TNO Chemistry

Nederlandse Organisatie voor
toegepast-natuurwetenschappelijk
onderzoek / Netherlands Organisation
for Applied Scientific Research

Location Zeist
Griffensteijnselaan 202
P.O. Box 360
3700 AJ Zeist
The Netherlands

www.tno.nl

T +31 30 694 41 44
F +31 30 695 72 24
infofood@voeding.tno.nl

TNO report

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Respiratory and dermal exposure to disinfectants during the disinfection of cattle trucks

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Author(s)	R.J. Snippe M.W.M. Lurvink L.J.W. Wezendonk I.H.M. Links H.J. Schipper
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Samenvatting

Deze studie werd uitgevoerd in overleg met het Ministerie van Sociale Zaken en Werkgelegenheid, ter karakterisering van werkgerelateerde blootstelling aan desinfectantia gedurende de desinfectie van vervoermiddelen voor het transport van vee. Doelstellingen waren zowel range finding, risicobeoordeling als blootstellingsmodellering. Onderzoeksvragen waren:

1. Wat is het niveau van de respiratoire blootstelling?
2. Wat is het niveau van de dermale blootstelling?
3. Wat is de relatie tussen blootstelling aan de ene kant en werkomgevings- en proceskarakteristieken aan de andere kant?
4. Hebben vrachtwagenchauffeurs die desinfectiewerkzaamheden uitvoeren meer negatieve dermale of respiratoire gezondheidsproblemen dan vrachtwagenchauffeurs die geen desinfectiewerkzaamheden uitvoeren?
5. Kan sensibilisatie tegen alkyl dimethylbenzyl ammoniumchloride worden aangetoond bij vrachtwagenchauffeurs die desinfectiewerkzaamheden uitvoer en, door analyse van bloedserum?

Dit rapport richt zich hoofdzakelijk op de blootstellinggerelateerde onderzoeksvragen (1-3). De gezondheidgerelateerde vragen (4-5) zouden worden beantwoord door middel van vragenlijstonderzoek en analyse van bloedmonsters, maar dit deel van het onderzoek is slechts gedeeltelijk uitgevoerd.

Omdat de resultaten van metingen aan verschillende desinfectantia slecht vergelijkbaar zijn, werden omstandigheden geselecteerd waarin slechts één specifieke quaternaire ammoniumverbinding werd gebruikt als actieve stof. De geselecteerde verbinding was alkyl dimethylbenzyl ammoniumchloride. Respiratoire blootstelling werd gemeten bij één bedrijf, waarna deze meting werd gestopt omdat de blootstelling (ook na verlaging van het meetbereik) steeds beneden de detectielimiet van (maximaal) 7,1 µg/m^3 alkyl dimethylbenzyl ammoniumchloride lag. Dermale blootstelling werd gemeten in vijf bedrijven. Zowel feitelijke (tevens potentiële) handblootstelling (n=46) als potentiële lichaamsblootstelling (n=15) werden gemeten; steeds tijdens de desinfectie van één voertuig.

De gemiddelde (GM) handblootstelling was 163 µg (bereik: <50 - 1898) alkyl dimethylbenzyl ammoniumchloride, of 0,63 mL (bereik: ND - 61) desinfectievloeistof. De gemiddelde lichaamsblootstelling (exclusief de handen) was 836 µg (bereik: 163 - 4719) alkyl dimethylbenzyl ammoniumchloride, of 3,1 mL (bereik: 0,5 - 39) desinfectievloeistof. De hoogst potentieel blootgestelde lichaamsdelen waren de benen en de handen; samen verantwoordelijk voor bijna 70% van de totale lichaamsblootstelling.

Twee werknemers werden bemonsterd tijdens de desinfectie van meerdere voertuigen. De hoogste potentiële blootstelling werd gevonden bij een werknemer die 10 voertuigen had gedesinfecteerd en was 21713 µg of 271 mL (gecombineerde hand- en lichaamsblootstelling).

Voor modellering ten behoeve van registratiedoeleinden wordt een totale potentiële lichaamsblootstelling van 0,8 mL spuitvloeistof per gebruikte liter spuitvloeistof voorgesteld. Voor uitsluitend de blootstelling aan de handen is dit 0,2 mL/L. Deze

waarden vertegenwoordigen het 90-percentiel van de gemeten blootstellingen. Een typische hoeveelheid spuitvloeistof is 18 liter per voertuig.

De potentiële lichaamsblootstelling tijdens de desinfectie van voertuigen voor veetransport laat zich het best verklaren door het gedesinfecteerde oppervlak (m^2), de tijdsduur (min.) en de flow van de desinfectievloeistof (L/min.). Deze laatste variabele werd gravimetrisch bepaald en was bedoeld als schatter van de spuitdruk. Op basis van deze variabelen werd een model ontwikkeld dat kan worden gebruikt voor schatting van de blootstelling tijdens desinfectie in een met deze studie vergelijkbare situatie.

Summary

This study was set-up to characterise occupational exposure to disinfectants during the disinfection of cattle transportation vehicles. The study was done for exposure range finding, risk assessment and exposure modelling purposes. Research questions were:

1. What is the level of respiratory exposure?
2. What is the level of dermal exposure?
3. What is the relation between exposure levels on one hand and work environment and process characteristics on the other hand?
4. Do truck drivers who perform disinfections experience more adverse dermal or respiratory health effects than truck drivers who do not perform disinfections?
5. Can sensitisation against alkyl dimethylbenzyl ammoniumchloride be demonstrated in truck drivers who perform disinfections, by means of blood serum analysis?

This report largely focuses on the exposure-related research questions (1-3). The health-related research questions (4-5) should have been answered by means of a questionnaire and blood serum analysis, but this part of the study was only partially executed.

Since results of exposure measurements with different or multiple disinfectants are difficult to compare, situations were selected in which one specific quaternary ammonium compound was used as active agent. The selected quaternary ammonium compound was alkyl dimethylbenzyl ammoniumchloride. Respiratory exposure was sampled at one company, after which it was stopped because the exposure levels were all below the detection limit of (maximum) 7.1 $\mu g/m^3$ alkyl dimethylbenzyl ammoniumchloride. Dermal exposure was sampled at five companies. Both actual (also potential) hand exposure (n=46) and potential whole body exposure (n=15) were sampled during the disinfection of one vehicle.

The mean (GM) hand exposure was 163 µg (range: <50 - 1898) alkyl dimethylbenzyl ammoniumchloride, or 0.63 mL (range: ND - 6.1) disinfection fluid. The mean whole body exposure (excluding the hands) was 836 µg (range: 163 - 4719) alkyl dimethylbenzyl ammoniumchloride, or 3.1 mL (range: 0.5 - 39) disinfection fluid. The body parts that received the highest potential exposure were the legs and hands; together they accounted for almost 70% of the total body exposure. Two workers were sampled during the disinfection of multiple vehicles. The highest potential exposure was found on a worker that disinfected 10 vehicles and was 21713 µg or 271 mL (combined hand and body exposure).

For modelling for authorisation purposes, a total potential whole body exposure of 0.8 mL spraying liquid per used litre spraying liquid is proposed. For potential hand exposure only, this value is 0.2 mL/L. These values represent the 90-percentile of the measured exposure. A typical amount of spraying liquid is 18 litres per vehicle.

The disinfected area (m^2), the work time (min.) and the flow of the disinfectant (L/min) best described exposure during the disinfection of cattle transportation vehicles. This last variable was determined by weight and was meant as estimator of the spraying pressure. With these variables, a model was made for estimation of the exposure during disinfection activities in situations similar to this study.

Contents

1 Introduction

1.1 Background

Because of their properties, disinfectants are potentially harmful for those who are exposed to them. The use of disinfectants for disinfection of rooms and contaminated materials is widespread, for example in medical or related institutions, in the production or processing of food, and in animal husbandry. Reports on health effects are merely restricted to health care centres, although for some other settings health effects have been suggested as well. Information on exposure levels is limited. Again, most of the (limited) information is based on studies in medical centres.

Because of their capacity to kill micro-organisms, disinfectants are classified as biocides (non-agriculture pesticides), since in 1998 the Biocidal Products Directive (Directive 98/8/EC) was brought into use. This Directive requires risk assessment of biocidal active substances, and biocidal products or preparations before they can be placed on the market. For the risk assessment, levels of exposure need to be compared to 'no adverse effect levels'. These 'no adverse effect levels' are based on human or animal studies taking the different routes of exposure into account. If studies on occupational exposure to the product or active substance for relevant use scenarios and with a representative sample size are present, a direct comparison with the 'no adverse effect level' is possible. However, if exposure data are lacking, inadequately presented, too limited in number or not sufficiently representative, one should seek for other ways to estimate the worker's exposure, for example by using other suitable reference studies. For the structuring of the exposure assessment process in the risk assessment for registration of pesticides a tiered approach has been developed (Henderson et al., 1993; EUROPOEM, 1997; BSG, 1998). The Biocides Steering Group, partly financed by the European Commission, DG XI, made an inventory of the current level of knowledge on occupational and non-occupational (consumer) exposure to biocides. Since data on exposure for different use scenario's is either lacking or not sufficient, studies focussed on different exposure scenarios are required.

In a previous study, respiratory and dermal exposure to disinfectants was assessed in slaughterhouses and the meat processing industry (Preller *et al.*, 1999). Workers, involved in that study, indicated that truck drivers experienced adverse health effects, which they attributed to the disinfection of their trucks. Since cattle transportation is a large sector of industry, of which no data with regard to exposure to disinfectants exist, it was decided to perform a study in that sector. Exposure to a disinfectant during disinfection of cattle transportation vehicles and the associations between exposure and potential determinants of exposure were studied. This information will be used for range finding of exposure levels in this type of industry, as well as a source of information for risk assessments. In addition to this, it was studied whether cattle truck drivers experience adverse dermal or respiratory health effects, by means of a questionnaire and analysis of blood samples.

This study was undertaken as part of the Health Hazard Survey program, supported by the Ministry of Social Affairs and Employment and in co-operation with Utrecht University.

1.2 Aims and objectives of the study

The main objective of this study was to characterise occupational exposure to disinfectants during the disinfection of cattle trucks. The study was done for exposure range finding, risk assessment and exposure modelling purposes.

The following questions were addressed in the study:

1. What is the level of respiratory exposure?
2. What is the level of dermal exposure?
3. What is the relation between exposure levels on one hand and work environment and process characteristics on the other hand?

Since results of exposure measurements with different or multiple disinfectants are difficult to compare, situations were selected in which one specific quaternary ammonium compound was used as active agent.

It was also planned to link the results of this study with the outcome of a questionnaire on health effects and blood serum analysis in co-operation with Utrecht University. This part of the study was set up to answer the research questions 4 and 5.

4. Do truck drivers who perform disinfections experience more adverse dermal or respiratory health effects than truck drivers who do not perform disinfections?
5. Can sensitisation against alkyl dimethylbenzyl ammoniumchloride be demonstrated in truck drivers who perform disinfections, by means of blood serum analysis?

However, only few workers were willing to donate a blood sample, and because of the outcome of this field study the survey was not completed and the answers were only partial studied.

2 Disinfection

In this study and in the pilot study several companies were visited. During these visits, characteristics of the companies and the disinfection process were investigated. This information was used for description of the disinfection process.

2.1 Disinfection process

Large differences in the disinfection methods were observed in the visited companies. For a large part, these differences were related to the type of cattle that was transported, probably due to the different legal regulations.

A distinction has to be made between swine and other cattle. The regulations for the disinfection of swine transportation vehicles were very strict at the time of this study (1999 – 2000). Each time the truck is unloaded, the vehicle has to be cleaned and disinfected at a registered disinfection place. For other cattle, the regulations are less strict. The truck should always be clean, and disinfected at least once a week.
Probably because of these differences in regulations, it was observed that, in general, swine transportation vehicles are disinfected (much) more thoroughly. Both cattle markets and slaughterhouses were visited. The cattle markets handled all kinds of cattle except swine, while the visited slaughterhouses only processed swine.

In all cases, the truck is previously cleaned with a large amount of cold water. Depending on the size of the vehicle, the cleaning takes about 15 minutes to one hour. After cleaning, the vehicle should be disinfected. According to the safety information of the supplier of the disinfectant, disinfection should take place using low-pressure non-vaporising equipment (max. pressure 10 Atm.). Usually, a long lance is used and the disinfection is done by the truck driver. He should spray the whole inside of the truck, including all floors, walls and ceilings, the outside, wheels and the floor mats of the cabin. When this is done properly, the disinfection process takes about two to five minutes, depending on the size of the vehicle and the number of floors. After completion, an inspector of the disinfection place should stamp a driver's booklet as proof of proper cleaning and disinfection.

At the visited slaughterhouses, the disinfections were usually performed as described above. However, at the visited cattle-markets it was noticed that most truck drivers did not pay much attention to the quality of the disinfection. In most cases, the trucks were only partly sprayed and the disinfection took only a few seconds.

2.2 Method of mixing/loading and application

At the visited slaughterhouses, the disinfection formulation is distributed from a central location to one ore more disinfection places. The undiluted formulation is added to the water by means of an automatic dosage system. Independent mixing and loading of the chemical did never take place. Containers with formulation are always loaded by a technician or the supervisor of the washing place; never by the truck drivers. At cattle markets, a mobile spraying tank with a capacity of a few hundred litres is also used. In that case, mixing and loading of the formulation is done by the supervisor of the disinfection place.

3 Methods

3.1 Selection of disinfectant

Criteria for the selection of the disinfectant for the present study were frequent and large-scale use, the availability of an analytical method, and a relative high dosage per disinfected vehicle. To disinfect cattle transportation vehicles, four products are mainly used: Halamid-D, P3 Incidin 03, P3 Incidin 05, and P3 Incidin 07 (A. Veldhuizen, National Inspection Service for Livestock and Meat (RVV), personal communication, 1999). The active ingredient of the first product is a chloramine, while the other three products are based on quaternary ammonium compounds, sometimes in combination with formaldehyde, glutaraldehyde, or potassium hydroxide. Only washing sites using the most widely used disinfectants P3 Incidin 03, 05, 07 were contacted for participation in this study to allow comparison of different measurements and because TNO already developed and validated analytical methods to analyse quaternary ammonium compounds. All the participating companies only used the P3 Incidin 05 formulation. Information on the product and the amount of active substance is summarised below.

Formulation	
Name:	P3 Incidin 05
Active substance that was sampled:	alkyl dimethylbenzyl ammonium chloride
CAS-number of active substance:	63449-41-2
Content of active substance:	19 g/L
Appearance:	liquid
Use:	disinfection
Application rate according to labelling:	150 mL/ 10 L (1.5%)

The disinfectant was applied using low pressure (<10 Atm.) spraying application. The actual concentrations applied varied between the locations. Tank samples and samples of the diluted product were taken at all visited disinfection locations.

3.2 Selection of companies en test subjects

3.2.1 Companies

The selection started with a list of registered disinfection places, that was obtained from the National Inspection Service for Livestock and Meat (RVV). Additionally, addresses obtained from the Yellow Pages and the Internet were used. A total of about 20 slaughterhouses and 6 cattle-markets were approached. Meat companies where pigs were slaughtered as well as cattle-markets, where mainly cows and sheep were marketed, were contacted by telephone and asked to participate in the study. When the person responsible for the disinfection procedure was interested, and the company used the P3 Incidin 03, -05 or -07 formulation, information on the study was sent. Some weeks later the company was contacted by telephone to ask whether they wanted to participate in the study.

Intentionally, both cattle-markets and slaughterhouses were to be included in the study. After visiting a cattle-market during the pilot study and one more during the field study,

it showed that the workers were not very willing to co-operate and that the disinfection of the cattle trucks was performed in a very short time (<1 min.). The exposure to the disinfectant was expected to be very low and the time that was taken for disinfection generally too short to allow meaningful measurements. For these reasons, it was decided that the search for more disinfection places should be aimed at slaughterhouses only.

3.2.2 Test subjects

Prior to the pilot- and the field study, information leaflets for the truck drivers were sent to the disinfection places willing to participate in the study. These leaflets were addressed to the supervisor of the disinfection facility, who was asked to hand out the information to the cattle-truck drivers. The test subjects (truck drivers) were selected on the field day. They were informed about the objectives of the study, the sample collection process and the handling of personal data, both verbally and in writing. All subjects had to sign the Informed Consent form (VOE/PRT/40643 F03) and a personal co-operation agreement (VOE/PRT/40643 F02) prior to participating in the study.

To be included in the study, the worker performing the disinfection of the cattle trucks had to:

- be self-employed or be employees of companies that have permitted the re search facility to request their employees to participate in the study;
- have work experience with disinfection of cattle-trucks for at least 1 month;
- disinfect cattle-trucks on a regular base;
- be at least eighteen years of age.

3.3 Exposure assessment

3.3.1 Respiratory exposure

Respiratory exposure was measured using an IOM sampling head. The sampling head contained two (front and back) glass fibre filters (25 mm, pore diameter 8.0 μm, Millipore Corporation, USA) which were placed in the cassette holder of the IOM sampling head. The IOM sampling head was attached to a constant flow air sampling pump, operating at 2 L/min (Dupont Personal Air sampler S2500, Delaware, USA), estimating the inhalable aerosol fraction (CEN, 1992). Flow rates were checked before and after sampling using pre-calibrated Rotameter tubes (ROTA, Dr. Henning GmbH, Germany). When flow rates differed more than 10%, the measurement was not found reliable and was rejected. The IOM sampling head was attached in the breathing zone of the worker. After sampling the IOM sampling head was removed, covered by a cap, and taken to the laboratory where the filters and the cassette holder were removed from the sampling cassette and analysed the next day.

In practise, the flow rates did not differ more than 5 percent, so all measurements could be used. To calculate the personal respiratory exposure, the amounts found on the front and back filters and cassettes were adjusted by the amount found on the blank sample. Observations below the limit of quantification (LOQ) were set at fifty percent of the LOQ, assuming a log normal distribution (Hornung and Reed, 1990). Concentrations measured using the IOM sampling heads were calculated in μg/m3, using the amount found on the filter (μg), the average flow rate (L/min) and the sampling time (min).

3.3.2 *Hand exposure*

Actual hand exposure was determined using a hand wash method. The worker washed his hands once before the start of disinfection to remove any residues present. This washing liquid was not retained for analysis. Whether gloves were used during disinfection was decided by the worker. After completion of the disinfection, the worker washed his hands twice. Workers were asked to work according to their normal working procedures. It was allowed to use gloves during disinfection, if the worker wanted to do so. These gloves were not handed out by the researchers, so the material and type of gloves varied between the workers.

For the hand wash, a polyethylene bag was used, which was filled with 500 mL Isopropylalcohol(IPA)/Water (60:40). The washing liquid was transported in 1-litre polyethylene bottles. Hands were washed for 30 seconds in the liquid. The hands were taken out the polyethylene bag and the water was poured back in the polyethylene bottles. For the second hand wash the same procedure was followed. Samples were stored at 2 - 8°C until analysis.

Exposure to the hands was calculated by adding the exposure levels measured in both hand washes. Observations below the limit of quantification (LOQ) were set at fifty percent of the LOQ. Exposure was presented as total dose per disinfection. The washing efficiency, determined in a small experiment with three volunteers (Preller *et al.*, 1999), varied between 73% and 91%. No correction was made for this recovery.

3.3.3 *Potential body exposure*

Potential whole body exposure was measured during application of the disinfectant. The dermal exposure was assessed using a Tyvek® coverall with hood (Pro tech, Dupont). After sampling, the coverall was cut into pieces, using a pair of scissors. The samples were collected in polyethylene bottles and stored at 2- 8°C until analysis. The coverall was cut into 7 pieces and the samples were composed according to the list below:

- head
- left and right lower leg
- left and right upper leg
- left and right lower arm
- left and right upper arm
- torso front
- torso back

Total potential body exposure was calculated by addition of the subsamples mentioned above. Observations below the limit of quantification (LOQ) were set at fifty percent of the LOQ. Exposure was presented as total dose per disinfection.

3.4 Questionnaire on health effects

During the days of the dermal and inhalation sampling, questionnaires were handed out to the cattle truck drivers arriving at the slaughter house. The questionnaire contained 10 general questions (age, education, smoking, etcetera), 13 questions on respiratory health effects, 14 questions on dermal health effects and 14 work-related questions. The questionnaire was based on earlier used questionnaires: 1) Disease and waste dust exposure [BMH$-CT96-0105], developed by I.M. Wouters, J. Douwes, G. Doekes, D.J.J. Heederik, all from the Department of Environmental and Occupational Health of the Wageningen University, and 2) Evaluation of a self administered questionnaire on hand dermatitis (Smit *et al.*, 1992). Workers were free to choose to fill in the

questionnaire at the disinfection place and hand it to the field workers, or take the questionnaire home and return it by mail.

3.5 Workplace and work characterisation

During the disinfection activities, the workers were observed and the time that was spent on a number of subtasks (like spraying exterior, spraying interior, moving spraying parts, handling or moving parts of the truck) was registered.

In addition to this time registration, information on the characteristics of the treated truck was noted (such as the area treated, the height and length of the loading area and what surfaces were disinfected). The dimensions of the truck were asked at the driver. If he was not sure, the dimensions were estimated. The total height of the truck was calculated by adding the heights of all floors of the truck. Because the floors are movable, the height of each floor may fluctuate and was not always noted in the same way by the different field workers. To correct for unrealistic heights, a maximum of 3.0 metres was set for the total height of the truck. Two methods were used for calculation of the treated area:

- Method 1: For all parts of the truck (like wall, floor 1, floor 2, ceiling, etc.) it was noted whether these parts were treated. The total treated area was calculated by the sum of all treated areas.
- Method 2: The fieldworker estimated, for both the inside and the outside of the vehicle, which part (in quarters) was treated. This fraction was multiplied by the total area of respectively the inside and the outside of the vehicle. The total treated area was calculated by addition of these two results.

With regard to the disinfection place, some variables like meteorological conditions, layout, concentration of the disinfection liquid and the flow of the disinfectant were noted. This last variable was added as a substitute for the spraying pressure and was estimated by weighing the amount of spraying liquid that was sprayed in a bucket during a precisely timed period of about ten seconds. The volume of the fluid was estimated by weighing the bucket before and after filling and assuming a density of the fluid of 1.0 kg/L. After weighing the filled bucket, a sample of the disinfection fluid was taken to determine the concentration of the diluted formulation.
Furthermore, observational data with regard to personal protection and hygiene of the worker, such as protective gloves and smoking during work activities, were noted.

3.6 Quality control

Field spikes were taken to assess the stability of the samples during transport. The spikes were prepared in the laboratory with P3 Incidin 05. Two concentrations were used for the potential body exposure spikes (coverall sample piece) and one concentration was used for the actual hand exposure spike (IPA/Water) and the inhalation exposure spike (sampling head with two filters). One spiked sample of each matrix was taken to the location of the measurements, while a bottle that contained the same amount of spike liquid stayed closed at the laboratory during the sampling period. Field blanks were taken to assess whether background exposure or contamination of samples as result of the sampling procedure occurred. Blank filters for personal sampling were taken before the sampling took place. For a blank sample of the hand wash liquid, one of the field workers pored a bottle of washing liquid in a polyethylene

bag, waited 30 seconds and recollected it in the same bottle. Field blanks of the Tyvek® coverall were collected by cutting a piece from a clean coverall, during the collection of a exposure sample. The spike and blank samples were treated in the same way as all other samples. After sampling, the spike and blank samples where transferred to the laboratory, where they were stored until analysis in a cooling chamber at a temperature between 2 and 8 C.

3.7 Chemical analysis

3.7.1 Tyvek® matrices and hand wash liquid

The Tyvek® coverall were extracted using methanol/water 60:40. The volumes added to the Tyvek® matrices varied between 200 and 500 mL depending on the weight of the dosimeter. Tyvek® matrices were extracted by placing them in an ultrasonic bath for 5 to 10 minutes. Subsequently, the samples were shaken for 30 minutes in a shaking apparatus at 300 strokes per minute. Hand wash liquid needed no extraction.

3.7.2 Analytical chemical methods

In a disinfectant solution, alkyl dimethylbenzyl ammoniumchloride consists of more than one component, the lengths of the alkyl groups vary. The standard of alkyl dimethylbenzyl ammoniumchloride used, existed for 66% of C12 alkyl groups and for 34% of C14 alkyl groups. For calculation of the total amount of alkyl dimethylbenzyl ammoniumchloride the area under the curve of the C12 and C14 component in the mixture were added.

Quaternary ammonium compounds were determined by HPLC using a Lichrosorb CN, Hibar, 250/4.0, 5 m column. For analysis of the Tyvek® coverall and the hand wash liquid eluens containing 50% demi-water, 50% acetonitril (pH = 2.2) was used. The flow was set on 1.0 mL per minute and the UV detection at 210 nm. For analysis, 10 to 100 µl of the extraction liquid was directly injected on the HPLC system. Linearity was found for all calibration curves in the concentration range from 0 to 200 mg/L. The LOQ of alkyl dimethylbenzyl ammoniumchloride varied for the different matrices between 50 and 100 µg/L. On the blank Tyvek® samples and in the hand wash liquid no background was found.

In an experimental setting, the wash efficiency was tested (Preller *et al.*, 1999). Three volunteers washed their hands after application of one high and one low dose. After a period of waiting, hands were washed three times for 30 seconds with 500 mL IPA/water 60:40. The wash efficiency for the lower dose was in the first wash on average 73% (range 72-74%). In the second wash, less than 5% was washed off. For the higher dose, 84% (range 80-87%) was washed off in the first wash and less than 4% was washed off in the second wash. Neither for the lower nor the higher dose a detectable amount of alkyl dimethylbenzyl ammoniumchloride was found in the third wash.

3.7.3 Recovery, stability and coefficient of variation

For the Tyvek® coveralls the coefficient of variation for between days (n=6) and within days (n=3) was below 10% and 5%, respectively. The recovery of alkyl dimethylbenzyl ammoniumchloride by extraction from the Tyvek® coverall was >85% (n=6). Stability was tested during the field work period. The Tyvek® matrices were stable for at least 51 days.

For the hand wash samples the coefficient of variation between days (n=5) and within days (n=6) was below 5%. The hand wash samples were stable for at least 26 days.

3.8 Data management and statistical analysis

Data analyses were done using SAS (version 8.1). First, the distribution of all exposure parameters was tested with PROC UNIVARIATE (Shapiro Wilk test). Descriptive statistics like AM, SD, GM, GSD, MIN, MAX and 90-p were calculated using PROC MEANS and PROC UNIVARIATE. Exposure values were expressed both in µg alkyl dimethylbenzyl ammoniumchloride and in mL diluted product.
In describing the association between exposure level and determinants of exposure, all determinants with sufficient distribution within the population were selected for evaluation. In all models log-transformed values were taken. Modelling exposure was done with linear regression analysis using PROC REG. Multivariate models were constructed using SAS 'stepwise', 'forward' and 'back ward' selection procedures (using default p-values for entry in and deletion from the model). In addition, the association of all variables with the dependent variable was evaluated separately in order not to miss potential relevant variables due to correlation with other variables selected by the stepwise procedure. Selected were those multivariate models with a minimum of independent variables, the highest significance of the model, and the largest explained variance. Influence of single observations on parameter estimates was evaluated based on Cook's D. If necessary, observations were deleted and stepwise regression procedures were per formed again to select optimal multivariate models.
Model validity was further evaluated by analysis of residuals. To use the results of the study for exposure assessments for registration purposes, the data needed to be converted to generally applicable units. Hand and body exposure is expressed in mL spray liquid per treated vehicle. For conversion of the exposure levels from µg to mL, the actual measured applied concentration (g/L) was used.

4 Results

4.1 Population and work environment

4.1.1 Companies

Exposure measurements were done at five slaughterhouses. At company 1 the vehicles were disinfected outside, in the open air, and at company 6 the vehicles were disinfected inside, in a fully enclosed area. At the companies 3 and 5, the disinfection area was three sided enclosed and roofed-over, like a garage box. All companies used P3 Incidin 05 for disinfection. According to the safety information of the supplier, this product should be applied in a concentration of 1.5-% using low pressure non-vaporising equipment (max. pressure 10 Atm.). The measured flow and concentration ranges are listed in Table 1. The analysis of the spray liquid showed variation in concentration. The variation in concentration and flow within one company is comparable with the variation between the companies.

Table 1 Concentration and flow of the disinfection fluid per company

Company	Flow (L/min)			Concentration diluted product (%)		
	n	mean	range	n	mean	range
1	19	7.1	4.5 – 8.7	19	1.3	0.5 – 2.6
2	0	ND	ND	0	ND	ND
3	9	4.4	2.7 – 7.6	8	2.1	1.9 – 2.3
4	2	7.9	7.9 – 7.9	1	0.45	0.45
5	8	7.6	3.2 – 10	10	1.4	0.9 – 1.9
6	9	3.2	1.6 – 5.0	10	1.9	1.6 – 2.1

ND = No Data. Company 2 was a cattle market. No measurements were done because none of the drivers was willing to co-operate.

4.1.2 Workers

Fifty-nine workers were monitored. The data of five workers were excluded from the standard analysis. This concerns the data of the persons 28, 32, 33, 34 and 45.

The persons 33 and 34 were supervisors who also performed the disinfection activities at company 4. Data of these workers were not compatible with the other workers, because these two persons disinfected several vehicles during one sample period. Individual disinfections were not sampled for these workers. Data of these two workers were analysed separate as a 'worst case scenario'.
Person 28 was a supervisor at company 3, who did not perform disinfections. He was sampled once, after he was exposed during trouble shooting activities because of a leakage of disinfection formulation. His data were excluded because the exposure was not due to disinfection activities and because the exact cause of the exposure was not observed by the researchers.

The remaining 56 workers were male, with a minimum age of 22 years and a maximum of 58 years. Their mean age was 36 years (SD = 9 years). Only two of these workers wore protective gloves (persons 32 and 45). Their hand exposure data were analysed separately.

4.1.3 *Vehicles and disinfection*

Each worker disinfected one vehicle, thus 56 vehicles were disinfected. These included 44 (articulated) lorries, 7 (semi-) trailers and 5 lorry and trailer combinations. The average vehicle had a length of 10 metres and had 2 floors. Statistics of these and other vehicle-related parameters are listed in Table 2.

Table 2 Statistics of vehicle parameters

Variable	Mean	Std dev	min.	max
Vehicle length (incl. trailer) [m]	10	3.8	3	25
Number of floors	2.4	0.6	1	3
Total height of all floors [m]	2.8	0.3	2.0	3.0
Volume of vehicle [m^3]	71	2.8	9.2	158

Disinfection of a vehicle lasted between 0.7 and 13.3 minutes (mean=3.9). Distribution of the work time values was tested using the Shapiro-Wilk test and appeared to be lognormal. Table 3 lists the mean duration of the individual sub tasks. From the results, it can be seen that spraying of the vehicle took on average 83% of the total time.

Table 3 Mean duration of individual subtasks during disinfection

Task	Absolute duration (minutes)			Relative duration (% of total time)		
	mean	min	max	mean	min	max
Total time of disinfection	3.9	0.7	13.3	100	100	100
Breaks	0.1	0	2.3	1	0	23
Mixing & loading	0	0	0	0	0	0
Spraying interior while standing outside	0.5	0	5.0	13	0	52
Spraying exterior	1.3	0	5.5	36	0	100
Spraying interior while standing inside	1.4	0	6.7	33	0	80
Handling equipment or vehicle parts	0.7	0	3.7	16	0	69

The treated area and the amount of disinfection fluid were calculated for each worker. The mean values are listed in Table 4. The treated area was calculated in two ways (see chapter 3). Because none of these two ways clearly provided the best estimate, both estimates are listed.

Table 4 Statistics of disinfection parameters

Variable	Mean	Std dev	Min	Max
Treated area (% of inside surfaces)	72	23	25	100
Treated area (% of outside surfaces)	62	29	0	100
Treated surface (method 1) [m^2]	206	97	8	473
Treated surface (method 2) [m^2]	175	81	16	445
Used amount of disinfection fluid [l]	18	18	2	95

Treated surface

Method 1: sum of the surfaces of all individual treated parts (floor 1, floor 2, ceailing 1, wall, etc.)

Method 2: sum of (total surface inside x % treated) + (total surface outside x % treated)

Although the spraying pressure was not measured directly, to the opinion of the researchers the spray pressure at the visited disinfection places was 10 atmospheres maximum as prescribed. This was concluded because the portable spraying tank at a cattle market that was, based on observation of the spray, believed to have the highest spraying pressure contained a pressure gauze indicating exactly 10 atmospheres. At the other disinfection places, the spraying pressure was, based on observation, believed to be much lower.

4.2 Clothing regime and hygiene

The use of protective clothing and personal protective equipment was registered for all workers except one. Table 5 shows the use of personal protective equipment per company. In all cases, rubber boots were worn. Usually these were boots provided by the slaughterhouse, because it was obligatory to wear these. In contrary to this, nobody wore any type of respiratory protective equipment. The use of protective gloves was also uncommon. The use of a Tyvek® coverall differed very much per company, probably based on the availability of these coveralls and whether or not the use of these was obligatory. If Tyvek® coveralls were used they were provided by the slaughterhouse and never brought in by the truck drivers. The researchers only provided coveralls for potential body exposure sampling. In all cases, it was common practice to wear a cotton coverall, independent of the fact whether an additional Tyvek® coverall was worn. It was also common practice to wash the hands after disinfection. Nobody was observed to eat, smoke or rub his face during disinfecting or cleaning activities.

Table 5 Use of protective clothing (frequencies and percentages per company)

Type of protective clothing	Company (number)								Total	
	1		3		5		6			
	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Tyvek® coverall [1]	2	14	0	7	0	8	8	0	10	29
	13%	87%	0%	100%	0%	100%	100%	0%	26%	74%
Rubber boots	2	17	0	11	0	12	0	12	2	52
	11%	89%	0%	100%	0%	100%	0%	100%	4%	96%
Gloves	16	3	10	1	11	1	12	0	49	5
	84%	16%	91%	9%	92%	8%	100%	0%	90%	9%
Any RPE [2]	19	0	11	0	12	0	12	0	54	0
	100%	0%	100%	0%	100%	0%	100%	0%	100%	0%

1) Workers wearing a Tyvek® coverall for dermal exposure measurements were not counted

2) RPE = Respiratory Protective Equipment

4.3 Sampling scheme and meteorological conditions

Samples were taken on ten days between November 26 1999 and November 28 2000. Personal air samples were only taken during the first four days. After these four days, it was concluded from the sampling results that the concentrations of the test substance in air were too low to continue these measurements. An overview of the amount of samples that was taken on each day is provided in Table 6. Only the samples that were actually used in the analysis are listed.

The meteorological conditions varied from typical winter conditions to typical summer conditions. Temperatures during sampling ranged from freezing point to 21 degrees Celsius (Table 6). Relative humidity was considered relevant for inhalation exposure only. During the four days when inhalation exposure was sampled, the relative humidity ranged from 46 to 98%.

Table 6 Sampling scheme and temperature

Date	Premise	Temperature in °C [1]		Number of samples		
		mean	range	hand wash	personal air	coverall
26-11-1999	1	5	2 – 8	2	2	1
28-11-1999	1	2	-1 – 6	5	5	1
29-12-1999	1	3	1 – 6	3	4	1
22-02-2000	1	3	-1 – 6	0	16	0
13-06-2000	3	17	14 – 20	7	0	2
14-06-2000	3	18	15 – 20	5	0	2
12-09-2000	5	18	14 – 21	6	0	2
13-09-2000	5	16	10 – 20	6	0	2
27-11-2000	6	7	5 – 8	6	0	2
28-11-2000	6	12	7 – 15	6	0	2
			SUM	46	27	15

[1] Source: Monthly statistics, Royal Dutch Meteorological Institute (KNMI)

4.4 Personal exposure levels

4.4.1 Respiratory exposure

A total of 27 personal air samples were taken. The first 11 samples did not contain a detecTable amount of alkyl dimethylbenzyl ammoniumchloride (LOQ= 0.5 µg/sample). As a test, the flow of the pumps was raised from 2.0 L/min to 3.5 L/min. on 22-02-2000. On that day, eight samples were taken in duplicate using two sampling heads: besides the IOM sampling head a GSP sampling head was used. This GSP sampling head was especially designed for use with these higher flows and outdoor conditions. Still, alkyl dimethylbenzyl ammoniumchloride was detected in only four of the 16 samples. These results are listed in Table 7. In all cases, the disinfectant was detected in only one of the duplicates. Besides, in four of the five subsamples, the disinfection fluid was only found on the cassette, which is in fact not meant for sampling. For these reasons, it was concluded that airborne concentrations of alkyl dimethylbenzyl ammoniumchloride were too low, or the disinfection time too short, for personal air sampling and it was decided to stop these measurements.

Table 7 Results of all personal air samples above detection limit

Date	Person (number)	subsample F/B/C [1)]	Duration (minutes)	Result ($\mu g/m^3$)
22-02-2000	13	C		67
22-02-2000	15	C	610	45
22-02-2000	16	F	6	62
22-02-2000	16	C	6	157
22-02-2000	17	C	13	26

[1)] Subsample: F = front filter, B = back-up filter, C = cassette

On 22-02-2000, the LOD's of the samples in which no alkyl dimethylbenzyl ammoniumchloride was detected were 2.19, 2.79, 4.76 (2x) and 7.14 (4x) $\mu g/m^3$. Based on this highest LOD, it is concluded that the inhalation exposure in this company is lower than 7.14 $\mu g/m^3$ alkyl dimethylbenzyl ammoniumchloride. This corresponds with approximately 0.03 mL disinfection fluid per m^3 (considering a mean concentration 1.3% P3 Incidin 05 in the diluted product).

4.4.2 Actual hand exposure

Alkyl dimethylbenzyl ammoniumchloride was detected in most hand wash samples. The results are listed in Table 8. To correct for differences in concentrations of the disinfection fluid, the values in µg were recalculated to mL disinfection fluid by dividing the value in µg by the concentration of the diluted product (µg/L). If the latter concentration was not available for a specific worker, the mean dilution that was measured for the other workers on the same day was used instead. The results of the hand wash samples were log-normally distributed, with limited variance (GSD=2.9/3.2).

Table 8 Results actual hand exposure samples

Statistic	Result hand wash (n=44)	
	µg test substance	mL disinfection fluid
Arithmetic mean	292	1.2
Standard deviation	384	1.4
Geometric mean	163	0.63
Geometric standard deviation	2.9	3.2
Range (min – max)	ND (<50) – 1898	ND – 6.1
90-percentile	688	2.8

ND = not detected

Two of the 46 workers that participated in the hand wash experiments wore rubber gloves for personal protection. Their data were analysed separately. Their actual hand exposure levels to alkyl dimethylbenzyl ammoniumchloride were 50 and 397 µg (respectively 0.31 and 0.89 mL diluted product). These exposure values are very comparable to the rest of the population (that did not wear gloves). Because only two workers wore gloves, no conclusions can be drawn based upon these results. However, obviously the gloves did not protect these two workers very well. Possibly, the gloves were contaminated or the workers touched some contaminated clothes or surfaces after removal of the gloves.

4.4.3 Potential whole body exposure

Alkyl dimethylbenzyl ammoniumchloride was detected in most coverall samples. The results are listed in Table 9. To correct for differences in concentrations of the disinfection fluid, the values in µg were recalculated to get the result in mL disinfection fluid. This was done the same way as for the hand wash samples. The results of the coverall samples were log-normally distributed. The log-transformed values show limited variance (GSD=2.8/3.8).

Table 9 Results potential whole body exposure samples (coverall only)

Statistic	Results coverall samples (N=15)	
	µg test substance	mL disinfection fluid
Arithmetic mean	1349	7.3
Standard deviation	1409	11
Geometric mean	836	3.1
Geometric standard deviation	2.8	3.8
Range (min – max)	163 – 4719	0.5 – 39
90-percentile [1)]	3746	25

[1)] The 90-percentile represents the 14th observation (n=15)

The results of the coverall samples and the hand wash samples were added to estimate the total potential exposure of the body (Table 10). Because one of the sampled workers wore protective gloves during the disinfection, his actual hand exposure does probably not reflect his potential hand exposure. This worker's hand exposure data were not used for calculation of the whole body potential exposure. Therefore potential whole body exposure data are available for only 14 workers.

Table 10 Results potential whole body exposure samples (coverall + hand wash)

Statistic	Combined results coverall + hand wash	
	µg test substance	mL disinfection fluid
Arithmetic mean	1629	8,8
Standard deviation	1580	13
Geometric mean	1087	4,1
Geometric standard deviation	2,6	34
Range (min-max)	253 – 5449	0,8 – 45
90-percentile [1)]	3979	28

1) The 90-percentile represents the 13th observation (n=14)

The distribution of the dermal exposure over the individual body parts is shown in figure 1 and in Table 11. In the table, the results are also provided as percentage of the total body exposure. The body parts with the highest exposure are legs and hands. Lower legs, upper legs and hands account for almost 70% of the total body exposure.

Table 11 Results potential whole body exposure samples (coverall + hand wash)

Body part	Exposure in µg				Exposure in mL				% of total
	mean	sd	min	max	mean	sd	min	max	body
Head	49	80	10	285	0.34	0.68	0.02	2.38	2.8
Torso front	5	190	15	666	0.93	1.57	0.04	5.55	9.2
Torso back	137	193	15	597	0.93	1.63	0.04	0.98	8.2
Upper arms	80	107	10	349	0.48	0.84	0.02	2.91	5.5
Lower arms	118	182	15	662	0.76	1.49	0.03	5.52	7.8
Upper legs	328	632	20	2457	1.34	1.93	0.06	5.99	15.3
Lower legs	548	496	20	1582	3.00	4.07	0.06	13.18	32.4
Hands	216	173	50	730	1.10	1.59	0.17	6.08	18.9
TOTAL	1629	1580	253	5449	8.87	12.92	0.81	45.41	100.0

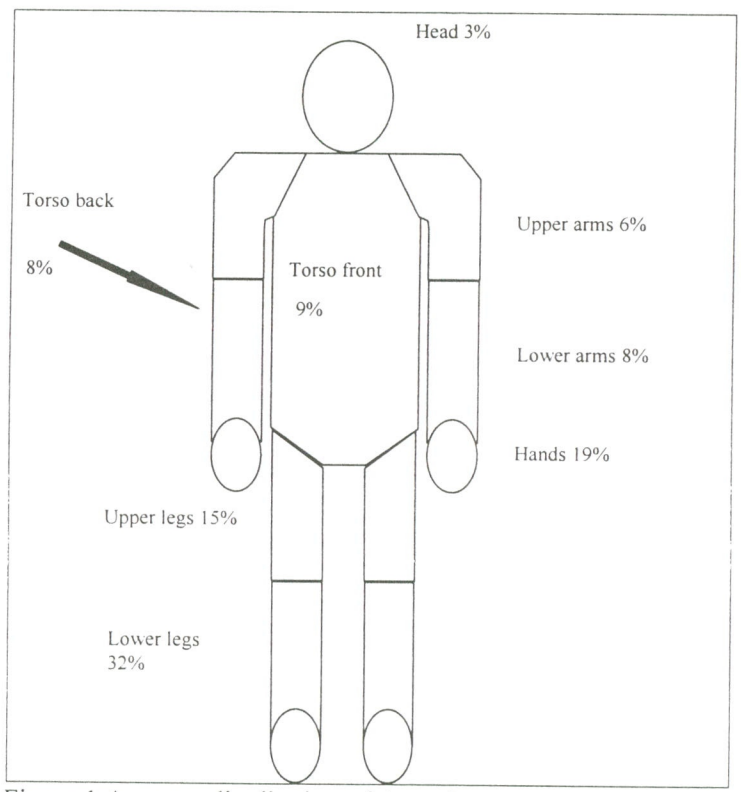

Figure 1 Average distribution of dermal exposure over the body

4.5 Determinants of dermal exposure

The following variables were selected for data analysis:

- flow of the disinfection fluid (in L/min);
- duration of the disinfection (in min.);
- volume of the treated vehicle(s) (in m^3);
- treated area (in m^2, calculated in two ways, see paragraph 4.1.3);
- the type of disinfection place (open air, 3-sided enclosed, indoor).

One additional variable was added by combination of two other variables; this was "the used amount of disinfection fluid" (in L., eq. 'flow x work time').

Interaction between the treated area (m^2, calculation method 1), the time needed for disinfection (min.) and the amount of used disinfection fluid (L.) was suspected. These interactions were studied with regression analysis. Although a significant relation between the treated area (method 1) and the time needed for disinfection was present ($p=0.014$), the model outcome was not very predictive (adjusted $R^2=0.100$). A similar relation existed between the treated area (calculation method 1) and the amount of disinfection fluid that was used ($P=0.006$ and adjusted $R^2=0.131$). Interaction between the treated area (calculation method 2) and the time needed for disinfection was comparable ($p=0.026$ and adjusted $R^2=0.080$). The relation between the treated area (calculation method 2) and the amount of disinfection fluid that was used was less strong ($p=0.066$ and adjusted $R^2=0.049$).

Thus, as can be expected, it can be concluded that the treated area, the time used for treatment and the amount of disinfection fluid are interrelated. Since the strength of these associations is comparable for both treated surface calculation methods, it can not be concluded that one of the calculation methods provides the 'best' results.

4.5.1 Actual hand exposure

A relation of the potential hand exposure with the type of location (indoor, out door, 3-sided enclosed) was tested using a 2-sided T-test. For this, the companies 3 and 5 (both 3-sided enclosed) were pooled. As a result, all three types of locations significantly differ from each other on a 0.05 level (Table 12).

Table 12 Between-company differences in average hand exposure, grouped on type of location (significant differences are marked **bold**, all values are in mL)

Comparison	Difference between means	95% confidence limits	
		lower limit	upper limit
Outdoor – 3 sided enclosed [companies 1 – (3+5)]	**1.15**	**0.22**	**2.09**
Outdoor – indoor [companies 1 – 6]	**2.13**	**1.08**	**3.18**
3 sided enclosed – indoor [companies (3+5) – 6]	**0.97**	**0.10**	**1.86**

Note: the difference between the means is calculated as:
(mean of first company)minus (mean of second company)

The comparison of the actual hand exposure for different types of locations suggests that the more a disinfection place is enclosed, the lower a worker is exposed. However, because of the limited number of locations, it may not be concluded that these differences are strictly due to the type of location. They may as well be inter-company differences caused by other variables.

The effects of the other variables on the actual hand exposure were studied with linear regression. The variables with a significant ($p<0.05$) relation with the hand exposure were selected with the SAS program. Only the used amount of disinfection fluid was significantly ($p<0.05$) related to the hand exposure. The linear regression model that was built with this variable had an adjusted R^2 of 0.26 and a significant outcome

($p<0.0003$). The combination of the R^2 and the parameter estimates show, that the used amount of disinfection fluid does not attribute very much to the variation in exposure. It seems that other factors, such as the initial exposure caused by handling the contaminated spraying equipment, attribute more to variation in exposure than the additional exposure caused by the spraying.

Table 13 Model: Hand exposure = 0.051 x amount of diluted product – 0.334 (mL disinfection fluid)

Parameter	Parameter estimate	P-value
Intercept (mL)	0.334	0.2434
Amount of diluted product (L)	0.051	0.0003

For a mean amount of diluted product (18 l.), the estimated hand exposure is 1.3 mL, which is very comparable tot the measured mean (AM=1.2 mL). For the highest amount of diluted product (95 l.), the estimated hand exposure is 5.2 mL. This is close to the highest measured hand exposure of 6.1 mL.

4.5.2 Potential whole body exposure (coverall)

An association of the potential body exposure with the type of location (indoor, outdoor, 3-sided enclosed) was tested using a 2 sided T-test. For this, the companies 3 and 5 (both 3-sided enclosed) were pooled. This did not change the results; still only company 1 differed from all other types of locations (Table 14).

Table 14 Between-company differences in whole body exposure, grouped on type of location (significant differences are marked **bold**, all values are in mL)

Comparison	Difference between means	95% confidence limits lower limit	upper limit
Outdoor – 3 sided enclosed [companies 1 – (3+5)]	**23.0**	**14.5**	**31.5**
Outdoor – indoor [companies 1 – 6]	**25.0**	**15.6**	**34.4**
3 sided enclosed – indoor [companies (3+5) – 6]	2.0	-5.7	9.7

Note: the difference between the means is calculated as:
(mean of first company)minus (mean of second company)

The comparison of the potential whole body exposure for different types of locations suggests that the more a disinfection place is enclosed, the lower a worker is exposed. However, the difference between 3-sided enclosed and indoor locations is insignificant. Besides, because of the limited number of locations, it may not be concluded that these differences are strictly due to the type of location. They may as well be inter-company differences caused by other variables.

The effect of the other variables on the potential whole body exposure was studied with linear regression. The variables with a significant ($p=0.05$) relation with the whole body exposure were selected with the SAS program,. The variables that were selected most often were then entered in the regression model. These were the variables:

- flow of disinfectant (L/min);
- treated area (m^2, calculation method 2);

- total duration of the disinfection (min).

In contrary to the hand exposure model, the used amount of diluted product was not significantly related to the whole body exposure.

The model with the three variables mentioned above had an adjusted R^2 of 0.89 and a p-value of <0.0001. The resulting parameter estimates and p-values are presented in Table 15.

Table 15 Model: Whole body exposure = 1.79 x flow + 0.08 x treated area + 2.05 x duration – 25 (mL disinfection fluid)

Parameter	Parameter estimate	P-value
Intercept (mL)	-26	0.0005
Flow of disinfectant (L/min)	1.79	0.0083
Treated area (m^2)	0.08	0.0116
Duration of disinfection (min)	2.05	0.0010

For a mean situation, (flow = 6 L/min, area = 175 m^2, duration = 3.9 min), the estimated whole body exposure is 6.7 mL, which is very comparable tot the measured mean exposure (Am=7.3 mL). For the highest measured whole body exposure (39 mL), the flow was 7.1 L/min, the treated area 272 m^2 and the duration 13.3 min. The estimated whole body exposure based on this input is 36 mL, which is very comparable to the measured exposure.
It was expected, that the parameter estimates of the above model could be strongly influenced by the highest measured exposure value. Therefore, the same model was also built without this highest value (Table 16). This model had an adjusted R^2 of 0.77 and a p-value of 0.0036. Without this highest result, the estimated mean exposure remains 6.7 mL, but the estimated highest exposure level is 32 mL.

Table 16 Model: Whole body exposure = 1.65 x flow + 0.07 x treated area + 1.68 x duration – 22 (mL diluted product); excluding the highest measured result.

Parameter	Parameter estimate	P-value
Intercept (mL)	-22	0.0038
Flow of disinfectant (L/min)	1.65	0.0118
Treated area (m^2)	0.07	0.0269
Duration of disinfection (min)	1.68	0.0072

Comparison of the two models shows that both models slightly underestimate the highest exposure levels, but that the second model deviated mostly from the measured value. It was concluded that the influence of the highest exposure value was less strong than expected and that the second model should be discarded.

4.5.3 *Combined hand and whole body exposure*

Differences in combined hand and body exposure between the three types of locations (indoor, outdoor, 3-sided enclosed) were tested using a two-sided T-test on the mean exposure per location. Results of this test were comparable with the results for whole body exposure only.

The effect of the other variables on the combined hand and whole body exposure was studied with linear regression. The variables with a significant (p=0.05) relation with the combined hand and whole body exposure were selected with the SAS program. These were the following variables.

- flow of disinfectant (L/min);
- treated area (m^2, calculation method 2);
- duration of the disinfection (min);
- used amount of diluted product (L).

Two models are presented: a model with only the amount of diluted product and a model with the other three variables. A model with all four variables resulted in a negative (-0.13) en insignificant (p=0.4113) parameter estimate for the used amount of diluted product. Therefore the results are not listed.
The model with only the used amount of diluted product was significant (p=0.0015) and had an adjusted R^2 of 0.55. The parameter estimates of this model are listed in Table 17.
The model with the other three variables was most significant (p=0.0001) and most predictive (adjusted R^2=0.89). The parameter estimates of this model are listed in Table 18.

Table 17 Model: Hand + whole body exposure = 0.04 x used amount of disinfection fluid + 0.47 (mL disinfection fluid)

Parameter	Parameter estimate	P-value
Intercept (mL)	0.47	0.0779
Used amount of diluted product (L)	0.04	0.0036

Using the model with only the amount of diluted product for a mean situation, (18 litres of diluted product used), the estimated combined hand + whole body exposure is 1.2 mL, which a large underestimate of the measured mean (AM=8.8 mL). For the highest measured hand + whole body exposure (45 mL, with 47 litres diluted product used), the estimated exposure is 2.35 mL, which largely underestimates the measured exposure.

Table 18 Model: Hand + whole body exposure = 1.99 x flow + 0.09 x treated area + 2.35 x duration – 29 (mL disinfection fluid)

Parameter	Parameter estimate	P-value
Intercept (mL)	-29	0.0007
Flow of disinfectant (L/min)	1.99	0.0105
Treated area (m^2)	0.09	0.0144
Duration of disinfection (min)	2.35	0.0011

For a mean situation, (flow = 6 L/min, area = 175 m^2, duration = 3.9 min), the estimated combined hand + whole body exposure is 7.9 mL, which is very comparable to the measured mean (AM=8.8 mL). For the highest measured hand + whole body exposure (45 mL), the flow was 7.1 L/min, the treated area 272 m^2 and the duration 13.3 min. The estimated hand + whole body exposure based on this input is 40 mL, which is a slight underestimate of the measured exposure.

Based on the comparison of the two models, it is concluded that the model with only the used amount of disinfection liquid as independent variable should be discarded.

4.6 A 'worst-case' scenario: spraying multiple vehicles

Two supervisors, working at company 4, were sampled during the disinfection of multiple vehicles. These data were not included in the previous paragraphs, because they were not comparable; all other workers disinfected just one vehicle.

Both supervisors were sampled on August 15th 2000. Table 19 shows the number of vehicles and the measured exposure.

The exposure levels in µg alkyl dimethylbenzyl ammoniumchloride were recalculated to the exposure per litre disinfection fluid (the diluted product). The exposure values per used litre disinfection fluid are very consistent. These are 0.03 mL/L for all hand exposure samples and are 0.55, 0.66 and 0.84 for the whole body (excl. hands) samples. These hand exposure samples are comparable with the averages of the other workers, but the whole body samples just exceed the range of these measurements.

Table 19 Exposure levels during disinfection of multiple vehicles

Worker number	Sample	Number of vehicles	Treated area method 1 [1]	Treated area method 2 [1]	Duration (min) [2]	Volume disinfectant (L) [3]	Exposure [4] µg	Exposure [4] mL
33	Hand wash 1	5	836	685	23	166	365	4.6
33	Hand wash 2	2	391	322	10	71	192	2.4
33	Coverall 1	7	1227	1007	33	127	10375	130
34	Hand wash 1	4	648	775	20	153	385	4.8
34	Coverall 1	4	948	1077	28	153	10357	129
34	Hand wash 2	6	648	775	20	199	399	5.0
34	Coverall 2	6	948	1077	28	199	10572	132
33	Sum of all [5]	7	1227	1007	33	237	10932	137
34	Sum of all [5]	10	1596	1852	48	352	21713	271

1) Methods 1 and 2 refer to the calculation methods for determining the disinfected area as explained before.
2) Duration of the disinfection includes all disinfection activities, but does not include breaks.
3) Volume is expressed as the used amount of diluted product, estimated by weighing as explained before.
4) Exposure is expressed in µg alkyl dimethylbenzyl ammoniumchloride and in mL disinfection fluid.
5) sum of all actual/potential hand exposure (hand wash) and potential whole body exposure (coverall) samples.

When the regression (§ 4.5.3) model is used to estimate the combined potential hand and whole body exposure when disinfecting multiple vehicles, the estimated exposure levels are 154 and 295 mL for worker 33 and 34 respectively. In both cases this estimate slightly overestimated the measured exposure (with 12% en 7%). Nevertheless, the model seems to be useful to estimate exposure during the disinfection of multiple vehicles.

4.7 Exposure data for registration purposes

For registration purposes, estimates are made based on observed exposure levels or on models with determinants of exposure in it. The 90-percentile is generally taken as the statistic of choice for 'reasonable worst case' estimates from data bases. For use of data for registration purposes, exposure values have to be converted to a suitable format. Dermal exposure will therefore be expressed as [mL spray liquid / L spray liquid]. These statistics are listed in Table 20, for actual hand exposure and potential whole body exposure (both including and excluding the hands).

The exposure values in mL/L disinfection fluid (Table 20) clearly show the limitations of the small population size. Excluding one person caused the whole body exposure excl. hands to be higher than the whole body exposure incl. hands. Because of this uncertainty, it is advised to add up the individual 90-percentiles for hand exposure and whole body exposure (excl. hands) for estimating the whole body exposure *incl. hands.* Thus, a 90-percentile of 0.8 mL/L is advised as a 'reasonable worst case' estimate for registration purposes.

Table 20 Exposure values for registration purposes [mL spray liquid / liter spray liquid used]

	Type of exposure, bodypart		
Statistic	Actual, hand	Potential, whole body (excl. hands)	Potential, whole body (incl. hands)
Number of observations	44	15	14
Arithmetic mean	0.08	0.26	0.27
Standard deviation	0.09	0.21	0.16
Geometric mean	0.05	0.19	0.22
Geometric standard deviation	2.38	2.31	2.00
Range	0.01 – 0.52	0.04 – 0.83	0.06 – 0.60
90-percentile	0.2	0.57 [1)]	0.48 [2)]

1) The 90-percentile represents the 14th observation (n=15)

2) The 90-percentile represents the 13th observation (n=14)

For the disinfection of cattle trucks, a default value of 34 litres diluted product is suggested. This is the 90-percentile in this study and would lead to an estimated whole body exposure (incl. hands) of 27 mL. This value approximates the 90-percentile of the measured exposure (90-percentile = 28 mL).

For specific situations where detailed information is available, the whole body exposure (incl. hands) may be estimated using the model:

Whole body exposure (incl. hands) = 1.99 x flow + 0.09 x treated area + 2.35 x duration – 29 (mL disinfection fluid)

If one or more variables in this model are unknown, the following rounded values are suggested as defaults, based on this study. Use of these values will result in an estimated exposure of 42 mL diluted product, which is close to the highest exposure measured during this study.

- flow: 8 L/min (the highest company-mean flow in this study);
- treated area: 450 m^2 per vehicle (the largest area in this study);
- duration: 6 minutes per vehicle (the 90-percentile duration in this study).

4.8 Questionnaire on health effect

Only cattle truck drivers were asked to fill in the questionnaire, containing some 50 questions. These truck-drivers perform disinfection at several workplaces. Because the results of the exposure sampling showed that exposure was, to a large degree, workplace-related, it was concluded that it would not be to determine a worker's history of exposure to disinfectants. Therefore it would not be possible to link the health outcome of the questionnaire to a worker's exposure to disinfectants. Besides, respiratory health effects could also be a result of contact with animals or animal excretion products. Dermal health effects could, to the opinion of a dermatologist, also very well be a result of working under wet conditions, due to the frequent cleaning of the truck.
For these reasons, the interviews among the cattle truck drivers were stopped and a control group was not approached.

However, the answers on some questions were analysed and compared to some reference groups from earlier studies. Table 21 shows the results of this analysis.

Table 21 Some results of the questionnaire, compared with some reference groups

	Cattle truck drivers	Swine farmers	Animal food workers	Animal food workers (controls)	Waste collectors	Waste collectors (controls)
Symptoms / n =	89	1432	265	175	155	38
"Hoest u vrijwel dagelijks gedurende een gedeelte van het jaar?"" *Do you cough almost daily during a part of the year?* *1) chronic cough* *2) "droge hoest" (dry cough)*	28%	18% *1)*	10% *1)*	5% *1)*	11% *2)*	13% *2)*
"Hoest u vrijwel dagelijks slijm op, gedurende een gedeelte van het jaar?" *Do you experience a phlegmy cough almost daily during a part of the year?* *3) chronic bronchitis* *4) chronic phlegm*	22%	14% *3)*	4% *4)*	5% *4)*	11%	5%
"Wordt u regelmatig 's ochtends vroeg wakker door hoesten?" *Do you frequently wake up because of a cough?*	12%				5%	0%
"Heeft u last van kortademigheid, wanneer u in normaal tempo met de trap een verdieping op gaat?" *Do you experience shortness of breath when you walk upstairs at a normal speed?*	15%	7%	5%	5%		

	Cattle truck drivers	Swine farmers	Animal food workers	Animal food workers (controls)	Waste collectors	Waste collectors (controls)
"Zo ja, heeft u last van kortademigheid wanneer u met leeftijdgenoten in normaal tempo op vlak terrein wandelt?" *If so, do you experience shortness of breath when you walk at a normal speed on a level terrain together with people of your age?*	2%				8%	3%
"Heeft u wel eens last gehad van piepen op de borst, ook zonder dat u verkouden was?" *Did you ever experience wheezing, also without having a flue?* *5) 'wheezing'* *6) 'ever wheezing'*	20%	17% *5)*	16% *6)*	16% *6)*	20%	8%
"Ook in de laatste 12 maanden?" *Also within the last 12 months?*	18%				10%	5%
Frequent wheeze			6%	2%		
Chest tightness		5%	4%	6%		
"Heeft u wel eens aanvallen van benauwdheid met piepen gehad?" *Did you ever experience chest tightness?*	12%					
"Ook in de laatste 12 maanden?" *Also within the last 12 months?*	10%					
"Heeft u last (gehad) van piepen, kortademigheid of beklemd gevoel op de borst als gevolg van bepaalde werkplekken of werkzaamheden?" *Did you ever experience wheezing or chest tightness as a result of specifiek working locations or work activities?*	24%					
"Binnen 4 uur na aanvang van het werk?" *Within 4 hours after starting the work activities?*	16%					

Reference populations are from previous IRAS studies among swine farmers (Peter Vogelenzang), Animal food workers (Tjabe Smid) and waste collectors (Inge Wouters).

5 Discussion

5.1 Selection of companies and test persons

In this study, exposure measurements were carried out only during the disinfection of vehicles that were used for the transportation of swine. During the study, it was noticed that generally these vehicles were cleaned much more thoroughly than vehicles meant for the transportation of other animals. Therefore, it is well possible that this selection has influenced the exposure levels, in such way that worker exposure may be lower during the disinfection of vehicles transporting animals other than swine.
However, this study may still underestimate exposure, concerning exposure when disinfection is carried out the way it should be carried out. This is because a considerable part of the truck drivers disinfected their vehicle in a remarkably short time and using very little disinfection fluid. In fact, there were still some truck drivers that, although obligatory, did not disinfect their vehicles at all. (Of course, these persons were not sampled).
In this perspective, it should be noted that, at the time of the measurements, infectious cattle diseases (like pigs pest or foot and mouth disease) were not observed in the Netherlands.

5.2 Exposure measurements

No standard methods exist for exposure assessment of disinfectants. For dermal exposure assessment, two methods were used next to each other: hand washing for assessment of actual hand exposure, and use of Tyvek® coveralls to assess potential whole body exposure. OECD guidelines (OECD, 1997) suggest the use of cotton overalls to assess whole body exposure, but this was not possible in this setting since it was expected that some workers would have become extremely wet. Under normal circumstances workers often use a Tyvek® coverall as well. Therefore, this material was considered to be an acceptable alternative, that was also successfully used in a previous study (Preller and Schipper, 1999). It remains unknown if the use of Tyvek® coveralls lead to underestimation of potential exposure, because of disinfection liquid dripping of this non-absorbing material.

The exposure measurements were not always done by the same field workers. This lead to some different interpretations of the observation forms. Especially the height of the individual loading platforms of the cattle truck was not always interpreted in the same way, because these platforms were often raised or lowered during the disinfection. To correct for these different interpretations, it was decided to use only the total height of all platforms (with a fixed maximum of 3.0 metres) for calculation of the disinfected area.

5.3 Personal exposure levels

The decision not to assess respiratory exposure after the pilot study was based on the results of measurements during disinfection with non-volatile substance in the open air under fairly good weather conditions. When trucks are sprayed indoor, outdoor with

strong winds, or when a more volatile substance is used, respiratory exposure may be different.
The absolute dermal exposure levels found in this study are much lower than the dermal exposure levels found in a previous study on exposure to disinfectants in slaughterhouses and the meat processing industry (Preller and Schipper, 1999). Preller and Schipper reported an average (GM) hand exposure of 1.4 mg (present study: 0.16 mg) and an average whole body exposure of 32.2 mg (including mixing and loading; present study: 0.84 mg, excluding mixing and loading). This is probably due to much higher concentrations of the quaternary ammonium compound and longer disinfection times (7-108 min. instead of 0.7-13) in the latter situation. Preller and Schipper did not publish the exposure in mL disinfection fluid; these values can for that reason not be compared.

The 'worst case' potential exposure of the supervisors who sprayed multiple vehicles are:
- Worker 33 (7 vehicles): hands: 0.6 mg, whole body (excl. hands): 10 mg.
- Worker 34 (10 vehicles): hands: 0.8 mg, whole body (excl. hands): 21 mg

These exposure values are much more comparable with the results reported by Preller and Schipper (1999).

The distribution over the body is more or less comparable for the two studies (Table 22); in both cases the legs and arms are highest exposed.

Table 22 Potential exposure per body part (excluding hands, as % of total body)

	Potential whole body exposure (% of total body)	
Body part	Current study	Preller and Schipper, 1999
Head	3	2
Torso front	11	8
Torso back	10	5
Lower and upper arms	16	12
Upper legs	18	22
Lower legs	42	51

5.4 Exposure modelling

One of the registered variables was the type of location (indoor, 3-sided enclosed, outdoor). The results suggest that dermal exposure is higher when the washing place is more open. Nevertheless, because of the very limited number of companies, this should not be interpreted as more than just an indication.

The measured exposure levels could well be explained by either the used amount of disinfection fluid (for potential/actual hand exposure) or a combination of the flow of the disinfectant, the treated area and the duration of the disinfection (potential whole body exposure). This provides reasonable estimates for exposure during the disinfection of one or multiple vehicles.

5.5 Data for registration purposes

For registration purposes, exposure values expressed in 'mL spray liquid / L spray liquid used' have been selected. These can be used regardless of the concentration of the active substance.

Respiratory exposure was too low to determine any surrogate value; probably less than 7.14 µg alkyl dimethylbenzyl ammoniumchloride or 0.03 mL diluted product per m^3, based on the measurements in company 1.

For actual hand exposure (n=44) the 90-percentile (0.2 mL/L) may be used as a worst-case estimate. For potential whole body exposure (excluding the hands), one should consider that the available number of data was very limited (n=15), when interpreting the 90-percentile exposure value (0.57 mL/L). For estimating whole body exposure *including the hands*, it is advised to add-up the 90-percentile values for hand exposure and whole body exposure (excl. hands).

5.6 Health effects

From the questionnaire results, it seems as if the prevalence of respiratory health symptoms is very high among cattle truck drivers. However, this conclusion may not be drawn from this results. Since the study population is relatively small (n=89), and general study population parameters, like age, atopy and smoking habits, were not studied, a selection bias may well be possible. Besides, even if the reported health symptoms represent the actual health status of this population, it is not possible to determine the causes of these symptoms with the current study. Nevertheless, the reported answers on the questionnaire can be seen as an indication of respiratory health problems in the studied population and may be a reason for further study among cattle truck drivers.

5.7 Risk

This study was not focussed on identification and quantification of health risks related to the disinfection of cattle trucks. However, in a previous study on exposure to disinfectants in slaughterhouses and the meat processing industry, Preller and Schipper (1999) did some research on potential health effects of exposure to quaternary ammonium compounds. Based on their report, no conclusions can be drawn on potential health risks by comparing exposure levels found in this study with OELs, since the latter are not available for quaternary ammonium compounds.
Therefore, any potential health effects related to the reported dermal exposure levels can not be quantified. Neither can be concluded from the personal air samples that negative health effects will not occur, since it is not known if the analytical limit represents a safe value.

6 Conclusions and recommendations

In this study, respiratory and dermal exposure to alkyl dimethylbenzyl ammoniumchloride was assessed for range finding as well as for modelling purposes for authorisation of biocides. Disinfectants were applied by low pressure dispersive liquid spraying, a situation with potential high exposure.

In all cases dermal exposure was found in detectable amount. Average exposure to alkyl dimethylbenzyl ammoniumchloride during disinfection of cattle transportation vehicles was: 162 µg for actual hand exposure (GM, GSD 2.9, range ND - 1898), and 836 mg for potential whole body exposure (GM, GSD 2.8, range 163- 4719). Respiratory exposure assessment was stopped because almost all samples that were taken at the first disinfection place were below the detection limit of 7.14 µg/m^3 alkyl dimethylbenzyl ammoniumchloride.

For modelling purposes for authorisation of biocides, the 90-percentile exposure levels should be used as a surrogate value for 'reasonable worst case' exposure. The following rounded values are advised.

Exposure in mL spraying liquid per used litre spraying liquid
- 0.6 mL spraying liquid for potential whole body exposure excluding the hands;
- 0.2 mL spraying liquid for actual hand exposure.
- 0.8 mL spraying liquid for potential whole body exposure including the hands (eq. sum of 0.6 and 0.2 mL).

The above values were derived for application of the disinfection liquid on one truck, trailer or truck-trailer combination, but also provided a reasonable estimate of the exposure during disinfection of multiple vehicles. A typical used amount of disinfection fluid is 18 litres per vehicle (AM=18, SD=18).

For specific situations where detailed information is available, the whole body exposure (incl. hands) may be estimated using the model:

Whole body exposure (incl. hands) = 1.99 x flow + 0.09 x treated area + 2.35 x duration – 29 (mL disinfection fluid)

If one or more variables in this model are unknown, the following rounded values are suggested as defaults, based on this study.
- flow: 8 L/min (the highest company-mean flow in this study);
- treated area: 450 m^2 per vehicle (the largest area in this study);
- duration: 6 minutes per vehicle (the 90-percentile duration in this study).

Several determinants of exposure levels (in mL spraying liquid) were identified. Significant differences between the companies were found. This may be due to differences in the lay-out of the disinfection areas. The data suggest that more enclosed areas lead to lower dermal exposure levels. For actual hand exposure, the initial exposure, probably caused by handling contaminated equipment, attributed mostly to the total exposure. The only determinant that was significantly associated with hand exposure was the used amount of diluted product. Potential whole body exposure (both including and excluding the hands) was strongest associated with the flow of the disinfectant, the treated area and the duration of the disinfection.

Based on the results, some suggestions for exposure reduction can be given. Since the major part of potential whole body exposure was found on the legs and hands, protection of these parts of the body should be considered. Apart from use of personal protective equipment, few other indications were obtained for reduction of exposure. Applied concentration, flow and spraying pressure should not be higher than the manufacturer's recommendations and in the education of truck-drivers attention may be paid to worker exposure during disinfection activities.

7 Acknowledgement

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8 Signature

This study is approved by:

Ir. R.J. Snippe
Study director

Ir. J. Marquart
Head Department of Chemical Exposure Assessment

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A Worker and use scenario

				Vehicle		Loading area					Sprayed parts inside					Sprayed parts outside				Covering (0 to 1)	
Worker Number	Date	Sample period	Source of particle dimensions	Type	Floors	Length (m)	Width (m)	Height 1st floor (m)	Height 2nd floor (m)	Height 3rd floor (m)	Floor 1	Floor 2	Floor 3	Walls	Ceiling	Walls	Wheels	Top	Bottom	Inside	Outside
1	26-11-99	1	.	(articulated) lorry	2	7.3	2.5	2.5	.	.	yes	.	.	yes	yes	yes	yes	no	no	1.00	0.75
1	26-11-99	1	.	(semi) trailer	2	18	2.5	2.5	.	.	no	no	.	no	no	yes	yes	no	no	0.13	0.75
2	26-11-99	1	.	(semi) trailer	2	7	2.6	1.5	1	.	yes	yes	.	yes	yes	yes	yes	no	no	0.88	0.63
3	26-11-99	1	.	(semi) trailer	3	12.65	2.4	.	.	.	yes	yes	yes	yes	yes	yes	yes	no	no	1.00	1.00
4	28-12-99	1	estimated	(articulated) lorry	3	14	2.65	2.5	1	.	yes	no	.	yes	yes	yes	yes	no	no	1.00	0.75
5	28-12-99	1	estimated	(articulated) lorry	2	14	2.65	2	1.5	.	yes	yes	.	yes	yes	yes	yes	no	no	0.75	0.50
6	28-12-99	1	asked driver	(articulated) lorry	2	8.5	2.6	1.35	1.35	.	yes	yes	.	yes	yes	yes	yes	no	no	0.50	0.50
6	28-12-99	1	asked driver	(semi) trailer	2	7	2.6	1.35	1.35	.	yes	yes	.	yes	yes	yes	yes	no	no	0.50	0.50
7	28-12-99	1	estimated	(articulated) lorry	3	12	2.6	1.6	1.5	0.8	yes	yes	yes	yes	yes	yes	yes	no	no	0.50	0.75
8	28-12-99	1	asked driver	(articulated) lorry	2	12.5	2.6	1.6	1.3	.	yes	yes	.	yes	yes	yes	yes	no	no	0.50	0.75
9	29-12-99	1	asked driver	(articulated) lorry	2	15	2.6	1.7	1.1	.	yes	yes	.	yes	yes	yes	yes	no	no	0.50	0.75
10	29-12-99	1	estimated	(articulated) lorry	2	11	2.6	2.1	1.2	.	yes	yes	.	yes	yes	yes	yes	no	no	0.75	0.75
11	29-12-99	1	asked driver	(articulated) lorry	1	7	2.6	3.6	.	.	yes	.	.	yes	no	yes	yes	no	no	0.25	1.00
12	29-12-99	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

				Vehicle		Loading area					Sprayed parts inside					Sprayed parts outside				Covering (0 to 1)	
Worker Number	Date	Sample period	Source of particle dimensions	Type	Floors	Length (m)	Width (m)	Height 1st floor (m)	Height 2nd floor (m)	Height 3rd floor (m)	Floor 1	Floor 2	Floor 3	Walls	Ceiling	Walls	Wheels	Top	Bottom	Inside	Outside
13	22-2-00	1	asked driver	(articulated) lorry	2	8	2.4	1.35	1.35	.	yes	yes	.	yes	yes	yes	yes	no	no	1.00	1.00
14	22-2-00	1	estimated	(articulated) lorry	2	8	2.45	1.5	1.5	.	yes	yes	.	yes	yes	yes	yes	no	no	0.50	0.75
15	22-2-00	1	estimated	(articulated) lorry	3	6.5	2.4	0.8	1	1	yes	yes	yes	yes	yes	yes	yes	no	no	1.00	1.00
15	22-2-00	1	estimated	(semi) trailer	3	7	2.4	0.8	1	1	yes	yes	yes	yes	yes	yes	yes	no	no	1.00	1.00
16	22-2-00	1	asked driver	(articulated) lorry	3	7.2	2.6	0.9	0.9	0.9	yes	yes	no	yes	yes	yes	yes	no	no	1.00	1.00
17	22-2-00	1	estimated	(articulated) lorry	2	6	3	2	1.5	.	yes	yes	.	yes	yes	yes	yes	no	no	1.00	1.00
17	22-2-00	2	estimated	(semi) trailer	2	7	3	2	1.5	.	yes	yes	.	yes	yes	yes	yes	no	no	1.00	1.00
18	22-2-00	1	estimated	(articulated) lorry	1	7	3	3	.	.	yes	.	.	yes	yes	yes	yes	no	no	0.75	0.75
19	22-2-00	1	estimated	(articulated) lorry	2	7	3	2	1.5	.	yes	yes	.	yes	yes	yes	yes	no	no	1.00	1.00
20	22-2-00	1	estimated	(articulated) lorry	3	8	2.6	1	1	1	yes	yes	yes	yes	yes	yes	yes	no	no	0.50	0.75
21	13-6-00	1	asked driver	(articulated) lorry	3	7.8	2.5	0.9	0.9	0.9	yes	yes	yes	yes	yes	yes	yes	no	no	1.00	1.00
22	13-6-00	1	asked driver	(articulated) lorry	2	8	2.6	1.4	1.4	.	yes	yes	.	yes	yes	yes	no	no	no	1.00	0.75
23	13-6-00	1	asked driver	(articulated) lorry	3	8.5	2.5	0.9	0.9	0.9	yes	yes	yes	yes	yes	yes	no	no	no	1.00	0.75
23	13-6-00	2	asked driver	(semi) trailer	3	7.5	2.5	0.9	0.9	0.9	yes	yes	yes	yes	no	yes	no	no	no	0.75	0.75
24	13-6-00	1	asked driver	(articulated) lorry	2	6	2.6	1.2	1.2	.	yes	yes	.	yes	yes	yes	no	no	no	0.75	0.75
25	13-6-00	1	estimated	(articulated) lorry	3	10	2.6	1	1	1	yes	yes	.	yes	yes	yes	yes	no	no	0.75	0.75
26	13-6-00	1	asked driver	(articulated) lorry	3	16	2.6	1	1	1	yes	yes	yes	yes	yes	yes	no	no	no	1.00	0.75

				Vehicle		Loading area					Sprayed parts inside					Sprayed parts outside				Covering (0 to 1)	
Worker Number	Date	Sample period	Source of particle dimensions	Type	Floors	Length (m)	Width (m)	Height 1st floor (m)	Height 2nd floor (m)	Height 3rd floor (m)	Floor 1	Floor 2	Floor 3	Walls	Ceiling	Walls	Wheels	Top	Bottom	Inside	Outside
27	14-6-00	1	.	(articulated) lorry	2	18.5	2.5	0.8	1.1	1	yes	yes	.	yes	no	yes	yes	no	no	0.50	0.50
28	14-6-00	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
29	14-6-00	1	estimated	(articulated) lorry	2	10	2.5	1	1	.	yes	yes	.	yes	yes	no	no	no	no	0.50	0.25
30	14-6-00	1	asked driver	(articulated) lorry	3	7.5	2.5	1	1	1	yes	no	.	yes	yes	no	no	no	no	0.50	0.25
31	14-6-00	1	asked driver	(articulated) lorry	2	7	2.5	1	1.3	.	yes	.	.	yes	no	yes	no	no	no	0.75	0.25
32	14-6-00	1	asked driver	(articulated) lorry	2	12	2.4	1	1	.	yes	no	.	yes	yes	no	no	no	no	0.50	0.25
33	15-8-00	1	asked driver	(articulated) lorry	2	10	2.5	1.5	1.5	.	yes	yes	.	yes	no	yes	yes	no	no	0.50	1.00
33	15-8-00	2	asked driver	(semi) trailer	2	6	2.5	1.5	1.5	.	yes	yes	.	yes	no	yes	yes	no	no	0.50	1.00
33	15-8-00	3	asked driver	(articulated) lorry	3	6	2.5	1	1	1	yes	yes	yes	yes	no	yes	yes	no	no	0.50	1.00
33	15-8-00	4	asked driver	(articulated) lorry	2	6	2.5	1.5	1.5	.	yes	yes	.	yes	no	yes	yes	no	no	0.50	1.00
33	15-8-00	5	asked driver	(articulated) lorry	3	10	2.5	2	1	0	yes	yes	yes	yes	no	yes	yes	no	no	0.50	1.00
33	15-8-00	6	asked driver	(articulated) lorry	2	8	2.5	1.5	1.5	.	yes	yes	.	yes	no	yes	yes	no	no	0.50	1.00
33	15-8-00	7	asked driver	(articulated) lorry	3	10	2.5	1	1	1	yes	yes	yes	yes	no	yes	yes	no	no	0.50	1.00
34	15-8-00	1	asked driver	(articulated) lorry	3	8	2.5	3	.	.	yes	no	no	yes	no	yes	yes	no	no	1.00	1.00
34	15-8-00	2	asked driver	(articulated) lorry	2	10.5	2.5	1.5	1.5	.	yes	yes	.	yes	no	yes	yes	no	no	1.00	1.00
34	15-8-00	3	asked driver	(semi) trailer	3	7.5	2.5	1	1	1	yes	yes	yes	yes	no	yes	yes	no	no	0.50	1.00
34	15-8-00	4	asked driver	(articulated) lorry	3	6	2.5	3	0	0	yes	.	.	yes	no	yes	yes	no	no	0.50	1.00

				Vehicle		Loading area					Sprayed parts inside					Sprayed parts outside				Covering (0 to 1)	
Worker Number	Date	Sample period	Source of particle dimensions	Type	Floors	Length (m)	Width (m)	Height 1st floor (m)	Height 2nd floor (m)	Height 3rd floor (m)	Floor 1	Floor 2	Floor 3	Walls	Ceiling	Walls	Wheels	Top	Bottom	Inside	Outside
34	15-8-00	5	asked driver	(articulated) lorry	3	10	2.5	3	0	0	yes	.	.	yes	no	yes	yes	no	no	0.50	1.00
34	15-8-00	6	asked driver	(articulated) lorry	3	10	2.5	1	1	1	yes	yes	yes	yes	no	yes	yes	no	no	0.50	1.00
34	15-8-00	7	asked driver	(articulated) lorry	3	8	2.5	3	0	0	yes	.	.	yes	no	yes	yes	no	no	0.50	1.00
34	15-8-00	8	asked driver	(semi) trailer	2	6	2.5	3	0	.	yes	.	.	yes	no	yes	yes	no	no	0.50	1.00
34	15-8-00	9	asked driver	(articulated) lorry	2	7.5	2.5	3	0	.	yes	.	.	yes	no	yes	yes	no	no	1.00	1.00
34	15-8-00	10	asked driver	(articulated) lorry	3	8	2.5	3	0	0	yes	.	.	yes	no	yes	yes	no	no	1.00	1.00
35	12-9-00	1	estimated	(articulated) lorry	2	8	2.4	1.5	1.5	.	yes	yes	.	yes	no	yes	yes	no	no	0.75	0.75
36	12-9-00	1	estimated	(articulated) lorry	3	7	2.4	2.5	0.3	0.2	yes	no	2	yes	no	yes	yes	no	no	0.50	0.75
37	12-9-00	1	estimated	(articulated) lorry	3	8	2.5	1	1	1	yes	yes	yes	yes	no	no	no	no	no	0.75	0.25
38	12-9-00	1	asked driver	(articulated) lorry	2	10	2.5	1.5	1.5	.	yes	yes	.	yes	no	no	no	no	no	0.50	0.25
39	12-9-00	1	estimated	(articulated) lorry	2	8	2.4	1.4	1.4	.	yes	yes	.	yes	no	yes	yes	no	no	0.75	0.75
40	12-9-00	1	asked driver	(articulated) lorry	2	8	2.5	1.5	1.5	.	yes	yes	.	yes	no	no	no	no	no	0.75	0.25
41	13-9-00	1	asked driver	(articulated) lorry	2	8	2.5	1.5	1.5	.	yes	yes	.	yes	no	yes	no	no	no	0.75	0.75
42	13-9-00	1	asked driver	(articulated) lorry	3	7	2.5	1.1	1	1	yes	yes	yes	yes	no	yes	no	no	no	0.25	0.50
43	13-9-00	1	asked driver	(semi) trailer	3	8	2.5	1	1	1	yes	yes	yes	yes	no	yes	yes	no	no	0.75	0.75
44	13-9-00	1	asked driver	(articulated) lorry	3	8	2.5	1	0.9	1	yes	yes	yes	yes	yes	no	no	no	no	0.75	0.25
45	13-9-00	1	estimated	(articulated) lorry	2	9	2.5	1.5	1.5	.	yes	yes	.	yes	yes	yes	no	no	no	1.00	0.75

				Vehicle		Loading area					Sprayed parts inside					Sprayed parts outside				Covering (0 to 1)	
Worker Number	Date	Sample period	Source of particle dimensions	Type	Floors	Length (m)	Width (m)	Height 1st floor (m)	Height 2nd floor (m)	Height 3rd floor (m)	Floor 1	Floor 2	Floor 3	Walls	Ceiling	Walls	Wheels	Top	Bottom	Inside	Outside
46	13-9-00	1	asked driver	(articulated) lorry	2	16	2.4	1.5	1.5	.	yes	yes	.	yes	no	yes	no	no	no	0.75	0.25
47	27-11-00	1	asked driver	(articulated) lorry	3	7.8	2.5	1	1	1	yes	yes	yes	yes	yes	no	yes	no	no	1.00	0.50
48	27-11-00	1	asked driver	(articulated) lorry	3	.	2.5	.	.	.	yes	yes	yes	yes	no	yes	yes	no	no	0.75	0.75
49	27-11-00	1	asked driver	(articulated) lorry	2	7	2.6	1.8	1.8	.	yes	no	.	yes	no	no	no	no	no	0.50	0.25
50	27-11-00	1	asked driver	(semi) trailer	3	3	1.4	1.5	0.7	.	yes	yes	.	no	no	no	no	no	no	0.25	0.25
51	27-11-00	1	asked driver	(articulated) lorry	3	5	2.5	.	.	.	yes	yes	yes	yes	yes	yes	yes	no	no	1.00	0.75
51	27-11-00	1	asked driver	(semi) trailer	3	5	2.5	.	.	.	yes	yes	yes	yes	yes	yes	yes	no	no	1.00	0.75
52	27-11-00	1	asked driver	(articulated) lorry	3	8	2.5	1	1	1	yes	no	no	yes	no	no	yes	no	no	0.75	0.25
53	28-11-00	1	asked driver	(articulated) lorry	2	12	2.5	1.5	1.5	.	yes	yes	.	yes	yes	no	no	no	no	0.75	0.00
54	28-11-00	1	estimated	(articulated) lorry	3	8	2.65	1	1	1	no	no	no	no	no	no	no	no	no	0.25	0.25
54	28-11-00	1	estimated	(semi) trailer	3	6	2.65	1	1	1	yes	yes	no	yes	no	yes	yes	no	no	.	.
55	28-11-00	1	asked driver	(articulated) lorry	1	8	2.5	3	.	.	yes	.	.	yes	no	yes	yes	no	no	0.75	1.00
56	28-11-00	1	asked driver	(articulated) lorry	3	10	2.5	3	0	0	yes	.	.	no	no	no	no	no	no	0.50	0.25
57	28-11-00	1	asked driver	(articulated) lorry	3	12	2.5	1	1	1	yes	yes	yes	yes	no	yes	yes	no	no	0.75	0.25
58	28-11-00	1	asked driver	(articulated) lorry	3	8	2.65	2	2	1	yes	yes	yes	yes	yes	no	no	no	no	1.00	0.25

B Observations

Worker number	Sample period	Date	Personal equipment stored near biocides	Other factors that influence exposure	Other; explanation	Extent of contact with desinfectant	Extent of contact with desinfectant; explanation	Non woven overall	Rubber boots	Respiratory protection	Mouth piece	Protective gloves	Other protective equipment	Other; explanation	Remarks
1	1	26-11-99	no	yes	open truck (more effect of wind)	normal	.	yes	yes	no	no	no	no	.	TNO tyvek
2	1	26-11-99	no	yes	closed vehicle	.	.	no	yes	no	no	no	no	.	.
3	1	26-11-99	no	no	.	normal	.	no	yes	no	no	no	yes	rubber 'garden pants'	.
4	1	28-12-99	no	no	.	.	.	yes	yes	no	no	no	yes	Tyvek	.
5	1	28-12-99	no	no	.	normal	.	yes	no	no	no	no	yes	Tyvek	.
6	1	28-12-99	no	no	.	normal	.	yes	yes	no	no	no	yes	Tyvek TNO	.
7	1	28-12-99	no	no	.	normal	.	yes	yes	no	no	no	yes	Tyvek	.
8	1	28-12-99	no	no	.	normal	.	yes	yes	no	no	no	yes	Tyvek	.
9	1	29-12-99	no	no	.	normal	.	yes	yes	no	no	no	yes	Tyvek	.
10	1	29-12-99	no	no	.	normal	.	yes	yes	no	no	no	yes	Tyvek TNO	.
11	1	29-12-99	no	no	.	normal	.	yes	yes	no	no	no	yes	Tyvek	.
12	1	29-12-99	.	.	.	.	.	.	.	.	.	.	.	.	.
13	1	22-02-00	don't know	no	.	normal	.	yes	yes	no	yes	yes	no	.	.
14	1	22-02-00	no	no	.	normal	.	yes	yes	no	yes	yes	no	.	.
15	1	22-02-00	no	no	.	normal	.	yes	yes	no	no	no	no	.	.

Worker number	Sample period	Date	Personal equipment stored near biocides	Other factors that influence exposure	Other; explanation	Extent of contact with desinfectant	Extent of contact with desinfectant; explanation	Non woven overall	Rubber boots	Respiratory protection	Mouth piece	Protective gloves	Other protective equipment	Other; explanation	Remarks
16	1	22-02-00	no	no	.	normal	.	yes	no	no	no	no	no	.	.
17	1	22-02-00	no	no	.	normal	.	yes	yes	no	no	no	no	.	.
18	1	22-02-00	no	no	.	normal	.	yes	yes	no	no	no	no	.	.
19	1	22-02-00	no	no	.	normal	.	yes	yes	no	yes	yes	no	.	.
20	1	22-02-00	no	no	.	normal	.	yes	yes	no	no	no	no	.	.
21	1	13-06-00	no	no	.	normal	.	yes	yes	no	no	no	no	.	TNO tyvek
22	1	13-06-00	no	no	.	normal	.	yes	yes	no	no	no	no	.	TNO tyvek
23	1	13-06-00	no	no	.	normal	.	yes	yes	no	no	no	no	.	.
23	2	13-06-00	no	no	.	normal	.	yes	yes	no	no	no	no	.	.
24	1	13-06-00	no	no	.	normal	.	yes	yes	no	no	no	no	.	.
25	1	13-06-00	no	no	.	normal	.	yes	yes	no	no	no	no	.	.
26	1	13-06-00	no	no	.	normal	.	yes	yes	no	no	no	no	.	.
27	1	14-06-00	no	no	.	normal	.	yes	yes	no	no	no	yes	coverall cotton	.
28	1	14-06-00	no	don't know	not present when accident happened	higher	leakage, hands fully contaminatedr	no	yes	no	no	no	no	.	.
29	1	14-06-00	no	no	.	normal	.	yes	yes	no	no	no	yes	except cotton coverall	TNO tyvek
30	1	14-06-00	no	no	.	normal	.	yes	yes	no	no	no	yes	katoenen overall	.
31	1	14-06-00	no	no	.	normal	did not ask driver	yes	yes	no	no	no	yes	katoenen overall	.

Worker number	Sample period	Date	Personal equipment stored near biocides	Other factors that influence exposure	Other, explanation	Extent of contact with desinfectant	Extent of contact with desinfectant; explanation	Non woven overall	Rubber boots	Respiratory protection	Mouth piece	Protective gloves	Other protective equipment	Other; explanation	Remarks
32	1	14-06-00	no	yes	hose around body	lower	very short sampling time	yes	yes	no	yes	yes	no	.	large yellow Marigold-like gloves, TNO tyvek
33	1	15-08-00	no	don't know	.	normal	.	yes	yes	no	no	no	no	.	TNO tyvek
34	1	15-08-00	no	no	.	normal	.	yes	yes	no	no	no	no	.	TNO tyvek
35	1	12-09-00	no	no	.	normal	.	yes	yes	no	no	no	no	.	.
36	1	12-09-00	no	no	.	normal	.	yes	yes	no	no	no	no	.	.
37	1	12-09-00	no	no	.	normal	.	yes	yes	no	no	no	no	.	.
38	1	12-09-00	no	no	.	normal	.	yes	yes	no	no	no	no	.	TNO tyvek
39	1	12-09-00	no	no	.	normal	.	yes	yes	no	no	no	no	.	TNO tyvek
40	1	12-09-00	no	no	.	normal	.	yes	yes	no	no	no	no	.	.
41	1	13-09-00	no	no	.	normal	.	yes	yes	no	no	no	no	.	.
42	1	13-09-00	no	no	.	normal	.	yes	yes	no	no	no	no	.	worker reports feeling disinfection fluid in his eyes during work. TNO tyvek
43	1	13-09-00	no	no	.	normal	.	yes	yes	no	no	no	no	.	.
44	1	13-09-00	no	no	.	normal	.	yes	yes	no	no	no	no	.	TNO tyvek
45	1	13-09-00	no	no	.	normal	.	yes	yes	no	yes	yes	no	.	short, red, rubber-;like gloves (with cotton liner)

Worker number	Sample period	Date	Personal equipment stored near biocides	Other factors that influence exposure	Other; explanation	Extent of contact with desinfectant	Extent of contact with desinfectant; explanation	Non woven overall	Rubber boots	Respiratory protection	Mouth piece	Protective gloves	Other protective equipment	Other; explanation	Remarks
46	1	13-09-00	no	no	.	normal	.	yes	yes	no	no	no	no	.	.
47	1	27-11-00	no	no	.	normal	.	no	yes	no	no	no	no	.	TNO tyvek
48	1	27-11-00	don't know	yes	longe lance, pressure approx. 4 Bar	normal	.	no	yes	no	no	no	no	.	TNO tyvek
49	1	27-11-00	don't know	yes	hose without a nozzle	normal	.	no	yes	no	no	no	no	.	.
50	1	27-11-00	no	yes	duration of disinfection very short	normal	.	no	yes	no	no	no	no	.	.
51	1	27-11-00	don't know	yes	long lance	normal	.	no	yes	no	no	no	no	.	TNO tyvek
52	1	27-11-00	no	no	.	normal	.	no	yes	no	no	no	no	.	.
53	1	28-11-00	don't know	yes	long lance	normal	.	no	yes	no	no	no	no	.	TNO tyvek
54	1	28-11-00	no	no	.	normal	.	no	yes	no	no	no	no	.	.
55	1	28-11-00	don't know	no	.	normal	.	yes	yes	no	no	no	no	.	TNO tyvek
56	1	28-11-00	no	no	.	normal	.	no	yes	no	no	no	no	.	(nozzle) defect; hardly any aerosol formation (positive effect)
57	1	28-11-00	no	no	.	normal	.	no	yes	no	no	no	no	only cottton	.
58	1	28-11-00	no	no	.	normal	.								

C Results dermal exposure sampling

All values are in µg alkyldimethylbenzyl ammoniumchloride and in mL disinfection fluid

Obs	Worker number	Date	Sampling period	Results hand wash (µg)	(mL)	Results coverall (µg)	(mL)
1	1	26NOV99	1	730	6.08333	4719	39.3250
2	2	26NOV99	1	198	1.65000	.	.
3	4	28DEC99	1	102	0.85000	.	.
4	5	28DEC99	1	131	1.09167	.	.
5	6	28DEC99	1	367	2.82308	3209	24.6846
6	7	28DEC99	1	557	5.06364	.	.
7	8	28DEC99	1	296	2.46667	.	.
8	9	29DEC99	1	159	1.59000	.	.
9	10	29DEC99	1	160	1.45455	1680	15.2727
10	11	29DEC99	1	50	0.38462	.	.
11	21	13JUN00	1	293	0.68140	1018	2.3674
12	22	13JUN00	1	233	0.56829	3746	9.1366
13	23	13JUN00	1	93	0.23250	.	.
14	23	13JUN00	2	1898	4.74500	.	.
15	24	13JUN00	1	50	0.13514	.	.
16	25	13JUN00	1	50	0.13514	.	.
17	26	13JUN00	1	637	1.38478	.	.
18	27	14JUN00	1	688	1.60000	.	.
19	29	14JUN00	1	255	0.57303	452	1.0157
20	30	14JUN00	1	1551	3.37174	.	.
21	31	14JUN00	1	919	2.06517	.	.
22	32	14JUN00	1	397	0.89213	446	1.0022
23	35	12SEP00	1	586	1.95333	.	.
24	36	12SEP00	1	464	2.72941	.	.
25	37	12SEP00	1	355	1.31481	.	.
26	38	12SEP00	1	245	0.81667	986	3.2867
27	39	12SEP00	1	109	0.38929	1306	4.6643
28	40	12SEP00	1	153	0.61200	.	.
29	41	13SEP00	1	285	1.09615	.	.
30	42	13SEP00	1	90	0.40000	163	0.7244
31	43	13SEP00	1	120	0.80000	.	.
32	44	13SEP00	1	131	0.58222	651	2.89333
33	45	13SEP00	1	50	0.31250	.	.
34	46	13SEP00	1	50	0.15152	.	.
35	47	27NOV00	1	50	0.14286	.	.
36	48	27NOV00	1	140	0.40000	775	2.21429
37	49	27NOV00	1	50	0.15267	.	.
38	50	27NOV00	1	50	0.15625	.	.
39	51	27NOV00	1	50	0.17241	568	1.95862
40	52	27NOV00	1	50	0.15267	.	.
41	53	28NOV00	1	106	0.31176	170	0.50000
42	54	28NOV00	1	50	0.15152	.	.
43	55	28NOV00	1	118	0.33714	339	0.96857
44	56	28NOV00	1	124	0.38750	.	.
45	57	28NOV00	1	50	0.14706	.	.
46	58	28NOV00	1	25	0.06579	.	.

Hobbelink, Drs. J.H.B.

Van: Lurvink, Ing. M.W.M.
Verzonden: maandag 22 juli 2002 9:16
Aan: Hobbelink, Drs. J.H.B.
Onderwerp: RE: aanvraag rapport

Rina

(ik denk dat je via Jan's account werkt...)

Ik weet niet waarom je aanneemt dat het vertrouwelijk is...maar het rapport desinfectie veewagens V3725 is dat volgens mij niet. Je kan het dus gerust opsturen.

als je nog een vraag hebt kan je ook bellen 44588

groeten
Marc

Van: Hobbelink, Drs. J.H.B.
Verzonden: vrijdag 19 juli 2002 15:39
Aan: Lurvink, Ing. M.W.M.
Onderwerp: aanvraag rapport

Goedemorgen Marc
Bij het informatiecentrum is een verzoek binnengekomen voor rapport V 3725. Dit is een vertrouwelijk rapport. Het verzoek is van TNO Arbeid, de heer R. Tijmens tel. 023-5549556. Aangezien onze archivaris nog 3 weken met vakantie is richt ik me tot jou als medeauteur van dit rapport. Laat je ons even weten wat wel en/of niet mag.
Alvast bedankt.
Rina de Boer