HEALTH AND HOUSING IN CANADIAN INDIGENOUS COMMUNITIES

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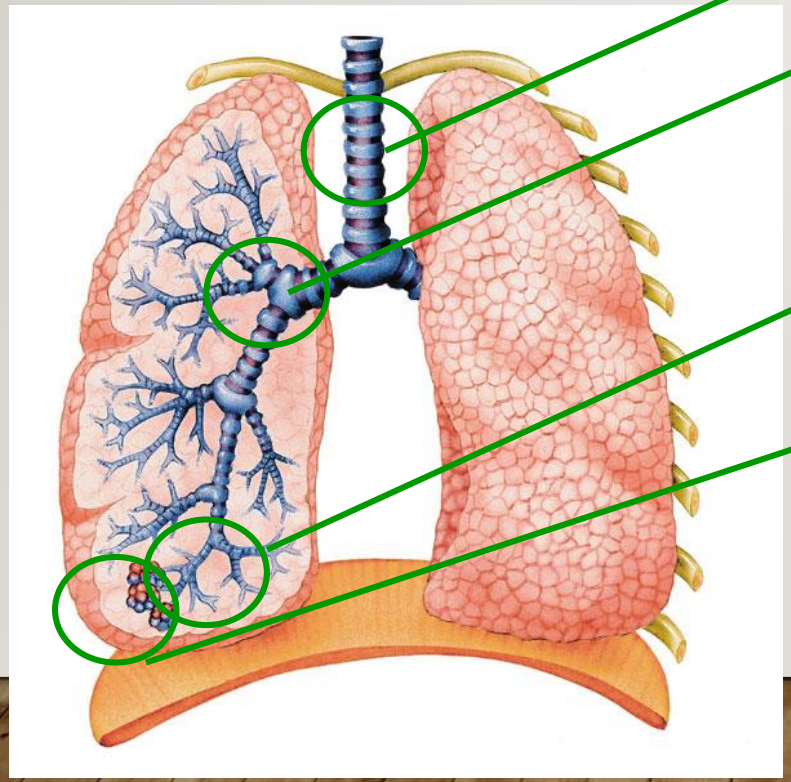
GRAY'S ANATOMY



Trachea: windpipe

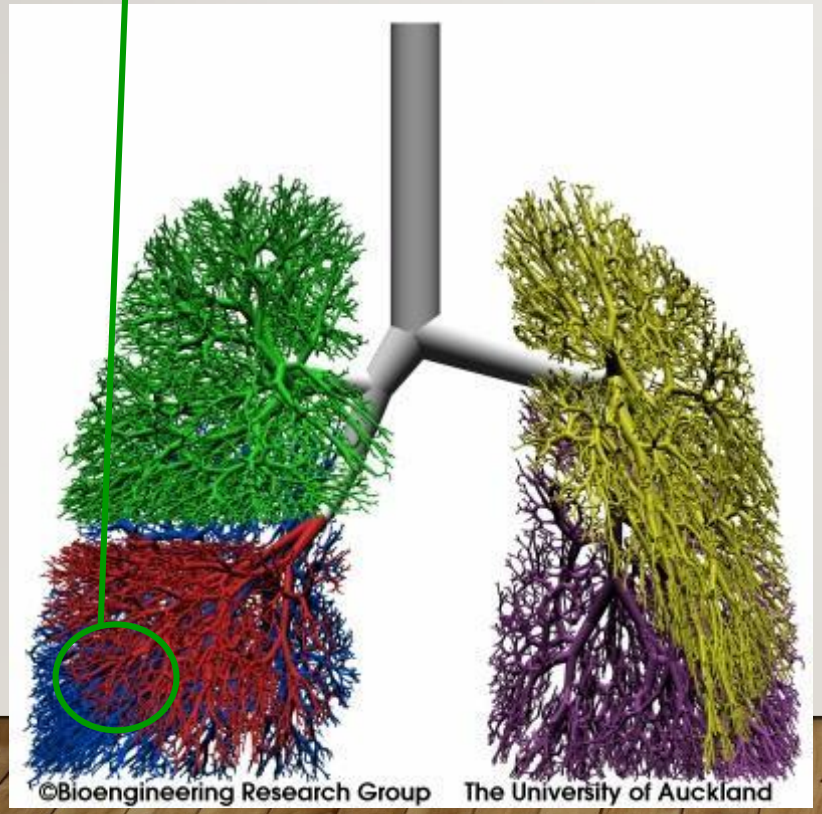
Bronchi: large airways (about 1-4 cm in diameter)

Bronchioles: very tiny airways (< 1 mm in diameter)

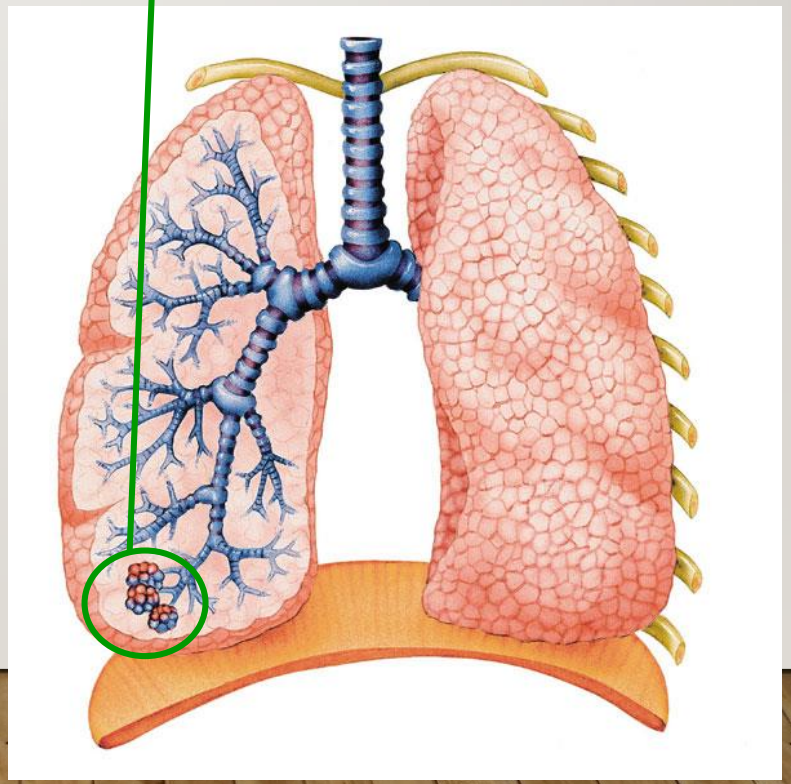
Alveoli: tiny air sacs where gas exchange takes place

LOWER RESPIRATORY TRACT INFECTIONS

Bronchiolitis is an infection, caused by a virus (RSV), of the very tiny airways in a baby's lungs; leads to wheezing

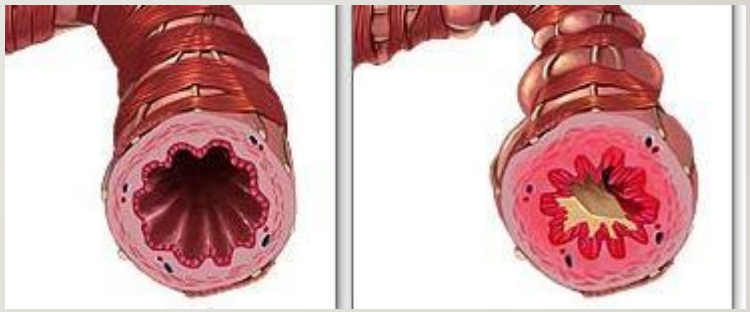


Pneumonia is an infection, caused by a virus or bacteria, of the air sacs (alveoli) in the lungs

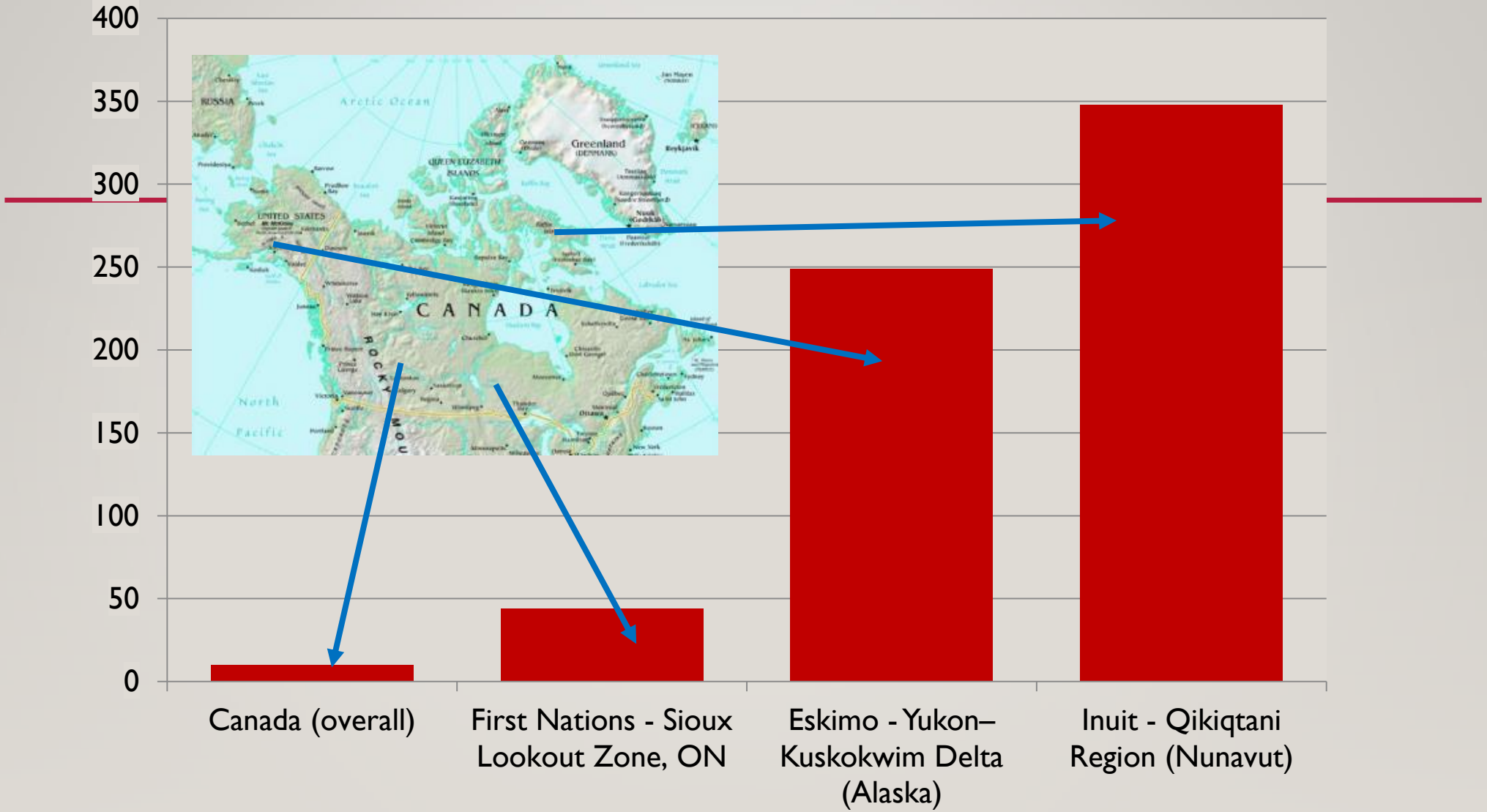


ASTHMA

- Recurrent episodes of:
  - swelling of the airway lining,
  - excess mucous production in the airways
  - tightening of the muscles around the airways
- Leads to:
  - wheezing,
  - cough,
  - chest tightness, trouble breathing
- Triggered by:
  - Viral infections - like colds
  - Allergies (trees, dust mites, pets, mice, cockroaches, molds),
  - Noxious fumes



BRONCHIOLITIS ADMISSIONS PER 1000 BABIES BORN



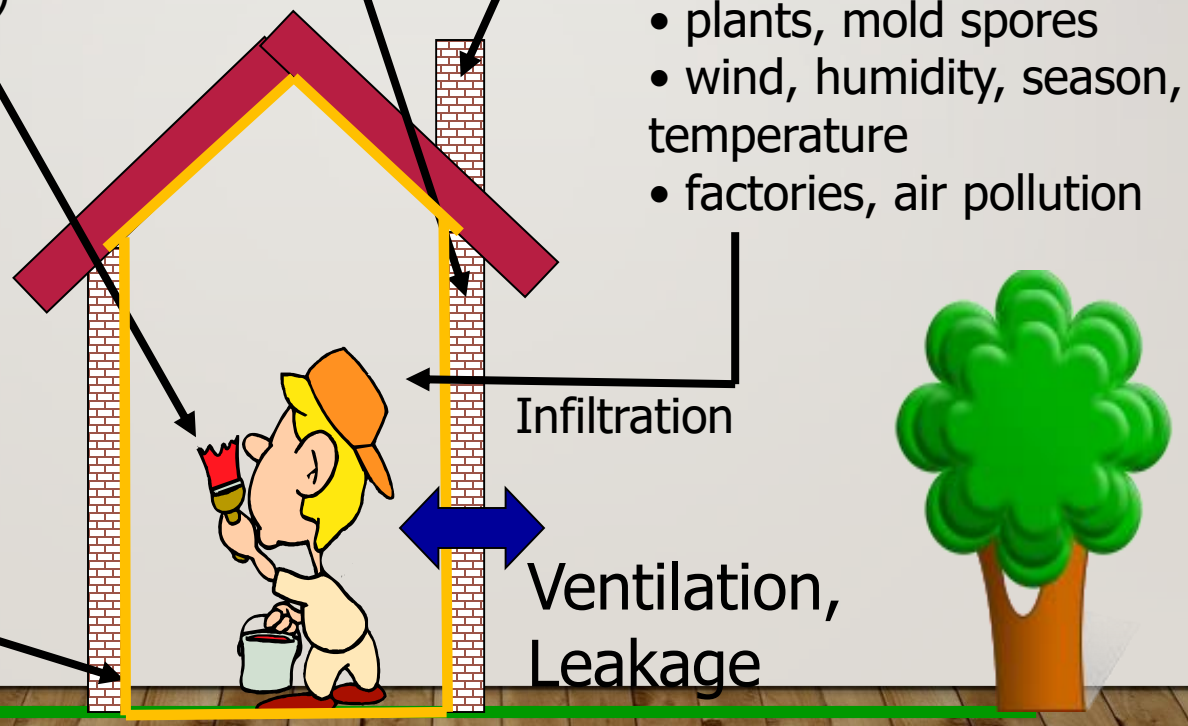
INDOOR AIR 101

Occupancy & Habits
- tobacco, marijuana smoking
- pets
- indoor plants
- cleaning, cleaners, dust mites
- hobbies
- furniture, furnishings, paints
- work (e.g. engine repair, carpentry)

Housing Construction
- wood, concrete…
- renovations
- house volume

Heating & Cooking
- indoor heating system
- indoor cooking system

Outdoor Air
- plants, mold spores
- wind, humidity, season, temperature
- factories, air pollution



Damage
- Water vapor barrier
- water damage, mold
- flooding…

Indoor air quality constantly changes with all these factors, and varies throughout the dwelling with local patterns of emission and airflow

CRITERIA AIR POLLUTANTS:[1] INDOOR & OUTDOOR AIR CONTAMINANTS

Contaminant	Effect	EPA National Standards
Particle Pollution • PM10 • PM2.5 (MMAD < µM)	• Airway irritation • Increased susceptibility to infections	• PM10: < 150 µg/m^3 (24 hours) • PM2.5: <35 µg/m^3 (24 hours) or <15 µg/m^3 (1 year)
Nitrogen dioxide (NO2)	• Wheezing	• 100 ppb (1 hour), 53 ppb (1 yr)
Sulfur dioxide (SO2)	• Wheezing	• 75 ppb (1 hour); 500 ppb (peak)
Carbon monoxide (CO)	• Reduced O_2 delivery – heart attacks & strokes (adults), risk to fetus	• 9 ppm (peak 35 ppm)

[1]Criteria pollutants: US clean air act requires EPA to set National Ambient (Outdoor) Air Quality Standards (also Lead, Ozone). [www3.epa.gov]

MITIGATING *ALL* INDOOR AIR CONTAMINANTS – THE ROLE OF VENTILATION

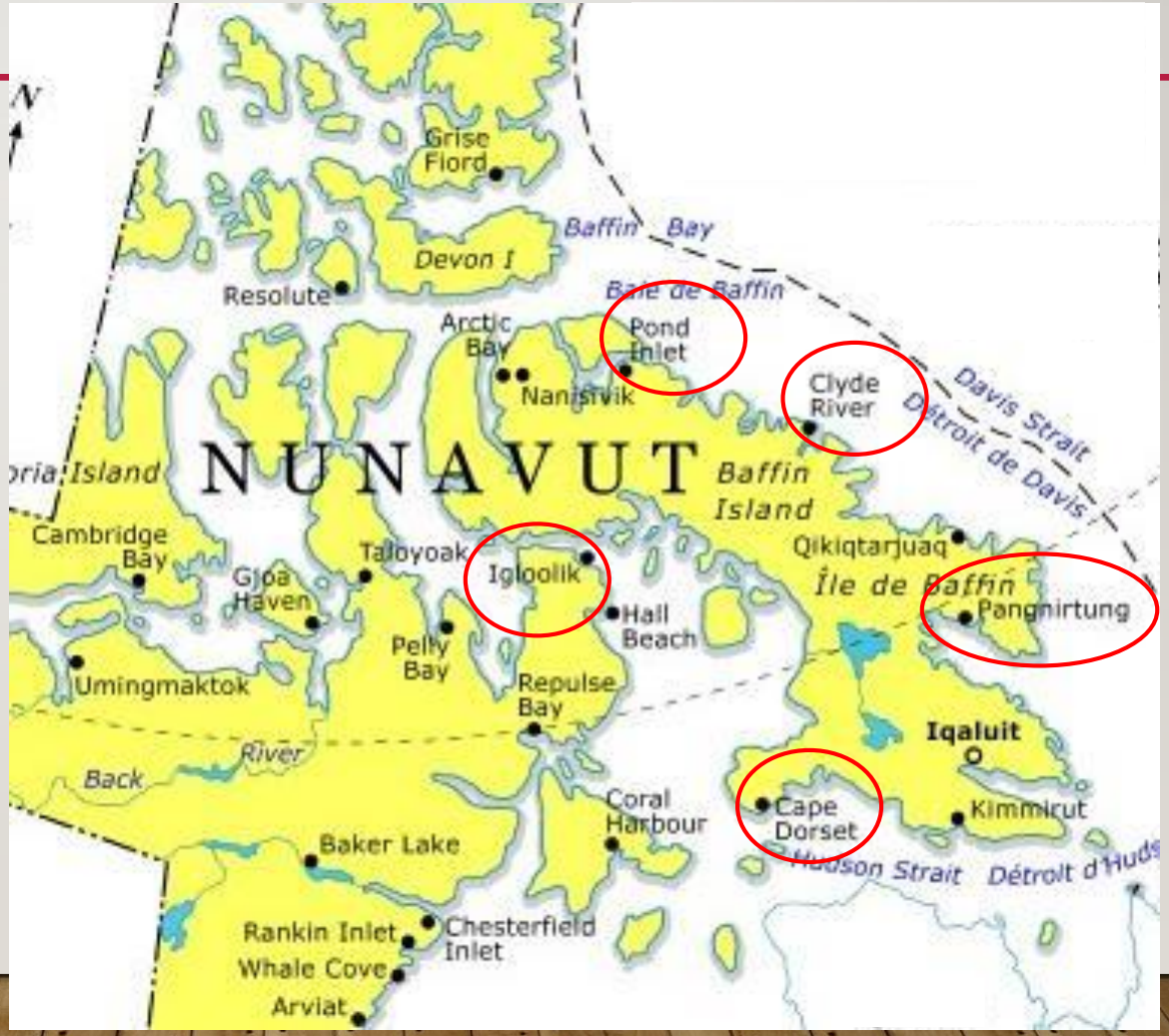
- Ventilation = introduction of outside air, diluting and displace indoor contaminants
  - Reduces indoor concentration of indoor contaminants, though not necessarily to safe levels
  - May introduce outdoor air pollutants, if outdoor concentrations higher than indoors
- Natural ventilation: Open windows, doors, infiltration
- Mechanical ventilation:
  - Exhaust-only: kitchen & bathroom fans (push air out, so fresh air leaks in)
  - Balanced: ducted fans, +/- heat recovery (HRV) heat & moisture (energy-recovery)

IMPORTANCE OF WATER: ALASKAN HOUSES

- 57,000 Alaska Native persons in 6 Alaskan rural regions nearly all only accessible by plane, snow machine or boat (*Hennessy Am J Pub Health 2008*)
- Communities with low proportion houses serviced with pressurized water (water from 5 L jugs instead), flush toilets (& septic tanks) had higher rates of hospitalization for RSV & pneumonia

INDOOR AIR QUALITY IN NUNAVUT

VENTILATION IN MULTIPLE COMMUNITIES IN NUNAVUT (*KOVESI, CMAJ 2007*)

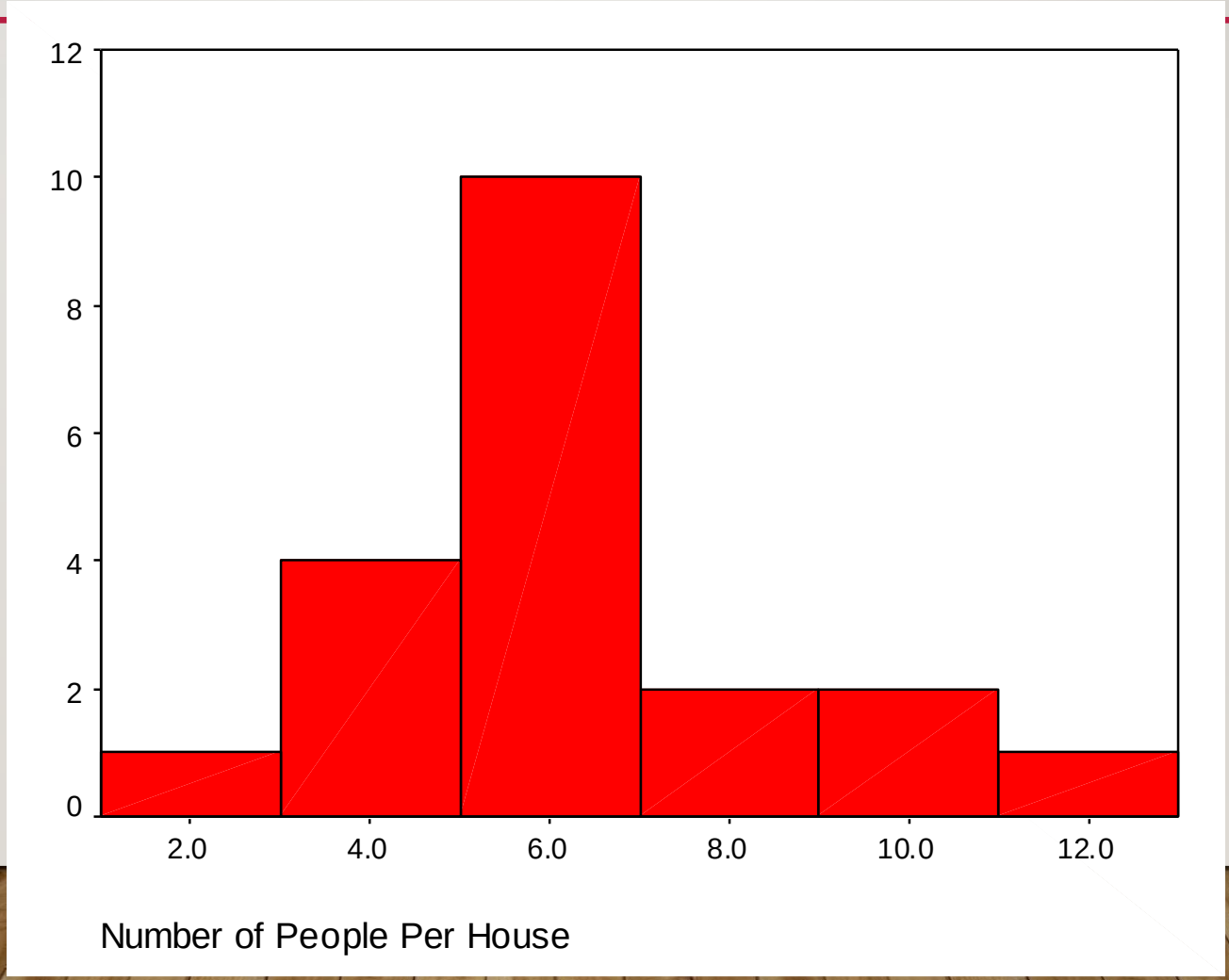


HOUSES IN CAPE DORSET, NUNAVUT
(KOVESI, INDOOR AIR 2006)

- Comprehensive assessment of Indoor air quality, measured in homes of 20 Inuit infants and children < 2 years
- Houses were single-story, raised above ground (due to permafrost)
- Houses were small (Mean indoor volume was 233 m^3 vs. 350-600 m_3 for small-medium houses southern Canada)
- Median occupancy 6 (range 2-12)/house (vs. 3.3-4.5 persons/house southern Canada)
- Houses kept warm (mean indoor temp 23.7 °C, vs. 20°C winter Saskatoon)
- Houses were very dry (mean RH 24.6%, vs. 35% winter Saskatoon)

OCCUPANCY

Number of Houses



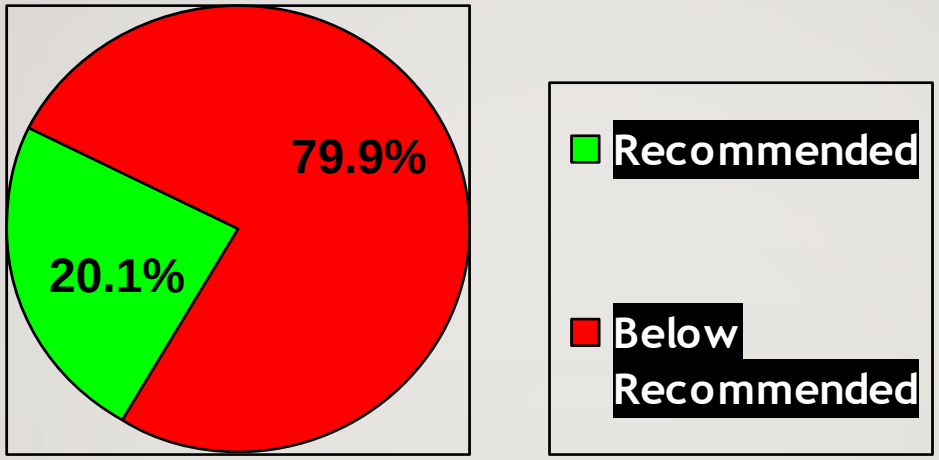
Igloolik

Clyde River

Pond Inlet

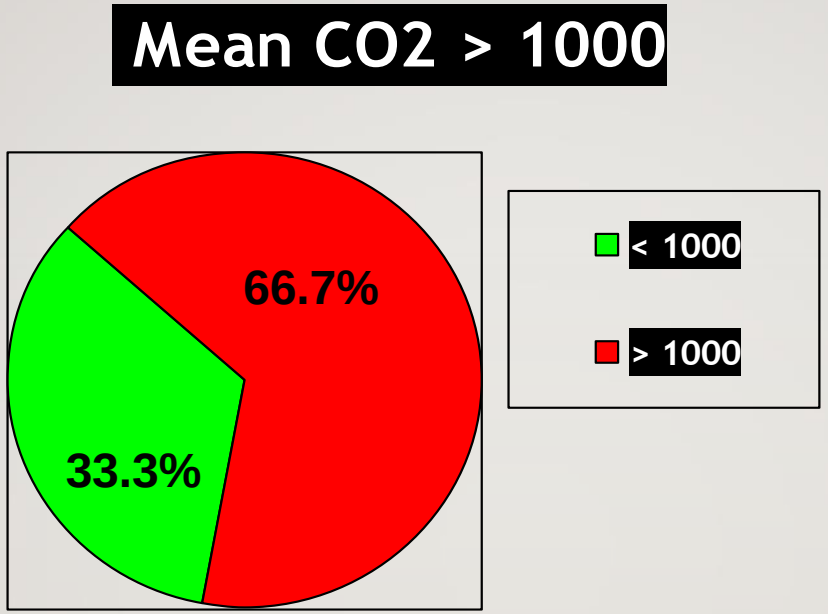
Pangnirtung

VENTILATION



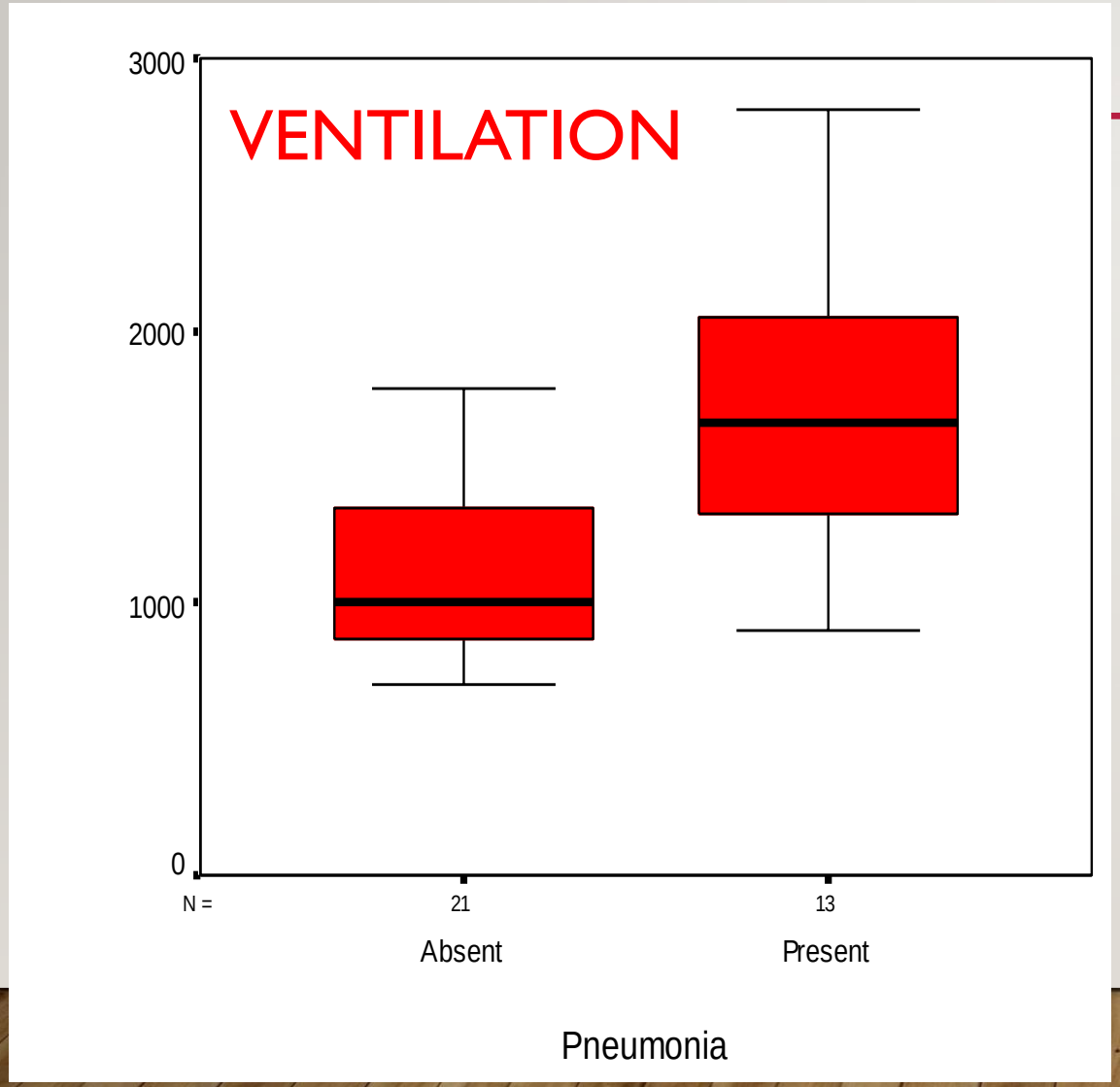
- Ventilation markedly reduced in homes of 96 Inuit children< 2 yrs in 4 communities: Median air flow rate: 5.6 L/s/person (Recommended: > 7.5 L/s/person (ASHRAE standard)) (*Kovesi, CMAJ 2007*)
- Minimal exhaust equipment reported (low-capacity kitchen and bathroom exhaust fans – often used intermittently because of noise, occasionally – passive pipe vents (*Appin, 1991*)

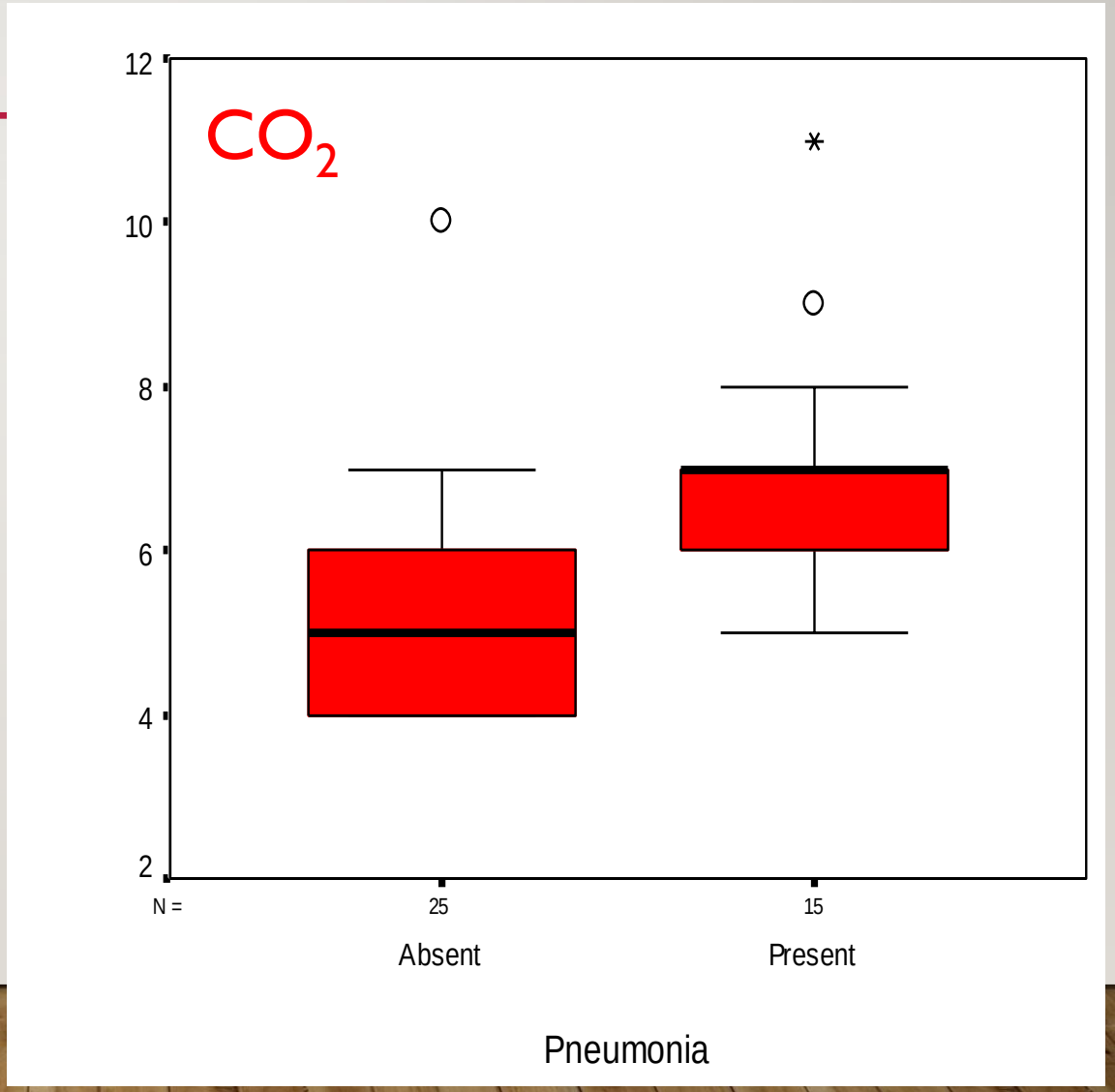
INDOOR CO_2



- Indoor CO_2 is a measure of adequacy of home ventilation relative to occupancy
- Mean CO_2 1358 ppm (CO2 < 1000 ppm often used as indicator of adequate ventilation (*Enmet Canada*)

RISK FACTORS FOR PNEUMONIA IN INUIT INFANTS





WHY DOES VENTILATION MATTER?

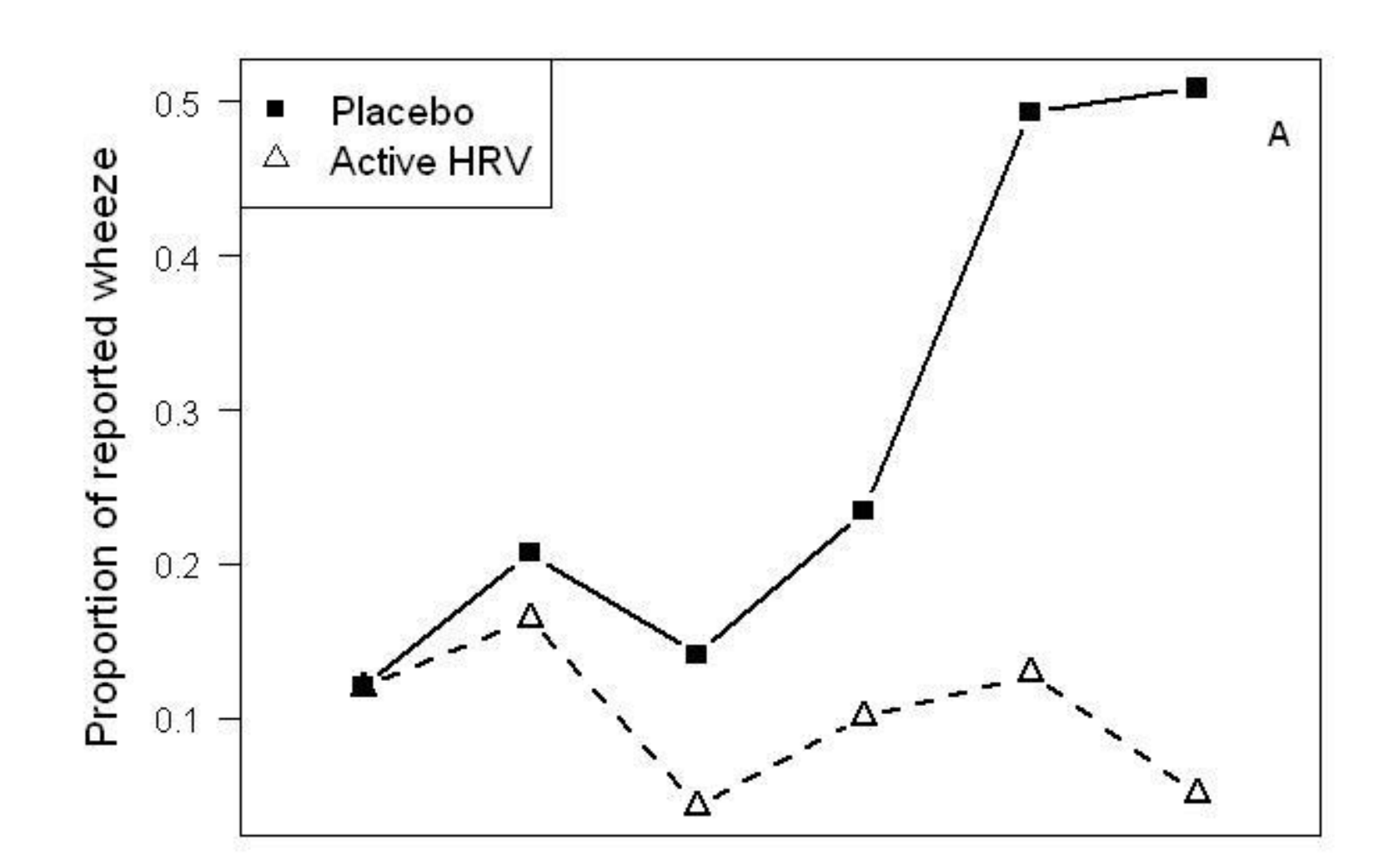
- Lack of ventilation may mean that clouds of virus generated by coughing and sneezing aren't cleared from room
- Reduced ventilation is associated with increased risk of viral infection (*Myatt, 2004*) and TB (*Menzies, 2000*)
- When influenza caught by airborne route rather than contact, higher risk of pneumonia, rather than "the flu" (*Tellier, 2006*)

MAKING KIDS BETTER: HRV TRIAL
(KOVESI, INDOOR AIR 2009)

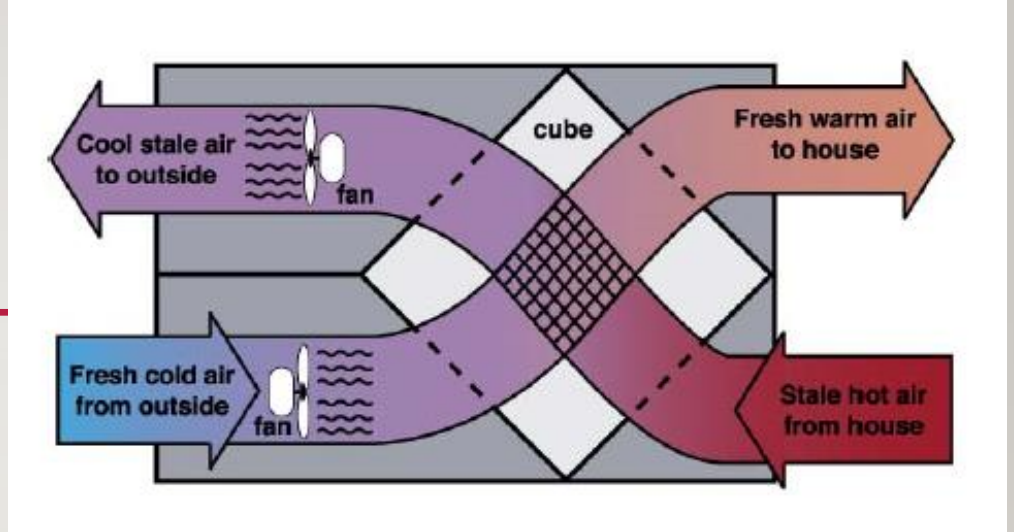
- 51 HRV's installed in homes of Inuit children 5 years & less, in 3 communities
- Units:
  - Active HRV: give 25-30 L/s ventilation for 15 minutes every hour (triggered by furnace)
  - Placebo units circulated air inside only
    - Converted to active HRVs after study
- HRV's significantly reduced indoor CO_2 (33%)
  - Mean CO_2 1385 ppb placebo units
  - Mean CO_2 924 ppb active units
- Also significantly reduced relative humidity (25.6 vs 30.9%) & tended to reduce indoor temperature

Venmar AVS Constructo 1.0 HRV

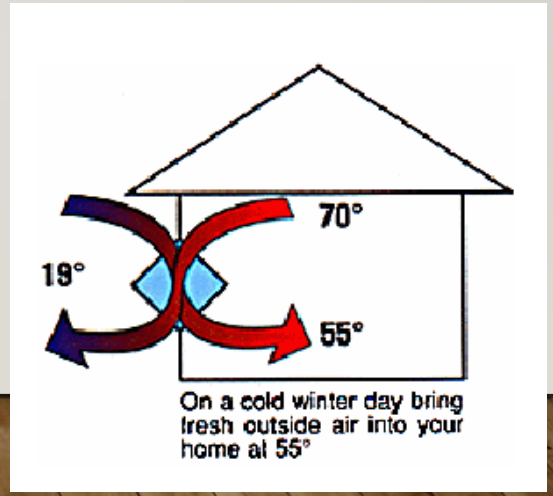
EFFECT OF HRV'S ON REPORTED WHEEZING



THE LIMITS TO HRV'S



- Limits in extreme cold conditions
  - Increase drafts (draw more cold air when severe cold ambient temperatures)
    - Complaints during HRV study – especially elders
  - HRV cores freezing
  - Research (NRC) ongoing
- Function best with ducting
- Hard to balance with changing (wood stove) heating conditions



FIRST NATIONS HOUSING IN NAN

- Nishnawbe Aski Nation
  - 49 First Nations
  - Political Territorial Organization
- According to ISC ICMS 2015/16: 6276 total housing units

DETERMINANTS OF POOR HOUSING IN INDIGENOUS COMMUNITIES

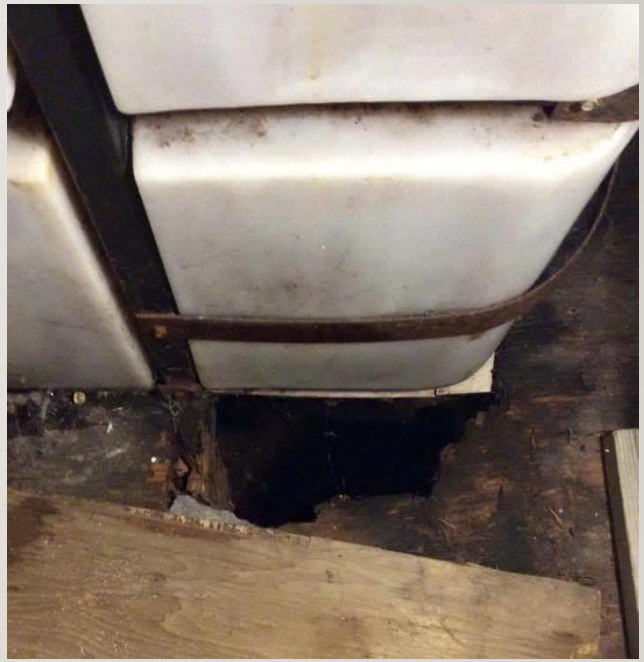
- Overcrowding due to housing shortage, Aging housing stock in disrepair
- Insufficient infrastructure
- Underfunding of housing programs
- Need for human resource capacity i.e. Housing Managers and Housing Maintenance Managers
- High transportation costs (32 remote communities in NAN)
- Limited options for heat sources

BACKGROUND

- In 1993, introduction of the R-2000 house which promoted energy efficiency and airtight building envelope
- This type of construction requires a mechanical system ie. Heat Recovery Ventilator

INSUFFICIENT INFRASTRUCTURE

- Lack of investments in infrastructure
- Impractical design practices



Photos: Water holding tanks in residential homes increase poor air quality due to excessive moisture and damage to home

IMPORTANCE OF DESIGN AND CULTURE

- Designs homes that fit the climate and life style of First Nation members & communities
- Photo: New construction practices are not meeting needs and accelerating deterioration of houses

Next steps:

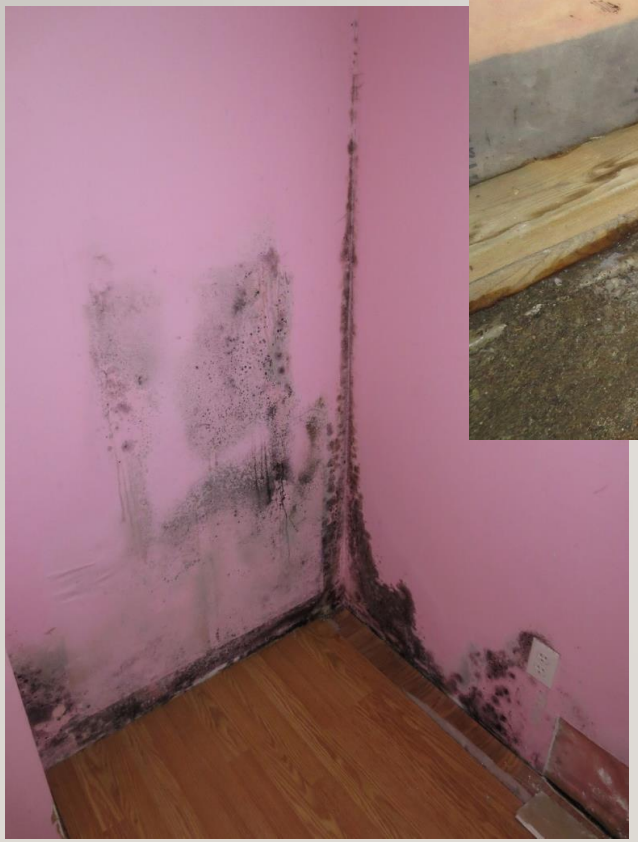
- Look at possible alternatives in design and building techniques
- Increased resources for proper installation of mechanical systems and trianing

ISSUES RELEVANT TO FIRST NATIONS HOUSING IN THE SIOUX LOOKOUT ZONE

- Wood stoves
  - Associated with cough, wheeze, young children in Michigan (*Honicky, Ped 1985*):
  - Associated with bronchiolitis, pneumonia Navajo children (*Morris, AJDC 1990*)
- Mold
  - High concentration (airborne or settled dust) associated with bronchiolitis, pneumonia infants in Boston (*Stark, AJRCCM 2003*)
  - (1,3)-Beta-D glucan (mold marker) associated with new or continuing allergic asthma (*Maheswaran, PLOS One 2014*)

DETERMINANTS OF POOR HOUSING IN INDIGENOUS COMMUNITIES

- Overcrowding due to housing shortage
- Poorly constructed housing
- Underfunding of housing programs, , high transportation costs
- Insufficient infrastructure
- Aging housing stock in disrepair
- Need for human resource capacity ie. Housing Managers
- Limited economic opportunities
- Limited options for heat sources



Walls damaged by moisture & mold. Picture courtesy of Michael McKay

Wood chip accumulation where firewood's stored

Dampness and damage under water holding tank

WOULD NEWER WOOD STOVES HELP?

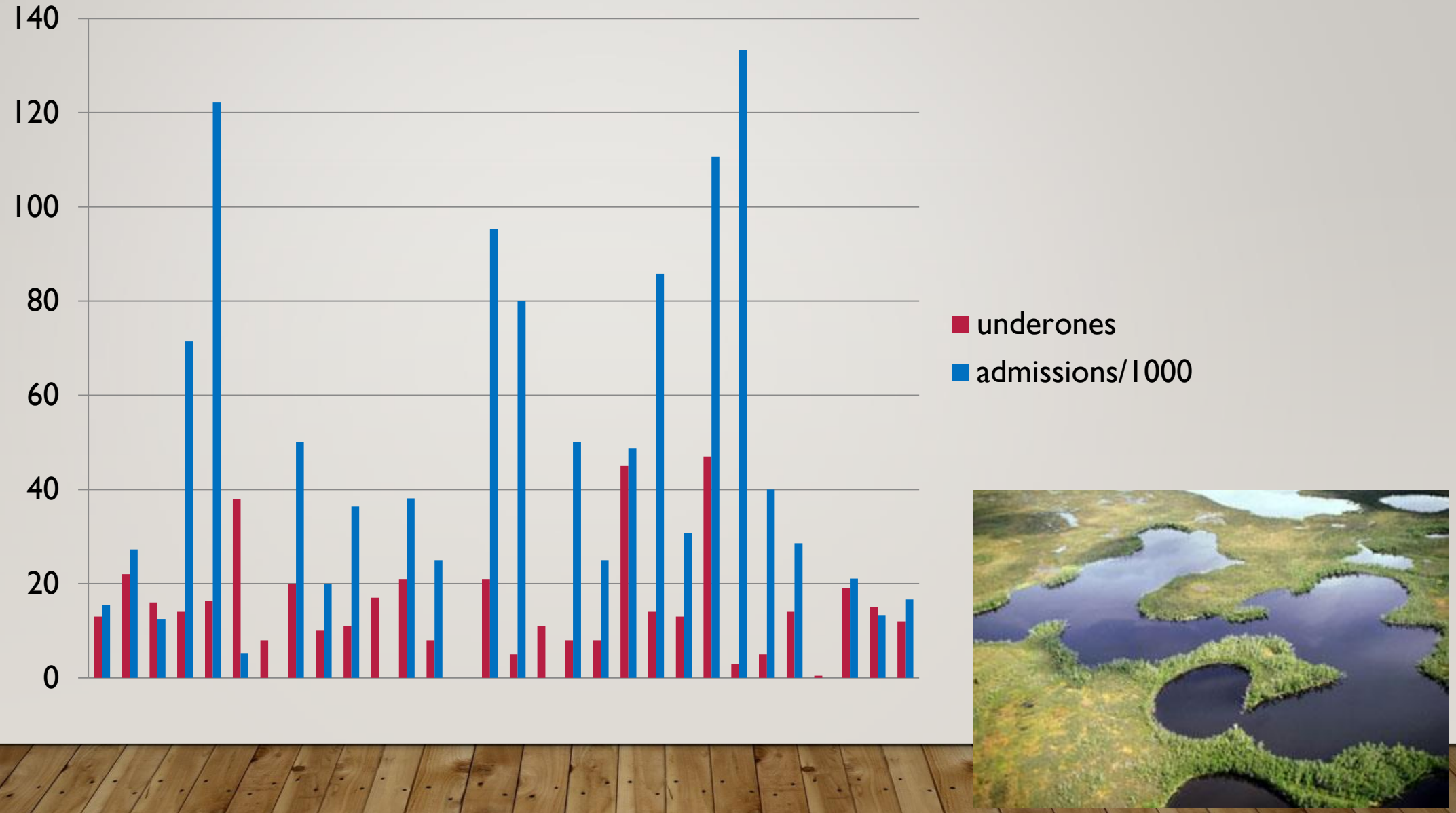
- Cleaner-Burning Wood Stoves, EPA certified (70% reduction emissions)
  - Libby, Montana (valley, with high concentration wood stoves): 1147 old woodstoves replaced (PM2.5 emission < 7.5 g/hr) (*Noonan, Health Effects Institute Res Report 2011*)
    - Ambient (outside) PM2.5 reduced 27 to 19 μg/m^3 and indoor reduced 45 to 21 μg/m^3
    - Significant reduction wheezing, colds, bronchitis, reported influenza school-age children
    - Improvements partly reflect less infiltration from ambient air
- No significant effect on PM2.5 with wood stove exchange 15 homes rural northern BC (PM2.5 13 μg/m_3 before, 12 after) (*Allen, Atm Env 2009*)
  - Education important on best practice use of wood stoves (based on change out Nez Perce Reservation, Idaho) (*Ward, Sci Total Env 2011*)

OUR STUDY

- Measure indoor air quality and examine relationship with lower respiratory tract infections, asthma, skin infections in ~100 First Nations children in 4 communities, 3 years of age or less
  - Includes communities with high, low prevalence respiratory infections
  - Communities chosen on this basis, as well as practicality (access, community support for research, safety, recommendations of Sioux Lookout FNHA Chiefs)
  - Study supported by Health Canada, Carleton University, Sioux Lookout First Nations Health Authority, Nishnawbe Aski Nation

Sioux Lookout First Nations Health Authority

Admission rates per 1000 children under 1 year, by community, SLZ



Sioux Lookout First Nations Health Authority
(Sioux Lookout Zone)

WHAT WE'RE MEASURING

- Respiratory health questionnaire
- Housing inspection by trained housing inspector
- Wood stove, commercial smoke: Indoor particulates ($PM_{2.5}$)
- Indoor mold: (settled dust Beta-1,3-D glucan)
- Indoor wood contamination: Endotoxin, possibly levoglucosan
- Ventilation: Indoor CO_2
- Health Center Visits

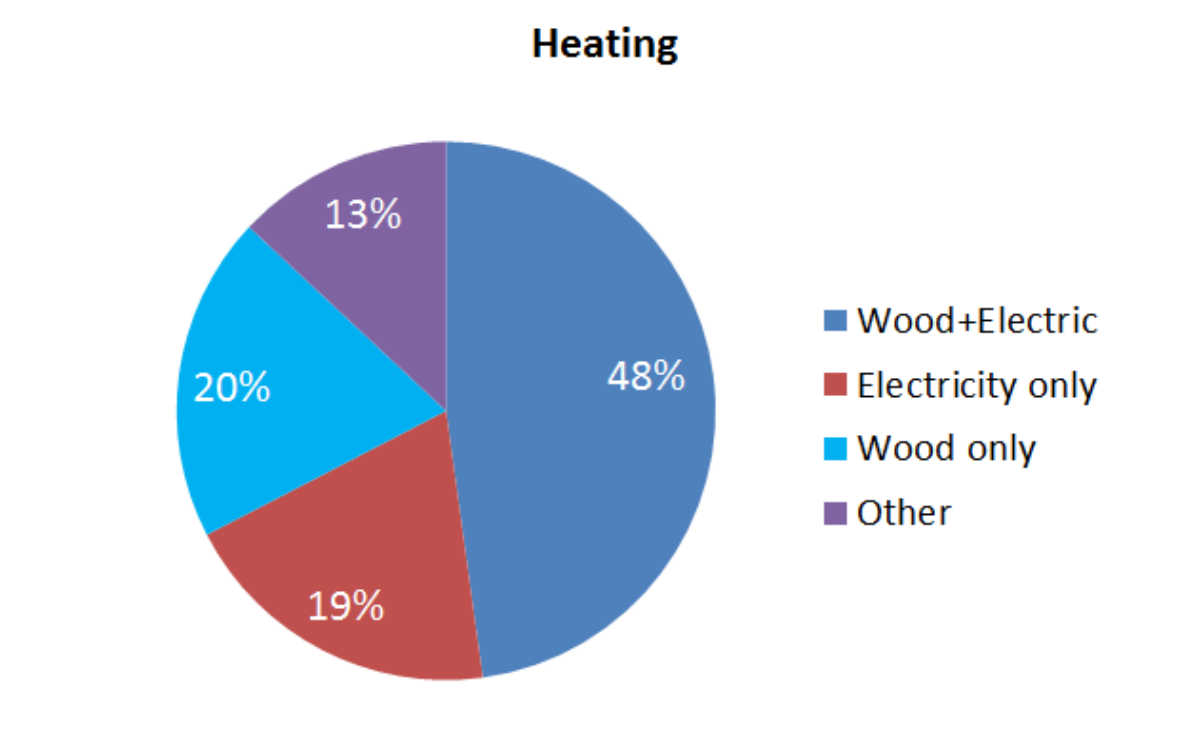
RESULTS SO FAR: THE CHILDREN

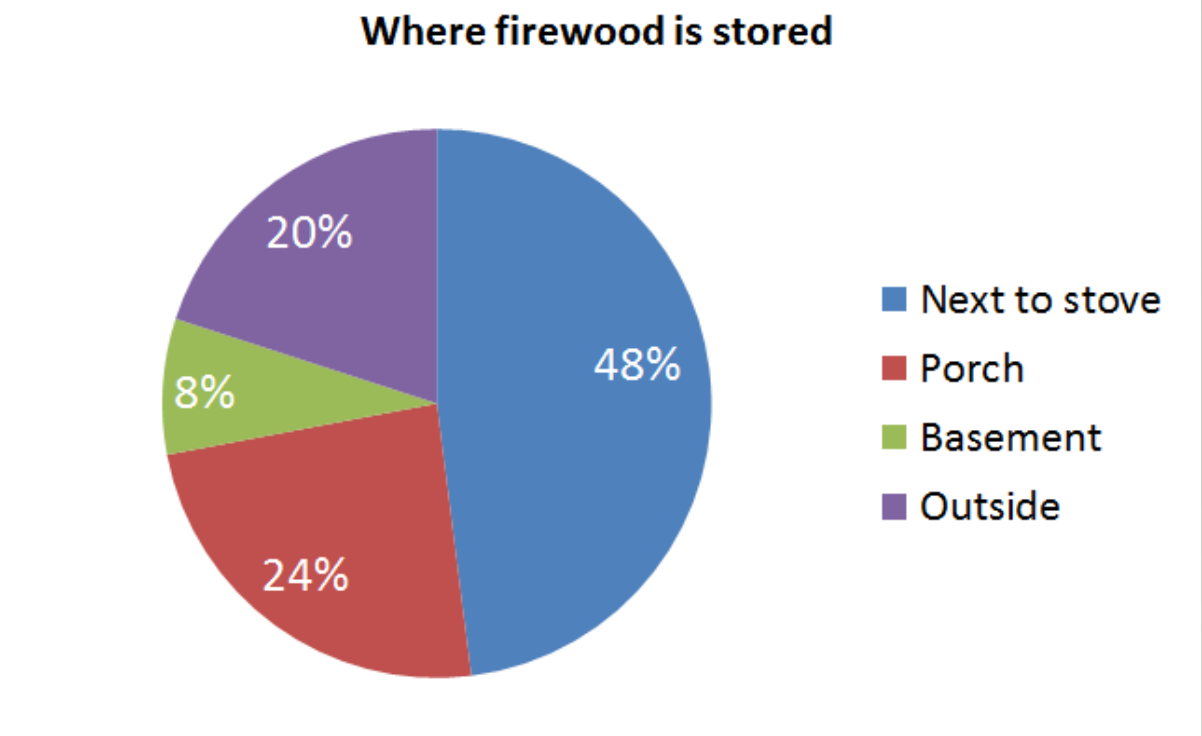
- 47 children enrolled first season in Lac Seul (22) and Kasabonika First Nations (45)
  - 26 male (55%), Average age 1.94 years
  - 11 (23%) **hospitalized** for chest illness during 1st 2 years of life
  - 4 (10.8%) children diagnosed/had acute visits for asthma
  - 43 (96%) male guardians smoked; 38 (83%) female guardians smoked
  - In 1st 3 years of life: average 2.7 urgent visits for respiratory illness (range 0-12)
    - Bronchiolitis: average 1.8, range 1-5
    - Pneumonia: average 1.3, range 1-2
    - Colds: average 2.1, range 1-7
    - Asthma: average: 1

RESULTS SO FAR: THE HOUSES

- 46 houses (2 kids studied in 1 house)
  - Average occupancy 6.3 persons/house (range 3-17 persons/house)
  - Average Mean volume 270.3 m^3.
- Average winter living room temperature: 25.1° (range 20.6 – 30.4)
- Average living room relative humidity: 32.4% (range 20.1 - 52.7)
- Dust mite allergens in settled dust:
  - Undetectable 35-91%

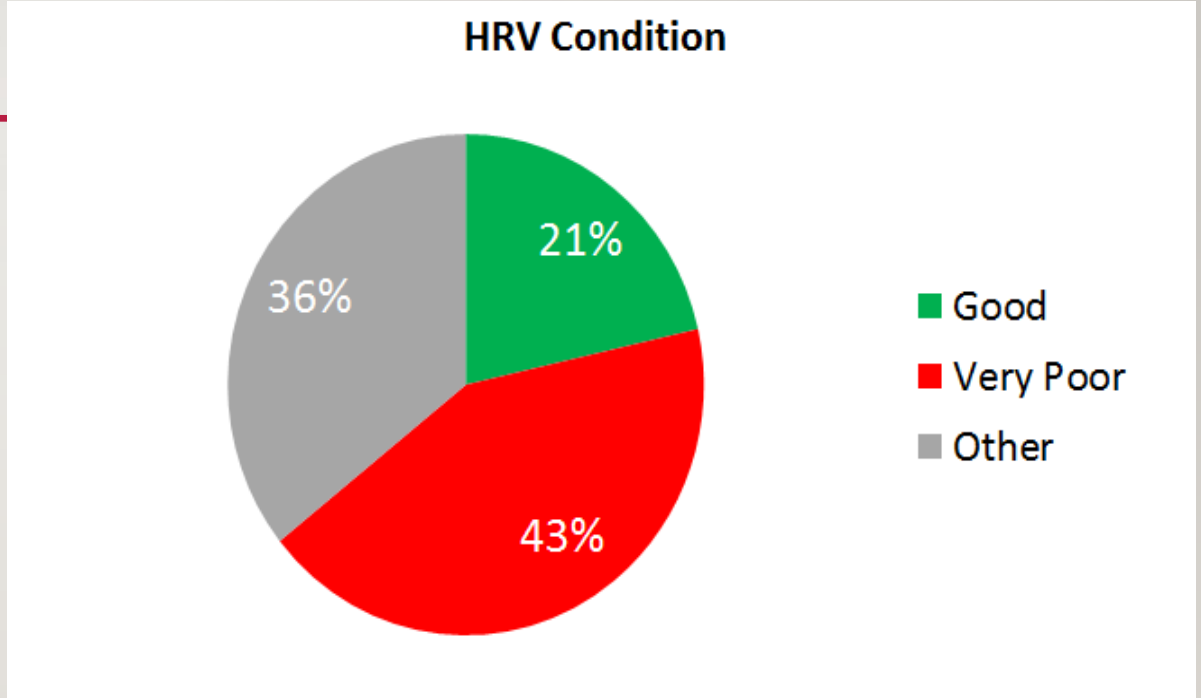
HEATING


Heating
13%
48%
20%
19%
Wood+Electric
Electricity only
Wood only
Other

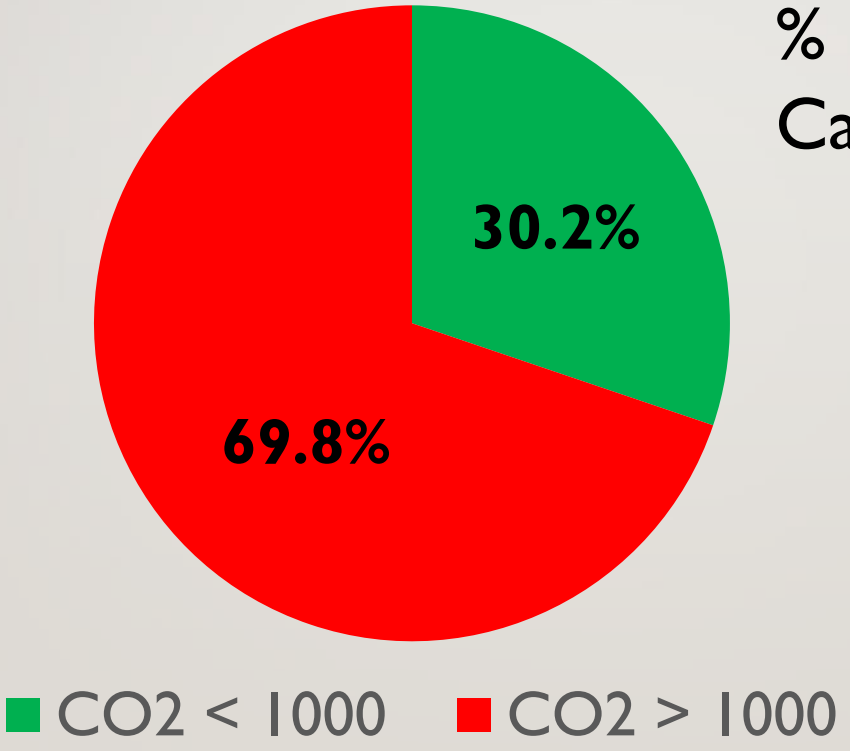

Where firewood is stored
20%
48%
8%
24%
Next to stove
Porch
Basement
Outside

DATA: VENTILATION

- HRV present in 28 houses (61%)
  - Used often or more: 10 (36% of HRV's)
- Mean CO_2 1209 ppm (range 583 – 2200
  - 30.2% (13/43)of houses had mean < 1000 ppm
  - Canadian guidelines: < 1000
- Average Maximum CO_2 1797 ppm



VENTILATION (2)



% Houses with CO_2 Meeting Canadian Standards

SMALL PARTICLES

- Mean PM2.5 13.8 mcg/m^3;
- Mean peak PM2.5 **159** ppm mcg/m^3
  - WHO guidelines (outdoor air):
    - annual mean 10 mcg/m^3;
    - 24-hour mean 25 mcg/m^3

	Indoor (Gravimetric)	Indoor (Dust Trak)	Outdoor (Gravimetric)
Ottawa	7		7
Halifax (wood stoves)		10	
Paris			16.2
Sioux Lookout Zone (mainly wood stoves	13.8	55	
Y-K Delta, Alaska (wood stoves)	12	33	
Libby Montana (wood stoves)	45		27

(Gravimetric corresponds to international outdoor air pollution standards); our estimated correction factor = 0.25; correlation r^2 = 0.86)

MOLD

- Mean 1,3-beta-D-glucan (marker of mold in settled dust):
- 324.6 mcg/g; 408 mcg/m^2
  - Average in U.S. homes 55 mcg/g or 18 mcg/m^2 (*Iossifova, Allergy 2007*); Canadian homes 1300 mcg/m^2 (*Miller, Air & Waste Management, 2007*)
- Mold present:
  - Child's bedroom's windows: 12 (26%)
  - Main bathroom's walls: 8 (17%)
  - Below grade walls: 6 (13%)

CONCLUSIONS FROM THE STUDY (SO FAR)

- Subjects have high rate of respiratory tract infections (though lower than Inuit)
- Ventilation in most houses doesn't meet Canadian standards
- Indoor small particle levels roughly double national average
- Glucan levels markedly elevated – consistent with high levels of mold; low levels of dust mite
- Knowledge Translation needed for effective use of HRV's – currently being developed with CMHC funding support
- Clear need for better funding for housing maintenance
- *Relationship between housing and heath in this study – pending.*

THE BOTTOM LINE

- Need to consider the relationship between housing and health:
  - Tighter houses more energy-efficient, but not acceptable for respiratory health
  - Importance of ventilation, maintaining vapor barrier
- Capacity-building: housing departments, families living on reserve housing
- Funding: more houses – that are culturally-appropriate and suitable for local conditions, maintenance of existing housing, clean water
- Research:
  - Better ways of "measuring mold"
  - Improving ventilation: more effective HRV's and ERV's that work without ducting, balanced with changing conditions with wood stove

ACKNOWLEDGEMENTS

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Chief & Council, Sandy Lake

- Environment and Climate Change Canada / Health Canada
- First Nations and Inuit Health Branch, Indigenous Services Canada
- Nishnawbe Aski Nation
- Sioux Lookout First Nations Health Authority & Chief's Committee on Health
- Children's Hospital of Eastern Ontario Research Institute
- Ottawa Hospital Research Institute
- Carleton University, Ottawa
- Northern Ontario School of Medicine
- Chief & Council, communities and study families of Lac Seul, Kasabonika, Sandy Lake, and Kitchenuhmaykoosib Inninuwug First Nations.