# Airborne transmission

## risk factors relevant in an infection control perspective


| | |
|---|---|
| **Carl-Johan Fraenkel** | Infection control Skåne, Infection medicine |
| **Jakob Löndahl** | Aerosol technology, Department of Design Sciences |
| **Malin Alsved** | Aerosol technology, Department of Design Sciences |
| **Sara Thuresson** | Aerosol technology, Department of Design Sciences |
| **Patrik Medstrand** | Translational Medicine |

LUNDS UNIVERSITET

Skånes universitetssjukhus
En del av Region Skåne

# Transmission pathways

Transmission:

Somehow a pathogen must leave a reservoir to reach a new target organ/cell/receptor

Why are we interested?

Our primary concern is to prevent transmission from occuring

# Transmission pathways

Transmission:

Somehow a pathogen must leave a reservoir to reach a new target organ/cell/receptor

By contact

By ballistic droplets

By inhalation of aerosols

How important are the different pathways?

# Chapin 1910 ”The Sources and Modes of Infection

*In reviewing the subject of air infection it becomes evident that our knowledge is still far to scanty….*

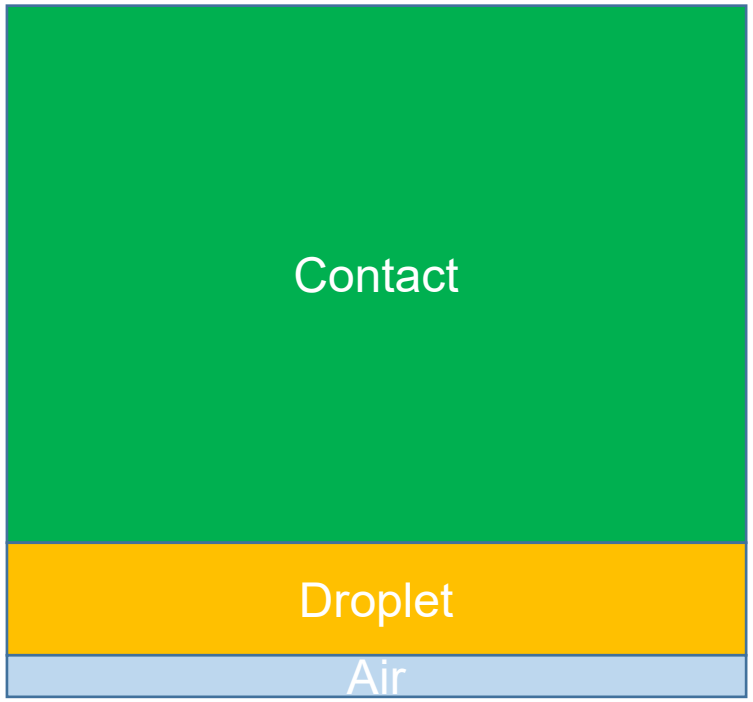
*If it should prove, as I firmly believe that contact infection is the chief way in which the contagion is spread, an exaggerated idea of air-borne infection is most mischievous.*

*It is impossible, as I know from experience, to teach people to avoid contact infection while they are firmly convinced that the air is the chief vehicle of infection*

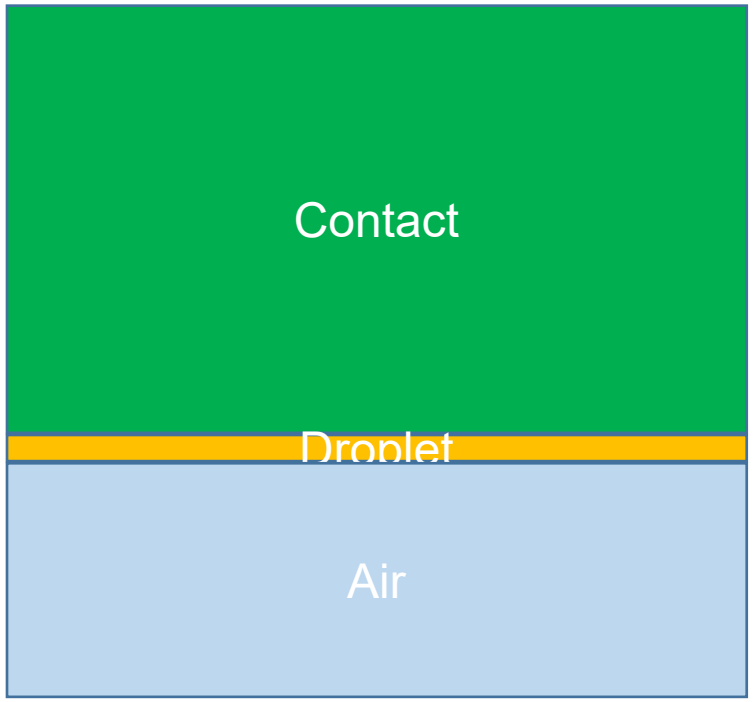
*We are warranted, then, in disregarding it as a working hypothesis and devoting our chief attention to the prevention of contact infection*

# Transmission pathways

Present paradigm




Hypothesis




LUNDS UNIVERSITET

Skånes universitetssjukhus
En del av Region Skåne

# Norovirus

*Clinical Infectious Diseases*

MAJOR ARTICLE

# Sources of Airborne Norovirus in Hospital Outbreaks

**Malin Alsved,[1,a] Carl-Johan Fraenkel,[2,3,4,a] Mats Bohgard,[1] Anders Widell,[5] Anna Söderlund-Strand,[6] Peter Lanbeck,[4] Torsten Holmdahl,[4] Christina Isaxon,[1] Anders Gudmundsson,[1] Patrik Medstrand,[5] Blenda Böttiger,[6] and Jakob Löndahl[1]**

[1]Division of Ergonomics and Aerosol Technology, Department of Design Sciences, Lund University, [2]Department of Infection Control, Region Skåne, [3]Division of Infection Medicine, Department of Clinical Sciences, Lund University, [4]Department of Infectious Diseases, Skåne University Hospital, [5]Department of Translational Medicine, Lund University, and [6]Department of Clinical Microbiology, University and Regional Laboratories, Lund, Sweden

Aim: Are noroviruses airborne?
if so - when?
if so - is it important?

Method: air collection from rooms with novoviruspatients

LUNDS UNIVERSITET

tetssjukhus
En del av Region Skåne

*Clinical Infectious Diseases*

MAJOR ARTICLE

# Sources of Airborne Norovirus in Hospital Outbreaks

**Malin Alsved,[1,a] Carl-Johan Fraenkel,[2,3,4,a] Mats Bohgard,[1] Anders Widell,[5] Anna Söderlund-Strand,[6] Peter Lanbeck,[4] Torsten Holmdahl,[4] Christina Isaxon,[1] Anders Gudmundsson,[1] Patrik Medstrand,[5] Blenda Böttiger,[6] and Jakob Löndahl[1]**

[1]Division of Ergonomics and Aerosol Technology, Department of Design Sciences, Lund University, [2]Department of Infection Control, Region Skåne, [3]Division of Infection Medicine, Department of Clinical Sciences, Lund University, [4]Department of Infectious Diseases, Skåne University Hospital, [5]Department of Translational Medicine, Lund University, and [6]Department of Clinical Microbiology, University and Regional Laboratories, Lund, Sweden

Norovirus RNA detected in 21 of 86 air samples (24 %) from 10 of 26 patients (38 %)

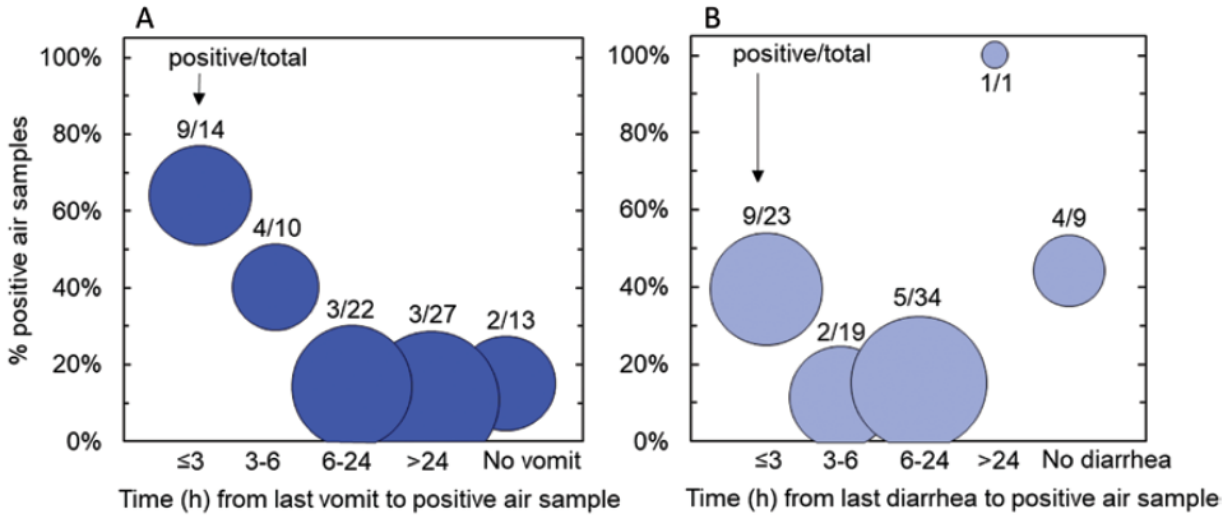



**Figure 1.** Percent of NoV-positive air samples in relation to time since (*A*) last vomiting episode and (*B*) last diarrhea. The area of each bubble is proportional to the total number of air samples within each time interval. The values above each bubble represent the number of positive and total air samples. Abbreviation: NoV, norovirus.

LUNDS UNIVERSITET

*Clinical Infectious Diseases*

MAJOR ARTICLE

# Sources of Airborne Norovirus in Hospital Outbreaks

**Malin Alsved,[1,a] Carl-Johan Fraenkel,[2,3,4,a] Mats Bohgard,[1] Anders Widell,[5] Anna Söderlund-Strand,[6] Peter Lanbeck,[4] Torsten Holmdahl,[4] Christina Isaxon,[1] Anders Gudmundsson,[1] Patrik Medstrand,[5] Blenda Böttiger,[6] and Jakob Löndahl[1]**

[1]Division of Ergonomics and Aerosol Technology, Department of Design Sciences, Lund University, [2]Department of Infection Control, Region Skåne, [3]Division of Infection Medicine, Department of Clinical Sciences, Lund University, [4]Department of Infectious Diseases, Skåne University Hospital, [5]Department of Translational Medicine, Lund University, and [6]Department of Clinical Microbiology, University and Regional Laboratories, Lund, Sweden

## Association to outbreaks

- 75 % av all outbreaks included at least 1 positive air sample.
- No single positive air sample if not an ongoing or coming outbreak.

LUNDS UNIVERSITET

Skånes universitetssjukhus
En del av Region Skåne

*Clinical Infectious Diseases*

MAJOR ARTICLE

# Sources of Airborne Norovirus in Hospital Outbreaks

**Malin Alsved,[1,a] Carl-Johan Fraenkel,[2,3,4,a] Mats Bohgard,[1] Anders Widell,[5] Anna Söderlund-Strand,[6] Peter Lanbeck,[4] Torsten Holmdahl,[4] Christina Isaxon,[1] Anders Gudmundsson,[1] Patrik Medstrand,[5] Blenda Böttiger,[6] and Jakob Löndahl[1]**

[1]Division of Ergonomics and Aerosol Technology, Department of Design Sciences, Lund University, [2]Department of Infection Control, Region Skåne, [3]Division of Infection Medicine, Department of Clinical Sciences, Lund University, [4]Department of Infectious Diseases, Skåne University Hospital, [5]Department of Translational Medicine, Lund University, and [6]Department of Clinical Microbiology, University and Regional Laboratories, Lund, Sweden

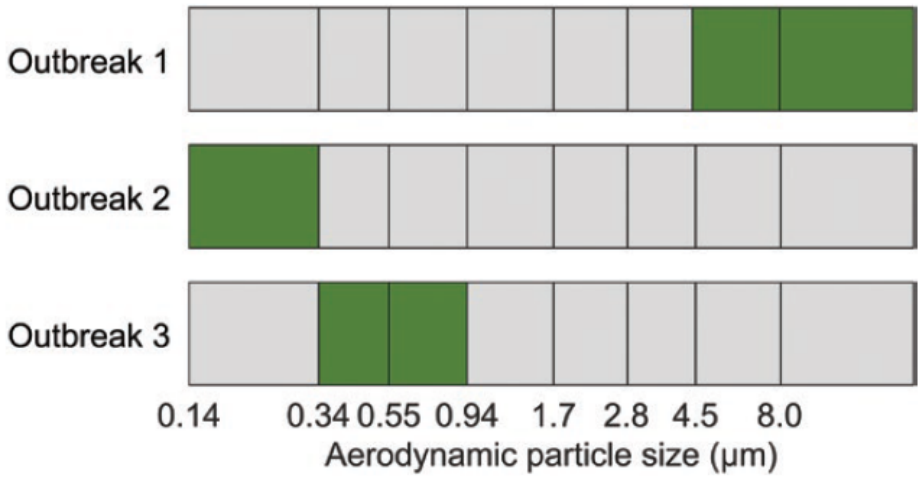



**Figure 3.** Size ranges of norovirus-positive aerosol samples (dark green) from the cascade impactor during 3 different outbreaks (negative stages are colored gray). During the fourth outbreak, all stages were negative. Note that the width of the stages is on a log scale.

LUNDS UNIVERSITET

Skånes universitetssjukhus
En del av Region Skåne

# SARS-CoV-2

Air samples from patient rooms

Exhaled air of covid patients in early disease

LUNDS UNIVERSITET

Skånes universitetssjukhus
En del av Region Skåne

# SARS-Cov-2 in air samples

**Aim:** Is SARS-CoV-2 airborne?

if so - when?

## Data collection

- Time since onset of disease
- Virus concentration in airways (ct-value)
- Aerosol generating procedures?
- Room ventilation

LUNDS UNIVERSITET

Skånes universitetssjukhus
En del av Region Skåne

# Luft på patientrum

310 air samples collected  - 26 positive (8%)

- 231 from patient rooms  - 22 positive (10 %)
- 182 directly connected to 88 unique patients
- 49 collected at covid-19 cohorts with information about aerosol generating procedures and ventilation

- 51 corridor air samples – 3 positive (6%)
- 15 anteroom air samples – 1 positiv (6%)

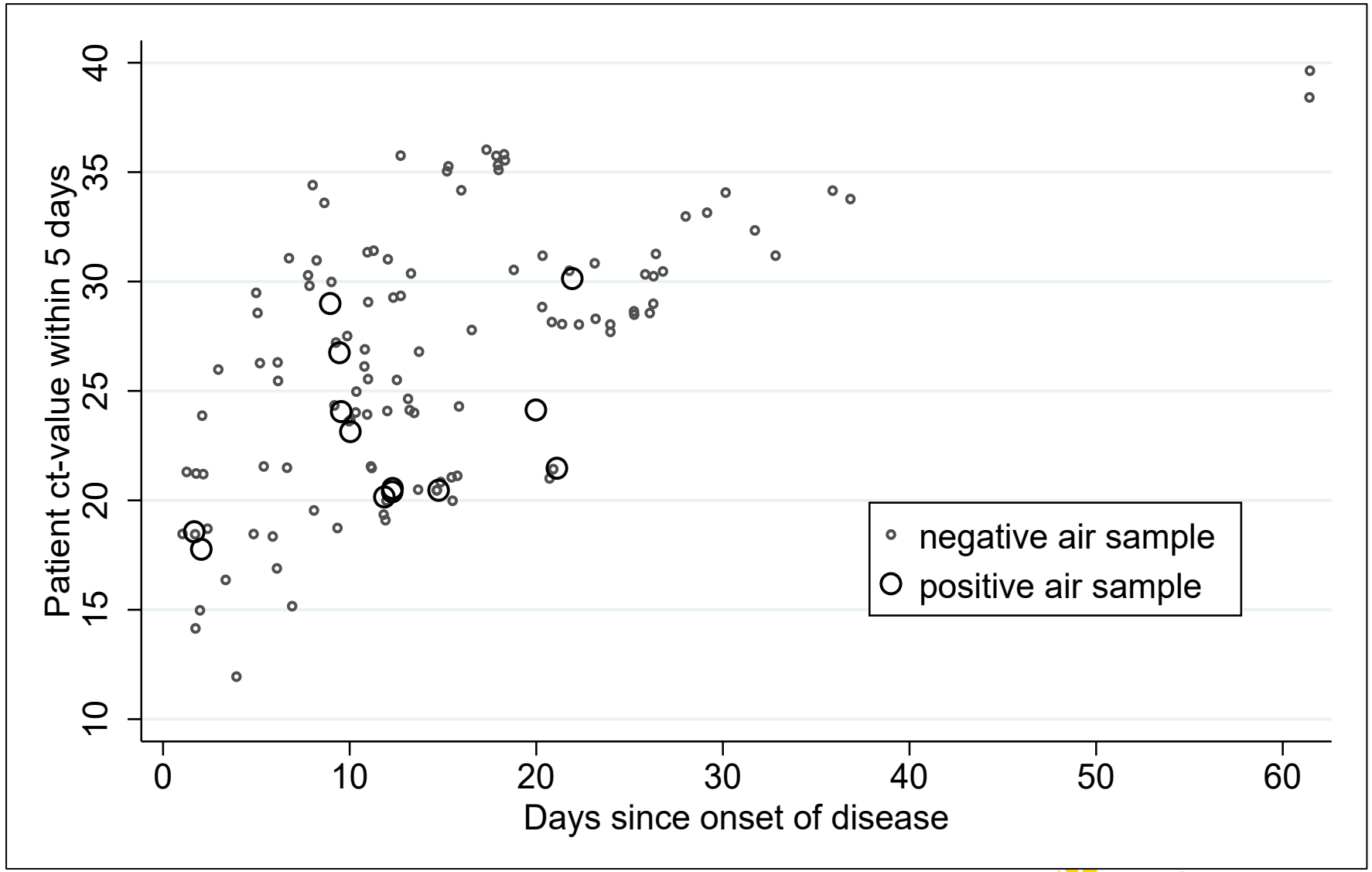
LUNDS UNIVERSITET

Skånes universitetssjukhus
En del av Region Skåne

| Sampling Related Factors | Total Air Samples (N = 231) | Positive Air Samples (n = 22) | P[a] |
|---|---|---|---|
| Patient and COVID-19 | | | |
| Age | | | .78 |
| <55 years | 49 | 7 (14%) | |
| 55–75 years | 86 | 9 (10%) | |
| >75 years | 47 | 5 (11%) | |
| Missing | 48 | 1 (2%) | |
| Sex | | | .74 |
| Male | 127 | 14 (11%) | |
| Female | 55 | 7 (13%) | |
| Missing | 48 | 1 (2%) | |
| Duration of illness | | | .33 |
| 1–7 days | 33 | 4 (12%) | |
| 8–14 days | 71 | 11 (15%) | |
| >15 days | 78 | 6 (8%) | |
| Missing | 48 | 1 (2%) | |
| Patient Ct values within 5 days[b] | | | <.05 |
| <25 | 54 | 10 (19%) | |
| >25 | 69 | 3 (4%) | |
| Missing | 108 | 9 (8%) | |

LUNDS UNIVERSITET

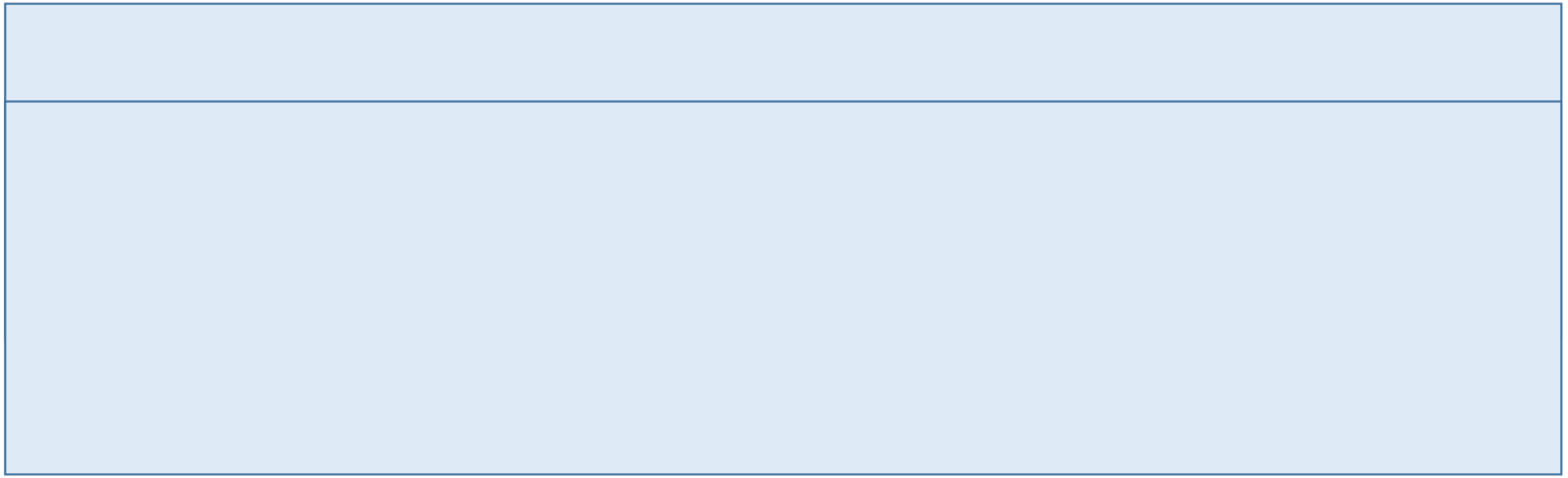
Skånes universitetssjukhus
En del av Region Skåne




LUNDS UNIVERSITET

Skånes universitetssjukhus
En del av Region Skåne

| | | | |
|---|---|---|---|
| Room and sampling | | | |
| Sampling distance | | | .13 |
| <1 m | 82 | 11 (13%) | |
| 1–2 m | 88 | 7 (8%) | |
| >2 m | 56 | 2 (4%) | |
| Missing | 5 | 2 (40%) | |



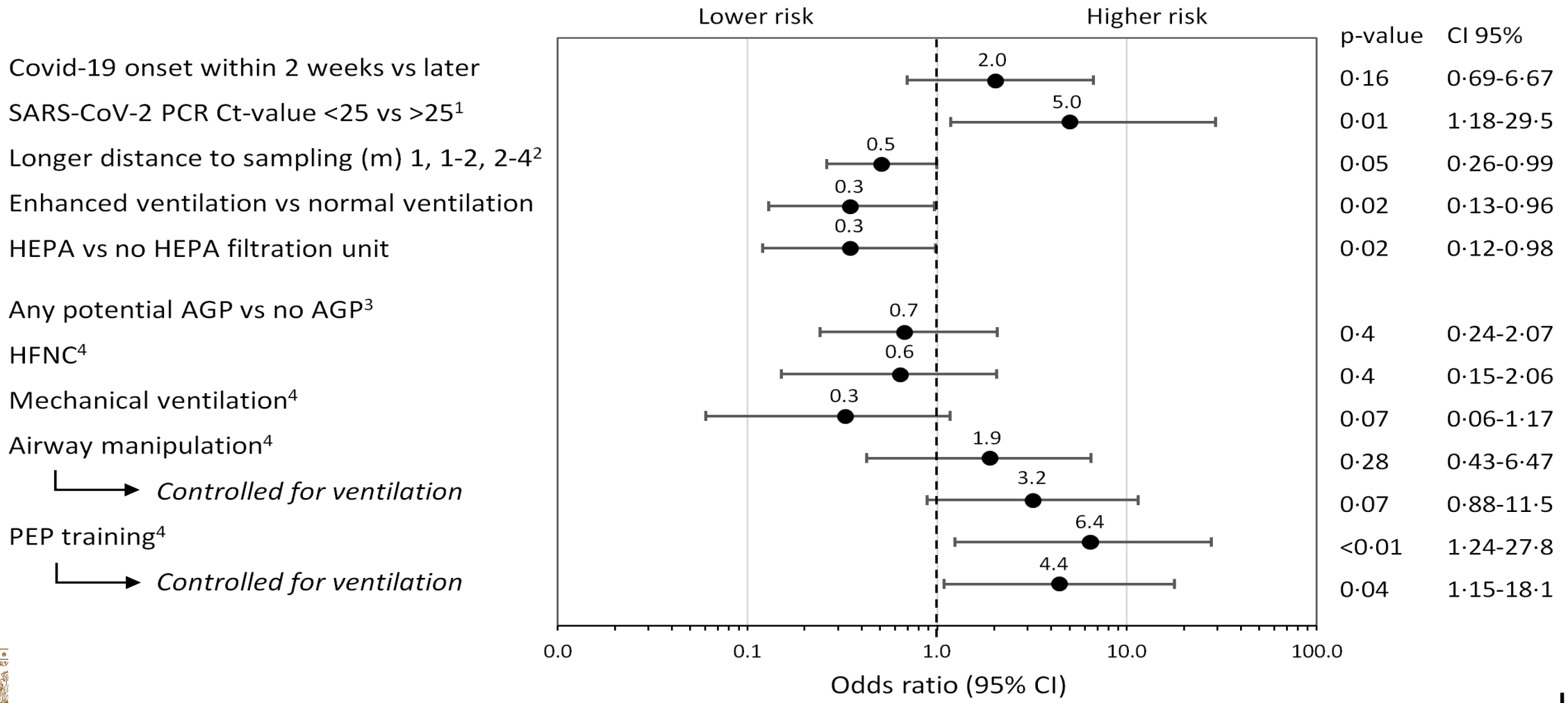
LUNDS UNIVERSITET

Skånes universitetssjukhus
En del av Region Skåne

| | | | |
|---|---|---|---|
| Aerosol-generating procedures | | | |
| HFNC[c] | | | .43 |
| Yes | 58 | 4 (7%) | |
| No | 173 | 18 (10%) | |
| Mechanical ventilation[3] | | | .07 |
| Yes | 71 | 3 (4%) | |
| No | 160 | 19 (12%) | |
| NIV | | | .38 |
| Yes | 7 | 0 (0%) | |
| No | 224 | 22 (10%) | |
| Airway manipulation[d] | | | .28 |
| Yes | 26 | 4 (15%) | |
| No | 205 | 18 (9%) | |
| PEP training | | | <.05 |
| Yes | 11 | 4 (36%) | |
| No | 220 | 18 (8%) | |
| Nebulizer treatment | | | .32 |
| Yes | 9 | 0 (0%) | |
| No | 222 | 22 (10%) | |

LUNDS UNIVERSITET

Skånes universitetssjukhus
En del av Region Skåne




LUNDS UNIVERSITET

Skånes universitetssjukhus
En del av Region Skåne

# Conclusions

- Association between positive air sample and
  - High virus concentration in patient airways
  - Close to the patient
  - Bad ventilation

- Aerosol generating procedures seem to be of less or no importance
  - Coughing and PEP training higher risk

# Exhaled breath in early covid-19

- Health-care workers were recruited
- Symptom onset <= 6 days
- Positiv SARS-CoV-2 test
- >=1 household member without known covid-19
  - Erbjöds besök

*Clinical Infectious Diseases*

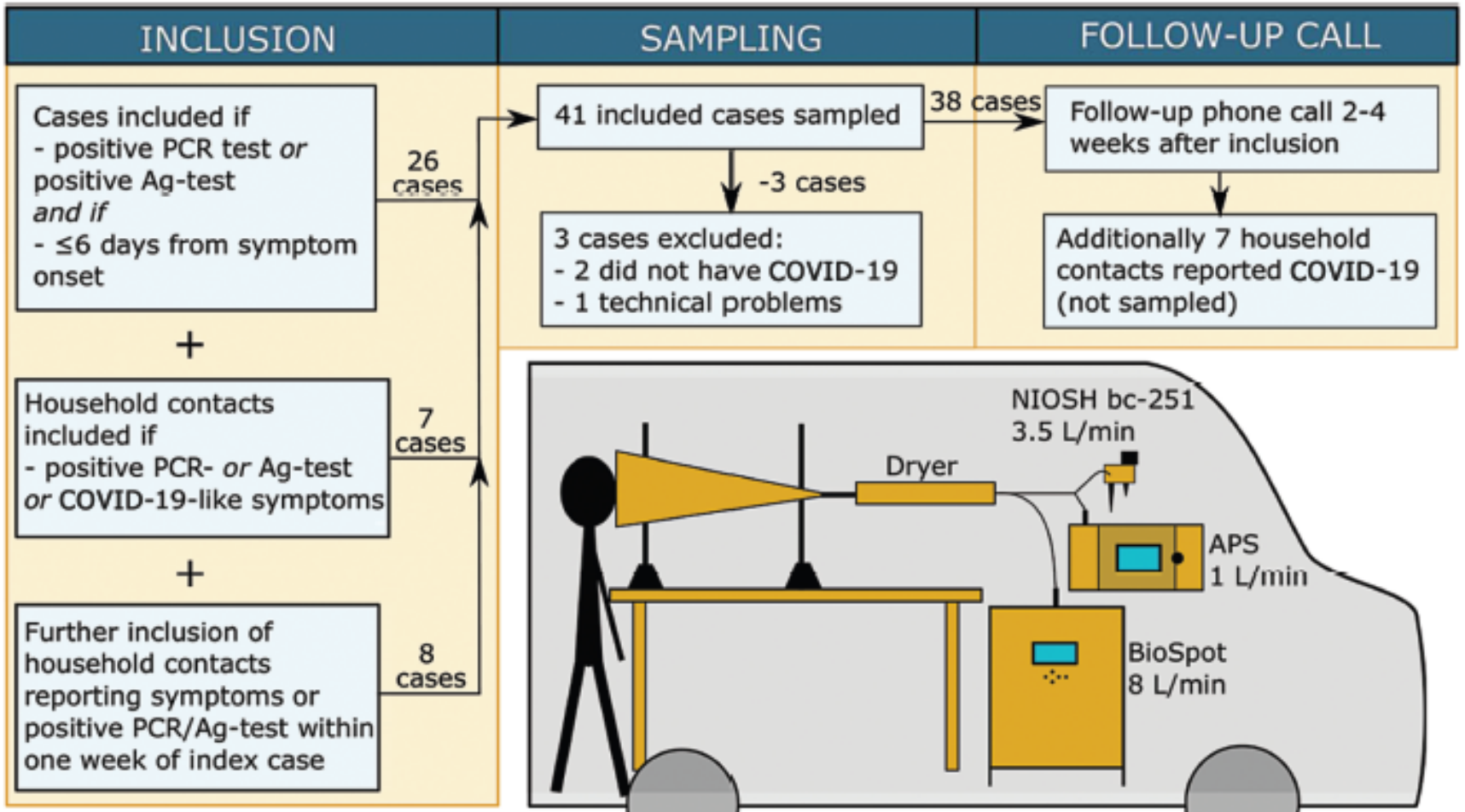
MAJOR ARTICLE

## SARS-CoV-2 in Exhaled Aerosol Particles from COVID-19 Cases and Its Association to Household Transmission

**Malin Alsved,[1] David Nygren,[2] Sara Thuresson,[1] Patrik Medstrand,[3] Carl-Johan Fraenkel,[2,4] and Jakob Löndahl[1]**

[1]Division of Ergonomics and Aerosol Technology, Department of Design Sciences, Lund University, Lund, Sweden; [2]Division of Infection Medicine, Department of Clinical Sciences, Lund University, Lund, Sweden; [3]Department of Translational Medicine, Lund University, Lund, Sweden; and [4]Department of Infection Control, Region Skåne, Lund, Sweden

LUNDS UNIVERSITET




Breathing – speaking - singing

MAJOR ARTICLE

SARS-CoV-2 in Exhaled Aerosol Particles from COVID-19 Cases and Its Association to Household Transmission

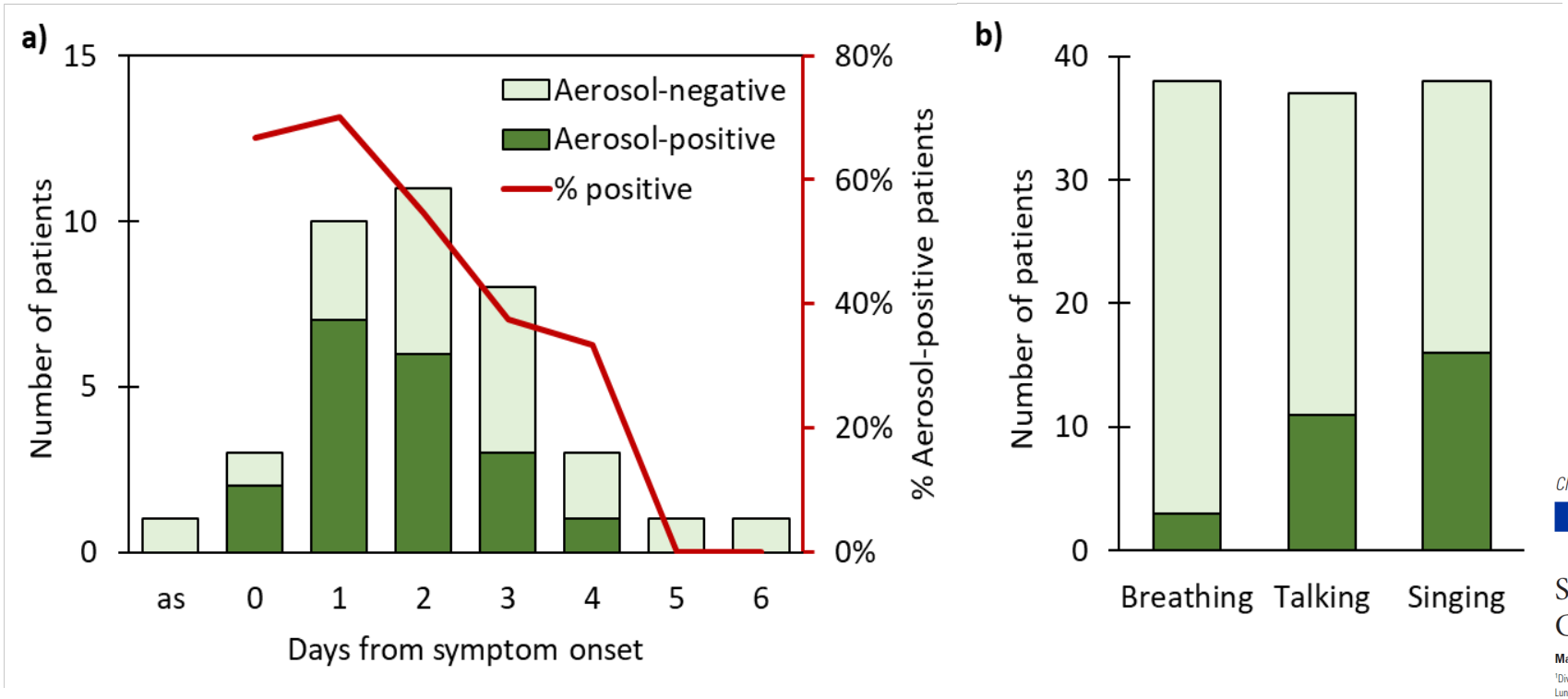
Malin Alsved,[1] David Nygren,[2] Sara Thuresson,[1] Patrik Medstrand,[3] Carl-Johan Fraenkel,[2,4] and Jakob Löndahl[1]

[1]Division of Ergonomics and Aerosol Technology, Department of Design Sciences, Lund University, Lund, Sweden; [2]Division of Infection Medicine, Department of Clinical Sciences, Lund University, Lund, Sweden; [3]Department of Translational Medicine, Lund University, Lund, Sweden; and [4]Department of Infection Control, Region Skåne, Lund, Sweden

LUNDS UNIVERSITET

# Exhaled breath in early covid-19

- 38 cases included in 16 unique households
- 19 of 38 (50%) patients within 4 days of symptom onset emitted detectable airborne SARS-CoV-2 RNA



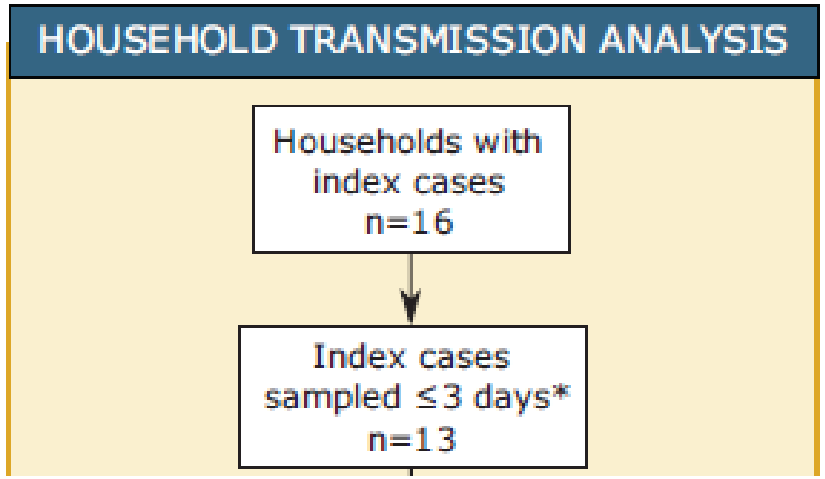

*Clinical Infectious Diseases*
MAJOR ARTICLE

SARS-CoV-2 in Exhaled Aerosol Particles from COVID-19 Cases and Its Association to Household Transmission

Malin Alsved,[1] David Nygren,[2] Sara Thuresson,[1] Patrik Medstrand,[3] Carl-Johan Fraenkel,[2,4] and Jakob Löndahl[1]

[1]Division of Ergonomics and Aerosol Technology, Department of Design Sciences, Lund University, Lund, Sweden; [2]Division of Infection Medicine, Department of Clinical Sciences, Lund University, Lund, Sweden; [3]Department of Translational Medicine, Lund University, Lund, Sweden; and [4]Department of Infection Control, Region Skåne, Lund, Sweden

# SARS-CoV-2 in exhaled breath may increase risk of household transmission




LUNDS UNIVERSITET

*Clinical Infectious Diseases*
MAJOR ARTICLE

SARS-CoV-2 in Exhaled Aerosol Particles from COVID-19 Cases and Its Association to Household Transmission

Malin Alsved,[1] David Nygren,[2] Sara Thuresson,[1] Patrik Medstrand,[3] Carl-Johan Fraenkel,[2,4] and Jakob Löndahl[1]

[1]Division of Ergonomics and Aerosol Technology, Department of Design Sciences, Lund University, Lund, Sweden; [2]Division of Infection Medicine, Department of Clinical Sciences, Lund University, Lund, Sweden; [3]Department of Translational Medicine, Lund University, Lund, Sweden; and [4]Department of Infection Control, Region Skåne, Lund, Sweden

# Airborne transmission

- Is this transmission pathway more important than we believe?
  - Yes –for covid-19
  - Probably - for other respiratory infections
  - Possibly  - for other contagious pathogens
- How to do relevant research on risk factors for airborne transmission and how to prevent it?
  - What outcome do we accept?
  - What exposure should be studied - Aerosolgenerating procedures, ventilation, masking etc…
- How to do relevant research to approximate importance of different transmission pathways?
  - Concerns infection control recommendations in health-care and in society
  - How to be ready for the next pandemic?

LUNDS UNIVERSITET

Skånes universitetssjukhus
En del av Region Skåne