HUMIDITY IN THE WORKPLACE

The prerequisite for employee health and performance

Humidification
Dehumidification
Evaporative cooling

An important health parameter

Sufficient humidity in the workplace

Foreword

The right level of humidity makes a vital contribution towards various situations in daily life — in a business environment as well as in your private home.
The moisture content of the air is so important that in many countries there are clear guidelines for the operation and maintenance of humidification systems.

A narrowly defined range of 40 to 60% relative humidity has been scientifically proven to provide ideal conditions for health, performance, well-being and value retention.
In modern buildings with an impermeable building shell, central heating and ventilation systems, these limits cannot be met in everyday life without active humidification.
This brochure is intended to outline the medical principles for the correct air humidity as well as the positive health and economic effects that can be achieved through correct air humidification in workplaces.

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1 Why is the air so unpleasantly dry in winter?

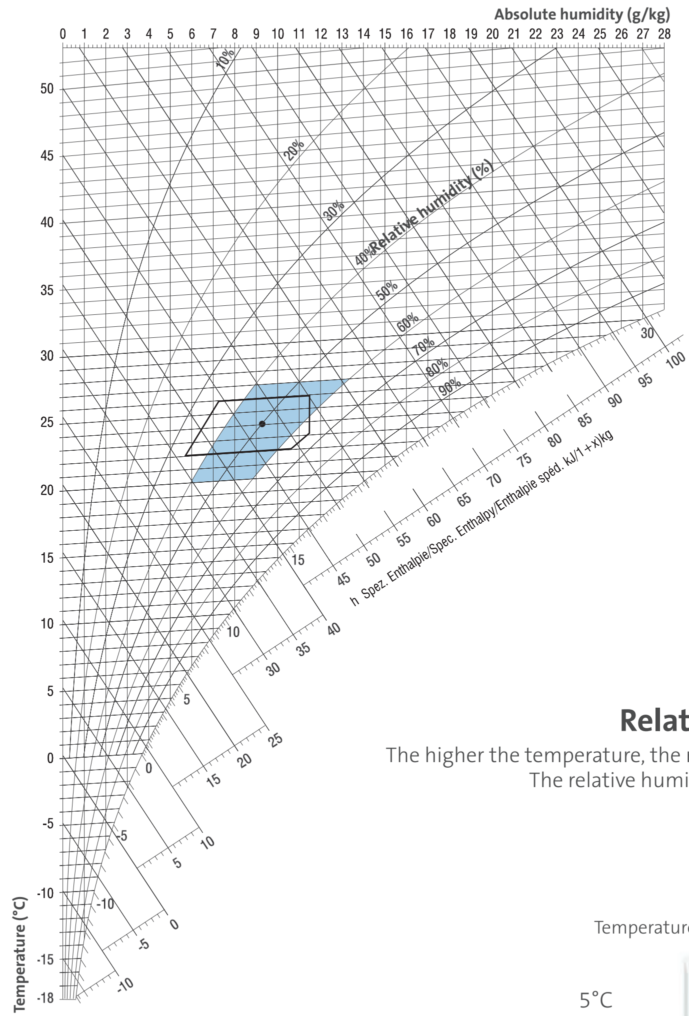
Everyone knows the unpleasant effects of excessively dry air: The skin becomes flaky and cracked, and the mucous membranes of the nose and throat, as well as the eyes dry out and become irritated.
This makes us feel uncomfortable and more susceptible to respiratory illnesses. But what are the reasons why room air is so unpleasantly dry, especially in the colder seasons?

A short digression into physics and thermodynamics provides answers.
Air always strives to absorb maximum moisture from the environment and to store this moisture as invisible water vapor.
For the resulting content of water vapor in the air, we use the term ‘relative humidity’ and the symbol φ.
φ = 1 (100% relative humidity) corresponds to a complete saturation of the air, for example after a long period of rain.
By contrast, if φ = 0, the air is completely free from water.

In these processes, however, the temperature of the air also plays a decisive role. The higher the air temperature, the more water can be bound to air and absorbed as vapor.
These physical relationships between air humidity and air temperature are shown in the so-called h,x diagram (see adjacent diagram).

As explained in the other chapters of the brochure, in order to avoid dehydration of the mucous membranes and to reduce health risks in winter, indoor air humidity should not fall below about 40%.
The example on pages 8 and 9 shows which factors frequently lead to extremely low and unhealthy levels of indoor humidity in winter.

h,x diagram according to Mollier to illustrate thermodynamic processes

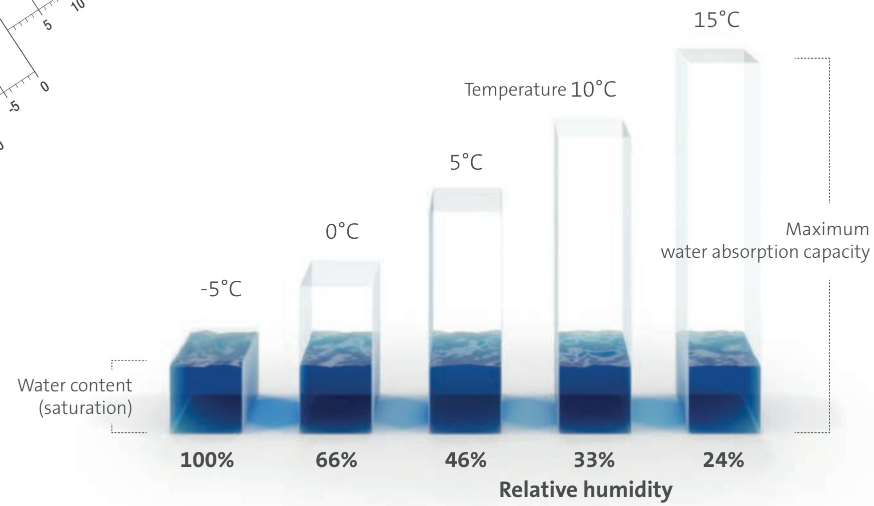


Comfortable indoor climate

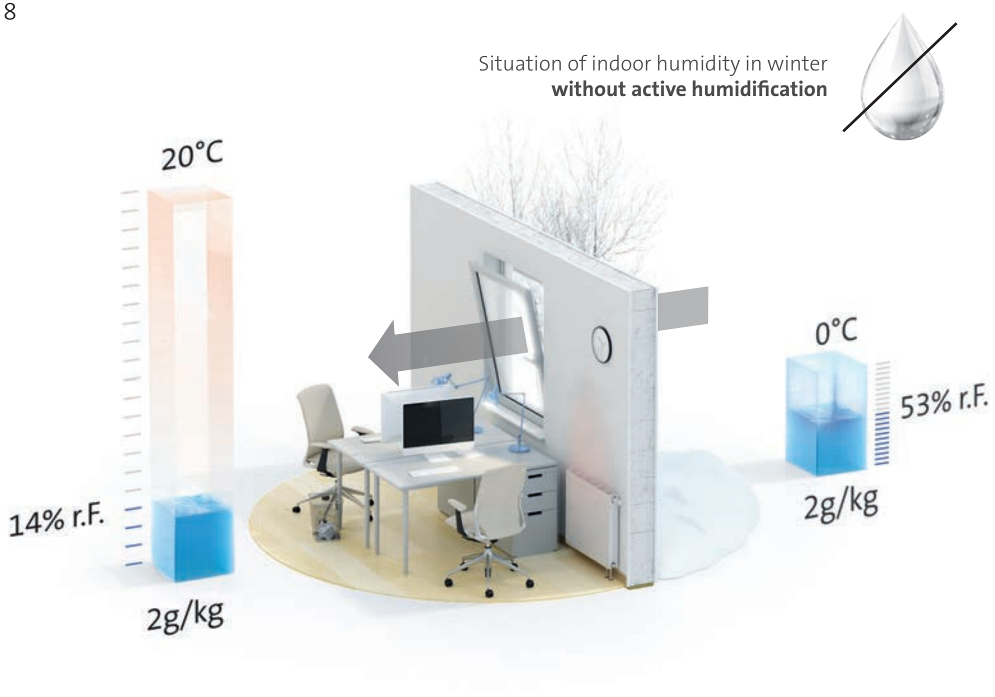
Recommended moisture range for health protection

Relative air humidity (%)

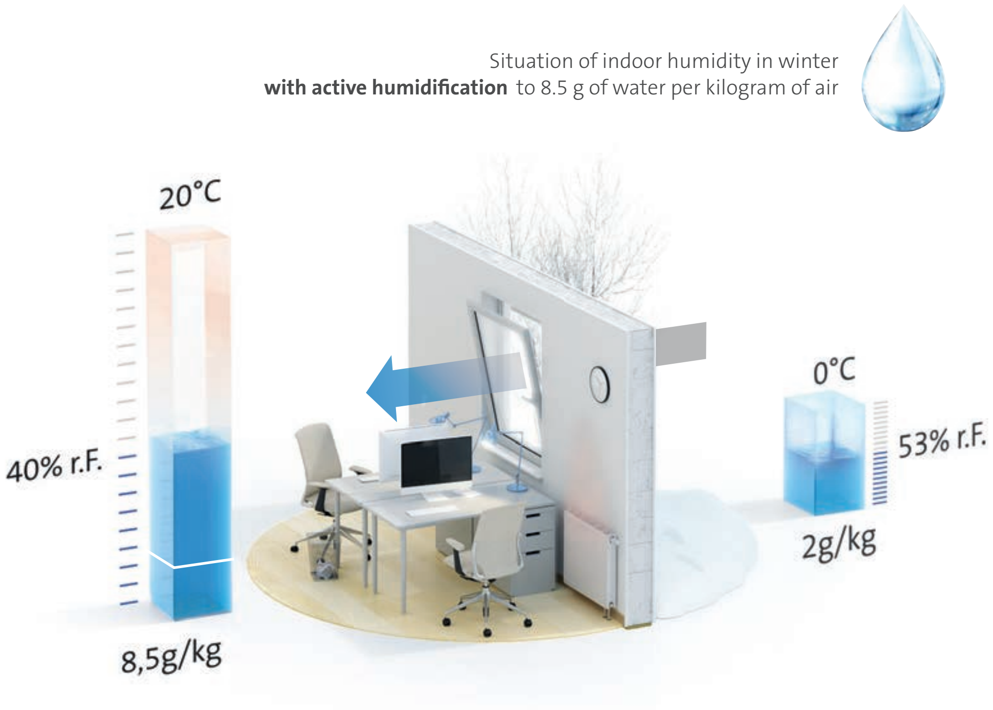
The higher the temperature, the more moisture air can absorb.
The relative humidity decreases in this process.



Situation of indoor humidity in winter
without active humidification



Situation of indoor humidity in winter
with active humidification to 8.5 g of water per kilogram of air



Here the outside air has a temperature of 0°C and a relative humidity of 53%. When a window is opened in an office or apartment with a temperature of 20°C and this cool outside air enters the room, it is also heated to 20°C by the heating system. As a result of this heating, the humidity drops to a mere 14%, as shown in the figure above.

In order to prevent such a sharp drop in indoor humidity and instead ensure a healthy and pleasant room air humidity of at least 40%, the dry room air must be continuously humidified in a controlled manner (see bottom figure with active humidification).

Humidification systems in ventilation units are particularly suitable for this purpose, as they condition the sucked in outside air precisely to a desired minimum level of supply air humidity. In buildings where there are no mechanical ventilation units, decentralized room air humidification units can be used.

Recommended air humidity range to protect the respiratory tract

In the h,x diagram on page 7, the comfortable indoor climate range is shown within black borders. This range is based on the results of numerous studies carried out worldwide and on specifications that were subsequently incorporated into technical rules such as standards and guidelines. Specialist planners base their planning and subsequent operation of air-conditioning systems on this comfort diagram as the target range for the best possible room comfort.

What does the blue area in the diagram show?

To ensure comfort, at room temperatures between about 22°C (winter) and 26°C (summer) the indoor humidity should always be between about 35% and 65%. Lower values are declared as “uncomfortably dry” and higher values as “uncomfortably humid”.
The pale blue field in the h,x diagram shows an extension of this comfort range to a room temperature range from 20°C to 27°C.
For optimum comfort and maximum health protection, it is recommended that the lower limit of relative room air humidity be raised to at least 40% (winter) and limited to a maximum of 60% in summer (humidity limit).
Reasons for these slight corrections to the comfort diagram are described subsequently in this brochure.

2 What are the consequences of low air humidity for human health?

Especially during the heating season, office workers complain about burning eyes, dry mucous membranes, difficulty swallowing, hoarseness, electrostatic effects and dry skin. In almost all cases, the cause is excessively dry room air.

There are a large number of worldwide studies dealing with the causes of loss of comfort, illness and reduced performance at high temperatures (> 26°C) and high humidity levels (> 65%) in office workplaces.

In addition, recent studies have provided further remarkable findings regarding the effects of insufficient indoor air humidity in the dry and colder winter months. Important results and findings from these studies are summarized below.

A low level of relative humidity keeps dust particles and the microorganisms and aerosols attached to them capable of floating for longer. At a higher level of relative humidity, bacteria are enclosed in water. This increases their weight, so that the particles sink to the ground faster, thus reducing the penetration of the particles into the respiratory tract.

The American scientists Lowen, Mubareka, Steel and Palese already discovered in 2007 that humidity has a significant influence on the transmission rate of influenza viruses. Within the range of 20 to 30% RH, the risk of infection is about 3 times higher than at 50% RH. In 2013, the team led by John D. Noti also demonstrated this connection with the study "High humidity leads to loss of infectious influenza virus from simulated coughs". At a humidity of 43%, the infectivity of the viruses was 15%, rising to 77% at a relative humidity between 7% and 23%.

The "Office Guide" ("Ratgeber Büro") produced by the German Office Network (Deutsches Netzwerk Büro) recommends a room humidity of 40% to 60%; the DGUV (German Social Accident Insurance) Guide 215–510 "Assessment of Indoor Climate" ("Beurteilung des Raumklimas") gives a comfortable humidity range of 45% ±15% and the information brochure of the DGUV 202-090 "(First-)Class Rooms for Schools" ("Klasse(n) – Räume für Schulen") states: "A good indoor climate promotes well-being, performance and concentration and boosts human health." It goes on: "What does a good indoor climate look like in numbers? Despite their individual perception of the climate, most people feel comfortable at a temperature of between 20 and 24°C and a relative humidity of between 40 and 65% (for activities with a high proportion of talk time)."

Thus the studies, guidebooks and brochures clearly document that office workplaces should have a room humidity of at least 40%

in order to offer employees a comfortable, healthy working atmosphere and thus minimize and prevent irritation of the respiratory tract, burning eyes, dry skin and the risk of illness.

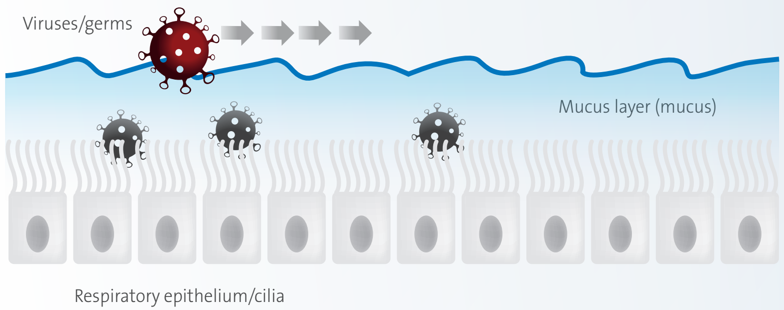
Study by Yale University

2.1 Effects of low humidity on susceptibility to influenza infections

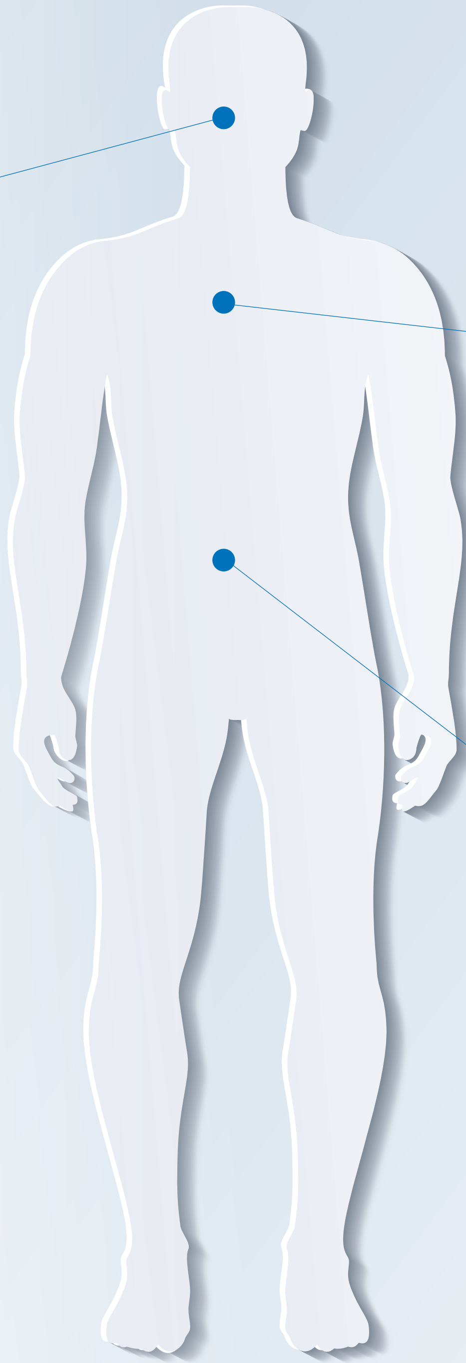
Dry air compromises the immune barriers that defend the body against influenza viruses.

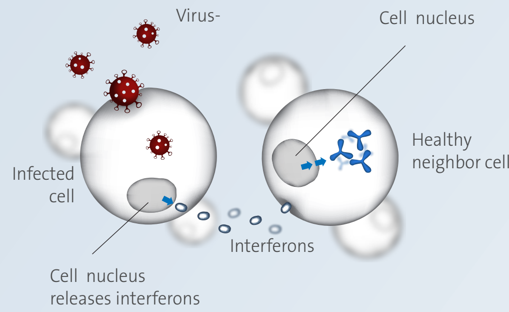
1. Mucous membrane barrier

The epithelial cells of the airways have cilia which are covered by a mucus layer. The majority of inhaled viruses, bacteria and toxic substances in the air adhere to this mucus. The cilia convey the mucus together with the microorganisms and toxic substances towards the larynx, where they can be coughed out or swallowed.



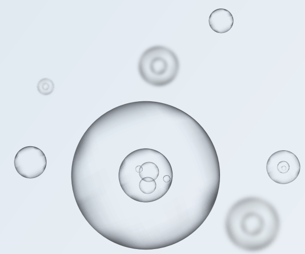
Conclusions of the Yale study:
In an environment with insufficient humidity, these three barriers become ineffective.
The severity of the infection increases at a low relative humidity, regardless of the viral burden.
In addition, low air humidity inhibits the ability of human cellular tissue to repair itself.





2. Innate immunity (early phase of infection control)

Microorganisms that have been able to cross the first line of defense are recognized and destroyed by white blood cells, the “police officers” of innate immunity. The scavenger cells release messenger substances (interferons), which trigger the production of proteins with which they jointly combat the invading microorganisms.



3. Acquired immunity (late phase of infection control)

In the late phase of the infection, when the first two barriers have been crossed, pathogen-specific antibodies are formed. This acquired immune response emanates from B and T lymphocytes, triggered by vaccinations or previous infections and stored in the immunological memory.

2.2 The influence of humidity on the spread of germ droplets

Germ droplets are tiny droplets that contain pathogens and are capable of floating. When breathing, sneezing or coughing, they enter the room air via the respiratory tract and can transmit pathogens such as flu viruses to other people.

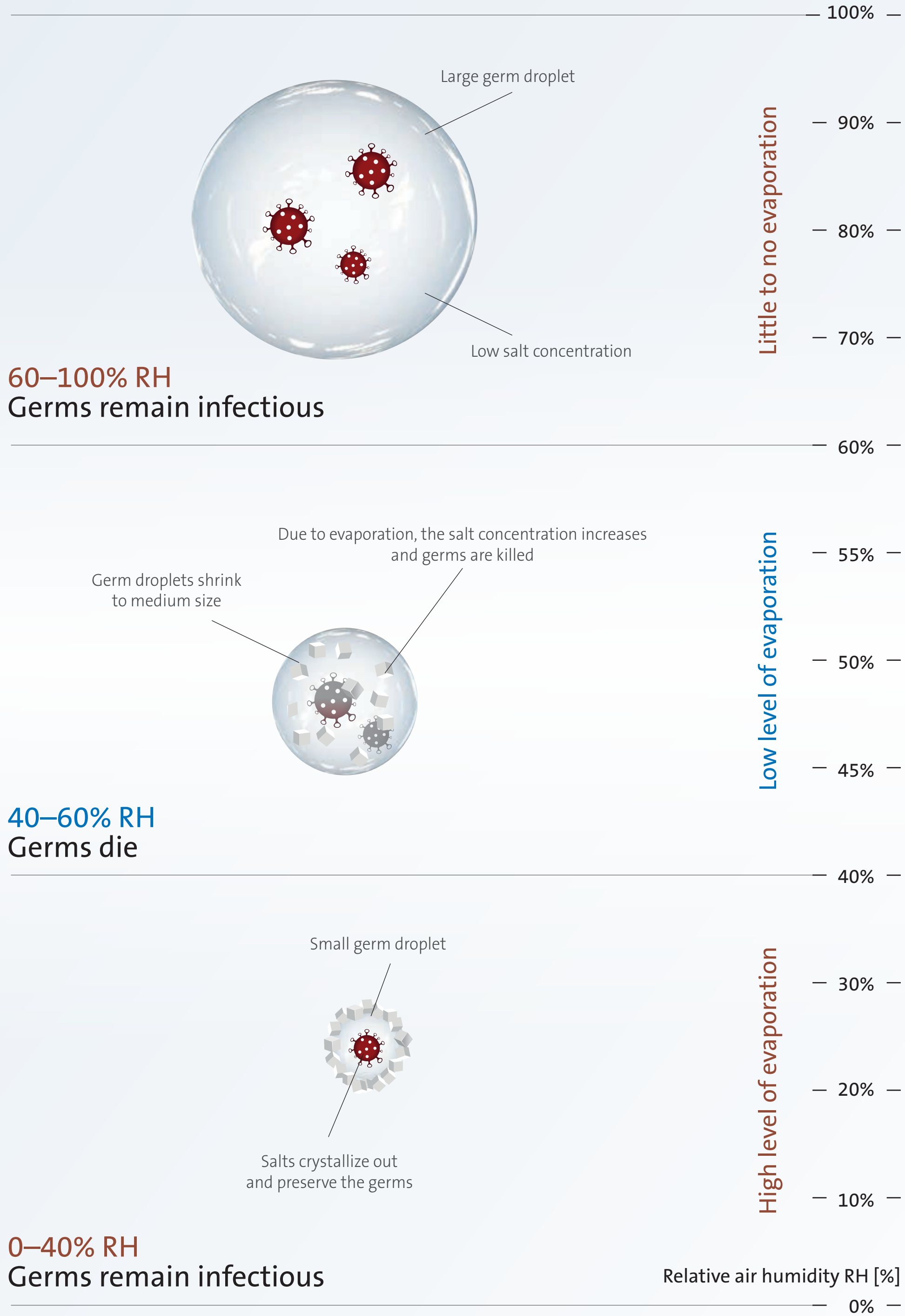
The room air humidity plays a decisive role in the capacity of the germs to survive and the floating behavior of the droplets. Dry room air with a relative humidity proportion of under 40% allows tiny droplets that are loaded with pathogens to dry up quickly.

As a result, the pathogens are preserved and remain infectious for a very long time.

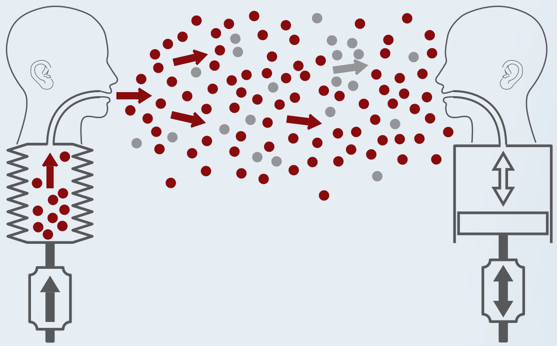
Within the optimum range of 40 to 60% relative humidity, aerosols shrink in the evaporation process only to such an extent that the salt concentration in the droplet rises sharply and the pathogens contained therein are killed.

2.3 The physics of germ droplets

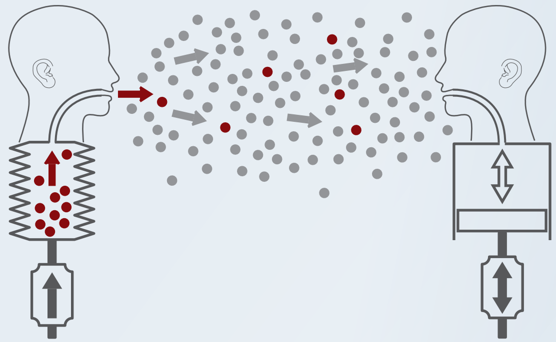
Humidity range	Ability to float	Length of stay	Risk of infection
60–100% RH	Large germ droplets sink and settle quickly	Short length of stay in the room air	Due to the low salt concentration in the water, the germs remain infectious
40–60% RH	Medium sized germ droplets with low ability to float	Short length of stay in the room air	High salt concentration kills the germs
0–40% RH	Small germ droplets remain capable of floating	Long length of stay in the room air	Salts crystallize out and preserve the germs



At a room humidity of 7–23% RH, the **infectivity** of entered germs after 60 minutes is **77%**



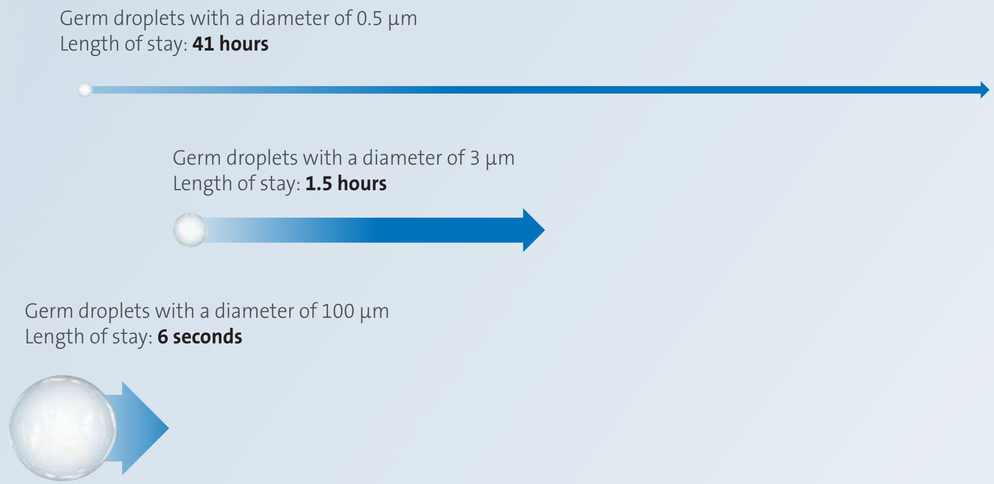
At a room humidity of 43% RH, the **infectivity** of entered germs after 60 minutes is minimal at **15%**.



2.4 The infectivity of germ droplets

Humidity has a major impact on the infectivity of germ droplets. At intermediate humidity levels, the risk of infection is minimal and increases rapidly with dry room air.

Source: Study: "High humidity leads to loss of infectious influenza virus from simulated coughs", by Dr. John D. Noti; see also page 32



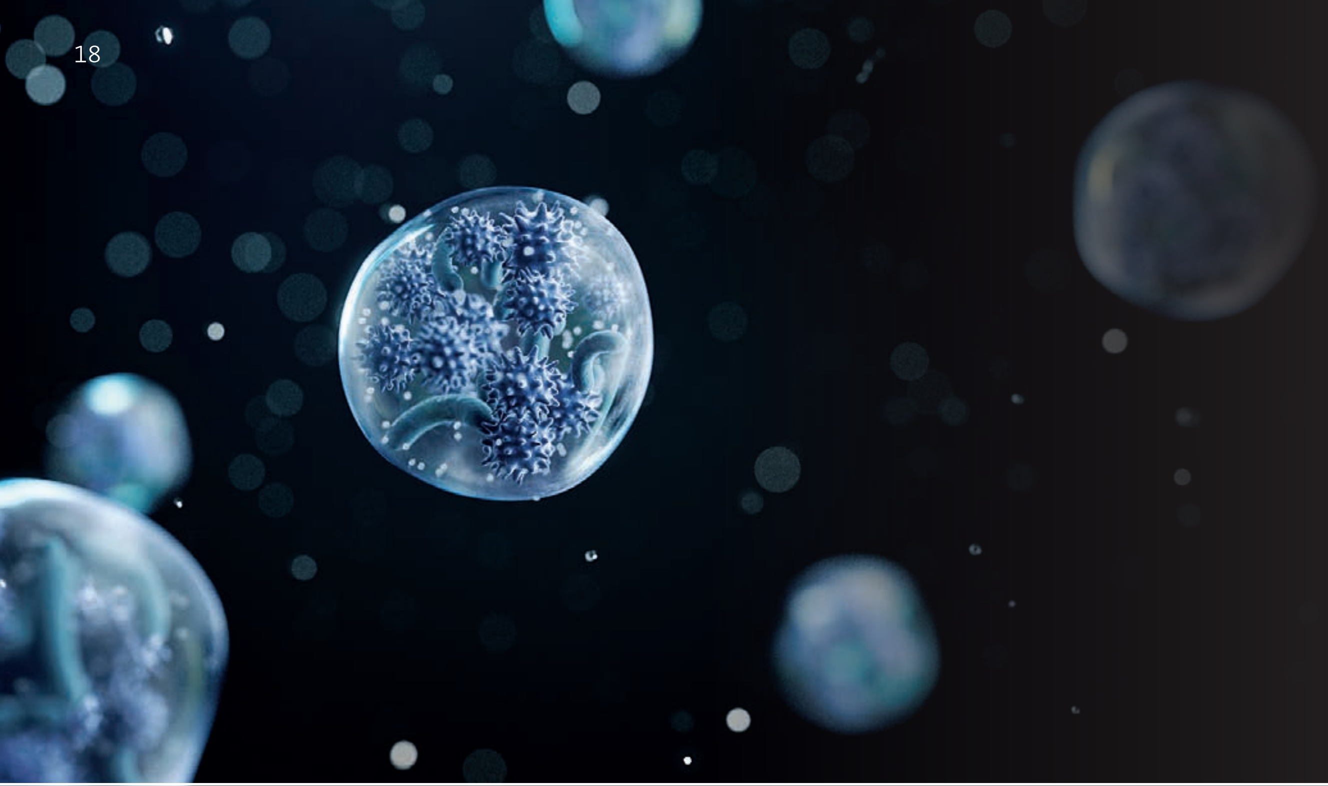
2.5 The length of stay of germ droplets in the air

When coughing and sneezing, pathogens such as flu viruses can be veritably shot into a room via germ droplets at speeds of up to 20 m/s and transferred to other people through inhalation.
The room humidity plays a decisive role in the floating behavior of the germ droplets. In dry room air, germ droplets shrink to diameters well below one micrometer and remain capable of floating for days.

As a result, the capacity of the pathogens to survive inside increases and at the same time the ability of the germ droplets to float increases sharply.

Germs can then "survive" for many hours. So if anyone who has a cold coughs or sneezes into a room that is too dry, this generates a contamination atmosphere that lasts for hours.

Source: Stephanie Taylor, MD, Taylor Healthcare Consulting

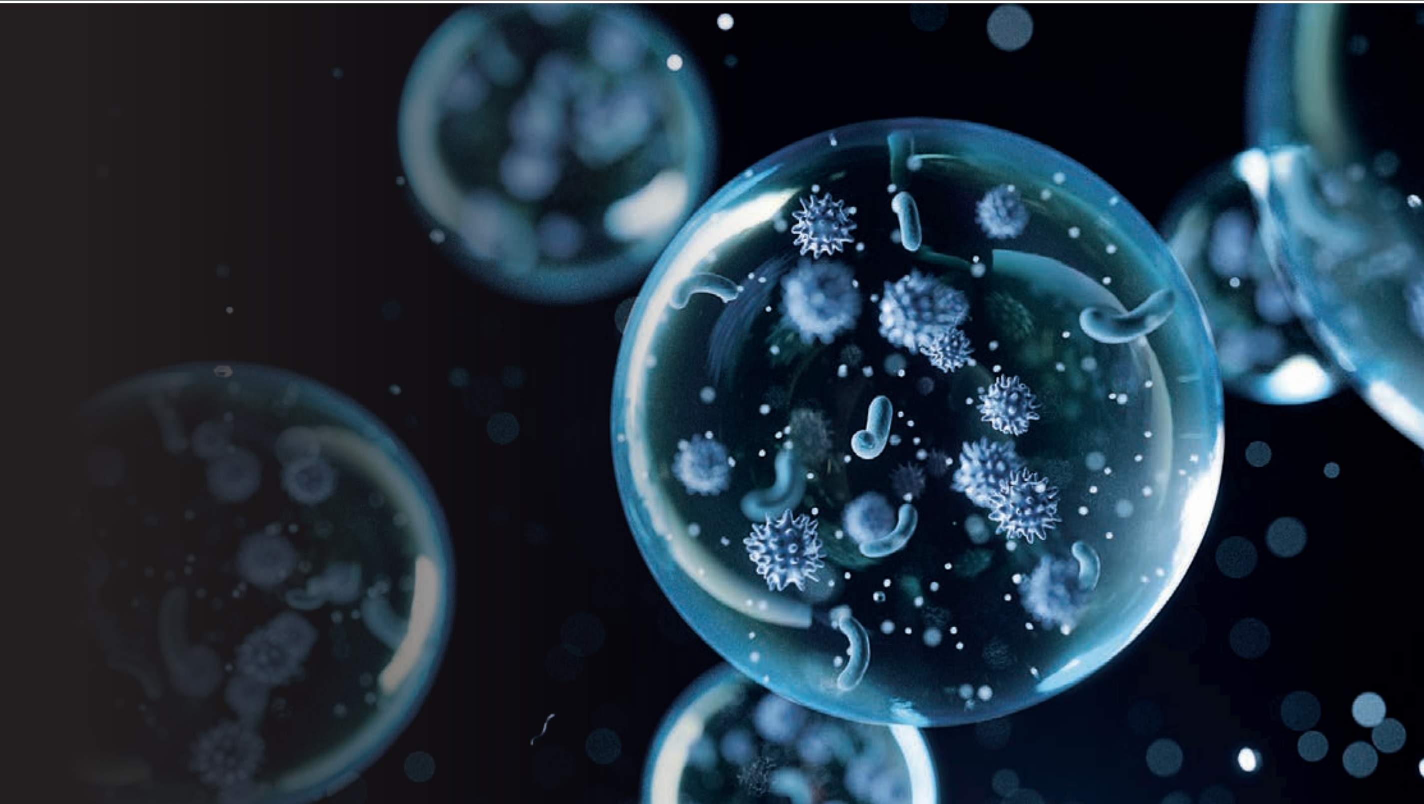


Germs love dry air

In dry air, germ droplets contract and dry out.
This preserves pathogens and keeps them capable of floating and highly infectious for a very long time.

Humid air kills germs

At optimal humidity (40–60% RH) the salts in the water of the germ droplet remain dissolved.
The salt concentration inside increases to such an extent that pathogens are inactivated within a short time.



3 Can plants increase the air humidity?

As an alternative to controlled air humidification, attempts are often made in office workplaces to increase air humidity by using plants. But is such an approach really helpful and effective?

The DGUV (German Social Accident Insurance) Guide “Climate in the Office” (“Klima im Büro”) contains an example with a sobering outcome: **Only in rare cases can plants help to significantly increase the humidity in a room.**

When outside air (-4°C, 50% relative humidity) flows into a 20 m² room (22°C, 50% relative humidity) at an air exchange rate of 0.5 per hour, the humidity in the room is reduced to 29% after one hour. In order to maintain the previous room humidity of 50%, the room air must be humidified with 230 g of water per hour. Typical office plants can achieve an evaporation rate of about 10 g of water per m² of leaf surface area per hour. Therefore, in this example, a large number of plants with a total leaf surface area of 23 m² would be needed to restore the original humidity of 50% in the office.

The office would become a jungle. A healthy room air humidity can be achieved much more easily and safely with active humidification systems.

Temperature = 22°C
Relative humidity = 29%

Temperature: 22°C
Relative humidity: 50%

To supply 230 g of water per hour to the room air, **16 plants** are required.

Study by the Fraunhofer Institute

4 How do employees assess the humidity in the workplace?

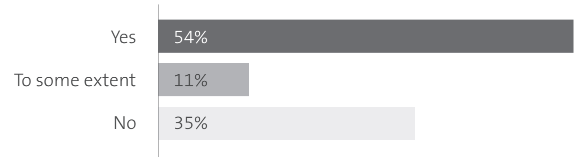
The Fraunhofer Institute for Industrial Engineering (IAO) examined the previously described negative aspects of room humidity that is too low compared to good room humidity levels in the two-year study “Humidity in the office workplace”. The results of this study clearly show that people in offices without controlled humidification complain about problems caused by excessively dry air,
which impairs their well-being, health and performance. On the other hand, a higher room air humidity was rated by the respondents as positive and pleasant.

Structure of the study
For the study, the humidification system in an existing building was switched on and off for several weeks at a room temperature of about 22 to 23°C. With controlled humidification, the relative room air humidity was around 40%, otherwise the humidity in the building was only around 23 to 28%. The evaluation of the respective working environment by the users was based on a five-point scale from “agree completely” to “do not agree at all”. The adjacent graphs show a summary of important results of this study.

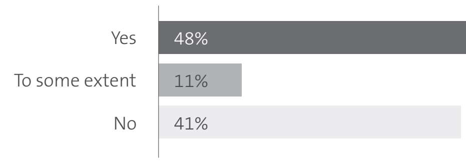
As the data shows, with an active increase of the room humidity to about 40%, none of the respondents considered the humidity to be too low — in fact for 84% the humidity was good.
In contrast, 77% of the participants felt that the humidity was too low when the humidification was switched off. In addition, 54% of the interviewees rated the humidification of indoor air as very refreshing. When evaluating the symptoms of “dry respiratory tract” and “burning eyes”, the results in the humidified rooms were also significantly better by about 20% each. The Fraunhofer study thus clearly confirms the negative impact of insufficient room air humidity on the general well-being, possible eye irritation and dryness of the mucous membranes. For all the symptoms surveyed, the respondents expressed significantly fewer complaints in the offices humidified to 40% relative humidity. In addition to good indoor air quality and a comfortable temperature, the humidity in the workplace is therefore an important factor in increasing well-being and reducing health risks in office workplaces.

Perception with humidification switched off:

Do you often have dry airways when working?



Do you often have burning eyes when working?



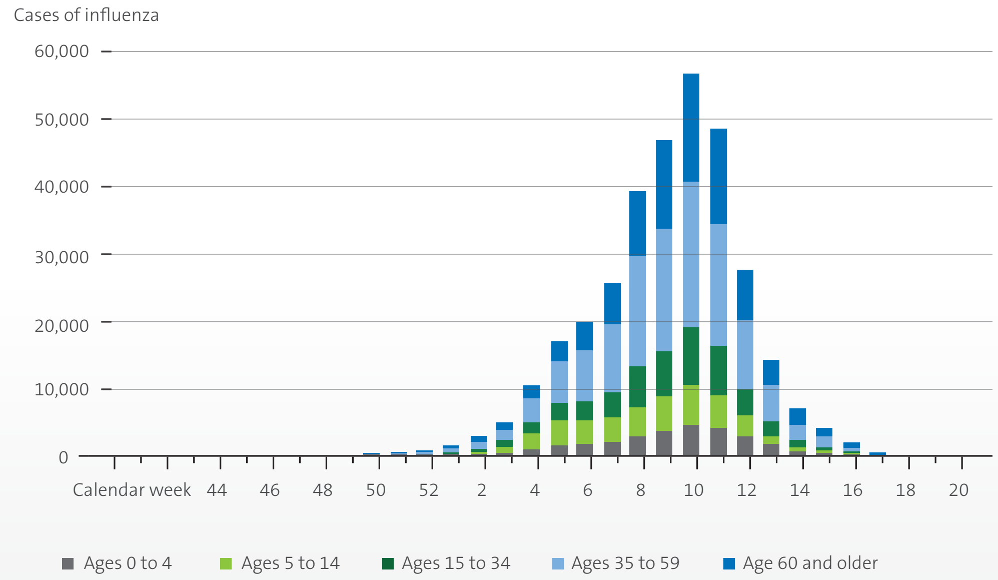
5 Low air humidity has a major impact on the spread of influenza viruses

The previous chapters have described the negative effects and risks of insufficient humidity levels on the well-being and health of people. However, these aspects are only part of a major global problem. According to a new study, low air humidity considerably promotes and increases the spread of flu viruses (influenza) and thus the risk of infection and an often severe or even fatal disease.

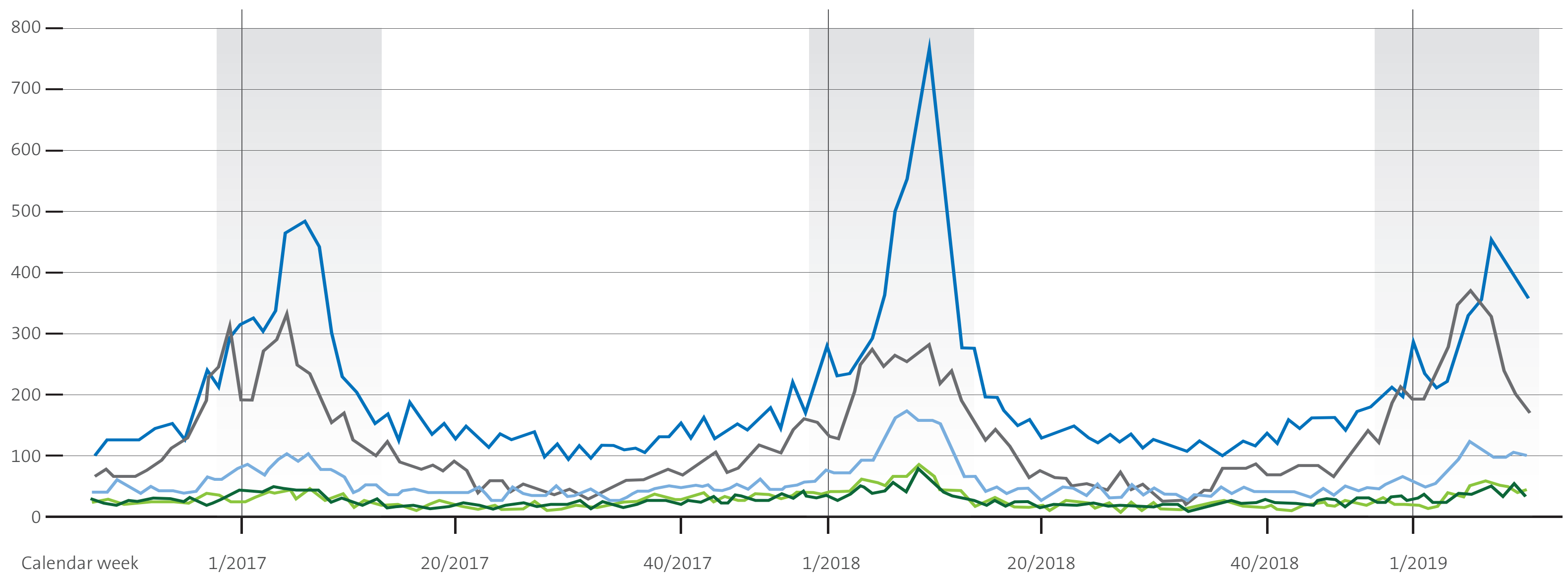
For many years, in its reports on the epidemiology of influenza, the Robert Koch Institute (RKI) has been recording cases of illness and death caused by influenza in Germany. In the report for 2017/2018, the Institute came to the following conclusions (see diagram: Number of acute respiratory infections):

- The flu epidemic started towards the end of the year (calendar week 50), reached its peak in February and March (week 6 to week 12) and then slowly subsided in April.
- In 2017/2018, the RKI registered around 9 million visits to doctors and 45,000 hospital admissions caused by influenza. In addition, the Institute estimates a further 5.3 million influenza-related sick days without a medical certificate from a doctor.
- The flu affects people over 35 years of age particularly severely. According to RKI, the data for 2017/2018 shows a huge increase in the number of flu cases by 2 million cases compared to the previous peak years of 2012/2013 and 2014/2015! The graph shown here is a statistic by the Robert Koch Institute on influenza-related sick leave in the year 2017/2018. It shows a clear peak in the cool, dry seasons between December and March (332,873 reported cases of illness were evaluated here).

Number of cases of influenza reported to the Robert Koch Institute in the period from calendar week 40/2017 to week 20/2018



Number of acute respiratory infections



Study by Yale University / May 2019

6 New study by Yale University shows that dry room air increases the effects of influenza

The graphs on page 25 show a significant correlation between flu cases and low humidity levels from December to April. Whether this connection actually exists has also been a controversial topic of discussion in medicine. Further proof has now been provided in 2019 by researchers from the renowned American Yale University in their study "Low ambient humidity impairs barrier function and innate resistance against influenza infection".
The most important findings already visualized on pages 12 and 13 are:

- The connection between low humidity levels and the ability of influenza viruses to survive and spread exists and has been clearly demonstrated.
- Insufficient air humidity reduces the self-cleaning mechanism of the respiratory tract, resulting in a lower resistance of the immune system to viruses. When the virus breaks through the mucus layer of the respiratory organs as the first immune barrier, interferon is released to activate genes that fight and block the viruses. If the virus also succeeds in breaking through this second defense stage, the immune system is activated as a third stage, triggering virus-specific immune responses. In an environment with insufficient humidity, these three barriers become ineffective and lead to an influenza infection.
- The severity of the infection increases at low relative humidity, regardless of the viral burden. In addition, low air humidity inhibits the ability of human cellular tissue to repair itself.

Head of Research Professor Dr. Akiko Iwasaki summarizes the key findings of the study:
Our new findings on humidity and the resulting aspects and measures to reduce flu-related illnesses are of enormous importance, as seasonal flu infections continue to increase and cause at least half a million deaths worldwide each year. It was also proven that a relative humidity between 40 and 60% minimizes a viral infection and impedes the transmission process. Therefore, we recommend the following: Low humidity is not the only factor that can lead to the spread of influenza viruses and diseases. However, ensuring a relative humidity of at least 40%, especially in the cold and dry seasons, is an appropriate measure to significantly reduce the spread of influenza viruses and the number of infections.

Source: www.pnas.org/content/early/2019/05/07/1902840116

Campus Yale, New Haven, USA

Professor Dr. Akiko Iwasaki
Head of Research of the Yale study:
Low ambient humidity impairs barrier function and innate resistance against influenza infection

7.1 Room air humidity from an economic perspective

Of a total of 40 million employees in Germany, some 17 million work in offices. Their health, well-being and performance also depends greatly on good air quality, comfortable temperatures and appropriate humidity levels in the offices. The great benefit of complying with these conditions is illustrated by the annual statistics “Economic costs of incapacity for work” (“Volkswirtschaftliche Kosten durch Arbeitsunfähigkeit”) published by the Federal Institute for Occupational Safety and Health (Bundesanstalt für Arbeitsschutz und Arbeitsmedizin — baua). For 2017, these statistics show an average incapacity for work of 16.7 days per employee, resulting in a total of 669 million sick days, corresponding to 1.8 million years of absence from work. Only “genuine” medical sick leave is counted in these statistics — in addition, there are quite a number of sick days that are not recorded by doctors. Based on this data, baua calculated total downtime costs for employers in 2017 amounting to €76 billion (average of €41,700 per employee p.a.) and

downtime costs for productivity of €136 billion (average of €74,000 per employee p.a.). With the highest gross value added of €97,500 (2017) and an incapacity for work of 14.6 days per employee, the financing, rental and business services sector ranks at the top of these statistics. A summary of key baua data for the years 2014 and 2017 is shown in the adjacent table.
According to the baua analyses, respiratory illnesses account for 13.9% of all illnesses. These correspond to approximately 93 million sick days, or around 250,000 years of absence. Based on these figures, and a few other assumptions, we will now use an example to illustrate the downtime costs that an employer with 100 office employees can expect if the room air humidity is insufficient and unhealthy.
For this purpose, around 18 sick days per office employee are assumed (including individual sick days without a medical certificate), of which 15% = 2.7 days are attributable to respiratory illnesses. This includes 1.5 days of absence due to insufficient humidity (colds, flu, headaches). If, in addition to this, we take into account a further loss of concentration and performance of the individuals (due to irritation of the mucous membranes of the nose and throat, dry eyes and itchy skin) in the office workplace itself, then a conservative estimate can be made assuming a total annual loss of production of 2.5 days per person. These 2.5 days of absence represent around 1.2% of the annual working hours.

Based on the baua value of an average gross value added per office job in the financing, rental and business services sector amounting to €97,500, employers thus have a rate of absence due to illness of 1.2% of €97,500, resulting in €1,170 per person and per year.
In the field of public services, including education and health, gross value added per person per year is quoted at €46,500. If a 1.2% loss of working time is assumed here, too, the cost per employee is €558 per person per year.

Economic costs due to incapacity for work from 2014 to 2017 with 40 million employees in Germany (source: baua)

	2014	2015	2016	2017
Sick days (total)	543 million	587 million	675 million	669 million
Production downtime (labor costs)	€57 billion	€64 billion	€75 billion	€76 billion
Gross value added (productivity)	€90 billion	€113 billion	€133 billion	€136 billion
Days of absence due to respiratory illnesses (total)				
Days	65.7 million	83.2 million	91.2 million	92.2 million
Days of absence due to respiratory illnesses (finance, insurance and services)				
Days	10.6 million	13.7 million	16.4 million	17.0 million
Production downtime (labor costs)	€1.1 billion	€1.5 billion	€1.8 billion	€1.9 billion
Gross value added (productivity)	€2.8 billion	€3.6 billion	€4.4 billion	€4.5 billion
Days of absence due to respiratory illness (public and other services, education and health)				
Days	20.4 million	25.0 million	35.1 million	36.9 million
Production downtime (labor costs)	€2.0 billion	€2.5 billion	€3.6 billion	€3.9 billion
Gross value added (productivity)	€2.5 billion	€3.1 billion	€4.4 billion	€4.7 billion

Sample calculation:

7.2 What costs must employers expect to avoid absenteeism?

A new office building in the Munich area for 100 employees is equipped with a ventilation system with an outside air volume flow of 50 m³/ per person = 5,000 m³/h to ensure good indoor air quality. At the same time, the company's CEO decides to install controlled humidification in the ventilation system in order to ensure a healthy air humidity of at least 40% in the rooms at a room temperature of 22°C on five working days per week, even in the cold seasons.

The investment costs for the installation of the humidification unit selected here on the basis of a Condair GS gas-fired steam humidifier,
including the necessary treatment of the humidifier water, amount to a one-off sum of around €29,000.
Without going into too much detail, the annual operating costs for the humidification system are about €3,600 due to the consumption of gas, water and electricity, as well as maintenance.

What does this mean over a 15-year period?

As previously calculated, the employer loses €1,170 per person in productivity per year due to the excessively dry office air. For 100 employees, this corresponds to a value of €117,000 per year, or a total of €1.755 million over 15 years.
To avoid these losses, the humidification unit costs him €29,000 as a one-off investment and €3,600 a year in operating costs x 15 years = €54,000. This results in a total of about €83,000 for 15 years.

From the comparison of the two results arises a "yield" for the company between the expenditure for a good and healthy air humidity and the avoidance of losses (lower productivity) of €1.755 million: €83,000 = 2,100%, or an avoided loss of productivity of €1.755 million - € 83,000, which leads to a yield of €1.672 million.

Calculation for 100 employees over an operating period of 15 years in the economic sector of public and other services, education and health

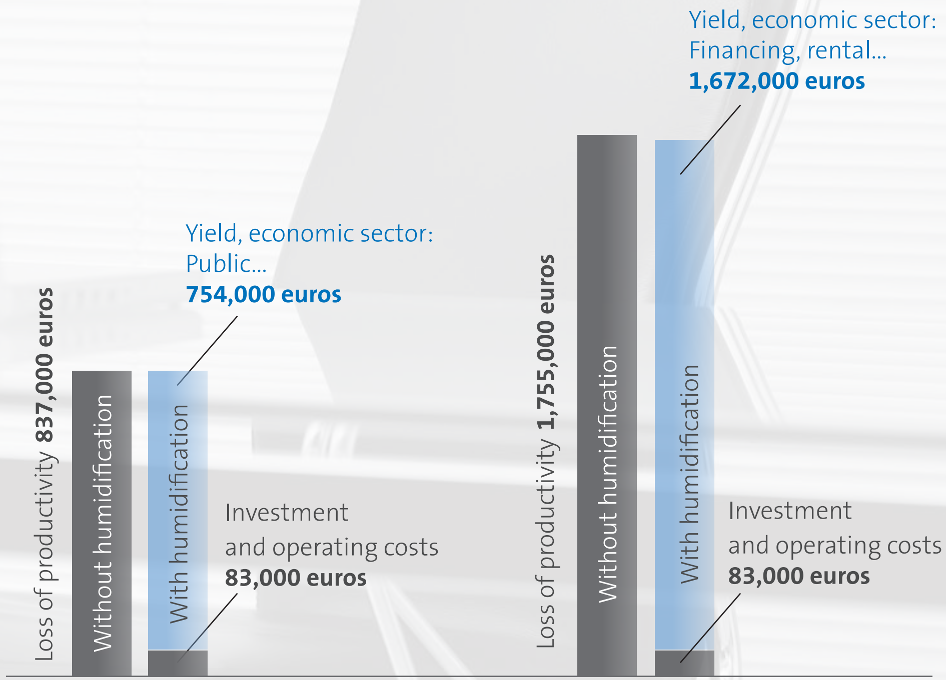
Gross value added per workplace* x downtime** = loss of production
46,500.00 euros x 1.2% = 585.00 euros per year, per person

Employees x loss of production per year x operating period = loss of production
100 x 585 euros x 15 years = 837,000 euros

Calculation for 100 employees over an operating period of 15 years in the economic sector of financing, rental and business services

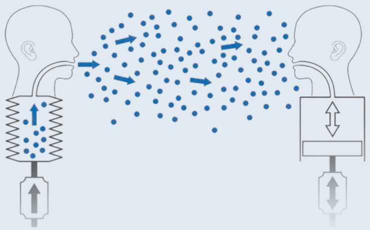
Gross value added per workplace* x downtime** = loss of production
97,500.00 euros x 1.2% = 1,170.00 euros per year, per person

Employees x loss of production per year x operating period = loss of production
100 x 1,170 euros x 15 years = 1,755,000 euros



* Federal Institute for Occupational Safety and Health
** Projected total downtime due to respiratory illnesses

8 An overview of the results of medical studies on the relevance of air humidity to health



Transmission of influenza viruses through the air

The percentage of coughed out flu viruses that were still contagious after one hour in a climate-controlled room at different room air humidity levels was measured. At a humidity below 23%, more than 70% of the coughed out flu viruses were still infectious after one hour. At a relative humidity of over 40%, less than 20% of the viruses were still infectious after one hour. Low humidity increases the risk of infection from exhaled or coughed out flu viruses, while a humidity level of over 40% reduces the risk of infection.

Original title:
High humidity leads to loss of infectious influenza virus from simulated coughs

Authors:
John D. Noti, Francoise M. Blachere, Cynthia M. McMillen, William G. Lindsley, Michael L. Kashon, Denzil R. Slaughter, Donald H. Beezhold

Published:
2013

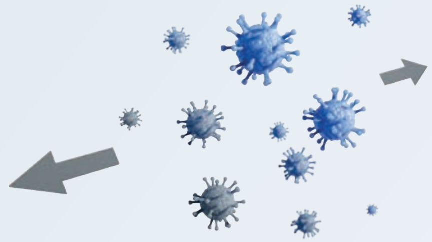
Viability of viruses in the air

The researchers observed a long survival period of the viruses at very high humidity close to 100%. The infectivity of the viruses was also maintained for a long time when the humidity was below 50%.
At humidity levels above 50%, the influenza viruses were inactivated within a short time. It is assumed that the extremely sharp increase in the salt concentration in the droplet during evaporation at decreasing air humidity inactivates the viruses. Below a humidity level of 50%, the salts crystallize, lose their inactivating effect and appear to preserve the viruses. The mechanism shown explains why flu epidemics frequently occur during the winter heating period due to the very low humidity of heated room air.

Original title:
Relationship between humidity and influenza A viability in droplets and implications

Authors:
Wan Yang, Subbiah Elankumaran, Lindsey C. Marr

Published:
2012



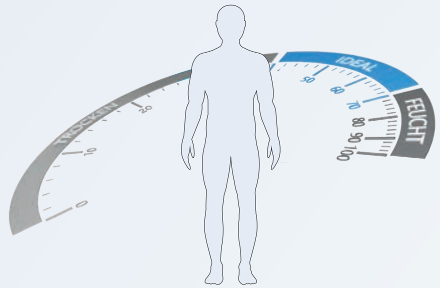
Influence of humidity and ventilation on the risk of influenza

Researchers used model calculations to investigate the risk of influenza infection at different levels of indoor air humidity and ventilation intensity.
An increase in ventilation reduces the risk of infection by thinning out and removing the flu viruses in the exhaust air. This is particularly effective for small germ droplets that are capable of floating for a long time in dry room air. The room air humidity determines the evaporation of coughed out germ droplets and thus their final size (float duration), and the viability time of the influenza viruses via the salt concentration. A humidity level above 40% reduces the risk of infection by quickly inactivating the viruses and causing the large droplets to sink rapidly. Dry room air does the opposite and increases the risk of flu.

Original title:
Dynamics of airborne influenza A viruses indoors and dependence on humidity

Authors:
Wan Yang, Linsey C. Marr

Published:
2011



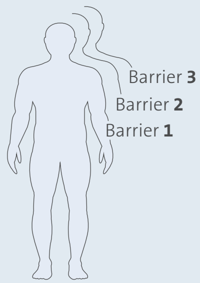
Intermediate humidity is ideal for our health

With 99 study references, this important literature study shows why an intermediate humidity level of 40–60% is the ideal range both in terms of direct impact such as the well-being and health of the users of the building and in terms of avoiding health problems caused by viral and bacterial infections, allergies, fungal infestation, mites and particulate and gaseous air pollution.
An intermediate humidity level protects and cares for the skin, mucous membranes, nose and airways. It optimizes the dynamics of turbulence, dispersion and sedimentation of airborne pathogens in order to reduce exposure.

Original title:
Criteria for human exposure to humidity in occupied buildings

Authors:
Sterling EM, Arundel A, Sterling TD

Published:
1985



Dry air is the best accomplice of flu viruses

The Yale study, published in 2019, shows the severe effects of low humidity on the respiratory tract's resistance to infection compared with the normal situation at 50% humidity. Exposure to 10% humidity for several days results in the following:
1) Cilia, which are supposed to remove mucus and viruses from the respiratory tract, become uncoordinated and inefficient.
2) The innate cellular and humoral immunity responsible for direct infection control is completely blocked.
3) The flu viruses penetrate unhindered, multiply and cause tissue damage.
This results in more frequent and more severe flu outbreaks.

Original title:
Low ambient humidity impairs barrier function and innate resistance against influenza infection

Authors:
Eriko Kudo, Eric Song, Laura J. Yockey, Patrick W. Wong, Robert J. Homer and Akiko Iwasaki

Published:
2019

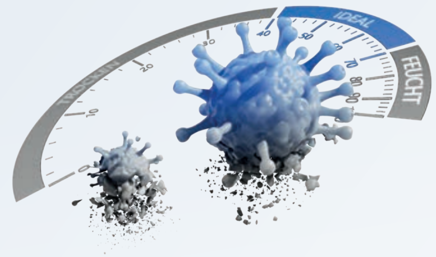
Healthcare-associated infections and low humidity

In a study at a university hospital, nine parameters (T, RF, Lux, CO_2, air pressure, fresh air percentage, air exchange, movement of persons, hand hygiene) were measured in 10 patient rooms. As a result of the high air exchange rates, the humidity averaged 40% in the six summer months and 30% in the six winter months.
In the winter months, the rate of healthcare-associated infections was significantly higher than in summer. Of all the measured parameters, the increase correlated best with the lower humidity. This raises the question whether the low winter humidity is the cause of the increase in healthcare-associated infections.

Original title:
Building science measurements for the hospital microbiom project, Thesis Ramos T, 2014
Is low indoor humidity a driver for healthcare-associated infections?

Authors:
Dr. Stephanie Taylor, Dr. med Walter Hugentobler

Published:
2016



Winter air, heating, ventilation and people as humidifiers

The study investigated the correlation between the above terms and the viability time of influenza viruses in classrooms. The room humidity is determined by the absolute humidity in the outside air (very low in cold winter air), the heating temperature, the ventilation intensity and the presence of persons who release moisture into the room air.
Without active humidification, the room humidity in winter is usually around 30% and varies depending on the presence of people and the outdoor temperature. In the classroom, 70% of the present flu viruses are viable for one hour. With humidifiers (output ≈2 l/h), the humidity in the classroom can be quickly increased to 40 or 60%, which reduces the viability rate of flu viruses to 50 or 35% after one hour and significantly reduces the risk of infection.

Original title:
Absolute humidity and the seasonal onset of influenza in the continental United States

Authors:
Koep T.H. et al.

Published:
2013

The lethal effect of relative humidity on air-borne bacteria

This was the title of a study published in 1947 in which it was shown that three of the most common bacterial pathogens of respiratory tract infections (pneumococci, streptococci and staphylococci) are rapidly inactivated at intermediate humidity levels (40–60%) in the air when atomized with a saline-containing suspension. All three species of bacteria can survive for a very long time at low and very high humidity.

Original title:
The lethal effect of relative humidity on air-borne bacteria

Authors:
Edward W. Dunklin, Theodore T. Puck, Ph.D.

Published:
1947

For more detailed information on the studies, visit www.condair.de/medizinische-studien or scan the QR code.

9 Do standards and guidelines reflect the state of the art in terms of indoor air humidity?

Ensuring indoor air humidity that protects and promotes the health, well-being and performance of people is also addressed in a number of technical rules such as standards and guidelines. However, in almost all cases, these technical rules only take into account high room air humidity levels of over 65% at room temperatures above 26°C and the negative effects that such a muggy working environment can have on office workers. In comparison, the topic of “minimum room humidity in colder and dry seasons” has so far been almost criminally neglected — in this regard, there are only, if at all, a few recommendations without any concrete specifications to be complied with. This may be due to the fact that the numerous findings on the many positive effects of a minimum room air humidity of around 40%, which have been described in detail in this brochure, have not yet been acknowledged by experts and must first gain recognition and acceptance before they can be incorporated into technical rules. However, this should only be a matter of time.

DIN EN 15251 “Indoor environmental input parameters” (now DIN EN 16798 Part 1) is a standard of vital importance for the issues of indoor air quality, temperatures and humidity. It contains the following statements on air humidity:
“Buildings that are not subject to any requirements other than those of human use (e.g. offices, schools and residential buildings) do not usually require humidification or dehumidification. If the relative humidity of the air is below 30%, health problems (e.g. dry mucous membranes) and unwanted static charges may occur. If humidification and/or dehumidification systems are used, excessive humidification and dehumidification must be avoided. The recommended design specifications for the indoor air humidity in rooms used by people, with humidification and dehumidification systems, as set out in the table, must be used.”

The minimum room humidity levels listed in the table, ranging from 30% (for best room category I) to 20% (worst room category III), are all below the minimum values of around 40% as recommended in the various studies and brochures.
They are therefore hardly suitable for ensuring a healthy and comfortable working environment and reducing the risk of illness.

Building/room type	Category	Design specification of the relative humidity	
		for dehumidification	for humidification
Rooms whose humidity criteria are determined by human use. Special rooms (museums, churches etc.) may require different limit values.	I	50%	30%
	II	60%	25%
	III	70%	20%

Similar statements can also be read in DIN EN 16798 Part 3 “Ventilation for non-residential buildings”. Accordingly, “humidification or dehumidification of the room air with supply air is generally not necessary. However, when used, they shall be designed for the limit values of the permissible humidity range, the minimum value in the event of humidification and the maximum value in the event of dehumidification”. For this purpose, there is a reference to DIN EN 15251 and the values in the adjacent table.
Unfortunately, other technical rules also point in the same wrong direction, frequently with references to DIN EN 15251. For example, technical rule (Arbeitsstättenregel) 3.6 “Ventilation” contains the following statement: “In the event of complaints about indoor air humidity, the risk assessment must examine whether and, if so, what measures should be taken.” The “Recommendation for air handling units 2018” (“Empfehlung RLT-Anlagen 2018”) of the Working Group on Mechanical and Electrical Engineering of State and Local Government (Arbeitskreis Maschinen- und Elektrotechnik staatlicher und kommunaler Verwaltungen AMEV), which applies to public buildings, also states that “humidification and dehumidification are usually only required in special buildings, such as museums and some healthcare facilities”.

VDI 3804 “Air-conditioning — Office buildings” contains a ray of hope regarding room air humidity with the following statements: “It is recommended to aim for category 1 of DIN EN 15251 with 30% RH as the lower limit. A humidifier is generally required for this purpose. Humidity levels < 30% RH can lead to irritation of the eyes and airways and thus favor infectious diseases. Problems with increased static charge may also occur. At low outside temperatures, it is to be expected that the room humidity will fall below 30%.”

Which air humidity is recommended?
Currently no mandatory minimum humidity in the workplace has been defined. The trade associations and accident insurance companies generally assume that the room air does not need to be additionally humidified.
A technical rule for workplaces, ASR A 3.6 “Ventilation”, only defines maximum values that the relative humidity at different room temperatures must not exceed.
The German Occupational Safety and Health at Work Act, Section 5 “Assessment of hazards on workplaces” states that a hazard in the workplace can also result from physical impacts. In the event that health problems occur, the employer must determine whether and which measures need to be taken.

As a result, current technical rules with regard to specifications and compliance with minimum room humidity levels unfortunately do not conform to the current state of medicine and science and should therefore urgently be revised to include specifications for minimum room humidity levels.

10 Quick analysis of the office climate with the indoor air humidity risk graph

If people in office workplaces complain about inadequate temperatures or humidity levels, or if frequent respiratory illnesses occur, the following procedure offers a quick and easy way to conduct an initial objective analysis and assessment of the indoor climate. The procedure is based on the so-called “Climate risk graph” (“Risikograph Klima”), which the German Social Accident Insurance (DGUV) recommends in its Guide 215-510 “Assessment of Indoor Climate” (“Beurteilung des Raumklimas”). However, since this DGUV risk graph only applies to complaints about high room temperatures and high humidity levels, Condair has developed a “Room humidity risk graph” for a dry indoor climate.
How should this risk graph be applied and what results does it provide?

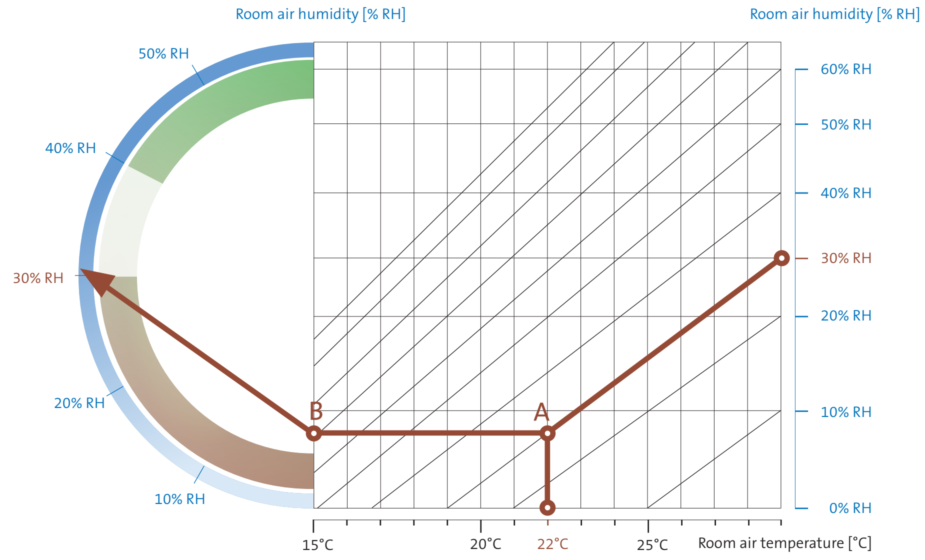
Step 1:
In offices where there are complaints about a dry, uncomfortable room climate, measure the room temperatures and room air humidity levels.

Step 2:
Record the measured values in the humidity risk graph:
Plot the temperature on the x-axis and the relative humidity along the diagonalroom air humidity lines.

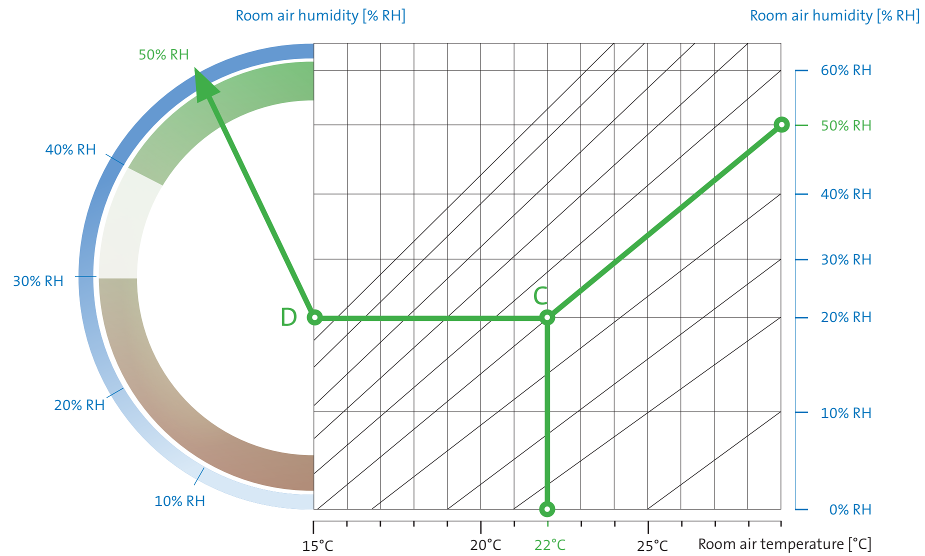
Step 3:
The two examples on the right illustrate the application of the humidity risk graph.

Example 1: Action required
This applies, for example, to a room temperature of 22°C and a room humidity of 30%. The point of intersection A in the diagram results from these values. From this point, draw a horizontal line to the edge of the graph on the left (y-axis) to point B. Then connect point B with the room air humidity scale on the far left of the diagram, i.e. with the measured value of the room air humidity (30% in the example). The resulting red line runs through the red area of the risk graph. This area signals insufficient room air humidity and, consequently, health hazards. If the result line crosses the red area of the risk graph, from a medical point of view an increase of the relative room air humidity is recommended.

Example 2: Optimal room air humidity
In comparison, this example with the green lines in the risk graph indicates a good indoor climate with sufficient indoor air humidity. A room temperature of 22°C and a relative room air humidity of 50% were measured.
This results in the point of intersection C, from which we again draw a horizontal line to the edge of the graph on the left to point D. When connecting point D with the humidity scale next to the diagram to the measured humidity value of 50%, the resulting line now crosses the green area. This area indicates a sufficient or good room air humidity and, consequently, a



Example 1: Action required
At a room temperature of 22°C and 30% RH. Room air humidity



Example 2: Optimal room air humidity
At a room temperature of 22°C and 50% RH. Room air humidity

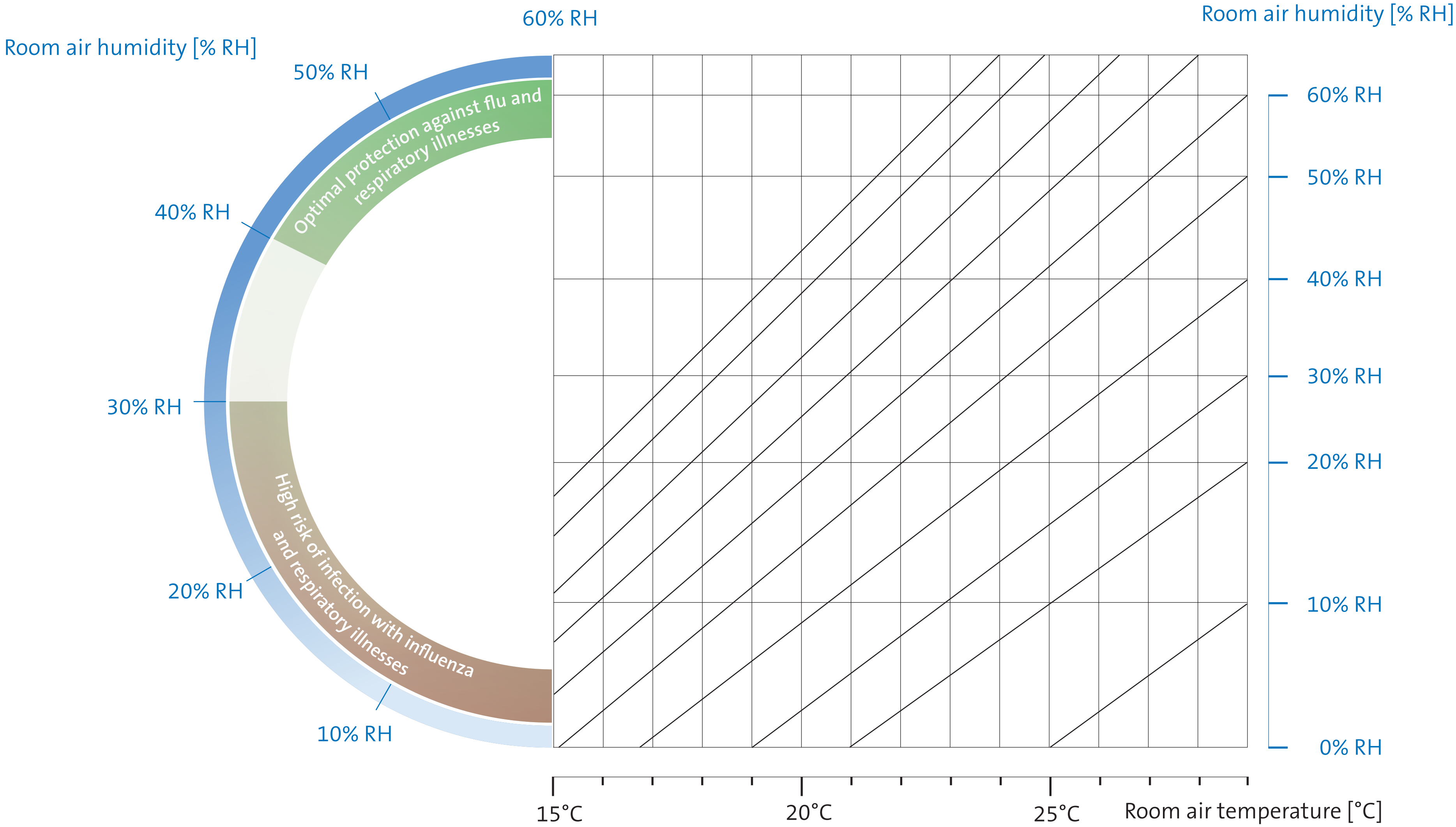
low risk of health hazards and low risks due to excessively dry air.

If the line runs through the neutral zone between the red and green areas of the room air humidity risk graph, it is also advisable to increase the room air humidity.

Copies of these risk graphs for indoor air humidity are available as free downloads on our website.

To download the risk graph, visit www.condair.de/Raumluftfeuchte or scan the QR code shown here.

Copy template: Indoor air humidity risk graph



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