Respiratory Hospitalizations in the Delta
What do we know?
What are we doing?

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RSV: Worldwide Impact on Children

- >60% of acute respiratory infection is due to RSV
- 80% of those affected less than 1 year old

Piedimonte & Perez, PIR 2014
**Global estimates of severe RSV:**

Rate of Severe or Hospitalized RSV/1000 infants/yr

- **Nunavut Canadian Inuit:** 289
- **Alaska YK Delta:** 113
- **Navajo:** 91
- **Kenya:** 13
- **All AI/AN:** 34
- **United States:** 27
- **Indonesia:** 30
- **Thailand:** 30
- **UK:** 28
- **Germany:** 28
- **Spain:** 26
- **South Africa:** 15
- **India:** 14
- **Kenya:** 13

Bronchiolitis Hospitalizations/1000/yr
Alaska Native infants by region, 2009-2011

Unpublished data, Singleton RJ, AIP-CDC, from IHS NIPRS data
RSV Hospitalization Rate, YK infants, before and after Synagis®, 2001

After Synagis, the rate in premies decreased 3-fold, while the rate in non-premies remained stable.

Methods:
AI/AN – Indian Health Service Direct/Contract Inpatient Dataset
U.S. – Nationwide Inpatient Sample

Results: 1998-99 to 2009-11
RSV-related hospitalizations declined 36% in AI/AN, 20% for US infants

Major Changes 2014 Redbook

- Palivizumab prophylaxis is recommended for infants born at less than 29 weeks gestation.

- Infants with chronic lung disease (CLD) qualify for prophylaxis only if they require supplemental oxygen for >28 days after birth.

- With rare exception (CLD meeting criteria), prophylaxis is not recommended during the second year of life.

- Monthly prophylaxis should be discontinued in any infant who experiences a breakthrough RSV hospitalization.

- Prophylaxis can be considered for <24 month old who are profoundly immunocompromised.
Redbook Statement on Alaska

Timing of Prophylaxis for Alaska Native/American Indian Infants.

Alaska Native infants in southwestern Alaska experience higher RSV hospitalization rates and a longer RSV season. On the basis of epidemiology of RSV in Alaska, particularly in remote regions where the cost of emergency air transport may alter a cost analysis, the selection of infants eligible for prophylaxis may differ from the remainder of the United States. Clinicians may wish to use RSV laboratory surveillance data generated by the state of Alaska to assist in determining onset and end of the RSV season for appropriate timing of palivizumab administration.

We have an Alaska state-wide workgroup that meets annually to review RSV data and make recommendations.

https://redbook.solutions.aap.org/chapter.aspx?sectionId=88187226&bookId=1484&resultClick=1
RSV positives, Alaska State Virology Laboratory, 2011-2017

Synagis start

Synagis end
YKHC RSV tests
9/1/16-5/10/17

Synagis Start

Synagis Stop

Week Ending Date

Number of RSV Tests

Week Ending Date

Presumptive Positive  RSV Tests
RSV season onset and offset and peak week during 21 years of RSV surveillance, YK Delta

<table>
<thead>
<tr>
<th>RSV Season</th>
<th>RSV Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1994 - 1995</td>
<td>245</td>
</tr>
<tr>
<td>1995 - 1996</td>
<td>166</td>
</tr>
<tr>
<td>1996 - 1997</td>
<td>113</td>
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<tr>
<td>1997 - 1998</td>
<td>149</td>
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<td>2000 - 2001</td>
<td>83</td>
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<td>2006 - 2007</td>
<td>36</td>
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<td>2007 - 2008</td>
<td>125</td>
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<td>2012 - 2013</td>
<td>50</td>
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<tr>
<td>2013 - 2014</td>
<td>61</td>
</tr>
<tr>
<td>2014 - 2015</td>
<td>63</td>
</tr>
<tr>
<td>2008 - 2015</td>
<td>50</td>
</tr>
</tbody>
</table>

2016-17 was the lowest incidence RSV season for YK infants

Acute Respiratory Infection (ARI) and RSV Hospitalization Rates, YK Delta, <1 year, 1994-2015

CDC, National Center for Emerging and Zoonotic Infectious Diseases. Arctic Investigations Program
Bruden et al, 18 years of RSV surveillance…PIDJ, 2015;34:945 and unpublished
RSV Seasonality: Summary

- There is considerable year-to-year and regional variation in RSV season.

- In 2016-17, there was low RSV activity in some regions.

- November 30 - May 15 appears to remain a good match for the RSV season.
<table>
<thead>
<tr>
<th>Condition</th>
<th>Age</th>
<th>Max doses/season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chronic Lung Disease</td>
<td>&lt;24 months</td>
<td>5</td>
</tr>
<tr>
<td>Congenital Heart Disease</td>
<td>≤24 months</td>
<td>5</td>
</tr>
<tr>
<td>&lt;29 wk gestation Premie</td>
<td>&lt;12 months</td>
<td>5</td>
</tr>
<tr>
<td>29-&lt;32 wk gestation Premie</td>
<td>&lt;6 months</td>
<td>5</td>
</tr>
<tr>
<td>32-&lt;35 wk gestation Premie with sib &lt;5yr, daycare, no running water, ≥3 in bedroom or ≥ 7 in household</td>
<td>&lt;3 months</td>
<td>3</td>
</tr>
<tr>
<td>Congenital airway/NeuroMusc. disease</td>
<td>&lt;12 months</td>
<td>5</td>
</tr>
</tbody>
</table>

Synagis Season: November 27 through May 15. Maximum 5 doses.

http://dhss.alaska.gov/dph/Epi/id/Pages/dod/rsv/default.aspx
The Future: RSV vaccines

- **Infants:** RSV vaccines for infants not effective enough

- **Adults:** RSV vaccines may be effective - in late clinical trials

- **Potential adult RSV uses:**
  - Adults with high risk conditions: COPD, asthma, CHF, immunocompromise
  - Pregnant women – to protect their newborn infants
    - Maternal vaccination look promising - high maternal-infant transfer of RSV antibodies
RSV Epidemiology in Adults

- **U.S. adults**
  - Annual attack rate 2-10%
  - Hospitalization rate similar to flu in one study
  - 10.6% of pneumonia hospitalizations, 11.4% COPD

- **Alaska Native adults**
  - No data on RSV!
  - Pneumonia/flu death rate twice that of other U.S. populations
  - Pneumonia and COPD most common causes of potentially preventable hospitalization in YK adults
Preventable hospitalizations, Alaska, 2010-12

Gounder PP et al. Preventive Medicine Reports 2016, http://dx.doi.org/10.1016/j.pmedr.2016.03.017
Incidence of RSV medical visits
Mortality due to RSV in older adults from special populations, by population and clinical setting.
YK Adult RSV Surveillance Study

- **Active Surveillance:** NP swab on consenting adults hospitalized for respiratory illness, COPD, asthma, CHF
- **Population:** YK Adults 18 years and older
- **Time Period:** 11/2016-9/2018
- **Location:** YKDRH, ANMC
- **Tests:** PCR for RSV, Flu, hMPV
- **Investigators:** CDC Atlanta & AIP, UW, ANTHC, YKHC
- **Research staff:** Research nurse recruits
Study Aims

1. Burden of RSV in hospitalized adults
2. Transmission of RSV in households
3. Reinfection with RSV during same season
   - Reinfection or new virus?
YK Adult RSV Surveillance Study
First Year Results

- **Active Surveillance:** NP swab on consenting adults hospitalized for respiratory illness, COPD, asthma, CHF

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- **Time Period:** 11/2016 - 9/2018

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- **Research staff:** Research nurse recruits

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**Graph:**

- **X-axis:** Month

- **Y-axis:** Number of Enrolled Participants
  - 0, 5, 10, 15, 20, 25, 30

- **Legend:**
  - Flu-B
  - RSV-B
  - RSV-A
  - Flu-A
  - Negative
Influenza 2016-17

Week of Aug 21: Three of 40 samples tested were positive for influenza A—1 influenza A H1 2009, 1 influenza A/H3
Influenza Recommendations 2017-18

- **LAIV (FluMist) not available** because of low efficacy in 2013-14 and 2015-16

- Quadrivalent Flu vaccines:
  - Change in H1N1 to A/Michigan/45/2015 (H1N1)pdm09–like virus,
  - A/Hong Kong/4801/2014 (H3N2)–like virus
  - B/Brisbane/60/2008–like virus (Victoria lineage),
  - B/Phuket/3073/2013–like virus (Yamagata lineage).

- Flublok quadrivalent licensed

- FluLaval (IIV3) licensed ≥6 months at 0.5 ml (not from State)

- Afluria Tribalent licensed >5 y; Afluria Quad licensed >18 y

- Pregnant women can get any licensed flu vaccine
2017-18 Flu vaccines provided by State Immunization Program

- **Pediatric Flu Vaccine**
  - Sanofi Fluzone pre-filled syringe, 0.25ml, quadrivalent, 2-35 months
  - Sanofi Fluzone multi-dose vial, 5ml, quadrivalent, 6 months+
  - GSK Fluarix pre-filled syringe, 0.5ml, quadrivalent, 36 months+

- **Adult Flu Vaccine**
  - Sanofi Fluzone multi-dose vial, 5ml, quadrivalent, 6 months+
  - GSK Fluarix pre-filled syringe, 0.5ml, quadrivalent, 36 months+
  - Sanofi Fluzone High-Dose pre-filled syringe, 0.5ml, trivalent, 65yr+
The Healthy Homes Study
Partnering with:
ANTHC Div. Environmental Health & Engineering
ANTHC Community Health and Environment
YKHC and BBAHC Office of Environmental Health
AVCP Village Housing
Lower Respiratory Tract Infection Hospitalization Rates; general US vs. American Indian/Alaska Native vs. Alaska Native, 2009-2011

Annual hospitalizations per 1000 children:

- **LRTI <1 YEAR**
  - General U.S.: 36
  - AI/AN: 75
  - Alaska Native: 136

  3.7-fold higher

- **LRTI 1-4 YEARS**
  - General U.S.: 8
  - AI/AN: 11
  - Alaska Native: 17
Pneumonia rates are decreasing but >2.5 fold higher than the general U.S. Rates for YK infants are 10-fold higher than for U.S.
LRTI in Indigenous Canadian, Australian, New Zealand Children

**Australia**
- Despite Australia being one of the wealthiest countries, Australian Indigenous children have a health status comparable to developing countries.
- Indigenous infants have 10 times the mortality rate for respiratory conditions.
- The LRTI rate in Australian Indigenous children is as high as that of children in developing countries, triple that of non-Indigenous Australian infants (201.7 vs. 62.6/1000, respectively).

*O’Grady KA. J Paediatr Child Health 2010;46:461-465*

**Canadian Arctic**
- LRTI rates varied: 39/1000 NW Territories to 456/1000 Nunavik
- LRTI rates in Nunavik/Nunavut are 10x rest of Canada and some of the highest worldwide

Long Term Effects of Pneumonia

• **Chronic Suppurative Lung Disease/Bronchiectasis**
  – Airway damage leads to loss of elasticity ("ectasia") of bronchi
  – Chronic Wet Cough → CSLD → Bronchiectasis
  – 1:63 Y.K. children w/ bronchiectasis vs. 1:2,000 U.S. children w/ CF

• **Decreased lung function and COPD in Adulthood**
  – Adults with childhood pneumonia have decreased lung function

[Image of CT scan of lungs]

[Bar graph showing rates per 100,000]
Indoor Environment Matters!

- Household crowding
- Tobacco Smoke
- Wood-burning
- Chemicals – fuel, fixing engines
- No in-home running water
- Poor ventilation

Rural Alaska houses are small, crowded, use woodstoves.
Risk Factors for LRTI and RSV Hospitalizations, Alaska Native children

- Medical conditions (premie, heart disease, chronic lung disease)
- Absence of breastfeeding
- Household crowding
- No piped water; <2 rooms with sinks
- Woodstove in the house
- Vomiting after feeding
- Low income

Hospitalization rate among infants by percentage of rural Alaska village homes with water service, 1999–2004

Invasive Pneumococcal Disease rates, Children <5 years, YK Delta, 2001-2007, by water service and socioeconomic factors

<table>
<thead>
<tr>
<th>Socioeconomic Factor</th>
<th>Socioeconomic Level</th>
<th>IPD Rate (Cases/100,000 per Year)</th>
<th>Univariate P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water service</td>
<td>&lt;10%*</td>
<td>390.9</td>
<td>0.008</td>
</tr>
<tr>
<td></td>
<td>10%–80%*</td>
<td>262.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>80%+*</td>
<td>146.7</td>
<td></td>
</tr>
<tr>
<td>Income per person</td>
<td>&lt;$6000 per year</td>
<td>286.3</td>
<td>0.71</td>
</tr>
<tr>
<td></td>
<td>≥$6000</td>
<td>256.6</td>
<td></td>
</tr>
<tr>
<td>Median family income</td>
<td>&lt;$32,000 per year</td>
<td>302.6</td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td>≥$32,000</td>
<td>232.4</td>
<td></td>
</tr>
<tr>
<td>Household size</td>
<td>≥5 persons</td>
<td>345.0</td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td>&lt;5 persons</td>
<td>199.2</td>
<td></td>
</tr>
</tbody>
</table>

*Of homes served with running water.

Rates of infectious disease in 4 rural Alaska villages 3 years before and after introduction of water service adjusted for age

Indoor Air Pollution: Navajo and Alaska Native Children

- Any wood burning stove in the home increased odds of childhood lower respiratory tract infection (LRTI) by 4.9 times in Navajo children.

- Household particulate matter concentration >65 μg/m³ resulted in an increase of odds of LRTI by 7 times in Navajo children.

- Risk Factors for LRTI hospitalizations in rural Alaska included household crowding and woodstove use.

Tobacco smoke exposure in AI/AN children

• 21% AI/AN prenatal exposure vs. 9-17% for general US population

• 75% AI/AN children exposed to passive tobacco smoke vs. 40% for general US population

• 21-38% of AI/AN youth smoke tobacco vs. 23% for general US youth

It started with a call from lung specialist, Dr. Madhani, to Environmental Health Specialist, Troy Ritter.

I think household air problems are making my COPD patients sicker.

Woodstoves could be one possible source. We'll look into this.
The Healthy Homes Study

**Partners**
- Alaska Native Tribal Health Consortium (lead)
- Yukon Kuskokwim Health Corporation
- Bristol Bay Area Health Corporation
- Arctic Investigations Program - CDC

**Goal**
- See if home improvements can reduce pollutants and improve health in children with lung disease

**Methods**
- Identify homes of children with lung problems
- Informed Consent
- Assess homes for indoor air quality
- Simple home renovations (woodstove changeout, vents, range hoods etc.) and education
- Check indoor air quality (PM2.5, VOC, CO2) and lung symptoms before and after
Methods

• Choose YKHC and BBAHC communities

• Eligible homes with child who has chronic lung problems

• Environmental Health and Housing Authority staff assess home:
  – Inadequate ventilation, leaky woodstove, moisture problems
  – Identify contaminants
  – Other factors (e.g., smoking, fuel storage inside home)

• The resident, housing and environmental health personnel decide scope of work

• Air sampling and household education

• Housing personnel complete modifications
Indoor air pollutants: PM2.5

PM2.5 gets into the lungs!

https://www.slideshare.net/faizanmohdiitb/air-pollution-and-smog
Volatile Organic Compounds

Chemicals containing carbon which easily become vapors

Household products, including:
- paints, paint strippers & solvents
- wood preservatives
- aerosol sprays
- cleansers and disinfectants
- moth repellents and air fresheners
- stored fuels and automotive products
- hobby supplies
- dry-cleaned clothing
- pesticide
Home Assessment and Remediation

• ANTHC, YKHC-OEH, and Tribal Housing Authority Staff, walk through each home to assess potential air quality issues
  – Inadequate ventilation, leaky woodstove, moisture problems

• The resident, housing personnel, regional health organization staff, and ANTHC personnel determine a scope of work for each home to remediate indoor air quality issues

• Tribal Housing Authority staff complete household remediation
  – Replace woodstoves, install range exhausts, improve ventilation, replace furnaces
How did study houses compare with general U.S. houses?

<table>
<thead>
<tr>
<th>Housing</th>
<th>Study houses</th>
<th>U.S. houses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean # occupants</td>
<td>7.3</td>
<td>2.6</td>
</tr>
<tr>
<td>Median sq. feet</td>
<td>920</td>
<td>2,465</td>
</tr>
<tr>
<td>&gt;1 person/room</td>
<td>73%</td>
<td>3%</td>
</tr>
<tr>
<td>% with woodstove primary heat</td>
<td>16%</td>
<td>2%</td>
</tr>
<tr>
<td>w/ smokers</td>
<td>49%</td>
<td>26%</td>
</tr>
<tr>
<td>no running water</td>
<td>60%</td>
<td>0.5%</td>
</tr>
</tbody>
</table>

New and/or Improved Vents

Ventilation intake plugged with a rag

New ventilation intake
Cooking Stove Exhaust Installed

Cooking stove with no range exhaust

New range exhaust
Cooking Stove Exhaust Installed

Cooking stove with no range exhaust

New range exhaust
Results: Home Assessments and Remediation

- 63 homes were assessed. 60 homes completed interventions

- Remediation in homes included:
  - Ventilation improvements (Fresh 80 vents, Range hoods, Bathroom fans) - 59 homes (98%)
  - Woodstove replacement – 28 homes (47%)
  - New oil-fueled furnace (Toyo stoves) – 14 homes (23%)
  - Moisture abatement 6 (10%)
Healthy Homes Study: Baseline findings

• **Indoor Air Quality**
  – High Volatile Organic Compounds (VOCs) and Particulates (PM2.5)

• **Respiratory symptoms in study household children**
  – high rates of cough between colds, hospitalization for lung infections, history of pneumonia, and wheezing in all household children.

• **Household factors and child symptoms**
  - VOCs
  - Primary wood heat
  - PM2.5
  - Cough between colds
  - Wheeze between colds
  - Asthma diagnosis
### Household factors contributing to indoor air pollution

<table>
<thead>
<tr>
<th>Factor</th>
<th>Pollutants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household smoking</td>
<td>PM2.5</td>
</tr>
<tr>
<td>Woodstove use</td>
<td>PM2.5, BTEX</td>
</tr>
<tr>
<td># persons in house</td>
<td>PM2.5, BTEX, VOC, CO&lt;sub&gt;2&lt;/sub&gt;, Relative Humidity</td>
</tr>
<tr>
<td>No Piped water</td>
<td>BTEX, VOC, CO&lt;sub&gt;2&lt;/sub&gt;</td>
</tr>
</tbody>
</table>
Healthy Homes Study Results

AFTER HOME IMPROVEMENT

• Decreased parent-reported symptoms in children
  ▼ colds or runny nose
  ▼ cough between cold
  ▼ wet cough
  ▼ wheezing with cold
  ▼ need for inhaler of nebulizer

• Decreased parent-reported missed school

• Decreased visits for lung infections in high risk children
Next Step…..
Environmental Health Hospital Consultation Study

Years: 2016-2019
Organizations: ANTHC, SCF, YKHC, Maniilaq, BBAHC
Objectives: Pilot project to test feasibility of hospital-based ANMC environmental consults
Methods: Environmental health specialists does consult with caregivers of inpatient children hospitalized with respiratory illness
  – Provide education on home environment, best burn practices, cleaning, water mitigation etc.
  – Mail Indoor Air “Toolkit” – CO monitor, wood moisture tester, cleaning supplies etc.
  – Village Housing referrals – to fix woodstoves, improve ventilation, fix furnace etc.
Questions?
1. Is it feasible to provide environmental health consults as a regular hospital service?
2. Do consults change caregiver behaviors. Do houses receive the remediation?
The Air Matters toolkit is comprised of items meant to promote health and safety in the home. The items either measure or control contaminants and encourage behaviors, like burning dry wood and controlling moisture, that will hopefully result in a healthier home environment for all and lower respiratory infections for children living in rural communities.

**Includes:**
- Chimney thermometer
- Green cleaning kit/ surface mold removal kit (Bon Ami cleaner, spray bottle, sponge, scrub brush, squeegee, N95 mask, and a microfiber cloth)
- Hygrometer
- Non-toxic pest trap
- Digital wood moisture meter
- Instant lead test kit
- Radon gas detection kit
- Allergen free pillowcase
- Carbon monoxide detector
- Cue cards
Acknowledgements

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• Yukon Kuskokwim Health Corporation
• Bristol Bay Area Health Corporation
• Bristol Bay Housing Authority (BBHA), and Association of Village Council Presidents (AVCP) Housing
• Funders: North American Commission for Environmental Cooperation, Environmental Protection Agency Project # 1.6.2.1.1.1 and the U.S. Department of Housing and Urban Development, Grant # AKHU0009-13.