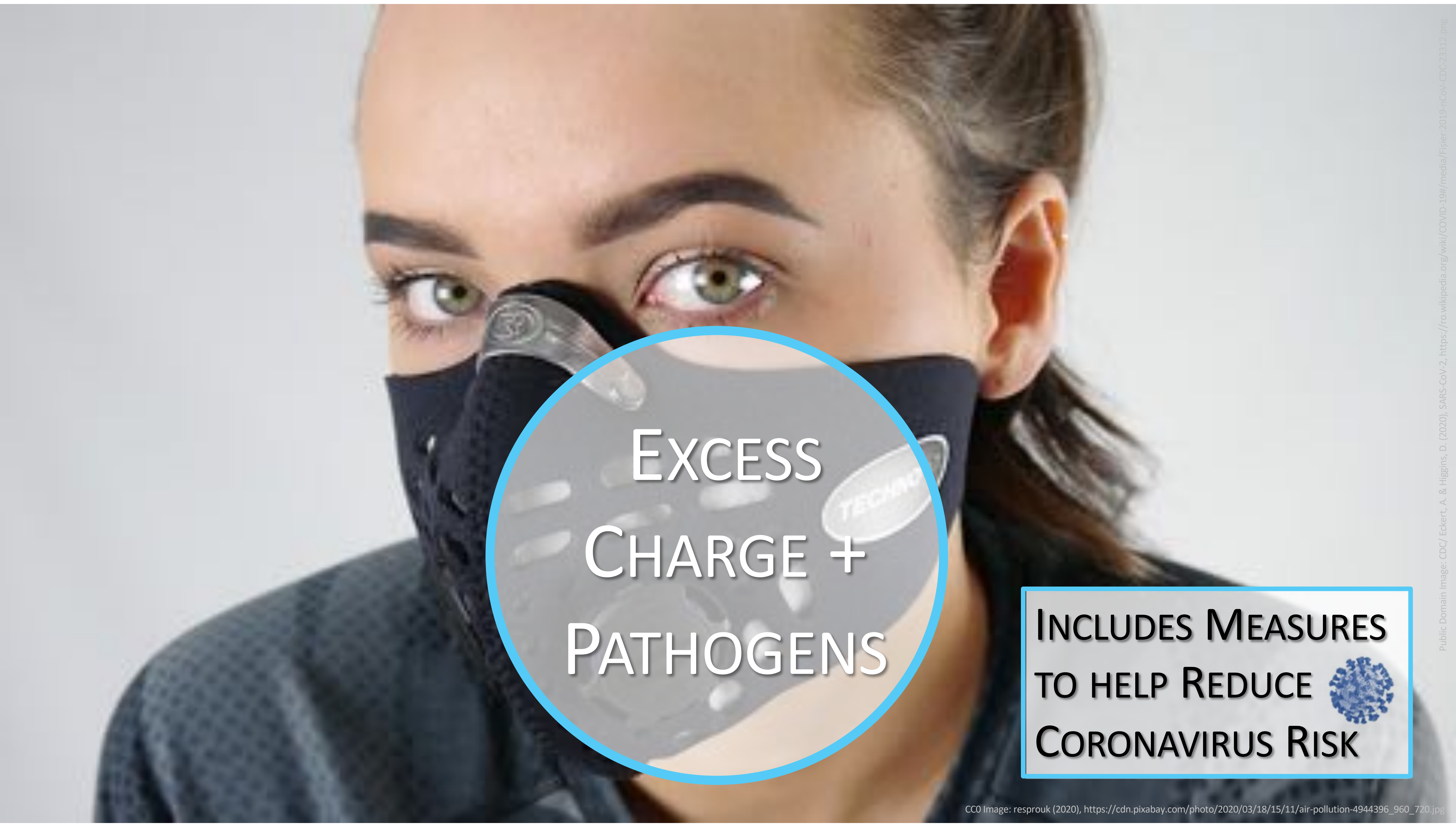
Rethinking Resilience:



BiOsustainable Designs

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RETHINKING RESILIENCE: EXCESS CHARGE

Includes Measures to help Reduce Coronavirus Risk

Contents

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Includes Measures to help Reduce Coronavirus Risk

Contents

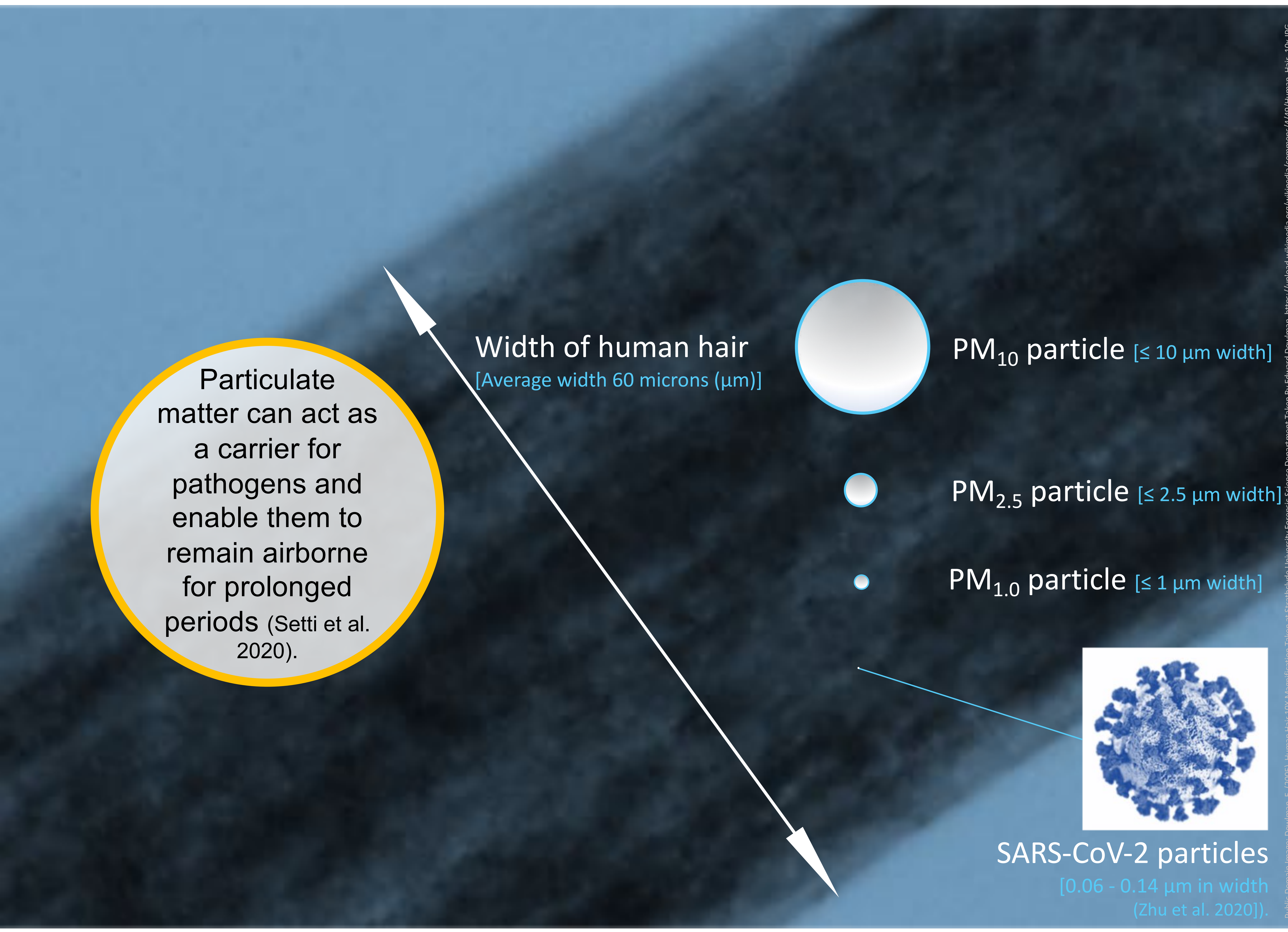
Electrostatic Charge and COVID-19 Risk, a BioSustainable Designs video of the topics covered in this document is available at: https://youtu.be/MlQzvmi7AMo [Issued on 28/05/20].

EXECUTIVE SUMMARY

Reducing excess charge can help reduce incidence of electrostatic shocks, pathogen infection, co-infection, surface contamination and inhalation of pollutants.

Improved electromagnetic hygiene can reduce risk of pathogen inhalation and deposition.

SIZE COMPARISONS OF AIRBORNE POLLUTANTS



Pathogens, can be carried on respiratory droplets, droplet nuclei and other kinds of contaminants, including dust and skin flakes
(WHO 2020, Mori et al. 2017, Dillon 2011).

EXCESS CHARGE AND SUBMICRON CONTAMINANTS

"… the gas cloud and its payload of pathogen-bearing droplets of all sizes can travel 23 to 27 feet (7-8 m)" Bourouiba (2020).

Electric fields can influence their deposition.

COMMON INDOOR PARTICLES ≤ 1µm DIAMETER

Pollutant	Size range
Nanoplastics and microplastics	<**0.1 µm to <5 mm**
Skin flakes	<**1–50 µm**
Cat dander	1–3 µm
Fungi	**0.5–30 µm**
Asbestos	0.25–1 µm
Outdoor fine particles (metals, sulphates)	**0.1–2.5 µm**
Environmental tobacco smoke	**0.1–0.8 µm**
Ozone and terpene formed aerosols	<0.1 µm
Metal fumes	<0.1 µm
Fresh combustion particles	<0.1 µm
Bacteria (also arise in droplet particles)	**0.05–10 µm**
Diesel soot	0.01–1 µm
Viruses (also arise in droplet particles)	<**0.01–0.31 µm**

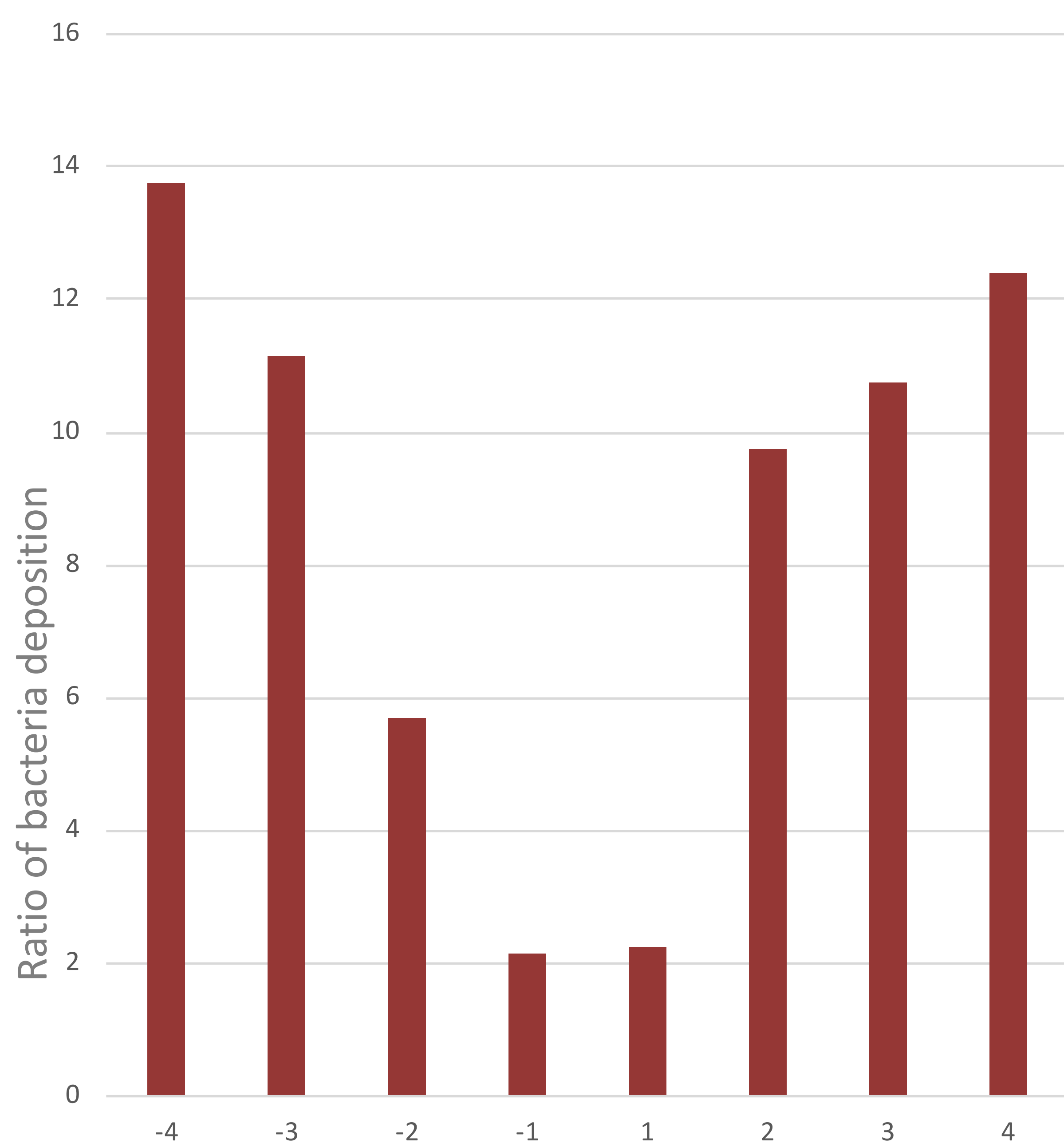
Co-infection from other pathogens can increase risks from both COVID-19 and influenza (Wu et al. 2020).

Main sources: Kowalski et al. (1999), McDonald & Ouyang (2001), Morawska (2005), Settles (2005), Craven & Selltels (2006),Prata (2018).

Improved electromagnetic hygiene can reduce risks of infection and co-infection.

CHARGE AND PATHOGEN DEPOSITION

Bacterial deposition on surfaces charged to different potentials



Potential at surface of metal plate, kV

Adapted from Allen (2005).

Excess charge can increase localised deposition of airborne pathogens.

Bacterial deposition is greatest on the surfaces with the highest charge (Allen 2005).

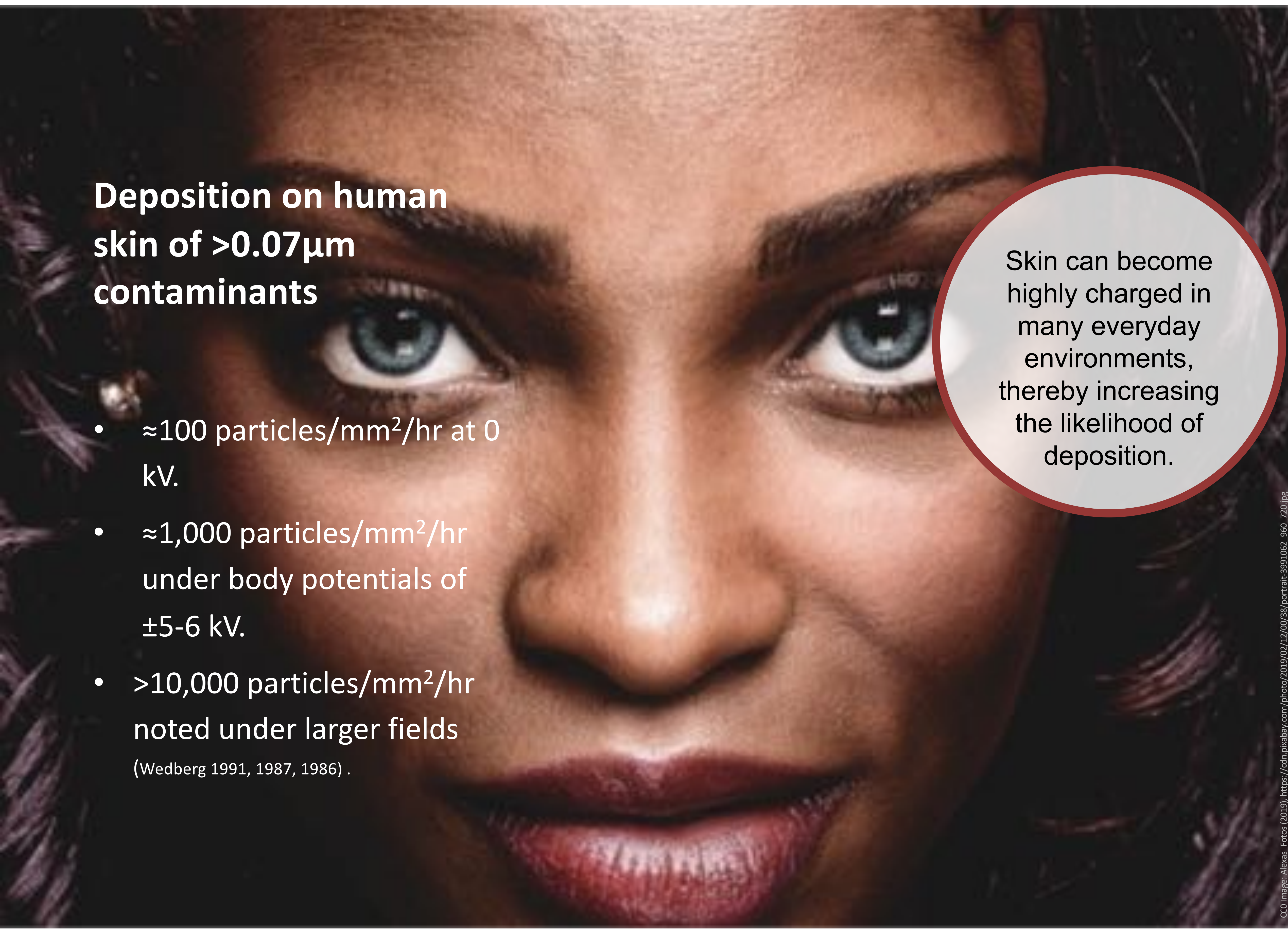
We propose that viral deposition may also increase most on surfaces with raised charge.

ELECTROSTATIC CHARGE IN HOSPITALS

Hospital wards, and the people within them, often experience high levels of excess charge (NEMA 1995).

Excess charge can increase contaminant deposition (Allen 2005).

EXCESS CHARGE AND SKIN CONTAMINATION



Deposition on human skin of >0.07µm contaminants

- ≈100 particles/mm²/hr at 0 kV.
- ≈1,000 particles/mm²/hr under body potentials of ±5-6 kV.
- >10,000 particles/mm²/hr noted under larger fields (Wedberg 1991, 1987, 1986) .

Skin can become highly charged in many everyday environments, thereby increasing the likelihood of deposition.

We suggest excess charge may increase virus deposition onto skin.

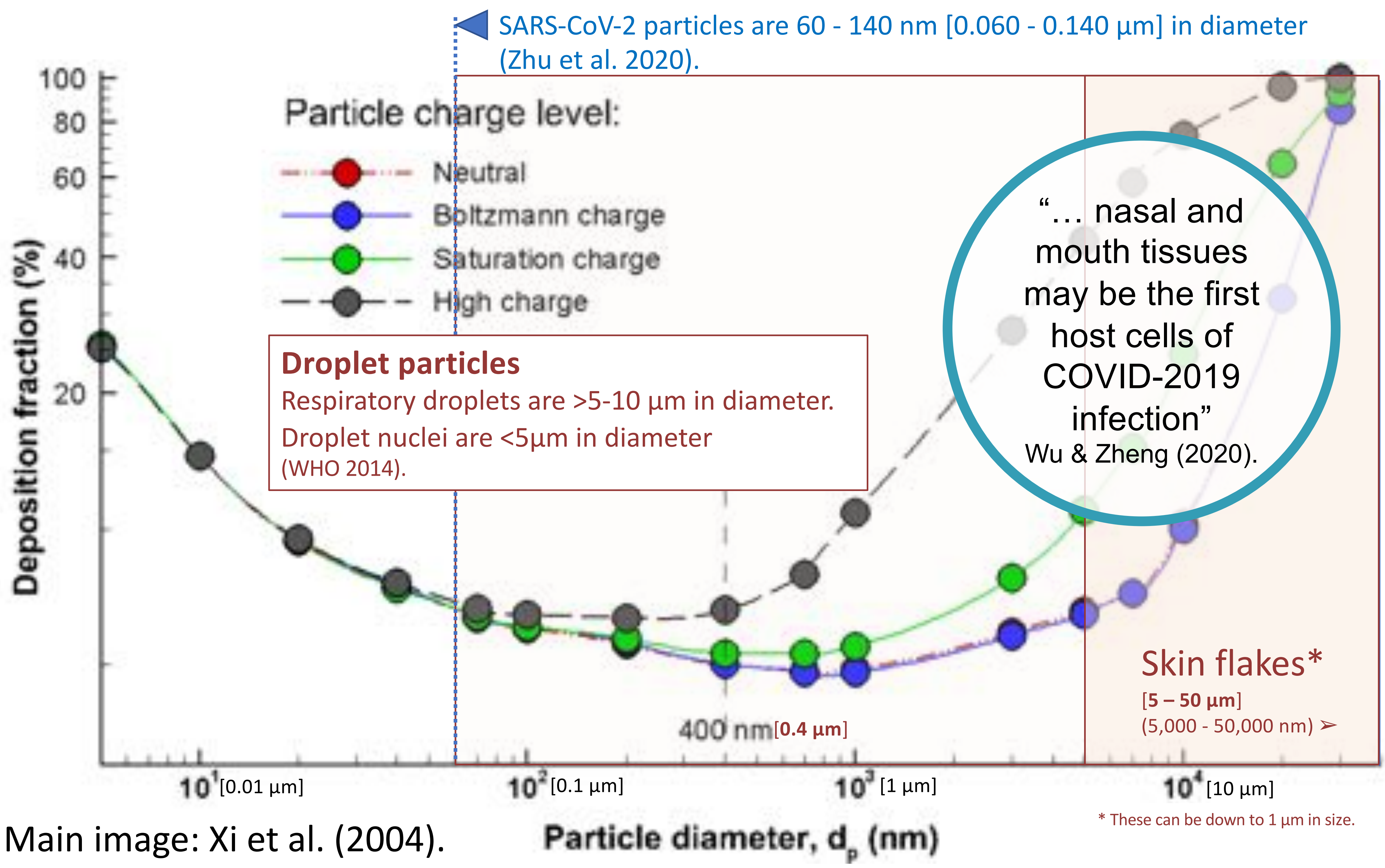
Raised exposure to contaminants can increase risk of poor health
(Jamieson et al. 2010, Morawska 2005, Morawska et al. 2004, Donaldson et al. 2001).

INHALATION OF SKIN FLAKES

We propose that there is a far higher chance of skin and skin flakes being contaminated if a person has been at high electrostatic potential, or adjacent a high field emitter, in a location where there is increased chance of infection.

CHARGE AND RETENTION OF PARTICLES IN AIRWAYS

Particulate matter may help carry SARS-CoV-2 into respiratory systems (Sanità di Toppi et al. 2020).



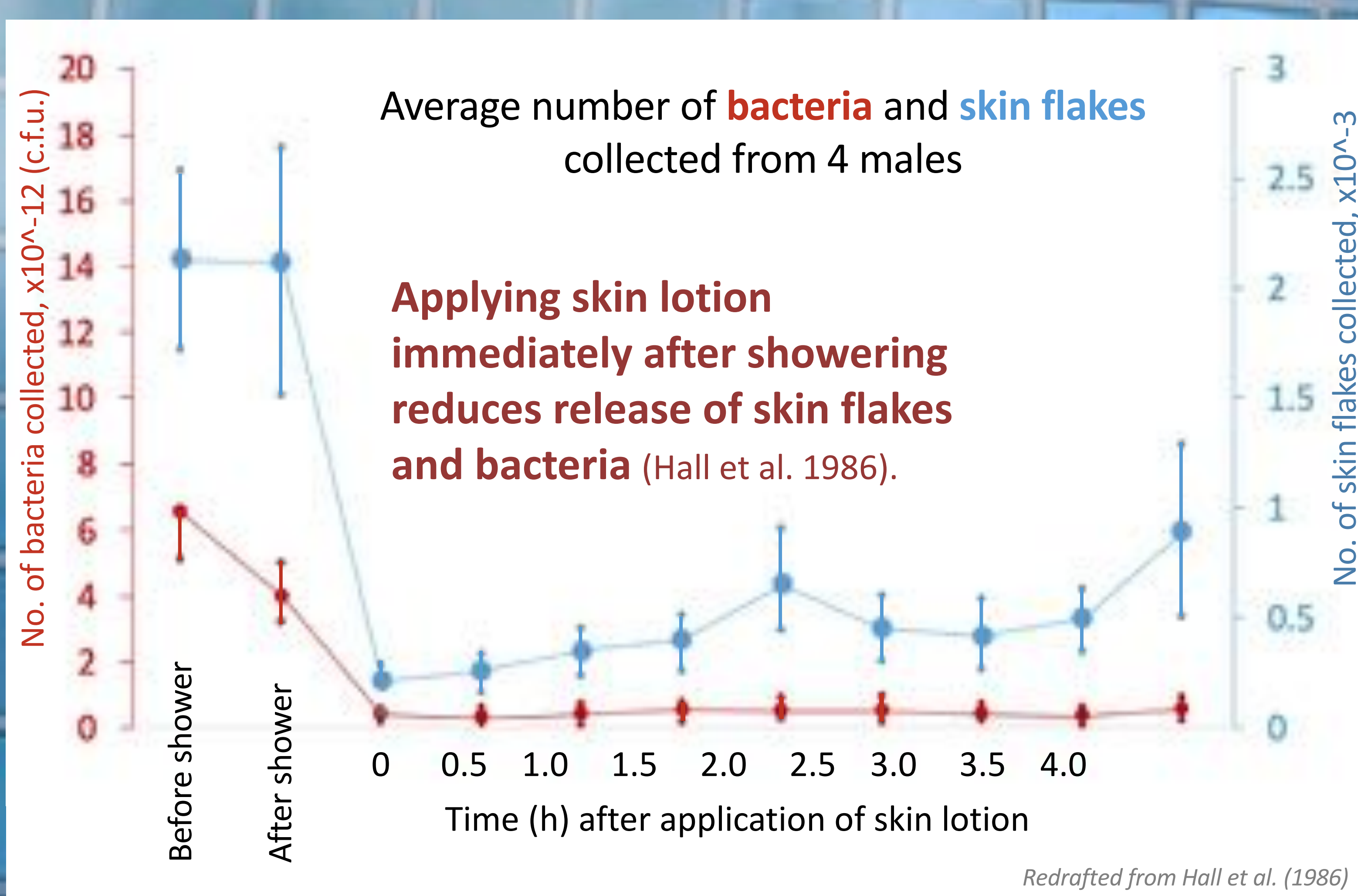
Main image: Xi et al. (2004).

The level of charge particles hold affects their likelihood of deposition in human airways. Pathogens can be carried on such particles.

Increased concentrations of charged particles are found in areas with poor electromagnetic hygiene (Jamieson et al. 2010).

EFFECTS OF SHOWERING AND SKIN MOISTURISATION ON SKIN FLAKE AND PATHOGEN RELEASE

Release of airborne bacteria from humans can greatly increase 10-45 minutes after showering (Bernard et al. 1965).



Reducing skin flake production reduces the chances of infection from inhaling pathogens originally deposited on the skin.

The use of skin lotions can also reduce the frictional charging created between skin and clothes, thereby helping reduce body potentials <u>and</u> the number of airborne contaminants attracted towards individuals.

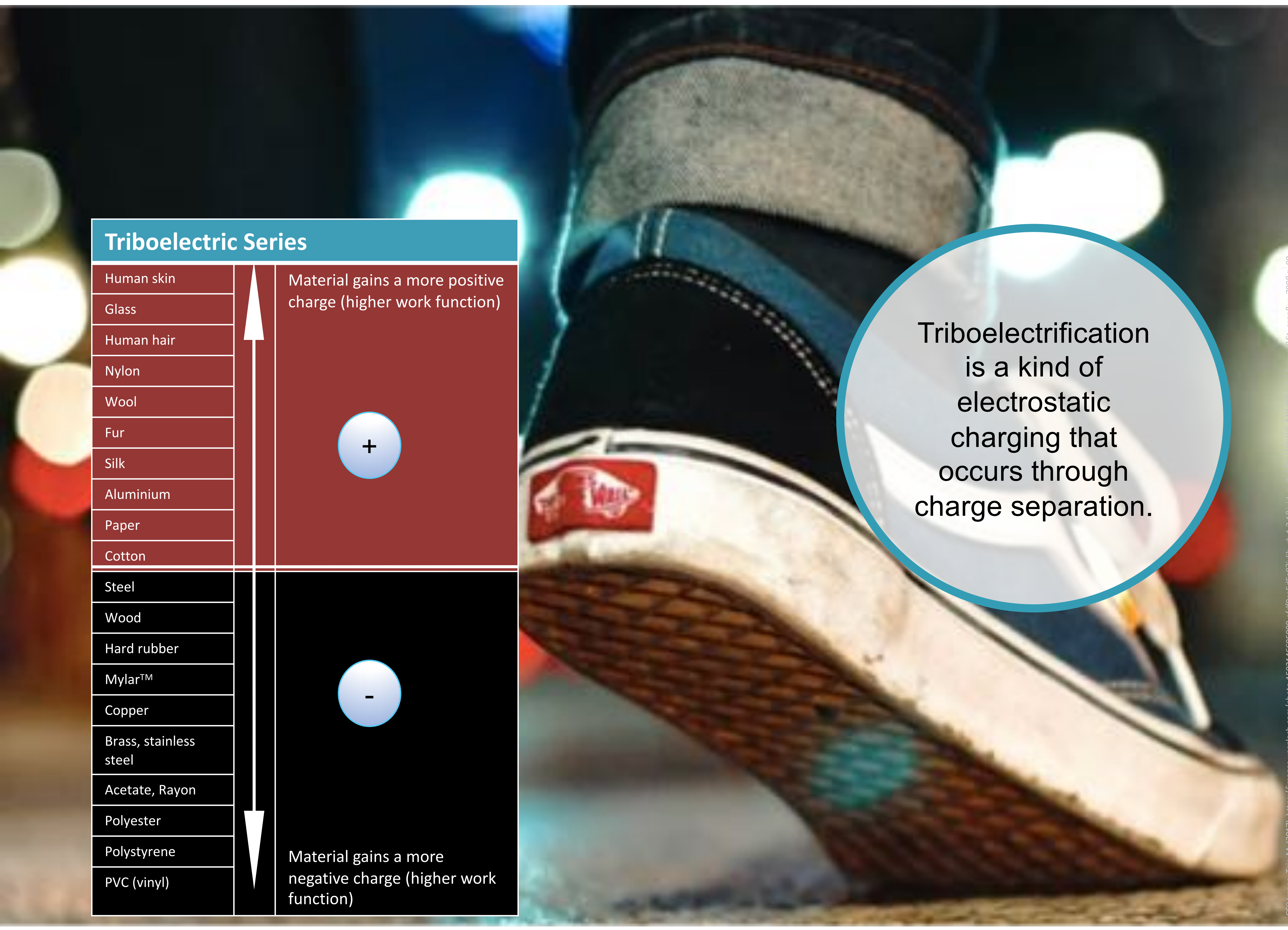
REDUCING LIKELIHOOD OF DRY SKIN AFTER BATHING

- **Shower or bathe for <10 mins**
  (Longer periods can dry out your skin).
- **Use warm not hot water**
  (Hot water strips the skin of its natural oils far quicker).
- **Use mild cleansers**
  (Avoid harsh cleansers and cleansers with strong surfactants).
- **Pat your skin dry using a soft towel**
  (Avoid rough drying with towels).
- **Moisturise immediately after drying.**
  (American Academy of Dermatology Association 2020, Oliver 2016).

If possible, try to take short baths or showers!

The less dry skin you have, the less likely you are to inhale your own, possibly contaminated, skin flakes.

TRIBOELECTRIC / CONTACT CHARGING



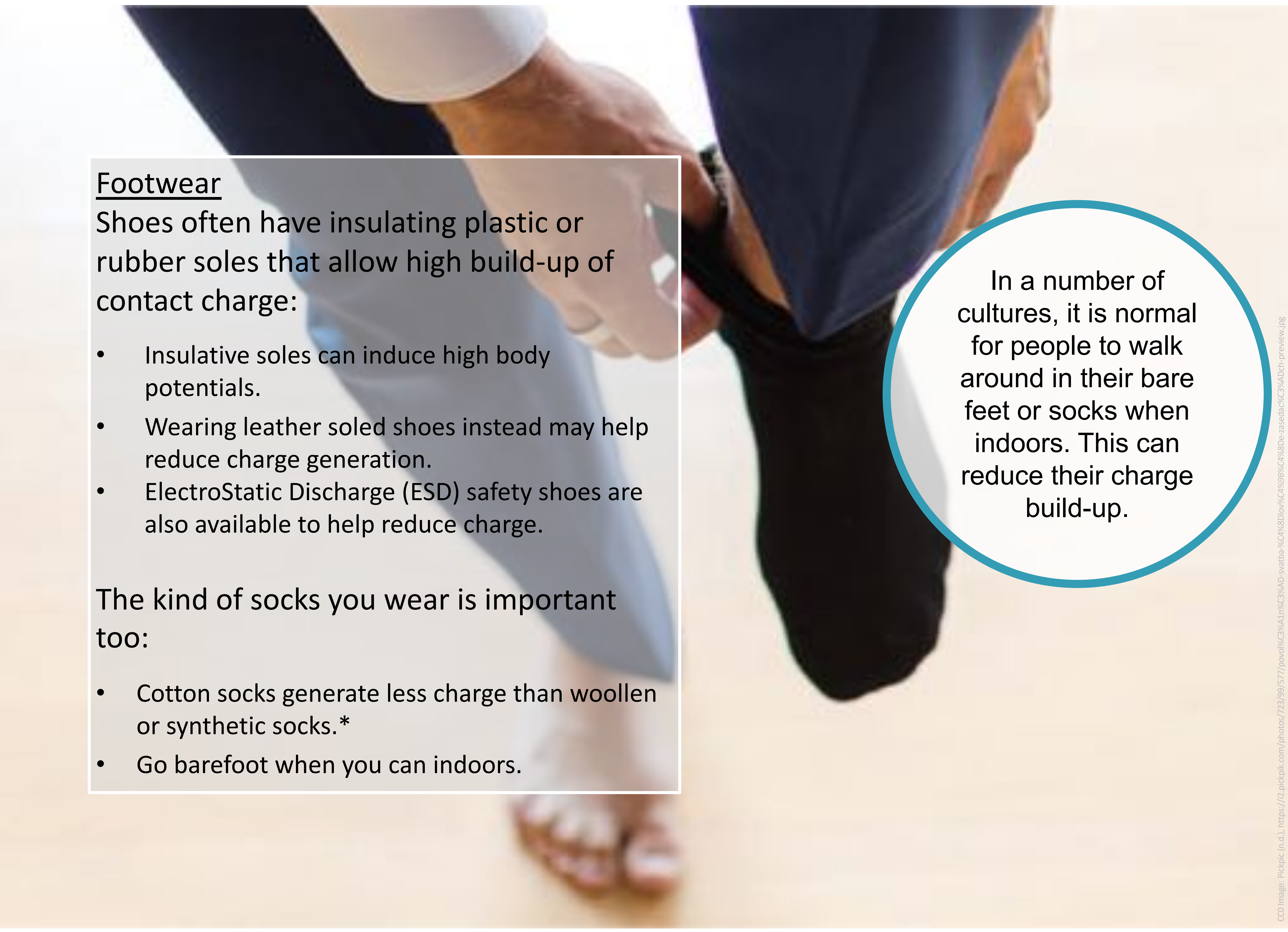
Triboelectric Series

Human skin	↑	Material gains a more positive charge (higher work function)
Glass		
Human hair		
Nylon		
Wool		
Fur		+
Silk		
Aluminium		
Paper		
Cotton		
Steel		
Wood		
Hard rubber		
Mylar™		-
Copper		
Brass, stainless steel		
Acetate, Rayon		
Polyester		
Polystyrene		
PVC (vinyl)	↓	Material gains a more negative charge (higher work function)

Triboelectrification is a kind of electrostatic charging that occurs through charge separation.

It can be caused by surface-friction between objects.

WALKING AND TRIBOELECTRIC / CONTACT CHARGING



Footwear

Shoes often have insulating plastic or rubber soles that allow high build-up of contact charge:

- Insulative soles can induce high body potentials.
- Wearing leather soled shoes instead may help reduce charge generation.
- ElectroStatic Discharge (ESD) safety shoes are also available to help reduce charge.

The kind of socks you wear is important too:

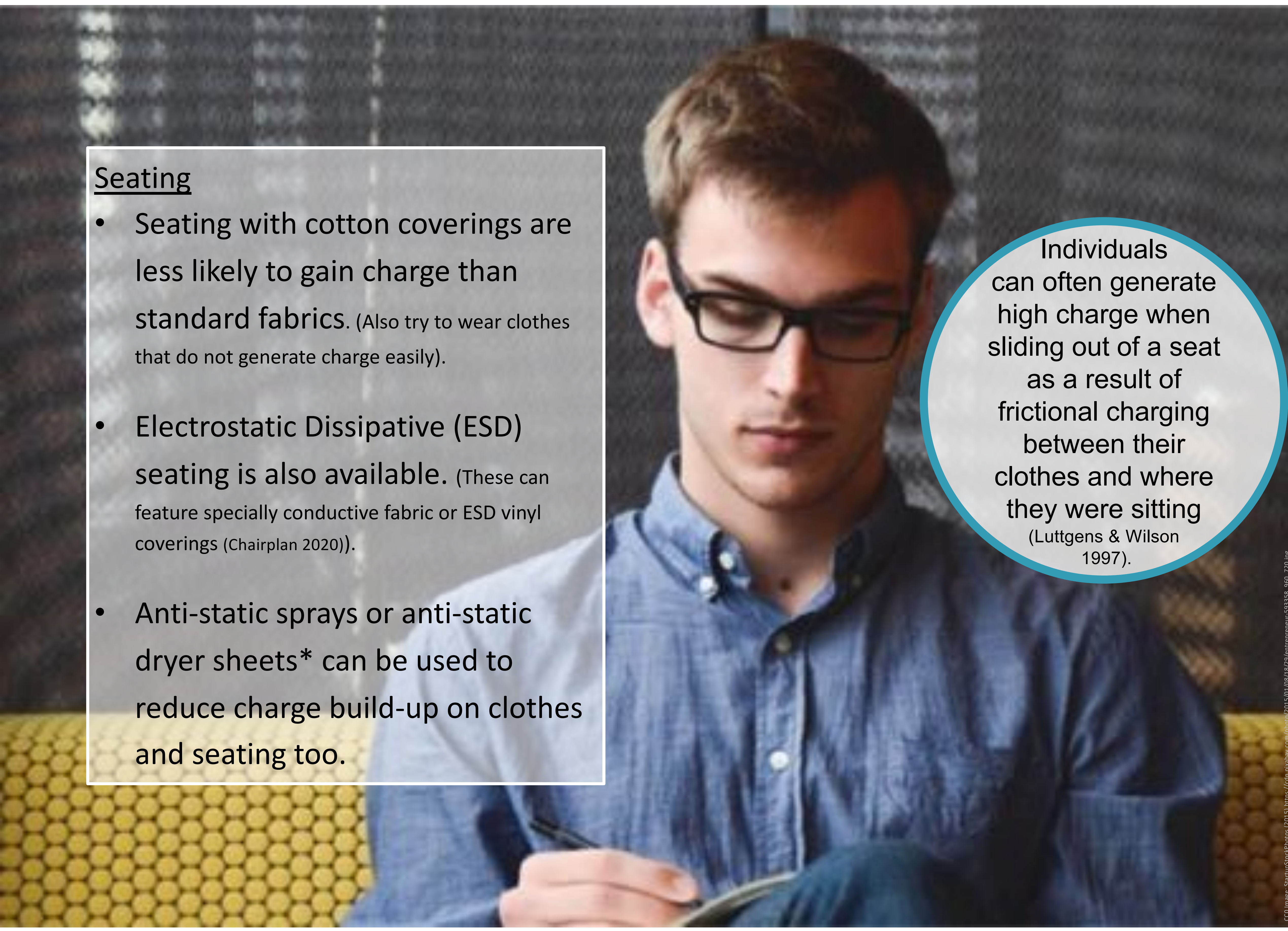
- Cotton socks generate less charge than woollen or synthetic socks.*
- Go barefoot when you can indoors.

In a number of cultures, it is normal for people to walk around in their bare feet or socks when indoors. This can reduce their charge build-up.

Some floor coverings can also contribute to generation of high triboelectric charge
(IBM (n.d.), Electrostatic Solutions Ltd. 2011).

* Moisturising the soles of your feet can further reduce charge generation (Fowler 2003).

SITTING AND TRIBOELECTRIC / CONTACT CHARGING



Seating

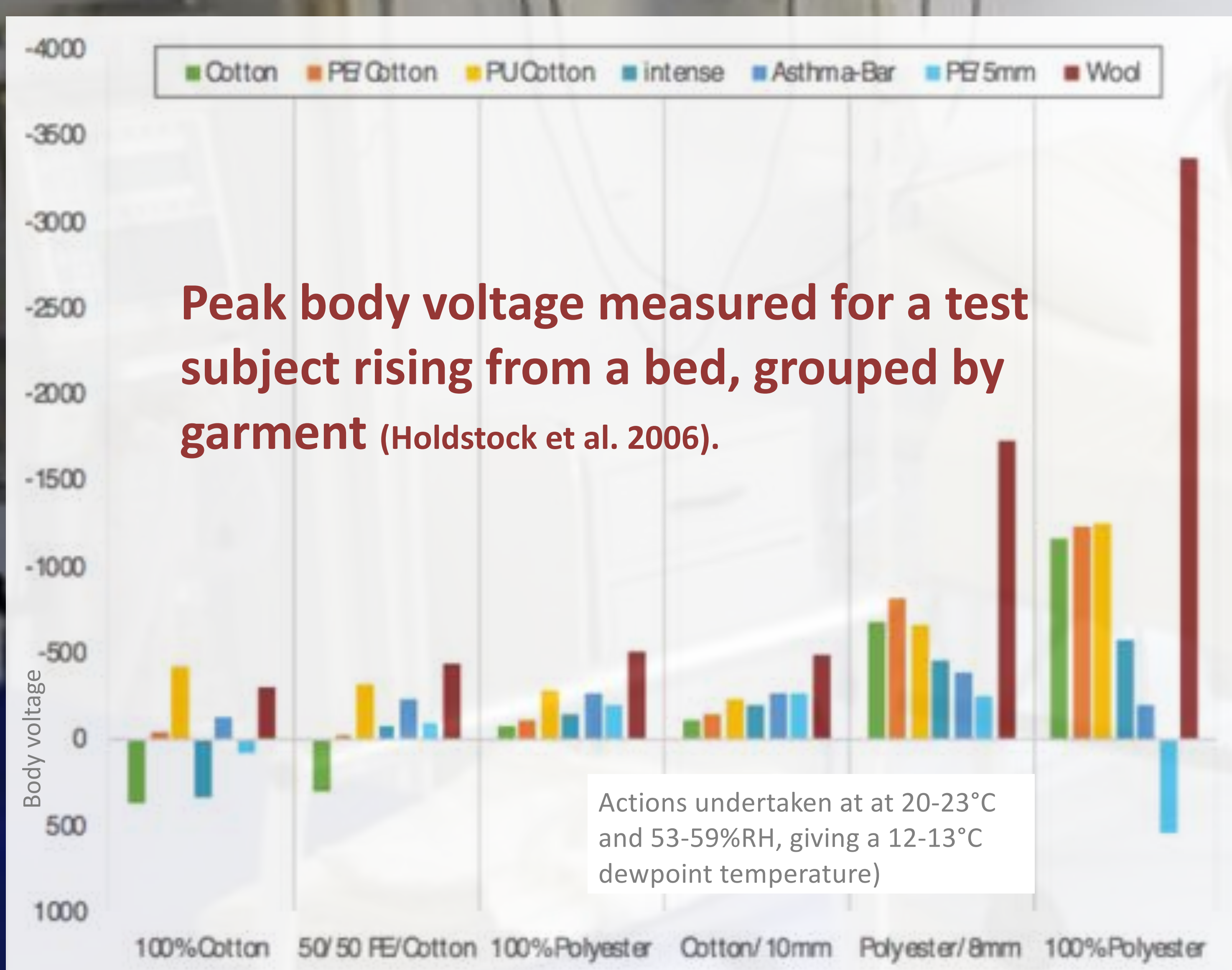
- Seating with cotton coverings are less likely to gain charge than standard fabrics. (Also try to wear clothes that do not generate charge easily).
- Electrostatic Dissipative (ESD) seating is also available. (These can feature specially conductive fabric or ESD vinyl coverings (Chairplan 2020)).
- Anti-static sprays or anti-static dryer sheets* can be used to reduce charge build-up on clothes and seating too.

Individuals can often generate high charge when sliding out of a seat as a result of frictional charging between their clothes and where they were sitting (Luttgens & Wilson 1997).

*Homemade versions of these can be inexpensively created. (The sheets are rubbed onto the fabric).

Furniture coverings can greatly contribute to charge generation (Electrostatic Solutions Ltd. 2011).

CLOTHING AND TRIBOELECTRIC / CONTACT CHARGING



Peak body voltage measured for a test subject rising from a bed, grouped by garment (Holdstock et al. 2006).

Particularly high charging can occur when materials at opposite ends of a triboelectric series are separated from each other.

- **Cotton is often a good choice to reduce charge generation. [Specialist materials are also available (Holdstock et al. 2006)].**
- Avoid wearing synthetics like acrylics, nylon and polyester if you can (IOP n.d.).

Suitable choice of materials can help mitigate against excess charge (Holdstock et al. 2006).

Triboelectric / Contact Charge Reduction

Treatment can reduce charge generation on both porous and non-porous surfaces. [Includes floors, work surfaces and furnishings].

- Some even effective at <15% Relative Humidity (ACL Staticide 2002-2005, 2001-2003).
- Anti-static treatments are available specifically for clothing, hair, and pets (Downy 2020, IGK 2020, Static Schmatic 2020).
- All-natural treatments are available (Static Schmatic 2020).

Treatments can be used to help reduce excess charge generation both indoors and in vehicles.

It is proposed that these kinds of treatments could be particularly useful in 'at risk' locations and areas where people congregate.

Try to avoid use of spray applications in high risk areas unless they have already been thoroughly disinfected.

REDUCING STATIC CHARGE ON HAIR

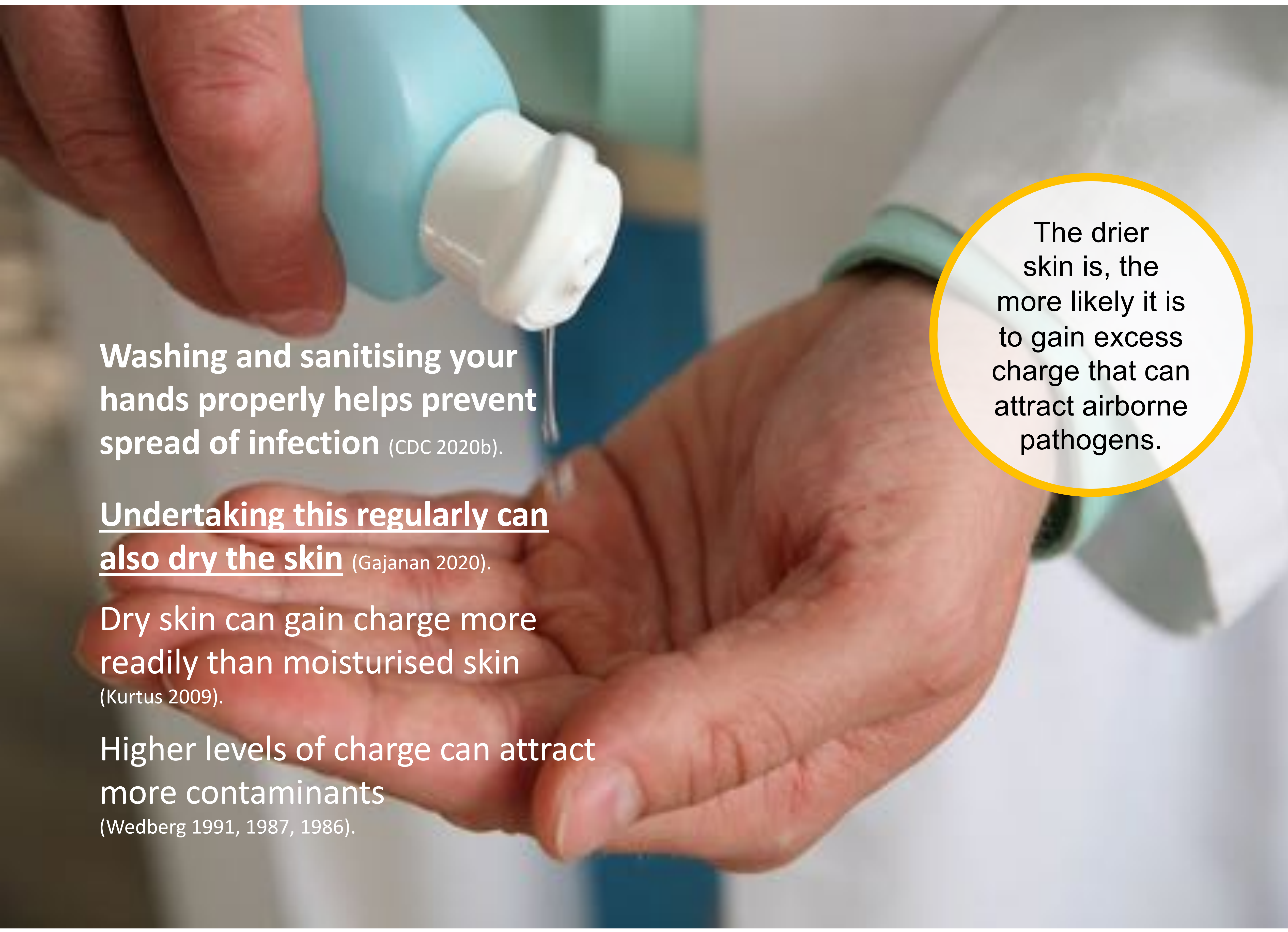
Coconut oil

- Rubbing a little coconut oil through your hair can reduce static charge.
- Coconut oil and its derivatives can also act as natural antibacterial, antifungal and antiviral agents (Dayrit & Newport 2020, Shilling et al. 2013, DebMandal & Mandal 2011).

The moisture level of your hair can influence the degree to which it may attract contaminants.

Other alternatives to reduce static charge in hair are available as well.

REDUCING STATIC CHARGE ON YOUR HANDS



Washing and sanitising your hands properly helps prevent spread of infection (CDC 2020b).

<u>Undertaking this regularly can also dry the skin</u> (Gajanan 2020).

Dry skin can gain charge more readily than moisturised skin (Kurtus 2009).

Higher levels of charge can attract more contaminants (Wedberg 1991, 1987, 1986).

The drier skin is, the more likely it is to gain excess charge that can attract airborne pathogens.

Moisturising your hands immediately after cleansing can help reduce skin dryness, charge build-up, pathogen deposition and skin scale release.

REDUCING CONTAMINANT LEVELS INDOORS

- Keep rooms as clean as practical.
- Avoid brushing up dust, as this increases contaminant levels in the air.
- Avoid using vacuum cleaners unless they have HEPA filtration.
- Using damp cloths and/or mops helps prevents dust becoming resuspended.*
- Follow manufacturer's guidance for cleaning electronics [if none given, consider careful cleaning with a soft damp cloth after unplugging. Avoid use of alcohol-based cleaners on screens, and avoid getting moisture in openings (McKean 2013)].

Routinely clean and disinfect frequently touched surfaces including: computer keyboards, desks, phones, handrails, and doorknobs (CDC 2020).

CC0 Image: Pickpik (n.d.), https://i1.pickpik.com/photos/39/647/693/cleaning-washing-cleanup-the-ilo-thumb.jpg

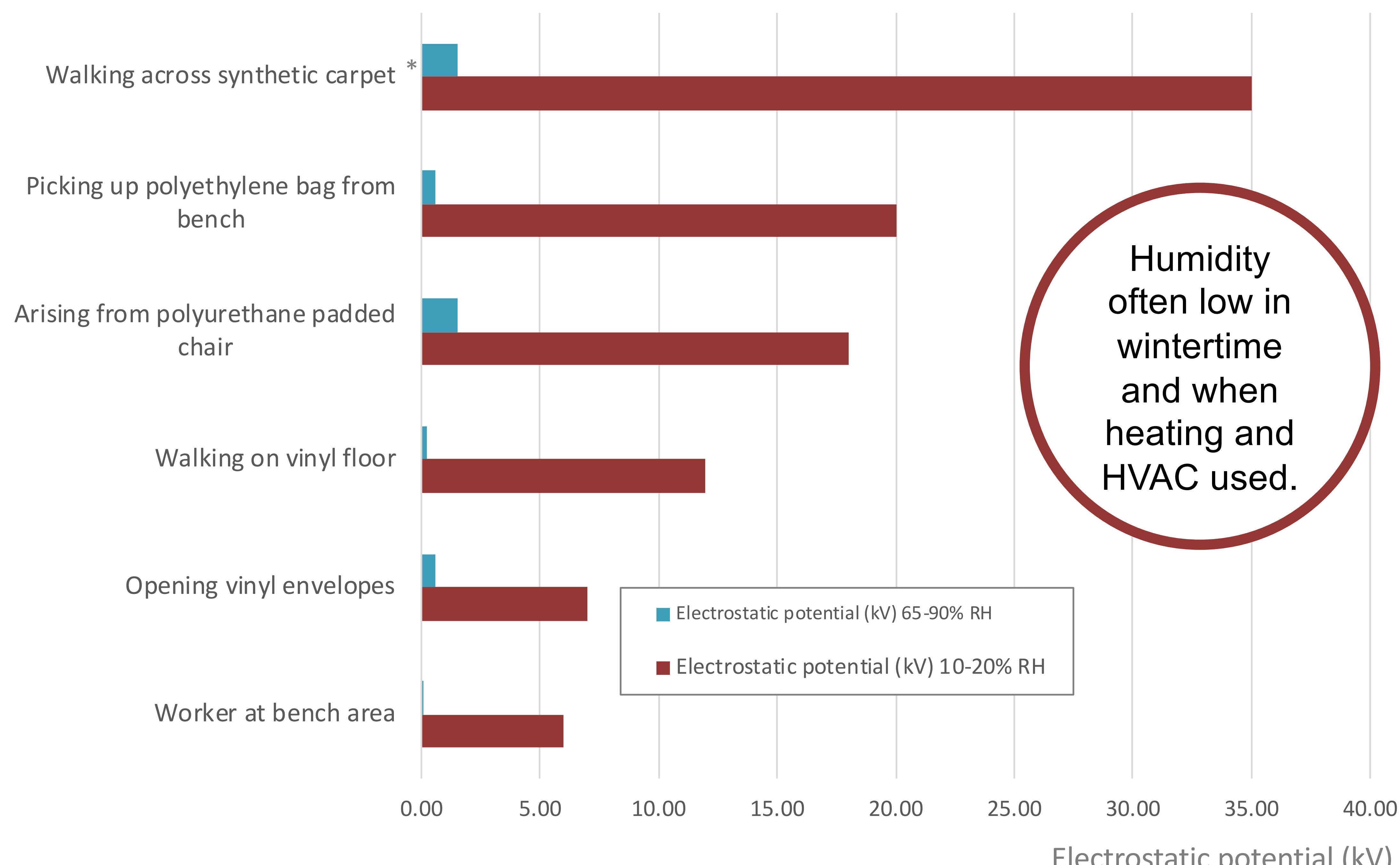
High field areas may often experience increased levels of pathogen deposition.

*For further details on cleaning measures related to COVID-19 refer to CDC (2020a), https://www.cdc.gov/coronavirus/2019-ncov/community/organizations/cleaning-disinfection.html

FRICTIONAL CHARGE GENERATED THROUGH EVERYDAY ACTIONS AT DIFFERENT HUMIDITIES

Higher electrostatic fields can arise when humidity is low

(Vonnegut 1973).



Sources: MHB (1994) and Moss (1987).

People often get electrostatic shocks at greater than 2 – 4 kV (University of Birmingham, n.d.).

Raised charge can increase the likelihood of contaminant deposition.

*Avoid shuffling your feet when you walk. If you do, even higher charges than those shown can be created!

WALKING BODY VOLTAGE AND EXCESS CHARGE

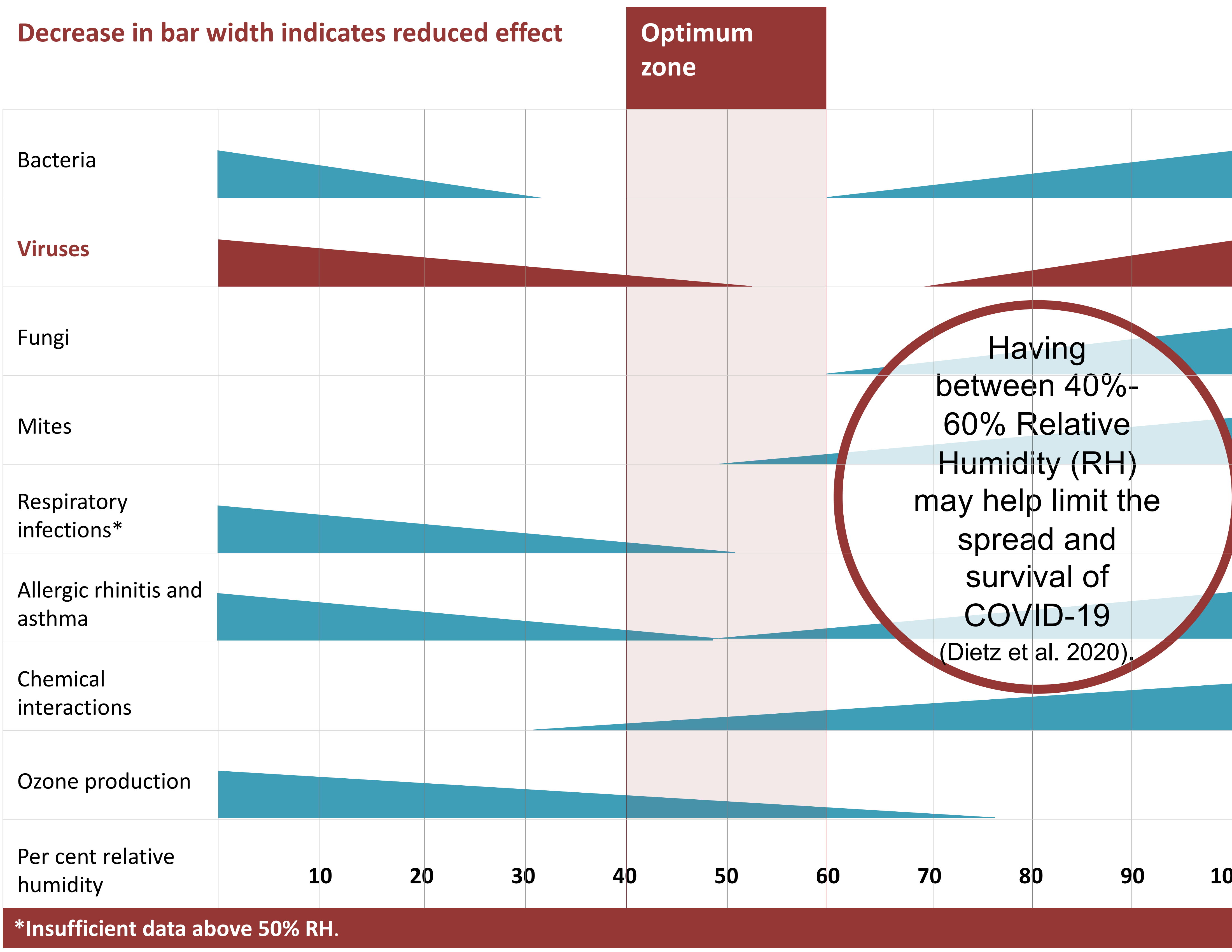
As people walk they can build-up excess charge due to friction between their footwear and the surface they walk on.

Raised 'walking body voltage' can remain until the person touches someone else or an object.

- When that contact is made electrostatic discharge arises.
- It can sometimes create an electric shock (Giuliano & Long 2005).

Excess charge can attract airborne pollutants.

EFFECTS OF HUMIDITY ON BIOLOGICAL CONTAMINANTS



Redrafted from Sterling et al. (1985).

There is an optimum range of between 40 and 60 % relative humidity where possible adverse health effects are most reduced.

In general both very low and very high humidity levels should be avoided.

Humidity Levels and Mortality Rates from Viral Infection

Percentage survival of mice kept under different relative humidity levels that had been exposed to influenza virus

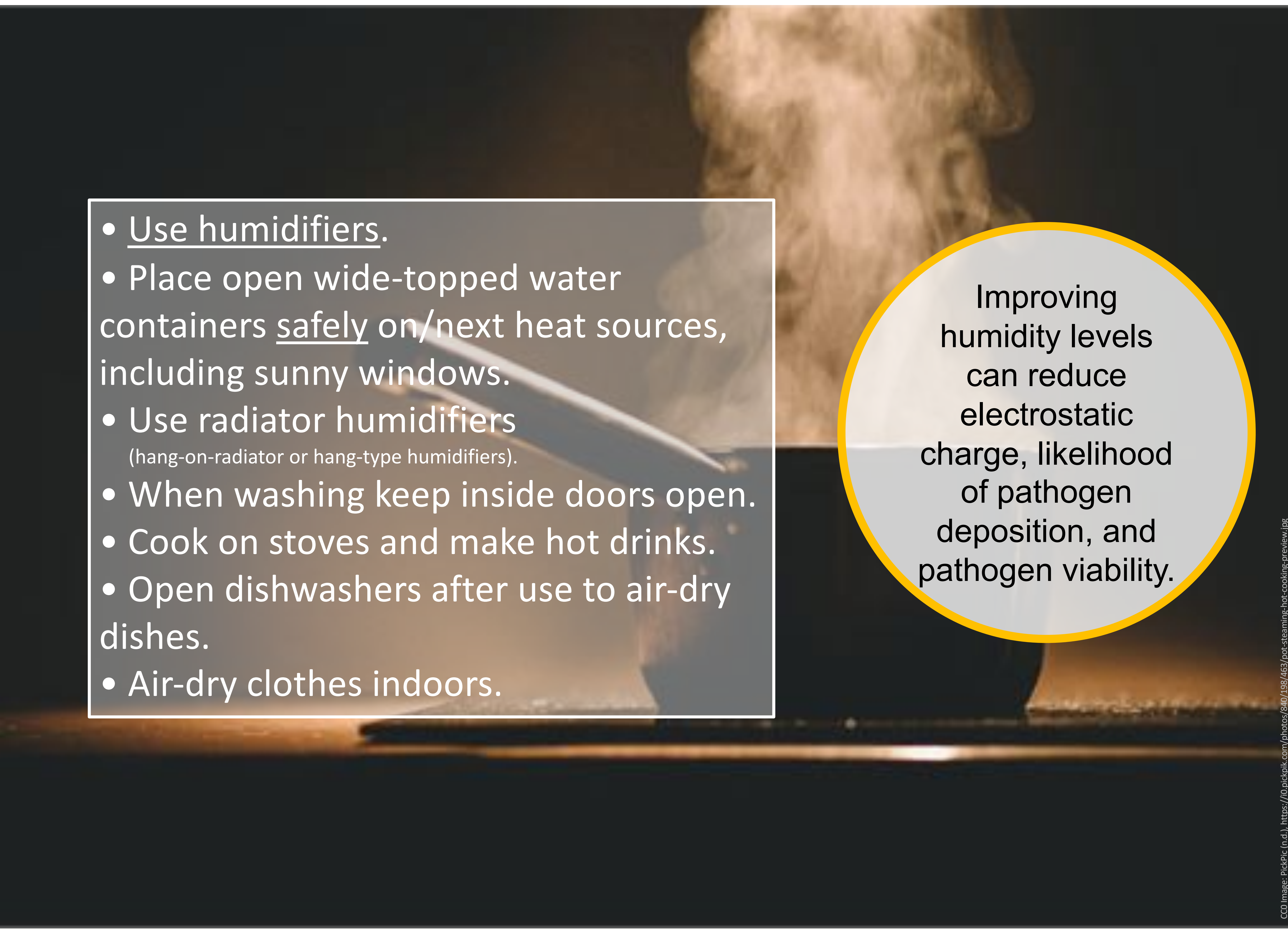
Redrafted from Kudo et al. (2019)

Low humidity levels increase the likelihood of test-animals catching influenza (Kudo et al. 2019).

A higher death rate was observed under the lower humidity exposure.

It has also been observed in humans that mucociliary clearance, which helps defend the respiratory system, can decrease in low humidity conditions (Oozawa et al. 2012).

How to Improve Humidity if the Air is Too Dry



- Use humidifiers.
- Place open wide-topped water containers safely on/next heat sources, including sunny windows.
- Use radiator humidifiers (hang-on-radiator or hang-type humidifiers).
- When washing keep inside doors open.
- Cook on stoves and make hot drinks.
- Open dishwashers after use to air-dry dishes.
- Air-dry clothes indoors.

Improving humidity levels can reduce electrostatic charge, likelihood of pathogen deposition, and pathogen viability.

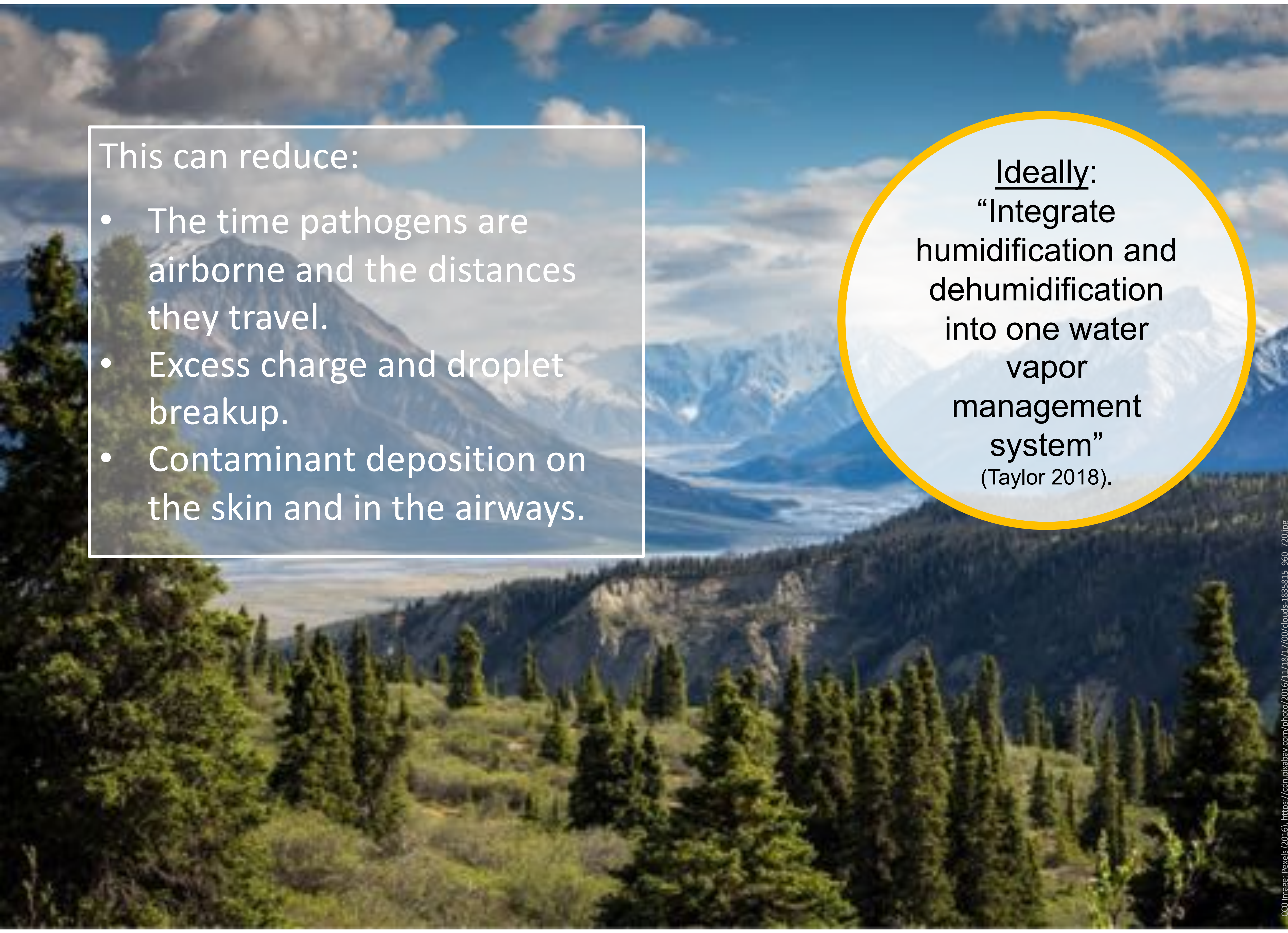
CC0 Image: PickPic (n.d.), https://i0.pickpik.com/photos/840/198/463/pot-steaming-hot-cooking-preview.jpg

- **Water spray bottles can be used for humidification too** (spray water into the air and not directly onto surfaces and not towards people).
- **Indoor fountains can also be used.**

Remember to avoid having humidity too high.*

*Hygrometers, which can be bought quite cheaply, can be used to let you check humidity levels.

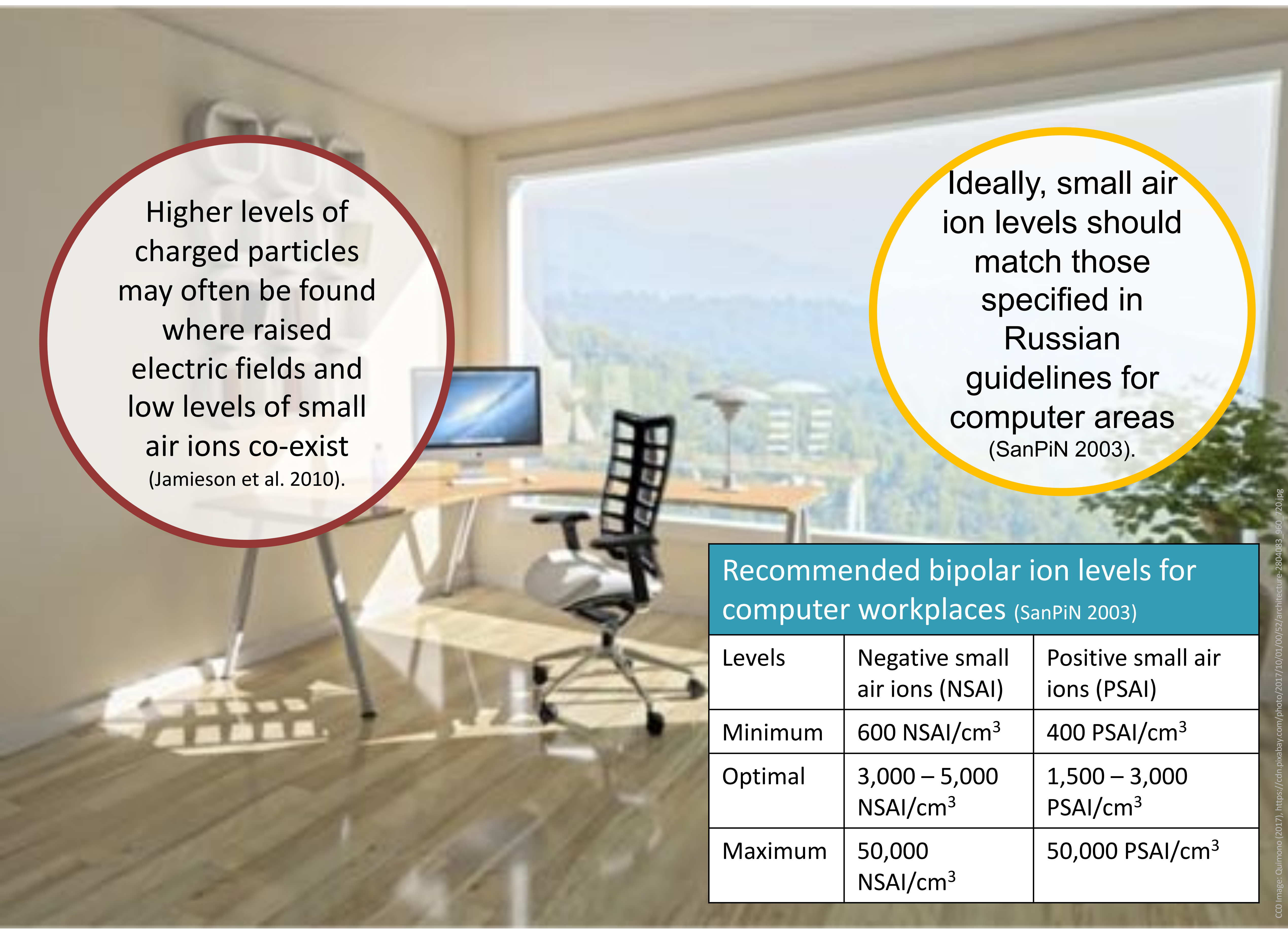
CREATE HUMIDITY LEVELS OF 40-60% RH INDOORS



" Moisture content in the air may … be the most important environmental factor influencing the survival of microbes". **Robert L. Dimmick, UC Berkeley** (Taylor 2018).

It may also be the most important factor with regards to reducing excess charge.

AIR IONS AND ENVIRONMENTAL QUALITY



Higher levels of charged particles may often be found where raised electric fields and low levels of small air ions co-exist (Jamieson et al. 2010).

Ideally, small air ion levels should match those specified in Russian guidelines for computer areas (SanPiN 2003).

Recommended bipolar ion levels for computer workplaces (SanPiN 2003)

Levels	Negative small air ions (NSAI)	Positive small air ions (PSAI)
Minimum	600 NSAI/cm^3	400 PSAI/cm^3
Optimal	3,000 – 5,000 NSAI/cm^3	1,500 – 3,000 PSAI/cm^3
Maximum	50,000 NSAI/cm^3	50,000 PSAI/cm^3

Bipolar ionisation can help reduce charge related deposition of pathogens
(Meschke et al. 2009).

CROSS-SECTION THROUGH HOME WORK AREA

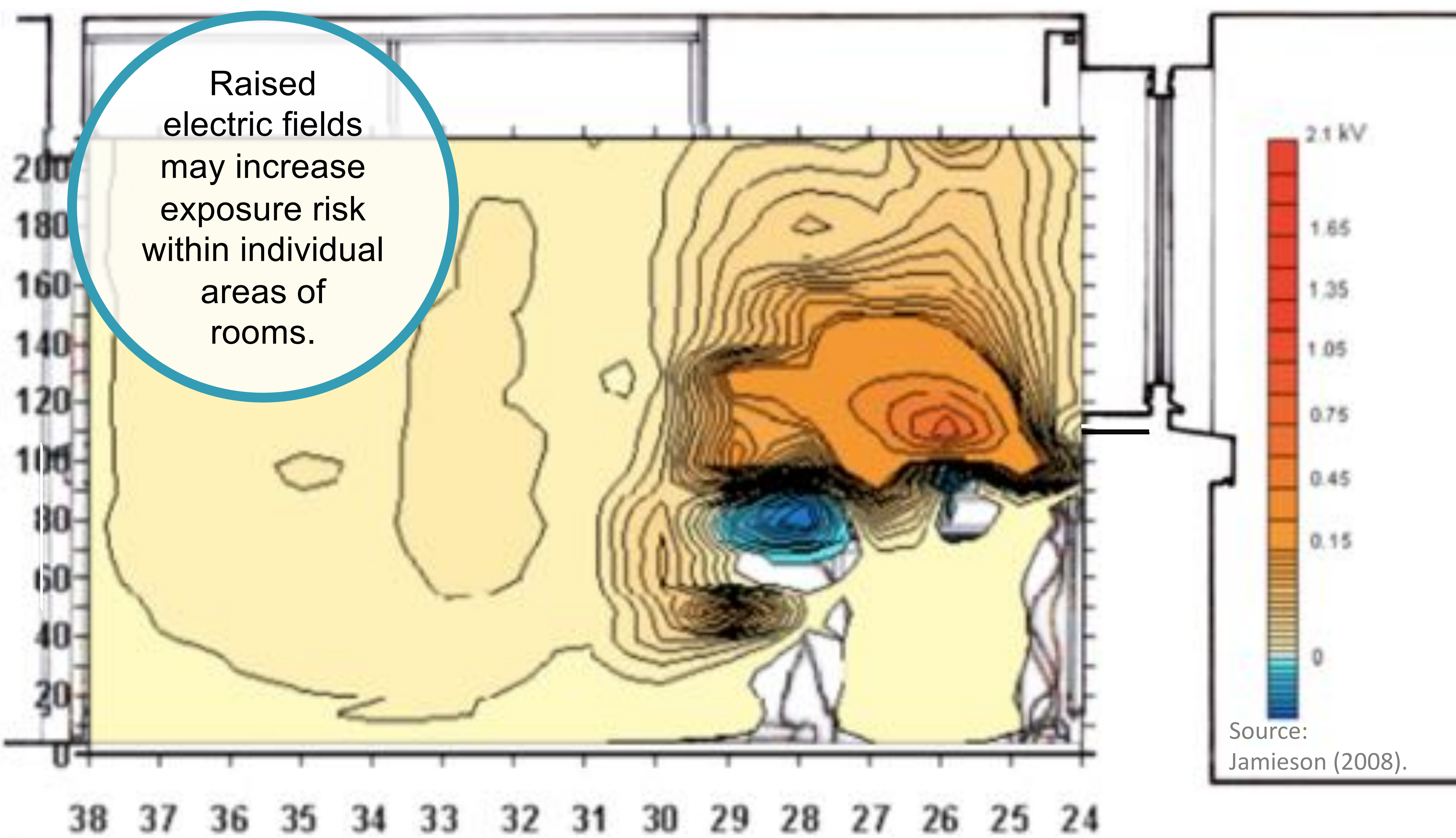
Improving electromagnetic hygiene can reduce risk.

Source: Jamieson (2008).

The electromagnetic characteristics of the micro-environments individuals occupy can influence the degree to which they may be exposed to contaminants.

EXCESS CHARGE AS AN INDICATOR OF RISK

Poorly designed electrical items and poorly specified surface finishes can increase the presence of excess charge.



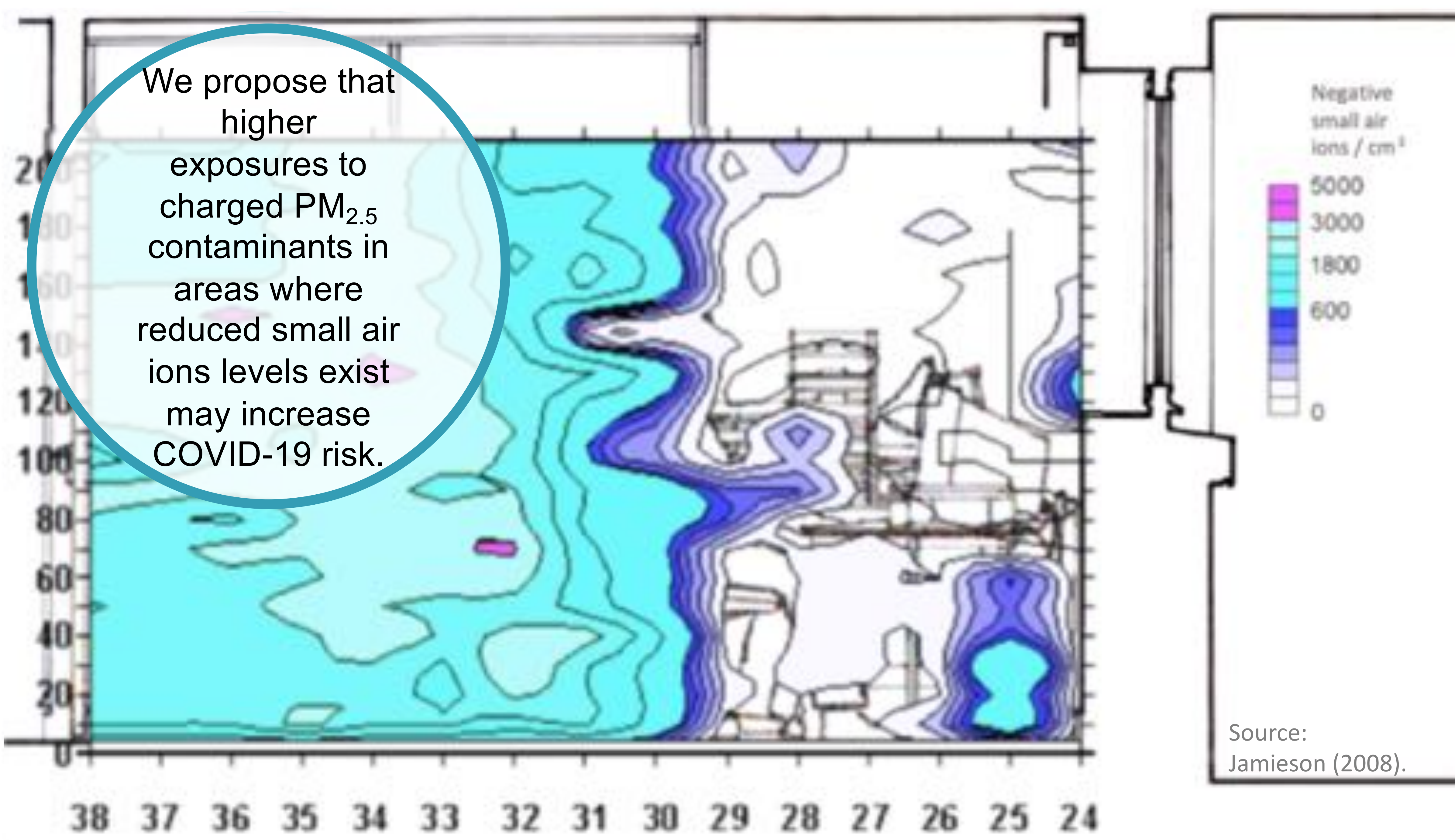
Source: Jamieson (2008).

Electrostatic fields recorded through work area with cathode-ray tube computer screen. (Modern computers create lower voltages than that shown).

Reducing electric field exposures reduces risk
[This includes unplugging what is not needed, avoiding electric cable contact with metal framework of desks, and earthing mains electrical equipment].

AIR ION LEVELS AS INDICATORS OF RISK

Reduced levels of small air ions are often found where raised electric fields exist, which can be indicative of increased levels of charged contaminants in the air.



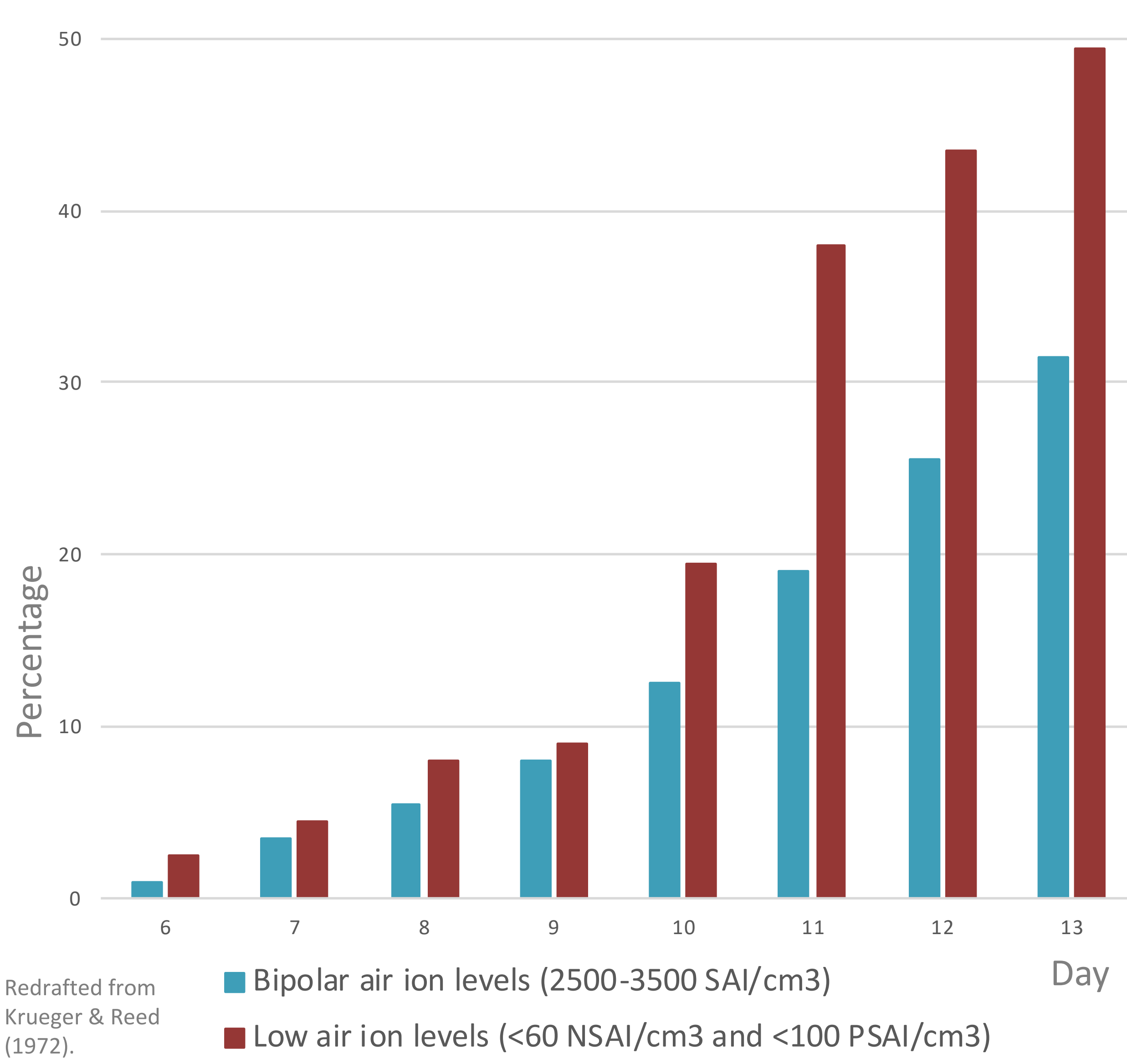
Source: Jamieson (2008).

"A small increase in long-term exposure to $PM_{2.5}$ leads to a large increase in the COVID-19 death rate" Wu et al. (2020a).

Optimising small air ion exposures can help reduce risk.

AIR ION LEVELS AND MORTALITY RATES AFTER VIRAL INFECTION

Day of death of mice infected with influenza virus kept under different small air ion (SAI) exposures



Redrafted from Krueger & Reed (1972).

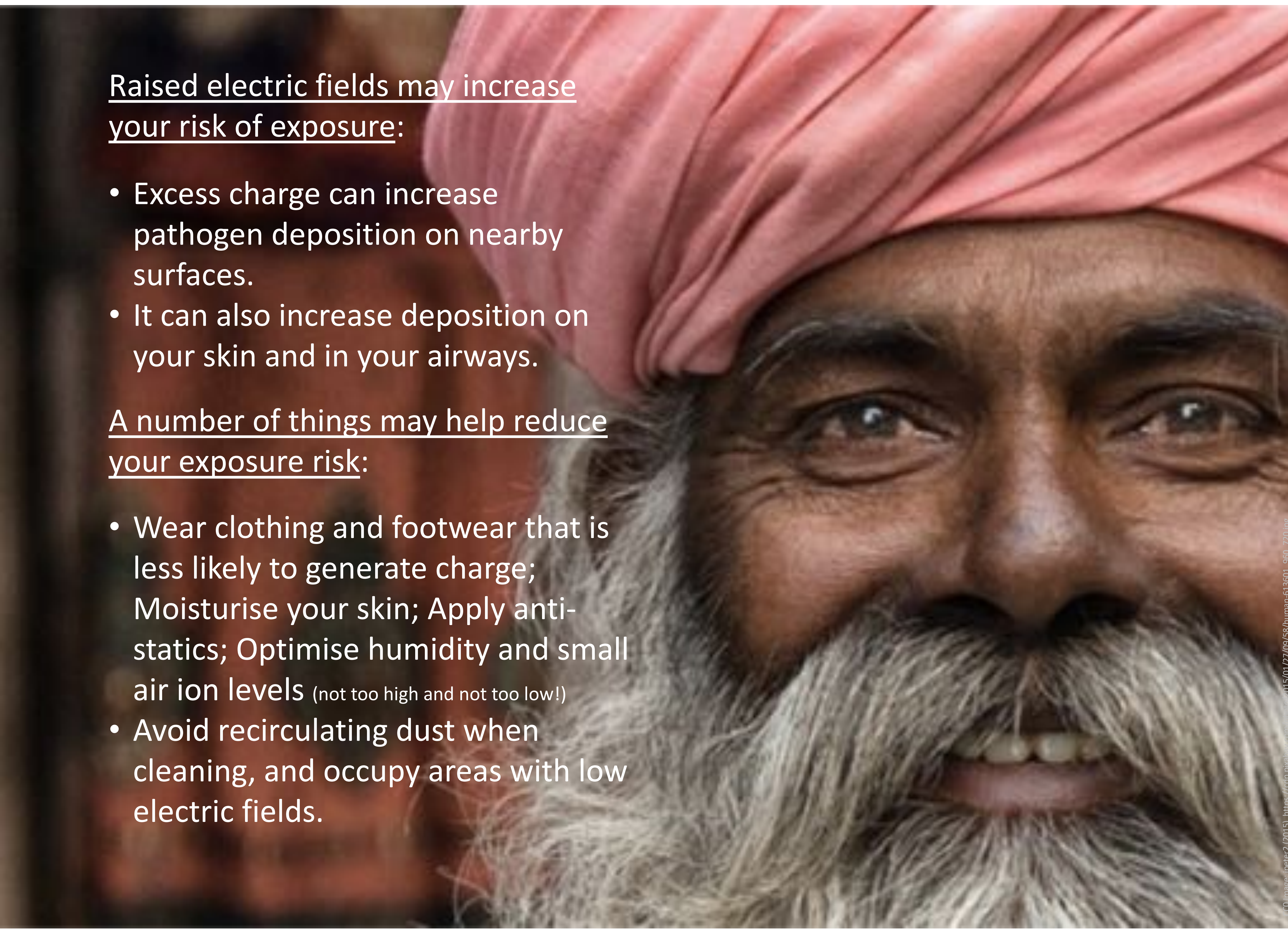
* The ratio of PSAI to NSAI was approximately 1.2 to 1 in that study.

SAI exposures can influence survival rates of animals with viral infection (Krueger & Reed 1972).

A reduced death rate was observed under the higher air ion exposure (Krueger & Reed 1972).

The levels of bipolar ionisation shown to help prolong life are similar to those recommended in Russian health guidelines (Jamieson 2008).

IN SUMMARY:



<u>Raised electric fields may increase your risk of exposure</u>:

- Excess charge can increase pathogen deposition on nearby surfaces.
- It can also increase deposition on your skin and in your airways.

<u>A number of things may help reduce your exposure risk</u>:

- Wear clothing and footwear that is less likely to generate charge; Moisturise your skin; Apply anti-statics; Optimise humidity and small air ion levels (not too high and not too low!)
- Avoid recirculating dust when cleaning, and occupy areas with low electric fields.

YOU CAN REDUCE YOUR OWN RISK.

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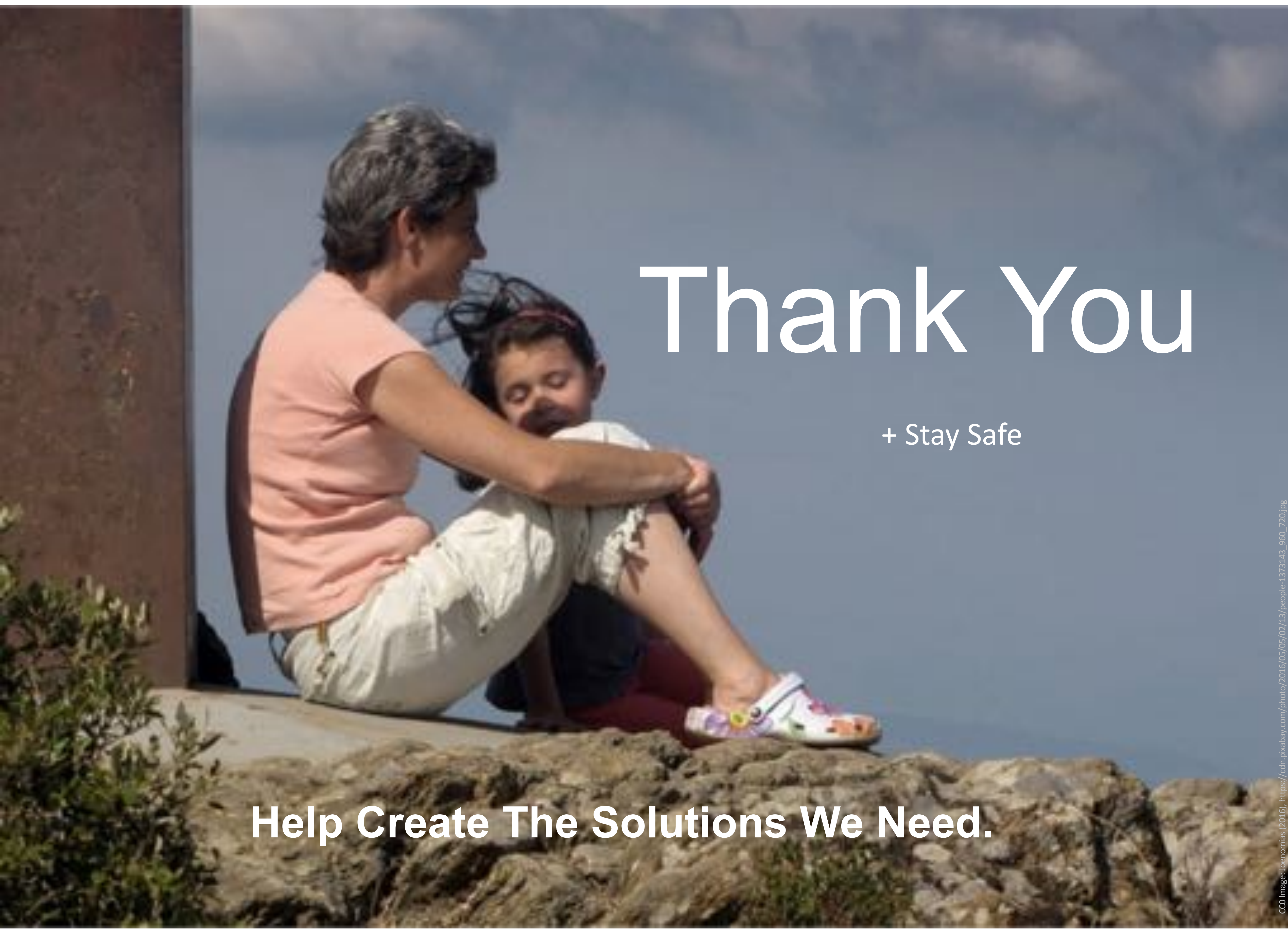

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