# The National Board of Urban Planning and Building (The Energy Building Code 1975)

- ▶ How much ventilation?
- ▶ Radon, formaldehyde, “odor”
- ▶ 0.35 L/s.m<sup>2</sup> (“The Sundell Number”)
- ▶ What type of ventilation?
  - ▶ Mechanical+ heat recovery
- ▶ What about energy?
  - ▶ Heat recovery

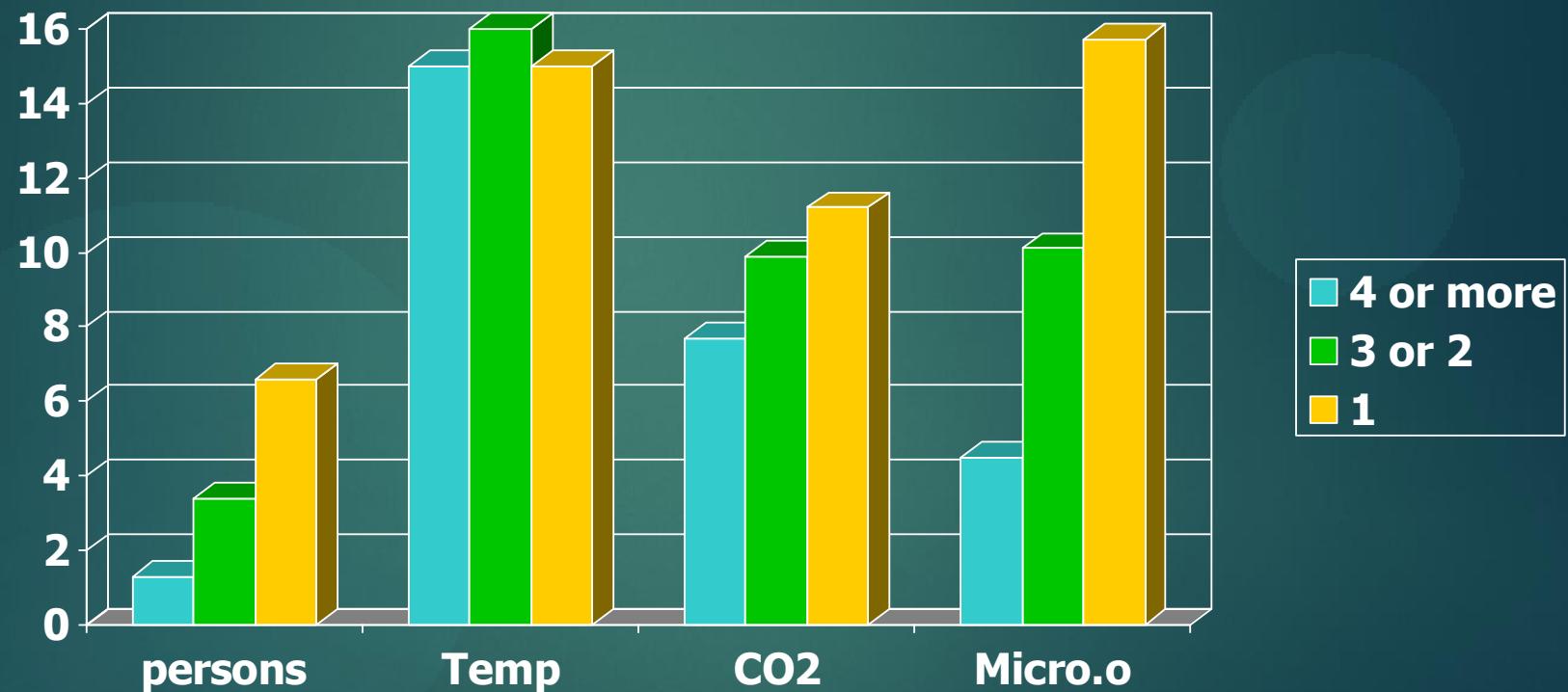


# HOUSING AND HEALTH

## A STUDY ON INDOOR CO<sub>2</sub>, ORGANIC COMPOUNDS, MICROBIALS and DEATH

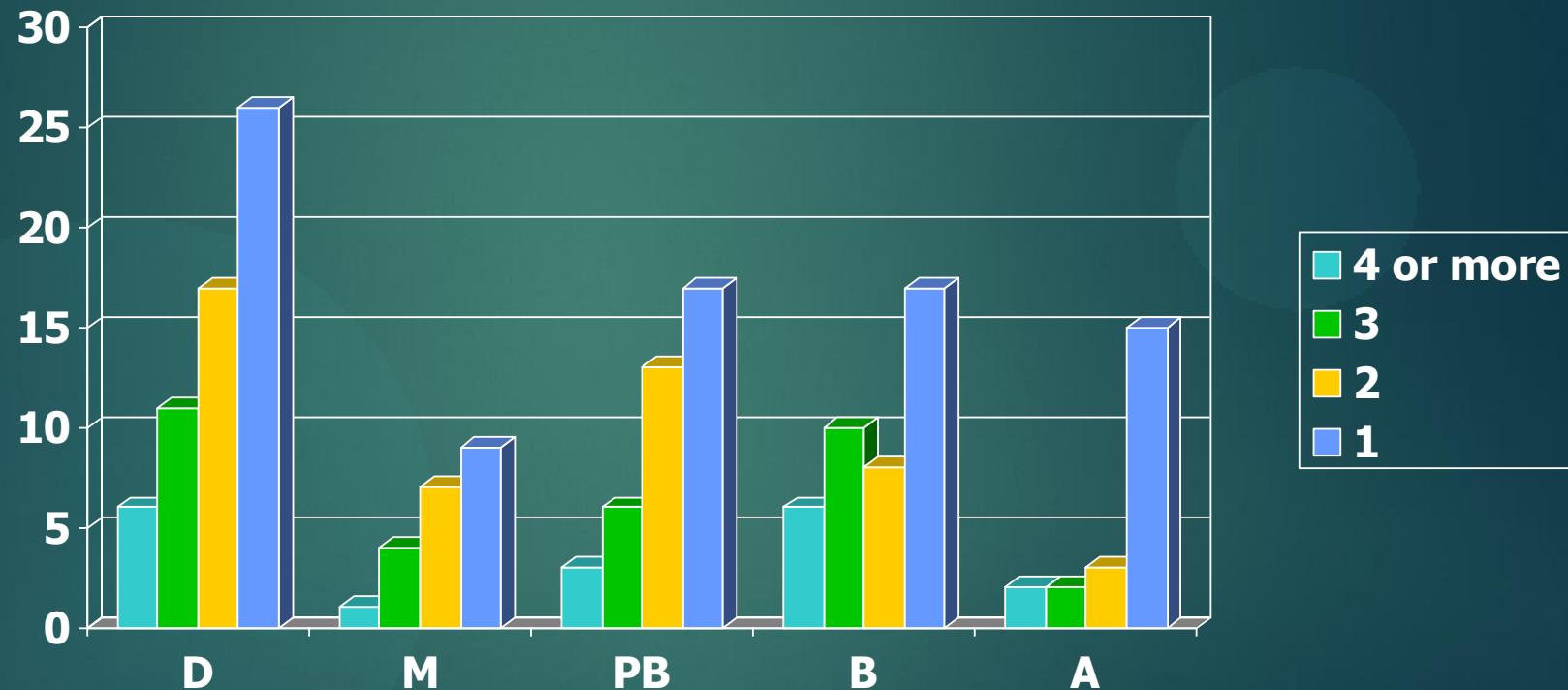
- ▶ 64 representative homes
- ▶ Measurements at night (0030-0430)
- ▶ Mobile laboratory
- ▶ Background data on housing and causes of death from 150 329 inhabitants

# EXPOSURES in homes



# DEATH per 10 000 INHABITANTS

D= Diarrhoea, M=Measles, PB=Premature birth, B=Bronchitis, pneumonia,  
A=Accidents (including overlaying)



# Carnelley T, Haldane JS, Anderson AM. (1887).

Philosophical Transactions of the Royal Society, Series B178,61-111

- ▶ Dundee, and Perth, Scotland
- ▶ Horse and covered van
- ▶ Houses visited without warning
- ▶ ONE OF THE BEST STUDIES ON IAQ AND HEALTH EVER!



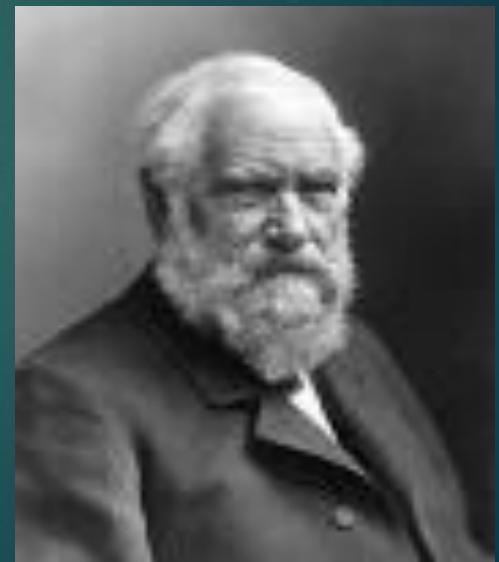
# John Griscom (surgeon), New York, 1850

- ▶ "...deficient ventilation ... (is) more fatal than all other causes put together"



# Early science!

- ▶ Using CO<sub>2</sub> concentrations as a measure of ventilation.
- ▶ Pettenkofer (1860)... 1000 ppm in all rooms
- ▶ Heyman (1875)... 700 ppm in bedrooms
- ▶ To keep people healthy...





Emil Hornemann  
Hygiejnisk komité, 1846

# IAQ and HEALTH, 1800-1900

## INDUSTRIALISM, CROWDED CITIES

## CHOLERA, TYPHUS, TUBERCULOSIS

### ENVIRONMENTAL ISSUES

WATER SUPPLY, SEWAGE  
TREATMENT, INDOOR AIR,  
DAMPNESS

MIASMA, the cause!

"An unexplainable  
atmospheric poison"

### HYGIENE!



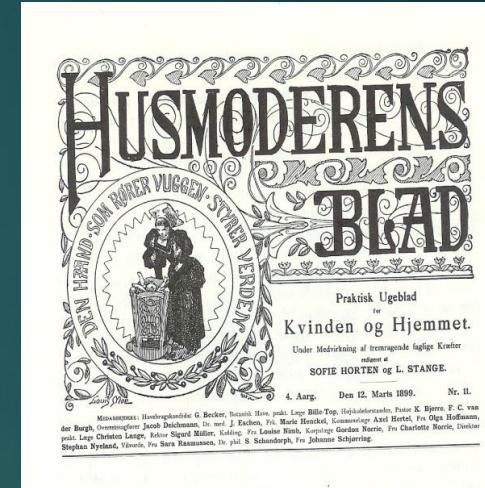
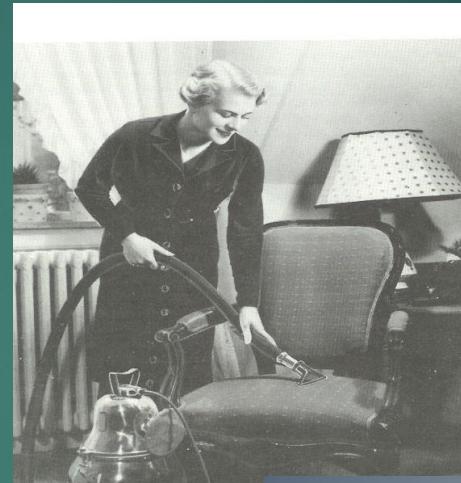
# IAQ AND health, 1900-1962

## TBC... - CLEANLINESS

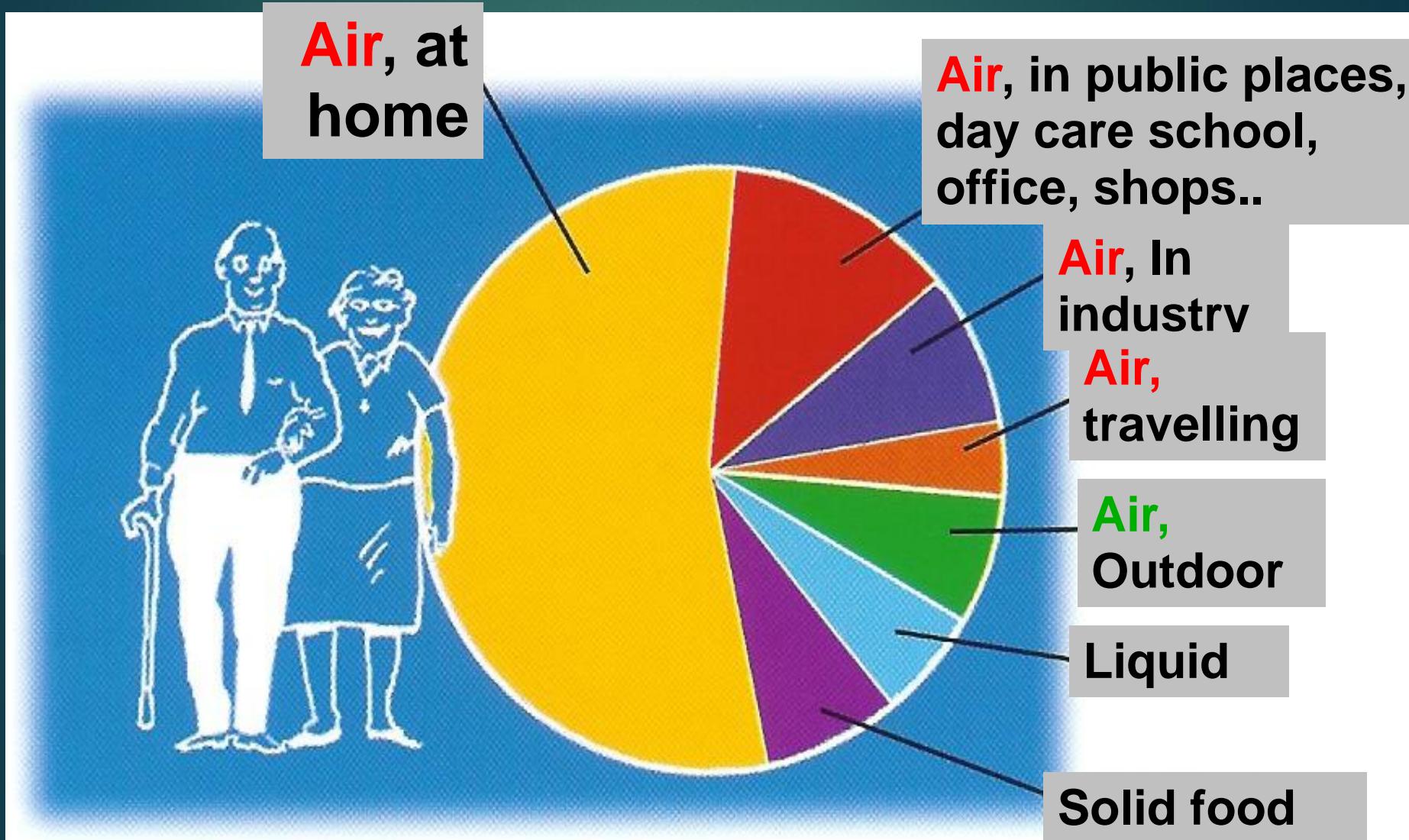
# ENVIRONMENTAL ISSUES

## HYGIENE!

## HOUSING, HOUSEWIFES, DAMPNESS ....



# Total exposure (kg) during 70 years





## WHAT IS THE ROLE OF INDOOR AIR in HOMES?



# VENTILATION: Definition

- ▶ Ventilation = The (continual) exchange of contaminated air , (in the lungs, or in the room), with “fresh” (less contaminated ) air.
- ▶ We need to breathe continuously! Perhaps we need “good” air continuously?
- ▶ You can not stop breathing for 5 hours, and then breath, much more!
- ▶ Opening of windows is a supplement to ventilation , in order to get rid of contaminant peaks. (Thus, the possibility to open windows is a necessity!)

# Radon – Lung cancer Sweden

Data from mine workers and  
the bombing of Hiroshima,  
Nagasaki.

Rolf Sievert 1896-1966

Gun Astri Swedjemark



# Radon – Lung cancer A topic everywhere!

Most cited: Darby, Hill, Auvinen et al. (2005, 415 citations)

- ▶ Radon: The reason for 0.5 ach in the Swedish Building Code 1975



# House Dust Mites (HdM)

“Dust” was a main risk of allergies. In the 60ies it was found that this mainly was due to HdM.

Netherland ...  
Denmark

Jens Korsgaard



# House Dust Mites. Spiders, 34 HdM species



# Highest dust mite concentration: in the bed

- ▶ A single bed can house a million of house dust mites .



Stockholm 1978. No HdM in homes of asthmatics (Turos 1979)

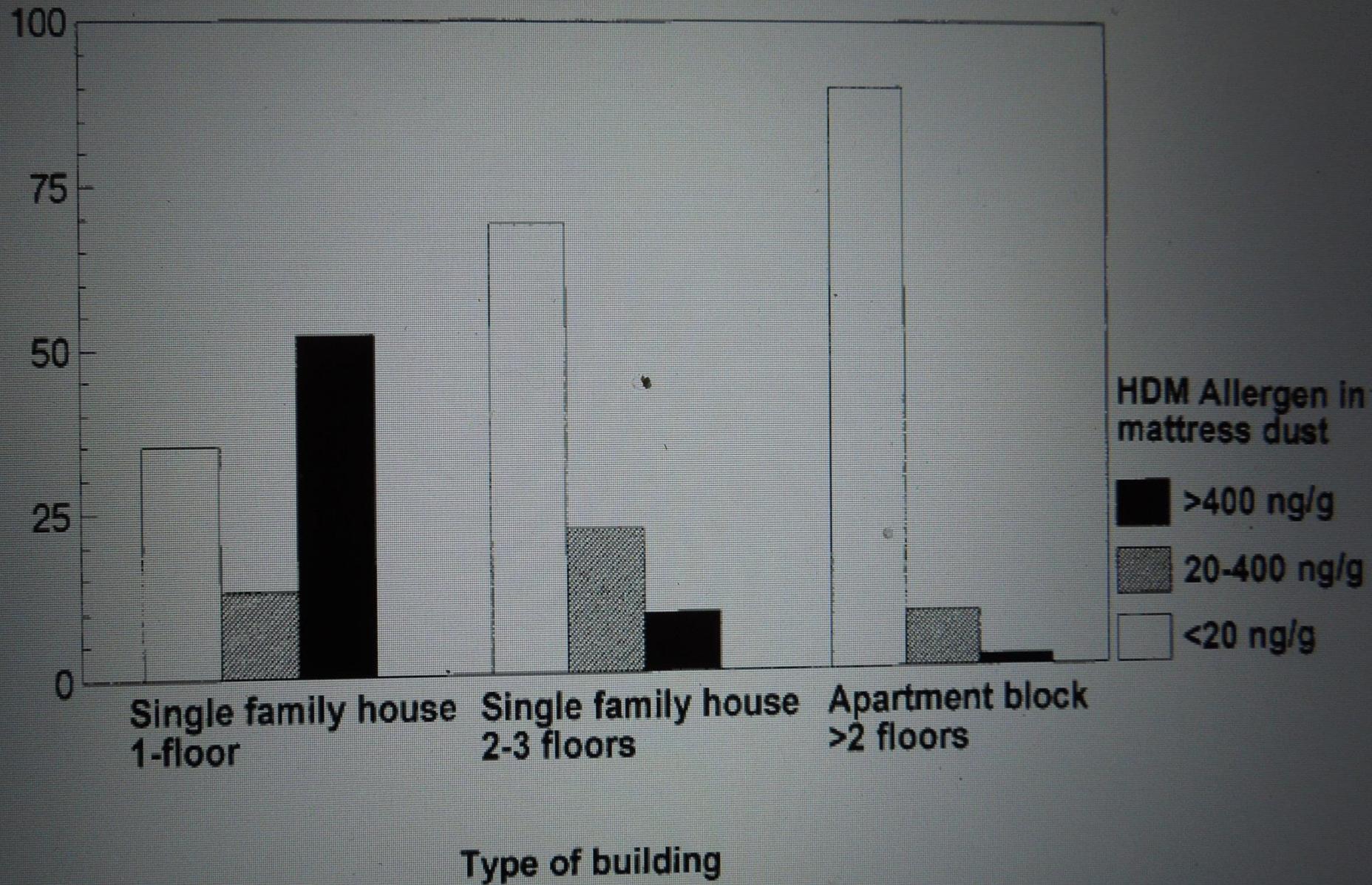
STOCKHOLM 1989

HDM IN 60% OF HOMES (SUNDELL 1994).

WHAT HAD HAPPENED?

ENERGY CONSERVATION, LESS VENTILATION.. HIGHER RH, MORE HDM!.. AND MORE SICK CHILDREN!

## Proportion of homes %

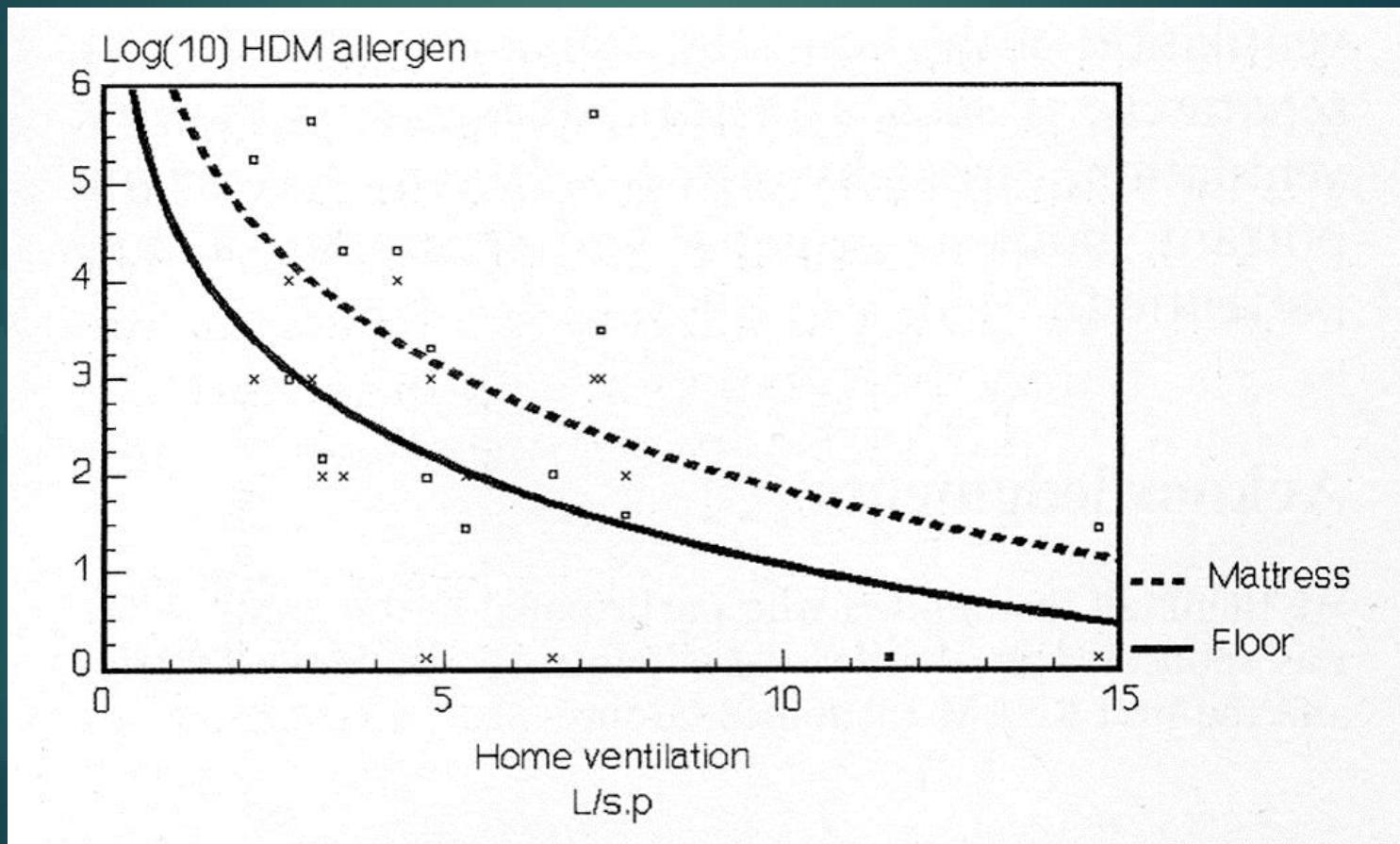


## Type of building

Fig. 2 House dust mite allergen content in mattress dust in 160 Stockholm homes (data from [paper I](#)).

# HOMES? Ventilation and allergy

Sundell et al. (1994)



# House Mites House Dust (HdM)

Energy saving in homes – low ventilation rates in bedroom.

Most articles: Heinrich J, Custovic A, and Brunekreef B

Most cited: Lau S et al. (2000, 414 citations).



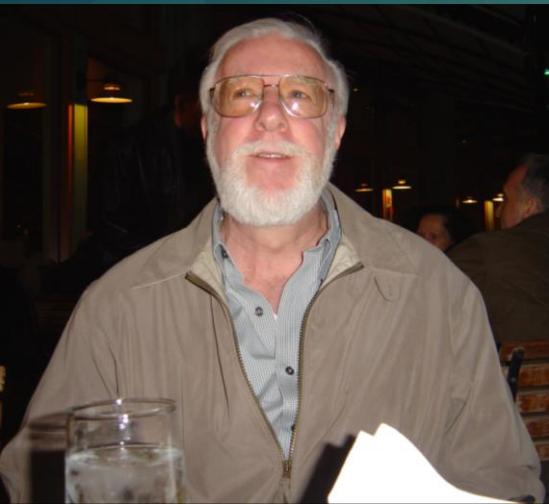
# NO2

Most articles: Brunekreef B, Spengler J, Lee K.  
Most cited: Finlayson-**Pitts** (2003, 212 citations)



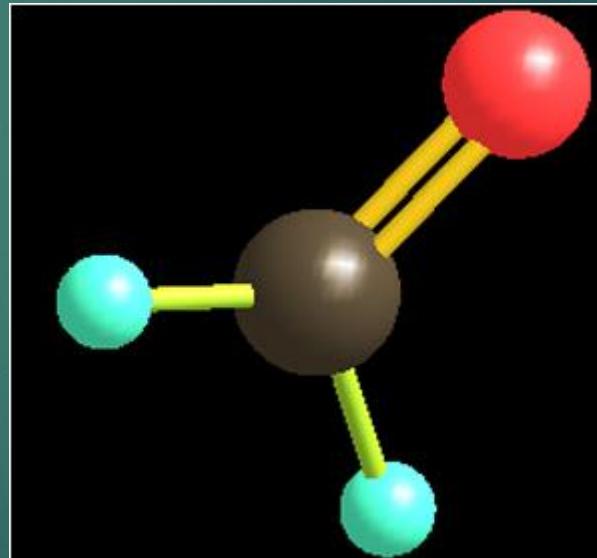
# Odor, psychophysics

Most articles: Wolkoff P, Sundell J, Norback D.  
Most cited: Meyer (2004, 457 citations)



# Formaldehyde, Sensation of Dryness!

Aarhus, early 70ies. Chamber studies, 7-78 % RH, air no difference in, dry air sensation, But any polluted air means, "Dryness"



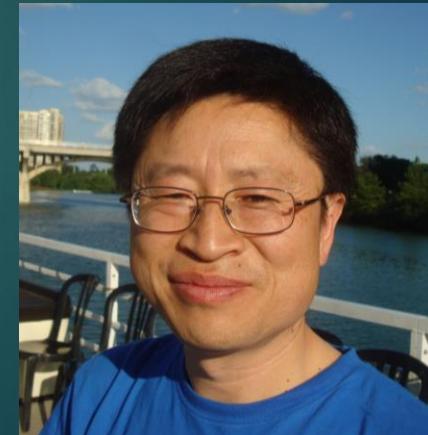
# Formaldehyde:

fiber board, plywood, Urea Formaldehyde Foam Insulation (UFFI, USA), mobile homes in USA. **Now China, East Asia**

Most articles: Norback D Zhang YP, and Salthammer T.

Most cited: Zhao and Yang (2003, 383 citations).

The industry changed the composition of the resin used in wood products



# VOC, TVOC

Most Articles: Norback D, Zhang YP and Salthammer.

Most cited: Jones. (1999, 386 citations)

The TEAM study (Lance Wallace)

Lars Molhave, Peder Wolkoff,  
NORDVOC, Bernt Seifert, ..

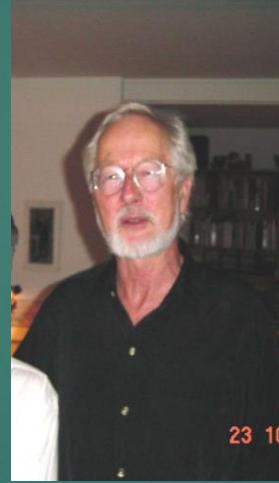


# Sick Building Syndrome

Most articles: Norback D, Wieslander G, Sundell J.

Most cited field study: Valbjorn, Pedersen (1989, 149 citations).  
Town Hall Study, England, Finland

The Northern Swedish Office  
Illness Study, The BASE study



# DAMPNESS, MOLD

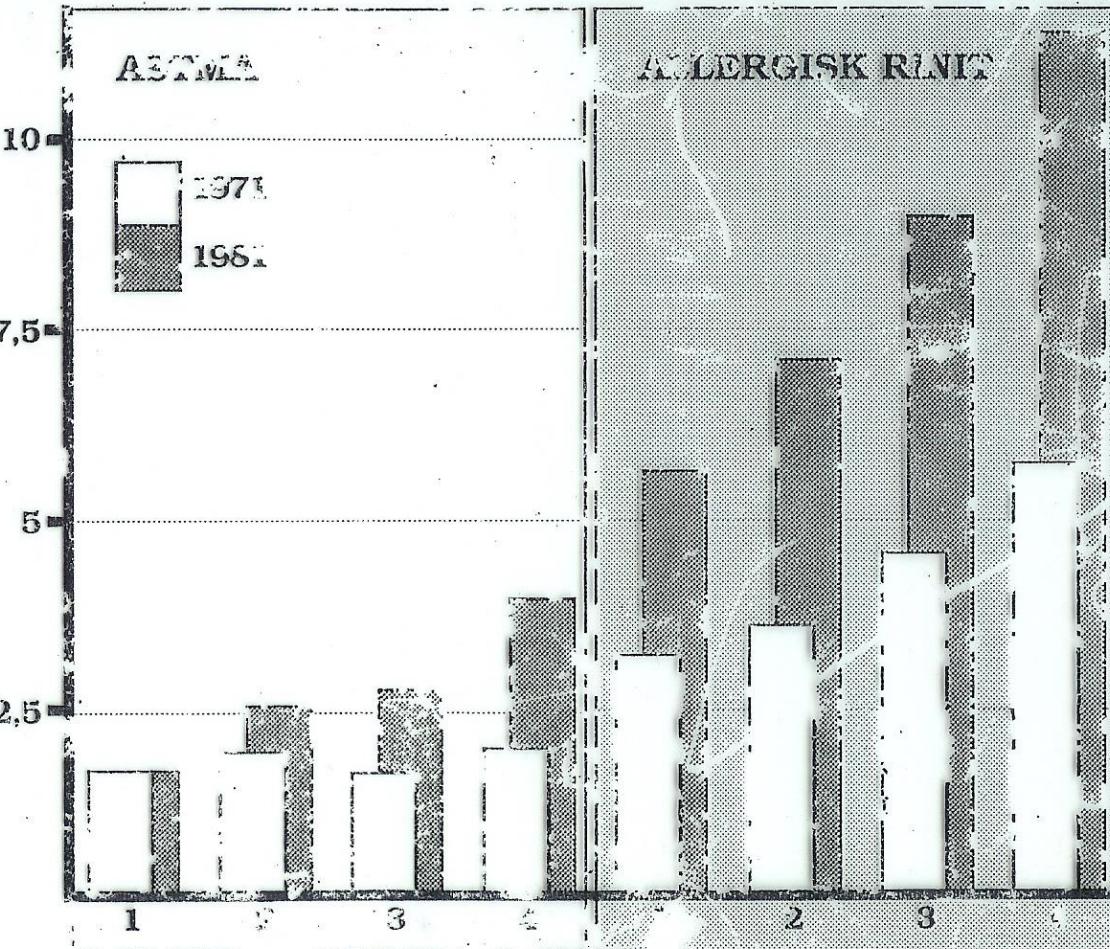
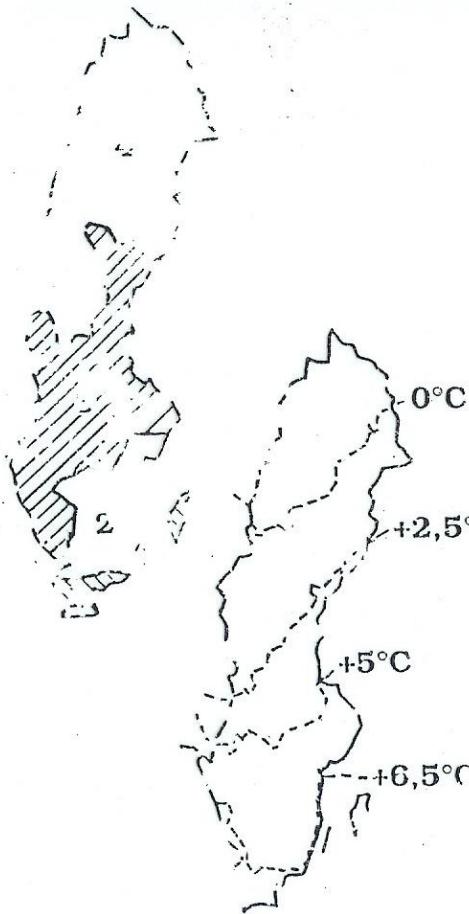
Most articles: Norback D, Nevalainen A, Sundell J.

Most cited Bornehag CG et al. (2001, 325 citations).



# BREVÄRENS AV ASTMA OCH ALERGIK RINITIS HOS VÄRNPLIKTIGA LÖVNA REGIONER

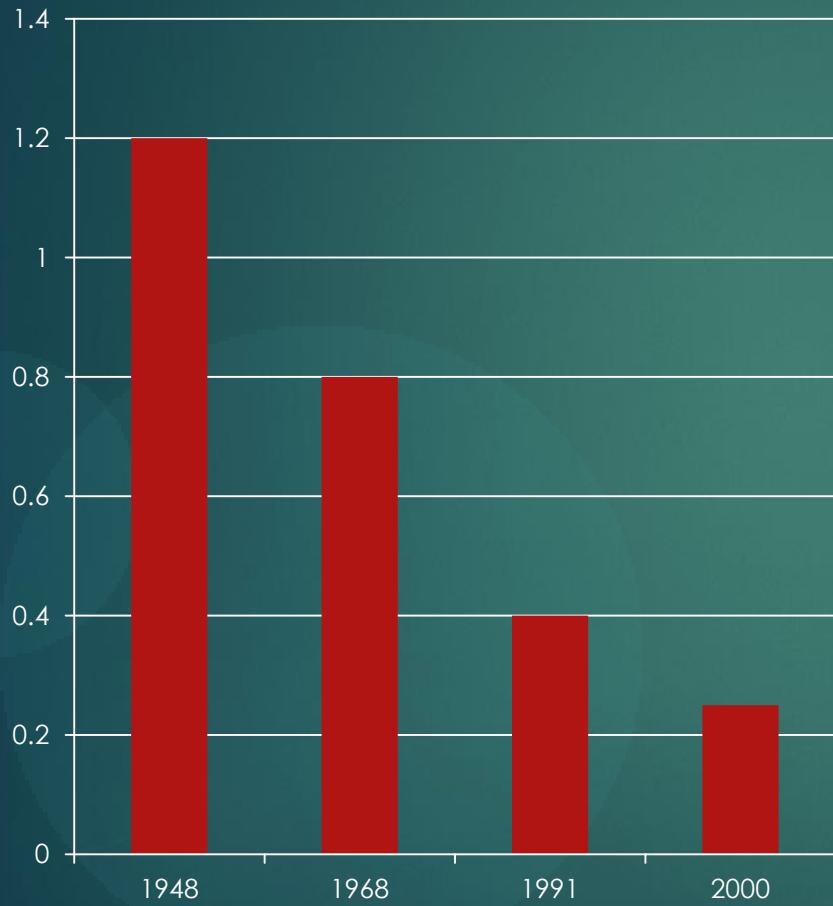
M. Åberg 1981



ISOTERMER

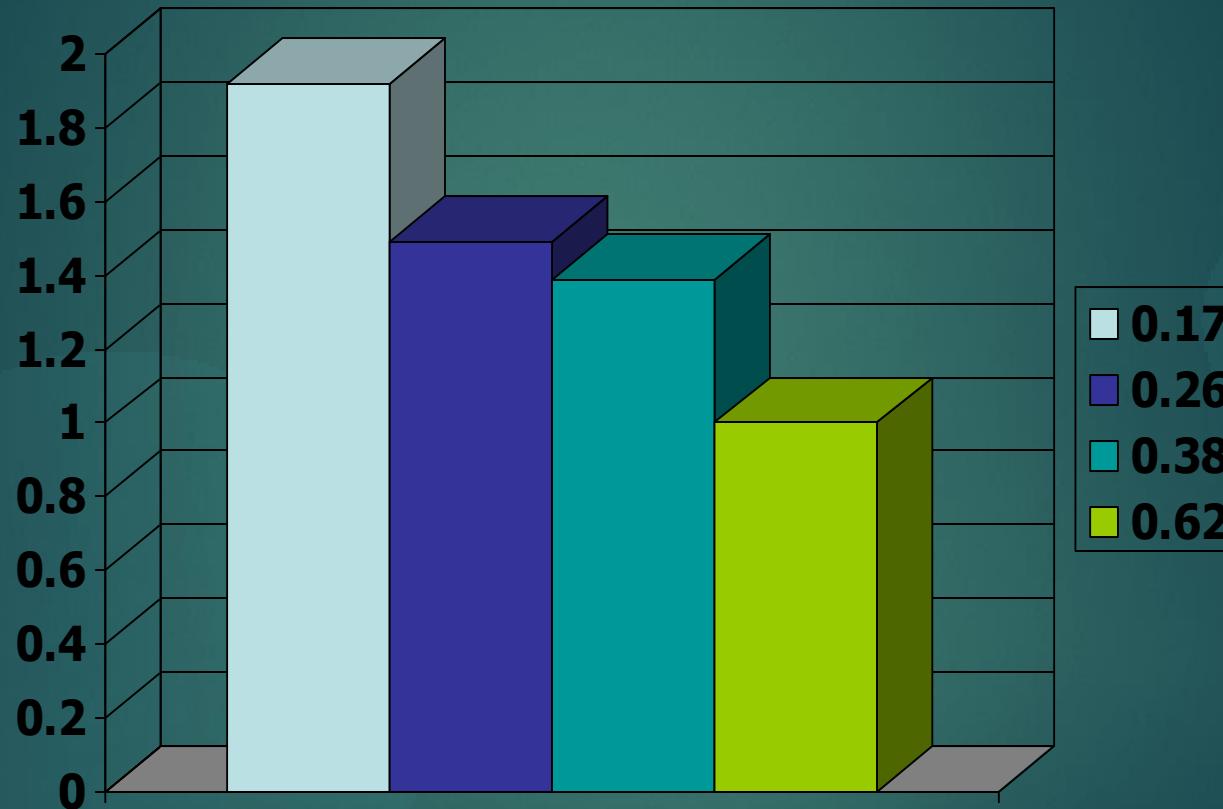
REGION

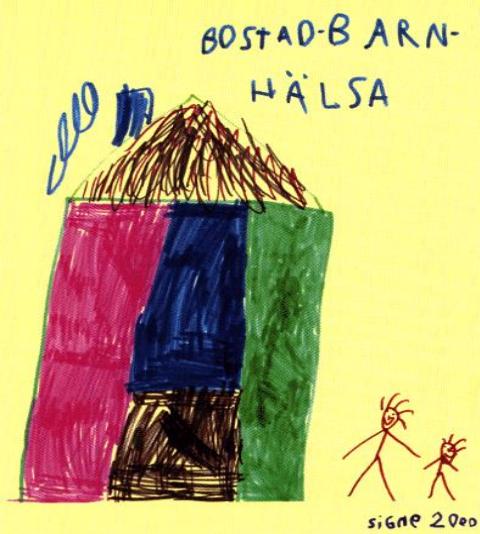
# VENTILATION RATES (ach) IN SWEDISH HOMES



- ▶ 1948, Rydberg
- ▶ 1968, Sundell
- ▶ 1991, ELIB
- ▶ 2000, DBH

# Ach-OR for "cases" in single family homes

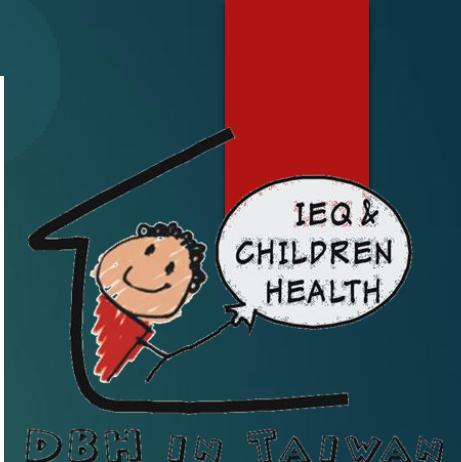
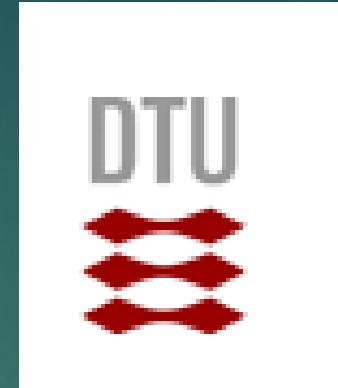




Sweden DBH

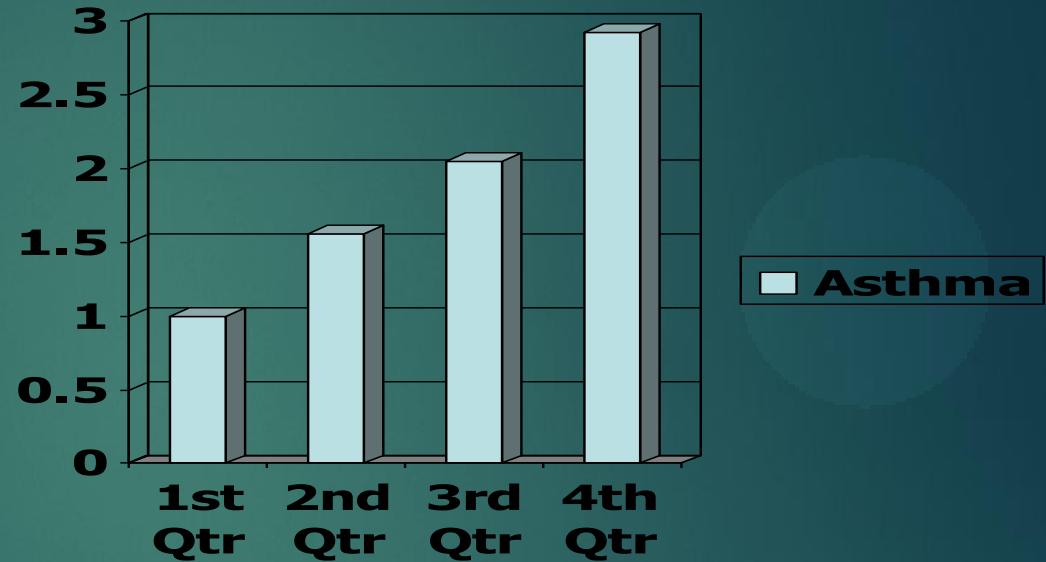


Bulgaria ALLHOME



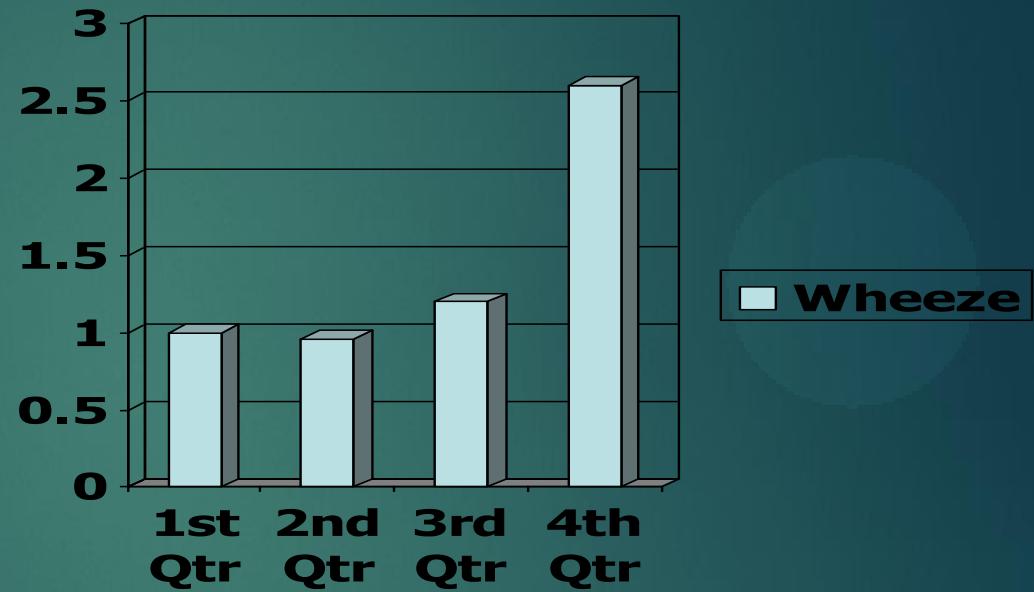
# DEHP and Asthma in Sweden

- ▶ Adjusted OR
- ▶ Quartiles of exposure (concentrations in dust)



# DEHP in Bulgaria (179 children)

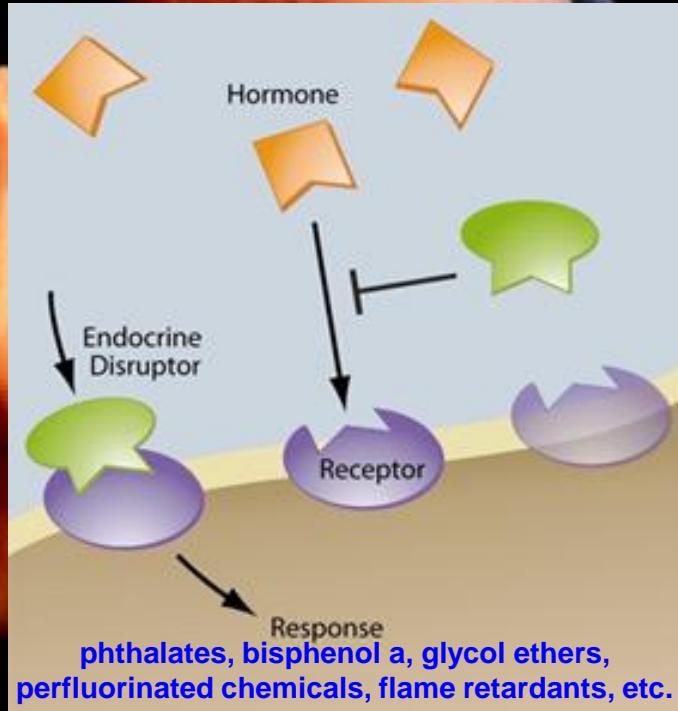
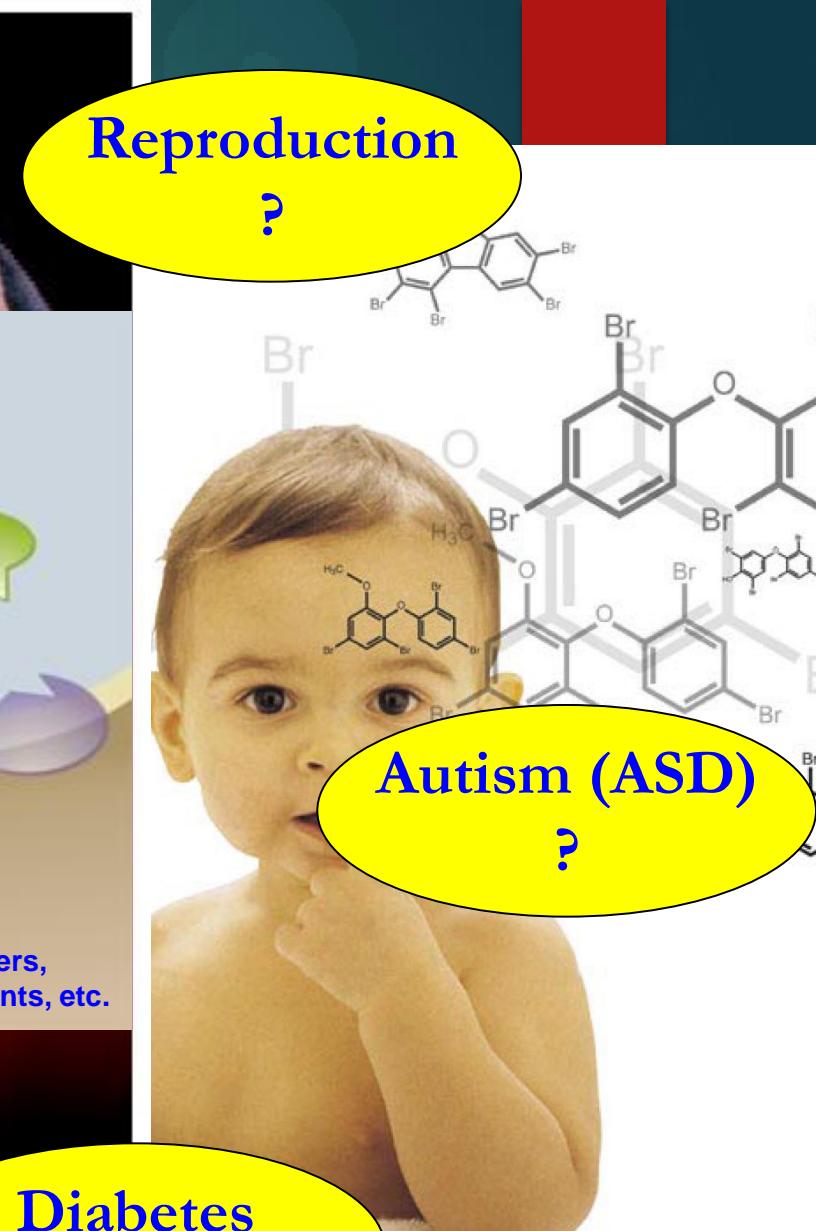
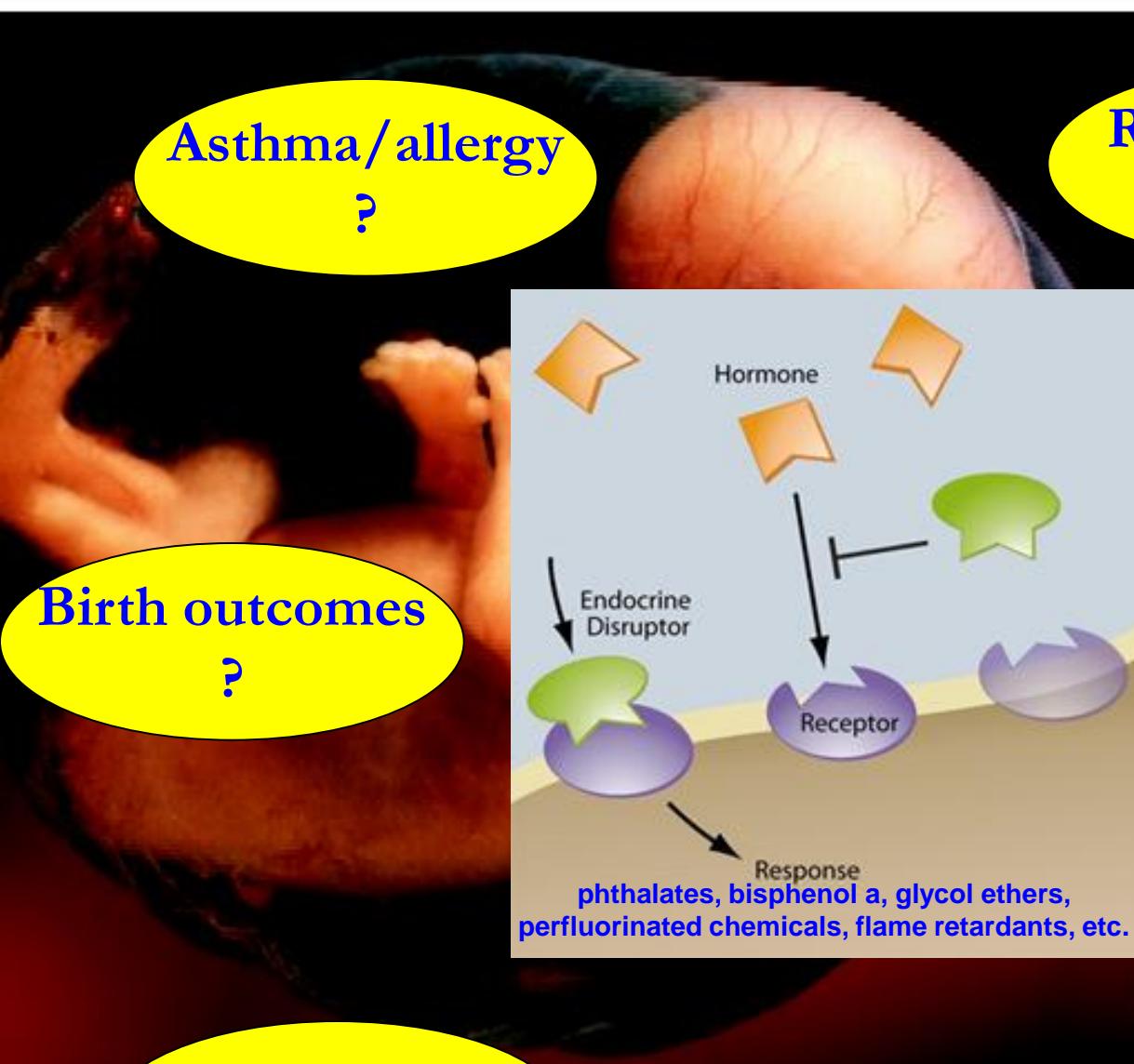
- ▶ Adjusted OR
- ▶ Quartiles of exposure (concentrations in dust)



PloS One (Public Library of Science)  
5(10):e13423.doi:10.1371/journal.pone.0013  
423

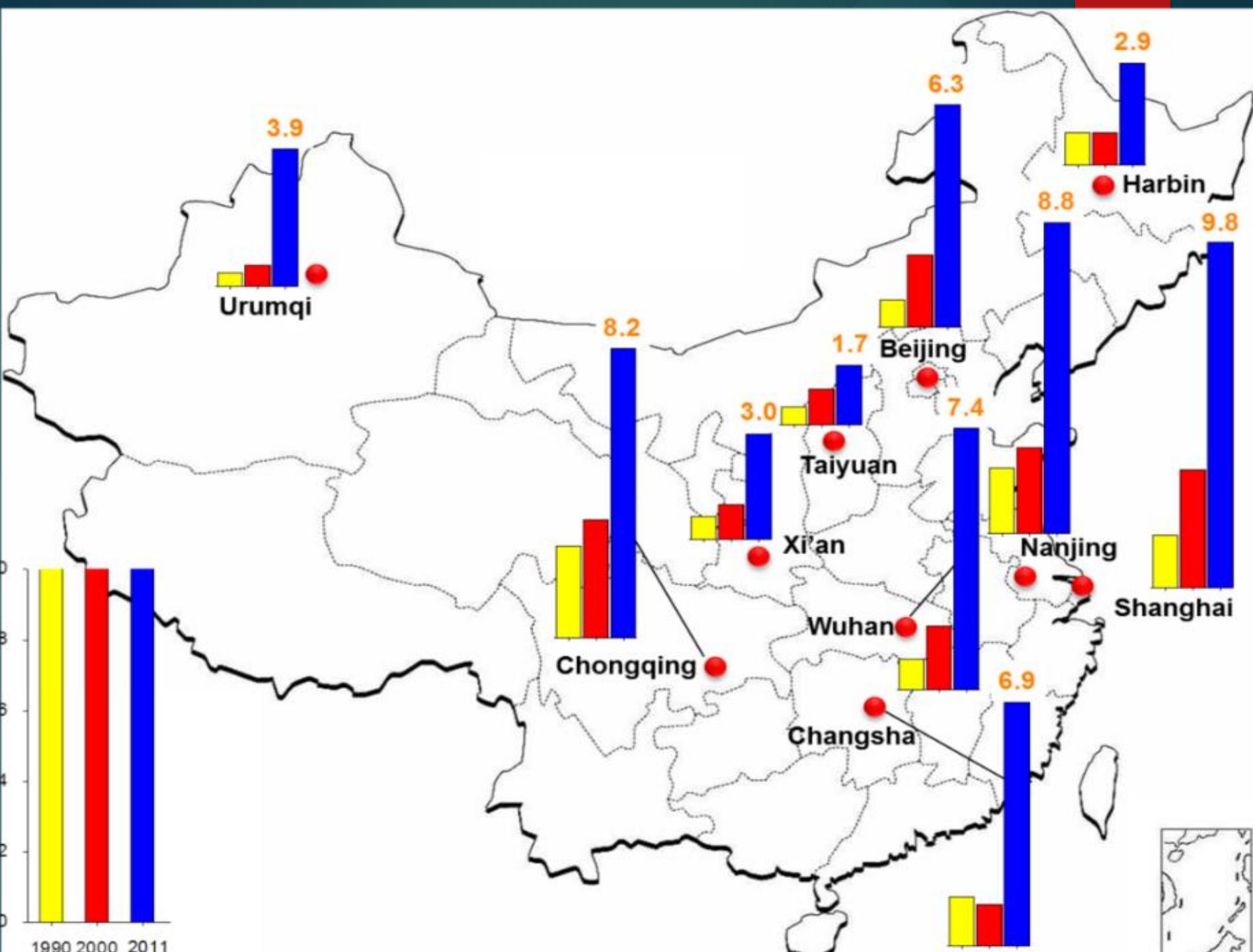
Common Household Chemicals and the  
Allergy Risks in Pre-School Age Children  
Choi, Schmidbauer, Sundell, Hasselgren, Spengler, Bornehag

Propylene glycol, glycol ethers (丙二醇, 乙二醇醚)....  
(water based paints, cleaning products.....), strong risk  
factors for allergies...



# CCHH, DBH groups







# Ventilation rates in homes

Measured ach in Sweden, Risk of having an allergic child

Yoshino, Sherman, Grimsrud



# The sick children in China, with “Modern diseases” live in new apartments!



# Results

- The air change rate in the whole apartment (calculated in single zone model by using volume weighted CO<sub>2</sub> concentration) and child's bedroom (0:00 am-7:00 am)

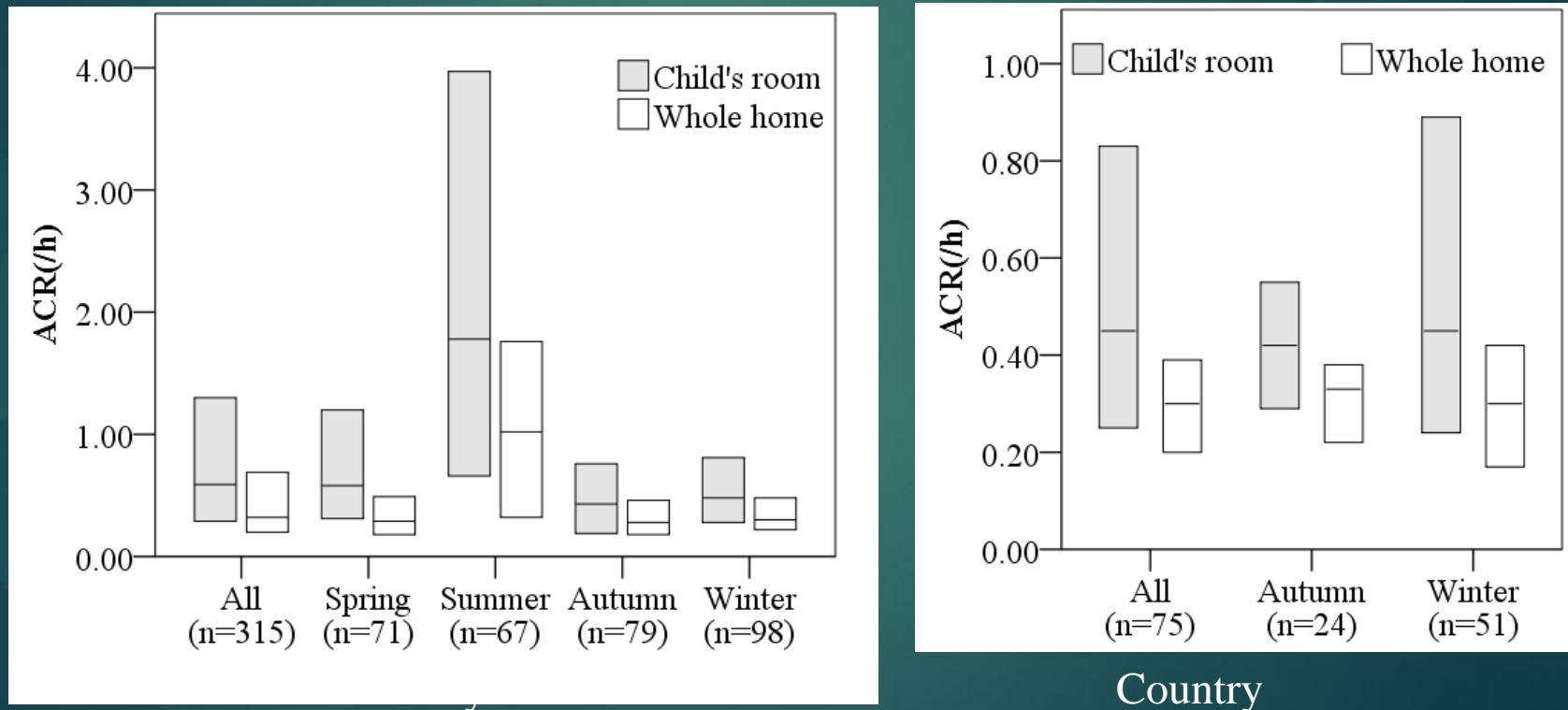


Fig.1 ACR in city and country of Tianjin area

# Results

- The average CO<sub>2</sub> concentration during night (0:00 am-7:00 am) in child's bedroom

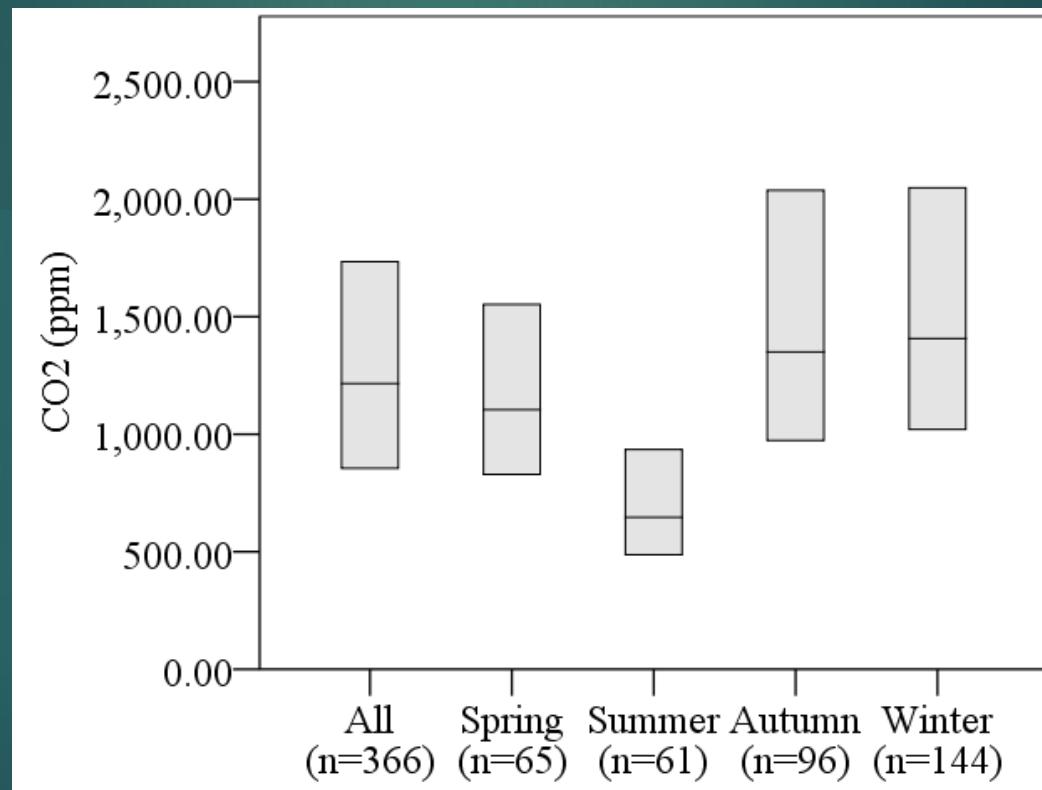


Fig.2 The average CO<sub>2</sub> concentration in city and country of Tianjin area

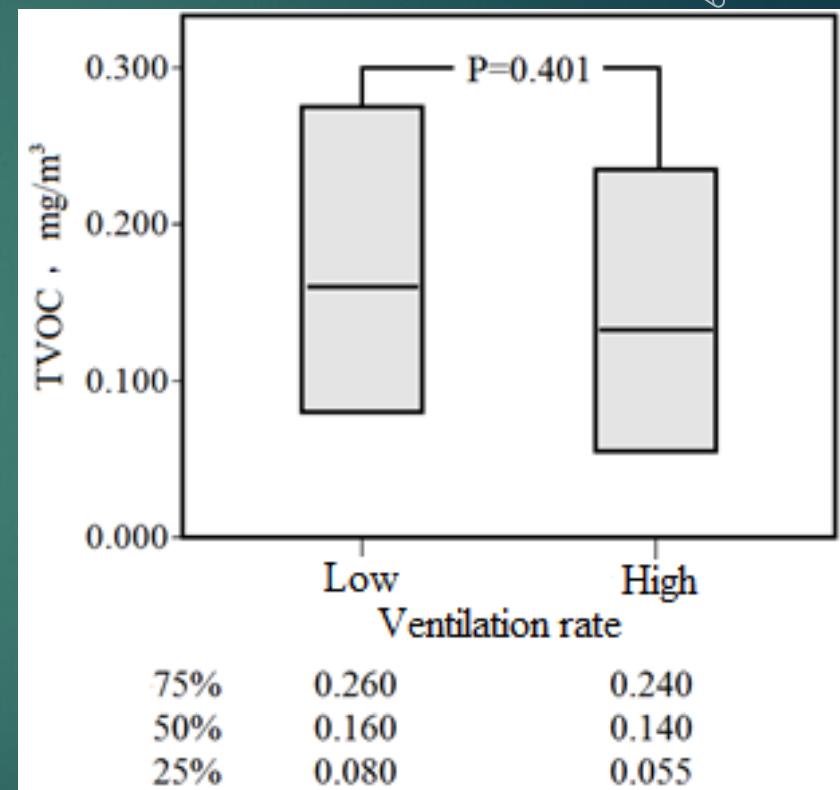
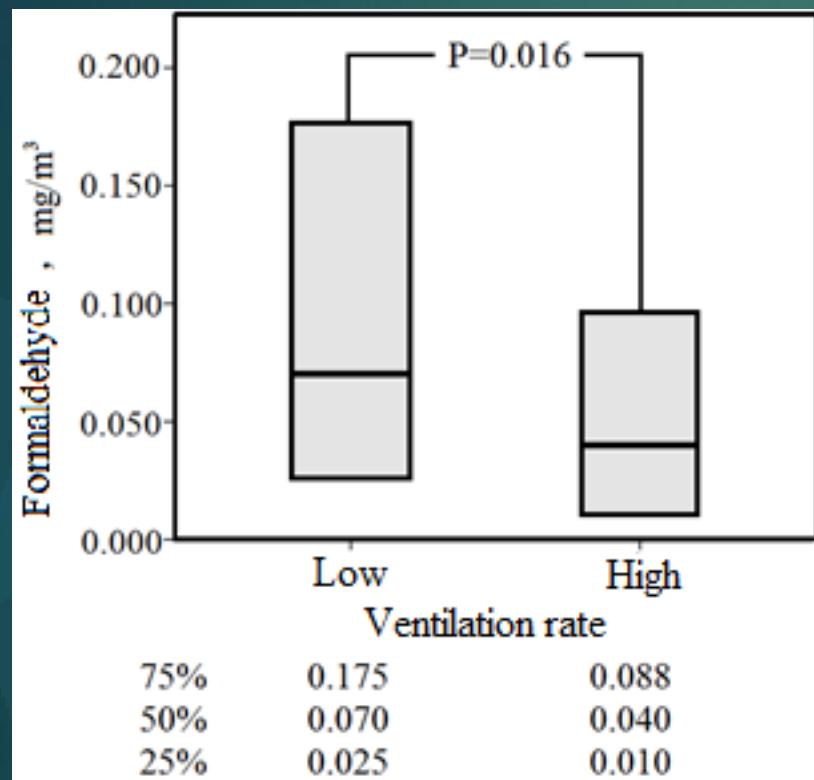


Fig.3 Associations between ACR in child's room and formaldehyde/TVOC

# Results

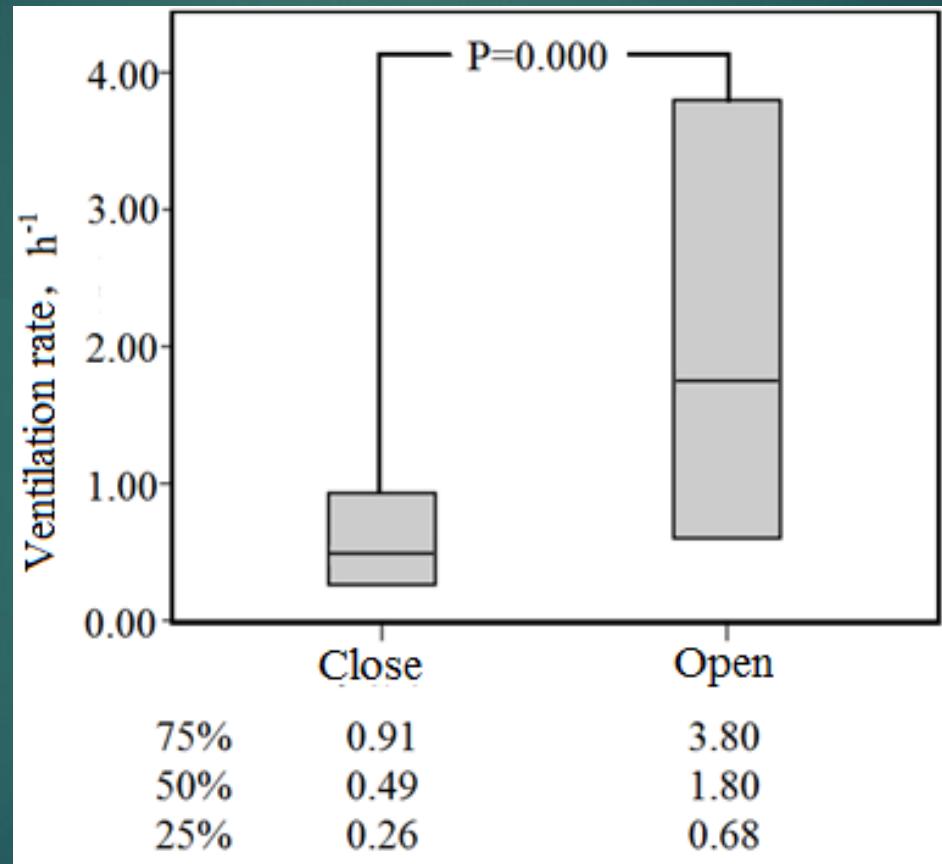
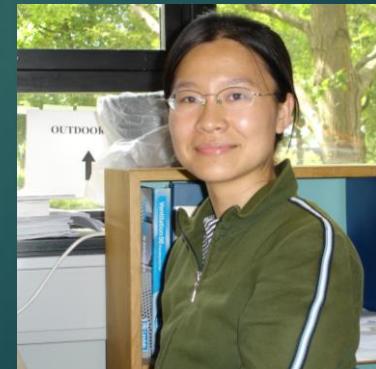
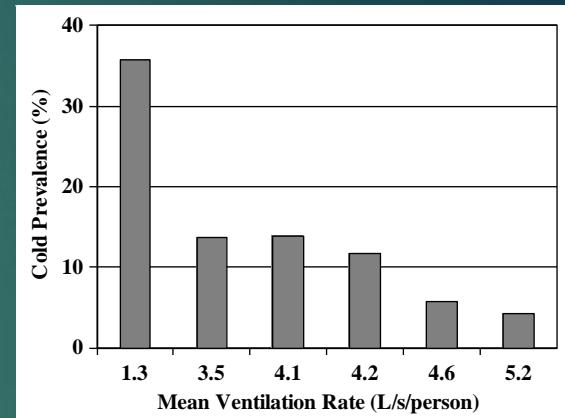
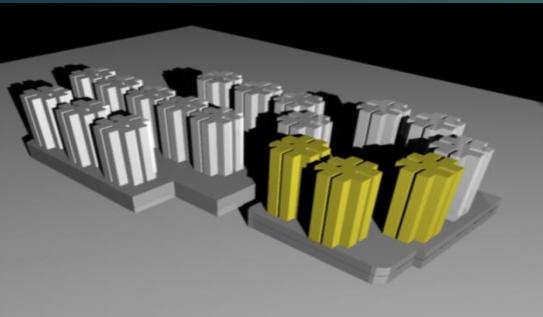


Fig.4 Associations between ACR in child's room and situation of window

# AIRBORNE INFECTIONS

SARS, Hong Kong, Yuguo Li,  
INDIVENT

Common cold, Yuexia Sun

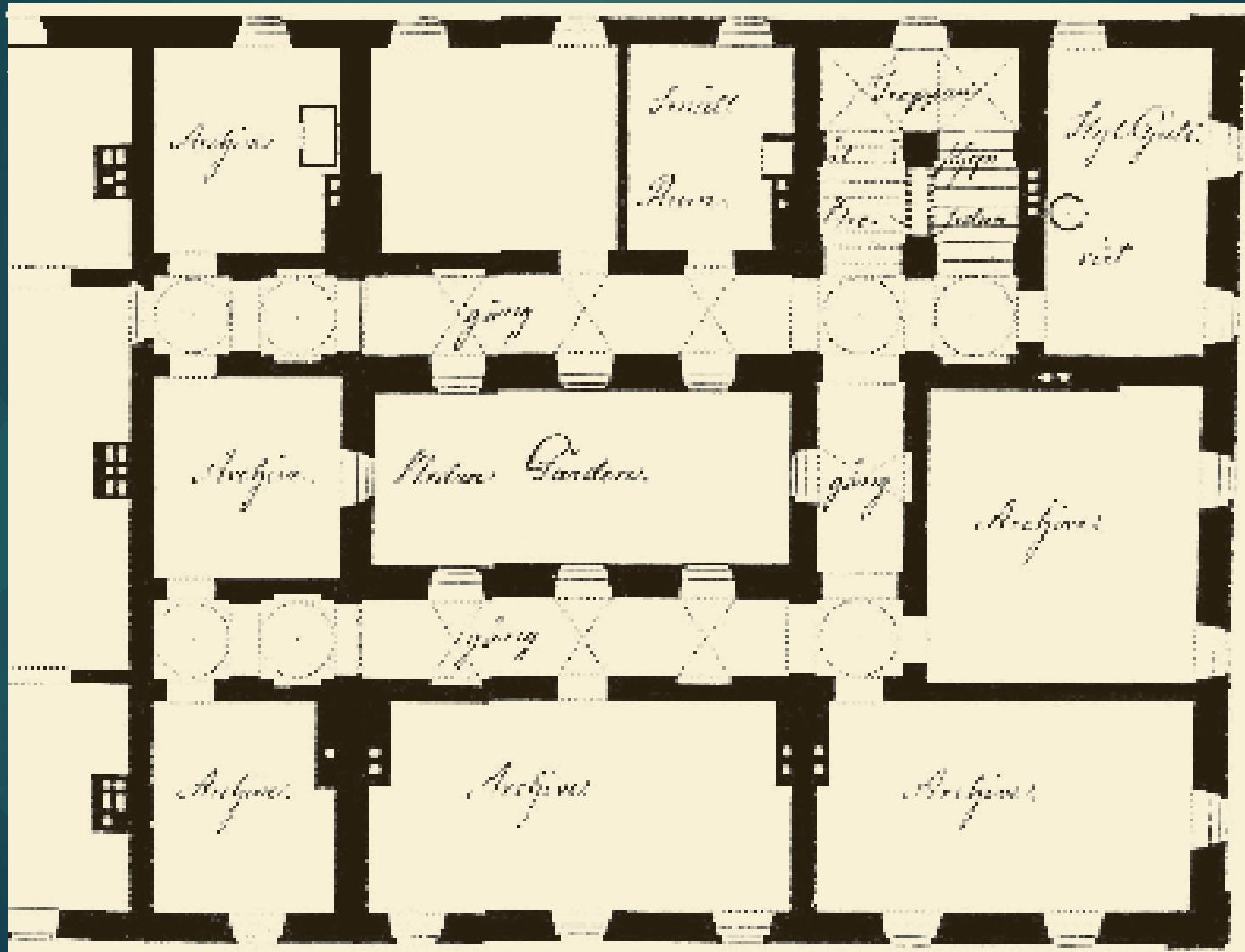


# Ventilation and heating combined.. 1750



# Ducts for heating (chimney) and ventilation, together..

1



# Early technology...up to 1900

- ▶ Leaky buildings..
- ▶ Stoves.. open fires... a chimney + ventilation ducts



# In kitchen?

- ▶ A cooker hood was always there... linked to the chimney from the stove... good ventilation...



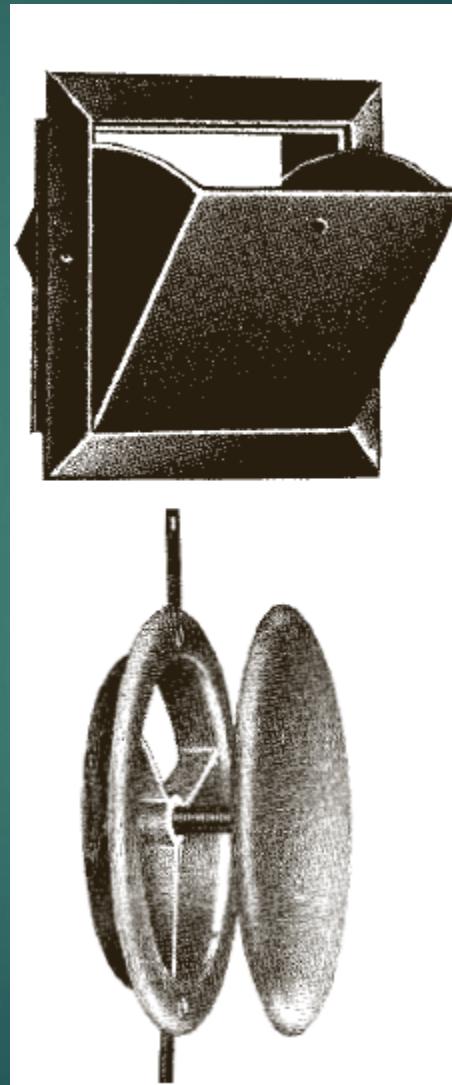
1920...

“Thick” buildings, Toilet indoors..  
no window in bathroom..  
dampness

- ▶ So, “Stockholm ventilation”.. Mechanical ventilation (from 1928)!...

In Swedish homes always  
a supply air terminal..





Klaffventil ur Ahsell & Bernströms katalog nr 32. Denna typ av ventil placerad i yttervägg användes ofta under 1800-talet och början av 1900-talet för att ta in ute-luft.

Tallriksventilen Disco ur Rylander & Asplunds katalog nr. 36. Vanligt förekommande som tillluftsventil i s. k. Stockholmsventilation.

# The discussion was ALL about ENERGY..

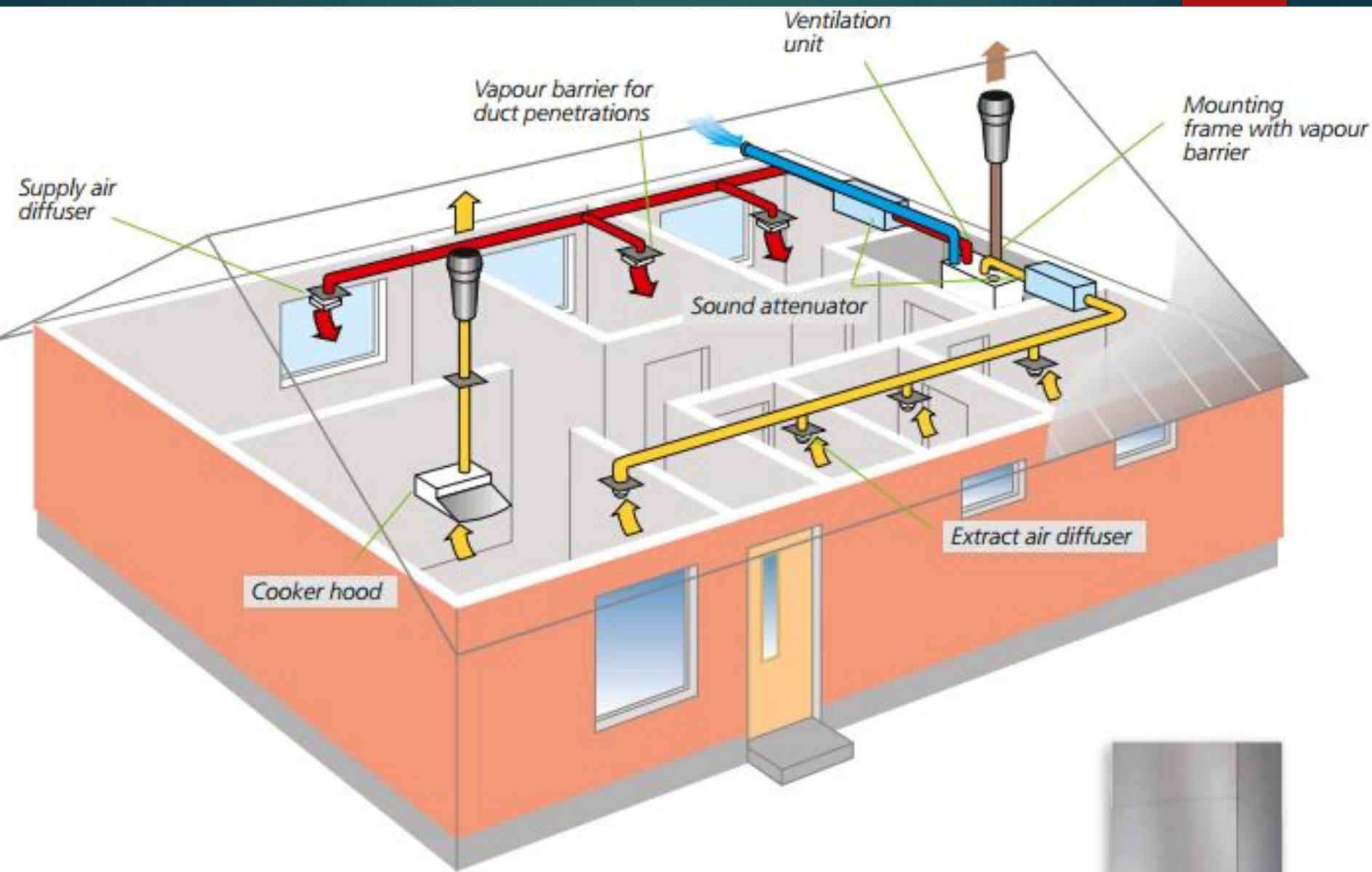
and

<sup>health</sup>

- ▶ In Sweden we tightened our homes.. (got money for that!)..
- ▶ District heating.. No “Chimneys”... natural ventilation do not work!!
- ▶ Then started the health issues.. Sick Building Syndrome..... House dust Mites, Allergies...

# Today : Different technologies are used..

- ▶ Air to air heat exchanger
- ▶ Exhaust air heat pumps..
- ▶ Ground source heat pumps...
- ▶ All linked to to a ventilation system..



# VENTILATION OF HOMES IS IMPORTANT FOR HEALTH

- ▶ INDOOR AIR THE MOST IMPORTANT EXPOSURE
- ▶ AND THE LEAST CONTROLLED AND STUDIED
- ▶ Radon, infectious agents, allergens (HdM..), VOCs, SVOCs, formaldehyde, ETS, particles, mold...
- ▶ The role of indoor air for health is NOT studied, in a good way.
- ▶ At least 0.5 ach is needed

# Questions

