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FEATHER DUSTER HYGIENE

Orientation research into the degree of contamination related to used feather dusters and the dispersion of micro-organisms into the ambient air and onto cleaned surfaces by cleaning with feather dusters

PUBLICATION

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Orientation research into the degree of contamination related to used feather dusters and the dispersion of micro-organisms into the ambient air and onto cleaned surfaces by cleaning with feather dusters

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SUMMARY

Despite the fact that feather dusters do not qualify for interior cleaning or other cleaning applications, feather dusters are still regularly used for this purpose, also in the health service. While cleaning with a feather duster, dirt and the micro-organisms will collet in the feather duster. Due to mechanical action, it is conceivable that at a certain point during the cleaning process, the collected dust will partly be dislodged into the ambient air and onto cleaned surfaces due to mechanical action. Because the dislodged dirt will also release the micro-organisms from one location to another, the feather duster could actually be a source of contamination in this way.

Given the relation regarding potential risks of infection, it is relevant to investigate the degree of contamination of feather dusters used in health care to ascertain the extent in which pathogens are spread through the air and onto cleaned surfaces and the potential health risks this poses for residents and cleaners.

The objective of the research was twofold: on the one hand it served to provide insight into the degree of contamination carried by the feather dusters used in daily practice and on the other hand, to quantify the degree in which the used feather dusters release the already present micro organisms back into the air and onto cleaned surfaces during use.

Determining viable pathogen release into ambient air

Used feather dusters were collected from seven hospitals. Some of the feather dusters were subsequently used in a cleaning activity in which an imitation of part of a ceiling with an air vent was cleaned - an activity for which feather dusters are regularly used in daily practice. Following on from this, samples were taken to establish how many pathogens were released into the ambient air. Subsequently, the quantities of the different types of micro-organisms present in the feather dusters were ascertained.

Determining viable pathogen release onto cleaned surfaces

Used feather dusters were collected from three hospitals. These feather dusters were used to clean three different surfaces consisting of three different material composites. Ascertaining how many pathogens were transferred from the feather dusters to the cleaned surfaces immediately followed this. Lastly, it was determined how many micro-organisms were present in the used feather dusters.

The primary conclusions of the research are:

- While cleaning objects positioned at a higher level with a used feather duster, the air below shows an increased level to a substantially increased level of air contamination.
- The increased pathogen concentration in the air is very local and, after mixing with the air in the environment, will result in a limited increase of the initial air contamination.
- Due to the local nature of the increase in air contamination, possible effects will be limited to persons in the immediate vicinity of the cleaning activity.
- The degree of contamination on the surfaces cleaned with the used feather dusters is negligible and only seems to be of relevance in risk situations.

Content

Chapter 1 Introduction

1.1 Background to the research

Despite the fact that feather dusters are not considered for interior cleaning or other applications by Vereniging Schoonmaak Research (VSR), feather dusters are still regularly used for this purpose. During cleaning activities with a feather duster, dirt and micro-organisms present in the dust will accumulate in the feather duster. It is plausible that at a certain moment during the cleaning process, due to mechanical action, the accumulated dust will be released to the ambient air and cleaned surfaces. Because the dirt will be released together with the micro-organisms it contains, these organisms will be moved from one location to another and in this way, the feather duster is a source of contamination.

There is no data available for the Dutch situation with regard to degree of contamination of feather dusters and the risks posed to the cleaners and occupants of the environments in which feather dusters are used for cleaning.

In relation to the potential risk of infection, finding the degree of contamination of the feather dusters used in health care is relevant in order to research the degree in which pathogens are spread via the air and cleaned surfaces during use and which potential health risks this could pose for the occupants and cleaning personnel.

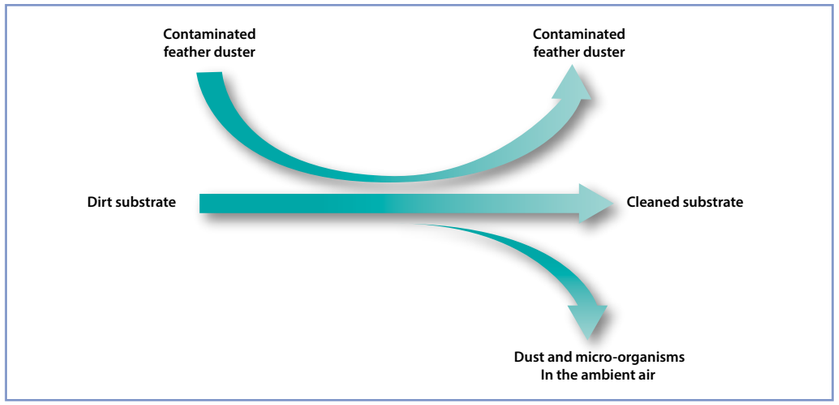
Definition of the research question

The types of micro-organisms that are able to collect in feather dusters are fungi, yeasts, bacteria and viruses. Because viruses distinguish themselves from other micro-organisms on important aspects (such as size, survival and growth) and because working with viruses require specialist facilities, viruses have not been included in this research.

Figure 1 is a conceptual model of 'dust removal' with a feather duster. Depending on the degree of contamination of the feather duster and the surface to be dusted, more or less micro-organisms will be dispersed on the surface and into the ambient air.

It is plausible that a fairly new feather duster is better able to retain dust than a feather duster that has been in use for some time so a newer feather duster would subsequently release fewer dust particles and micro-organisms. The degree of contamination of the feather dusters being used in practice and the dispersal of micro-organisms into the environment will therefore vary greatly.

Figure 1: Schematic diagram of the cleaning process with a feather duster.



Objective of the research

On the one hand, the objective of the research is to increase the general understanding of the infection rate pertaining to the use of feather dusters in practice. On the other hand, the objective is to ascertain the degree in which used feather dusters release and disperse the micro-organisms already present in the feather dusters back into the ambient air and cleaned surfaces when used for cleaning purposes.

Chapter 2
Measuring methods and means

2.1 General design of the research

Ascertaining the germ dispersal into the ambient

Used feather dusters were collected from seven hospitals. Some of the feather dusters were subsequently used in a cleaning activity in which an imitation of part of a ceiling with an air vent was cleaned - an activity for which feather dusters are regularly used in daily practice. Following on from this, measurements were taken to ascertain how many pathogens were released into the ambient air. Subsequently, the quantities of the different types of micro-organisms present in the feather dusters were established. A suitable sampling time and sampling volume was determined in a preliminary preparative investigation.

Ascertaining germ dispersal on cleaned surfaces

Used feather dusters were collected at three hospitals. These feather dusters were used to clean three different surfaces consisting of three different material composites. Ascertaining how many pathogens were transferred from the feather dusters to the cleaned surfaces immediately followed this. Lastly, it was determined how many micro-organisms were present in the used feather dusters.

2.2 Determining the numbero of germs per m^3 air

To obtain a measurement for each of the feather dusters to be sampled from the air below, each feather duster was pushed through the test plate three times. This activity simulates the cleaning of an air vent. After completion of the cleaning activity, a certain amount of air was sampled. The sampling was executed 5 minutes after completion of the activity at a distance of 60cm vertically below the hole.

A Biotest air sampler was used for measuring the number of pathogens in the sampled air. An air sampler is a device that is able to collect a pre-set number of air particles in a short time e.g. 1 to 5 minutes). The air that is taken in by the sampler is blown over a surface containing a (culture) medium. Micro-organisms in this air sample adhere to the surface. For sampling, the air sampler was fitted with an Agar Strip TC (Merck 1.44253.0050) for measuring the total number of germs or with an Agar Strip S (Merck 1.44102.0025) for measuring the number of Staphylococci present.

After sampling the samples were kept a temperature of 30° C in an incubator for 1-5 days after which the number of colonies present on the culture media were counted. The number of pathogens are expressed in Colony Forming Units. These units are used to estimate the number of CFU of viable pathogens per m^3.

The CFU of the feather dusters is ascertained within 10 hours after sampling has been completed.

2.3 Determining the numbero of pathogens per surface unit

For measuring the dissipation of pathogens onto cleaned surfaces, previously positioned horizontal surfaces consisting of trespa, glass and stainless steel were disinfected. The surfaces to be sampled were disinfected with a 70% alcohol solution just before sampling.
For each measurement, the sampling surface was wiped with 5 'dusting' movements with the feather duster and after a waiting time of five minutes, two samples were taken from the cleaned surface.

The disinfected surfaces (trespa, stainless steel and glass) were positioned in the sampling room from the beginning. The contamination on these surfaces was sampled before, but after disinfection, and after being in the room for 4 hours.

Swabbing over 100 cm^2 of the sampled surface with a wet swab did the sampling of the test surfaces. After swabbing, the swab was returned to a 5ml neutral buffer. The samples ere stored at 4°C and diluted in PFZ (Peptone Physiological Saline solution, Biotrading) plated on various micro-organisms within two hours:

- *Total number of viable pathogens: Using a spatula, dilutions were transferred to TSA (Biotrading) and incubated at 30°C for two days. All resulting colonies were counted.*
- *Staphylococcus Aureus: Dilutions were transferred onto Baird Parker-agar (Biotrading) by spatula and stored atj 37°C for 48 hours. All resulting black, shiny (coagulase positive) colonies were counted.*

The number of pathogens were expressed in Colony Forming Units (CFU and used to estimate the number of CFU of viable pathogens per m^3 of sampling surface.

The viable pathogens of feather dusters was determined within ten hours after sampling.

2.4 Ascertaining the number of pathogens (CFU) in the feather dusters

Within ten hours after the determination of pathogen dispersion in the ambient air or cleaned surfaces, the number of pathogens in the feather dusters themselves was ascertained. For this purpose, the feather dusters were shaken out with ±260 ml buffered peptone water (BPW). The suspension obtained in this way was used to make a duplicate dilution series in peptone physiological saline solution (PFS). This liquid was subsequently plated on the media concerned (table 1). For calculating the number of viable pathogens, an average of all the countable plates of both dilution series was calculated, which was the source for calculating the total number of viable pathogens (CFU) per feather duster.

Organism	Culture medium	Incubation
TPC	mix plate on PCA	3 days at 30°C
Entero's	double layered mix plate on VRBGA	1 day at 30°C
SA	spread plate on BP	2 days at 37°C
Bacilli	spread plate on MYP	2 days at 30°C
Yeast/fungi	spread plate on OGGA	2 days at 30°C, 5 days at 25°C

Table 1: Organisms, culture media and incubation conditions

2.5 Orientating sampling

Preceding the measurements of air contamination, orientating sampling was executed to establish:

- which air volume(s) would probably yield usable results and
- what would be a suitable simulation for cleaning air vents.

Measurements were taken with two different simulation techniques: one whereby a feather duster is used to hit on a surface before sampling the air contamination and the other in which the feather duster is puled to and fro through a hole in a plate once. These tests were executed with three different diameter holes: 5, 7.5 and 10cm. Both techniques are executed with different sampling volumes: 10, 100 and 200 litre.

The measurements of the viable pathogen concentration in the ambient air after hitting on a surface yielded differing results: this method was not applied for this reason.
Sampling of both 10 litres and 100 litres yielded suitable measurements. The count at a sampling volume of 10 litres yielded numbers of pathogens that were too low per strip and it was decided to use sampling volumes of 20 and 100 litres for ascertaining the total number of viable pathogens. To establish the number of Staphylococci in the ambient air, sampling units of 100 and 500 litres were used.

In summary:

- the measurements of the total number of viable pathogens in the ambient air is executed with sampling volumes of 20 and 100 litres of air,
- the measurements of the number of Staphylococci in the ambient air are executed with sampling volumes of 100 and 500 litres of air,
- cleaning of the air vents is simulated by pushing and pulling the feather dusters through a hole of 7.5 cm diameter in a plate once.

2.6 Feather dusters

The codes, structure and use history of the examined feather dusters and the measurements executed with the feather dusters are provided in table 2.

The feather dusters came from seven institutions in health care (code A up to and including G). The air contamination was measured after using feather dusters A to G. A second feather duster that also comes from these hospitals was also used and the air contamination sampled (A2, B2 and C2). The objective is to obtain an overall impression of the variation inside the hospital.

In theory, a substantial part of the pathogens present in the feather duster can be removed in a use simulation. For this reason, three unused feather dusters were used for the use simulation in which measurements of viable pathogens were sampled (code B3, D2 and G2). Feather dusters A3, F2 and G3 were used to ascertain how many viable pathogens are released during a cleaning action on a cleaned surface and how many pathogens are left in the feather duster.

Based on the structure, the feather dusters used can be grouped into three types: feather dusters with singular filaments, feather dusters with bundled filaments and feather dusters that seem to have twisted fibres. Images of the three types can be seen in appendix 6.3.

2.7 Micro-organisms

For determining the contamination of the ambient air by cleaning with used feather dusters, the total number of viable pathogens and the number of Staphylococci are measured.

For ascertaining the number of viable pathogens that are transferred to a hard surface during cleaning, the total number of Staphylococci aureus is determined.

Measuring the total number of viable pathogens in the feather dusters was determined by measuring the numbers of entero bacteria, Staphylococci aureus, fungi and yeasts.

2.8 Test area and test setup

The measurements are executed in a laboratory space. The global dimensions of the sampling area are: a floor surface of 240 m2 volume 720 m^3.

For the simulations of the cleaning activities for measuring the air contamination, a horizontal plate with a 7 cm diameter round hole was positioned at 60 cm from the wall at a height of 190 cm. In the preliminary investigation, holes were used with a diameter of 5 and 10 cm respectively.

For the simulations of the cleaning activities for measuring the surface contamination in the test area the test surfaces (50x30 cm) were set up horizontally at a height of 90 cm.

2.9 Sampling conditions

All measurements were executed in a surrounding temperature of 19°C ± 3 °C and in a relative humidity of approximately 55% ± 5% RH.

2.10 Air sampler

For measuring the number of viable pathogens in the ambient air, a Biotest Hycon RCS isolator was used. For the sampling, the air intake of the air sampler was positioned a distance of 60 cm vertically below the hole in the test plate.

Feather Duster code	Type of duster *	Application	Measurement air contamination	Measurement pathogens in duster	Measurement pathogens on surface
A	Singular fibres; type 1	such as ventilation grates in public spaces (no operating theatres or patient rooms)	x	x	
A2	Singular fibres; type 1	idem	x		
A3	Singular fibres; type 1	idem		x**	x
B	Bundled fibres; type 2	high edges, cupboards and grates in nursing rooms	x	x	
B2	Singular fibres; type 1	idem	x		
B3	Singular fibres; type 1	idem		x	
C	Singular fibres; type 1	difficult to reach places in outpatient clinics (and surgery)	x	x	
C2	Singular fibres; type 1	idem	x		
D	Bundled fibres; type 2	high edges and ridges, high cupboards, underneath beds and window sills in wards, offices and workplaces	x	x	
D2	Bundled fibres; type 2	idem		x	
E	Singular fibres; type 1 (new?)	Dusting central heating units, not for grates in public spaces (hallway and passages)	x	x	
F	Bundled fibres; type 2	High edges and ridges, cupboards and grates in treatment rooms, traffic areas and offices	x	x	
F2	Bundled fibres; type 2	idem		x**	x
G	Platted threads; type 3	High edges and ridges as well as computers in treatment rooms, offices and outpatient rooms (no operating theatres)	x	x	
G2	Platted threads; type 3	idem		x	
G3	Platted threads; type 3	idem		x**	x

** In appendix 6.3 the different types of feather dusters are shown.*

*** Only the total viable pathogen count and the number of Staphylococcus Aureus is measured.*

Table 2: Tested feather dusters.

Table 3: Technical information air sampler.

Type	Biotest Hycon RCS isolator
Manufacturer	Biotest
Air flow	100 l/m
Impact speed	0,07 – 7 m/sec
Physical efficiency	Not specified

2.11 Measuring schedule and reference values

For measuring the air contamination, a rest period of 45 minutes was adhered to between sampling the different feather dusters. Preceding, halfway through and after completion of sampling, the contamination of the ambient air was determined without the use simulation of a feather duster. The average of these three measurements is the 'normal' level of contamination of the test area: the reference value.

The sampling of viable pathogens of the feather dusters started 10 hours after the sampling of air contamination.

2.12 Supplement measurements

To obtain a reference pertaining to the pathogen concentration in the surrounding air in a number of representative environments, sampling was done in six living and working environments. The total number of viable pathogen measurements were sampled in three hospitals, two lounges of private homes (one with little activity and one with substantial activity) and the ground floor of a university building.

Chapter 3 Results

3.1 Pathogen concentration in the ambient air

The measured concentration of different kinds of pathogens at different sampling volumes are provided in table 4. When counting micro-organisms, whether it be in the air, water or a product, the values are not usually given in absolute values. In general, the 10log value of that number is used (with one decimal). In this report, both the values and the 10log values are provided.

The pathogen concentration for the total number of viable pathogens was measured for the different feather dusters at a sampling volume of 20 litres and it varies from 800 to 5000 CFU per m^3 of ambient air. The median is 1475 CFU per m^3. The total number of viable pathogens varies between 440 and 740 CFU per m^3 air.

The number of Staphylococci measured in the ambient air at a sampling volume of 100 litre varies between 130 to 660 CFU per m^3 air; median 390 CFU per m^3 air. The number of Staphylococci measured at a sampling volume of 500 litres varies between 72 and172 CFU per m3 air; median 120 CFU per m^3 air.

The average number of pathogens in the test and sampling area without the simulation use (reference value), amount to a total of 394 CFU per m^3 air (sampling volume 20 litres) and the Staphylococci measured 55 CFU per m^3 air (sampling volume 100 litre).

For all use simulations and for both determinations of the number of viable pathogens in the ambient air, the concentration of pathogens in the ambient air exceeded the reference values. The increase compared to the reference values varies between 0.3 to 1.1 Log for the total number of pathogens (sampling volume 20 litres) and between 0.4 to 1.1 Log for the Staphylococci (sampling volume 100 litres)
For both types of pathogens the results showed that at higher sampling volumes, the number of viable pathogens per m^3 decreased. The total number of pathogens in the pathogen concentration measured 2.3 times lower at a sampling volume of 100 litres than at 20 litres. For the Staphylococci this difference is a factor 3.5.

Table 4: Number of pathogens (CFU) per m³ ambient air (N, Log N).
** number of pathogens not countable.*
*** air contamination of the sampling area without use simulation; average of three measurements.*
**** Due to a technical malfunction, the sampling volume for this sample was 600 litres.*

Code	Type of feather duster *	Total number of viable pathogens CFU/m³		Staphylococci CFU/m³	
		sampling volume			
		20 litres	100 litres	100 litres	500 litres
A	Singular fibres	800 / 2.9	550 / 2.7	660 / 2.8	94 / 2.0
A2	Singular fibres	1550 / 3.2	510 / 2.7	630 / 2.8	172 / 2.2
B	Bundled fibres	1400 / 3.1	580 / 2.8	450 / 2.7	100 / 2.0
B2	Singular fibres	1000 / 3.0	740 / 2.9	180 / 2.3	72 / 1.9
C	Singular fibres	1300 / 3.1	600 / 2.8	130 / 2.1	94 / 2.0
C2	Singular fibres	1950 / 3.3	-*	280 / 2.4	130 / 2.1
D	Bundled fibres	1600 / 3.2	-*	370 / 2.6	104 / 2.0
E	Singular fibres	1300 / 3.1	630 / 2.8	460 / 2.7	94 / 2.0
F	Bundled fibres	5000 / 3.7	-*	410 / 2.6	125 / 2.1***
G	Twisted filaments	1850 / 3.3	440 / 2.6	340 / 2.5	122 / 2.1
	Reference values **	394 / 2.6		55 / 1.7	

3.2 Pathogen concentrations on cleaned surfaces

Table 5 provides an overview of the total number of viable pathogens and the number of Staphylococcus aureus measured in CFU per 100 cm² sampled surface during cleaning simulations with the three feather dusters at different times.

Table 5 is based on counts of all plates on which colonies were observed. In microbiology it is usual to exclude plates with a count below ten CFU. If this guideline is applied, it means excluding the values smaller than 50 CFU per 100 cm² for the total viable pathogen count and the values that are smaller than 500 CFU per 100 cm² for Staphylococcus aureus in table 5. Appendix 6.1 contains a table that is based on this formal approach.

The pathogen concentration for the total number of viable pathogens measured on trespa, stainless steel and glass range from < 5 to 295 CFU per 100 cm². For Staphylococcus aureus these values range from < 50 to 100 KVE per 100 cm².

There are no indications that there is any systematic difference between the different test surfaces. There are a few situations where a Staphylococcus aureus infection is indicated.

Table 5: Number of pathogens (CFU) per 100 cm² surface (N, Log N).
** If no values are stated, no pathogens were found; the CFU are <5 per 100 cm².*
**** For cleaning with the feather duster but after disinfection with alcohol.*
***** Surface contamination from a non-cleaned surface.*

Code of feather duster	Sample moment	Total number pathogens* (CFU/100 cm²)			Staphylococcus aureus** (CFU/100 cm²)		
		Trespa	S Steel	Glass	Trespa	S Steel	Glass
A3	Before ***		5/0.7				
	After cleaning	5/0.7					
	5 minutes later	20/1.3		10/1.0			
F2	Before ***			5/0.7			
	After cleaning	50/1.7		60/1.8	295/2.5		
	5 minutes later	43/1.6	23/1.4	113/2.1	50/1.7		50/1.7
G3	Before ***		5/0.7				
	After cleaning		53/1.7	43/1.6	35/1.5	100/2.0	
	5 minutes later	20/1.3	23/1.4	23/1.4			
Reference value ***	Before ***						
	4 hour exposure	35/1.5	55/1.7	50/1.7			

3.3 Pathogens in the feather duster

The total number of viable pathogens (CFU) and the total number of 4 classifications of micro-organisms were sampled in13 feather dusters. The results of this sampling is provided in table 6. The feather dusters come from 7 different hospitals (A up to and including G).

Seven feather dusters were used for measuring the degree of contamination in the feather dusters themselves and for the simulated cleaning of an air vent (A up to and including G) Three feather dusters were used for cleaning hard surfaces (A3, F2 and G3). Feather dusters D2 ad G2 were not used for a cleaning activity.

Plates with less than 10 CFU were included in the calculations regarding the total number of viable pathogens. Generally, these sampling results are not included in calculating the results. Appendix 6.2 provides the results for the total number of pathogens calculated if plates with less than 10 CFU are excluded from calculations to obtain the total number of viable pathogens.

Table 6: Pathogens in the feather dusters; CFU (N (Log N)).
** If nothing is stated, the values found were smaller than 2. 6E+2*
*** If nothing is stated the values found are smaller than 2. 6E+3*

Code	TPC	Entero's*	Bacilli**	SA**	Yeast/fungi **
A	1.3E+08 / 8. 1	2. 6E+02 / 2. 4	1. 6E+04 / 4. 2	1. 3E+04 / 4. 1	5. 2E+03 / 3. 7
A3	5. 2E+04 / 4. 7	Not sampled	Not sampled		Not sampled
B	2. 2E+06 / 6. 3	4. 2E+03 / 3. 6	2. 0E+04 / 4. 3	2. 6E+05 / 5. 4	1. 6E+05 / 5. 2
B3	2. 3E+05 / 5. 4	5. 4E+02 / 2. 7	4. 1E+03 / 3. 6	2. 2E+04 / 4. 3	9. 5E+03 / 4. 4
C	3. 7E+05 / 5. 6	2. 3E+03 / 3. 4		1. 4E+04 / 4. 2	1. 7E+05 / 5. 2
D	1. 0E+07 / 7. 0	4. 0E+02 / 2. 6	4. 0E+03 / 3. 6		1. 3E+06 / 6. 1
D2	5. 6E+05 / 5. 7	7. 8E+02 / 2. 9	6. 5E+03 / 3. 8	1. 6E+04 / 4. 2	1. 7E+04 / 4. 2
E	4. 4E+05 / 5. 6	4. 0E+02/ 2. 6	7. 9E+03 / 3. 9	2. 0E+04 / 4. 3	6. 6E+03 / 3. 8
F	7. 0E+08 / 8. 8	2. 3E+04 / 4. 4	7. 8E+03 / 3. 9	3. 1E+04 / 4. 5	3. 0E+05 / 5. 5
F2	1. 4E+07 / 7. 1	Not sampled	Not sampled	1. 1E+06 / 6. 1	Not sampled
G	2. 7E+05 / 5. 4	2. 6E+02 /2. 4	2. 4E+04 / 4. 4	1. 0E+04 / 4. 0	1. 7E+04 / 4. 0
G2	5. 8E+05 / 5. 8	5. 9E+03 / 3. 8	1. 8E+04 / 4. 3	6. 6E+03 / 3. 8	6. 8E+04 / 4. 8
G3	2. 3E+05 / 5. 4	Not sampled	Not sampled	1. 1E+05 / 5. 0	Not sampled

The feather dusters show substantial differences between the quantities of the different types of viable pathogen organisms present. The total number of pathogens varies between 4.7 Log to 8.8 Log, which means that it exceeds a factor 1000. With regard to entero, bacilli, Staphylococcus aureus and the fungi/yeasts the variation is 2.0 , > 0.8 , > 2.3 and > 2.4 Log.

Figure 2: Pathogens in the feather dusters Log(N).

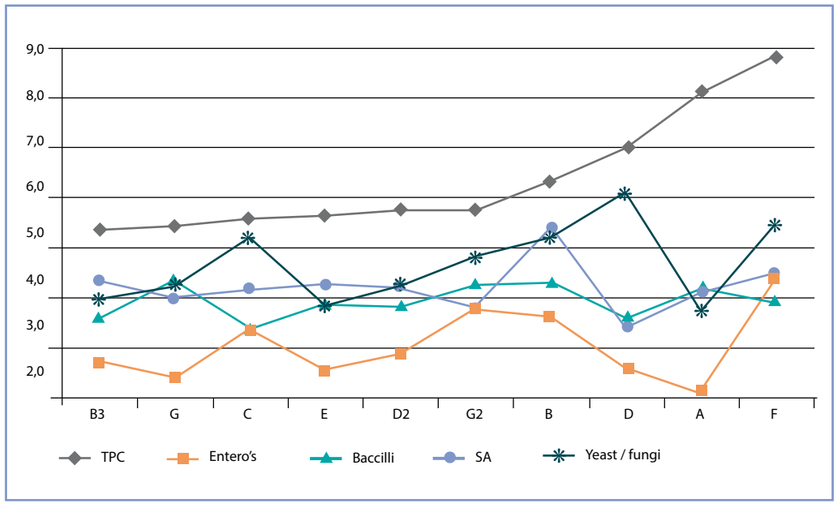


Figure 2 is a graphic overview showing the number of viable pathogens in the different feather dusters. The feather dusters are arranged on the horizontal axel in order of increasing number of pathogens. Only the feather dusters of which the complete set of micro-organisms were sampled are shown.

The graph does not provide any indication that a systematic connection should be assumed between the total number of viable pathogens and the infection rate of the other pathogens.

3.4 Relation between degree of contamination and air contamination

It seems plausible that a dirtier feather duster would distribute a larger number of pathogens in the ambient air and onto cleaned surfaces. A global comparison of the results shows that there is no indication to assume such a causal relation.

3.5 Ambient air contamination in defferent environments

Three hospitals, two homes and a university building were sampled for the number of pathogens in the air. The measured values are provided in table 7.

Table 7: Air contamination in different environments CFU per m^3.

Type location	Sampling conditions	Total number of viable pathogens (N (Log N))
Hospital 1	Samples from hallway of the outpatient clinic	345/ 2.5
Hospital 2	Samples from hallway and various traffic areas	640/ 2.8
Hospital 3	Samples from the passages and waiting rooms	650/ 2.8
Home 1	Living room: little activity and hard floor covering	200/ 2.3
Home 2	Living room: much activity and soft floor covering	575/ 2.8
University building	Entrance and hall on the ground floor	150/ 2.2

Chapter 4
Discussion and conclusions

The objective of this research is to ascertain the degree in which feather dusters that are used for facility cleaning activities in cleaning in health care are contaminated with micro-organisms and the degree in which these pathogens can be dispersed into the ambient air and cleaned surfaces due to cleaning activity with the feather dusters. For this purpose, various cleaning tests were executed with feather dusters that were used in hospitals. The contamination of ambient air, cleaned surfaces and the contamination of the feather dusters was measured.

4.1 Contamination of the ambient air

Air contamination is increased due to cleaning activities with a feather duster – this applies to all feather dusters. The degree of contamination is a factor 2 to 12 times higher than the initial contamination for both the number of viable pathogens (total viable pathogens: 800 to 5000 CFU / m^3 at a sampling volume of 20 litres) as for the number of Staphylococci (viable pathogens 130 to 660 CFU per m^3 at a sampling volume of 100 litres). Because of the setup of the research, these pathogens can only derive from the used feather dusters. It can therefore be concluded that cleaning with a contaminated feather duster increases the number of pathogens in the air where the cleaning is done.

Because the pathogens in the feather duster came from areas that were previously cleaned, it can be assumed that (disease causing) pathogens can be spread in this manner. It is therefore recommended that, in specific risk situations, feather dusters are not used for cleaning (hard) surfaces.

The question arises how the pathogen concentrations measured ought to be interpreted. In 2003, the Vereniging Leveranciers Luchttechnische Apparaten (Association for Manufacturers of Technical Air Equipment) published the "Measuring protocol Health Care 'Air sampling micro-organisms'". In this protocol, drafted for health care, target values are provided for the number of CFU/m3 for air in the operating theatres (Recommendations 2011). The following is stated:

There is an international classification of rooms according to order of cleanliness. Operating theatres are categorized in three different classifications:

- class 1 <10 CFU/m^3 (e.g. ultraclean operation theatres),
- class 2 < 200 CFU/m^3 (not very infection sensitive surgery) and
- class 3 < 500 CFU/m^3 (treatment rooms for minor surgery).

The values in the research at hand were established after cleaning with used feather dusters and are 10 times higher (5000 CFU m^3) than the threshold values for treatment rooms for minor surgery.

The initial air contamination (total number of pathogens) in the sampling room of this research was 400 CFU per m^3. In three hospitals, one living room in a private home with little activity and hard floor covering, one living room with soft floor covering in an active private household and on the ground floor of a university building (entrance and entrance hall), the (total) number of viable pathogens were sampled according to the same method and with the same equipment. The viable pathogens measured vary from 150 CFU/m^3 to 575 CFU/m^3. We can therefore conclude that the initial contamination in research sampling was not exceptional.

The increase in pathogen concentration (total viable pathogens – initial number of total viable pathogens) in the air is on average 5 times higher at a sampling volume of 20 litres than it is at a sampling volume of 100 litres. Analogue to this, an increase in the number of Staphylococcus measured at a sampling volume of 100 litre is more than 6 times higher than it is at a sampling volume of 500 litres. It is evident that the spatial dispersion of pathogens that are released from the feather dusters is limited; it creates a 'cloud' with increased numbers of pathogens. The differences between the measured values at 20 litres and 100 litres seems to indicate that the size of the 'cloud' immediately after the cleaning activity seems to be in the double digit with regard to litres. After all, the number of 'added' pathogens in both volumes are similar in size. This seems to be confirmed by the measurements of the Staphylococcus because the average number of 'added pathogens' in 100 litres is just about exact to the number in 500 litres.

The above seems to indicate, that while cleaning with feather dusters, fairly small clouds with an increased pathogen concentration are created. By mixing with air from the rest of the room, the concentration of pathogens in the cloud will decrease substantially in the surrounding area. It means that mainly the cleaners are exposed to the increased concentration of pathogens.

4.2 Pathogens on cleaned surfaces

After cleaning the different disinfected surfaces, trespa, stainless steel and glass respectively, with the contaminated feather dusters, pathogens are found on the surfaces. The degree of contamination ranges from < 5 pathogens per 100 cm^2 to 295 CFU per 100 cm^2 for the total number of viable pathogens and < 50 pathogens per 100 cm^2 to 200 cm^2 CFU for Staphylococcus aureus. On 3 of the 18 cleaned test surfaces no pathogens were found (< 5 CFU/100 cm^2) for the total pathogen count while no Staphylococcus aureus pathogens (< 5 CFU/100 cm^2) were found on 14 of the18 sampled surfaces.

4 hours exposure to the ambient air (total number of pathogens 400 *CFU/m^3*) without cleaning the test surface shows a degree of (total) contamination that is comparable to the degree of contamination that could occur after cleaning. One exception is the degree of contamination of glass after cleaning with feather duster F2.

In the publication "How do we assess hospital cleaning? A proposal for microbiological standards for surface hygiene", Dancer proposed a boundary for the contamination of hard surfaces in hospitals. He suggests a maximum value of 500 CFU per 100 cm^2 for hand contact surfaces. According to Dancer, a higher value would result in a higher risk of infection for patients (Dancer 2004). The highest degree of contamination ascertained in this research of 300 CFU/100 cm^2 is below the levels proposed by Dancer.

From the above, it can be concluded that there are no indications to assume that cleaning with contaminated feather dusters leads to relevant contamination of cleaned surfaces.
Only in risk situations does one need to take the probability of the spreading of pathogens into account via hard surfaces by contaminated feather dusters

4.3 Pathogens in used feather dusters

The contamination (total number of viable pathogens) of the used feather dusters varies between Log 4.7 to Log 8.8. In absolute terms this contamination is comparable to that of used household textile (Arild, Brusdal et al. 2003).

The contamination (total number of pathogens) of the feather dusters sampled in the research vary considerably and within one type of measurement they vary quite substantially:

- feather dusters A to G; used for cleaning air vents: Log 5.4 to Log 8.8
- feather dusters A3, F2 and G3; used for cleaning hard surfaces: Log 4.7 to Log 7.1
- feather dusters B3, D2 and G2; not used for cleaning in the test lab: Log 5.7 and Log 5.8

The feather duster pairs B-B3, D-D2 and G-G2 are the first to be sampled for total number of pathogens in cleaning an air vent. The differences between the feather dusters in one pair are so small in comparison to the variance within group A to G, that there is no indication that cleaning substantially reduces the contamination level in the feather dusters.

4.4 Summary of conclusions

- Feather dusters used in hospitals are contaminated with micro-organisms.
- During the cleaning of objects in high places the pathogens in the ambient air below the object is substantially increased. The local degree of contamination is 2 to 2 times higher than the initial degree of contamination of 400 CFU per m^3 air.
- The degree of contamination by the feather dusters on the cleaned surfaces is negligible and it will only be of importance in risk situations.
- While working with contaminated feather dusters, pathogens are dispersed in the air. The increased concentration of pathogens is local and after mixing with the ambient air, result in a limited increase of the initial level of contaminated air.
- Due to the local characteristic of the increased air contamination, possible effects will be limited to persons in the immediate vicinity of the cleaning activity.
- No systematic correlation was found between the total number of pathogens and the number of entero bacteria, bacilli, Staphylococcus aureus and yeasts and fungi in the sampled feather dusters.

- The contamination of the feather dusters is a cumulative effect of repeated and lengthy use of the feather dusters in a hospital. Therefore, it is not plausible that a cleaning activity, such as executed in the this lab test, would substantially alter the degree of contamination of the feather dusters. The results of this research support this assumption.

4.5 Limitations of the research

This research is intended and was setup as orientation research. Research parameters such as the number of participating hospitals, the number of feather dusters per hospital etc are based on this. This means that based on the results, no statements can be made about the hygiene in Dutch hospitals, for instance. However, precautionary measures can be formulated based on the results of this research and guidelines can be set for the use of feather dusters, for example. It is particularly relevant to consider the situations in which cleaning staff should or should not work with feather dusters. The risks of alternative methods should also be taken into consideration.

Furthermore, it should be noted that many factors have an effect on the air hygiene in hospitals. Waegemaeker provides a number of examples such as the number of door movements, open doors and the number of people in a space (Waegemaeker 2013).

Chapter 5
Literature references

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Chapter 6 Appendix

6.1 Number of pathogens calculated with exclusion of sample counts with less than 10 CFU per plate - formal calculation; CFU per 100 cm² surface (n, log n)

Code of feather duster	Sample moment	Total number pathogens* (KVE/100 cm²)			Staphylococcus aureus** (KVE/100 cm²)		
		Trespa	RVS	Glass	Trespa	RVS	Glass
A3	Before ***						
	After cleaning						
	5 minutes later						
F2	Before ***						
	After cleaning	55/ 1.7	80/ 1.8	295/2.5			
	5 minutes later	70/1.8		113/2.1			
G3	Before ***						
	After cleaning	75/ 1.9	70/ 1.8				
	5 minutes later						
Reference value ***	Before ***						
	4 hour exposure		75/1.7	50/1.4			

** If no values are stated, no pathogens were found; the CFU are <5 per 100 cm².*
*** If no values are stated, no pathogens were found; the number of CFU is less than 500 per 100 cm².*
**** For cleaning with the feather duster but after disinfection with alcohol.*
***** Surface contamination from a surface that has not been cleaned.*

6.2 Pathogens in the feather dusters calculated excluding counts with less than 10 CFU per plate - formal calculation; CFU per m³ (n (log n))

** If nothing is stated, the values found were smaller than 2. 6E+3*
*** If nothing is stated the values found are smaller than 2. 6E+44*

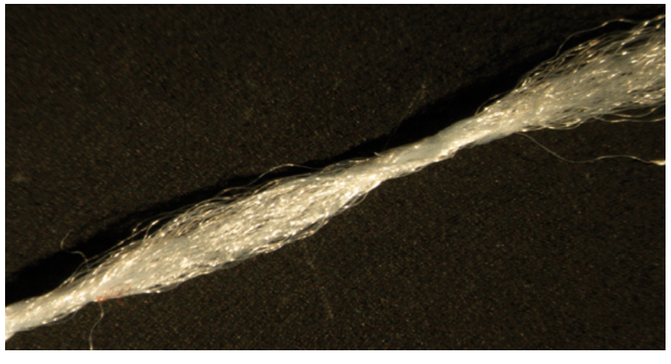
Code	TPC	Entero's*	Bacilli**	SA**	Yeast/fungi**
A	1,3E+08 / 8,1				
A3	5,2E+04 / 4,7	Not measured	Not measured		Not measured
B	2,3E+06 / 6,4	4,2E+03 / 3,6	2,9E+04 / 4,5	3,0E+05 / 5,5	
B3	2,3E+05 / 5,4			2,7E+04 / 4,4	
C	3,7E+05 / 5,6	2,6E+03 / 3,4			1,7E+05 / 5,2
D	1,0E+07 / 7,0				1,3E+06 / 6,1
D2	5,6E+05 / 5,7				2,6E+04 / 4,4
E	4,4E+05 / 5,6			2,9E+04 / 4,5	
F	7,0E+08 / 8,8	2,3E+04 / 4,4		3,9E+04 / 4,6	3,0E+05 / 5,5
F2	1,4E+07 / 7,1	Not measured	Not measured	1,1E+06 / 6,1	Not measured
G	2,7E+05 / 5,4				
G2	5,8E+05 / 5,8	5,9E+03 / 3,8			6,8E+04 / 4,8
G3	2,3E+05 / 5,4	Not measured	Not measured	1,1E+05 / 5,0	Not measured

6.3 Typs of feather dusters

An example of a feather duster that consist of singular fibres.

An example of a feather duster consisting of more or less bundled fibres.

An example of a feather duster consisting of twined fibres.



An example of a twined / twisted fibre.

6.4 Target values air contamination in operating theatres

Appendix A3 Target values for colony forming units per cubic metres of air in operating theatres (Advies 2011)

a. number of CFU in rest

The values of the CFU as measured in an operating theatre when not in use for surgery, are a measure for the quality of the air being blown in and with that, of the technical equipment to the plenum and/or whether the cleaning activities are sufficient. A target value of < 1 CFU/m^3 is within reach of a well functioning system, irrespective of whether it is a displacement or a mixing system. This value always has to be sampled after the completion of an air treatment system and after (radical) change.

b. number of CFU in OR during surgery

The number of CFU measured during surgery is a result of the CFU generated in the OR and the capacity of the air treatment system to discharge contaminated air rapidly and adequately. The current situation from the plenum in the OR is reflected by the numbers that supply data on (unnecessary) activities, (too) many people etc., or about flaws in the air flow profile.

In literature on this, distinction is generally made between operating theatres that are used for large implants such as like wrist prosthesis for instance and other operating theatres. The same classification is used by the Working Party of the Hospital Infection Society (HIS) in their recently published recommendations. In their reports, they distinguish between “ultraclean ventilated” (UCV) and “conventionally ventilated” operating theatres. For the Netherlands, this is in fact comparable to laminar down-flow systems and mixing systems.

There is also an international classification system for categorising rooms according to cleanliness. Operating theatres are categorized in 3 classes: class 1 < 10 CFU/m^3 (e.g. ultraclean operating theatres), class 2 < 200 CFU/m^3 (not very infection sensitive surgery) and class 3 < 500 CFU/m^3 (treatment rooms for small surgery).

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