

Joint development of a new Greenhouse Agricultural Operator Exposure Model for hand-held application

Project Report

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observed by EFSA¹⁰⁾

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1 Abstract

A new greenhouse model for operator exposure has been developed for the purpose of risk assessment of plant protection products in the EU. It is based on exposure data from the Southern European Greenhouse project that were statistically reanalysed and modelled according to procedures already established for the outdoor AOEM project. The model is suitable for operator exposure during mixing/loading and spraying in low crops or high crops using hand-held equipment with stationary mix tanks. Based on a statistical analysis of the data a joint approach was chosen for the tank mixing/loading: data from the outdoor AOEM and the greenhouse database were combined resulting in a tank mixing/loading model valid for outdoor and greenhouse uses. For the application task in low crops and high crops a normal scenario and a dense scenario (frequent contact with treated crop) are available. Exposure mitigation for the use of work wear, gloves and impermeable clothing (for dense application scenario only) is integrated in the model and can be selected for a stepwise risk assessment. Assuming that conditions and practices are similar across Europe the new greenhouse model can be applied by all MS as a harmonised approach for the evaluation and the authorisation of plant protection products.

2 Summary

The EU wide authorisation of plant protection products for uses in greenhouses requires the harmonisation of evaluation principles. This involves the exposure assessment for operators for which at the moment no agreed concept is available in Europe. Exposure studies from the Southern European Greenhouse project served as starting point for the development of a new greenhouse model. The aim was to create a transparent model and to apply statistical methods for data evaluation, modelling and validation. The underlying procedures and methods including quality criteria for the exposure data were the same as for the outdoor agricultural operator exposure model (AOEM). In a first step a database containing all data and information from the exposure studies was created. Independent scenarios were then identified from the database and possible exposure factors for each scenario and exposure variable (i.e. inhalation, head, body and hand exposure) were postulated. Models containing these exposure factors were plotted with quantile regression and analysed for their fit and their validity.

At the end of the process models could be obtained for three identified scenarios, for tank mixing and loading, for application with handheld spray guns in high crops and for application with hand-held spray guns in low crops. The first one, the tank mixing/loading model, is an adjusted version of the tank mixing/loading model from the outdoor AOEM and contains data from both, greenhouse and outdoor uses. In all studies of the database the operators prepared the spray solution in large stationary mix-tanks, a work task that is considered to be identical to the mixing/loading for tank outdoor applications. The inclusion of the greenhouse data into the tank mixing/loading database resulted in minor changes of the model coefficients while the exposure factors, total amount of active substance handled per day and formulation type of the product, remain the same. The most relevant modification is the availability of a further formulation type, a powder formulation packed in small bags. The second model is a pure greenhouse model and applies to spraying with hand-held equipment in high crops. Like the other models from the AOEM project it is primarily based on a log linear dependency between exposure and total amount of active substance. In addition exposure depends from the crop growing conditions (either normal or dense): operators in the so called dense scenario had frequent contact with the treated crop and gained a much higher exposure than in the normal scenario. For the third scenario from the greenhouse database, spraying with hand-held equipment in low crops, no dependency from the total amount of active substance handled could be observed due to the available data covering only a small range of total amounts. Instead, percentiles of the absolute exposure values

were calculated, one set of percentiles for exposure in a dense scenario with frequent contact with the treated crop and one set of percentiles for exposure in a normal cropping scenario. No data were available for applications in greenhouses with knapsack sprayers; therefore, no models could be derived for this type of equipment.

For tank mixing/loading as well as for greenhouse application in low and high crops exposure mitigation can be taken into account by calculating actual (inner) body exposure beneath work clothing and protected hand exposure beneath nitrile gloves. Both, actual body exposure and protected hand exposure refer to measured study data and are not based on default factors. The analysis of the study data revealed that work clothing was not sufficiently protective for the dense scenario, neither in low crops nor in high crops; in those cases impermeable clothing such as rain suits or rain trousers that displayed a very good protection in the greenhouse studies can be selected. However, the responsibility remains to Member States to assess the PPE recommended by notifiers.

The greenhouse database is currently relatively small making a full statistical analysis of exposure factors difficult and neglecting special greenhouse scenarios such as dusting or fogging. It is, therefore, important to amend the greenhouse database with new valid exposure data to improve the existing models and to develop new models for missing scenarios. With the slightly changed tank mixing/loading model a first revision of the AOEM tank mixing/loading model has been successfully made in order to achieve a more robust model. The adjusted tank mixing/loading model is now based on a broader range of data and can replace the first version.

3 Introduction

Application on crops grown in greenhouses is a major field of use for plant protection products in Europe. For the approval of this use the products have to be assessed for their health risks to operators and workers. According to the zonal authorisation procedure for plant protection products this risk assessment should be valid for greenhouse uses in all EU Member States. This raises problems since until now no harmonised approach exists for the assessment of greenhouse operator exposure in the EU.

At present different models are used by the Member States the most important ones being the Dutch greenhouse model, the EUROPOEM, the Southern European Greenhouse Model and the IVA model. All these models are based on the assumption of a linear relationship between the level of exposure and the amount of active substance used and follow a deterministic approach by simply calculating suitable percentiles for a distribution of empirical exposure values. The acceptance of these models in the EU is variable since the applicability of the model and its assumptions to conditions and practices in greenhouses all over Europe was questioned by several Member States.

To establish an approach that is transparent and applicable to all EU Member States a project was initiated by experts from national competent authorities. The European Crop Protection Association (ECPA) collaborating in this project provided access to operator exposure studies in greenhouses; these studies were re-evaluated for this project applying the same methodology used for the development of the new Agricultural Operator Exposure Model (AOEM) before.

4 Scope

The intention of this project was to develop a harmonised greenhouse operator exposure model for use in the zonal authorisation of plant protection products and approval of active substances in Europe. Depending on the availability of data the model should comprise the most relevant scenarios for greenhouse applications and fit for conditions and practices in typical greenhouses in Europe. A greenhouse database should be created and analysed in the course of the model development by applying a comprehensive statistical approach. Impact factors of exposure should be elucidated and considered for the model. At the end of the process the final model should be validated and transcribed into an excel spreadsheet for exposure calculations (calculator).

5 Model development

5.1 Database

5.1.1 Exposure studies

The database for the new greenhouse model comprises seven exposure studies that were conducted on behalf of the ECPA Operator Exposure Monitoring (EOEM) task force, an initiative of the crop protection industry in Europe, to monitor typical operator exposure in southern greenhouses. The studies were already evaluated by the task force resulting in the Southern European Greenhouse Model which is accepted by some EU MS for the assessment of active substances and PPP.

Before inclusion into the database the studies were examined for their quality as it was done for the studies in the AOEM database. All studies were of good quality and fulfilled the following criteria:

- Compliance with OECD Series No. 9 (OECD, 1997)
- Full compliance with GLP
- Monitoring of professional agricultural operators (e.g. farmers and contractors) working in accordance with GAP (Good Agricultural Practice)
- Data recording and observations according to current scientific knowledge
- Consistent field recovery (any outlying data must be explainable on a scientific basis)
- Suitable data form for model development (e.g. separately measured head, hand and body exposure)
- Whole body dosimetry for dermal exposure (exclusion of patch data)
- Inhalation exposure determined with appropriate inhalation fraction samplers
- Representative application methods and application techniques reflecting current agricultural application practices in Europe

The selected studies were designed to reflect a typical day's work in the greenhouse including all relevant tasks, i.e. the mixing/loading and the application of the PPP. Both tasks were assessed separately by using different operators or different sets of dosimeters. Cleaning of the spray equipment as part of the application task was monitored in a few trials. During work the operators complied with the principles of Good Agricultural Practice/Good Plant Protection Practice.

The studies took place between 2001 and 2006 in commercial greenhouses in Italy and Spain. Sites were selected that were representative for the conditions in this region. The size of the areas treated per day ranged from 0.1 to 1.1 ha. Amongst the crops treated in the studies were low crops (melon, ornamentals, up to a height of 0.5 m) and high crops (pepper, cucumber, tomato); some of them were grown in such a way that the operator could not avoid contact with the treated foliage during spraying (dense scenario). The different crops and scenarios are shown in Figure 1.

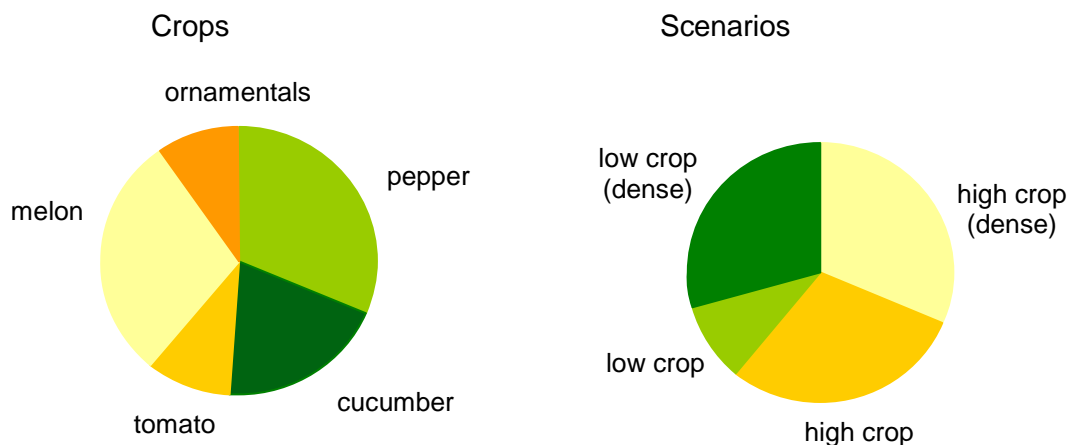


Figure 1: Study overview; the proportions shown refer to the number of replicates for each crop and the identified scenarios

The equipment used was similar in all studies and consisted of hand-held spray guns or lances that were connected via hoses to large mix-tanks (200 to 3000 L) placed outside or at the edge of the glasshouses. The operators sprayed the crop by walking through the rows and manually pulling the hose. In most of the cases the operators prepared no pre-mix but poured the product directly into the tank. The mixing/loading step took between 3 to 40 min; spraying was finished within 17 to 202 min.

Only two different formulations were applied in the studies – a WG (water dispersible granule) formulation packed in 1 to 3 kg bags containing 750 g/kg chlorothalonil and a WP (wetable powder) formulation packed in 50 g non-soluble sachets containing 750 g/kg cyromazine. Hence, no data for liquid formulations are available in the database. The WG formulation was applied at a rate of 0.5 to 2.4 kg a.s./ha and the WP formulation was applied at a rate of 0.2 kg a.s./ha. Water volumes ranged from 130 to 1000 L per hectare.

An overview about the study parameters is given in Figures 2 to 6. A brief description of each study including the exposure data is presented in Appendix 1.

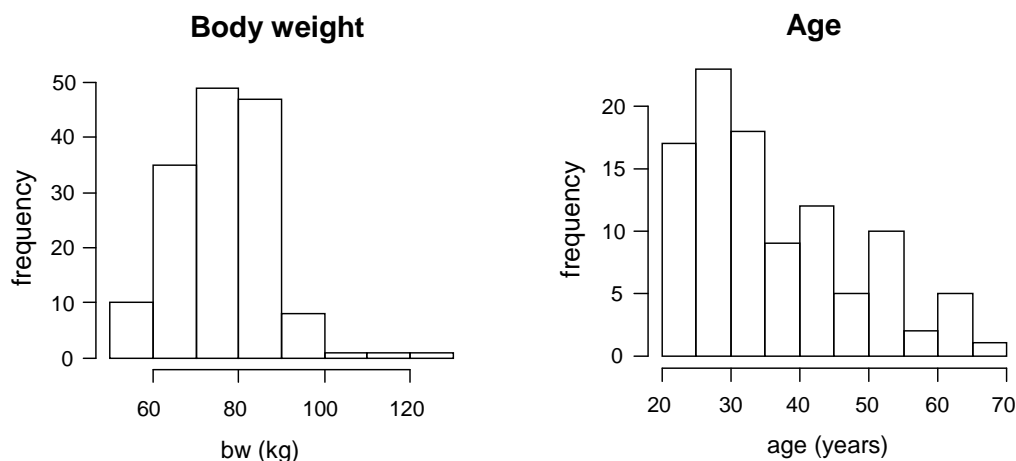


Figure 2: Body weight (bw) and age of the monitored subjects; body weight ranged from 55 to 125 kg (median: 83 kg), the age varied from 20 to 69 years (median: 33 years); all subjects were male except for two female operators.

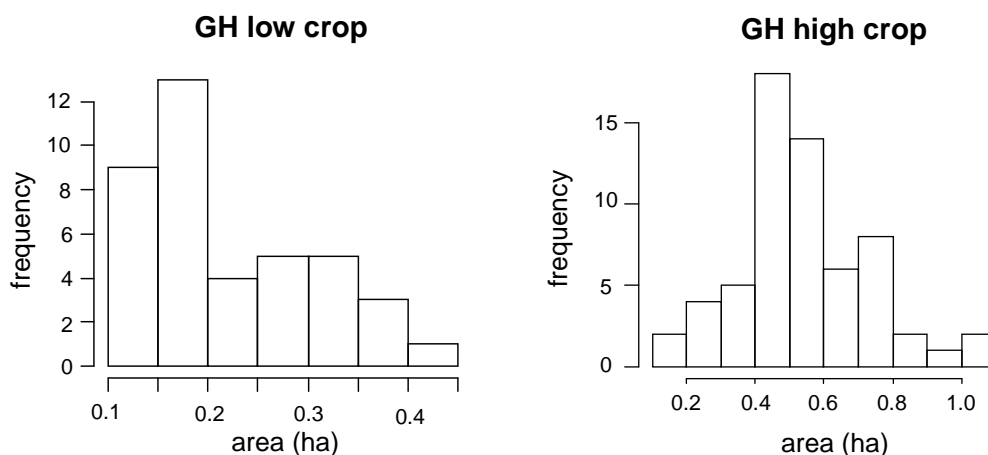


Figure 3: Target area; for application in low crops the target area was in a small range of 0.10 to 0.42 ha (median: 0.19 ha); application in high crops took place on slightly larger areas ranging from 0.18 to 1.10 ha (median: 0.56 ha).

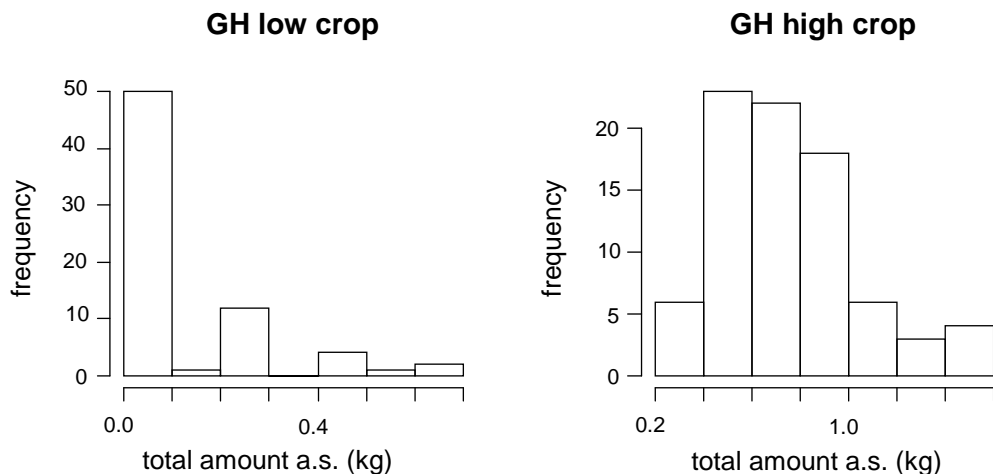


Figure 4: Sum of active substance applied per day (total amount a.s.); the amount varied between 0.02 and 0.60 kg a.s. per day for application in low crops (median: 0.06 kg a.s. per day), on high crops 0.27 to 1.51 kg a.s. were applied per day (median: 0.61 kg a.s. per day).

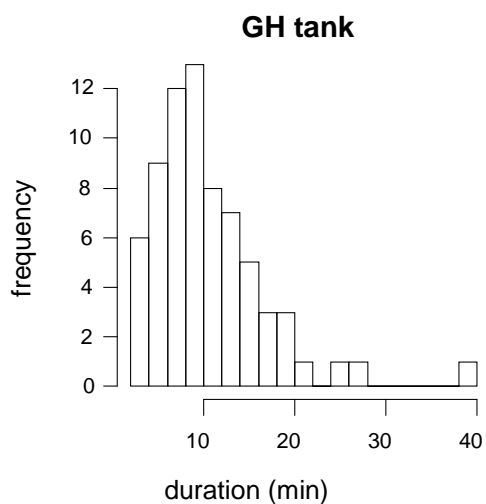


Figure 5: Duration of the mixing/loading task; operators finished mixing and loading of the product within 3 to 40 min (median: 10 min); data are only available for large mix-tanks.

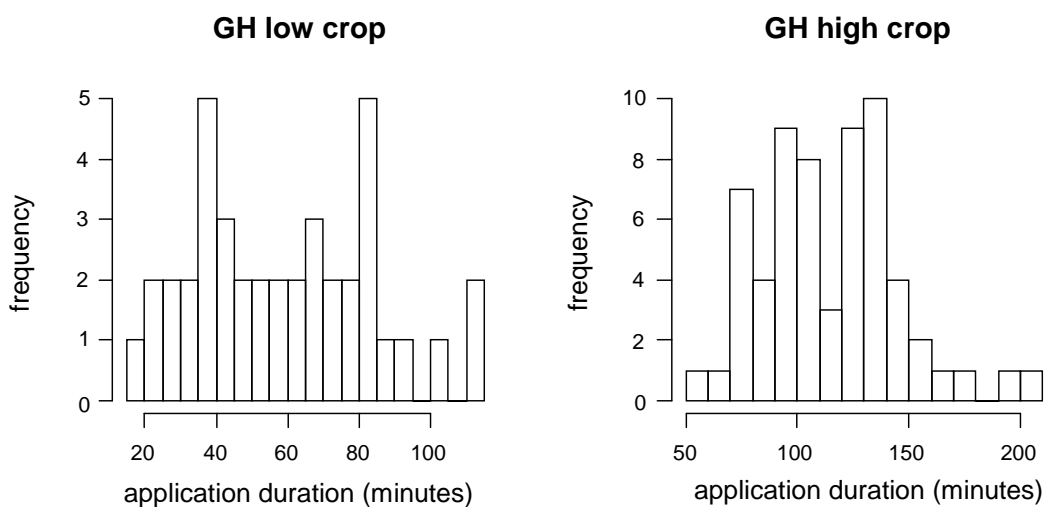


Figure 6: Duration of the application task; in low crops application was completed after 17 to 113 min (median: 58 min) and in high crops after 51 to 202 min (median: 117 min).

5.1.2 Sampling methodology

The exposure data were obtained by whole body dosimetry and personal air sampling according to the quality criteria for study inclusion. The personal air samplers consisted of a pump operating at a flow rate of approximately 2 L/min and an IOM sampling unit with glass fibre filter located in the breathing zone of the operator; the body dosimeters consisted of two layers of clothing – one layer of full-length cotton undergarment and one layer of work clothing (65 %/35 % polyester/cotton coverall; ca. 250 g/m²). Exposure of the head was determined by taking face/neck wipes and hand exposure was assessed by taking hand washes whenever the operator wished to wash his hands and at the end of the working task. Protective (nitrile) gloves, if used by the operators, were analysed as well.

Body exposure during mixing/loading was generally not monitored. The operators wore Tyvek suits above their normal clothing while performing this task.

In two studies, the operators wore protective coveralls or rain suits/rain trousers instead of work clothing. This type of clothing was not analysed.

5.1.3 Data entry

Exposure data as well as information on the study parameters and conditions (equipment, size of area treated, duration, etc.) were extracted from the study report and collected in an Excel table to create a database.

5.1.4 Quality control

On completion of data entry by an evaluator, to ensure that information had been correctly transcribed, a second evaluator independently checked the data transcription.

5.1.5 Exposure data

The database contains seven exposure studies which give in total 70 sets of data records (replicates) for mixing/loading and 102 sets of data records (replicates) for application. The data records comprise data for inhalation exposure and dermal body (torso plus arms and legs), head and hand exposure.

Depending on the use of protective gloves data for residues on gloves, on hands beneath protective gloves or on unprotected hands are available. During mixing/loading all operators wore gloves; hence, for this task only data for gloves and protected hands exist in the database. Additional hand exposure data (hand wash samples and glove samples) were obtained for those mixer/loaders supporting the applicators during application by handling the hose to prevent it from tangling. As this task is usually performed by the applicator the hand exposure data of the applicator and the mixer/loader working together during application were aggregated. Where it was mentioned in the study observations that the operator washed his gloves during or at the end of the work the respective value for the amount of residues detected on the gloves was excluded from the database as it does not reflect the whole exposure. In total, three glove values, one for mixing/loading and two for application had to be discarded.

In case of body exposure data are available for residues on work clothing (outer body), on undergarment below one layer of work clothing (inner body I) or on undergarment below protective clothing (rain suits / rain trousers; inner body II). Some values were also available for body exposure below a certified protective coverall (Teflon coated polyester/cotton blend;

category 3, type 6 certified coverall). However, these data were not used for the model due to the small number of replicates ($n = 6$). Outer body data for residues on a work jacket worn in combination with the rain trousers were also not used as they do not allow calculating exposure for the whole outer body (lack of data for lower torso and legs). For the mixing/loading task no body exposure data were generated in the greenhouse studies, data on body exposure are restricted to the application task.

In addition, no head exposure data were obtained for the powder formulation during mixing/loading. For all other scenarios in the database head data are available. It should be noted that the majority of the head data were obtained from operators wearing face masks during the respective task.

An overview over the exposure data in the greenhouse database is given in Table 1.

Table 1: Number of data for mixing/loading and application; the numbers in brackets indicate head exposure data from operators wearing face masks, outer body: residues on work clothing, inner body I: residues on undergarment beneath work clothing, inner body II: residues on undergarment beneath rain suit (high crop) or rain trousers (low crop)

	Inhala- tion	Outer body	Inner body I	Inner body II	Nitrile gloves	Gloved hands	Bare hands	Head
Mixing/loading								
WG	50	-	-	-	49	50	-	30 (11)
WP	20	-	-	-	20	20	-	-
Application								
High crop	30	30	30	-	20	22	8	29 (16)
High crop dense	32	10	10	22	5	18	14	31 (31)
Low crop	10	10	10	-	10	10	-	10 (10)
Low crop dense	29	20	20	10	30	30	-	30 (12)

5.1.6 Data processing

For some data processing was necessary. All values below the limit of quantification (LOQ) were considered as half of the LOQ and flagged in the table. A correction for recovery was made where the field recovery for the sample matrix was below 70 %. For nitrile gloves a higher threshold was chosen with respect to the inadequacies of this sampling matrix; in this case corrections were made where the field recovery was below 95 %.

In all selected studies head exposure was determined by taking face/neck wipes. To account for the exposure of the whole head the values were adjusted by a factor of 2. Those values that were derived from operators using face masks were marked as they do not reflect the whole exposure to the face.

As already mentioned, the hand exposure data of applicators and the hand exposure data of mixer/loaders supporting the applicators during application were added. The mixer/loader managed the hose in these trials while the applicator was walking down the rows and spraying the crop. In all other trials the applicator managed the hose himself.

Inhalation exposure in the database is given as the amount of residues determined on the filter or tube of the air sampler at the flow rate of the air sampling pump (ca. 2 L/min). Before

using the data for modelling the values were adjusted for a breathing rate of 1.25 m³/h for mean work activity (in accordance to the EFSA guidance).

5.1.7 Exposure scenarios

The equipment used was similar in all greenhouse studies: The operators applied the product with hand-held spray guns or lances that were connected via hoses to a large static mix-tank. Consequently, the number of different scenarios in the database is small.

With respect to mixing/loading only one scenario for large mix-tanks exists in the greenhouse database. The exposure data for this scenario are limited as no body exposure was measured in the studies and only two different formulations were used. The members of the project group, however, consider that this scenario does not substantially differ from the AOEM outdoor tank mixing/loading scenario and concluded that it is reasonable to combine both scenarios for developing a revised AOEM model for tank mixing/loading. This approach was finally supported by the statistical analysis of the mixing/loading data (see 5.2.6).

Exposure scenarios for using hand-held equipment in high crops and in low crops were identified for the application task. Within these two scenarios high exposure levels for those operators were identified who could not avoid coming into contact with the treated crop. It was decided by the project group to consider these conditions as so called dense scenarios for low crop applications and high crop applications.

5.2 Statistical evaluation

5.2.1 Variables

In analogy to the AOEM model the following exposure variables were defined according to the data structure.

Inhalation exposure: All residues that were found on air sampling filters or tubes, calculated for a generic respiration rate of 1.25 m³/h; this is considered to be representative of inhalation exposure.

Head exposure: All residues that were found on head dosimeters including a correction factor of 2 for face/neck wipes; this is considered identical to head exposure without using personal protective equipment.

'Inner' body exposure: All residues that were found on an inner layer of clothing beneath an outer layer of clothing (head and hands excluded); this is considered identical to actual body exposure or protected body exposure.

Total body exposure: All residues that were found on an inner layer of clothing ('inner' body exposure) and on an outer layer of clothing ('outer' body exposure), excluding head and hands; this is considered identical to potential body exposure.

Protected hand exposure: All residues that were found on the hands of operators protected in any case of exposure; this is considered identical to hand exposure using personal protective equipment.

Total hand exposure: All residues that were found on hands and gloves of the operator; this is considered identical to potential hand exposure and exposure without using any personal protective equipment.

5.2.2 Form of the model

For the greenhouse model the same log linear model was chosen as for the AOEM model with X as the exposure variable and with A and F as factors that drive the exposure:

$$\log X = \alpha \cdot \log A + \sum [F_i]$$

The respective non-logarithmic form of the model is given below:

$$X = A^\alpha \cdot \prod c_i$$

The exponent α was set to be between 0 and 1 resulting in a sub linear or linear dependency from the major exposure factor A. An exponential increase in exposure with e.g. increasing amounts of active substance applied per day is considered unlikely.

5.2.3 Choice of factors

Separate models were developed for the mixing/loading task and the two different application scenarios. The exposure factors were selected independently for each model. The total amount of active substance applied per day (TA) was determined as a major factor for exposure. In addition to that the extent of contact with treated foliage (dense or normal scenario) was relevant for both application scenarios. With respect to the limited number of data and the very homogenous database (i.e. similar application equipment, only two different products with the same concentration of active substance) a statistical analysis of a greater number of possible impact factors as it was done for the AOEM data was not possible.

In case of mixing/loading the existing tank model from the AOEM was adjusted by including the new greenhouse tank data. Hence, the same exposure factors were used as for the original tank mixing/loading model.

5.2.4 Choice of exposure reference value and summation of percentiles

According to the recommendation given in the EFSA guidance the 75th percentile was chosen as the statistical reference for exposure modelling. In addition to the 75th percentile the 95th percentile was used in parallel for modelling acute exposure in order to comply with possible future requirements for an acute risk assessment.

5.2.5 Methods

As mentioned before, a log-linear model was assumed to explain the exposure values. Two regression methods were used for the model statistics. First least squares regression was used for the selection of the model, based on diagnostic figures such as R^2 or p-values. As this method is sensitive to outliers, to variable standard deviation and in particular to the assumed values of measurements below the limit of quantification quantile regression was used for the prediction of the 75th and the 95th. This non-parametric method gives an independent estimate for every percentile. As long as the percentile is well within the range of measured data, the resulting fit can be expected to be more robust than one obtained from ordinary least squares regression. In particular, it will not depend on the actual choice of the value substituted for non-detects and does not assume the same standard deviation over the whole range.

The method is described in more detail in the AOEM project report (BfR Wissenschaft, 2013).

For those exposure variables for which no statistical model could be derived the respective empirical percentiles were calculated with quantile regression.

5.2.6 Results

The statistical analysis of the exposure data resulted in models for the tank mixing/loading scenario and the application scenarios in high crops with hand-held spray guns or lances that were connected via hoses to large mix-tanks. Due to the limited number of data no statistical model could be derived for the application scenario in low crops; instead the 75th or 95th percentiles were calculated. The model predictions and estimations of the percentiles are shown in Appendices 2 to 5; the precise model equations and values are presented in chapter 6.

ML tank

The mixing/loading data from the greenhouse database fitted well into the exposure data from the AOEM database (see Figure 7). Hence, the approach to combine both datasets for one tank mixing/loading scenario is justified. The greenhouse data improve the predictivity of the tank model for lower amounts of active substance used per day and resulted in slight changes of the model coefficients. A fourth formulation type was added to the model: powder formulations packed in small non-soluble sachets (WP_s) were considered different from powder formulations packed in large containers or boxes (WP). However, the tank model was only adjusted for hand, head and inhalation exposure but not for body exposure as no data for potential or inner (actual) body exposure during mixing/loading had been generated in the greenhouse studies.

The head data from greenhouse operators wearing face masks were not included into the model. Exposure values in nine of the eleven cases with face masks were below the limit of quantification. With respect to the small number of data these values were not used to create an additional exposure factor for using face masks during mixing/loading. Moreover, a factor for using face shields already exists in the outdoor AOEM tank model.

HCHH

A dependency from the total amount of active substance applied per day (TA) was postulated for the exposure during application in high crops with respect to the results from the AOEM project. This could be confirmed for the greenhouse for total body exposure, inner body exposure, total hand exposure, head exposure and inhalation exposure. No dependency from TA was observed for protected hand exposure. For this exposure variable the respective percentiles based on the absolute exposure values were calculated. The exposure percentiles are assumed valid for an application amount of up to 1.6 kg a.s. per day for the normal scenario and 1.05 kg a.s. per day for the dense scenario. Above these amounts that are the highest amounts applied in the examined studies linear extrapolation of exposure will be required.

Operators were generally higher exposed in the dense scenario having direct contact with the treated crop except for the total hand exposure for which no impact of the dense scenario could be observed. For all other exposure variables contact with treated crop in a dense scenario is considered as a separate exposure factor or separate percentile.

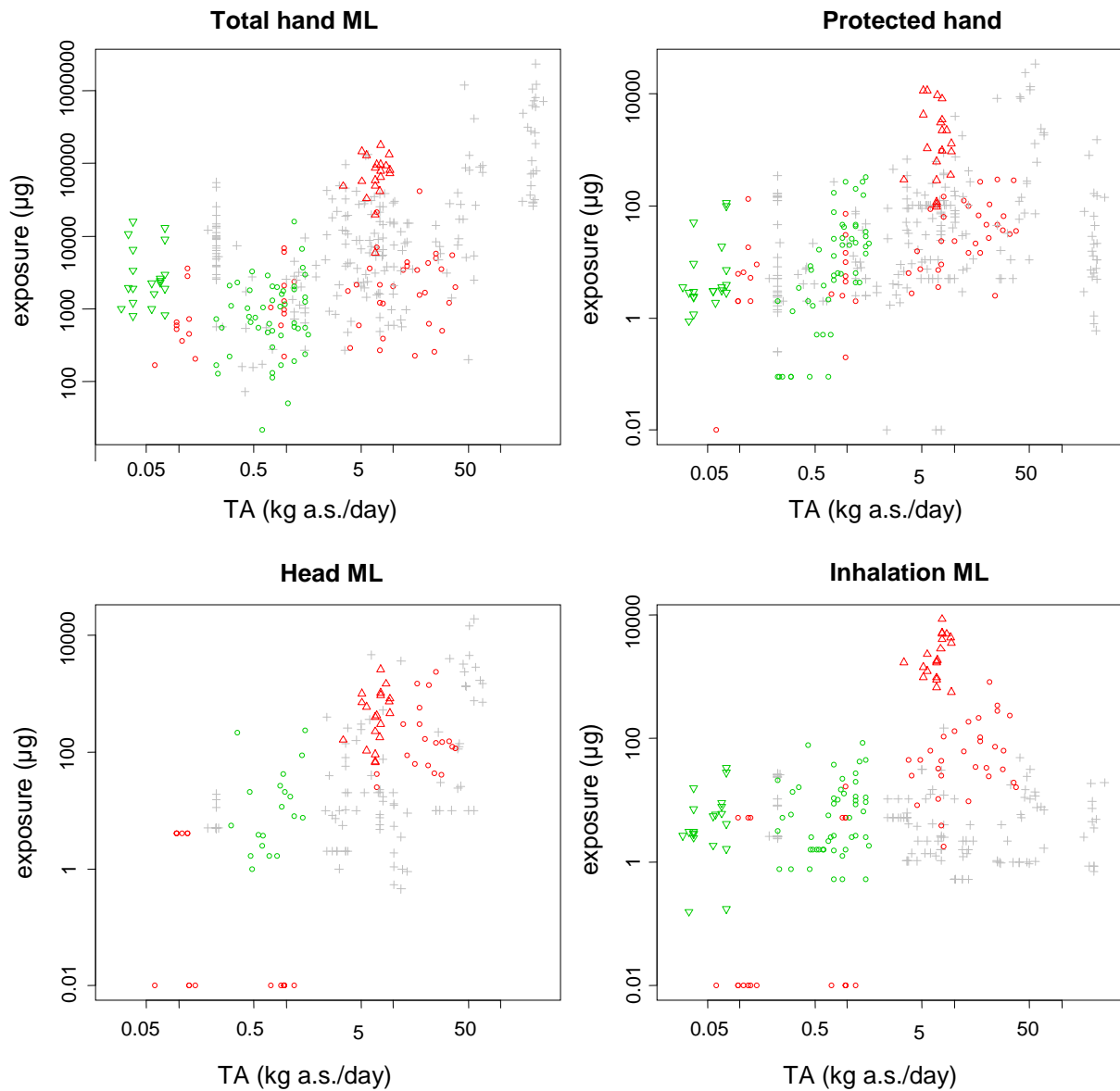


Figure 7: Comparison of outdoor and greenhouse mixing/loading data for tank equipment; red = outdoor, green = greenhouse, o = WG, Δ = WP, ▽ = WP (sachets), + = liquid (grey, outdoor only)

The use of rain suits was identified as additional exposure factor for actual body exposure in case of a dense scenario resulting in a reduction of inner body exposure compared to normal work clothing (see Figure 8). The reduction of exposure by a rain suit is not to be combined with actual exposure from a normal scenario.

All head exposure data were taken into account for the model irrespective of the use of face masks during application. No significant differences were observed for the exposure with and without face mask in respective scenarios (see Figure 9). In general, head exposure only accounts for a small amount of the overall exposure.

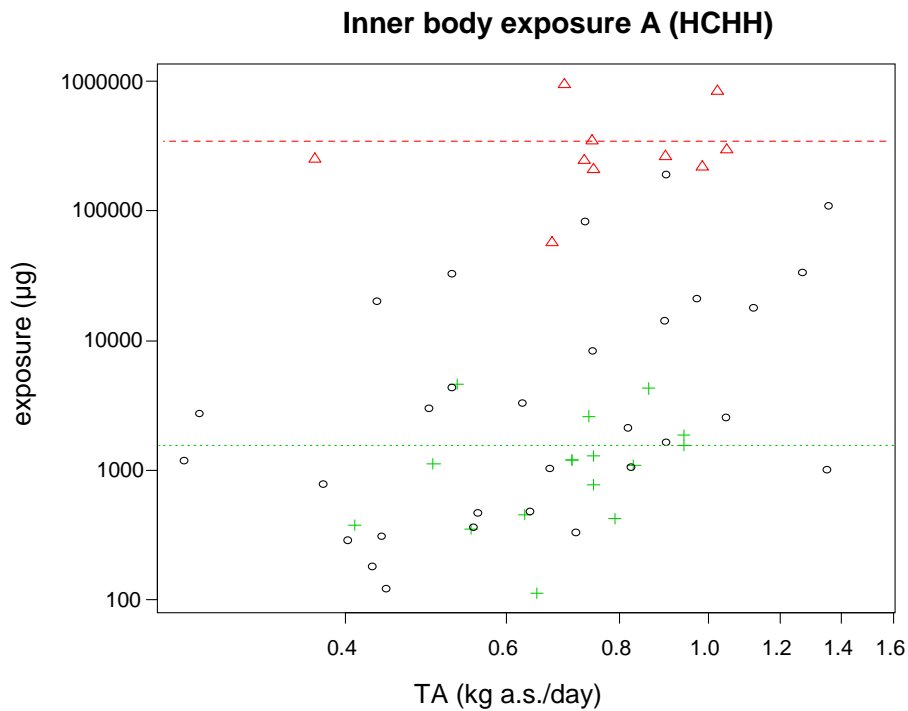


Figure 8: Inner body exposure data for application in greenhouses; o = normal scenario, Δ = dense scenario, + = with rain suits in dense scenario; red line: 75th percentile of exposure beneath work clothing in dense scenario; green line: 75th percentile of exposure beneath rain suits in dense scenario.

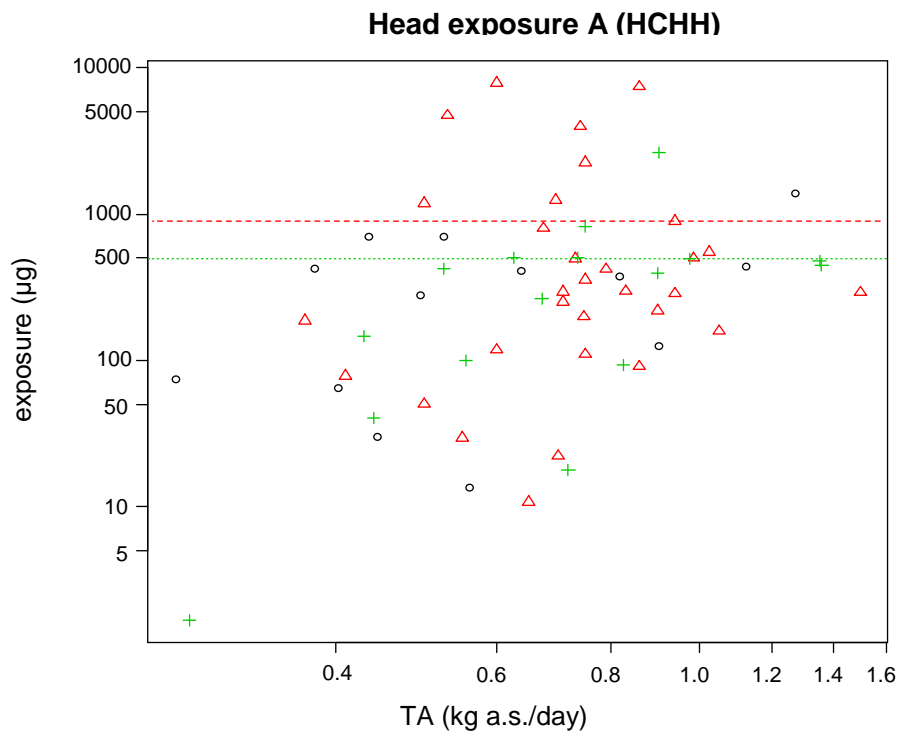


Figure 9: Head exposure data for application in greenhouses; o = without face mask, Δ = with face mask in dense scenario, + = with face mask in normal scenario; red line: 75th percentile of exposure with face masks in dense scenario; green line: 75th percentile of exposure with face masks in normal scenario.

LCHH

No reasonable statistical model could be derived for this scenario due to the small number of data (see Appendix 2.3). Instead the 75th and 95th percentiles based on the absolute exposure values were calculated.

For the normal scenario and the dense scenario separate sets of percentiles were derived. The absolute exposure in the dense scenario was generally higher except for potential hand exposure and inhalation exposure which were lower. Nevertheless, when looking at relative exposure (exposure in relation to total amount applied per day) potential hand exposure and inhalation exposure were higher for the dense scenario as well (Figure 10). To avoid the paradox when using absolute exposure data the datasets for dense and normal scenario were combined and percentiles of all data were derived in case of potential hand exposure and inhalation exposure. The percentiles for the dense scenario are assumed valid for an application amount of up to 0.075 kg active substance per day and in case of the normal and combined scenario for an application amount of up to 0.6 kg active substance per day. Above these amounts linear extrapolation is required.

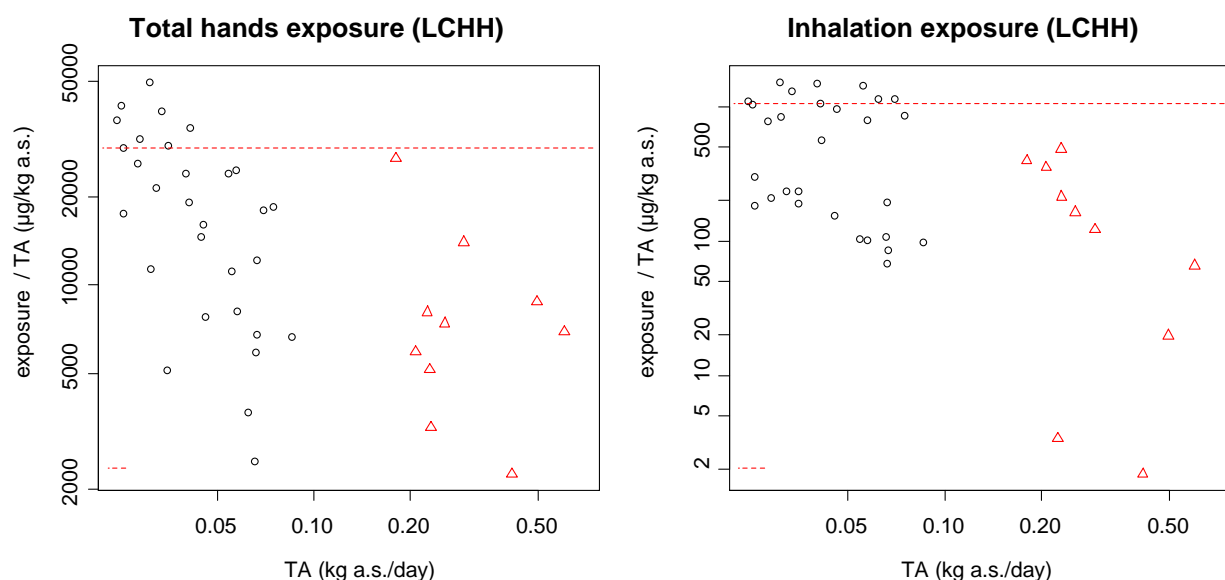


Figure 10: Potential hand and inhalation exposure data for the normal (red triangles) and dense scenario (black circles); shown are relative exposure values (ratios of absolute exposure and total amount of active substance applied per day); red line: 75th percentile of all data.

The use of rain trousers in the dense scenario resulted in a significantly lower exposure of the body. Hence, a separate evaluation of these data was conducted yielding a separate percentile for inner body exposure with rain trousers (see Figure 11).

Like for the high crop application scenario all head exposure data were taken into account for the low crop scenario irrespective of the use of face masks during application (see Figure 12).

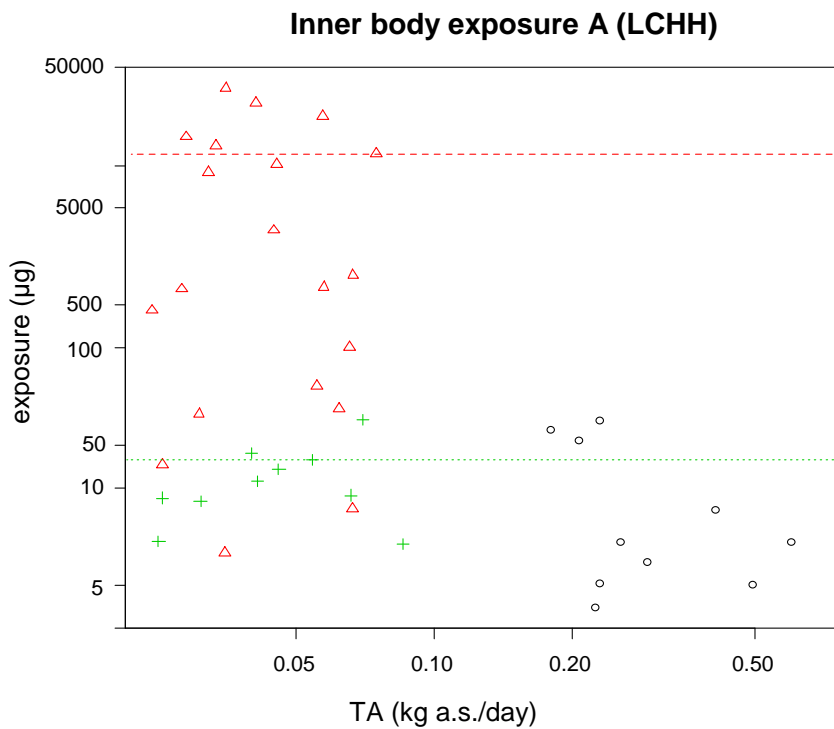


Figure 11: Inner body exposure data for application in greenhouses; o = normal scenario, Δ = dense scenario, + = with rain trousers in dense scenario; red line: 75th percentile of exposure beneath work clothing in dense scenario; green line: 75th percentile of exposure beneath rain trousers in dense scenario.

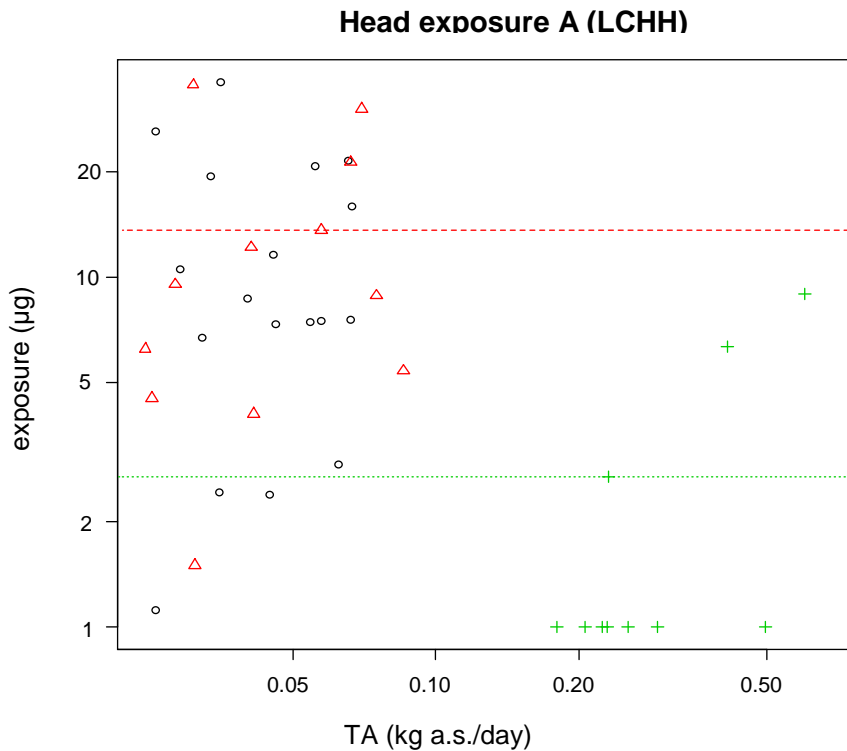


Figure 12: Head exposure data for application in greenhouses; o = without face mask, Δ = with face mask in dense scenario, + = with face mask in normal scenario; red line: 75th percentile of exposure with face masks in dense scenario; green line: 75th percentile of exposure with face masks in normal scenario.

5.3 Validation

5.3.1 Robustness analysis through cross validation

The robustness of the models was examined using cross validation. The approach of this method is to repeatedly remove a portion of the data from the database and to compare the models obtained with the reduced databases (see AOEM project report for more details). The more similar the models for the reduced databases are the more robust is the model.

The results for the tank mixing/loading scenario and the greenhouse HCHH scenario are presented in Figure 13 and Figure 14. The diagrams each show ten random data subsets together with the model line (in the same colour) that would be obtained for the remaining data. The model lines for all modelled exposure variables are close to each other; hence, it can be concluded that the respective model for the whole database is robust, e.g. to some extent independent from single exposure values.

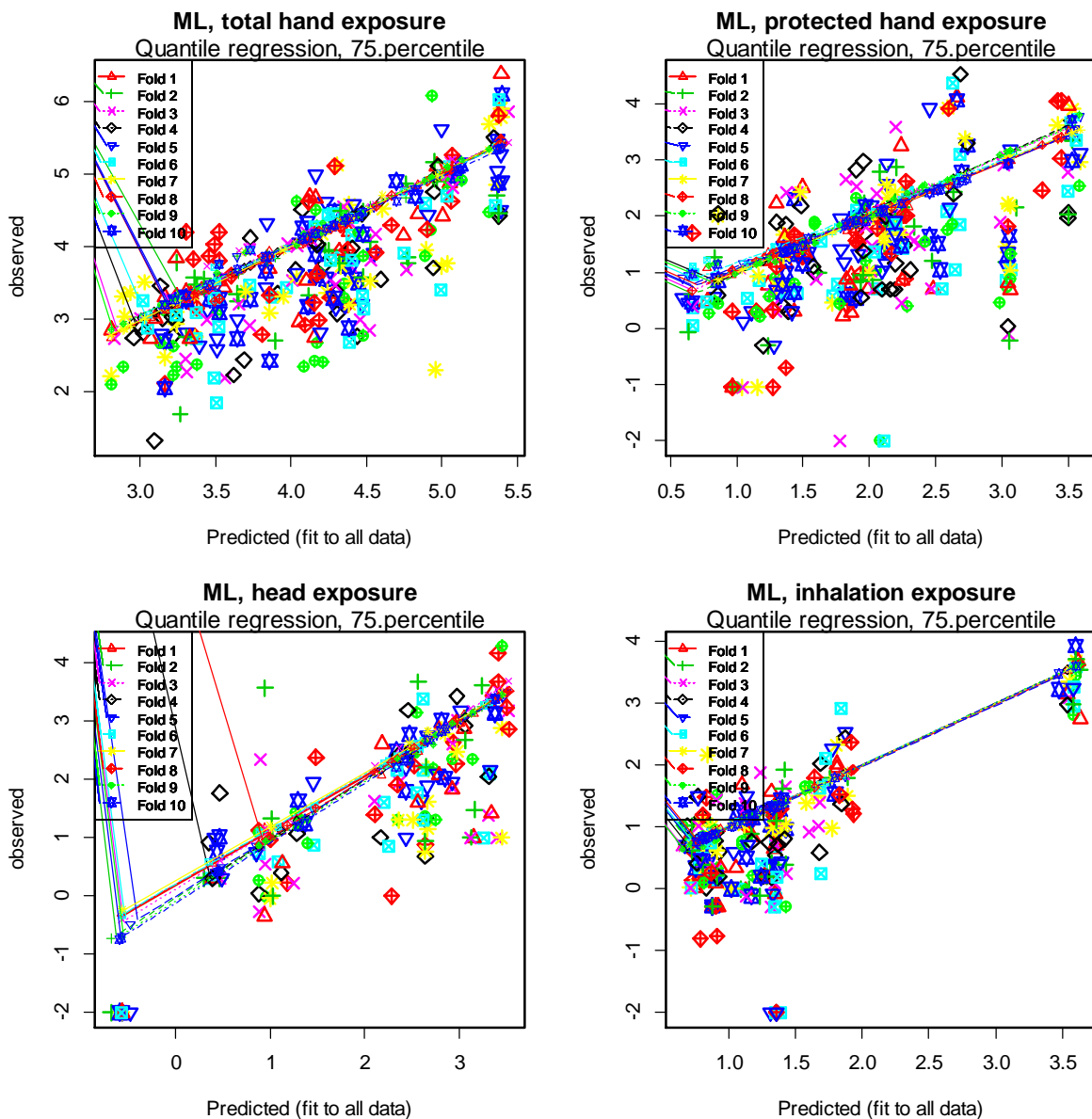


Figure 13: Cross validation of the revised tank mixing/loading model; shown are random subsets of the model (in different colours) together with the model prediction of the reduced datasets (line in same colour as the data subset)

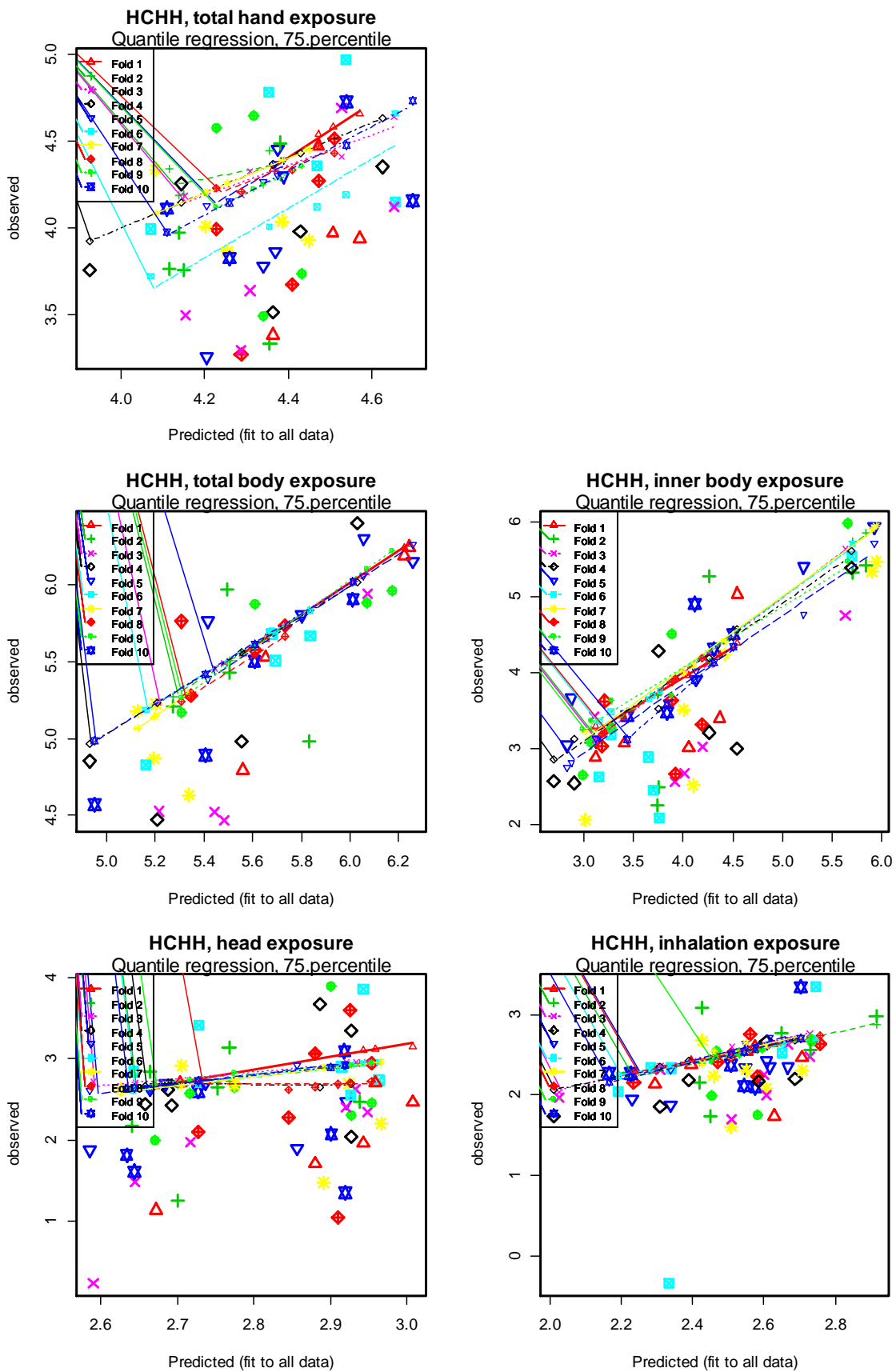


Figure 14: Cross validation of the greenhouse HCHH model; shown are random subsets of the model (in different colours) together with the model prediction of the reduced datasets (line in same colour as the data subset).

5.3.2 Prediction capability

The prediction of the greenhouse models was tested with greenhouse data for operator exposure from the open literature (Machera et al., 2009; Tsakirakis et al., 2010) and from the EUROPOEM project (studies 31, 32 and 72-78). The data for application in high crops (crop height ≥ 0.8 m) and application in low crops (crop height < 0.8 m) were each plotted together with the model data and the model prediction (Figure 15 and Figure 16). Ideally, a maximum of 25 % of the data should be above the line for prediction at the 75th percentile level.

In case of high crop greenhouse application the validation data (indicated as empty circles) fit well to the model data (indicated as filled circles). However, for some exposure variables (especially for inner body and head exposure) more than 25 % of the data are higher than the prediction of the model. This might be in part due to the fact that some of these data belong to the dense scenario rather than to the normal scenario. No classification of the greenhouse data from the EUROPOEM project into dense or normal scenario was possible; therefore, these data were grouped as normal scenario. The data from the two studies from open literature represent dense scenario.

For the low crop greenhouse scenario the 75th percentile is indicated as line in the figures since no model could be derived. For actual hand and inner body exposure no validation data were available. For the other exposure variables a dependency of exposure from the total amount of active substance applied could be assumed. The calculated 75th percentile from the model is exceeded by more than 25 % of the validation data. The reason for this result is the crop height in the validation studies reaching up to 1.5 m for ornamentals such as carnations (considered as low crop) while in the model studies the crop height did not exceed 0.5 m. A higher crop height is expected to result in a higher operator exposure.

As no new validation data were available for the mixing/loading scenario the prediction of the revised tank mixing/loading model was not checked again. The difference to the previous tank mixing/loading model from the AOEM project is small; hence the prediction test made for the AOEM project is expected to be still valid.

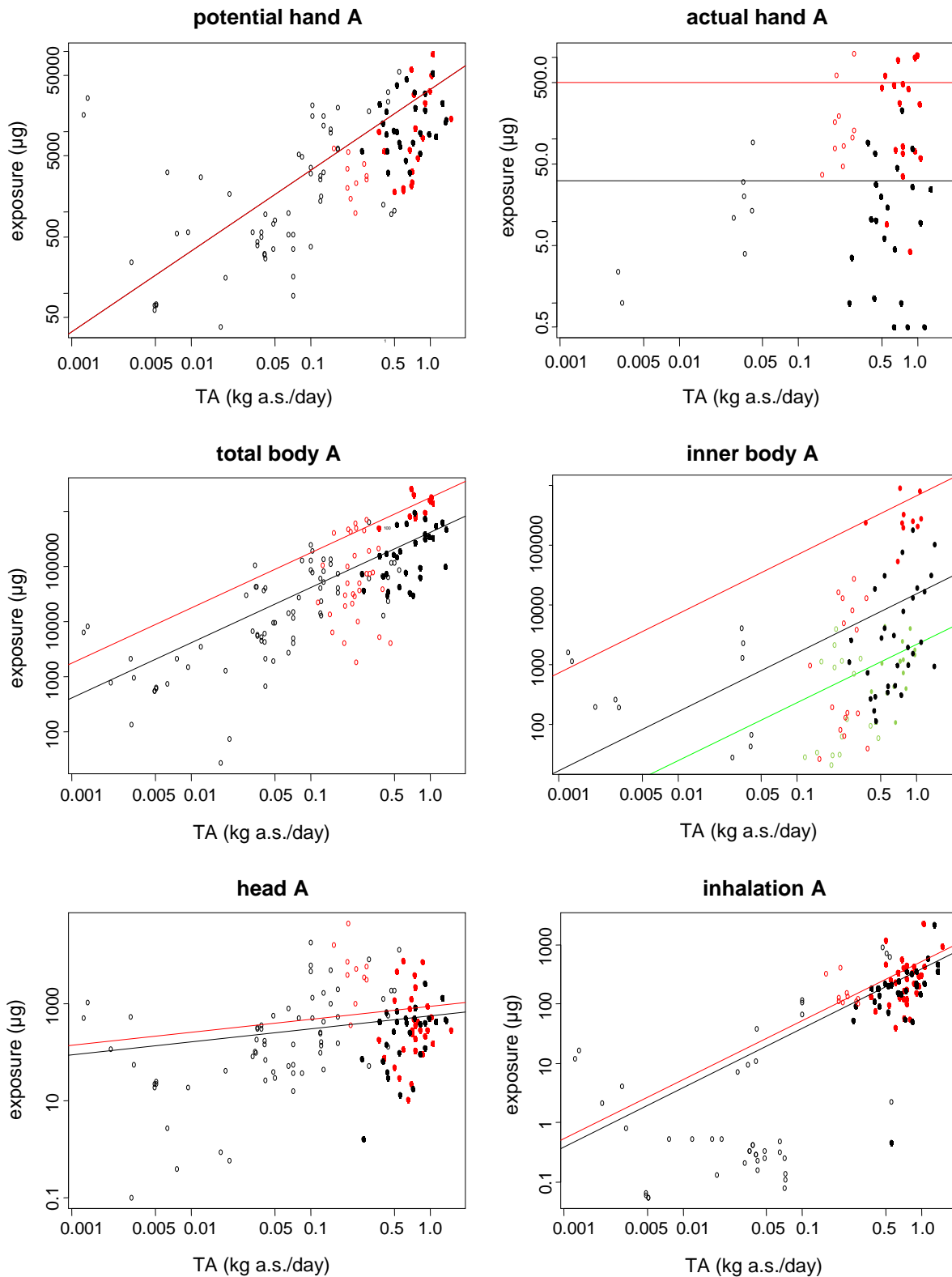


Figure 15: Validation data (empty circles) for high crop application in greenhouse in comparison to model data (filled circles) and model prediction (75th percentile; solid lines); black: normal culture, red: dense culture; green: dense culture with rain suits/water repellent clothing

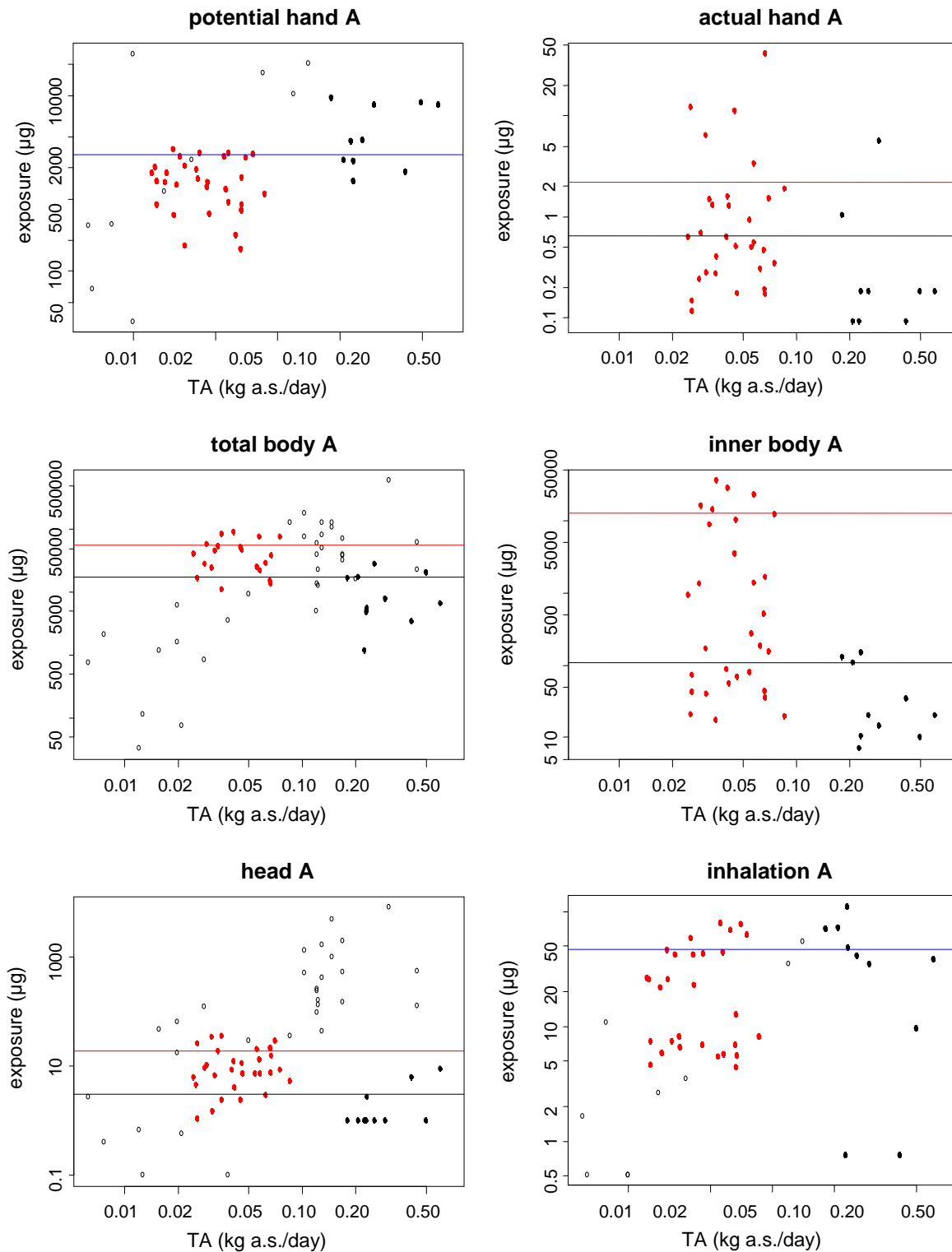


Figure 16: Validation data (empty circles) for low crop application in greenhouse in comparison to model data (filled circles); black: normal culture, red: dense culture; black line: 75th percentile for normal scenario; red line: 75th percentile for dense scenario; blue line: 75th percentile for normal and dense scenario combined

6 Predictive exposure model

6.1 Model

6.1.1 Calculation

Within the scope of the greenhouse project new models were developed for the prediction of operator exposure. The models give exposure estimates for spray applications in low crops or high crops with hand-held spray guns or lances connected to a stationary mix-tank.

- Low crop hand-held application, static tank (LCHH)
- High crop hand-held application, static tank (HCHH)

The exposure from mixing/loading and the exposure from application are calculated separately for both the dermal exposure route including body, hands and head and the inhalative exposure route. For the total exposure the single exposures for each task, route and body part are added. The model equations or exposure percentiles for the single exposures are given in Table 2 (75th percentile level) and Table 3 (95th percentile level).

It should be noted that the model for tank mixing/loading is based on the combined datasets from the AOEM outdoor database and the greenhouse database. As a consequence the tank mixing/loading model from the AOEM project will be replaced by the combined model except for total body and inner body exposure for which data from the greenhouse database do not exist (shown in grey in the tables below).

Table 2: Exposure models predicting the 75th percentile; in case no model could be derived the 75th percentile was calculated (normal scenario/dense scenario/dense scenario with rain trousers); exposure is given in µg/person; * with or without face mask.

		$\log \exp = \alpha \log TA + [\text{formulation type}] + \text{constant}$
Tank ML	total hands	$\log D_{ML(H)} = 0.70 \log TA + 0.52 [\text{liquid}] + 1.20 [\text{WP}] + 1.26 [\text{WP}_s] - 0.37 [\text{glove wash}] + 3.25$
	prot. hands	$\log D_{ML(Hp)} = 0.65 \log TA + 0.15 [\text{liquid}] + 1.57 [\text{WP}] + 0.21 [\text{WP}_s] + 1.38$
	total body	$\log D_{ML(B)} = 0.70 \log TA + 0.46 [\text{liquid}] + 1.83 [\text{WP}] + 3.09$
	inner body	$\log D_{ML(Bp)} = 0.89 \log TA + 0.11 [\text{liquid}] + 1.76 [\text{WP}] + 1.27$
	head	$\log D_{ML(C)} = 0.93 \log TA + 0.50 [\text{liquid}] + 0.84 [\text{WP}] - 1.88 [\text{face shield}] + 1.32$
	inhalation	$\log I_{ML} = 0.36 \log TA - 0.85 [\text{liquid}] + 1.92 [\text{WP}] - 0.04 [\text{WP}_s] + 1.36$
		$\log \exp = \alpha \log TA + [\text{dense}] + \text{constant}$
GH HCHH	total hands	$\log D_{A(H)} = \log TA + 4.51$
	prot. hands	28 / 481 (above 1.60 kg a.s. / 1.05 kg a.s. linear extrapolation)
	total body	$\log D_{A(B)} = \log TA + 0.63 [\text{dense}] + 5.60$
	inner body	$\log D_{A(Bp)} = \log TA + 1.64 [\text{dense}] - 0.85 [\text{rain suit}] + 4.19$
	head*	$\log D_{A(C)} = 0.27 \log TA + 0.22 [\text{dense}] + 2.74$
	inhalation	$\log I_A = \log TA + 0.13 [\text{dense}] + 2.59$
		75 th percentile (above 0.60 kg a.s./ 0.075 kg a.s. / 0.086 kg a.s. linear extrapolation)
GH LCHH	total hands	1323
	prot. hands	0.18 / 1.5
	total body	17207 / 55521
	inner body	107 / 12180 / 80
	head*	2.7 / 19
	inhalation	47

Table 3: Exposure models predicting the 95th percentile; in case no model could be derived the 95th percentile was calculated (normal scenario/dense scenario/with rain trousers); exposure is given in µg/person; * with or without face mask.

		$\log \exp = \alpha \log TA + [\text{formulation type}] + \text{constant}$
Tank ML	total hands	$\log D_{ML(H)} = 0.79 \log TA + 0.50 [\text{liquid}] + 1.15 [\text{WP}] + 1.59 [\text{WP}_s] - 0.79 [\text{glove wash}] + 3.73$
	prot. hands	$\log D_{ML(Hp)} = \log TA + 0.08 [\text{liquid}] + 1.08 [\text{WP}] + 0.90 [\text{WP}_s] + 2.22$
	total body	$\log D_{ML(B)} = 0.29 \log TA + 0.65 [\text{liquid}] + 1.25 [\text{WP}] + 4.21$
	inner body	$\log D_{ML(Bp)} = \log TA + 0.37 [\text{liquid}] + 1.50 [\text{WP}] + 1.79$
	head	$\log D_{ML(C)} = 0.82 \log TA + 0.54 [\text{liquid}] + 0.20 [\text{WP}] - 1.45 [\text{face shield}] + 2.23$
	inhalation	$\log I_{ML} = 0.54 \log TA - 0.88 [\text{liquid}] + 1.54 [\text{WP}] - 0.37 [\text{WP}_s] + 1.69$
		$\log \exp = \alpha \log TA + [\text{dense}] + \text{constant}$
GH HCHH	total hands	$\log D_{A(H)} = \log TA + 0.10 [\text{dense}] + 4.84$
	prot. hands	$\log D_{A(Hp)} = \log TA + 0.77 [\text{dense}] + 2.38$
	total body	$\log D_{A(B)} = 0.47 \log TA + 0.58 [\text{dense}] + 5.89$
	inner body	$\log D_{A(Bp)} = \log TA + 1.09 [\text{dense}] - 1.10 [\text{rain suit}] + 5.04$
	head*	$\log D_{A(C)} = 0.94 \log TA + 0.75 [\text{dense}] + 3.18$
	inhalation	$\log I_A = \log TA + 0.62 [\text{dense}] + 2.72$
		95 th percentile (above 0.60 kg a.s./ 0.075 kg a.s. / 0.086 kg a.s. linear extrapolation)
GH LCHH	total hands	4159
	prot. hands	5.7 / 12
	total body	28078 / 85382
	inner body	150 / 27958 / 154
	head*	8.9 / 35
	inhalation	80

6.1.2 Applicability domain

The new greenhouse model allows the calculation of operator exposure from spray applications in greenhouses with hand-held spray guns or lances. Spray applications with knapsack sprayers are not covered by the model as data for this scenario are missing and no prediction is possible whether exposure with lance equipment covers exposure with knapsack sprayers. However, knapsack spray applications are very rare and only relevant for the treatment of small areas well below 1 ha.

The exposure assessment includes the preparation of the spray solution in large tanks and the application of the spray solution but not the cleaning of the equipment as this task was not part of the exposure monitoring in the vast majority of the trials.

Two application scenarios can be chosen: application in low crops and application in high crops. The height of the low crops in the studies (ornamentals, melons) did not exceed 0.5 m; therefore, the high crop scenario should be chosen for crops exceeding a height of 0.5 m. High crops in the studies (pepper, cucumber, tomato) ranged from 1.1 to 2.4 m. The height of the target might substantially differ from the height of the crop itself (e.g. ornamentals in pots placed on tables, strawberries in hydroculture). Hence, it is recommended to select the model based on the target height and not on the crop height itself.

The tank mixing/loading scenario is considered to be identical for outdoor and greenhouse application; hence the revised tank mixing/loading model is applicable for outdoor and greenhouse applications. The tank equipment used in the greenhouse studies is similar to

the tank equipment used in the outdoor hand-held scenario; thus the procedure of mixing/loading should be similar as well. No data are available for body exposure when preparing the spray solution with WP formulations packed in small sachets. In this case the exposure from loose powder formulations is used as a surrogate.

The area treated in the studies ranged from 0.1 to 1.1 ha and was designated in the study reports to cover a typical day's work. For treatments with hand-held equipment in greenhouses an area of 1 ha per day is considered realistic.

The data were obtained in greenhouses located in Spain and Italy. The pictures given in the study report show typical wooden or steel constructions of approximately 2-4 m height with plastic shelters as described in Van der Velden et al. (2012). As long as no data or information are available showing that the conditions and exposure levels in a certain region or country are substantially different the model could be applied for greenhouse uses in all EU MS. At least for operator exposure, the conditions in greenhouses in Spain and Italy might be considered as worst-case for the conditions in greenhouses in the central or northern zone. According to an EFSA guidance document (EFSA, 2014b) various structures/systems exist for covered crop ranging from low tunnels to high-tech greenhouses; nevertheless, up to now all covered crop structures are considered as greenhouses when assessing operator exposure. This is in line with the minimum definition of greenhouses given in Reg. (EC) No 1107/2009.

Depending on the crop stage or the growing situation (e.g. row distance) it is necessary to consider a dense scenario where a frequent contact of the operator with the treated crop is assumed. Cultivation practices for greenhouse crops can be different between countries i.e. it can be a dense crop in one country and a normal crop in another country or both exist in one country. It is therefore recommended to run both models in parallel unless explanation for the non-relevance of a dense scenario is provided by the applicant.

Modelling exposure for dust applications, fogging, drip irrigations or watering in greenhouses was out of the scope of this project.

6.1.3 Work clothes and personal protective equipment

According to good occupational hygiene practice the operators should wear at least work clothing completely covering their legs and arms. For that reason exposure calculations could start with the assumption that the operator is wearing at least one layer of work clothing as proposed for the outdoor AOEM.

The reduction of exposure resulting from the use of work clothes is integrated into the model since data were available from the database. For mixing/loading new data for body exposure from the greenhouse were not available. Hence, the same reduction for work wear as described for the original outdoor tank mixing/loading model also applies to the greenhouse mixing/loading scenario. For the application task data exist for the greenhouse. Work clothes were worn by all operators during application and consisted of polyester/cotton coveralls (65 % / 35 %; ca. 250 g/m²). According to the greenhouse data from the normal scenario the coveralls resulted in a reduction of body exposure by 96.5 % (3.5 % penetration calculated as the 75th percentile of the ratios of inner body exposure and total body exposure) which is similar to the protection of 96 % provided by the coveralls worn in the AOEM outdoor studies.

Penetration was substantially higher in the dense scenario where operators came into contact with treated foliage (see Table 4). In those cases the reduction by wearing coveralls was only 71.3 % (28.7 % penetration calculated as the 75th percentile of the ratios of inner body exposure and total body exposure). The use of work wear was not sufficiently

protective in the dense scenario as the inner body exposure levels were quite high. Therefore, work wear is not recommended for the dense scenario. Instead, some operators wore non-certified rain suits or rain trousers made of a Nylon/PVC fabric. The comparison of body exposure beneath work clothing and body exposure beneath rain suits (both related to the amount of active substance handled per day and given as the 75th percentile) revealed that rain suits allow for a more than 230 fold better protection. The rain trousers provided an even 370 fold better protection of the legs when looking at the 75th percentile of leg exposure beneath work clothing and the 75th percentile of leg exposure beneath rain trousers. Certified impermeable clothing for HCHH application or LCHH application can be chosen in the greenhouse model based on the data for rain suits or rain trousers from the greenhouse, but only for the dense scenario. For the normal scenario no data are available.

New data from the greenhouse are also available for the protection provided by nitrile gloves. Exposure of the hands during mixing and loading was by a factor of 0.024 (75th percentile) lower when gloves were used corresponding to a protection of 97.6 %. This reduction is similar to the protection level of nitrile gloves observed in the AOEM outdoor studies. In case gloves were worn during spray application the exposure to the hands was reduced by a factor of 0.002 (75th percentile, normal scenario) or 0.004 (75th percentile, dense scenario). The highest penetration of 0.06 was observed for the dense scenario in high cultures.

It should be noted that the exact exposure reduction when choosing workwear, gloves or certified impermeable clothing in the greenhouse model for a specific scenario and application rate will differ from the figures given in the table below as these figures are calculated as the empirical percentile of all values.

Some operators wore face masks during the operations. A precise description of the type of face mask is not possible as this information was not given in the study reports. As described in section 5.2.6 the respective head data were used for the application models (but not for the mixing/loading model). As no significant difference in head exposure with and without face mask was observed all data were pooled. Care should be taken when considering respiratory protection; no reduction for the head should be applied in addition to inhalation exposure.

Table 4: Distribution of penetration factors for gloves and work clothes derived from the greenhouse database; shown are the 75th percentile and median values of the ratios of gloved hand exposure and total hand exposure and of inner body exposure and total body exposure (n: number of data; CV: coefficient of variation).

		Gloves				Work clothes			
		n	75 th perc.	median	CV%	n	75 th perc.	median	CV%
ML	WG	49	0.042	0.012	198				
	WP_{sachet}	20	0.005	0.002	109				
A	normal								
	HCHH	20	0.003	0.0009	150	30	0.050	0.020	143
	LCHH	10	0.0002	0.0001	180	10	0.007	0.004	131
	dense								
	HCHH	5	0.033	0.006	166	10	0.435	0.264	56
	LCHH	30	0.002	0.001	249	20	0.225	0.054	108

6.1.4 Tiered approach

The greenhouse model allows a stepwise risk refinement starting with work clothing and allowing further reduction by selection of personal protective equipment (e.g. protective gloves). Risk mitigation by additional protective measures can be considered in addition.

6.2 Operator exposure calculator

Within the scope of this project an excel spreadsheet has been developed. The excel spreadsheet (distributed with the project report) enables the user to calculate exposure on the basis of the new greenhouse models.

6.3 Data gaps

The number of data in the greenhouse database as well as the variation in the parameters such as formulation type, application rate or application equipment is limited. Due to that fact the new greenhouse model covers only certain scenarios for which data were available. Hence, more data are needed e.g. for different application equipment including knapsack sprayers. More data are also needed to improve the statistical power when analysing exposure factors and the robustness of the models. For the application scenario in low crops no model factors could be identified because of the limitations mentioned above.

6.4 Future perspectives

The models shall be amended or revised in case that new valid data become available. This could be realised in an EU wide concerted process including a review by all MS.

7 Conclusions

With the end of this project new models for operator exposure during greenhouse hand-held application were developed. They were created on a highly scientific basis and can be used for the evaluation of plant protection products for authorisation in the EU once they are agreed by all MS. As a prerequisite for a broad acceptance of these models all data are presented and all steps of the modelling process are described in detail in this report.

8 Supplementary information

Additional information on the data and the model are given in the supplementary information at the end of this report. It comprises a complete list of the raw data used for the model, a table with percentiles of the raw data and the detailed model computations.

9 References

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10 Abbreviations

A	application
AOEM	agricultural operator exposure model
a.s.	active substance
CV	coefficient of variation
HCHH	high crop hand-held
LCHH	low crop hand-held
ML	mixing/loading
TA	total amount of active substance mixed or applied per day (in kg a.s./day)
WG	water dispersible granules
WP	wettable powder

Appendix 1 Study descriptions

HCHH 1

Active substance: Chlorothalonil (750 g/kg)
Formulation type: Water dispersible granules
Pesticide function: Fungicide
Crop: Peppers

Setting:

The study was conducted at several pepper growing sites in the Almeria region in Southern Spain. Initially, 10 operators were monitored in a first field phase during October 2001. The operators wore cotton/polyester coveralls and performed the mixing/loading task and the application task. A second field phase was conducted in October 2003 with operators dressed in certified coveralls (n = 6) or rain suits (n = 16). The operators were monitored only during application; mixing/loading was conducted by the study personnel. In both field phases the operators used hand-held spray guns that were connected via a hose to a static or tractor drawn tank. The crop was grown in rows with a distance of 0.8 to 2.0 m; the crop height ranged from 1.1 to 2.1 m. While spraying the area the operators frequently brushed against the treated crop. Between 0.7 and 1.8 kg a.s were applied per hectare diluted in a water volume of 439 to 1240 L/ha. The treated area ranged from 0.4 to 1.1 ha; the respective application duration ranged from 91 to 202 min. In almost all trials one mixing/loading cycle was sufficient. The product was supplied in 1 kg and 3 kg containers and poured directly into the tank. The whole task of mixing and loading took between 4 and 21 min. All operators wore face masks during the tasks.

Exposure assessment:

Dermal exposure of the body and the head was determined in both field phases only during application. In the first field phase the operators (1-10) were provided with cotton/polyester coveralls, cotton long-sleeved shirts and long johns before start of the application to monitor potential and actual body exposure. In the second field phase actual body exposure was also determined with cotton long-sleeved shirts and long johns worn beneath protective suits (Teflon coated polyester/cotton blend; category 3, type 6 certified coverall, operators 11-17) or rain suits (Nylon/PVC; operators 18-33); neither the protective coverall nor the rain suits were analysed. Face/neck wipes were collected whenever the operator wished to wash his face but at least at the end of the application task to assess head exposure. Hand exposure was determined by sampling protective nitrile gloves and carrying out hand washes at least at the end of the mixing/loading task (field phase I) or application task (field phase I and II). During application protective gloves were not used by all operators. Inhalation exposure was assessed for both tasks separately using personal air samplers with glass fibre filters operating at a flow rate of about 2 L/min. Chlorothalonil was extracted from the samples with hexane or, in case of the hand wash specimens, in a mixture of petroleum ether and diethyl ether after addition of sulphuric acid and aqueous sodium chloride and quantified by gas chromatography with electron-capture detection.

Results:

The results of the study are given below. Correction for recovery was done for all glove samples (61 % for values at the low fortification level and 77 % for values at the high fortification level). Inhalation exposure has been recalculated for a respiratory rate of 1.25 m³/h. All values were above the LOQ.

Mixing/loading

Operator	TA a.s. [kg]	Exposure time [min]	Inhalation [μg]	Hands [μg]	Gloves [μg]	Body _{inner} [μg]	Body _{outer} [μg]	Face/neck [μg]
1	1.20	4	2.7	43	<i>1967</i>			
2	1.50	21	9.4	19	<i>523</i>			
3	1.20	10	19.8	200	<i>15745</i>			
4	1.50	7	2.5	327	<i>2623</i>			
5	0.75	16	2.7	26	<i>104</i>			
6	0.75	14	37.1	6	<i>1298</i>			
7	0.90	14	1.3	46	<i>123</i>			
8	1.20	14	10.0	46	<i>142</i>			
9	0.75	7	8.7	13	<i>2007</i>			
10	1.20	5	8.6	22	<i>619</i>			

italic – corrected for recovery

Application

Operator	TA a.s. [kg]	Exposure time [min]	Inhalation [μg]	Hands [μg]	Gloves [μg]	Body _{inner} [μg]	Body _{outer} [μg]	Face/neck [μg]
1	1.05	158	436.9	59	<i>92241</i>	294375	1121415	80
2	1.05	143	2253.1	270	<i>48749</i>	846244	913783	275
3	0.99	123	302.8	1083	<i>31310</i>	219191	1330735	250
4	0.70	174	402.4	277	<i>59805</i>	951656	1562003	625
5	0.75	140	267.7	481	<i>6472</i>	209289	667815	55
6	0.75	137	120.8	10877		346213	416389	100
7	0.68	139	566.4	950	<i>5075</i>	57091	747321	400
8	0.73	157	391.2	28332		247535	1759914	247
9	0.38	97	137.2	9822		252623	224704	94
10	0.93	143	157.3	22674		265844	650149	109
11	0.86	128	429.2	4	n.a.	24209		45
12	1.50	202	951.4	14320		475732		147
13	0.60	99	40.6	1865		4347		59
14	0.50	104	1211.5	1806		141919		25
15	0.70	99	125.0	2163		135311		11
17	0.60	115	236.1	1977		29551		3953
18	0.65	140	130.2	74	n.a.	4248		5
19	0.55	140	258.3	9	n.a.	421		15
20	0.94	120	202.8	72	n.a.	375		449
21	0.94	125	291.7	998	n.a.	1276		143
22	0.63	100	338.5	469	n.a.	4645		n.a.
23	0.50	100	478.1	430	n.a.	2605		591
24	0.86	106	224.0	8444		1197		3712
25	0.79	104	54.6	4715		1196		211
26	0.41	101	75.0	5791		768		39
27	0.75	128	458.3	81	n.a.	1085		1125
28	0.53	128	99.0	602	n.a.	4248		2361
29	0.74	118	178.0	69	n.a.	421		1986
30	0.71	91	57.3	2415		375		147
31	0.71	107	172.9	3253		1276		126
32	0.75	127	101.0	36	n.a.	4645		178
33	0.83	132	334.4	419	n.a.	2605		148

n.a. – not analysed italic – corrected for recovery

HCHH 2

Active substance: Chlorothalonil (750 g/kg)
 Formulation type: Water dispersible granules
 Pesticide function: Fungicide
 Crop: Cucumbers

Setting:

A total of ten operators were monitored in October 2001 in the Almeria region in Southern Spain to obtain data on the treatment of cucumbers grown in plastic tunnels. The operators, both mixing/loading and applying the product, used spray lances connected by a hose to a static tank. The product was supplied in 3 kg cardboard containers and poured directly into the tank. Applications were conducted at a rate of 0.5 to 2.4 kg a.s. diluted in 350 to 1214 L per hectare. The mixing/loading step was finished within 3 to 40 min and application was finished within 79 to 197 min. The cucumbers grew in rows of 1.3 to 2.5 m spacing and reached a height of 1.3 to 3.0 m. Areas of 0.5 to 1.1 ha were treated per day. All operators wore face masks during the operations.

Exposure assessment:

The exposure to hands and inhalation exposure was measured for both tasks separately while body exposure and head exposure were monitored only during application. Hand exposure was assessed by taking hand washes during or at least at the end of the operations and analysing the protective gloves used during mixing/loading. IOM samplers with glass fibre filters connected to a pump (flow rate: ca. 2 L/min) were used to determine inhalation exposure. For the application task the operators were dressed in outer and inner whole body dosimeters represented by cotton/polyester coveralls and full-length cotton undergarment. Face/neck wipes were collected whenever the operator wished to wash his face but at least at the end of the application task. All collected specimens were analysed for chlorothalonil. For that purpose chlorothalonil was extracted from the samples with hexane or, in case of the hand wash specimens, in a mixture of petroleum ether and diethyl ether after addition of sulphuric acid and aqueous sodium chloride and quantified by gas chromatography with electron-capture detection.

Results:

The exposure values for mixing/loading and application are presented in the following tables. Inhalation exposure values were recalculated for a respiratory rate of 1.25 m³/h; glove values were adjusted for field recovery (61 % for values at the low fortification level and 77 % for values at the high fortification level). Values below the LOQ were calculated with ½ of the LOQ.

Mixing/loading

Operator	TA a.s. [kg]	Exposure time [min]	Inhalation [μ g]	Hands [μ g]	Gloves [μ g]	Body _{inner} [μ g]	Body _{outer} [μ g]	Face/neck [μ g]
14	1.20	7	11.5	6	558			
15	0.75	13	* 0.5	5	109			
16	1.50	40	44.9	34	1385			
17	0.90	9	* 0.5	27	403			
18	1.60	18	1.8	22	417			
19	0.75	13	1.5	78	420			
20	1.30	14	42.6	4	537			
21	0.75	3	10.7	169	128			
22	1.05	10	5.2	20	29			
23	1.50	7	* 0.5	14	224			

* ½ LOQ italic – corrected for recovery

Application

Operator	TA a.s. [kg]	Exposure time [min]	Inhalation [μg]	Hands [μg]	Gloves [μg]	Body _{inner} [μg]	Body _{outer} [μg]	Face/neck [μg]
14	0.98	145	149.6	9335		20632	315580	249
15	0.67	197	144.5	44	<i>3048</i>	1023	32213	132
16	0.90	140	219.1	76	n.a.	13921	303905	198
17	0.90	147	354.9	18523		190124	553341	1326
18	1.36	140	466.6	13984		109038	356352	223
19	0.75	110	354.2	19742		8262	258849	414
20	0.56	79	* 0.5	7305		361	42538	50
21	0.53	102	204.2	37264		4324	143414	213
22	0.82	134	50.6	5439		1040	61366	47
23	1.35	130	360.2	13122		988	95230	238

* ½ LOQ n.a. – not analysed *italic* – corrected for recovery

LCHH 1

Active substance: Chlorothalonil (750 g/kg)
 Formulation type: Water dispersible granules
 Pesticide function: Fungicide
 Crop: Ornamentals

Setting:

The study provides exposure data for greenhouse applications on ornamentals. The trials took place during August and September 2002 at several sites in the Toscana and Veneto regions of Northern Italy. The ornamentals were grown in pots either placed directly on the floor or slightly raised on upturned modules. The height of the crops (including the plant pot/module tray) ranged between 5 to 50 cm. Single applications were performed on 0.1 to 0.4 ha with hand-held spray guns linked by a hose to a mix-tank (tank volume: 300 to 1000 L). A total of 20 operators were monitored with one mixer/loader and one applicator at each site. The product was contained in 1 kg bags and applied at a rate of 1.4 to 1.8 kg a.s. in 1242 to 2404 L per hectare. In most of the cases the operators prepared a pre-mix; only two operators (1; 3) poured the product directly into the tank. The duration of mixing/loading was in the range of 8 to 27min; for application the range was 67 to 104 min. During application the majority of the mixer/loaders supported the applicators by managing the hose to prevent tangling. Cleaning of the equipment was included in the monitoring of operator 2, 4 and 16. All operators used face masks.

Exposure assessment:

The body exposure of the applicators was determined with two layers of sampling clothing. The inner dosimeter consisted of full-length cotton undergarment, the outer dosimeter of a polyester/cotton coverall. Face/neck wipes were taken from the mixer/loaders and the applicators prior to the beginning of the work activity (these specimens were discarded) and at least at the end of the work task. All operators were equipped with a personal air sampler with glass fibre filter operating at a pump flow rate of 2 L/min. Exposure to the hands was determined by collecting hand washes and protective gloves that were worn during the work. Additional hand wash samples and glove samples were taken from those mixer/loaders who were involved in the application (the obtained exposure values were later added to the values from the respective applicator). Specimens were analysed for residues of chlorothalonil by extraction with either acidified ethyl acetate or hexane followed by quantification using gas chromatography or high performance liquid chromatography.

Results:

The results of the exposure monitoring are shown below. The results for hand wash and gloves of mixer/loaders from application were added to the results of the respective

applicators. Inhalation exposure was adjusted for a respiratory rate of 1.25 m³/h. Correction for field recovery was done for all glove values (81 % for the low fortification level, 74 % for the high fortification level), hand wash values (55 %), outer body values (59 % for the low fortification level, 48 % for the high fortification level) and inhalation values (68 %). In case that the values were below the LOQ they were calculated with ½ of the LOQ.

Mixing/loading

Operator	TA a.s. [kg]	Exposure time [min]	Inhalation [µg]	Hands [µg]	Gloves [µg]	Body _{inner} [µg]	Body _{outer} [µg]	Face/neck [µg]
1	0.23	19	21.2	* 0.09	712			* 0.5
3	0.23	8	3.1	2.02	164			* 0.5
5	0.30	18	* 0.8	* 0.09	219			* 0.5
7	0.68	20	5.6	2.13	2868			2.0
9	0.68	27	2.1	* 0.09	476			* 0.5
11	0.30	16	5.8	* 0.09	2091			* 0.5
13	0.45	12	* 0.8	* 0.09	776			* 0.5
15	0.25	16	5.2	* 0.09	541			* 0.5
17	0.44	12	76.9	2.02	1015			* 0.5
19	0.23	15	* 0.8	* 0.09	127			* 0.5

* ½ LOQ *italic* – corrected for recovery

Application

Operator	TA a.s. [kg]	Exposure time [min]	Inhalation [µg]	Hands [µg]	Gloves [µg]	Body _{inner} [µg]	Body _{outer} [µg]	Face/neck [µg]
2	0.21	84	73.1	* 0.09	1222	** 107	17100	* 0.5
4 #	0.18	95	71.2	** 1.04	4877	** 130	16637	* 0.5
6 #	0.26	83	41.6	* 0.18	1886	** 20	28057	* 0.5
8 #	0.50	104	9.8	* 0.18	4337	** 10	21107	* 0.5
10 #	0.60	82	39.3	* 0.18	4159	** 20	6729	4.5
12 #	0.29	84	35.5	** 5.67	4098	** 15	8007	* 0.5
14 #	0.23	74	49.3	* 0.18	751	** 10	5622	1.3
16 #	0.23	81	111.2	* 0.18	1179	** 150	4751	* 0.5
18	0.41	77	* 0.8	* 0.09	931	** 35	3435	3.2
20	0.23	67	* 0.8	* 0.09	1817	** 7	1194	* 0.5

* ½ LOQ ** partly calculated with ½ LOQ *italic* – corrected for recovery # hand exposure of mixer/loader from managing hose during application included

HCHH 3

Active substance: Chlorothalonil (750 g/kg)
 Formulation type: Water dispersible granules
 Pesticide function: Fungicide
 Crop: Cucumber

Setting:

Ten mixer/loaders and ten applicators were monitored during April and May 2003 while applying chlorothalonil to cucumbers grown in greenhouses. The study sites were located in the regions of Almeria, Murcia and Alicante in South Eastern Spain and were of sufficient size to allow application for a typical work day. All operators used spray gun application equipment connected to mix-tanks with a capacity of 400 to 3000 L. A single application of the product was performed on an area of 0.2 to 0.8 ha at a rate of 1.4 to 1.6 kg a.s./ha. Water volumes ranged from 733 to 2167 L/ha. The product was supplied in 1 kg bags and directly added to the tank without pre-mixing. Mixing and loading was finished within 4 to 7

min and application was finished within 73 to 165 min. The cucumbers were grown in single or double rows with 1.9 to 2.6 m spacing and reached a height of 1.8 to 2.2 m. In five trials the applicators were supported by the mixer/loader operators who handled the hose. Some applicators wore a face mask during work.

Exposure assessment:

All operators were provided with protective nitrile gloves that were worn throughout the operations and collected for analysis at the end of the task. Actual hand exposure beneath the gloves was determined by hand washes and face/neck wipes were collected for head exposure. The applicators were also monitored for dermal body exposure using polyester/cotton coveralls and full-length cotton undergarment as sampling clothing. Inhalation exposure was assessed by personal air sampling. The IOM samplers were equipped with glass fibre filters and connected to a pump working at a flow rate of 2 L/min. The mixer/loaders that handled the hose were provided with a separate set of protective gloves that were collected as well. In addition hand wash samples were also collected from the mixer/loaders at the end of application. After the field phase chlorothalonil was extracted from the specimens with hexane or acidified ethyl acetate and quantified with gas chromatography or high performance liquid chromatography.

Results:

The results of the study are given in the following tables. Values below the LOQ were considered as ½ of the LOQ. Correction for field recovery was made for all inhalation exposure values (21 % at the low fortification level, 68% at the high fortification level), for some face/neck values (60 %), some inner body exposure values (67 % at the low fortification level) and some glove values (60 % at the low fortification level). Inhalation exposure was recalculated for a respiratory rate of 1.25 m³/h. The additional exposure values of the mixer/loaders from application were included in the exposure of the respective applicator.

Mixing/loading

Operator	TA a.s. [kg]	Exposure time [min]	Inhalation [µg]	Hands [µg]	Gloves [µg]	Body _{inner} [µg]	Body _{outer} [µg]	Face/ neck [µg]
1	1.50	7	<i>10.9</i>	28.3	1212			<i>117.1</i>
3	1.10	6	* <i>2.5</i>	25.6	856			8.6
7	0.70	6	* <i>2.5</i>	* 0.5	615			* <i>0.8</i>
9	1.43	4	6.5	153.4	3539			3.8
11	0.83	4	<i>10.1</i>	6.3	1950			* <i>0.8</i>
13	0.47	5	* <i>2.5</i>	7.1	638			* <i>0.8</i>
15	0.88	7	<i>14.9</i>	6.0	1066			<i>13.3</i>
17	0.35	6	<i>15.9</i>	3.4	2299			<i>108.2</i>
19	0.31	4	<i>13.7</i>	1.3	1097			2.8
21	0.91	6	<i>22.1</i>	20.0	1555			5.9

* ½ LOQ italic – corrected for recovery

Application

Operator	TA a.s. [kg]	Exposure time [min]	Inhalation [μg]	Hands [μg]	Gloves [μg]	Body _{inner} [μg]	Body _{outer} [μg]	Face/neck [μg]
2	1.28	165	2213.5	24.7	22320	32872	602720	687.9
4	0.82	77	317.6	* 0.5	9513	2067	93503	187.8
8 #	0.53	74	71.7	** 6.1	9839	32742	544710	349.4
10	1.13	129	591.0	* 0.5	8623	17680	521630	219.6
12	0.63	88	154.3	* 0.5	4342	3271	74735	252.7
14	0.43	134	186.1	1.1	9349	179	74133	73.7
16 #	0.56	73	216.8	14.6	6648	** 462	188762	6.8
18 #	0.28	74	93.7	** 3.6	222	** 2714	34401	* 0.8
20 #	0.27	77	53.8	* 1.0	5707	1170	70089	37.2
22 #	0.72	85	54.9	* 1.0	7272	326	29177	8.9

* ½ LOQ ** partly calculated with ½ LOQ *italic* – corrected for recovery # hand exposure of mixer/loader from managing hose during application included

HCHH 4

Active substance: Chlorothalonil (750 g/kg)
 Formulation type: Water dispersible granules
 Pesticide function: Fungicide
 Crop: Tomatoes

Setting:

The study provides exposure data from ten trials conducted during March, April and May in the Murcia and Alicante regions of South Eastern Spain. At each site pairs of one mixer/loader and one applicator treated greenhouse tomatoes with hand-held spray guns connected to large mix-tanks (capacity: 500 to 3000 L). The product was contained in 1 kg bags and applied at a rate of 1.3 to 1.7 kg a.s. in 750 to 1563 L per hectare. No pre-mix was prepared but the granules were poured directly into the tank. The whole mixing/loading operation was finished after 4 to 25 min. Application was performed for 51 to 122 min; in that time an area of 0.3 to 0.7 ha was treated. A few operators wore face masks during their work. The tomatoes were 1.6 to 2.4 m tall and were grown with inter-row distances of 1 to 2.5 m. In all trials the applicators were supported by the mixer/loaders who handled the hose to prevent it from tangling.

Exposure assessment:

Dermal body exposure was determined only during the application phase. For that purpose the applicators were dressed in polyester/cotton coveralls and full-length cotton undergarment to determine potential and actual body exposure. Exposure of the head was determined in both phases by wiping the face and neck of the operator. Protective nitrile gloves were worn throughout the mixing/loading task and the application task and collected for analysis at the end. Additionally hand washes were performed to determine the exposure beneath the gloves. Separate hand wash samples and glove samples were taken from the mixer/loaders involved in the application task. Exposure via inhalation was monitored with personal air samplers with glass fibre filters connected to a pump with a flow rate of 2 L/min. The specimens were finally analysed by extraction of the chlorothalonil residues with either acidified ethyl acetate or hexane and quantification with gas chromatography or high performance liquid chromatography.

Results:

The exposure of the mixer/loaders and applicators is presented in the tables below. Half of the LOQ was considered for values below the quantification limit and inhalation exposure was adjusted for a respiratory rate of 1.25 m³/h. A correction for recovery was done for all inhalation exposure values at the low fortification level (33 % field recovery) and for all glove

values at the low (81 % field recovery) and the high fortification level (88 % field recovery). The results for the hand wash samples and glove samples of the mixer/loaders from the application phase were added to the exposure results of the respective applicators.

Mixing/loading

Operator	TA a.s. [kg]	Exposure time [min]	Inhalation [μg]	Hands [μg]	Gloves [μg]	Body _{inner} [μg]	Body _{outer} [μg]	Face/neck [μg]
1	0.48	25	* 1.6	1.7	3227			* 0.5
3	0.60	18	* 1.6	* 0.5	21			1.2
5	0.94	8	12.7	42.2	1692			21.3
9	1.2	8	27.4	4.3	1857			4.0
11	0.55	5	* 1.6	16.3	531			1.9
13	0.52	10	* 1.6	* 0.5	746			6.2
15	0.97	7	* 1.6	270.1	873			10.2
17	0.61	6	* 1.6	3.8	1028			1.8
19	0.46	4	* 1.6	8.5	1765			10.5
21	1.40	8	85.4	267.9	6418			43.4

* ½ LOQ italic – corrected for recovery

Application

Operator	TA a.s. [kg]	Exposure time [min]	Inhalation [μg]	Hands [μg]	Gloves [μg]	Body _{inner} [μg]	Body _{outer} [μg]	Face/neck [μg]
2 #	0.44	103	142.9	10.2	3114	121	33537	15.1
4 #	0.50	92	219.6	19.9	10177	2973	159140	138.7
6 #	0.74	92	172.1	226.1	30483	81308	848880	252.8
10 #	1.05	122	223.6	9.5	52933	2514	319042	n.a.
12 #	0.44	83	90.3	28.2	5666	306	29188	20.1
14 #	0.40	64	111.9	10.7	12884	282	66811	32.2
16 #	0.64	74	241.6	4.5	44215	470	580456	205.6
18 #	0.44	84	186.6	66.9	17816	19673	148090	348.4
20 #	0.38	51	186.0	90.3	21524	772	150861	211.7
22 #	0.90	94	203.6	26.2	29636	1633	378239	62.9

n.a. – not analysed italic – corrected for recovery # hand exposure of mixer/loader from managing hose during application included

LCHH 2

Active substance: Cyromazine (750 g/kg)
 Formulation type: Wettable powder
 Pesticide function: Insecticide
 Crop: Melons

Setting:

The exposure of 20 mixer/loaders and 20 applicators was assessed during a typical working day. The field phase took place in April 2004 at different representative test sites in the Vittoria region of Sicily, Italy. The test sites comprised commercial melon greenhouses with a canopy cover of 10 to 100 % and a crop height of 10 to 50 cm. The applicators were generally spraying in front and to the side while walking between the melons and into the dense spray mist. Only one applicator (9) walked backwards during spraying to avoid contact with the spray drift. The areas treated per day ranged from 0.1 to 0.4 ha. The application equipment consisted of hand-held spray guns with hoses connected to a mix-tank (volume: 200 to 1000 L). Applications were conducted at a rate of 0.2 to 0.3 kg a.s./ha; the water volume ranged from 819 to 1150 L/ha. In most of the cases the operators performed one mixing/loading cycle by adding the powder directly to the tank without preparing a pre-mix;

some operators (22; 25; 26), however, had to repeat the mixing/loading step once again. The bags were either opened with a scissor or by pulling them apart. About half of the operators weighed the product before adding it to the tank. Mixing and loading took in total 7 to 19 min while application was finished in 24 to 79 min. A few applicators wore face masks during spraying.

Exposure assessment:

For the mixing/loading task only hand exposure and inhalation exposure was monitored. Hand exposure was generally determined by collecting hand wash samples as well as glove samples and inhalation exposure was determined by using personal air samplers with glass fibre filters (pump flow rate: ca. 2 L/min). All mixer/loaders and all applicators wore protective gloves during their work. The applicators were additionally provided with sampling clothing consisting of polyester/cotton coveralls and cotton long sleeved shirts and long johns. Face and neck of the applicators were wiped at the end of application prior to the removal of the body dosimeters. Inner and outer body dosimeters were extracted with methanol/water/acetic acid (50:50:1) and cleaned up using SCX solid phase extraction. Nitrile gloves, IOM filters and face/neck wipe samples were extracted with water, while hand wash samples were extracted using SCX solid phase extraction. All samples were finally analysed for cyromazine using LC-MS.

Results:

The exposure values are summarised below. All values were above the LOQ. Inhalation exposure was adjusted for a respiratory rate of 1.25 m³/h and glove data were corrected for field recovery (89 % at the low fortification level and 93 % at the high fortification level).

Mixing/loading

Operator	TA a.s. [kg]	Exposure time [min]	Inhalation [μ g]	Hands [μ g]	Gloves [μ g]	Body _{inner} [μ g]	Body _{outer} [μ g]	Face/neck [μ g]
21	0.038	9	3.1	2.3	<i>6423</i>			
22	0.068	12	7.9	3.5	<i>2286</i>			
23	0.059	14	5.9	1.9	<i>1601</i>			
24	0.068	9	6.1	3.1	<i>2584</i>			
25	0.075	19	33.2	99.4	<i>12957</i>			
26	0.075	10	4.1	111.7	<i>8880</i>			
27	0.075	10	27.7	3.9	<i>819</i>			
28	0.038	9	2.8	2.9	<i>1897</i>			
29	0.075	11	1.6	7.2	<i>1863</i>			
30	0.038	16	7.1	2.4	<i>15828</i>			
31	0.056	9	1.8	3.0	<i>2224</i>			
32	0.056	7	5.5	3.0	<i>983</i>			
33	0.038	5	2.9	9.3	<i>1201</i>			
34	0.034	12	0.2	2.8	<i>1941</i>			
35	0.075	12	0.2	2.8	<i>2976</i>			
36	0.038	9	15.7	50.1	<i>3304</i>			
37	0.029	10	2.6	3.5	<i>998</i>			
38	0.068	12	9.1	18.6	<i>2397</i>			
39	0.038	11	2.5	1.1	<i>794</i>			
40	0.034	9	3.1	0.9	<i>10590</i>			

italic – corrected for recovery

Application

Operator	TA a.s. [kg]	Exposure time [min]	Inhalation [μg]	Hands [μg]	Gloves [μg]	Body _{inner} [μg]	Body _{outer} [μg]	Face/neck [μg]
1	0.028	39	22.1	0.2	740	1313	27200	4.8
2	0.057	59	45.1	0.6	1423	22629	55059	6.8
3	0.041	67	43.1	1.6	785	27958	64092	6.1
4	0.066	61	4.5	0.2	448	36	13782	3.8
5	0.067	79	5.7	41.4	770	1654	36598	7.9
6	0.058	75	5.8	3.4	465	1364	20917	3.7
7	0.075	88	63.6	0.3	1392	12180	65379	4.4
8	0.035	34	6.6	0.4	1057	35803	49580	18.0
9	0.062	63	70.2	0.3	228	183	29211	1.5
10	0.029	43	6.0	0.7	916	15990	42048	5.3
11	0.045	42	7.0	0.5	729	10177	37041	5.8
12	0.045	36	n.a.	11.2	641	3448	50043	1.2
13	0.034	37	43.3	1.3	1322	13959	41562	9.7
14	0.026	17	7.6	0.1	755	73	17119	13.0
15	0.066	67	7.1	0.5	163	509	14767	10.7
16	0.032	53	7.6	1.5	689	8888	37454	3.4
17	0.024	29	26.6	0.6	898	925	40831	3.1
18	0.056	57	79.8	0.5	621	269	25064	10.4
19	0.035	40	8.3	0.3	179	17	11009	1.2
20	0.031	24	46.9	6.4	1524	168	24508	17.7

n.a. – not analysed italic – corrected for recovery

LCHH 3

Active substance: Cyromazine (750 g/kg)
 Formulation type: Wettable powder
 Pesticide function: Insecticide
 Crop: Melons

Setting:

The exposure of ten operators was monitored during May 2006 at several melon growing sites in Sicily, Italy. The monitoring was restricted to the application task; mixing/loading was conducted by a separate person. Applications were made with commercial spray lance equipment connected to mix tanks with a volume of 200 to 1000 L positioned at the edge of the greenhouses. The applicators were walking through the melons while spraying (generally in front and to the side, thus walking into the spray mist). The product was sprayed on an area of 0.1 to 0.4 ha at a rate of 0.2 kg a.s./ha in 702 to 996 L water and for a duration of 23 to 113 min. The melons had a height of 20 to 60 cm and covered the area to an extent of 50 to 100 %. All operators wore rain trousers and some of them also a face mask.

Exposure assessment:

The applicators were dressed in one layer of outer sampling clothing consisting of a polyester/cotton jacket and one layer of inner sampling clothing consisting of a cotton long-sleeved vest and long johns. In addition to that each applicator wore PVC coated rain trousers which were not sampled. Gloves were used by all operators as well and collected afterwards to determine potential hand exposure. Hand wash samples were taken at the end of the application task to monitor the exposure beneath the gloves. Residues of the pesticide were also determined on the head by wiping face and neck of the applicators at the end of the trial. Personal air samplers with glass fibre filter and pump (flow rate: 2 L/min) were used to assess inhalation exposure. For the analysis of cyromazine residues inner and outer body dosimeters were extracted with methanol/water/acetic acid (50:50:1) and cleaned up using SCX solid phase extraction. Nitrile gloves, IOM filters and face/neck wipe samples were

extracted with water, while hand wash samples were extracted using SCX solid phase extraction. The quantification was performed with LC-MS.

Results:

The results of the study are given in the following table. All values were above the LOQ and were not corrected for field recovery which was in the range of 81 to 104 %. An adjustment of the inhalation exposure values was made for a respiratory rate of 1.25 m³/h.

Application

Operator	TA a.s. [kg]	Exposure time [min]	Inhalation [μg]	Hands [μg]	Gloves [μg]	Body _{inner} [μg]	Body _{outer} * [μg]	Face/neck [μg]
1	0.066	51	12.8	0.2	390	44	451	10.6
2	0.025	26	25.9	12.3	1024	21	1795	2.3
3	0.041	45	23.4	1.3	1426	55	3630	2.0
4	0.046	37	44.3	0.2	360	68	1062	3.7
5	0.086	111	8.3	1.9	566	20	837	2.7
6	0.031	32	26.1	0.3	351	40	717	0.8
7	0.040	48	59.8	0.6	968	89	5565	4.3
8	0.070	113	78.6	1.5	1255	154	21416	15.1
9	0.054	49	5.6	0.9	1306	80	8315	3.7
10	0.026	23	4.7	0.1	450	42	974	0.6

* without leg exposure

Appendix 2 Model predictions (75th percentile)

A 2.1 ML tank

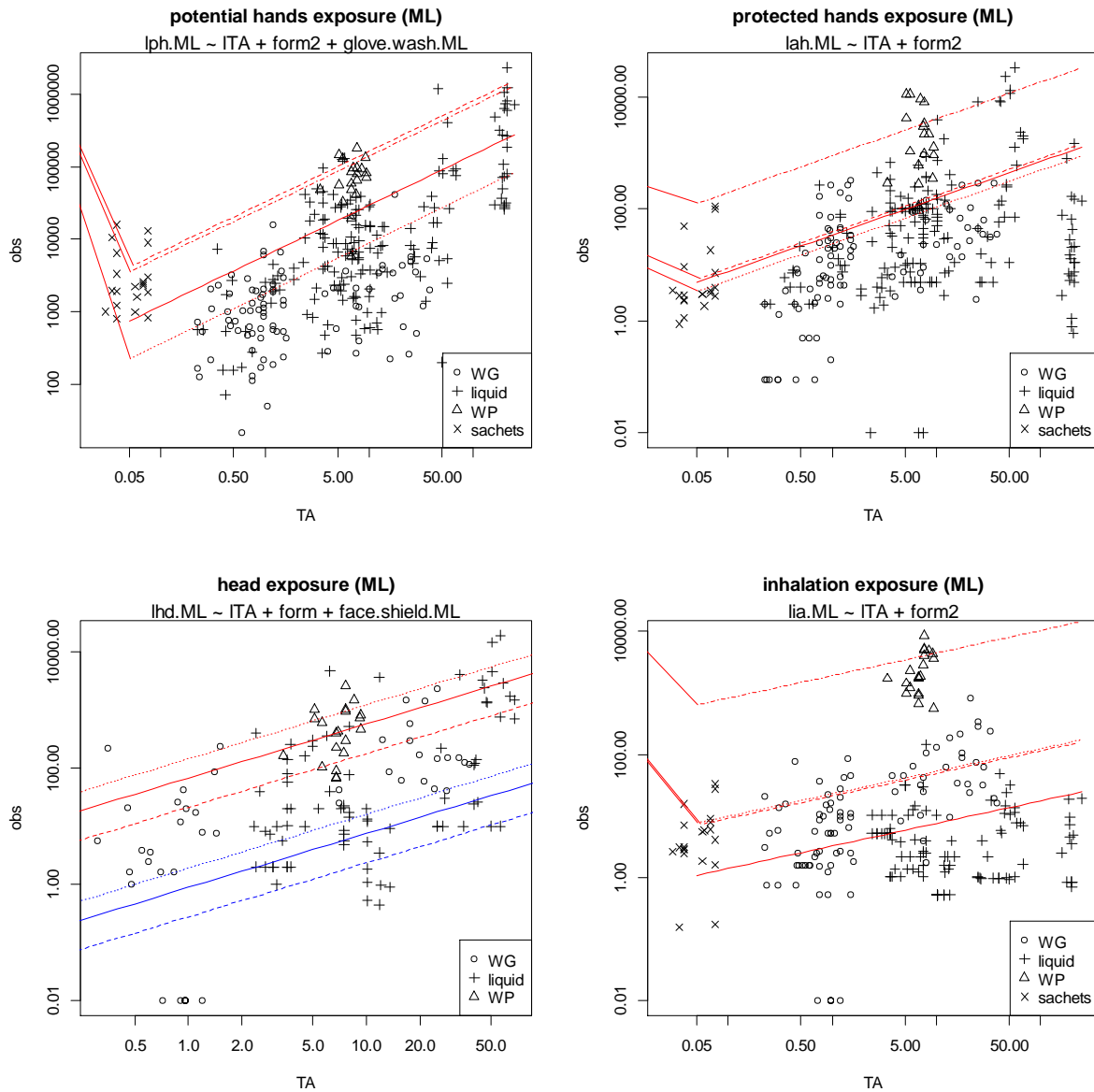


Figure A 1: Model prediction with quantile regression for tank mixing/loading (outdoor and greenhouse database); broken line: liquid formulations, broken/dotted line: sachets (WP), solid line: WG formulations, dotted line: WP formulations; blue lines: head exposure when using face shields.

A 2.2 Greenhouse HCHH application

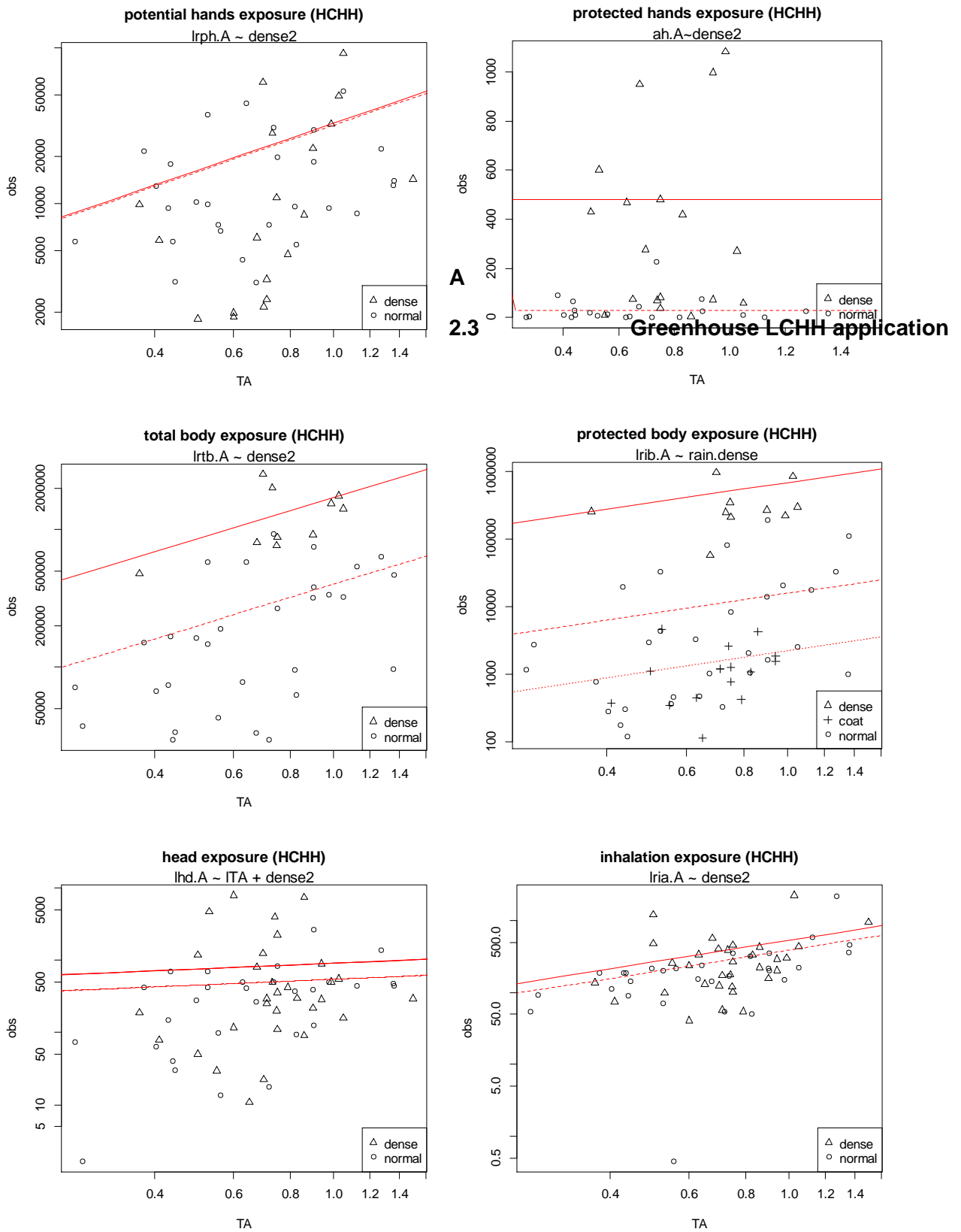


Figure A 2: Model prediction with quantile regression for greenhouse application on high crops; solid line: dense scenario, broken line: normal scenario, dotted line: dense scenario with rain suit.

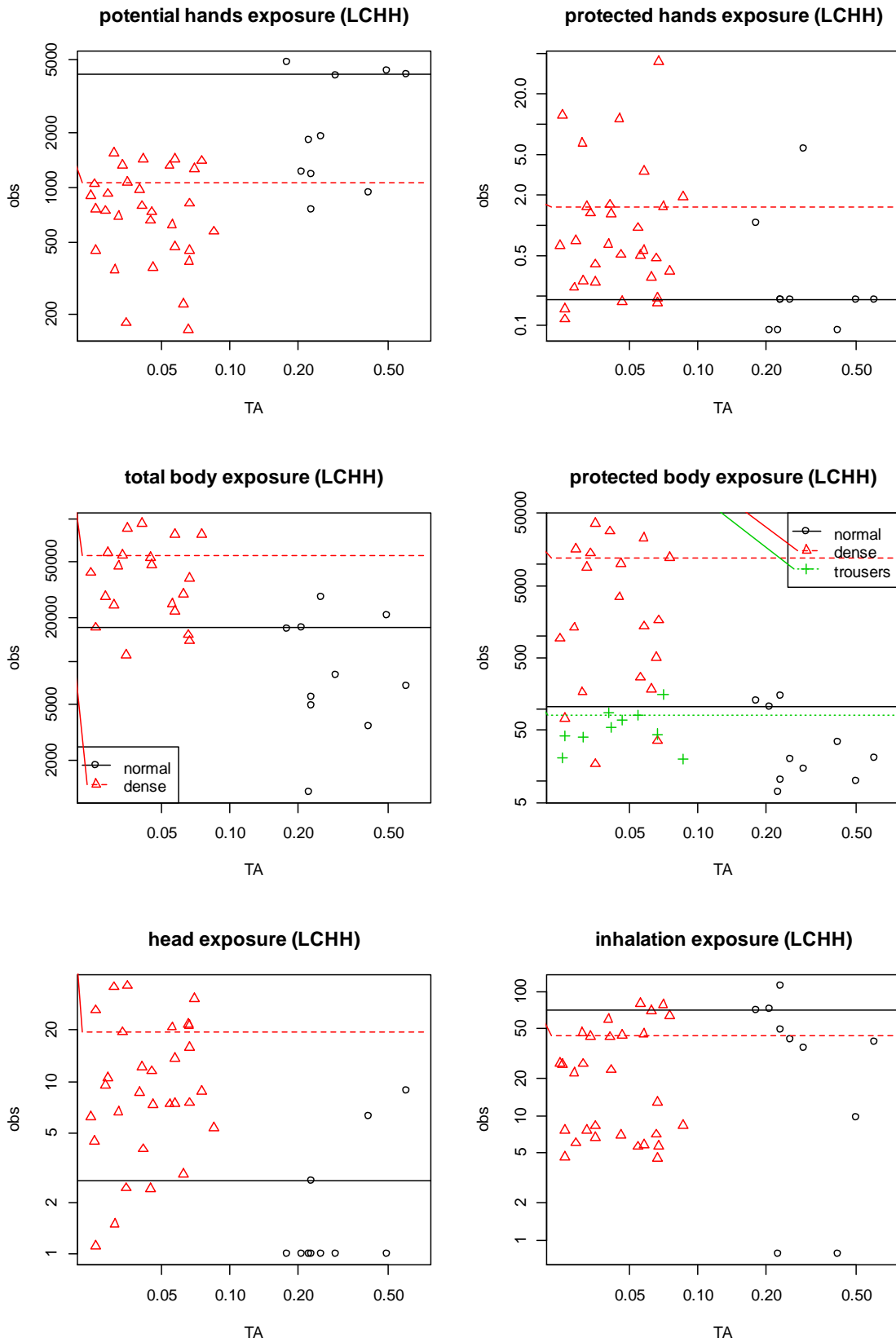


Figure A 3: Model prediction with quantile regression for greenhouse application on low crops; solid line: normal scenario, broken line: dense scenario, dotted line: dense scenario with rain trousers.

Appendix 3 Estimations of the 75th percentile

A 3.1 Greenhouse HCHH application (protected hand)

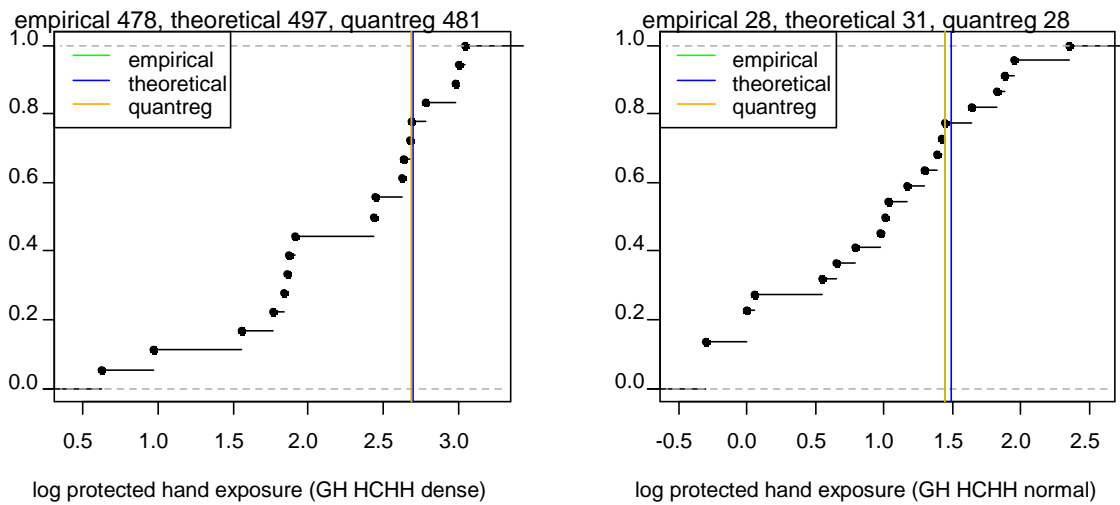


Figure A 4: Comparison of the empirical 75th percentile (green line) with the parametric estimate of the percentile calculated acc. to EFSA (blue line) and the 75th percentile obtained by quantile regression (orange line); the y-axis gives the proportion of data with values below a certain level of exposure.

A 3.2 Greenhouse LCHH application (normal scenario)

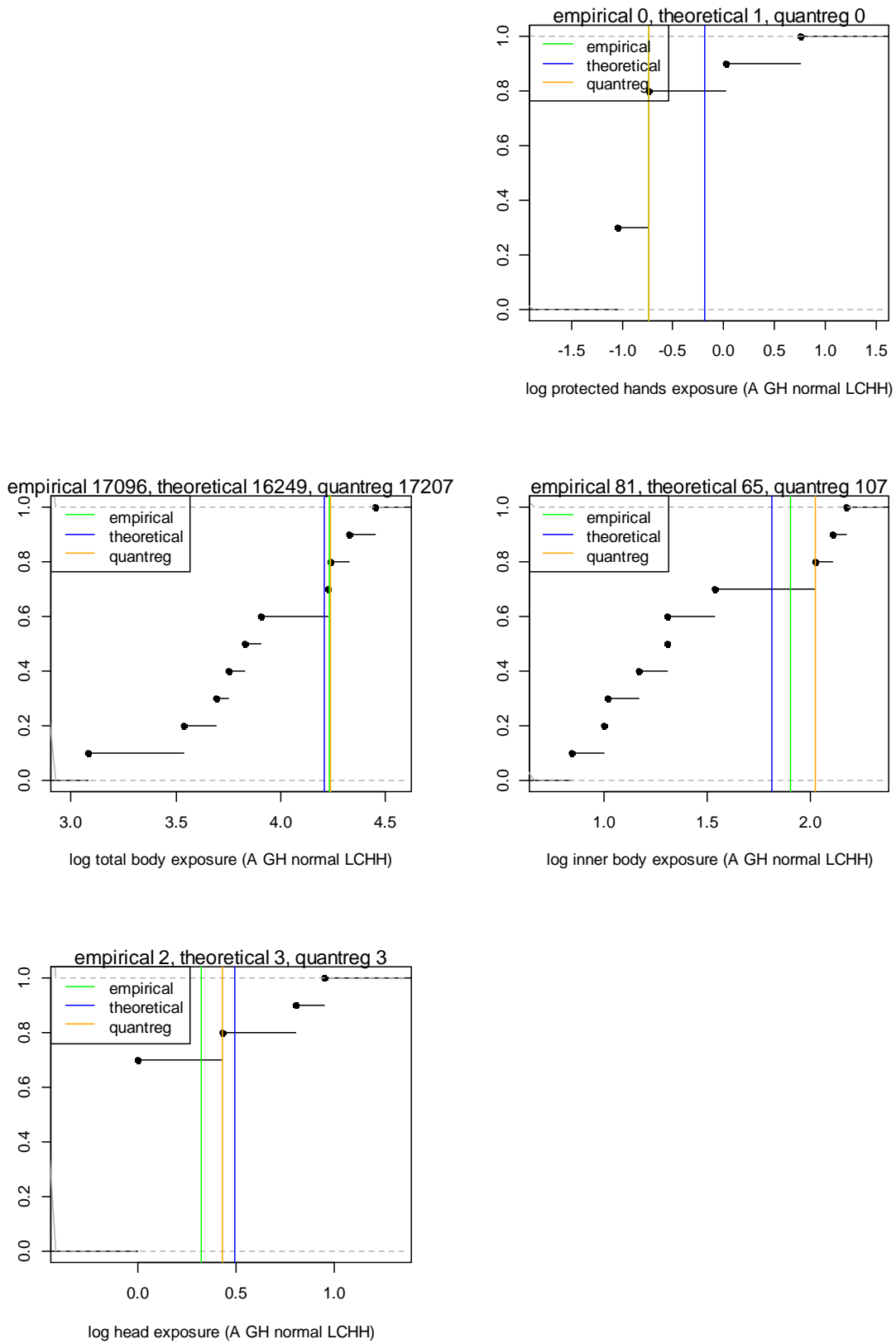


Figure A 5: Comparison of the empirical 75th percentile (green line) with the parametric estimate of the percentile calculated acc. to EFSA (blue line) and the 75th percentile obtained by quantile regression (orange line); the y-axis gives the proportion of data with values below a certain level of exposure.

A 3.3 Greenhouse LCHH application (dense scenario)

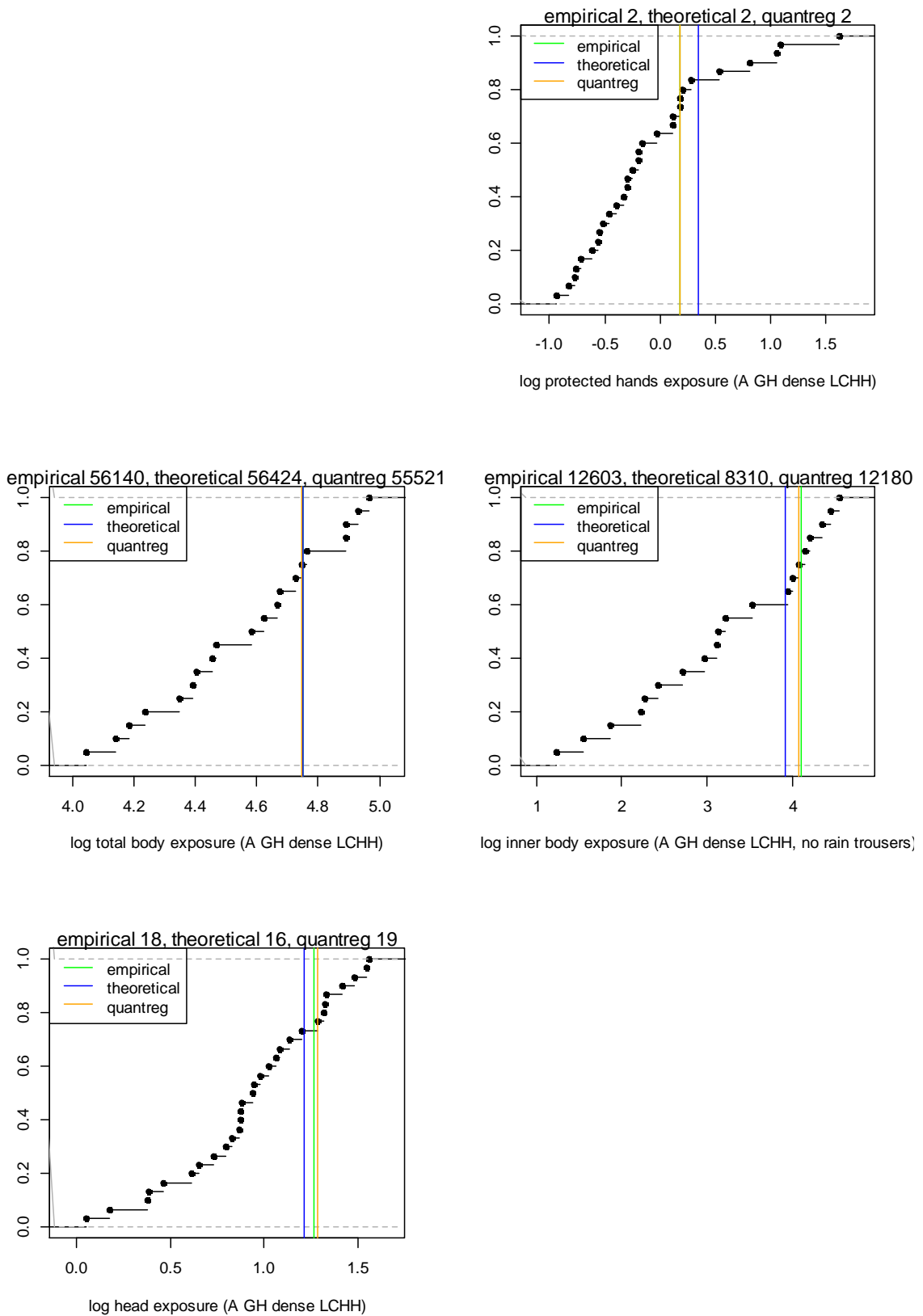


Figure A 6: Comparison of the empirical 75th percentile (green line) with the parametric estimate of the percentile calculated acc. to EFSA (blue line) and the 75th percentile obtained by quantile regression (orange line); the y-axis gives the proportion of data with values below a certain level of exposure.

A 3.4 Greenhouse LCHH application (dense scenario, inner body)

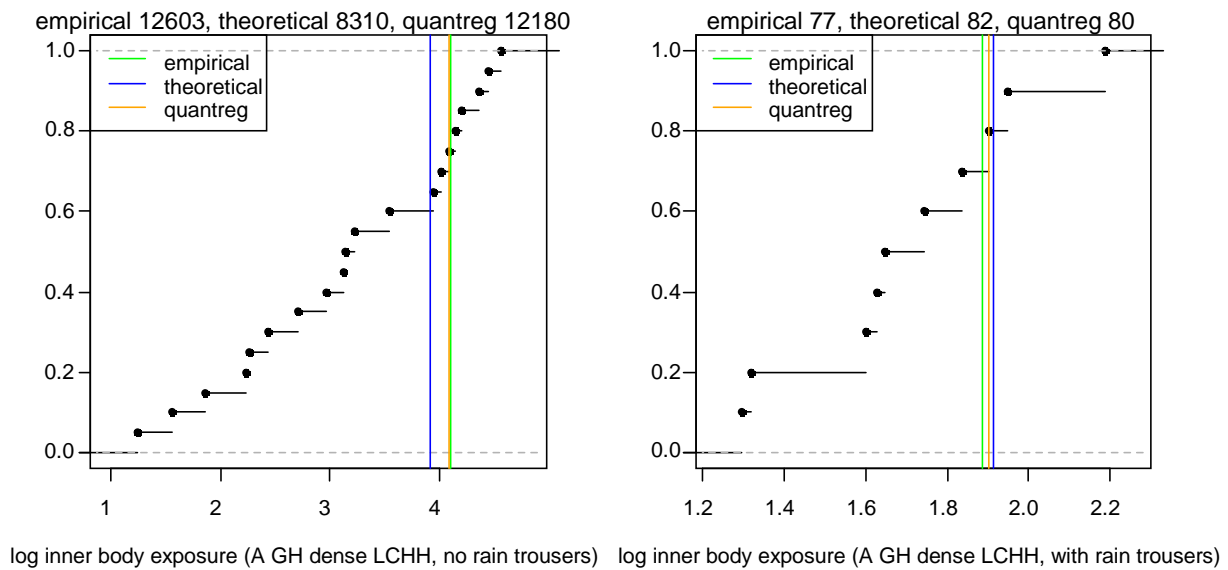


Figure A 7: Comparison of the empirical 75th percentile (green line) with the parametric estimate of the percentile calculated acc. to EFSA (blue line) and the 75th percentile obtained by quantile regression (orange line); the y-axis gives the proportion of data with values below a certain level of exposure.

A 3.5 Greenhouse LCHH application (dense and normal scenario combined)

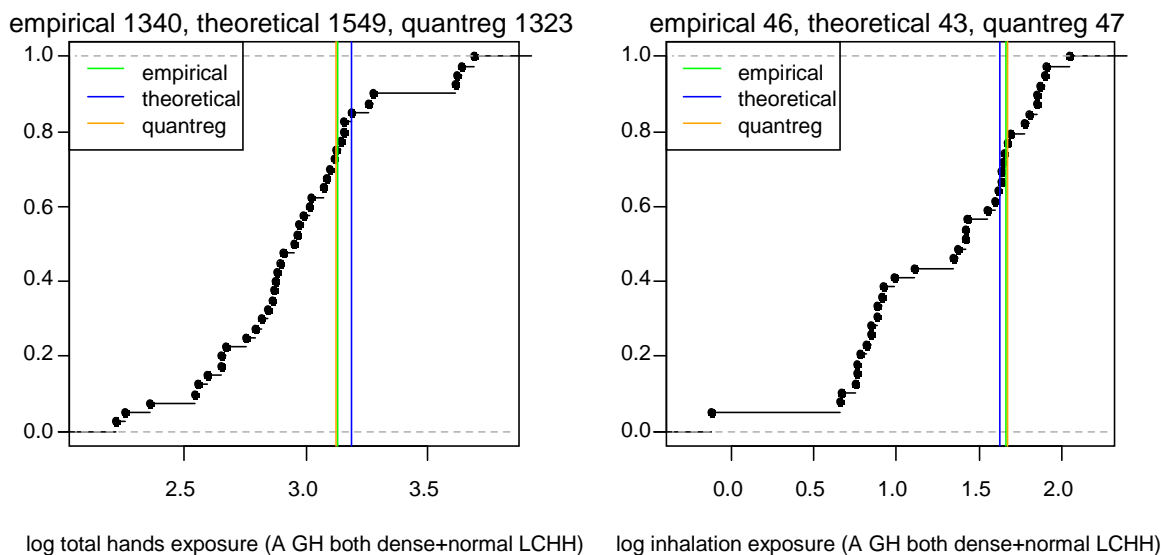


Figure A 8: Comparison of the empirical 75th percentile (green line) with the parametric estimate of the percentile calculated acc. to EFSA (blue line) and the 75th percentile obtained by quantile regression (orange line); the y-axis gives the proportion of data with values below a certain level of exposure.

Appendix 4 Model predictions (95th percentile)

A 4.1 ML tank

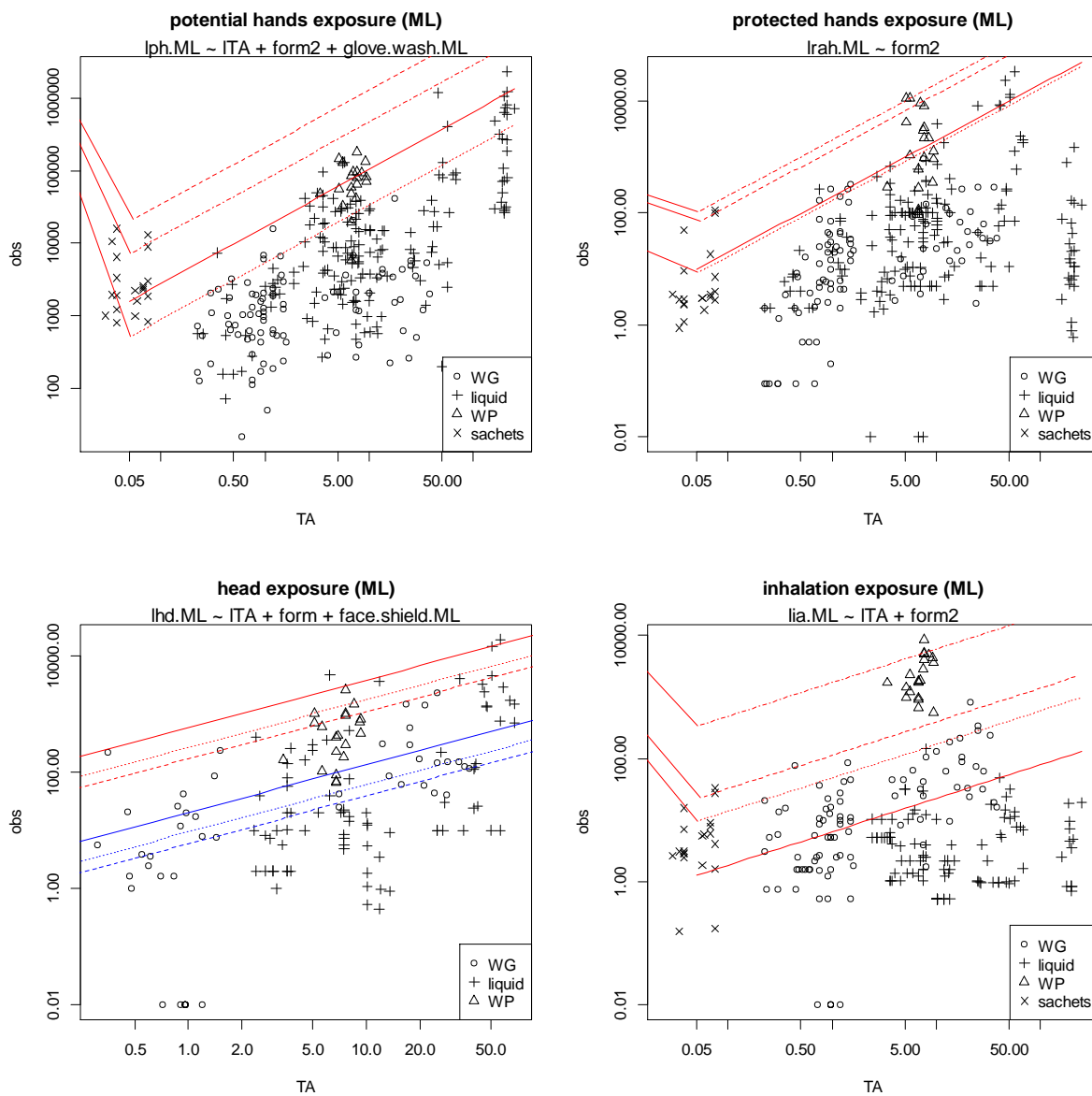


Figure A 9: Model prediction with quantile regression for tank mixing/loading (outdoor and greenhouse database); broken line: liquid formulations, broken/dotted line: sachets (WP), solid line: WG formulations, dotted line: WP formulations; blue lines: head exposure when using face shields.

A 4.2 Greenhouse HCHH application

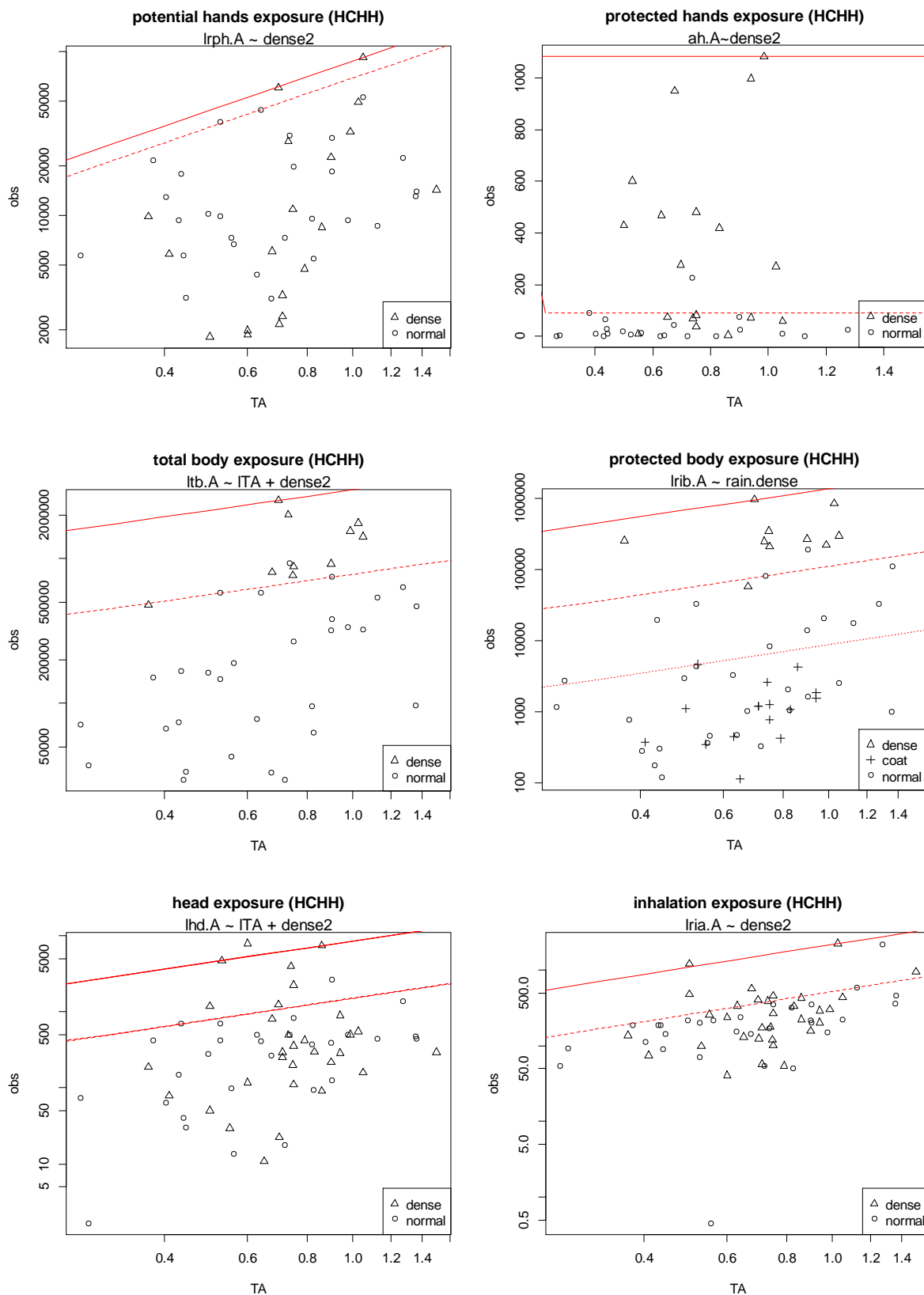


Figure A 10: Model prediction with quantile regression for greenhouse application on high crops; solid line: dense scenario, broken line: normal scenario, dotted line: dense scenario with rain suit.

A 4.3 Greenhouse LCHH application

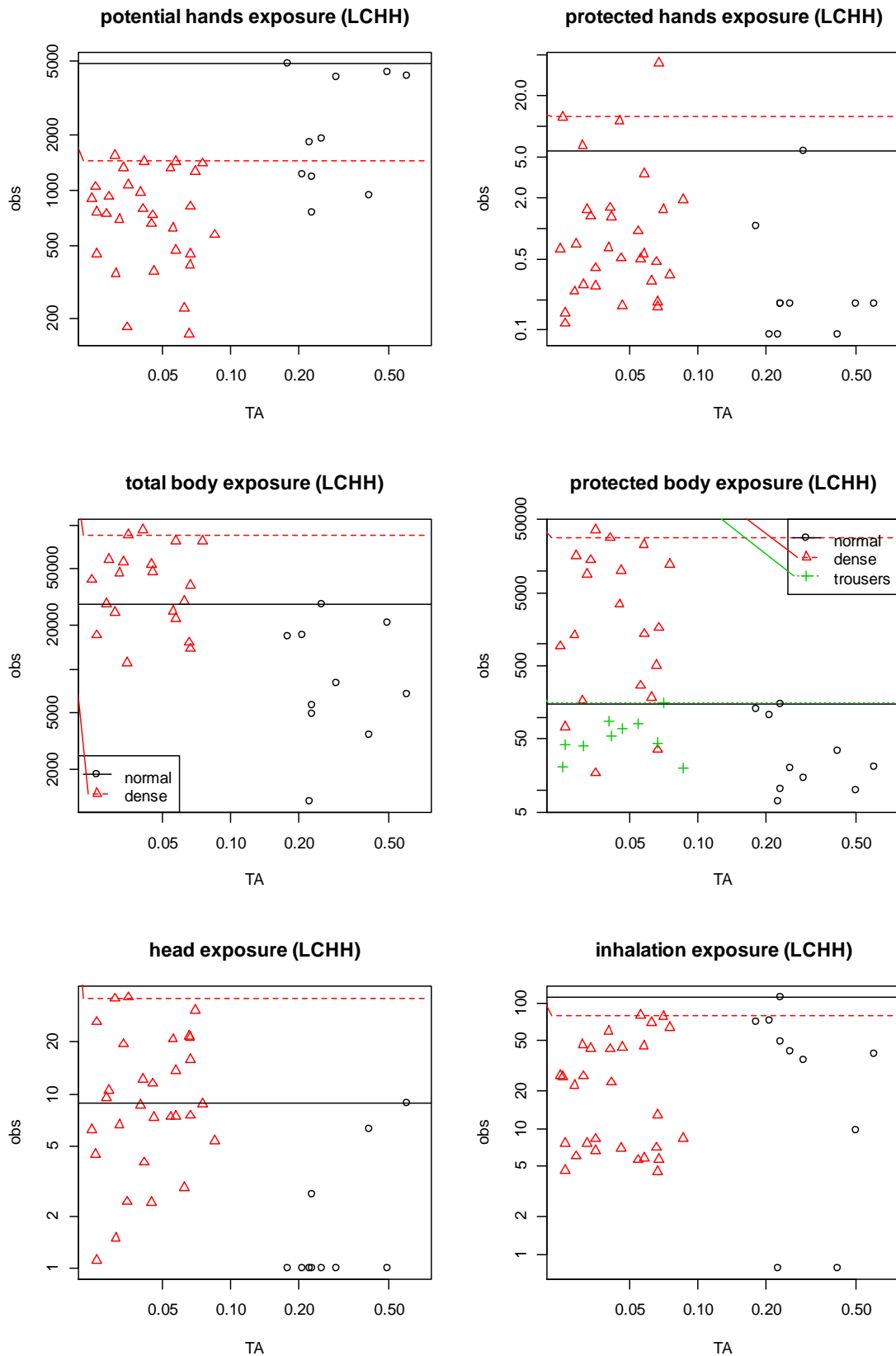


Figure A 11: Model prediction with quantile regression for greenhouse application on low crops; solid line: normal scenario, broken line: dense scenario, dotted line: dense scenario with rain trousers.

Appendix 5 Estimations of the 95th percentile

A 5.1 Greenhouse LCHH application (normal scenario)

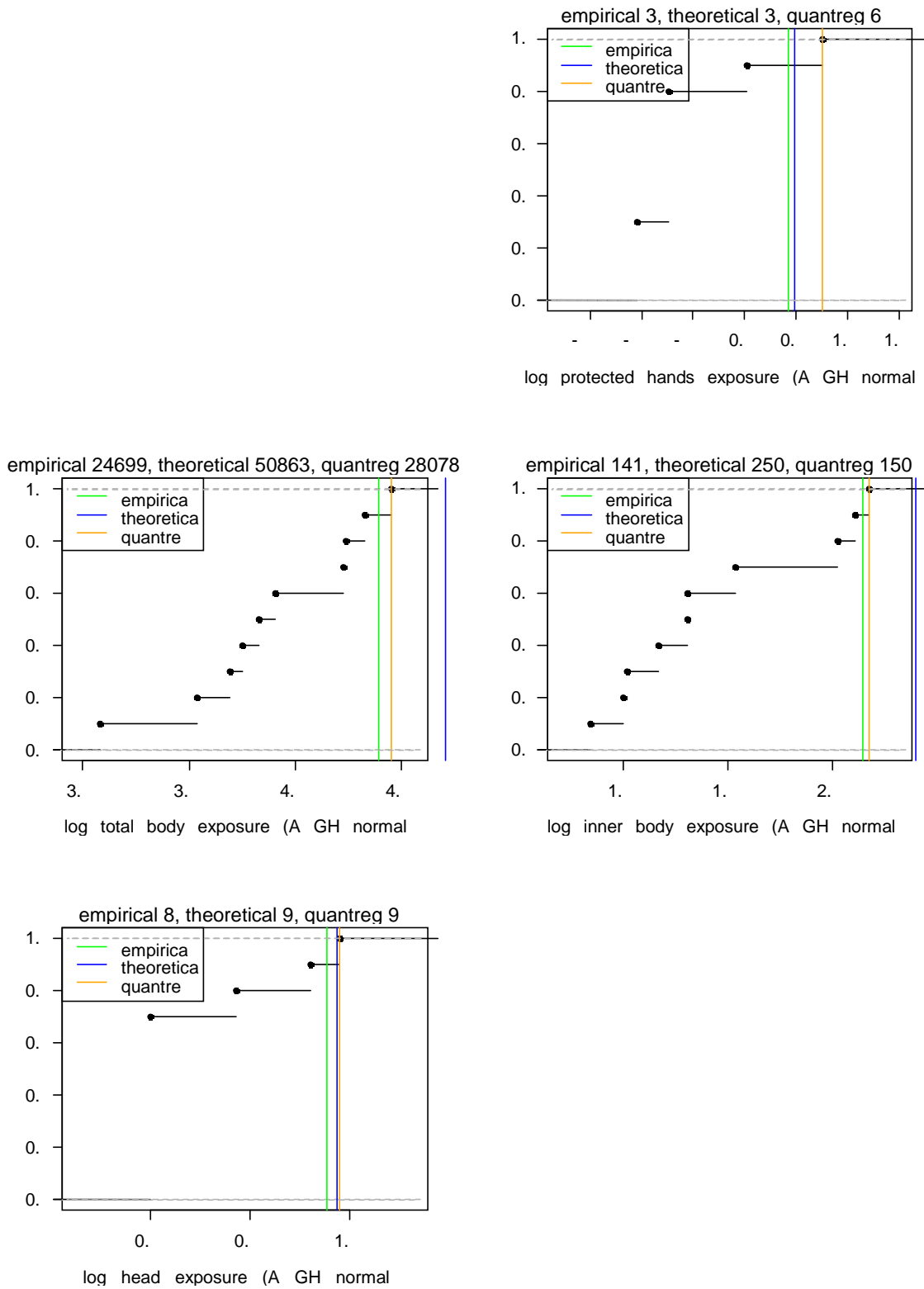


Figure A 12: Comparison of the empirical 95th percentile (green line) with the parametric estimate of the percentile calculated acc. to EFSA (blue line) and the 95th percentile obtained by quantile regression (orange line); the y-axis gives the proportion of data with values below a certain level of exposure.

A 5.2 Greenhouse LCHH application (dense scenario)

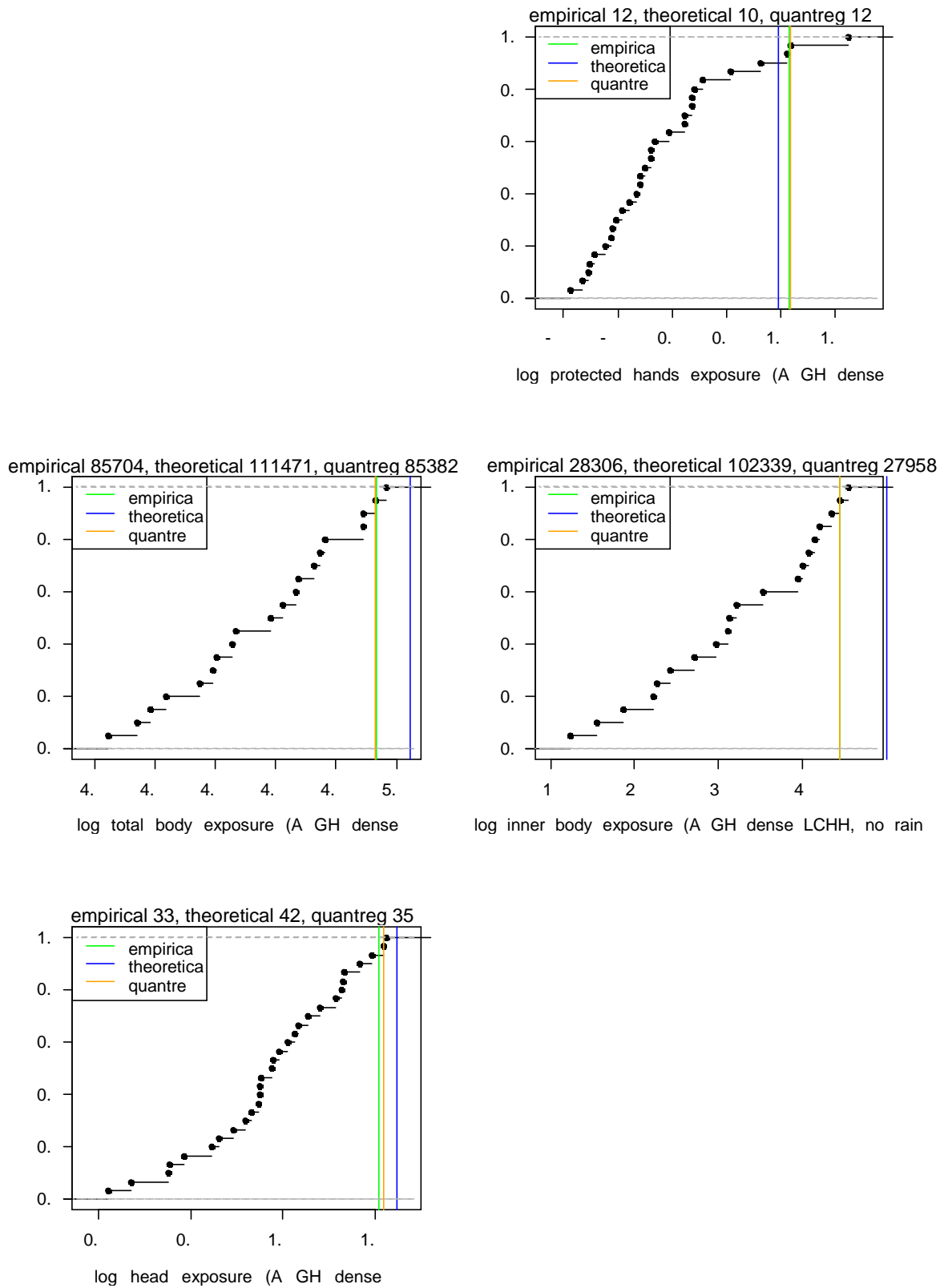


Figure A 13: Comparison of the empirical 95th percentile (green line) with the parametric estimate of the percentile calculated acc. to EFSA (blue line) and the 95th percentile obtained by quantile regression (orange line); the y-axis gives the proportion of data with values below a certain level of exposure.

A 5.3 Greenhouse LCHH application (dense scenario, inner body)

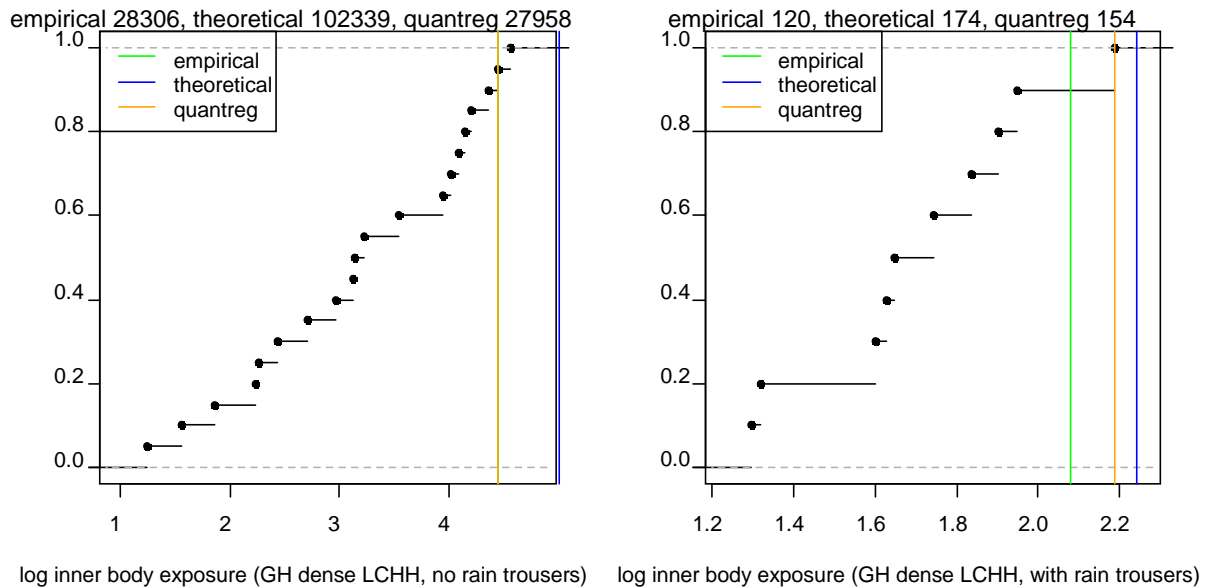


Figure A 14: Comparison of the empirical 95th percentile (green line) with the parametric estimate of the percentile calculated acc. to EFSA (blue line) and the 95th percentile obtained by quantile regression (orange line); the y-axis gives the proportion of data with values below a certain level of exposure.

A 5.4 Greenhouse LCHH application (dense + normal scenario combined)

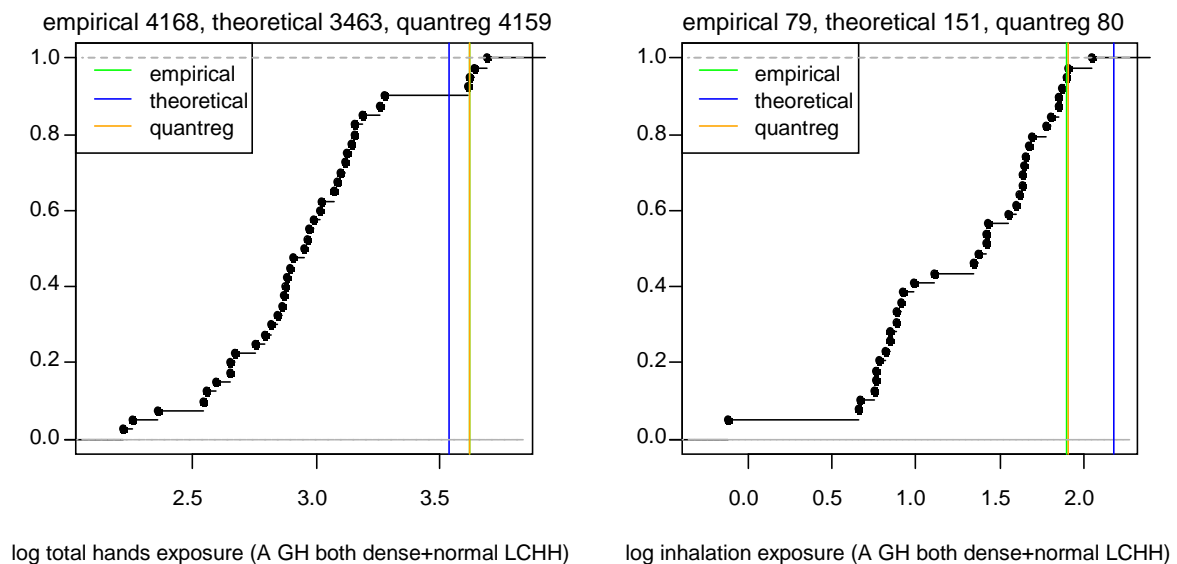


Figure A 15: Comparison of the empirical 95th percentile (green line) with the parametric estimate of the percentile calculated acc. to EFSA (blue line) and the 95th percentile obtained by quantile regression (orange line); the y-axis gives the proportion of data with values below a certain level of exposure.

Supplementary information

on the new Greenhouse Agricultural Operator Exposure Model

I Raw data used for the model

I-1: Mixing/loading

Study code	Operator	ML type	TA (kg a.s.)	Form. type	Face mask	Glove wash	Total hands (µg)	Prot. Hands (µg)	Total body (µg)	Inner body (µg)	Head (µg)	Inhalation (µg)
ECPA_2	1	tank	1.20	WG	no		2010	42.9	NA	NA	NA	2.7
ECPA_2	2	tank	1.50	WG	no		542	18.6	NA	NA	NA	9.4
ECPA_2	3	tank	1.20	WG	no		15945	199.6	NA	NA	NA	19.8
ECPA_2	4	tank	1.50	WG	no		2950	327.2	NA	NA	NA	2.5
ECPA_2	5	tank	0.75	WG	no		130	25.6	NA	NA	NA	2.7
ECPA_2	6	tank	0.75	WG	no		1304	5.7	NA	NA	NA	37.1
ECPA_2	7	tank	0.90	WG	no		169	45.8	NA	NA	NA	1.3
ECPA_2	8	tank	1.20	WG	no		189	46.4	NA	NA	NA	10.0
ECPA_2	9	tank	0.75	WG	no		2019	12.6	NA	NA	NA	8.7
ECPA_2	10	tank	1.20	WG	no		641	21.7	NA	NA	NA	8.6
ECPA_3	14	tank	1.20	WG	no		564	6.3	NA	NA	NA	11.5
ECPA_3	15	tank	0.75	WG	no		114	4.8	NA	NA	NA	0.5
ECPA_3	16	tank	1.50	WG	no		1419	34.4	NA	NA	NA	44.9
ECPA_3	17	tank	0.90	WG	no		430	26.7	NA	NA	NA	0.5
ECPA_3	18	tank	1.60	WG	no		438	21.6	NA	NA	NA	1.8
ECPA_3	19	tank	0.75	WG	no		497	77.6	NA	NA	NA	1.5
ECPA_3	20	tank	1.30	WG	no		541	4.3	NA	NA	NA	42.6
ECPA_3	21	tank	0.75	WG	no		297	168.9	NA	NA	NA	10.7
ECPA_3	22	tank	1.05	WG	no		49	20.3	NA	NA	NA	5.2
ECPA_3	23	tank	1.50	WG	no		238	13.9	NA	NA	NA	0.5
ECPA_10	1	tank	0.23	WG	yes		713	0.1	NA	NA	NA	21.2
ECPA_10	3	tank	0.23	WG	yes		166	2.0	NA	NA	NA	3.1
ECPA_10	5	tank	0.30	WG	yes		219	0.1	NA	NA	NA	0.8
ECPA_10	7	tank	0.68	WG	yes		2870	2.1	NA	NA	NA	5.6
ECPA_10	9	tank	0.68	WG	yes		476	0.1	NA	NA	NA	2.1
ECPA_10	11	tank	0.30	WG	yes		2091	0.1	NA	NA	NA	5.8

Study code	Operator	ML type	TA (kg a.s.)	Form. type	Face mask	Glove wash	Total hands (µg)	Prot. Hands (µg)	Total body (µg)	Inner body (µg)	Head (µg)	Inhalation (µg)
ECPA_10	13	tank	0.45	WG	yes		777	0.1	NA	NA	NA	0.8
ECPA_10	15	tank	0.25	WG	yes		542	0.1	NA	NA	NA	5.2
ECPA_10	17	tank	0.44	WG	yes		1017	2.0	NA	NA	NA	76.9
ECPA_10	19	tank	0.23	WG	yes		127	0.1	NA	NA	NA	0.8
ECPA_12	1	tank	1.50	WG	no		1240	28.3	NA	NA	234.3	10.9
ECPA_12	3	tank	1.10	WG	no	yes	NA	25.6	NA	NA	17.3	2.5
ECPA_12	7	tank	0.70	WG	no		615	0.5	NA	NA	1.7	2.5
ECPA_12	9	tank	1.43	WG	no		3692	153.4	NA	NA	7.6	6.5
ECPA_12	11	tank	0.83	WG	no		1956	6.3	NA	NA	1.7	10.1
ECPA_12	13	tank	0.47	WG	no		645	7.1	NA	NA	1.7	2.5
ECPA_12	15	tank	0.88	WG	no		1072	6.0	NA	NA	26.5	14.9
ECPA_12	17	tank	0.35	WG	no		2302	3.4	NA	NA	216.4	15.9
ECPA_12	19	tank	0.31	WG	no		1098	1.3	NA	NA	5.6	13.7
ECPA_12	21	tank	0.91	WG	no		1575	20.0	NA	NA	11.7	22.1
ECPA_13	1	tank	0.48	WG	no		3229	1.7	NA	NA	1.0	1.6
ECPA_13	3	tank	0.60	WG	no		21	0.5	NA	NA	2.5	1.6
ECPA_13	5	tank	0.94	WG	no		1734	42.2	NA	NA	42.5	12.7
ECPA_13	9	tank	1.20	WG	no		1861	4.3	NA	NA	8.0	27.4
ECPA_13	11	tank	0.55	WG	no		548	16.3	NA	NA	3.8	1.6
ECPA_13	13	tank	0.52	WG	yes		746	0.5	NA	NA	NA	1.6
ECPA_13	15	tank	0.97	WG	no		1143	270.1	NA	NA	20.4	1.6
ECPA_13	17	tank	0.61	WG	no		1032	3.8	NA	NA	3.7	1.6
ECPA_13	19	tank	0.46	WG	no		1773	8.5	NA	NA	21.0	1.6
ECPA_13	21	tank	1.40	WG	no		6686	267.9	NA	NA	86.8	85.4
ECPA_14	21	tank	0.04	sachets	no		6425	2.3	NA	NA	NA	3.1
ECPA_14	22	tank	0.07	sachets	no		2290	3.5	NA	NA	NA	7.9
ECPA_14	23	tank	0.06	sachets	no		1603	1.9	NA	NA	NA	5.9
ECPA_14	24	tank	0.07	sachets	no		2587	3.1	NA	NA	NA	6.1
ECPA_14	25	tank	0.08	sachets	no		13056	99.4	NA	NA	NA	33.2
ECPA_14	26	tank	0.08	sachets	no		8991	111.7	NA	NA	NA	4.1
ECPA_14	27	tank	0.08	sachets	no		823	3.9	NA	NA	NA	27.7
ECPA_14	28	tank	0.04	sachets	no		1900	2.9	NA	NA	NA	2.8

Study code	Operator	ML type	TA (kg a.s.)	Form. type	Face mask	Glove wash	Total hands (µg)	Prot. Hands (µg)	Total body (µg)	Inner body (µg)	Head (µg)	Inhalation (µg)
ECPA_14	29	tank	0.08	sachets	no		1871	7.2	NA	NA	NA	1.6
ECPA_14	30	tank	0.04	sachets	no		15830	2.4	NA	NA	NA	7.1
ECPA_14	31	tank	0.06	sachets	no		2227	3.0	NA	NA	NA	1.8
ECPA_14	32	tank	0.06	sachets	no		987	3.0	NA	NA	NA	5.5
ECPA_14	33	tank	0.04	sachets	no		1210	9.3	NA	NA	NA	2.9
ECPA_14	34	tank	0.03	sachets	no		1944	2.8	NA	NA	NA	0.2
ECPA_14	35	tank	0.08	sachets	no		2979	2.8	NA	NA	NA	0.2
ECPA_14	36	tank	0.04	sachets	no		3354	50.1	NA	NA	NA	15.7
ECPA_14	37	tank	0.03	sachets	no		1001	3.5	NA	NA	NA	2.6
ECPA_14	38	tank	0.07	sachets	no		2415	18.6	NA	NA	NA	9.1
ECPA_14	39	tank	0.04	sachets	no		795	1.1	NA	NA	NA	2.5
ECPA_14	40	tank	0.03	sachets	no		10591	0.9	NA	NA	NA	3.1

I-2: Application

Study code	Operator	A type	TA (kg a.s.)	Scenario	Prot. clothing	Face mask	Glove wash	Total hand (μg)	Prot. hand (μg)	Total body (μg)	Inner body (μg)	Head (μg)	Inhalation (μg)
ECPA_2	1	HCHH	1.05	dense	none	yes		92300	58.5	1415790	294375	159.1	436.9
ECPA_2	2	HCHH	1.03	dense	none	yes		49019	270.1	1760027	846244	549.4	2253.1
ECPA_2	3	HCHH	0.99	dense	none	yes		32393	1083.0	1549926	219191	500.0	302.8
ECPA_2	4	HCHH	0.70	dense	none	yes		60082	277.0	2513658	951656	1250.2	402.4
ECPA_2	5	HCHH	0.75	dense	none	yes	yes	NA	481.3	877104	209289	110.2	267.7
ECPA_2	6	HCHH	0.75	dense	none	yes		10877	NA	762603	346213	200.0	120.8
ECPA_2	7	HCHH	0.68	dense	none	yes		6025	950.0	804412	57091	800.6	566.4
ECPA_2	8	HCHH	0.73	dense	none	yes		28332	NA	2007448	247535	494.6	391.2
ECPA_2	9	HCHH	0.37	dense	none	yes		9822	NA	477327	252623	187.2	137.2
ECPA_2	10	HCHH	0.90	dense	none	yes		22674	NA	915993	265844	218.4	157.3
ECPA_2	11	HCHH	0.86	dense	yes	yes		NA	4.2	NA	NA	90.8	429.2
ECPA_2	12	HCHH	1.50	dense	yes	yes		14320	NA	NA	NA	293.0	951.4
ECPA_2	13	HCHH	0.60	dense	yes	yes		1865	NA	NA	NA	117.6	40.6
ECPA_2	14	HCHH	0.50	dense	yes	yes		1806	NA	NA	NA	50.2	1211.5
ECPA_2	15	HCHH	0.70	dense	yes	yes		2163	NA	NA	NA	22.2	125.0
ECPA_2	17	HCHH	0.60	dense	yes	yes		1977	NA	NA	NA	7905.4	236.1
ECPA_2	18	HCHH	0.65	dense	rain suit	yes		NA	73.7	NA	113	10.8	130.2
ECPA_2	19	HCHH	0.55	dense	rain suit	yes		NA	9.3	NA	351	29.6	258.3
ECPA_2	20	HCHH	0.94	dense	rain suit	yes		NA	72.3	NA	1543	897.8	202.8
ECPA_2	21	HCHH	0.94	dense	rain suit	yes		NA	997.8	NA	1865	286.4	291.7
ECPA_2	22	HCHH	0.63	dense	rain suit			NA	468.7	NA	453	NA	338.5
ECPA_2	23	HCHH	0.50	dense	rain suit	yes		NA	429.8	NA	1107	1182.2	478.1
ECPA_2	24	HCHH	0.86	dense	rain suit	yes		8444	NA	NA	4248	7423.6	224.0
ECPA_2	25	HCHH	0.79	dense	rain suit	yes		4715	NA	NA	421	422.0	54.6
ECPA_2	26	HCHH	0.41	dense	rain suit	yes		5791	NA	NA	375	78.6	75.0
ECPA_2	27	HCHH	0.75	dense	rain suit	yes		NA	81.2	NA	1276	2249.2	458.3
ECPA_2	28	HCHH	0.53	dense	rain suit	yes		NA	602.2	NA	4645	4721.2	99.0
ECPA_2	29	HCHH	0.74	dense	rain suit	yes		NA	68.5	NA	2605	3972.0	178.0
ECPA_2	30	HCHH	0.71	dense	rain suit	yes		2415	NA	NA	1197	294.2	57.3
ECPA_2	31	HCHH	0.71	dense	rain suit	yes		3253	NA	NA	1196	251.0	172.9

Study code	Operator	A type	TA (kg a.s.)	Scenario	Prot. clothing	Face mask	Glove wash	Total hand (µg)	Prot. hand (µg)	Total body (µg)	Inner body (µg)	Head (µg)	Inhalation (µg)
ECPA_2	32	HCHH	0.75	dense	rain suit	yes		NA	35.7	NA	768	356.0	101.0
ECPA_2	33	HCHH	0.83	dense	rain suit	yes		NA	418.7	NA	1085	296.2	334.4
ECPA_3	14	HCHH	0.98	normal	none	yes		9335	NA	336211	20632	498.0	149.6
ECPA_3	15	HCHH	0.67	normal	none	yes		3092	44.3	33236	1023	263.8	144.5
ECPA_3	16	HCHH	0.90	normal	none	yes		NA	76.0	317826	13921	395.8	219.1
ECPA_3	17	HCHH	0.90	normal	none	yes		18523	NA	743465	190124	2651.6	354.9
ECPA_3	18	HCHH	1.36	normal	none	yes		13984	NA	465391	109038	446.8	466.6
ECPA_3	19	HCHH	0.75	normal	none	yes		19742	NA	267111	8262	827.8	354.2
ECPA_3	20	HCHH	0.56	normal	none	yes		7305	NA	42899	361	99.6	0.5
ECPA_3	21	HCHH	0.53	normal	none	yes		37264	NA	147738	4324	425.0	204.2
ECPA_3	22	HCHH	0.83	normal	none	yes		5439	NA	62406	1040	93.1	50.6
ECPA_3	23	HCHH	1.35	normal	none	yes		13122	NA	96218	988	475.8	360.2
ECPA_10	2	LCHH	0.21	normal	none	yes		1222	0.1	17207	107	1.0	73.1
ECPA_10	4	LCHH	0.18	normal	none	yes		4878	1.0	16767	130	1.0	71.2
ECPA_10	6	LCHH	0.26	normal	none	yes		1886	0.2	28078	20	1.0	41.6
ECPA_10	8	LCHH	0.50	normal	none	yes		4337	0.2	21117	10	1.0	9.8
ECPA_10	10	LCHH	0.60	normal	none	yes		4159	0.2	6749	20	8.9	39.3
ECPA_10	12	LCHH	0.29	normal	none	yes		4104	5.7	8021	15	1.0	35.5
ECPA_10	14	LCHH	0.23	normal	none	yes		751	0.2	5633	10	2.7	49.3
ECPA_10	16	LCHH	0.23	normal	none	yes		1179	0.2	4901	150	1.0	111.2
ECPA_10	18	LCHH	0.41	normal	none	yes		931	0.1	3469	35	6.3	0.8
ECPA_10	20	LCHH	0.23	normal	none	yes		1817	0.1	1201	7	1.0	0.8
ECPA_12	2	HCHH	1.28	normal	none			22345	24.7	635592	32872	1375.8	2213.5
ECPA_12	4	HCHH	0.82	normal	none			9514	0.5	95570	2067	375.7	317.6
ECPA_12	8	HCHH	0.53	normal	none			9845	6.1	577452	32742	698.8	71.7
ECPA_12	10	HCHH	1.13	normal	none			8624	0.5	539310	17680	439.2	591.0
ECPA_12	12	HCHH	0.63	normal	none	yes		4343	0.5	78006	3271	505.4	154.3
ECPA_12	14	HCHH	0.43	normal	none	yes		9350	1.1	74312	179	147.3	186.1
ECPA_12	16	HCHH	0.56	normal	none			6663	14.6	189224	462	13.5	216.8
ECPA_12	18	HCHH	0.28	normal	none	yes	yes	NA	3.6	37115	2714	1.7	93.7
ECPA_12	20	HCHH	0.27	normal	none			5708	1.0	71259	1170	74.3	53.8

Study code	Operator	A type	TA (kg a.s.)	Scenario	Prot. clothing	Face mask	Glove wash	Total hand (µg)	Prot. hand (µg)	Total body (µg)	Inner body (µg)	Head (µg)	Inhalation (µg)
ECPA_12	22	HCHH	0.72	normal	none	yes		7273	1.0	29504	326	17.9	54.9
ECPA_13	2	HCHH	0.44	normal	none			3124	10.1	33658	121	30.2	142.9
ECPA_13	4	HCHH	0.50	normal	none			10197	19.9	162113	2973	277.4	219.6
ECPA_13	6	HCHH	0.74	normal	none	yes		30709	226.1	930188	81308	505.6	172.1
ECPA_13	10	HCHH	1.05	normal	none			52942	9.5	321556	2514	NA	223.6
ECPA_13	12	HCHH	0.44	normal	none	yes		5694	28.2	29494	306	40.1	90.3
ECPA_13	14	HCHH	0.40	normal	none			12895	10.7	67094	283	64.4	111.9
ECPA_13	16	HCHH	0.64	normal	none			44219	4.5	580926	470	411.2	241.6
ECPA_13	18	HCHH	0.44	normal	none			17883	66.9	167763	19673	696.8	186.6
ECPA_13	20	HCHH	0.38	normal	none			21614	90.3	151633	772	423.4	186.0
ECPA_13	22	HCHH	0.90	normal	none			29663	26.2	379872	1633	125.8	203.6
ECPA_14	1	LCHH	0.03	dense	none	yes		740	0.2	28514	1313	9.6	22.1
ECPA_14	2	LCHH	0.06	dense	none	yes		1423	0.6	77688	22629	13.6	45.1
ECPA_14	3	LCHH	0.04	dense	none	yes		787	1.6	92050	27958	12.2	43.1
ECPA_14	4	LCHH	0.07	dense	none			448	0.2	13818	36	7.6	4.5
ECPA_14	5	LCHH	0.07	dense	none			811	41.4	38252	1654	15.9	5.7
ECPA_14	6	LCHH	0.06	dense	none			469	3.4	22282	1364	7.5	5.8
ECPA_14	7	LCHH	0.08	dense	none	yes		1393	0.3	77560	12181	8.8	63.6
ECPA_14	8	LCHH	0.04	dense	none			1057	0.4	85383	35803	36.1	6.6
ECPA_14	9	LCHH	0.06	dense	none			228	0.3	29394	183	2.9	70.2
ECPA_14	10	LCHH	0.03	dense	none			916	0.7	58038	15990	10.5	6.0
ECPA_14	11	LCHH	0.05	dense	none			730	0.5	47218	10177	11.5	7.0
ECPA_14	12	LCHH	0.05	dense	none			653	11.2	53492	3448	2.4	NA
ECPA_14	13	LCHH	0.03	dense	none			1323	1.3	55521	13959	19.4	43.3
ECPA_14	14	LCHH	0.03	dense	none			755	0.1	17192	73	26.1	7.6
ECPA_14	15	LCHH	0.07	dense	none			164	0.5	15276	509	21.5	7.1
ECPA_14	16	LCHH	0.03	dense	none			691	1.5	46342	8888	6.7	7.6
ECPA_14	17	LCHH	0.02	dense	none	yes		898	0.6	41756	925	6.2	26.6
ECPA_14	18	LCHH	0.06	dense	none			622	0.5	25333	269	20.7	79.8
ECPA_14	19	LCHH	0.04	dense	none			179	0.3	11026	17	2.4	8.3
ECPA_14	20	LCHH	0.03	dense	none	yes		1530	6.4	24676	168	35.4	46.9
ECPA_15	1	LCHH	0.07	dense	rain trousers	yes		390	0.2	NA	44	21.2	12.8

Study code	Operator	A type	TA (kg a.s.)	Scenario	Prot. clothing	Face mask	Glove wash	Total hand (μg)	Prot. hand (μg)	Total body (μg)	Inner body (μg)	Head (μg)	Inhalation (μg)
ECPA_15	2	LCHH	0.03	dense	rain trousers	yes		1036	12.3	NA	21	4.5	25.9
ECPA_15	3	LCHH	0.04	dense	rain trousers	yes		1427	1.3	NA	56	4.1	23.4
ECPA_15	4	LCHH	0.05	dense	rain trousers			360	0.2	NA	68	7.4	44.3
ECPA_15	5	LCHH	0.09	dense	rain trousers	yes		568	1.9	NA	20	5.4	8.3
ECPA_15	6	LCHH	0.03	dense	rain trousers	yes		351	0.3	NA	40	1.5	26.1
ECPA_15	7	LCHH	0.04	dense	rain trousers			969	0.6	NA	89	8.7	59.8
ECPA_15	8	LCHH	0.07	dense	rain trousers	yes		1257	1.5	NA	154	30.2	78.6
ECPA_15	9	LCHH	0.05	dense	rain trousers			1307	0.9	NA	80	7.5	5.6
ECPA_15	10	LCHH	0.03	dense	rain trousers			450	0.1	NA	42	1.1	4.7

II Tables of empirical percentiles

II-1: ML tank

Total hand exposure ($\mu\text{g}/\text{kg a.s.}$)

	n	min	50 th perc.	75 th perc.	90 th perc.	95 th perc.	max
WG	90	10.67	658.1	1738	3597	6426	13287
WP	20	859.5	10661	13905	23044	23730	28571
Liquid	169	4.02	1068	2842	5653	11636	26853
sachets	20	10979	38938	97058	188011	318789	422143

Protected hand exposure ($\mu\text{g}/\text{kg a.s.}$)

	n	min	50 th perc.	75 th perc.	90 th perc.	95 th perc.	max
WG	91	0.1032	6.20	18.49	50.84	146.4	279.0
WP	20	13.91	164.4	537.1	1398	2025	2198
Liquid	167	0.0013	6.11	18.89	62.20	194.5	595.2
sachets	20	26.14	62.89	152.3	1326	1342	1489

Head exposure ($\mu\text{g}/\text{kg a.s.}$)

	n	min	50 th perc.	75 th perc.	90 th perc.	95 th perc.	max
WG	48	0.0083	5.26	63.19	92.42	613.1	18.83
WP	20	9.67	60.05	176.3	206.1	341.2	127.2
Liquid	80	0.0380	2.80	69.51	172.6	742.4	23.26
sachets	0	NA	NA	NA	NA	NA	NA

Inhalation exposure ($\mu\text{g}/\text{kg a.s.}$)

	n	min	50 th perc.	75 th perc.	90 th perc.	95 th perc.	max
WG	91	0.0083	4.99	12.92	24.31	44.78	176.7
WP	20	59.83	325.6	501.6	653.3	693.0	1112
Liquid	100	0.0035	0.2079	0.8917	1.94	3.50	18.23
sachets	20	2.32	89.77	121.4	374.3	419.7	442.5

II-2: LCHH applicationTotal hand exposure ($\mu\text{g}/\text{kg a.s.}$)

	n	min	50 th perc.	75 th perc.	90 th perc.	95 th perc.	max
normal	10	2254	7164	8591	15316	21208	27100
dense	30	2500	18274	28618	37045	40370	49638

Protected hand exposure ($\mu\text{g}/\text{kg a.s.}$)

	n	min	50 th perc.	75 th perc.	90 th perc.	95 th perc.	max
normal	10	0.2201	0.5761	0.7897	7.12	13.24	19.36
dense	30	2.55	13.71	36.79	213.2	380.5	620.7

Total body exposure ($\mu\text{g}/\text{kg a.s.}$)

	n	min	50 th perc.	75 th perc.	90 th perc.	95 th perc.	max
normal	10	5339	25880	73009	94845	102477	110108
dense	20	208173	1020583	1491668	2033757	2256573	2422199

Inner body exposure ($\mu\text{g}/\text{kg a.s.}$)

	n	min	50 th perc.	75 th perc.	90 th perc.	95 th perc.	max
normal	10	20.23	64.95	407.6	660.1	690.0	719.9
dense	20	488.7	42120	305297	566661	699384	1015685
dense (beneath rain trousers)	10	231.5	1405	1611	2208	2210	2211

Head exposure ($\mu\text{g}/\text{kg a.s.}$)

	n	min	50 th perc.	75 th perc.	90 th perc.	95 th perc.	max
normal	10	2.02	4.64	10.12	14.94	15.13	15.32
dense	30	43.49	337.0	334.8	621.8	1020	1149

Inhalation exposure ($\mu\text{g}/\text{kg a.s.}$)

	n	min	50 th perc.	75 th perc.	90 th perc.	95 th perc.	max
normal	10	1.86	142.3	318.4	404.4	443.8	483.3
dense	29	68.41	564.1	1053	1321	1470	1521

II-3: HCHH applicationTotal hand exposure ($\mu\text{g}/\text{kg a.s.}$)

	n	min	50 th perc.	75 th perc.	90 th perc.	95 th perc.	max
normal	28	4601	18139	32219	52404	64941	70979
dense	19	3090	9818	29680	55472	86416	87904

Protected hand exposure ($\mu\text{g}/\text{kg a.s.}$)

	n	min	50 th perc.	75 th perc.	90 th perc.	95 th perc.	max
normal	22	0.444	21.14	58.04	146.8	234.1	307.2
dense	18	4.88	330.5	830.7	1110	1177	1407

Total body exposure ($\mu\text{g}/\text{kg a.s.}$)

	n	min	50 th perc.	75 th perc.	90 th perc.	95 th perc.	max
normal	30	41034	316872	396482	831907	1014052	1263843
dense	10	1017770	1318352	1679513	2832397	3220432	3608467

Inner body exposure ($\mu\text{g}/\text{kg a.s.}$)

	n	min	50 th perc.	75 th perc.	90 th perc.	95 th perc.	max
normal	30	273	3453	15643	64142	96818	210547
dense	10	84579	317003	627266	878934	1122539	1366144
dense (beneath rain suit)	16	174	1663	2042	4229	5895	8764

Head exposure ($\mu\text{g}/\text{kg a.s.}$)

	n	min	50 th perc.	75 th perc.	90 th perc.	95 th perc.	max
normal	29	6.02	392.6	806.1	1160	1494	2936
dense	31	16.62	414.4	1071	5368	8770	13176

Inhalation exposure ($\mu\text{g}/\text{kg a.s.}$)

	n	min	50 th perc.	75 th perc.	90 th perc.	95 th perc.	max
normal	30	0.816	299.7	392.0	474.7	509.6	1736
dense	32	67.71	333.6	535.7	818.6	1514	2423

III Model computations

III-1: 75th percentile level

ML tank

Model: lrph.ML ~ form2 + glove.wash.ML

Table of measured values:

	n	min	50%	75%	90%	95%	max
WG	90	21.21605	1186.713	2266.130	5006.698	6790.453	40938.82
WP	20	5844.70000	75873.000	96066.000	134405.730	147403.600	179582.00
liquid	169	71.49891	8250.000	30250.500	127822.263	553048.508	2346735.63
sachets	20	795.01397	2258.122	4121.988	10837.719	13195.040	15830.36

Table of predicted values (75th percentile):

	TA	form2	glove.wash.ML	lTA	LS.75	QR.75
1	1	WP		0	30553.903	14504.325
2	10	WP		1	305539.034	145043.246
3	100	WP		2	3055390.335	1450432.462
4	1	WG		0	1610.323	1738.556
5	10	WG		1	16103.230	17385.556
6	100	WG		2	161032.299	173855.563
7	1	liquid		0	2738.492	3144.000
8	10	liquid		1	27384.920	31440.000
9	100	liquid		2	273849.196	314400.000
10	1	sachets		0	144770.314	89449.362
11	10	sachets		1	1447703.137	894493.620
12	100	sachets		2	14477031.367	8944936.201

Summary of LS fit (mean):

Call:

```
lm(formula = frm, contrasts.arg = contrasts)
```

Residuals:

Min	1Q	Median	3Q	Max
-2.40370	-0.43677	0.03463	0.46186	1.42106

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	2.77621	0.06804	40.804	< 2e-16 ***
form2WP	1.26970	0.15728	8.073	1.77e-14 ***
form2liquid	0.23172	0.08276	2.800	0.00545 **
form2sachets	1.94565	0.15728	12.371	< 2e-16 ***
glove.wash.MLyes	-0.37996	0.12691	-2.994	0.00299 **

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.6341 on 294 degrees of freedom

(356 observations deleted due to missingness)

Multiple R-squared: 0.4204, Adjusted R-squared: 0.4125

F-statistic: 53.31 on 4 and 294 DF, p-value: < 2.2e-16

Summary of RQ fit (75th percentile):

Call: rq(formula = frm, tau = TAU, contrasts = contrasts)

Formula: lrph.ML ~ form2 + glove.wash.ML

N: 299 tau: 0.75 AIC: 615.035696987568

	coefficients	lower bd	upper bd	Std. Error	t value	Pr(> t)
(Intercept)	3.2401886	3.1580743	3.3689027	0.06417624	50.488915	0.000000e+00
form2WP	0.9213089	0.8438665	1.1302667	0.10835749	8.502494	8.881784e-16

```
form2liquid      0.2572939  0.1177559  0.3647721  0.08774498  2.932293  3.629144e-03
form2sachets     1.7113887  1.4098661  2.0093663  0.26578632  6.438964  4.890710e-10
glove.wash.MLyes -0.2740367 -0.4554491 -0.1416841  0.08720704 -3.142369  1.846877e-03
```

Formula for mean (based on LS-estimate):

```
log(ph.ML) = log(TA) + 2.776 + 1.27 form2WP + 0.232 form2liquid + 1.946
form2sachets + -0.38 glove.wash.MLyes
```

Formula for 75th percentile (based on quantile regression):

```
log(ph.ML) = log(TA) + 3.24 + 0.921 form2WP + 0.257 form2liquid + 1.711
form2sachets + -0.274 glove.wash.MLyes
```

=====
Model: lph.ML ~ lTA + form2 + glove.wash.ML

Table of measured values:

	n	min	50%	75%	90%	95%	max
WG	90	21.21605	1186.713	2266.130	5006.698	6790.453	40938.82
WP	20	5844.70000	75873.000	96066.000	134405.730	147403.600	179582.00
liquid	169	71.49891	8250.000	30250.500	127822.263	553048.508	2346735.63
sachets	20	795.01397	2258.122	4121.988	10837.719	13195.040	15830.36

Table of predicted values (75th percentile):

	TA	form2	glove.wash.ML	lTA	LS.75	QR.75
1	1	WP		0	55105.334	28493.755
2	10	WP		1	252727.419	141312.486
3	100	WP		2	1167267.750	700827.911
4	1	WG		0	1919.229	1789.808
5	10	WG		1	8835.393	8876.409
6	100	WG		2	40966.401	44021.836
7	1	liquid		0	5687.352	5976.187
8	10	liquid		1	26048.886	29638.419
9	100	liquid		2	120170.118	146989.354
10	1	sachets		0	50010.675	32905.702
11	10	sachets		1	232802.851	163193.184
12	100	sachets		2	1090952.444	809343.472

Summary of LS fit (mean):

Call:

```
lm(formula = frm, contrasts.arg = contrasts)
```

Residuals:

Min	1Q	Median	3Q	Max
-2.17269	-0.37271	-0.01293	0.40586	1.62188

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	2.87897	0.06580	43.752	< 2e-16 ***
lTA	0.66249	0.05262	12.589	< 2e-16 ***
form2WP	1.44921	0.15016	9.651	< 2e-16 ***
form2liquid	0.47137	0.08616	5.471	9.6e-08 ***
form2sachets	1.40590	0.16984	8.278	4.5e-15 ***
glove.wash.MLyes	-0.38282	0.11904	-3.216	0.00145 **

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.5948 on 293 degrees of freedom
(356 observations deleted due to missingness)

Multiple R-squared: 0.5721, Adjusted R-squared: 0.5648

F-statistic: 78.35 on 5 and 293 DF, p-value: < 2.2e-16

Summary of RQ fit (75th percentile):

Call: rq(formula = frm, tau = TAU, contrasts = contrasts)

Formula: lph.ML ~ lTA + form2 + glove.wash.ML

N: 299 tau: 0.75 AIC: 587.34592168794

	coefficients	lower bd	upper bd	Std. Error	t value	Pr(> t)
(Intercept)	3.2528064	3.1721256	3.3421833	0.07006302	46.426867	0.000000000000000
lTA	0.6954309	0.5936785	0.8223129	0.07101780	9.792346	0.000000000000000
form2WP	1.2019432	1.0144665	1.4421394	0.12054292	9.971081	0.000000000000000
form2liquid	0.5236177	0.3501806	0.7119563	0.09104617	5.751123	0.00000002227744
form2sachets	1.2644647	0.9260286	1.7587325	0.31402914	4.026584	0.00007213928989
glove.wash.MLyes	-0.3731761	-0.4999633	-0.2743425	0.06352214	-5.874740	0.00000001148834

Formula for mean (based on LS-estimate):

$$\log(\text{ph.ML}) = 2.879 + 0.662 \log(\text{TA}) + 1.449 \text{ form2WP} + 0.471 \text{ form2liquid} + 1.406 \text{ form2sachets} + -0.383 \text{ glove.wash.MLyes}$$

Formula for 75th percentile (based on quantile regression):

$$\log(\text{ph.ML}) = 3.253 + 0.695 \log(\text{TA}) + 1.202 \text{ form2WP} + 0.524 \text{ form2liquid} + 1.264 \text{ form2sachets} + -0.373 \text{ glove.wash.MLyes}$$

=====
Model: lrah.ML ~ form2

Table of measured values:

	n	min	50%	75%	90%	95%	max
WG	91	0.09090909	15.22027	45.68000	153.40	269.0000	948.10
WP	20	94.60000000	1180.50000	3586.50000	9459.50	11215.0000	11310.00
liquid	167	0.01000000	44.11000	127.50000	698.00	2270.0844	33747.49
sachets	20	0.88360000	3.07500	7.76275	54.98	99.9675	111.70

Table of predicted values (75th percentile):

	TA	form2	lTA	LS.75	QR.75
1	1	WP	0	852.59640	443.00654
2	10	WP	1	8525.96398	4430.06536
3	100	WP	2	85259.63980	44300.65359
4	1	WG	0	26.40474	18.64481
5	10	WG	1	264.04735	186.44809
6	100	WG	2	2640.47354	1864.48087
7	1	liquid	0	17.30028	18.88969
8	10	liquid	1	173.00277	188.89693
9	100	liquid	2	1730.02772	1888.96929
10	1	sachets	0	495.02529	120.06803
11	10	sachets	1	4950.25290	1200.68027
12	100	sachets	2	49502.52901	12006.80272

Summary of LS fit (mean):

Call:

```
lm(formula = frm, contrasts.arg = contrasts)
```

Residuals:

Min	1Q	Median	3Q	Max
-3.4465	-0.5595	0.0905	0.6638	2.2032

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	0.7534	0.1032	7.303	2.65e-12 ***
form2WP	1.4963	0.2430	6.157	2.43e-09 ***
form2liquid	-0.1820	0.1282	-1.419	0.157
form2sachets	1.2602	0.2430	5.185	4.03e-07 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.9841 on 294 degrees of freedom

(357 observations deleted due to missingness)

Multiple R-squared: 0.2194, Adjusted R-squared: 0.2114

F-statistic: 27.54 on 3 and 294 DF, p-value: 1.007e-15

Summary of RQ fit (75th percentile):

Call: rq(formula = frm, tau = TAU, contrasts = contrasts)

Formula: lrah.ML ~ form2

N: 298 tau: 0.75 AIC: 840.109218711197

	coefficients	lower bd	upper bd	Std. Error	t value	Pr(> t)
(Intercept)	1.270557933	1.1635693	1.4726134	0.09894483	12.84107402	0.00000000000
form2WP	1.375852201	1.1399230	1.8939595	0.33447435	4.11347595	0.00005064399
form2liquid	0.005666964	-0.1145190	0.1719218	0.12587930	0.04501903	0.96412270497
form2sachets	0.808869442	0.6032635	1.8924535	0.58510709	1.38242975	0.16788903634

Formula for mean (based on LS-estimate):

$\log(\text{ah.ML}) = \log(\text{TA}) + 0.753 + 1.496 \text{ form2WP} + -0.182 \text{ form2liquid} + 1.26 \text{ form2sachets}$

Formula for 75th percentile (based on quantile regression):

$\log(\text{ah.ML}) = \log(\text{TA}) + 1.271 + 1.376 \text{ form2WP} + 0.006 \text{ form2liquid} + 0.809 \text{ form2sachets}$

=====
Model: lah.ML ~ lTA + form2

Table of measured values:

	n	min	50%	75%	90%	95%	max
WG	91	0.09090909	15.22027	45.68000	153.40	269.0000	948.10
WP	20	94.60000000	1180.50000	3586.50000	9459.50	11215.0000	11310.00
liquid	167	0.01000000	44.11000	127.50000	698.00	2270.0844	33747.49
sachets	20	0.88360000	3.07500	7.76275	54.98	99.9675	111.70

Table of predicted values (75th percentile):

	TA	form2	lTA	LS.75	QR.75
1	1	WP	0	2112.56593	894.88474
2	10	WP	1	6358.63232	4038.39059
3	100	WP	2	19349.94219	18224.24484
4	1	WG	0	34.47762	24.16403
5	10	WG	1	104.38879	109.04622
6	100	WG	2	319.59344	492.09828
7	1	liquid	0	53.55892	34.51937
8	10	liquid	1	160.86545	155.77725
9	100	liquid	2	488.60777	702.98369
10	1	sachets	0	96.39804	39.42438
11	10	sachets	1	296.94358	177.91234
12	100	sachets	2	924.22527	802.87381

Summary of LS fit (mean):

Call:

`lm(formula = frm, contrasts.arg = contrasts)`

Residuals:

Min	1Q	Median	3Q	Max
-3.5205	-0.5197	-0.0334	0.5539	2.5859

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	0.90977	0.09996	9.102	< 2e-16 ***
lTA	0.48015	0.08181	5.869	1.18e-08 ***
form2WP	1.77384	0.23238	7.633	3.24e-13 ***
form2liquid	0.19055	0.13393	1.423	0.156
form2sachets	0.43077	0.26292	1.638	0.102

 Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.9242 on 293 degrees of freedom

(357 observations deleted due to missingness)

Multiple R-squared: 0.3071, Adjusted R-squared: 0.2976

F-statistic: 32.47 on 4 and 293 DF, p-value: < 2.2e-16

Summary of RQ fit (75th percentile):

Call: `rq(formula = frm, tau = TAU, contrasts = contrasts)`

Formula: lah.ML ~ lTA + form2

N: 298 tau: 0.75 AIC: 825.384584112632

	coefficients	lower bd	upper bd	Std. Error	t value	Pr(> t)
(Intercept)	1.3831694	1.19302732	1.5794588	0.04898423	28.2370366	0.000000e+00
lTA	0.6544412	0.37915196	0.8659892	0.07760127	8.4333832	1.554312e-15
form2WP	1.5685977	1.35471691	2.1287564	0.32158052	4.8777759	1.763174e-06
form2liquid	0.1548934	0.01671736	0.3443259	0.10097536	1.5339722	1.261155e-01
form2sachets	0.2125954	-0.32530690	1.4190871	0.60921263	0.3489676	7.273643e-01

Formula for mean (based on LS-estimate):

log(ah.ML) = 0.91 + 0.48 log(TA) + 1.774 form2WP + 0.191 form2liquid + 0.431 form2sachets

Formula for 75th percentile (based on quantile regression):

log(ah.ML) = 1.383 + 0.654 log(TA) + 1.569 form2WP + 0.155 form2liquid + 0.213 form2sachets

=====
Model: lrhd.ML ~ form + face.shield.ML

Table of measured values:

	n	min	50%	75%	90%	95%	max
WG	48	0.01	23.01	129.806	301.250	1120.508	2358.922
WP	20	65.76	443.00	856.400	1073.620	1533.650	2610.000
liquid	80	0.45	20.00	245.000	2428.076	4027.780	19050.450

Table of predicted values (75th percentile):

	TA	form	face.shield.ML	lTA	LS.75	QR.75
1	1	WP	no	0	218.6126952	124.7320261
2	10	WP	no	1	2186.1269520	1247.3202614
3	100	WP	no	2	21861.2695202	12473.2026144
4	1	WG	no	0	21.1765767	21.1157025
5	10	WG	no	1	211.7657668	211.1570248
6	100	WG	no	2	2117.6576684	2111.5702479
7	1	liquid	no	0	40.8799973	51.8852288
8	10	liquid	no	1	408.7999729	518.8522876
9	100	liquid	no	2	4087.9997287	5188.5228758
10	1	WP	yes	0	5.1879014	2.0033323
11	10	WP	yes	1	51.8790141	20.0333231
12	100	WP	yes	2	518.7901414	200.3332309
13	1	WG	yes	0	0.4973295	0.3391412
14	10	WG	yes	1	4.9732951	3.3914120
15	100	WG	yes	2	49.7329507	33.9141200
16	1	liquid	yes	0	0.9555324	0.8333333
17	10	liquid	yes	1	9.5553243	8.3333333
18	100	liquid	yes	2	95.5532428	83.3333333

Summary of LS fit (mean):

Call:

lm(formula = frm, contrasts.arg = contrasts)

Residuals:

Min	1Q	Median	3Q	Max
-1.78961	-0.58671	0.01389	0.52493	3.08542

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	0.7501	0.1266	5.927	0.0000000218 ***
formWP	1.0062	0.2269	4.435	0.0000181463 ***
formliquid	0.2875	0.1545	1.861	0.0649 .
face.shield.MLyes	-1.6358	0.1694	-9.658	< 2e-16 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.842 on 144 degrees of freedom
 Multiple R-squared: 0.4799, Adjusted R-squared: 0.4691
 F-statistic: 44.29 on 3 and 144 DF, p-value: < 2.2e-16

Summary of RQ fit (75th percentile):

Call: rq(formula = frm, tau = TAU, contrasts = contrasts)
 Formula: lrhd.ML ~ form + face.shield.ML

N: 148 tau: 0.75 AIC: 395.461343489194

	coefficients	lower bd	upper bd	Std. Error	t value	Pr(> t)
(Intercept)	1.3246055	0.96850111	1.6259605	0.2468032	5.367052	3.127963e-07
formWP	0.7713724	0.49399283	1.0311613	0.2711305	2.845023	5.088598e-03
formliquid	0.3904382	0.03530622	0.7243653	0.2648774	1.474034	1.426553e-01
face.shield.MLyes	-1.7942250	-2.08770575	-1.1350409	0.2370937	-7.567578	4.149792e-12

Formula for mean (based on LS-estimate):

log(hd.ML) = log(TA) + 0.75 + 1.006 formWP + 0.287 formliquid + -1.636
 face.shield.MLyes

Formula for 75th percentile (based on quantile regression):

log(hd.ML) = log(TA) + 1.325 + 0.771 formWP + 0.39 formliquid + -1.794
 face.shield.MLyes

=====
Model: lhd.ML ~ lTA + form + face.shield.ML

Table of measured values:

	n	min	50%	75%	90%	95%	max
WG	48	0.01	23.01	129.806	301.250	1120.508	2358.922
WP	20	65.76	443.00	856.400	1073.620	1533.650	2610.000
liquid	80	0.45	20.00	245.000	2428.076	4027.780	19050.450

Table of predicted values (75th percentile):

	TA	form	face.shield.ML	lTA	LS.75	QR.75
1	1	WP	no	0	257.1778580	144.4129866
2	10	WP	no	1	2131.5080627	1223.4915896
3	100	WP	no	2	18297.7030779	10365.6305798
4	1	WG	no	0	23.5177450	21.0663107
5	10	WG	no	1	196.8980453	178.4773974
6	100	WG	no	2	1707.7944571	1512.0911199
7	1	liquid	no	0	51.5753088	67.3722060
8	10	liquid	no	1	422.4007041	570.7888842
9	100	liquid	no	2	3585.1885063	4835.8213192
10	1	WP	yes	0	5.5926640	1.9024859
11	10	WP	yes	1	47.0768943	16.1181868
12	100	WP	yes	2	410.0002687	136.5560426
13	1	WG	yes	0	0.5083594	0.2775260
14	10	WG	yes	1	4.3231336	2.3512479
15	100	WG	yes	2	38.0421510	19.9201754
16	1	liquid	yes	0	1.0988256	0.8875564
17	10	liquid	yes	1	9.1425074	7.5195301
18	100	liquid	yes	2	78.8054778	63.7067487

Summary of LS fit (mean):

Call:
 lm(formula = frm, contrasts.arg = contrasts)

Residuals:

Min	1Q	Median	3Q	Max
-1.74472	-0.56194	0.02995	0.51224	3.11220

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	0.7919	0.1482	5.342	3.54e-07 ***
lTA	0.9236	0.1402	6.587	8.00e-10 ***
formWP	1.0281	0.2310	4.451	1.70e-05 ***

```

formliquid      0.3347      0.1775      1.886      0.0613 .
face.shield.MLyes -1.6696      0.1807     -9.237 3.18e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

```

Residual standard error: 0.8441 on 143 degrees of freedom
Multiple R-squared:  0.6402,    Adjusted R-squared:  0.6302
F-statistic: 63.62 on 4 and 143 DF,  p-value: < 2.2e-16

```

Summary of RQ fit (75th percentile):

```

Call: rq(formula = frm, tau = TAU, contrasts = contrasts)
Formula: lhd.ML ~ lTA + form + face.shield.ML

```

```

N: 148      tau: 0.75      AIC: 396.759300911915

```

	coefficients	lower bd	upper bd	Std. Error	t value	Pr(> t)
(Intercept)	1.3235885	1.03513261	1.606069	0.2218158	5.967060	1.812972e-08
lTA	0.9279947	0.62095288	1.231410	0.1667781	5.564247	1.258027e-07
formWP	0.8360178	0.53364686	1.205082	0.2597173	3.218953	1.592193e-03
formliquid	0.5048923	0.05213901	1.018461	0.2579160	1.957585	5.222586e-02
face.shield.MLyes	-1.8802848	-2.03863457	-1.387400	0.2408257	-7.807659	1.130207e-12

Formula for mean (based on LS-estimate):

```

log(hd.ML) = 0.792 + 0.924 log(TA) + 1.028 formWP + 0.335 formliquid + -1.67
face.shield.MLyes

```

Formula for 75th percentile (based on quantile regression):

```

log(hd.ML) = 1.324 + 0.928 log(TA) + 0.836 formWP + 0.505 formliquid + -1.88
face.shield.MLyes

```

=====
Model: lria.ML ~ form2

Table of measured values:

	n	min	50%	75%	90%	95%	max
WG	91	0.0100000	9.981061	34.016927	89.84375	199.62565	824.89583
WP	20	559.4298246	1811.458333	4051.741372	4997.47807	5301.26096	8504.38596
liquid	100	0.5208333	3.096413	7.677895	15.10592	30.18280	145.83333
sachets	20	0.1562500	3.622396	7.317909	16.89530	27.97703	33.18376

Table of predicted values (75th percentile):

	TA	form2	lTA	LS.75	QR.75
1	1	WP	0	1045.8183027	495.495495
2	10	WP	1	10458.1830269	4954.954955
3	100	WP	2	104581.8302693	49549.549550
4	1	WG	0	12.0007375	13.229167
5	10	WG	1	120.0073752	132.291667
6	100	WG	2	1200.0737517	1322.916667
7	1	liquid	0	0.6949483	1.041667
8	10	liquid	1	6.9494829	10.416667
9	100	liquid	2	69.4948285	104.166667
10	1	sachets	0	253.1879301	117.129630
11	10	sachets	1	2531.8793015	1171.296296
12	100	sachets	2	25318.7930149	11712.962963

Summary of LS fit (mean):

```

Call:
lm(formula = frm, contrasts.arg = contrasts)

```

Residuals:

Min	1Q	Median	3Q	Max
-2.6297	-0.3432	0.0638	0.5047	1.9473

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	0.55050	0.08159	6.747	1.24e-10 ***


```

form2WP      1.93014    0.19222  10.041 < 2e-16 ***
form2liquid -1.23700    0.11276 -10.970 < 2e-16 ***
form2sachets 1.31413    0.19222   6.837 7.41e-11 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

```

Residual standard error: 0.7783 on 227 degrees of freedom
(424 observations deleted due to missingness)
Multiple R-squared:  0.6424,    Adjusted R-squared:  0.6377
F-statistic:  136 on 3 and 227 DF,  p-value: < 2.2e-16

```

Summary of RQ fit (75th percentile):

```

Call: rq(formula = frm, tau = TAU, contrasts = contrasts)
Formula: lria.ML ~ form2

```

```

N: 231      tau: 0.75      AIC: 540.060047561365

```

	coefficients	lower bd	upper bd	Std. Error	t value	Pr(> t)
(Intercept)	1.1215325	1.0003834	1.1577610	0.07566213	14.822904	0.000000e+00
form2WP	1.5735072	1.4781176	1.7344442	0.11757989	13.382452	0.000000e+00
form2liquid	-1.1038037	-1.4403424	-0.8934966	0.16064160	-6.871220	6.061729e-11
form2sachets	0.9471343	0.8572424	1.4881275	0.26632513	3.556308	4.576884e-04

Formula for mean (based on LS-estimate):

```

log(ia.ML) = log(TA) + 0.55 + 1.93 form2WP + -1.237 form2liquid + 1.314
form2sachets

```

Formula for 75th percentile (based on quantile regression):

```

log(ia.ML) = log(TA) + 1.122 + 1.574 form2WP + -1.104 form2liquid + 0.947
form2sachets

```

=====
Model: lia.ML ~ lTA + form2

Table of measured values:

	n	min	50%	75%	90%	95%	max
WG	91	0.0100000	9.981061	34.016927	89.84375	199.62565	824.89583
WP	20	559.4298246	1811.458333	4051.741372	4997.47807	5301.26096	8504.38596
liquid	100	0.5208333	3.096413	7.677895	15.10592	30.18280	145.83333
sachets	20	0.1562500	3.622396	7.317909	16.89530	27.97703	33.18376

Table of predicted values (75th percentile):

	TA	form2	lTA	LS.75	QR.75
1	1	WP	0	2608.558288	1890.024811
2	10	WP	1	7889.886633	4387.887660
3	100	WP	2	24239.697669	10186.934057
4	1	WG	0	15.802873	22.866578
5	10	WG	1	48.201576	53.087121
6	100	WG	2	149.360331	123.247230
7	1	liquid	0	2.691912	3.259943
8	10	liquid	1	8.094347	7.568294
9	100	liquid	2	24.729731	17.570575
10	1	sachets	0	50.431071	21.193231
11	10	sachets	1	157.613179	49.202273
12	100	sachets	2	499.593202	114.228154

Summary of LS fit (mean):

```

Call:
lm(formula = frm, contrasts.arg = contrasts)

```

Residuals:

Min	1Q	Median	3Q	Max
-2.74423	-0.35685	0.03431	0.49888	1.79480

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	0.70599	0.08033	8.789	3.87e-16 ***

```

lTA          0.48294    0.08655    5.580 6.86e-08 ***
form2WP      2.20620    0.18490   11.932 < 2e-16 ***
form2liquid -0.77308    0.13062   -5.919 1.19e-08 ***
form2sachets 0.48919    0.22610    2.164 0.0315 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

```

Residual standard error: 0.7249 on 226 degrees of freedom
(424 observations deleted due to missingness)
Multiple R-squared:  0.5589,    Adjusted R-squared:  0.5511
F-statistic: 71.6 on 4 and 226 DF,  p-value: < 2.2e-16

```

Summary of RQ fit (75th percentile):

```

Call: rq(formula = frm, tau = TAU, contrasts = contrasts)
Formula: lia.ML ~ lTA + form2

```

```

N: 231      tau: 0.75      AIC: 487.488025084826

```

	coefficients	lower bd	upper bd	Std. Error	t value	Pr(> t)
(Intercept)	1.35920118	1.1981880	1.5132286	0.1028055	13.2210908	0.000000000000
lTA	0.36578799	0.3008988	0.5673715	0.1034971	3.5342815	0.000495794735
form2WP	1.91726633	1.7186971	2.0862519	0.1581929	12.1198032	0.000000000000
form2liquid	-0.84599118	-1.0304209	-0.7534095	0.1561232	-5.4187410	0.000000153439
form2sachets	-0.03300401	-0.2676859	0.6640757	0.3043896	-0.1084269	0.913753296272

Formula for mean (based on LS-estimate):

```

log(ia.ML) = 0.706 + 0.483 log(TA) + 2.206 form2WP + -0.773 form2liquid + 0.489
form2sachets

```

Formula for 75th percentile (based on quantile regression):

```

log(ia.ML) = 1.359 + 0.366 log(TA) + 1.917 form2WP + -0.846 form2liquid + -0.033
form2sachets

```

HCHH greenhouse

Model: lrph.A ~ dense2

Table of measured values:

	n	min	50%	75%	90%	95%	max
normal	28	3091.792	10020.99	20209.75	32675.49	41784.86	52942.41
dense	19	1805.800	8443.70	25503.10	51231.71	63304.05	92299.54

Table of predicted values (75th percentile):

	TA	dense2	lTA	LS.75	QR.75
1	0.2	dense	-0.69897	4740.109	6569.843
2	1.0	dense	0.00000	23700.545	32849.214
3	5.0	dense	0.69897	118502.725	164246.072
4	0.2	normal	-0.69897	6808.764	6399.405
5	1.0	normal	0.00000	34043.818	31997.025
6	5.0	normal	0.69897	170219.090	159985.123

Summary of LS fit (mean):

Call:

```

lm(formula = frm, contrasts.arg = contrasts)

```

Residuals:

	Min	1Q	Median	3Q	Max
	-0.60215	-0.29346	-0.00805	0.32020	0.85186

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	4.25171	0.07655	55.539	<2e-16 ***
dense2dense	-0.15956	0.12040	-1.325	0.192

```

---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

Residual standard error: 0.4051 on 45 degrees of freedom
 (35 observations deleted due to missingness)
 Multiple R-squared: 0.03756, Adjusted R-squared: 0.01617
 F-statistic: 1.756 on 1 and 45 DF, p-value: 0.1918

Summary of RQ fit (75th percentile):

Call: rq(formula = frm, tau = TAU, contrasts = contrasts)
 Formula: lrph.A ~ dense2

N: 47 tau: 0.75 AIC: 65.4969412090659

	coefficients	lower bd	upper bd	Std. Error	t value	Pr(> t)
(Intercept)	4.50510960	4.3312471	4.690120	0.1158828	38.87642964	0.0000000
dense2dense	0.01141539	-0.2815134	0.307471	0.2392647	0.04771031	0.9621582

Formula for mean (based on LS-estimate):

$\log(\text{ph.A}) = \log(\text{TA}) + 4.252 + -0.16 \text{ dense2dense}$

Formula for 75th percentile (based on quantile regression):

$\log(\text{ph.A}) = \log(\text{TA}) + 4.505 + 0.011 \text{ dense2dense}$

=====
Model: lph.A ~ lTA + dense2

Table of measured values:

	n	min	50%	75%	90%	95%	max
normal	28	3091.792	10020.99	20209.75	32675.49	41784.86	52942.41
dense	19	1805.800	8443.70	25503.10	51231.71	63304.05	92299.54

Table of predicted values (75th percentile):

	TA	dense2	lTA	LS.75	QR.75
1	0.2	dense	-0.69897	5713.357	6223.063
2	1.0	dense	0.00000	23365.013	32864.847
3	5.0	dense	0.69897	118942.642	173563.735
4	0.2	normal	-0.69897	8067.267	6248.813
5	1.0	normal	0.00000	33409.772	33000.835
6	5.0	normal	0.69897	172082.358	174281.908

Summary of LS fit (mean):

Call:
 lm(formula = frm, contrasts.arg = contrasts)

Residuals:

	Min	1Q	Median	3Q	Max
	-0.60652	-0.28514	0.01302	0.31194	0.86490

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	4.2371	0.1010	41.937	<2e-16 ***
lTA	0.9180	0.3639	2.522	0.0154 *
dense2dense	-0.1562	0.1226	-1.274	0.2093

 Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.4094 on 44 degrees of freedom
 (35 observations deleted due to missingness)
 Multiple R-squared: 0.1425, Adjusted R-squared: 0.1036
 F-statistic: 3.657 on 2 and 44 DF, p-value: 0.03393

Summary of RQ fit (75th percentile):

Call: rq(formula = frm, tau = TAU, contrasts = contrasts)
 Formula: lph.A ~ lTA + dense2

N: 47 tau: 0.75 AIC: 67.3817380340511

	coefficients	lower bd	upper bd	Std. Error	t value	Pr(> t)
(Intercept)	4.518524929	4.29338882	4.714895	0.1742835	25.926290638	0.0000000
lTA	1.033989118	-0.02371211	1.621313	0.6253927	1.653343677	0.1053794
dense2dense	-0.001793319	-0.34058672	0.332503	0.2532005	-0.007082603	0.9943810

Formula for mean (based on LS-estimate):

$\log(\text{ph.A}) = 4.237 + 0.918 \log(\text{TA}) + -0.156 \text{dense2dense}$

Formula for 75th percentile (based on quantile regression):

$\log(\text{ph.A}) = 4.519 + 1.034 \log(\text{TA}) + -0.002 \text{dense2dense}$

=====
Model: lrib.A ~ rain.dense

Table of measured values:

	n	min	50%	75%	90%	95%	max
normal	30	121.21	2290.537	16740.108	37715.61	96559.71	190123.9
dense	10	57091.10	259233.450	333253.775	856785.27	904220.53	951655.8
suit	16	113.10	1151.900	1623.375	3426.05	4346.85	4644.9
trousers	NA	NA	NA	NA	NA	NA	NA
prot	NA	NA	NA	NA	NA	NA	NA

Table of predicted values (75th percentile):

	TA	rain.dense	lTA	LS.75	QR.75
1	0.2	normal	-0.69897	2489.8815	3140.28
2	1.0	normal	0.00000	12449.4073	15701.40
3	5.0	normal	0.69897	62247.0366	78507.01
4	0.2	dense	-0.69897	216223.9238	136368.80
5	1.0	dense	0.00000	1081119.6189	681843.99
6	5.0	dense	0.69897	5405598.0943	3409219.97
7	0.2	suit	-0.69897	808.3293	442.96
8	1.0	suit	0.00000	4041.6467	2214.80
9	5.0	suit	0.69897	20208.2337	11074.00

Summary of LS fit (mean):

Call:

`lm(formula = frm, contrasts.arg = contrasts)`

Residuals:

	Min	1Q	Median	3Q	Max
	-1.21126	-0.39876	-0.02094	0.35680	1.67593

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	3.6474	0.1184	30.805	< 2e-16 ***
rain.densedense	1.9245	0.2368	8.127	7.02e-11 ***
rain.densesuit	-0.4949	0.2008	-2.465	0.017 *

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.6485 on 53 degrees of freedom

(26 observations deleted due to missingness)

Multiple R-squared: 0.6343, Adjusted R-squared: 0.6205

F-statistic: 45.96 on 2 and 53 DF, p-value: 2.647e-12

Summary of RQ fit (75th percentile):

Call: `rq(formula = frm, tau = TAU, contrasts = contrasts)`

Formula: `lrib.A ~ rain.dense`

N: 56 tau: 0.75 AIC: 124.794559998059

	coefficients	lower bd	upper bd	Std. Error	t value	Pr(> t)
(Intercept)	4.1959384	3.955609	4.7210479	0.2528868	16.592163	0.00000000000
rain.densedense	1.6377466	1.188595	2.0173248	0.3457749	4.736453	0.00001666607
rain.densesuit	-0.8506039	-1.183108	-0.3955326	0.2908201	-2.924846	0.00506212602

Formula for mean (based on LS-estimate):

$\log(\text{ib.A}) = \log(\text{TA}) + 3.647 + 1.925 \text{ rain.densedense} + -0.495 \text{ rain.densesuit}$

Formula for 75th percentile (based on quantile regression):

$\log(\text{ib.A}) = \log(\text{TA}) + 4.196 + 1.638 \text{ rain.densedense} + -0.851 \text{ rain.densesuit}$

=====
Model: lib.A ~ lTA + rain.dense

Table of measured values:

	n	min	50%	75%	90%	95%	max
normal	30	121.21	2290.537	16740.108	37715.61	96559.71	190123.9
dense	10	57091.10	259233.450	333253.775	856785.27	904220.53	951655.8
suit	16	113.10	1151.900	1623.375	3426.05	4346.85	4644.9
trousers	NA	NA	NA	NA	NA	NA	NA
prot	NA	NA	NA	NA	NA	NA	NA

Table of predicted values (75th percentile):

	TA	rain.dense	lTA	LS.75	QR.75
1	0.2	normal	-0.69897	941.7243	1605.2581
2	1.0	normal	0.00000	18181.2647	21491.0204
3	5.0	normal	0.69897	481659.7282	287719.4400
4	0.2	dense	-0.69897	72390.3866	60647.7058
5	1.0	dense	0.00000	1356856.8225	811944.8779
6	5.0	dense	0.69897	34790947.1964	10870229.5765
7	0.2	suit	-0.69897	292.7185	155.3434
8	1.0	suit	0.00000	5592.4020	2079.7204
9	5.0	suit	0.69897	146387.8095	27843.0699

Summary of LS fit (mean):

Call:

`lm(formula = frm, contrasts.arg = contrasts)`

Residuals:

Min	1Q	Median	3Q	Max
-1.06644	-0.47779	-0.00844	0.35476	1.54949

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	3.8132	0.1549	24.610	< 2e-16 ***
lTA	1.8878	0.5464	3.455	0.0011 **
rain.densedense	1.8623	0.2364	7.879	1.98e-10 ***
rain.densesuit	-0.5168	0.1982	-2.608	0.0119 *

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.6387 on 52 degrees of freedom

(26 observations deleted due to missingness)

Multiple R-squared: 0.6817, Adjusted R-squared: 0.6633

F-statistic: 37.12 on 3 and 52 DF, p-value: 5.756e-13

Summary of RQ fit (75th percentile):

Call: `rq(formula = frm, tau = TAU, contrasts = contrasts)`

Formula: `lib.A ~ lTA + rain.dense`

N: 56 tau: 0.75 AIC: 124.623310272737

	coefficients	lower bd	upper bd	Std. Error	t value	Pr(> t)
(Intercept)	4.332257	4.0669075	4.7075883	0.2600579	16.658815	0.00000000000
lTA	1.611961	0.8849043	2.2399704	0.7822316	2.060721	0.04434792243
rain.densedense	1.577270	1.3353518	2.0595542	0.3257785	4.841540	0.00001195877
rain.densesuit	-1.014252	-1.0286841	-0.4327162	0.2385450	-4.251827	0.00008836832

Formula for mean (based on LS-estimate):

$\log(\text{ib.A}) = 3.813 + 1.888 \log(\text{TA}) + 1.862 \text{ rain.densedense} + -0.517 \text{ rain.densesuit}$

Formula for 75th percentile (based on quantile regression):

```
log(ib.A) = 4.332 + 1.612 log(TA) + 1.577 rain.densedense + -1.014 rain.densesuit
```

```
=====
```

Model: lrtb.A ~ dense2

Table of measured values:

	n	min	50%	75%	90%	95%	max
normal	30	29493.7	156873.2	368956.5	586392.7	694922.1	930188.1
dense	10	477327.4	1165891.1	1707501.9	2058069.4	2285863.9	2513658.4

Table of predicted values (75th percentile):

	TA	dense2	lTA	LS.75	QR.75
1	0.2	dense	-0.69897	555253.66	343085.20
2	1.0	dense	0.00000	2776268.28	1715426.02
3	5.0	dense	0.69897	13881341.38	8577130.12
4	0.2	normal	-0.69897	84318.47	80017.59
5	1.0	normal	0.00000	421592.35	400087.97
6	5.0	normal	0.69897	2107961.77	2000439.84

Summary of LS fit (mean):

Call:

```
lm(formula = frm, contrasts.arg = contrasts)
```

Residuals:

Min	1Q	Median	3Q	Max
-0.75906	-0.19261	0.05287	0.21799	0.72949

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	5.37221	0.06664	80.612	< 2e-16 ***
dense2dense	0.81054	0.13329	6.081	0.00000044 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.365 on 38 degrees of freedom

(42 observations deleted due to missingness)

Multiple R-squared: 0.4932, Adjusted R-squared: 0.4799

F-statistic: 36.98 on 1 and 38 DF, p-value: 0.0000004405

Summary of RQ fit (75th percentile):

Call: rq(formula = frm, tau = TAU, contrasts = contrasts)

Formula: lrtb.A ~ dense2

N: 40 tau: 0.75 AIC: 37.3386410093183

	coefficients	lower bd	upper bd	Std. Error	t value	Pr(> t)
(Intercept)	5.6021555	5.5427917	5.8063137	0.1031325	54.319993	0.00000000
dense2dense	0.6322165	0.4828467	0.9880907	0.1810167	3.492586	0.00123058

Formula for mean (based on LS-estimate):

```
log(tb.A) = log(TA) + 5.372 + 0.811 dense2dense
```

Formula for 75th percentile (based on quantile regression):

```
log(tb.A) = log(TA) + 5.602 + 0.632 dense2dense
```

```
=====
```

Model: ltb.A ~ lTA + dense2

Table of measured values:

	n	min	50%	75%	90%	95%	max
normal	30	29493.7	156873.2	368956.5	586392.7	694922.1	930188.1
dense	10	477327.4	1165891.1	1707501.9	2058069.4	2285863.9	2513658.4

Table of predicted values (75th percentile):

	TA	dense2	lTA	LS.75	QR.75
1	0.2	dense	-0.69897	421778.71	216667.27
2	1.0	dense	0.00000	2996966.00	1703093.75
3	5.0	dense	0.69897	26052862.46	13387016.20
4	0.2	normal	-0.69897	65871.98	58934.23
5	1.0	normal	0.00000	477066.57	463247.25
6	5.0	normal	0.69897	4233655.66	3641313.60

Summary of LS fit (mean):

Call:

```
lm(formula = frm, contrasts.arg = contrasts)
```

Residuals:

	Min	1Q	Median	3Q	Max
	-0.77042	-0.17671	0.03886	0.22279	0.71547

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	5.42102	0.09143	59.293	< 2e-16 ***
lTA	1.26145	0.33325	3.785	0.000546 ***
dense2dense	0.79221	0.13599	5.826	0.00000108 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.3669 on 37 degrees of freedom

(42 observations deleted due to missingness)

Multiple R-squared: 0.6086, Adjusted R-squared: 0.5875

F-statistic: 28.77 on 2 and 37 DF, p-value: 0.00000002902

Summary of RQ fit (75th percentile):

Call: rq(formula = frm, tau = TAU, contrasts = contrasts)

Formula: ltb.A ~ lTA + dense2

N: 40 tau: 0.75 AIC: 37.2920031223759

	coefficients	lower bd	upper bd	Std. Error	t value	Pr(> t)
(Intercept)	5.6658128	5.5452853	5.9248759	0.08875108	63.839370	0.0000000000
lTA	1.2810925	0.9608907	1.4079714	0.46080429	2.780123	0.0084931704
dense2dense	0.5654257	0.5232938	0.9651337	0.14674520	3.853112	0.0004481649

Formula for mean (based on LS-estimate):

$\log(\text{tb.A}) = 5.421 + 1.261 \log(\text{TA}) + 0.792 \text{dense2dense}$

Formula for 75th percentile (based on quantile regression):

$\log(\text{tb.A}) = 5.666 + 1.281 \log(\text{TA}) + 0.565 \text{dense2dense}$

=====
Model: lrhd.A ~ dense2

Table of measured values:

	n	min	50%	75%	90%	95%	max
normal	29	1.666667	395.8	498.0	724.6	1156.6	2651.6
dense	31	10.800000	294.2	849.2	3972.0	6072.4	7905.4

Table of predicted values (75th percentile):

	TA	dense2	rain	lTA	LS.75	QR.75
1	0.2	dense	suit	-0.69897	267.3942	237.2148
2	1.0	dense	suit	0.00000	1336.9709	1186.0741
3	5.0	dense	suit	0.69897	6684.8543	5930.3704
4	0.2	normal	suit	-0.69897	176.5372	161.2121
5	1.0	normal	suit	0.00000	882.6860	806.0606
6	5.0	normal	suit	0.69897	4413.4301	4030.3030
7	0.2	dense	none	-0.69897	267.3942	237.2148
8	1.0	dense	none	0.00000	1336.9709	1186.0741
9	5.0	dense	none	0.69897	6684.8543	5930.3704
10	0.2	normal	none	-0.69897	176.5372	161.2121
11	1.0	normal	none	0.00000	882.6860	806.0606

12 5.0 normal none 0.69897 4413.4301 4030.3030

Summary of LS fit (mean):

Call:

lm(formula = frm, contrasts.arg = contrasts)

Residuals:

Min	1Q	Median	3Q	Max
-1.71635	-0.38463	0.03428	0.40086	1.44325

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	2.4957	0.1211	20.614	<2e-16 ***
dense2dense	0.1808	0.1684	1.073	0.288

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.652 on 58 degrees of freedom

(22 observations deleted due to missingness)

Multiple R-squared: 0.01948, Adjusted R-squared: 0.002574

F-statistic: 1.152 on 1 and 58 DF, p-value: 0.2875

Summary of RQ fit (75th percentile):

Call: rq(formula = frm, tau = TAU, contrasts = contrasts)

Formula: lrhd.A ~ dense2

N: 60 tau: 0.75 AIC: 130.384604005397

	coefficients	lower bd	upper bd	Std. Error	t value	Pr(> t)
(Intercept)	2.9063677	2.7425483	3.0464676	0.1082237	26.8551880	0.0000000
dense2dense	0.1677441	-0.3100409	0.6305597	0.2991242	0.5607842	0.5771047

Formula for mean (based on LS-estimate):

log(hd.A) = log(TA) + 2.496 + 0.181 dense2dense

Formula for 75th percentile (based on quantile regression):

log(hd.A) = log(TA) + 2.906 + 0.168 dense2dense

=====
Model: lhd.A ~ lTA + dense2

Table of measured values:

	n	min	50%	75%	90%	95%	max
normal	29	1.666667	395.8	498.0	724.6	1156.6	2651.6
dense	31	10.800000	294.2	849.2	3972.0	6072.4	7905.4

Table of predicted values (75th percentile):

	TA	dense2	rain	lTA	LS.75	QR.75
1	0.2	dense	suit	-0.69897	149.1838	593.6144
2	1.0	dense	suit	0.00000	1598.7000	912.7744
3	5.0	dense	suit	0.69897	23227.6099	1403.5325
4	0.2	normal	suit	-0.69897	103.3269	356.8915
5	1.0	normal	suit	0.00000	1134.0901	548.7762
6	5.0	normal	suit	0.69897	16803.7777	843.8287
7	0.2	dense	none	-0.69897	149.1838	593.6144
8	1.0	dense	none	0.00000	1598.7000	912.7744
9	5.0	dense	none	0.69897	23227.6099	1403.5325
10	0.2	normal	none	-0.69897	103.3269	356.8915
11	1.0	normal	none	0.00000	1134.0901	548.7762
12	5.0	normal	none	0.69897	16803.7777	843.8287

Summary of LS fit (mean):

Call:

lm(formula = frm, contrasts.arg = contrasts)

Residuals:

	Min	1Q	Median	3Q	Max
	-1.52278	-0.36402	-0.01831	0.38690	1.48671

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	2.5989	0.1596	16.279	< 2e-16 ***
lTA	1.5324	0.5366	2.856	0.00598 **
dense2dense	0.1522	0.1709	0.891	0.37684

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.6521 on 57 degrees of freedom

(22 observations deleted due to missingness)

Multiple R-squared: 0.1504, Adjusted R-squared: 0.1206

F-statistic: 5.046 on 2 and 57 DF, p-value: 0.009602

Summary of RQ fit (75th percentile):

Call: rq(formula = frm, tau = TAU, contrasts = contrasts)

Formula: lhd.A ~ lTA + dense2

N: 60 tau: 0.75 AIC: 130.215167455779

	coefficients	lower bd	upper bd	Std. Error	t value	Pr(> t)
(Intercept)	2.7393953	2.6565595	3.0388547	0.1408641	19.4470847	0.0000000
lTA	0.2673348	-0.3694892	2.1771235	0.6110573	0.4374955	0.6634053
dense2dense	0.2209682	-0.2711752	0.4639182	0.2918630	0.7570955	0.4521110

Formula for mean (based on LS-estimate):

log(hd.A) = 2.599 + 1.532 log(TA) + 0.152 dense2dense

Formula for 75th percentile (based on quantile regression):

log(hd.A) = 2.739 + 0.267 log(TA) + 0.221 dense2dense

=====
Model: lria.A ~ dense2

Table of measured values:

	n	min	50%	75%	90%	95%	max
normal	30	0.4528986	186.3419	237.0747	370.8438	534.9991	2213.542
dense	32	40.6250000	247.2222	409.0885	557.5313	1068.4371	2253.125

Table of predicted values (75th percentile):

	TA	dense2	lTA	LS.75	QR.75
1	0.2	dense	-0.69897	135.07819	107.02960
2	1.0	dense	0.00000	675.39096	535.14799
3	5.0	dense	0.69897	3376.95478	2675.73996
4	0.2	normal	-0.69897	98.23112	78.60373
5	1.0	normal	0.00000	491.15562	393.01864
6	5.0	normal	0.69897	2455.77808	1965.09321

Summary of LS fit (mean):

Call:

lm(formula = frm, contrasts.arg = contrasts)

Residuals:

	Min	1Q	Median	3Q	Max
	-2.46497	-0.16959	0.05089	0.21450	0.86904

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	2.37667	0.08325	28.548	<2e-16 ***
dense2dense	0.13865	0.11588	1.197	0.236

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.456 on 60 degrees of freedom
 (20 observations deleted due to missingness)
 Multiple R-squared: 0.02331, Adjusted R-squared: 0.007027
 F-statistic: 1.432 on 1 and 60 DF, p-value: 0.2362

Summary of RQ fit (75th percentile):

Call: rq(formula = frm, tau = TAU, contrasts = contrasts)
 Formula: lria.A ~ dense2

N: 62 tau: 0.75 AIC: 52.079572162863

	coefficients	lower bd	upper bd	Std. Error	t value	Pr(> t)
(Intercept)	2.5944132	2.58262870	2.6598143	0.03623713	71.595445	0.0000000
dense2dense	0.1340607	0.02778595	0.1986398	0.09406814	1.425145	0.1592967

Formula for mean (based on LS-estimate):

$\log(\text{ia.A}) = \log(\text{TA}) + 2.377 + 0.139 \text{ dense2dense}$

Formula for 75th percentile (based on quantile regression):

$\log(\text{ia.A}) = \log(\text{TA}) + 2.594 + 0.134 \text{ dense2dense}$

=====
Model: lia.A ~ lTA + dense2

Table of measured values:

	n	min	50%	75%	90%	95%	max
normal	30	0.4528986	186.3419	237.0747	370.8438	534.9991	2213.542
dense	32	40.6250000	247.2222	409.0885	557.5313	1068.4371	2253.125

Table of predicted values (75th percentile):

	TA	dense2	lTA	LS.75	QR.75
1	0.2	dense	-0.69897	113.36767	105.09825
2	1.0	dense	0.00000	726.19338	542.22560
3	5.0	dense	0.69897	5726.38008	2797.46419
4	0.2	normal	-0.69897	83.24548	76.32938
5	1.0	normal	0.00000	540.52883	393.80050
6	5.0	normal	0.69897	4310.32630	2031.70562

Summary of LS fit (mean):

Call:

`lm(formula = frm, contrasts.arg = contrasts)`

Residuals:

	Min	1Q	Median	3Q	Max
	-2.45161	-0.18688	0.05309	0.22508	0.89981

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	2.4128	0.1088	22.185	< 2e-16 ***
lTA	1.1936	0.3715	3.213	0.00213 **
dense2dense	0.1300	0.1178	1.104	0.27407

 Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.4588 on 59 degrees of freedom

(20 observations deleted due to missingness)

Multiple R-squared: 0.1782, Adjusted R-squared: 0.1503

F-statistic: 6.396 on 2 and 59 DF, p-value: 0.00306

Summary of RQ fit (75th percentile):

Call: rq(formula = frm, tau = TAU, contrasts = contrasts)

Formula: lia.A ~ lTA + dense2

N: 62 tau: 0.75 AIC: 54.0708668633863

	coefficients	lower bd	upper bd	Std. Error	t value	Pr(> t)
(Intercept)	2.5952763	2.546464278	2.7193796	0.05547017	46.786878	0.000000000000000
lTA	1.0194780	0.755705430	1.3338936	0.16544558	6.162014	0.00000006951745
dense2dense	0.1389038	0.005000392	0.1950696	0.10006166	1.388182	0.17030138485920

Formula for mean (based on LS-estimate):

$\log(\text{ia.A}) = 2.413 + 1.194 \log(\text{TA}) + 0.13 \text{ dense2dense}$

Formula for 75th percentile (based on quantile regression):

$\log(\text{ia.A}) = 2.595 + 1.019 \log(\text{TA}) + 0.139 \text{ dense2dense}$

III-2: 95th percentile level

ML tank

Model: lrph.ML ~ form2 + glove.wash.ML

Table of measured values:

	n	min	50%	75%	90%	95%	max
WG	90	21.22	1187	2266	5007	6790	40939
WP	20	5844.70	75873	96066	134406	147404	179582
liquid	169	71.50	8250	30251	127822	553049	2346736
sachets	20	795.01	2258	4122	10838	13195	15830

Table of predicted values (95th percentile):

	TA	form2	glove.wash.ML	lTA	LS.75	QR.75
1	1	WP		0	30554	36940
2	10	WP		1	305539	369402
3	100	WP		2	3055390	3694024
4	1	WG		0	1610	6522
5	10	WG		1	16103	65225
6	100	WG		2	161032	652247
7	1	liquid		0	2738	12019
8	10	liquid		1	27385	120185
9	100	liquid		2	273849	1201852
10	1	sachets		0	144770	313349
11	10	sachets		1	1447703	3133493
12	100	sachets		2	14477031	31334930

Summary of LS fit (mean):

Call:

```
lm(formula = frm, contrasts.arg = contrasts)
```

Residuals:

Min	1Q	Median	3Q	Max
-2.4037	-0.4368	0.0346	0.4619	1.4211

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	2.7762	0.0680	40.80	< 2e-16 ***
form2WP	1.2697	0.1573	8.07	1.8e-14 ***
form2liquid	0.2317	0.0828	2.80	0.0055 **
form2sachets	1.9456	0.1573	12.37	< 2e-16 ***
glove.wash.MLyes	-0.3800	0.1269	-2.99	0.0030 **

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.634 on 294 degrees of freedom

(356 observations deleted due to missingness)

Multiple R-squared: 0.42, Adjusted R-squared: 0.413

F-statistic: 53.3 on 4 and 294 DF, p-value: <2e-16

Summary of RQ fit (95th percentile):

Call: rq(formula = frm, tau = TAU, contrasts = contrasts)

Formula: lrph.ML ~ form2 + glove.wash.ML

N: 299 tau: 0.95 AIC: 717.058328290493

	coefficients	lower bd	upper bd	Std. Error	t value	Pr(> t)
(Intercept)	3.8144	3.6359	3.853e+00	0.09109	41.876	0.0000000000
form2WP	0.7531	0.5854	1.798e+308	0.18933	3.978	0.0000876883
form2liquid	0.2654	0.1092	5.881e-01	0.16827	1.577	0.1157705189
form2sachets	1.6816	1.4385	1.798e+308	0.13480	12.475	0.0000000000

glove.wash.MLyes -0.6800 -0.8036 1.798e+308 0.13570 -5.011 0.0000009345

Formula for mean (based on LS-estimate):

log(ph.ML) = log(TA) + 2.776 + 1.27 form2WP + 0.232 form2liquid + 1.946 form2sachets + -0.38 glove.wash.MLyes

Formula for 95th percentile (based on quantile regression):

log(ph.ML) = log(TA) + 3.814 + 0.753 form2WP + 0.265 form2liquid + 1.682 form2sachets + -0.68 glove.wash.MLyes

=====
Model: lph.ML ~ lTA + form2 + glove.wash.ML

Table of measured values:

	n	min	50%	75%	90%	95%	max
WG	90	21.22	1187	2266	5007	6790	40939
WP	20	5844.70	75873	96066	134406	147404	179582
liquid	169	71.50	8250	30251	127822	553049	2346736
sachets	20	795.01	2258	4122	10838	13195	15830

Table of predicted values (95th percentile):

	TA	form2	glove.wash.ML	lTA	LS.75	QR.75
1	1	WP		0	55105	76237
2	10	WP		1	252727	470421
3	100	WP		2	1167268	2902735
4	1	WG		0	1919	5414
5	10	WG		1	8835	33407
6	100	WG		2	40966	206140
7	1	liquid		0	5687	16978
8	10	liquid		1	26049	104761
9	100	liquid		2	120170	646427
10	1	sachets		0	50011	212062
11	10	sachets		1	232803	1308534
12	100	sachets		2	1090952	8074321

Summary of LS fit (mean):

Call:

lm(formula = frm, contrasts.arg = contrasts)

Residuals:

Min	1Q	Median	3Q	Max
-2.1727	-0.3727	-0.0129	0.4059	1.6219

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	2.8790	0.0658	43.75	< 2e-16 ***
lTA	0.6625	0.0526	12.59	< 2e-16 ***
form2WP	1.4492	0.1502	9.65	< 2e-16 ***
form2liquid	0.4714	0.0862	5.47	9.6e-08 ***
form2sachets	1.4059	0.1698	8.28	4.5e-15 ***
glove.wash.MLyes	-0.3828	0.1190	-3.22	0.0014 **

 Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.595 on 293 degrees of freedom

(356 observations deleted due to missingness)

Multiple R-squared: 0.572, Adjusted R-squared: 0.565

F-statistic: 78.3 on 5 and 293 DF, p-value: <2e-16

Summary of RQ fit (95th percentile):

Call: rq(formula = frm, tau = TAU, contrasts = contrasts)

Formula: lph.ML ~ lTA + form2 + glove.wash.ML

N: 299 tau: 0.95 AIC: 686.387675350587

	coefficients	lower bd	upper bd	Std. Error	t value	Pr(> t)
(Intercept)	3.7335	3.6970	3.849e+00	0.05647	66.117	0.000e+00

lTA	0.7903	0.7070	8.327e-01	0.07203	10.973	0.000e+00
form2WP	1.1486	0.8243	1.798e+308	0.16982	6.764	7.282e-11
form2liquid	0.4964	0.3585	6.610e-01	0.09268	5.355	1.728e-07
form2sachets	1.5929	1.1536	1.798e+308	0.16674	9.554	0.000e+00
glove.wash.MLyes	-0.7911	-0.8974	1.798e+308	0.06921	-11.432	0.000e+00

Formula for mean (based on LS-estimate):

$\log(\text{ph.ML}) = 2.879 + 0.662 \log(\text{TA}) + 1.449 \text{ form2WP} + 0.471 \text{ form2liquid} + 1.406 \text{ form2sachets} + -0.383 \text{ glove.wash.MLyes}$

Formula for 95th percentile (based on quantile regression):

$\log(\text{ph.ML}) = 3.734 + 0.79 \log(\text{TA}) + 1.149 \text{ form2WP} + 0.496 \text{ form2liquid} + 1.593 \text{ form2sachets} + -0.791 \text{ glove.wash.MLyes}$

=====
Model: lrah.ML ~ form2

Table of measured values:

	n	min	50%	75%	90%	95%	max
WG	91	0.09091	15.220	45.680	153.40	269.00	948.1
WP	20	94.60000	1180.500	3586.500	9459.50	11215.00	11310.0
liquid	167	0.01000	44.110	127.500	698.00	2270.08	33747.5
sachets	20	0.88360	3.075	7.763	54.98	99.97	111.7

Table of predicted values (95th percentile):

	TA	form2	lTA	LS.75	QR.75
1	1	WP	0	852.6	2016.0
2	10	WP	1	8526.0	20160.4
3	100	WP	2	85259.6	201604.3
4	1	WG	0	26.4	166.3
5	10	WG	1	264.0	1663.3
6	100	WG	2	2640.5	16633.3
7	1	liquid	0	17.3	198.1
8	10	liquid	1	173.0	1980.7
9	100	liquid	2	1730.0	19806.8
10	1	sachets	0	495.0	1334.7
11	10	sachets	1	4950.3	13346.7
12	100	sachets	2	49502.5	133466.7

Summary of LS fit (mean):

Call:

`lm(formula = frm, contrasts.arg = contrasts)`

Residuals:

Min	1Q	Median	3Q	Max
-3.447	-0.559	0.090	0.664	2.203

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	0.753	0.103	7.30	2.7e-12 ***
form2WP	1.496	0.243	6.16	2.4e-09 ***
form2liquid	-0.182	0.128	-1.42	0.16
form2sachets	1.260	0.243	5.19	4.0e-07 ***

 Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.984 on 294 degrees of freedom

(357 observations deleted due to missingness)

Multiple R-squared: 0.219, Adjusted R-squared: 0.211

F-statistic: 27.5 on 3 and 294 DF, p-value: 1.01e-15

Summary of RQ fit (95th percentile):

Call: `rq(formula = frm, tau = TAU, contrasts = contrasts)`

Formula: `lrah.ML ~ form2`

N: 298 tau: 0.95 AIC: 959.875114702029

	coefficients	lower bd	upper bd	Std. Error	t value	Pr(> t)
(Intercept)	2.22098	2.0151	2.351e+00	0.1214	18.2901	0.000e+00
form2WP	1.08352	0.8734	1.798e+308	0.1248	8.6823	2.220e-16
form2liquid	0.07583	-0.1363	3.885e-01	0.1950	0.3888	6.977e-01
form2sachets	0.90439	0.8416	1.798e+308	0.1268	7.1323	7.704e-12

Formula for mean (based on LS-estimate):

$\log(\text{ah.ML}) = \log(\text{TA}) + 0.753 + 1.496 \text{ form2WP} + -0.182 \text{ form2liquid} + 1.26 \text{ form2sachets}$

Formula for 95th percentile (based on quantile regression):

$\log(\text{ah.ML}) = \log(\text{TA}) + 2.221 + 1.084 \text{ form2WP} + 0.076 \text{ form2liquid} + 0.904 \text{ form2sachets}$

=====
Model: lah.ML ~ lTA + form2

Table of measured values:

	n	min	50%	75%	90%	95%	max
WG	91	0.09091	15.220	45.680	153.40	269.00	948.1
WP	20	94.60000	1180.500	3586.500	9459.50	11215.00	11310.0
liquid	167	0.01000	44.110	127.500	698.00	2270.08	33747.5
sachets	20	0.88360	3.075	7.763	54.98	99.97	111.7

Table of predicted values (95th percentile):

	TA	form2	lTA	LS.75	QR.75
1	1	WP	0	2112.57	1689.5
2	10	WP	1	6358.63	21390.4
3	100	WP	2	19349.94	270815.6
4	1	WG	0	34.48	163.3
5	10	WG	1	104.39	2066.9
6	100	WG	2	319.59	26168.3
7	1	liquid	0	53.56	150.5
8	10	liquid	1	160.87	1905.9
9	100	liquid	2	488.61	24130.3
10	1	sachets	0	96.40	1868.4
11	10	sachets	1	296.94	23655.0
12	100	sachets	2	924.23	299486.7

Summary of LS fit (mean):

Call:

`lm(formula = frm, contrasts.arg = contrasts)`

Residuals:

Min	1Q	Median	3Q	Max
-3.520	-0.520	-0.033	0.554	2.586

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	0.9098	0.1000	9.10	< 2e-16 ***
lTA	0.4801	0.0818	5.87	1.2e-08 ***
form2WP	1.7738	0.2324	7.63	3.2e-13 ***
form2liquid	0.1906	0.1339	1.42	0.16
form2sachets	0.4308	0.2629	1.64	0.10

 Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.924 on 293 degrees of freedom

(357 observations deleted due to missingness)

Multiple R-squared: 0.307, Adjusted R-squared: 0.298

F-statistic: 32.5 on 4 and 293 DF, p-value: <2e-16

Summary of RQ fit (95th percentile):

Call: `rq(formula = frm, tau = TAU, contrasts = contrasts)`

Formula: lah.ML ~ lTA + form2

N: 298 tau: 0.95 AIC: 959.452725610658

	coefficients	lower bd	upper bd	Std. Error	t value	Pr(> t)
(Intercept)	2.21287	1.9755	2.354e+00	0.1433	15.4449	0.000e+00
lTA	1.10245	0.6956	1.498e+00	0.1202	9.1693	0.000e+00
form2WP	1.01490	0.7090	1.798e+308	0.1233	8.2281	6.217e-15
form2liquid	-0.03521	-0.4890	4.945e-01	0.2005	-0.1757	8.607e-01
form2sachets	1.05860	0.8346	1.798e+308	0.2593	4.0828	5.746e-05

Formula for mean (based on LS-estimate):

log(ah.ML) = 0.91 + 0.48 log(TA) + 1.774 form2WP + 0.191 form2liquid + 0.431 form2sachets

Formula for 95th percentile (based on quantile regression):

log(ah.ML) = 2.213 + 1.102 log(TA) + 1.015 form2WP + -0.035 form2liquid + 1.059 form2sachets

=====
Model: lrhd.ML ~ form + face.shield.ML

Table of measured values:

	n	min	50%	75%	90%	95%	max
WG	48	0.01	23.01	129.8	301.2	1121	2359
WP	20	65.76	443.00	856.4	1073.6	1534	2610
liquid	80	0.45	20.00	245.0	2428.1	4028	19050

Table of predicted values (95th percentile):

	TA	form	face.shield.ML	lTA	LS.75	QR.75
1	1	WP	no	0	218.6127	198.941
2	10	WP	no	1	2186.1270	1989.412
3	100	WP	no	2	21861.2695	19894.118
4	1	WG	no	0	21.1766	93.981
5	10	WG	no	1	211.7658	939.810
6	100	WG	no	2	2117.6577	9398.096
7	1	liquid	no	0	40.8800	284.558
8	10	liquid	no	1	408.8000	2845.581
9	100	liquid	no	2	4087.9997	28455.806
10	1	WP	yes	0	5.1879	11.264
11	10	WP	yes	1	51.8790	112.637
12	100	WP	yes	2	518.7901	1126.365
13	1	WG	yes	0	0.4973	5.321
14	10	WG	yes	1	4.9733	53.210
15	100	WG	yes	2	49.7330	532.101
16	1	liquid	yes	0	0.9555	16.111
17	10	liquid	yes	1	9.5553	161.111
18	100	liquid	yes	2	95.5532	1611.111

Summary of LS fit (mean):

Call:

lm(formula = frm, contrasts.arg = contrasts)

Residuals:

Min	1Q	Median	3Q	Max
-1.7896	-0.5867	0.0139	0.5249	3.0854

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	0.750	0.127	5.93	0.000000022 ***
formWP	1.006	0.227	4.44	0.000018146 ***
formliquid	0.287	0.155	1.86	0.065 .
face.shield.MLyes	-1.636	0.169	-9.66	< 2e-16 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.842 on 144 degrees of freedom

Multiple R-squared: 0.48, Adjusted R-squared: 0.469
F-statistic: 44.3 on 3 and 144 DF, p-value: <2e-16

Summary of RQ fit (95th percentile):

Call: rq(formula = frm, tau = TAU, contrasts = contrasts)
Formula: lrhd.ML ~ form + face.shield.ML

N: 148 tau: 0.95 AIC: 482.371273757783

	coefficients	lower bd	upper bd	Std. Error	t value	Pr(> t)
(Intercept)	1.9730	1.84693	1.798e+308	0.4268	4.6226	0.000008352
formWP	0.3257	0.05528	1.798e+308	0.4499	0.7239	0.470310470
formliquid	0.4811	-0.62078	9.873e-01	0.5200	0.9252	0.356405005
face.shield.MLyes	-1.2470	-2.37845	1.798e+308	0.9865	-1.2642	0.208214280

Formula for mean (based on LS-estimate):

log(hd.ML) = log(TA) + 0.75 + 1.006 formWP + 0.287 formliquid + -1.636
face.shield.MLyes

Formula for 95th percentile (based on quantile regression):

log(hd.ML) = log(TA) + 1.973 + 0.326 formWP + 0.481 formliquid + -1.247
face.shield.MLyes

=====
Model: lhd.ML ~ lTA + form + face.shield.ML

Table of measured values:

	n	min	50%	75%	90%	95%	max
WG	48	0.01	23.01	129.8	301.2	1121	2359
WP	20	65.76	443.00	856.4	1073.6	1534	2610
liquid	80	0.45	20.00	245.0	2428.1	4028	19050

Table of predicted values (95th percentile):

	TA	form	face.shield.ML	lTA	LS.75	QR.75
1	1	WP	no	0	257.1779	266.858
2	10	WP	no	1	2131.5081	1762.006
3	100	WP	no	2	18297.7031	11634.131
4	1	WG	no	0	23.5177	168.021
5	10	WG	no	1	196.8980	1109.406
6	100	WG	no	2	1707.7945	7325.158
7	1	liquid	no	0	51.5753	578.097
8	10	liquid	no	1	422.4007	3817.042
9	100	liquid	no	2	3585.1885	25203.077
10	1	WP	yes	0	5.5927	9.369
11	10	WP	yes	1	47.0769	61.861
12	100	WP	yes	2	410.0003	408.456
13	1	WG	yes	0	0.5084	5.899
14	10	WG	yes	1	4.3231	38.950
15	100	WG	yes	2	38.0422	257.175
16	1	liquid	yes	0	1.0988	20.296
17	10	liquid	yes	1	9.1425	134.010
18	100	liquid	yes	2	78.8055	884.841

Summary of LS fit (mean):

Call:

lm(formula = frm, contrasts.arg = contrasts)

Residuals:

Min	1Q	Median	3Q	Max
-1.745	-0.562	0.030	0.512	3.112

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	0.792	0.148	5.34	3.5e-07 ***
lTA	0.924	0.140	6.59	8.0e-10 ***
formWP	1.028	0.231	4.45	1.7e-05 ***
formliquid	0.335	0.177	1.89	0.061 .

```
face.shield.MLyes  -1.670      0.181   -9.24  3.2e-16 ***
```

```
---
```

```
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
Residual standard error: 0.844 on 143 degrees of freedom
```

```
Multiple R-squared:  0.64, Adjusted R-squared:  0.63
```

```
F-statistic: 63.6 on 4 and 143 DF,  p-value: <2e-16
```

```
Summary of RQ fit (95th percentile):
```

```
Call: rq(formula = frm, tau = TAU, contrasts = contrasts)
```

```
Formula: lhd.ML ~ lTA + form + face.shield.ML
```

```
N: 148      tau: 0.95      AIC: 482.860510510147
```

	coefficients	lower bd	upper bd	Std. Error	t value	Pr(> t)
(Intercept)	2.2254	1.7245	2.595e+00	0.4048	5.4970	0.0000001725
lTA	0.8197	0.5127	1.219e+00	0.2877	2.8489	0.0050347294
formWP	0.2009	0.1843	1.798e+308	0.2334	0.8609	0.3907612621
formliquid	0.5366	-1.1628	8.597e-01	0.2784	1.9274	0.0559091802
face.shield.MLyes	-1.4546	-2.5560	3.458e-01	1.0181	-1.4287	0.1552814583

```
Formula for mean (based on LS-estimate):
```

```
log(hd.ML) = 0.792 + 0.924 log(TA) + 1.028 formWP + 0.335 formliquid + -1.67
```

```
face.shield.MLyes
```

```
Formula for 95th percentile (based on quantile regression):
```

```
log(hd.ML) = 2.225 + 0.82 log(TA) + 0.201 formWP + 0.537 formliquid + -1.455
```

```
face.shield.MLyes
```

```
=====  
Model: lria.ML ~ form2
```

```
Table of measured values:
```

	n	min	50%	75%	90%	95%	max
WG	91	0.0100	9.981	34.017	89.84	199.63	824.90
WP	20	559.4298	1811.458	4051.741	4997.48	5301.26	8504.39
liquid	100	0.5208	3.096	7.678	15.11	30.18	145.83
sachets	20	0.1562	3.622	7.318	16.90	27.98	33.18

```
Table of predicted values (95th percentile):
```

	TA	form2	lTA	LS.75	QR.75
1	1	WP	0	1045.8183	670.938
2	10	WP	1	10458.1830	6709.380
3	100	WP	2	104581.8303	67093.797
4	1	WG	0	12.0007	45.107
5	10	WG	1	120.0074	451.066
6	100	WG	2	1200.0738	4510.657
7	1	liquid	0	0.6949	4.017
8	10	liquid	1	6.9495	40.169
9	100	liquid	2	69.4948	401.688
10	1	sachets	0	253.1879	418.519
11	10	sachets	1	2531.8793	4185.185
12	100	sachets	2	25318.7930	41851.852

```
Summary of LS fit (mean):
```

```
Call:
```

```
lm(formula = frm, contrasts.arg = contrasts)
```

```
Residuals:
```

	Min	1Q	Median	3Q	Max
	-2.6297	-0.3432	0.0638	0.5047	1.9473

```
Coefficients:
```

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	0.5505	0.0816	6.75	1.2e-10 ***

```

form2WP          1.9301      0.1922    10.04 < 2e-16 ***
form2liquid     -1.2370      0.1128   -10.97 < 2e-16 ***
form2sachets    1.3141      0.1922     6.84 7.4e-11 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

```

Residual standard error: 0.778 on 227 degrees of freedom
(424 observations deleted due to missingness)
Multiple R-squared:  0.642,    Adjusted R-squared:  0.638
F-statistic: 136 on 3 and 227 DF,  p-value: <2e-16

```

Summary of RQ fit (95th percentile):

```

Call: rq(formula = frm, tau = TAU, contrasts = contrasts)
Formula: lria.ML ~ form2

```

```

N: 231      tau: 0.95      AIC: 613.774735134097

```

	coefficients	lower bd	upper bd	Std. Error	t value	Pr(> t)
(Intercept)	1.6542	1.5171	1.951e+00	0.1510	10.953	0.000000000000
form2WP	1.1724	1.1211	1.798e+308	0.2160	5.427	0.000000146787
form2liquid	-1.0504	-1.4078	-7.896e-01	0.2092	-5.021	0.000001037324
form2sachets	0.9675	0.8817	1.798e+308	0.1520	6.366	0.000000001063

Formula for mean (based on LS-estimate):

```

log(ia.ML) = log(TA) + 0.55 + 1.93 form2WP + -1.237 form2liquid + 1.314
form2sachets

```

Formula for 95th percentile (based on quantile regression):

```

log(ia.ML) = log(TA) + 1.654 + 1.172 form2WP + -1.05 form2liquid + 0.967
form2sachets

```

=====
Model: lia.ML ~ lTA + form2

Table of measured values:

	n	min	50%	75%	90%	95%	max
WG	91	0.0100	9.981	34.017	89.84	199.63	824.90
WP	20	559.4298	1811.458	4051.741	4997.48	5301.26	8504.39
liquid	100	0.5208	3.096	7.678	15.11	30.18	145.83
sachets	20	0.1562	3.622	7.318	16.90	27.98	33.18

Table of predicted values (95th percentile):

	TA	form2	lTA	LS.75	QR.75
1	1	WP	0	2608.558	1699.059
2	10	WP	1	7889.887	5936.850
3	100	WP	2	24239.698	20744.542
4	1	WG	0	15.803	48.743
5	10	WG	1	48.202	170.318
6	100	WG	2	149.360	595.126
7	1	liquid	0	2.692	6.474
8	10	liquid	1	8.094	22.620
9	100	liquid	2	24.730	79.038
10	1	sachets	0	50.431	113.177
11	10	sachets	1	157.613	395.464
12	100	sachets	2	499.593	1381.831

Summary of LS fit (mean):

```

Call:
lm(formula = frm, contrasts.arg = contrasts)

```

Residuals:

Min	1Q	Median	3Q	Max
-2.7442	-0.3569	0.0343	0.4989	1.7948

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	0.7060	0.0803	8.79	3.9e-16 ***

```

lTA          0.4829    0.0866    5.58  6.9e-08 ***
form2WP      2.2062    0.1849   11.93 < 2e-16 ***
form2liquid -0.7731    0.1306   -5.92  1.2e-08 ***
form2sachets 0.4892    0.2261    2.16  0.032 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

```

Residual standard error: 0.725 on 226 degrees of freedom
(424 observations deleted due to missingness)
Multiple R-squared:  0.559,    Adjusted R-squared:  0.551
F-statistic: 71.6 on 4 and 226 DF,  p-value: <2e-16

```

Summary of RQ fit (95th percentile):

```

Call: rq(formula = frm, tau = TAU, contrasts = contrasts)
Formula: lia.ML ~ lTA + form2

```

```

N: 231      tau: 0.95      AIC: 569.736205935529

```

	coefficients	lower bd	upper bd	Std. Error	t value	Pr(> t)
(Intercept)	1.6879	1.6029	2.365e+00	0.1525	11.070	0.000e+00
lTA	0.5433	0.2727	6.207e-01	0.1729	3.142	1.902e-03
form2WP	1.5423	1.4520	1.798e+308	0.2411	6.396	9.045e-10
form2liquid	-0.8768	-1.0713	-6.581e-01	0.2593	-3.381	8.511e-04
form2sachets	0.3658	-0.2545	1.798e+308	0.3024	1.210	2.277e-01

Formula for mean (based on LS-estimate):

```

log(ia.ML) = 0.706 + 0.483 log(TA) + 2.206 form2WP + -0.773 form2liquid + 0.489
form2sachets

```

Formula for 95th percentile (based on quantile regression):

```

log(ia.ML) = 1.688 + 0.543 log(TA) + 1.542 form2WP + -0.877 form2liquid + 0.366
form2sachets

```

HCHH greenhouse

Model: lrph.A ~ dense2

Table of measured values:

	n	min	50%	75%	90%	95%	max
normal	28	3092	10021	20210	32675	41785	52942
dense	19	1806	8444	25503	51232	63304	92300

Table of predicted values (95th percentile):

	TA	dense2	lTA	LS.75	QR.75
1	0.2	dense	-0.699	4740	17581
2	1.0	dense	0.000	23701	87904
3	5.0	dense	0.699	118503	439522
4	0.2	normal	-0.699	6809	13840
5	1.0	normal	0.000	34044	69201
6	5.0	normal	0.699	170219	346004

Summary of LS fit (mean):

Call:

```

lm(formula = frm, contrasts.arg = contrasts)

```

Residuals:

	Min	1Q	Median	3Q	Max
	-0.602	-0.293	-0.008	0.320	0.852

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	4.2517	0.0766	55.54	<2e-16 ***

```
dense2dense -0.1596      0.1204   -1.33      0.19
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
Residual standard error: 0.405 on 45 degrees of freedom
(35 observations deleted due to missingness)
Multiple R-squared:  0.0376,    Adjusted R-squared:  0.0162
F-statistic: 1.76 on 1 and 45 DF,  p-value: 0.192
```

```
Summary of RQ fit (95th percentile):
[1] "No nid summary"
```

```
Call: rq(formula = frm, tau = TAU, contrasts = contrasts)
Formula: lrph.A ~ dense2
```

```
N: 47      tau: 0.95      AIC: 69.2393796648367
```

```
      coefficients lower bd  upper bd
(Intercept)      4.8401  4.73809 1.798e+308
dense2dense      0.1039 -0.04836 1.798e+308
```

```
Formula for mean (based on LS-estimate):
log(ph.A) = log(TA) + 4.252 + -0.16 dense2dense
Formula for 95th percentile (based on quantile regression):
log(ph.A) = log(TA) + 4.84 + 0.104 dense2dense
```

```
=====
Model: lph.A ~ lTA + dense2
```

```
Table of measured values:
      n  min   50%   75%   90%   95%   max
normal 28 3092 10021 20210 32675 41785 52942
dense  19 1806  8444 25503 51232 63304 92300
```

```
Table of predicted values (95th percentile):
      TA dense2   lTA LS.75  QR.75
1 0.2 dense -0.699  5713 16282
2 1.0 dense  0.000 23365 87706
3 5.0 dense  0.699 118943 472440
4 0.2 normal -0.699  8067 13116
5 1.0 normal  0.000 33410 70650
6 5.0 normal  0.699 172082 380565
```

```
Summary of LS fit (mean):
```

```
Call:
lm(formula = frm, contrasts.arg = contrasts)
```

```
Residuals:
      Min       1Q   Median       3Q      Max
-0.607 -0.285  0.013  0.312  0.865
```

```
Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)    4.237      0.101   41.94  <2e-16 ***
lTA             0.918      0.364    2.52   0.015 *
dense2dense    -0.156      0.123   -1.27   0.209
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
Residual standard error: 0.409 on 44 degrees of freedom
(35 observations deleted due to missingness)
Multiple R-squared:  0.143,    Adjusted R-squared:  0.104
F-statistic: 3.66 on 2 and 44 DF,  p-value: 0.0339
```

```
Summary of RQ fit (95th percentile):
[1] "No nid summary"
```

```
Call: rq(formula = frm, tau = TAU, contrasts = contrasts)
Formula: lph.A ~ lTA + dense2
```

```
N: 47      tau: 0.95      AIC: 71.1247721244853
```

```
      coefficients lower bd  upper bd
(Intercept)    4.84911    4.6912 1.798e+308
lTA             1.04628   -0.3989 2.708e+00
dense2dense     0.09392   -0.2555 1.798e+308
```

Formula for mean (based on LS-estimate):

```
log(ph.A) = 4.237 + 0.918 log(TA) + -0.156 dense2dense
```

Formula for 95th percentile (based on quantile regression):

```
log(ph.A) = 4.849 + 1.046 log(TA) + 0.094 dense2dense
```

```
=====  
Model: lrah.A ~ dense2
```

Table of measured values:

	n	min	50%	75%	90%	95%	max
normal	22	0.5	10.44	27.67	75.09	89.61	226.1
dense	18	4.2	273.55	478.15	964.34	1010.58	1083.0

Table of predicted values (95th percentile):

	TA	dense2	lTA	LS.75	QR.75
1	0.2	dense	-0.699	146.82	281.48
2	1.0	dense	0.000	734.08	1407.41
3	5.0	dense	0.699	3670.38	7037.04
4	0.2	normal	-0.699	10.02	47.67
5	1.0	normal	0.000	50.09	238.34
6	5.0	normal	0.699	250.43	1191.69

Summary of LS fit (mean):

```
Call:
lm(formula = frm, contrasts.arg = contrasts)
```

Residuals:

Min	1Q	Median	3Q	Max
-1.638	-0.476	0.160	0.616	1.324

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	1.164	0.164	7.09	0.000000019 ***
dense2dense	1.163	0.245	4.76	0.000028429 ***

```
---  
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Residual standard error: 0.77 on 38 degrees of freedom
(42 observations deleted due to missingness)

Multiple R-squared: 0.373, Adjusted R-squared: 0.357

F-statistic: 22.6 on 1 and 38 DF, p-value: 0.0000284

Summary of RQ fit (95th percentile):

```
[1] "No nid summary"
```

```
Call: rq(formula = frm, tau = TAU, contrasts = contrasts)
Formula: lrah.A ~ dense2
```

```
N: 40      tau: 0.95      AIC: 95.1546533584078
```

```
      coefficients lower bd  upper bd
(Intercept)    2.3772    2.220e+00 1.798e+308
dense2dense     0.7712   -1.798e+308 1.798e+308
```

Formula for mean (based on LS-estimate):
 $\log(\text{ah.A}) = \log(\text{TA}) + 1.164 + 1.163 \text{ dense2dense}$
 Formula for 95th percentile (based on quantile regression):
 $\log(\text{ah.A}) = \log(\text{TA}) + 2.377 + 0.771 \text{ dense2dense}$

=====
Model: lah.A ~ lTA + dense2

Table of measured values:

	n	min	50%	75%	90%	95%	max
normal	22	0.5	10.44	27.67	75.09	89.61	226.1
dense	18	4.2	273.55	478.15	964.34	1010.58	1083.0

Table of predicted values (95th percentile):

	TA	dense2	lTA	LS.75	QR.75
1	0.2	dense	-0.699	595.99	176.75
2	1.0	dense	0.000	569.69	1635.77
3	5.0	dense	0.699	957.38	15138.71
4	0.2	normal	-0.699	30.54	37.33
5	1.0	normal	0.000	31.88	345.45
6	5.0	normal	0.699	57.33	3197.10

Summary of LS fit (mean):

Call:

`lm(formula = frm, contrasts.arg = contrasts)`

Residuals:

	Min	1Q	Median	3Q	Max
	-1.585	-0.387	0.164	0.491	1.412

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	0.9542	0.2483	3.84	0.00046 ***
lTA	0.0902	0.8114	0.11	0.91208
dense2dense	1.2602	0.2587	4.87	0.000021 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.767 on 37 degrees of freedom

(42 observations deleted due to missingness)

Multiple R-squared: 0.423, Adjusted R-squared: 0.392

F-statistic: 13.6 on 2 and 37 DF, p-value: 0.0000381

Summary of RQ fit (95th percentile):

[1] "No nid summary"

Call: `rq(formula = frm, tau = TAU, contrasts = contrasts)`

Formula: lah.A ~ lTA + dense2

N: 40 tau: 0.95 AIC: 96.648304038354

	coefficients	lower bd	upper bd
(Intercept)	2.5384	1.9213	1.798e+308
lTA	1.3826	-3.6430	3.372e+00
dense2dense	0.6753	0.5612	1.798e+308

Formula for mean (based on LS-estimate):

$\log(\text{ah.A}) = 0.954 + 0.09 \log(\text{TA}) + 1.26 \text{ dense2dense}$

Formula for 95th percentile (based on quantile regression):

$\log(\text{ah.A}) = 2.538 + 1.383 \log(\text{TA}) + 0.675 \text{ dense2dense}$

=====
Model: lrtb.A ~ dense2

Table of measured values:

	n	min	50%	75%	90%	95%	max
--	---	-----	-----	-----	-----	-----	-----

```
normal 30 29494 156873 368957 586393 694922 930188
dense 10 477327 1165891 1707502 2058069 2285864 2513658
```

Table of predicted values (95th percentile):

	TA	dense2	lTA	LS.75	QR.75
1	0.2	dense	-0.699	555254	721693
2	1.0	dense	0.000	2776268	3608467
3	5.0	dense	0.699	13881341	18042337
4	0.2	normal	-0.699	84318	219982
5	1.0	normal	0.000	421592	1099908
6	5.0	normal	0.699	2107962	5499541

Summary of LS fit (mean):

Call:

```
lm(formula = frm, contrasts.arg = contrasts)
```

Residuals:

	Min	1Q	Median	3Q	Max
	-0.7591	-0.1926	0.0529	0.2180	0.7295

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	5.3722	0.0666	80.61	< 2e-16 ***
dense2dense	0.8105	0.1333	6.08	0.00000044 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.365 on 38 degrees of freedom

(42 observations deleted due to missingness)

Multiple R-squared: 0.493, Adjusted R-squared: 0.48

F-statistic: 37 on 1 and 38 DF, p-value: 0.00000044

Summary of RQ fit (95th percentile):

[1] "No nid summary"

Call: rq(formula = frm, tau = TAU, contrasts = contrasts)

Formula: lrtb.A ~ dense2

N: 40 tau: 0.95 AIC: 50.5895264219002

	coefficients	lower bd	upper bd
(Intercept)	6.041	5.9366	1.798e+308
dense2dense	0.516	0.3668	1.798e+308

Formula for mean (based on LS-estimate):

$\log(\text{tb.A}) = \log(\text{TA}) + 5.372 + 0.811 \text{dense2dense}$

Formula for 95th percentile (based on quantile regression):

$\log(\text{tb.A}) = \log(\text{TA}) + 6.041 + 0.516 \text{dense2dense}$

=====
Model: ltb.A ~ lTA + dense2

Table of measured values:

	n	min	50%	75%	90%	95%	max
normal	30	29494	156873	368957	586393	694922	930188
dense	10	477327	1165891	1707502	2058069	2285864	2513658

Table of predicted values (95th percentile):

	TA	dense2	lTA	LS.75	QR.75
1	0.2	dense	-0.699	421779	1405343
2	1.0	dense	0.000	2996966	2974872
3	5.0	dense	0.699	26052862	6297299
4	0.2	normal	-0.699	65872	368317
5	1.0	normal	0.000	477067	779665
6	5.0	normal	0.699	4233656	1650418

Summary of LS fit (mean):

Call:

```
lm(formula = frm, contrasts.arg = contrasts)
```

Residuals:

	Min	1Q	Median	3Q	Max
	-0.7704	-0.1767	0.0389	0.2228	0.7155

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	5.4210	0.0914	59.29	< 2e-16 ***
lTA	1.2614	0.3333	3.79	0.00055 ***
dense2dense	0.7922	0.1360	5.83	0.0000011 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.367 on 37 degrees of freedom

(42 observations deleted due to missingness)

Multiple R-squared: 0.609, Adjusted R-squared: 0.587

F-statistic: 28.8 on 2 and 37 DF, p-value: 0.000000029

Summary of RQ fit (95th percentile):

[1] "No nid summary"

Call: rq(formula = frm, tau = TAU, contrasts = contrasts)

Formula: ltb.A ~ lTA + dense2

N: 40 tau: 0.95 AIC: 52.1393692865681

	coefficients	lower bd	upper bd
(Intercept)	5.8919	5.8424	1.798e+308
lTA	0.4660	-1.0068	2.604e+00
dense2dense	0.5816	0.3741	1.798e+308

Formula for mean (based on LS-estimate):

$\log(\text{tb.A}) = 5.421 + 1.261 \log(\text{TA}) + 0.792 \text{dense2dense}$

Formula for 95th percentile (based on quantile regression):

$\log(\text{tb.A}) = 5.892 + 0.466 \log(\text{TA}) + 0.582 \text{dense2dense}$

=====
Model: lrib.A ~ rain.dense

Table of measured values:

	n	min	50%	75%	90%	95%	max
normal	30	121.2	2291	16740	37716	96560	190124
dense	10	57091.1	259233	333254	856785	904221	951656
suit	16	113.1	1152	1623	3426	4347	4645
trousers	NA	NA	NA	NA	NA	NA	NA
prot	NA	NA	NA	NA	NA	NA	NA

Table of predicted values (95th percentile):

	TA	rain.dense	lTA	LS.75	QR.75
1	0.2	normal	-0.699	2489.9	22095
2	1.0	normal	0.000	12449.4	110473
3	5.0	normal	0.699	62247.0	552365
4	0.2	dense	-0.699	216223.9	273229
5	1.0	dense	0.000	1081119.6	1366144
6	5.0	dense	0.699	5405598.1	6830719
7	0.2	suit	-0.699	808.3	1753
8	1.0	suit	0.000	4041.6	8764
9	5.0	suit	0.699	20208.2	43820

Summary of LS fit (mean):

Call:

```
lm(formula = frm, contrasts.arg = contrasts)
```

Residuals:

Min	1Q	Median	3Q	Max
-1.2113	-0.3988	-0.0209	0.3568	1.6759

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	3.647	0.118	30.80	<2e-16 ***
rain.densedense	1.925	0.237	8.13	7e-11 ***
rain.densesuit	-0.495	0.201	-2.46	0.017 *

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.649 on 53 degrees of freedom

(26 observations deleted due to missingness)

Multiple R-squared: 0.634, Adjusted R-squared: 0.621

F-statistic: 46 on 2 and 53 DF, p-value: 2.65e-12

Summary of RQ fit (95th percentile):

[1] "No nid summary"

Call: rq(formula = frm, tau = TAU, contrasts = contrasts)

Formula: lrib.A ~ rain.dense

N: 56 tau: 0.95 AIC: 141.730197905205

	coefficients	lower bd	upper bd
(Intercept)	5.043	4.8495	1.798e+308
rain.densedense	1.092	0.7333	1.798e+308
rain.densesuit	-1.101	-1.6212	1.798e+308

Formula for mean (based on LS-estimate):

$\log(\text{ib.A}) = \log(\text{TA}) + 3.647 + 1.925 \text{ rain.densedense} + -0.495 \text{ rain.densesuit}$

Formula for 95th percentile (based on quantile regression):

$\log(\text{ib.A}) = \log(\text{TA}) + 5.043 + 1.092 \text{ rain.densedense} + -1.101 \text{ rain.densesuit}$

=====
Model: lib.A ~ lTA + rain.dense

Table of measured values:

	n	min	50%	75%	90%	95%	max
normal	30	121.2	2291	16740	37716	96560	190124
dense	10	57091.1	259233	333254	856785	904221	951656
suit	16	113.1	1152	1623	3426	4347	4645
trousers	NA	NA	NA	NA	NA	NA	NA
prot	NA	NA	NA	NA	NA	NA	NA

Table of predicted values (95th percentile):

	TA	rain.dense	lTA	LS.75	QR.75
1	0.2	normal	-0.699	941.7	5265.6
2	1.0	normal	0.000	18181.3	154805.3
3	5.0	normal	0.699	481659.7	4551181.0
4	0.2	dense	-0.699	72390.4	69181.3
5	1.0	dense	0.000	1356856.8	2033888.8
6	5.0	dense	0.699	34790947.2	59795079.6
7	0.2	suit	-0.699	292.7	599.6
8	1.0	suit	0.000	5592.4	17627.7
9	5.0	suit	0.699	146387.8	518242.5

Summary of LS fit (mean):

Call:

lm(formula = frm, contrasts.arg = contrasts)

Residuals:

Min	1Q	Median	3Q	Max
-----	----	--------	----	-----

-1.0664 -0.4778 -0.0084 0.3548 1.5495

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)	
(Intercept)	3.813	0.155	24.61	<2e-16	***
lTA	1.888	0.546	3.46	0.0011	**
rain.densedense	1.862	0.236	7.88	2e-10	***
rain.densesuit	-0.517	0.198	-2.61	0.0119	*

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.639 on 52 degrees of freedom

(26 observations deleted due to missingness)

Multiple R-squared: 0.682, Adjusted R-squared: 0.663

F-statistic: 37.1 on 3 and 52 DF, p-value: 5.76e-13

Summary of RQ fit (95th percentile):

[1] "No nid summary"

Call: rq(formula = frm, tau = TAU, contrasts = contrasts)

Formula: lib.A ~ lTA + rain.dense

N: 56 tau: 0.95 AIC: 141.532329060361

	coefficients	lower bd	upper bd
(Intercept)	5.1898	4.9022	1.798e+308
lTA	2.1007	-0.2791	3.193e+00
rain.densedense	1.1185	0.7888	1.798e+308
rain.densesuit	-0.9436	-1.6002	1.798e+308

Formula for mean (based on LS-estimate):

log(ib.A) = 3.813 + 1.888 log(TA) + 1.862 rain.densedense + -0.517 rain.densesuit

Formula for 95th percentile (based on quantile regression):

log(ib.A) = 5.19 + 2.101 log(TA) + 1.119 rain.densedense + -0.944 rain.densesuit

=====
Model: lrhd.A ~ dense2

Table of measured values:

	n	min	50%	75%	90%	95%	max
normal	29	1.667	395.8	498.0	724.6	1157	2652
dense	31	10.800	294.2	849.2	3972.0	6072	7905

Table of predicted values (95th percentile):

	TA	dense2	rain	lTA	LS.75	QR.75
1	0.2	dense	suit	-0.699	267.4	1781.6
2	1.0	dense	suit	0.000	1337.0	8907.9
3	5.0	dense	suit	0.699	6684.9	44539.6
4	0.2	normal	suit	-0.699	176.5	320.4
5	1.0	normal	suit	0.000	882.7	1601.8
6	5.0	normal	suit	0.699	4413.4	8009.2
7	0.2	dense	none	-0.699	267.4	1781.6
8	1.0	dense	none	0.000	1337.0	8907.9
9	5.0	dense	none	0.699	6684.9	44539.6
10	0.2	normal	none	-0.699	176.5	320.4
11	1.0	normal	none	0.000	882.7	1601.8
12	5.0	normal	none	0.699	4413.4	8009.2

Summary of LS fit (mean):

Call:

lm(formula = frm, contrasts.arg = contrasts)

Residuals:

	Min	1Q	Median	3Q	Max
	-1.7164	-0.3846	0.0343	0.4009	1.4433

```

Coefficients:
      Estimate Std. Error t value Pr(>|t|)
(Intercept)  2.496      0.121  20.61  <2e-16 ***
dense2dense  0.181      0.168   1.07   0.29
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.652 on 58 degrees of freedom
(22 observations deleted due to missingness)
Multiple R-squared:  0.0195,    Adjusted R-squared:  0.00257
F-statistic: 1.15 on 1 and 58 DF,  p-value: 0.288

Summary of RQ fit (95th percentile):
[1] "No nid summary"

Call: rq(formula = frm, tau = TAU, contrasts = contrasts)
Formula: lrhd.A ~ dense2

N: 60      tau: 0.95      AIC: 146.391475917482

      coefficients lower bd  upper bd
(Intercept)    3.2046    3.0929 1.798e+308
dense2dense    0.7452    0.4788 9.718e-01

Formula for mean (based on LS-estimate):
log(hd.A) = log(TA) + 2.496 + 0.181 dense2dense
Formula for 95th percentile (based on quantile regression):
log(hd.A) = log(TA) + 3.205 + 0.745 dense2dense

```

=====
Model: lrhd.A ~ lTA + dense2

Table of measured values:

	n	min	50%	75%	90%	95%	max
normal	29	1.667	395.8	498.0	724.6	1157	2652
dense	31	10.800	294.2	849.2	3972.0	6072	7905

Table of predicted values (95th percentile):

	TA	dense2	rain	lTA	LS.75	QR.75
1	0.2	dense	suit	-0.699	149.2	1898
2	1.0	dense	suit	0.000	1598.7	8548
3	5.0	dense	suit	0.699	23227.6	38496
4	0.2	normal	suit	-0.699	103.3	337
5	1.0	normal	suit	0.000	1134.1	1517
6	5.0	normal	suit	0.699	16803.8	6834
7	0.2	dense	none	-0.699	149.2	1898
8	1.0	dense	none	0.000	1598.7	8548
9	5.0	dense	none	0.699	23227.6	38496
10	0.2	normal	none	-0.699	103.3	337
11	1.0	normal	none	0.000	1134.1	1517
12	5.0	normal	none	0.699	16803.8	6834

Summary of LS fit (mean):

```

Call:
lm(formula = frm, contrasts.arg = contrasts)

```

Residuals:

	Min	1Q	Median	3Q	Max
	-1.5228	-0.3640	-0.0183	0.3869	1.4867

Coefficients:

```

      Estimate Std. Error t value Pr(>|t|)
(Intercept)  2.599      0.160  16.28  <2e-16 ***
lTA          1.532      0.537   2.86   0.006 **
dense2dense  0.152      0.171   0.89   0.377

```

```
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
Residual standard error: 0.652 on 57 degrees of freedom
(22 observations deleted due to missingness)
```

```
Multiple R-squared:  0.15, Adjusted R-squared:  0.121
```

```
F-statistic: 5.05 on 2 and 57 DF,  p-value: 0.0096
```

```
Summary of RQ fit (95th percentile):
```

```
[1] "No nid summary"
```

```
Call: rq(formula = frm, tau = TAU, contrasts = contrasts)
```

```
Formula: lhd.A ~ lTA + dense2
```

```
N: 60      tau: 0.95      AIC: 148.205152120094
```

	coefficients	lower bd	upper bd
(Intercept)	3.1811	3.0537	1.798e+308
lTA	0.9350	-3.1765	2.873e+00
dense2dense	0.7507	0.2025	9.980e-01

```
Formula for mean (based on LS-estimate):
```

```
log(hd.A) = 2.599 + 1.532 log(TA) + 0.152 dense2dense
```

```
Formula for 95th percentile (based on quantile regression):
```

```
log(hd.A) = 3.181 + 0.935 log(TA) + 0.751 dense2dense
```

```
=====  
Model: lria.A ~ dense2
```

```
Table of measured values:
```

	n	min	50%	75%	90%	95%	max
normal	30	0.4529	186.3	237.1	370.8	535	2214
dense	32	40.6250	247.2	409.1	557.5	1068	2253

```
Table of predicted values (95th percentile):
```

	TA	dense2	lTA	LS.75	QR.75
1	0.2	dense	-0.699	135.08	439.2
2	1.0	dense	0.000	675.39	2196.0
3	5.0	dense	0.699	3376.95	10980.1
4	0.2	normal	-0.699	98.23	105.0
5	1.0	normal	0.000	491.16	524.9
6	5.0	normal	0.699	2455.78	2624.3

```
Summary of LS fit (mean):
```

```
Call:
```

```
lm(formula = frm, contrasts.arg = contrasts)
```

```
Residuals:
```

	Min	1Q	Median	3Q	Max
	-2.4650	-0.1696	0.0509	0.2145	0.8690

```
Coefficients:
```

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	2.3767	0.0833	28.6	<2e-16 ***
dense2dense	0.1387	0.1159	1.2	0.24

```
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
Residual standard error: 0.456 on 60 degrees of freedom
```

```
(20 observations deleted due to missingness)
```

```
Multiple R-squared:  0.0233,    Adjusted R-squared:  0.00703
```

```
F-statistic: 1.43 on 1 and 60 DF,  p-value: 0.236
```

```
Summary of RQ fit (95th percentile):
```

```
[1] "No nid summary"
```

```
Call: rq(formula = frm, tau = TAU, contrasts = contrasts)
```

Formula: lria.A ~ dense2

N: 62 tau: 0.95 AIC: 102.594302468667

	coefficients	lower bd	upper bd
(Intercept)	2.7200	2.6829	1.798e+308
dense2dense	0.6216	-0.2776	6.902e-01

Formula for mean (based on LS-estimate):

$\log(\text{ia.A}) = \log(\text{TA}) + 2.377 + 0.139 \text{ dense2dense}$

Formula for 95th percentile (based on quantile regression):

$\log(\text{ia.A}) = \log(\text{TA}) + 2.72 + 0.622 \text{ dense2dense}$

=====
Model: lia.A ~ lTA + dense2

Table of measured values:

	n	min	50%	75%	90%	95%	max
normal	30	0.4529	186.3	237.1	370.8	535	2214
dense	32	40.6250	247.2	409.1	557.5	1068	2253

Table of predicted values (95th percentile):

	TA	dense2	lTA	LS.75	QR.75
1	0.2	dense	-0.699	113.37	80.03
2	1.0	dense	0.000	726.19	2138.11
3	5.0	dense	0.699	5726.38	57122.34
4	0.2	normal	-0.699	83.25	50.46
5	1.0	normal	0.000	540.53	1348.08
6	5.0	normal	0.699	4310.33	36015.54

Summary of LS fit (mean):

Call:

`lm(formula = frm, contrasts.arg = contrasts)`

Residuals:

	Min	1Q	Median	3Q	Max
	-2.4516	-0.1869	0.0531	0.2251	0.8998

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	2.413	0.109	22.18	<2e-16 ***
lTA	1.194	0.372	3.21	0.0021 **
dense2dense	0.130	0.118	1.10	0.2741

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.459 on 59 degrees of freedom

(20 observations deleted due to missingness)

Multiple R-squared: 0.178, Adjusted R-squared: 0.15

F-statistic: 6.4 on 2 and 59 DF, p-value: 0.00306

Summary of RQ fit (95th percentile):

[1] "No nid summary"

Call: `rq(formula = frm, tau = TAU, contrasts = contrasts)`

Formula: lia.A ~ lTA + dense2

N: 62 tau: 0.95 AIC: 97.8545580665283

	coefficients	lower bd	upper bd
(Intercept)	3.1297	2.7059	1.798e+308
lTA	2.0413	0.8942	2.068e+00
dense2dense	0.2003	-0.2438	7.216e-01

Formula for mean (based on LS-estimate):

$$\log(\text{ia.A}) = 2.413 + 1.194 \log(\text{TA}) + 0.13 \text{ dense2dense}$$

Formula for 95th percentile (based on quantile regression):

$$\log(\text{ia.A}) = 3.13 + 2.041 \log(\text{TA}) + 0.2 \text{ dense2dense}$$

=====

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