THE AIRBORNE SPREAD OF INFECTIOUS AGENTS: SURVIVAL AND DECONTAMINATION OF HUMAN PATHOGENS IN INDOOR AIR

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SATTAR – TELECLASS ON INDOOR AIR-MAY 18-2017

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OBJECTIVES:

- ‘AEROBIOLOGY’ & POTENTIAL OF PATHOGEN SPREAD BY AIR
- CHALLENGES OF STUDYING PATHOGENS IN AIR
- OBSTACLES IN LINKING AIR TO ACQUISITION OF INFECTIONS
- SET-UP TO STUDY AIRBORNE SURVIVAL & REMOVAL/INACTIVATION
- TESTING OF AIR DECONTAMINATION DEVICES
- FUTURE DIRECTIONS

AEROBIOLOGY & INDOOR AIR QUALITY

- ‘AEROBIOLOGY’ – STUDY OF LIVING ORGANISMS & THEIR PARTS IN AIR
  - INCLUDES MICROBIAL QUALITY OF INDOOR AIR
  - INDOOR AIR IS AN ENVIRONMENTAL EQUALIZER!
  - EXPOSURE TO ‘INDOOR AIR’ WITH CAVE-DWELLING ~200,000 YEARS AGO
  - DOMESTICATED ANIMALS (CATTLE, DOGS & PIGS) FACILITATED RISE OF ZOONOSES INCLUDING AIRBORNE ONES (E.G., MEASLES)
  - WE SPEND MORE TIME INDOORS & BREATHE ~11,000 L OF AIR/DAY
  - WE ALL LEAVE OUR OWN PERSONAL MICROBIAL ‘FOOTPRINT’ INDOORS
  - BUT, LACK OF STANDARDIZED WAYS TO STUDY MICROBIAL AIR QUALITY
  - ALSO, DEARTH OF MEANS TO ASSESS INDOOR AIR DECONTAMINATION
### FACTORS AFFECTING INDOOR AIR QUALITY (SATTAR ET AL., 2016)

**CHEMICAL**
- GASES (CO, CO₂, O₃, NO)
- VOLATILE ORGANIC CHEMICALS (PERFUMES, CLEANERS, DISINFECTANTS, PAINTS, PESTICIDES, OFF-GASES)
- ASBESTOS

**BIOLOGICAL**
- HUMANS
- PET ANIMALS (CATS, DOGS, BIRDS)
- VERMIN (MICE, COCKROACHES)
- HOUSE PLANTS
- MICROBES (FREE-FLOATING, BIOFILM-BASED, MYCOTOXINS)
- POLLEN & ALLERGENS (ANIMAL DANDER, DUST MITES)

**PHYSICAL**
- RADON
- PARTICulates (CIGARETTE SMOKE, PRINTERS/COPIERS)
- SMOKE FROM COOKING & HEATING FUELS
- DUST

**ENVIRONMENTAL**
- OUTDOORS (WEATHER & CLIMATE)
- HVAC SYSTEM
- LIFE-STYLES (AIR TEMP., RH, OCCUPANT TYPE & DENSITY)

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### AIRBORNE SPREAD OF HUMAN PATHOGENS (SATTAR ET AL., 2015)

**INHALED DROPLET NUCLEI (<5 μm IN DIAM.) REACHING ALVEOLAR SPACES**

**RETENTION OF INHALED PARTICLES IN TONSILLAR REGION; SUBSEQUENT TRANSLOCATION TO GUT**

**SUSCEPTIBLE HOST**

**TRANSFER OF DRIED AIRBORNE CONTAMINATION ON ENVIRONMENTAL SURFACES TO HANDS AND OTHER VEHICLES**

**REAEROSOLIZATION OF DRIED AIRBORNE CONTAMINATION OF ENVIRONMENTAL SURFACES**

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### CHALLENGES IN STUDYING AEROBIOLOGY OF PATHOGENS (SATTAR ET AL., 2016)

<table>
<thead>
<tr>
<th>FACTOR(S)</th>
<th>REFINEMENTS REQUIRED</th>
</tr>
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<tbody>
<tr>
<td>EXPERIMENTAL SET-UP</td>
<td>SPACE, BIOSAFETY, FIELD-RELEVANCE, EASE OF CONTROL &amp; MONITORING OF TEST PARAMETERS</td>
</tr>
<tr>
<td>CHALLENGE-MICROBE SELECTION</td>
<td>REPRESENTATIVE OF AIRBORNE PATHOGENS, EASE OF CULTURE &amp; RECOVERY, STABILITY DURING AEROSOLIZATION &amp; IN AIR, PREP, CONC., PROTECTION</td>
</tr>
<tr>
<td>SUSPENSION TO BE NEBULIZED</td>
<td>SAFE &amp; STANDARDIZED SOIL LOAD REPRESENTING BODY FLUIDS, ANTI-FOAM, PHYSICAL TRACER (IF NEEDED)</td>
</tr>
<tr>
<td>NEBULIZATION &amp; PARTICLE SIZE DISTRIBUTION</td>
<td>SAFETY FOR MICROBE, GENERATION OF AEROSOLS/DROPLET NUCLEI, GRANULOMETRICS, UNIFORM DISTRIBUTION</td>
</tr>
<tr>
<td>AGING &amp; EXPOSURE CONDITIONS</td>
<td>BETTER CONTROL OF AIR TEMP. &amp; RH; TESTING AT RH BELOW 20%; HARMONIZED FOR MAJOR MICROBIAL TYPES</td>
</tr>
<tr>
<td>AEROSOL COLLECTION &amp; SIZING</td>
<td>PROTECTION OF VIABILITY, OPTIMAL GROWTH CONDITIONS, NEUTRALIZATION OF ACTIVES,</td>
</tr>
<tr>
<td>ASSESSING DECONTAMINATION</td>
<td>PROPER CONTROLS, REALISTIC EFFICACY CRITERIA FOR METHOD/DEVICE AIR-DECONTAMINATION TECHNOLOGIES, NUMBER OF REPEATS</td>
</tr>
<tr>
<td>INTERPRETATION OF DATA</td>
<td>STATISTICAL ANALYSES, FIELD RELEVANCE &amp; REGULATORY REQUIREMENTS</td>
</tr>
</tbody>
</table>

### AEROBIOLOGY CHAMBER TO STUDY MICROBIAL SURVIVAL & DECONTAMINATION IN INDOOR AIR (IJAZ ET AL., 2016)

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**Survival of Bacterial Pathogens in Indoor Air**

*IJAZ ET AL., 2016*

**A. BAUMANNII**

\[ y = -0.0064x + 4.6558; R^2 = 0.9992 \]

**S. AUREUS**

\[ y = -0.0244x + 4.423; R^2 = 0.9988 \]

**K. PNEUMONIAE**

\[ y = -0.0037x + 4.6773; R^2 = 0.9875 \]

**Testing in the Aerobiology Chamber:**

Air Temp. 22±2°C; Relative Humidity = 50±2%

**Testing Pathogen Survival & Decontamination**

*ZARGAR ET AL., 2016*

Challenge Microbe - Staphylococcus Aureus

All devices based on HEPA filtration & UV light but with different air exchange rates.
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**Air Decontamination upon Repeated Microbial Challenge (Zargar et al., 2016)**

**Does In-Car Air Pose a Risk to Human Health? (Sattar et al., 2016)**

- **World total of passenger cars** to increase from current one billion to >2.5 billion by 2050; family cars represent ~74% of world’s yearly output of motorized vehicles.
- ~80% of N. American commuters use their own car with another 5.6% travelling as passengers.
- With a life-expectancy of ~79 years, the average N. American spends 4.3 years driving a car!
- This equates to driving ~100 minutes/day with a lifetime driving distance of nearly 1.3 million km inside the confined & often shared space of the car.
- Exposure to a mix of potentially harmful pollutants

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RISK FACTORS FOR IN-CAR SPREAD OF PATHOGENS (SATTAR ET AL., 2016)

<table>
<thead>
<tr>
<th>FACTORS</th>
<th>IMPACT</th>
</tr>
</thead>
<tbody>
<tr>
<td>LENGTH OF COMMUTE</td>
<td>RISK OF EXPOSURE TO HARMFUL AIRBORNE CONTAMINANTS INCREASES IN DIRECT PROPORTION TO LENGTH &amp; FREQUENCY OF COMMUTE</td>
</tr>
<tr>
<td>CAR-POOLING</td>
<td>RISK OF EXPOSURE TO HARMFUL AIRBORNE CONTAMINANTS INCREASES IN DIRECT PROPORTION TO THE NUMBER OF OCCUPANTS</td>
</tr>
<tr>
<td>IMMUNOSUPPRESSION</td>
<td>INCREASING PROPORTION OF THE IMMUNOSUPPRESSED IN SOCIETY</td>
</tr>
<tr>
<td>POTENTIAL HOSTS</td>
<td>WIDE VARIATION IN THE AGE &amp; GENERAL HEALTH STATUS OF OCCUPANTS</td>
</tr>
<tr>
<td>STRESS OF DRIVING</td>
<td>STRESS OF DRIVING MAY LOWER BODY’S GENERAL RESISTANCE MECHANISMS</td>
</tr>
<tr>
<td>RESPIRABLE PARTICLES (E.G., PM 2.5)</td>
<td>INHALATION OF SUCH PARTICULATES MAY ENHANCE EXPOSURE &amp; SUSCEPTIBILITY TO INFECTIOUS AGENTS</td>
</tr>
<tr>
<td>VOLATILE ORGANIC CHEMICALS (VOCs)</td>
<td>EXPOSURE TO VOCs MAY OCCUR SIMULTANEOUSLY WITH INHALATION OF RESPIRABLE PARTICULATES &amp; MICROBES WITH POTENTIAL NEGATIVE ADDITIVE EFFECTS ON HEALTH</td>
</tr>
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SOURCES OF MICROBES, ALLERGENS & ENDOTOXINS IN IN-CAR AIR (SATTAR ET AL. 2016)

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CAR CHAMBER (SATTAR ET AL., APPL. ENVIRON. MICROBIOL., 2017)

Outlet for nebulized microbes
Muffin fan
Air decontamination device
Collision nebulizer
Access gloves
Compressed air cylinder with pressure gauge
Switch for operating the muffin fan and air decontamination device
Copper wire to discharge static electricity
Inlet for air to be sampled
Inlet to air microbial sampler

TESTING OF THREE IN-CAR AIR DECONTAMINATION DEVICES (SATTAR ET AL., 2017)

ALL DEVICES BASED ON HEPA FILTRATION & UV LIGHT BUT WITH DIFFERENT AIR EXCHANGE RATES

CHALLENGE MICROBE - STAPHYLOCOCCUS AUREUS

DEVICE #3
DEVICE #2
DEVICE #1

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SUMMARY OF THE MAIN FINDINGS

- Pathogens indoors come from humans, pets, plants, plumbing, toilets, showerhead, heating/cooling/ventilation systems.
- Vacuuming/mopping/dusting resuspend settled dust.
- A. *Baumannii* more stable than *K. Pneumoniae* in air; potentially a better surrogate for Gram-negatives.
- Devices #1 & #2 reduced test microbes by $>3\log_{10}$ in ~45 minutes.
- Device #1 remained effective after 3 microbial challenges.
- Testing of pathogen survival & decontamination in in-car air.
- Aerobiology protocol approved by U.S. EPA!
- Treating indoor air to prevent environ. surface contamination.

FUTURE DIRECTIONS FOR R&D

- Study of aerobiology of human pathogens is in its infancy!
- Standardized test facilities, protocols & guidelines needed.
- Efficient ways to detect low levels of airborne pathogens.
- Better field investigations with unequivocal results.
- More information on health impact of various levels of RH/temp. on humans & their susceptibility to airborne pathogens.
- Combined health impact of airborne pollutants.
- Relevance of data from molecular studies to assess risks?
- Better & longer-term research funding.

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FURTHER READING


“CLEAN AIR IS A BASIC REQUIREMENT OF LIFE. THE QUALITY OF AIR INSIDE HOMES, OFFICES, SCHOOLS, DAY CARE CENTRES, PUBLIC BUILDINGS, HEALTH CARE FACILITIES OR OTHER PRIVATE AND PUBLIC BUILDINGS WHERE PEOPLE SPEND A LARGE PART OF THEIR LIFE IS AN ESSENTIAL DETERMINANT OF HEALTHY LIFE AND PEOPLE’S WELL-BEING. …………” - WHO, 2010

THANK YOU!

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www.webbertraining.com/schedule1.php

(European Teleclass)
THE GOOD THE BAD AND THE UGLY METHODS FOR BEDPAN MANAGEMENT
Speaker: Gertie van Knippenberg-Gordebeke, International Consultant Infection Prevention, The Netherlands
Sponsored by CleanIs (www.cleanis.com)

May 30, 2017

USING UNOFFICIAL SOURCES TO MONITOR OUTBREAKS OF EMERGING INFECTIOUS DISEASES: LESSONS FROM PROMED
Speaker: Prof. Lawrence Medoff, Harvard University Medical School, Editor of ProMED Mail

June 1, 2017

(South Pacific Teleclass)
THE IMPACT OF CATHETER ASSOCIATED URINARY TRACT INFECTION
Speaker: Prof. Brett Mitchell, Avondale College of Higher Education, Australia

June 7, 2017

(FREE Teleclass)
ESTABLISHING A NATIONAL IPC PROGRAM ON A SHOESTRING BUDGET
Speaker: Prof. Shaheen Mehtar, Infection Control Africa Network, and Stellenbosch University, Cape Town

June 8, 2017

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