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

Project Report

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Content

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 develope 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 develope 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.

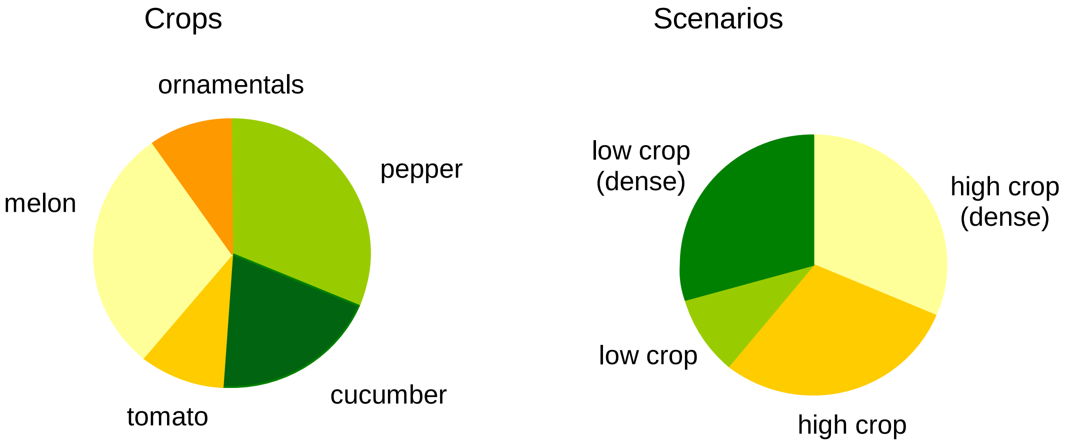

Figure 1: Study overview; the proportions shown refer to the number of replicates for each crop and the identified scenarios

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 (wettable 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.

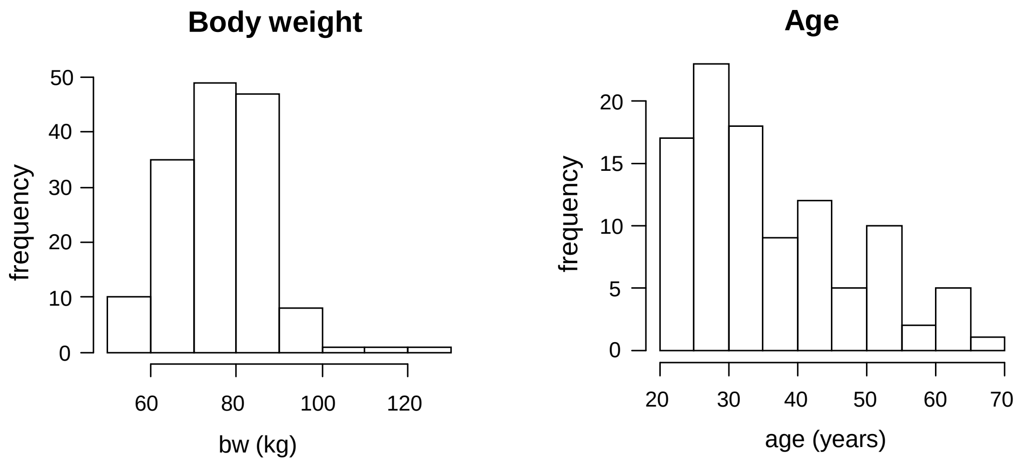

Figure 2: Body weight (bw) and age of the monitored subjects; body weight ranged from 55 to 125 kg (median: 83 kg), the age varied from 20 to 69 years (median: 33 years); all subjects were male except for two female operators.

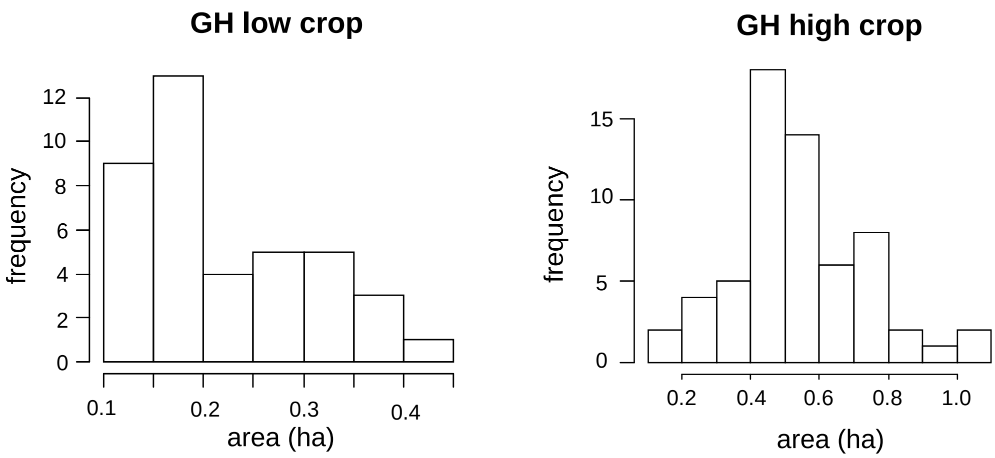

Figure 3: Target area; for application in low crops the target area was in a small range of 0.10 to 0.42 ha (median: 0.19 ha); application in high crops took place on slightly larger areas ranging from 0.18 to 1.10 ha (median: 0.56 ha).

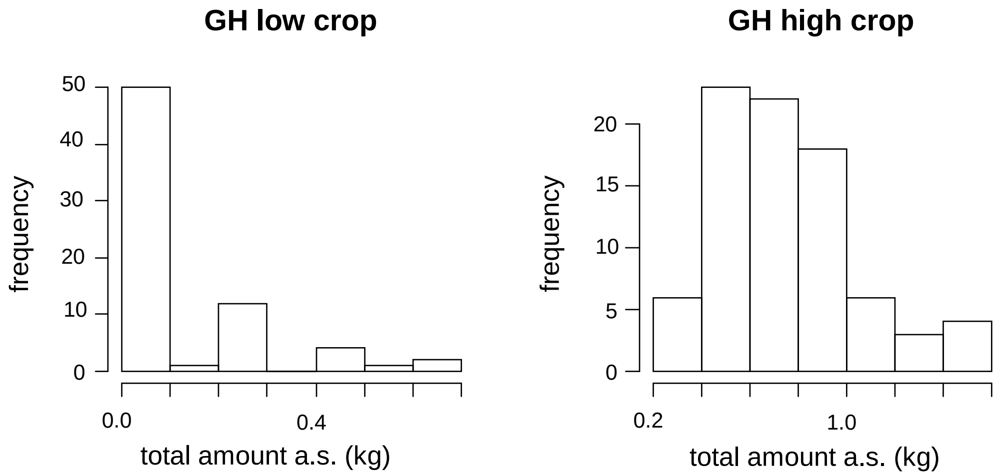

Figure 4: Sum of active substance applied per day (total amount a.s.); the amount varied between 0.02 and 0.60 kg a.s. per day for application in low crops (median: 0.06 kg a.s. per day), on high crops 0.27 to 1.51 kg a.s. were applied per day (median: 0.61 kg a.s. per day).

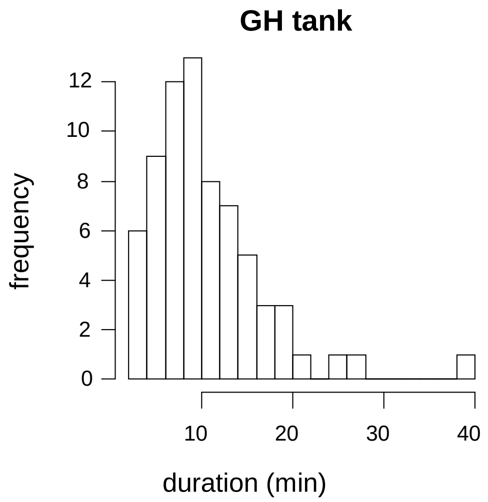

Figure 5: Duration of the mixing/loading task; operators finished mixing and loading of the product within 3 to 40 min (median: 10 min); data are only available for large mix-tanks.

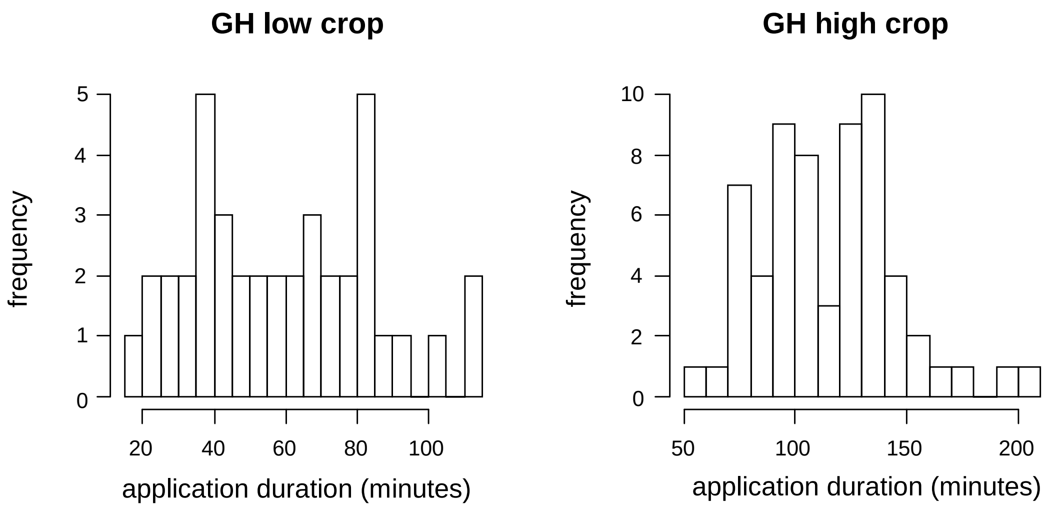

Figure 6: Duration of the application task; in low crops application was completed after 17 to 113 min (median: 58 min) and in high crops after 51 to 202 min (median: 117 min).

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/m^2). 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 m^3/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 m^3/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:

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

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

$$X = A^{\alpha} \cdot \Pi\, c_i$$

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 75^{th} percentile was chosen as the statistical reference for exposure modelling. In addition to the 75^{th} percentile the 95^{th} 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 75^{th} and the 95^{th}. 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.

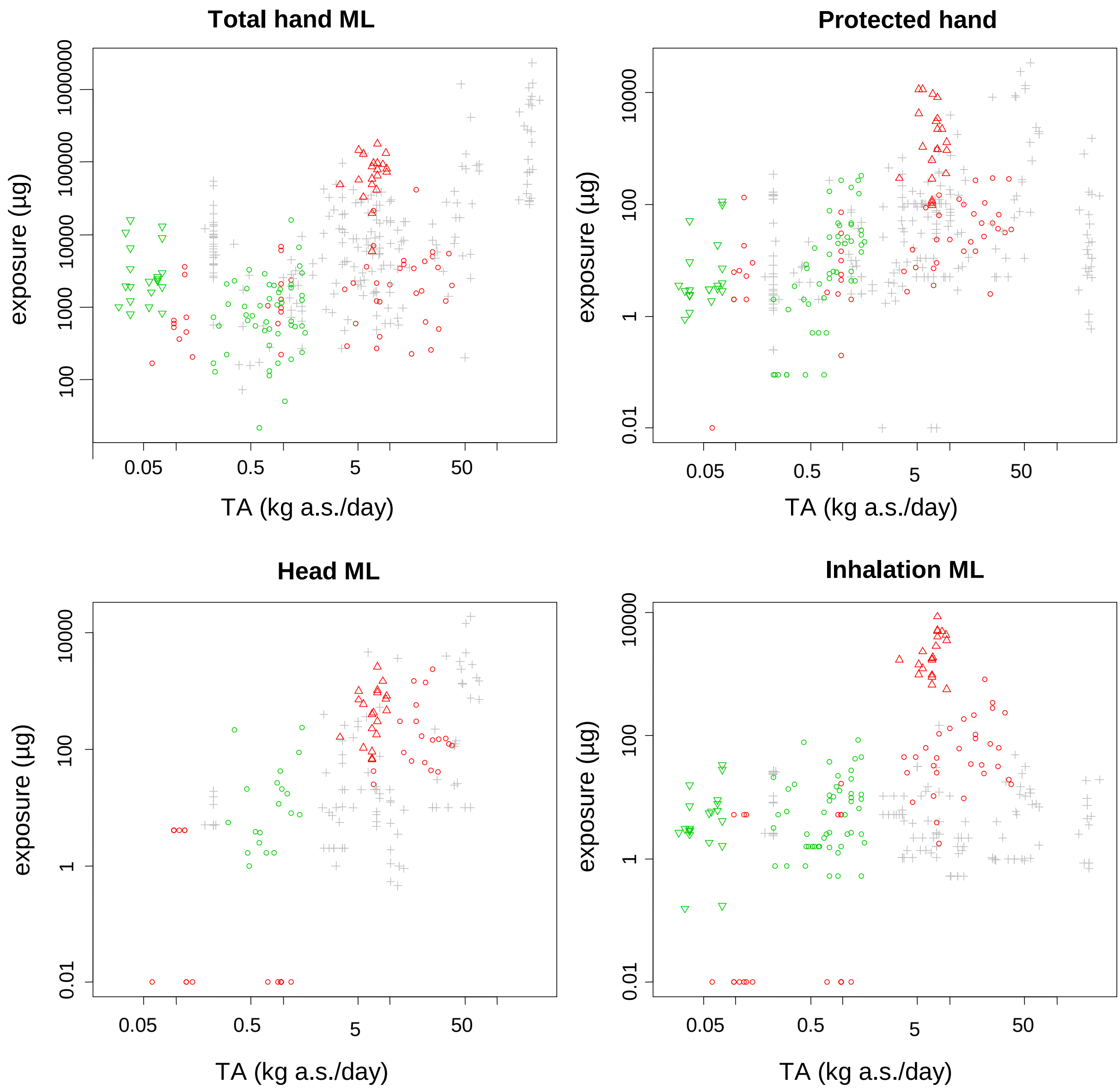

Figure 7: Comparison of outdoor and greenhouse mixing/loading data for tank equipment; red = outdoor, green = greenhouse, o = WG, Δ = WP, ∇ = WP (sachets), + = liquid (grey, outdoor only)

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.

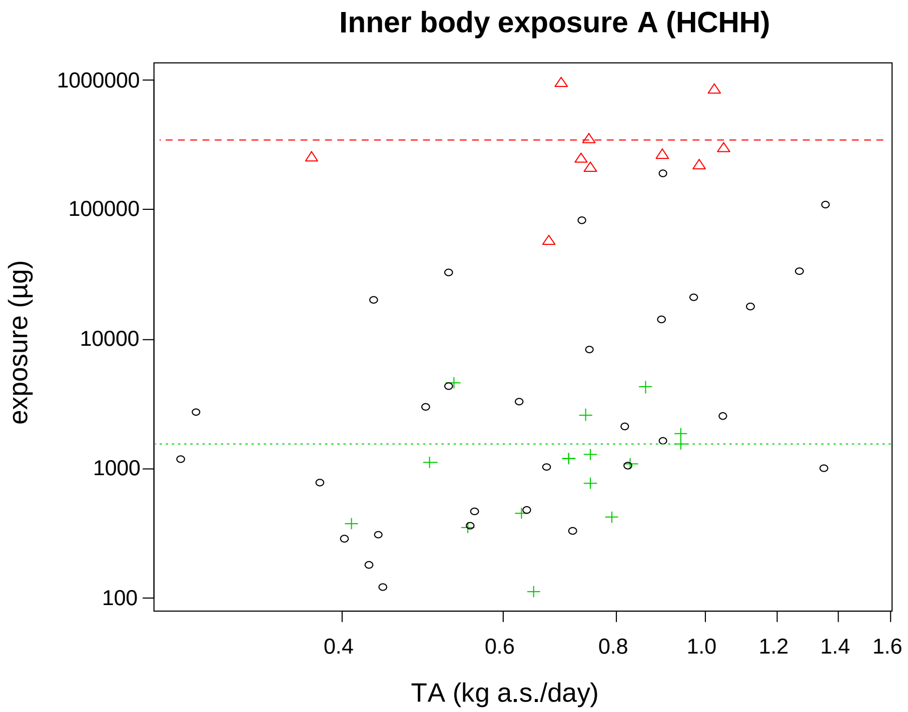

Figure 8: Inner body exposure data for application in greenhouses; o = normal scenario, Δ = dense scenario, + = with rain suits in dense scenario; red line: 75th percentile of exposure beneath work clothing in dense scenario; green line: 75th percentile of exposure beneath rain suits in dense scenario.

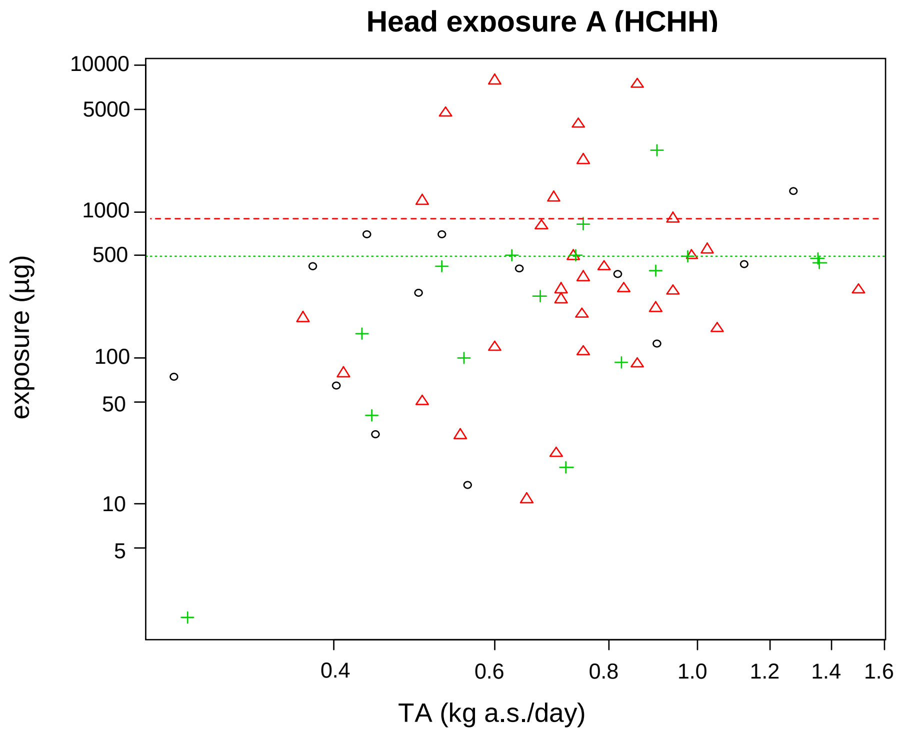

Figure 9: Head exposure data for application in greenhouses; o = without face mask, Δ = with face mask in dense scenario, + = with face mask in normal scenario; red line: 75th percentile of exposure with face masks in dense scenario; green line: 75th percentile of exposure with face masks in normal scenario.

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.

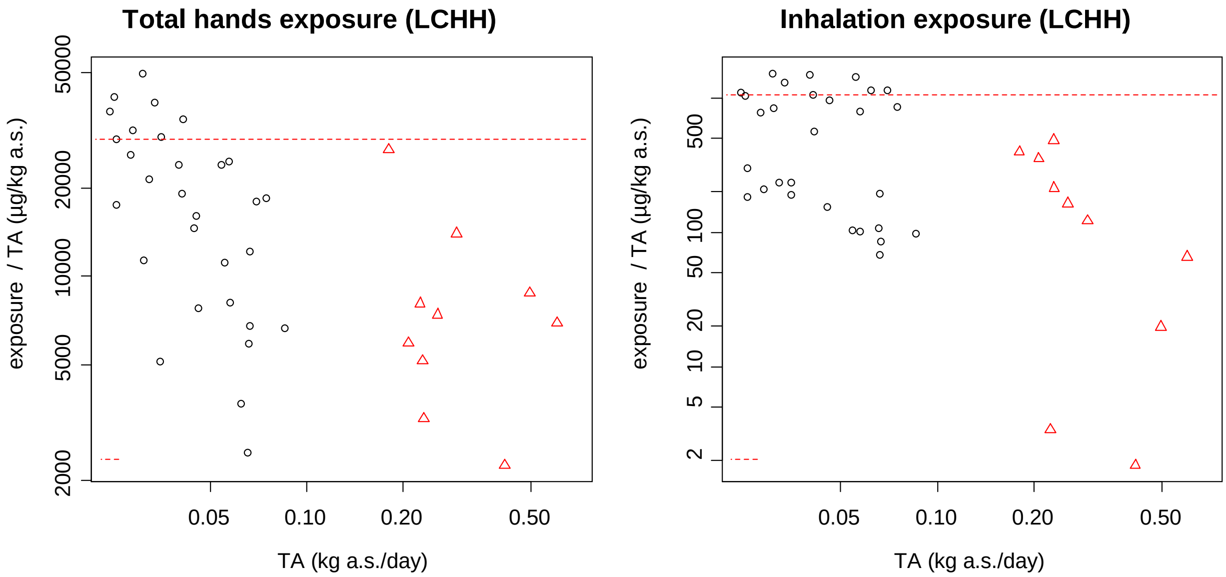

Figure 10: Potential hand and inhalation exposure data for the normal (red triangles) and dense scenario (black circles); shown are relative exposure values (ratios of absolute exposure and total amount of active substance applied per day); red line: 75th percentile of all data.

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).

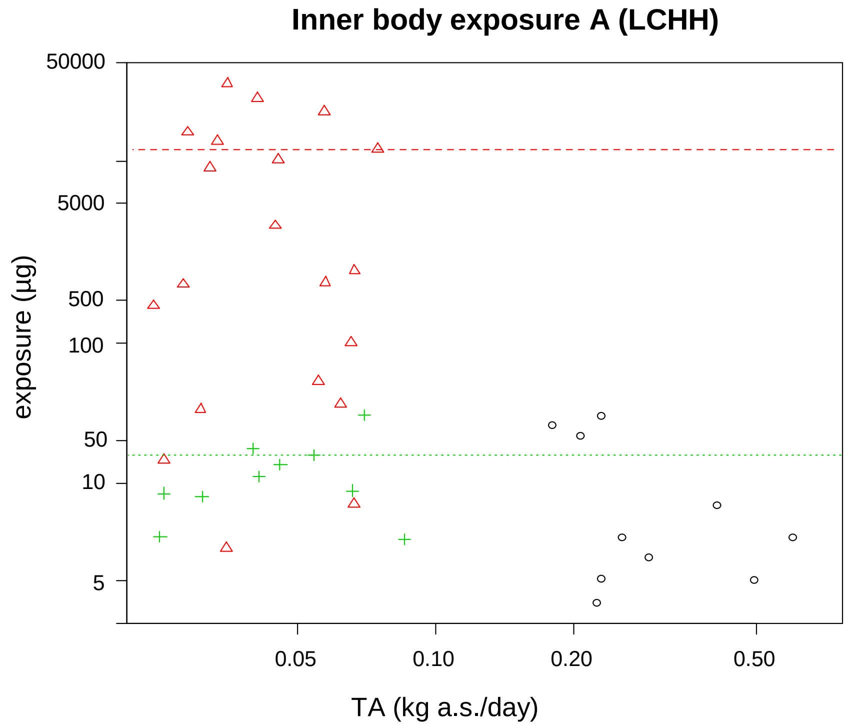

Figure 11: Inner body exposure data for application in greenhouses; o = normal scenario, Δ = dense scenario, + = with rain trousers in dense scenario; red line: 75th percentile of exposure beneath work clothing in dense scenario; green line: 75th percentile of exposure beneath rain trousers in dense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

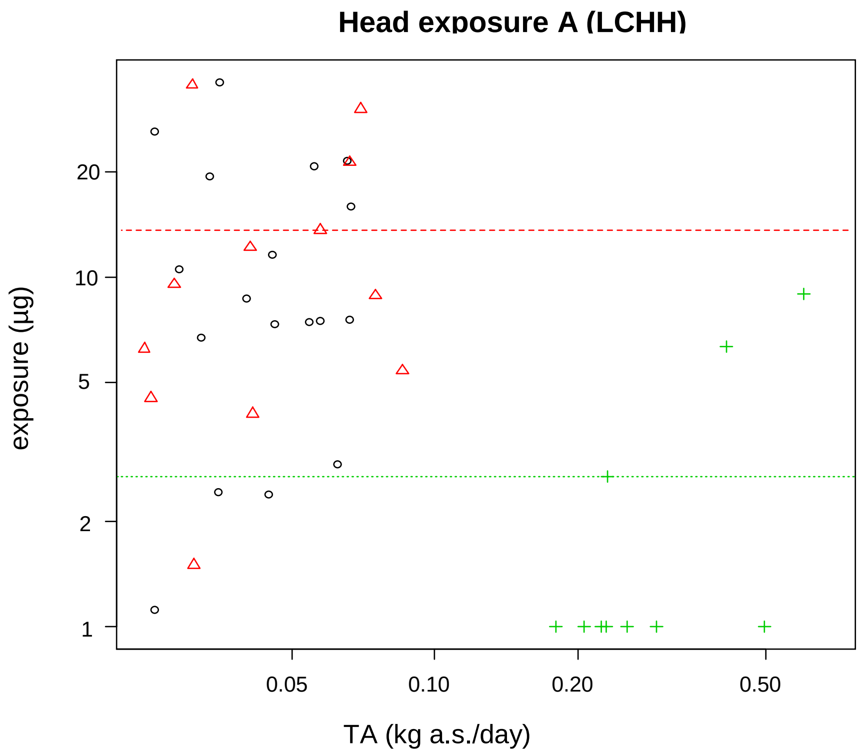

Figure 12: Head exposure data for application in greenhouses; o = without face mask, Δ = with face mask in dense scenario, + = with face mask in normal scenario; red line: 75th percentile of exposure with face masks in dense scenario; green line: 75th percentile of exposure with face masks in normal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

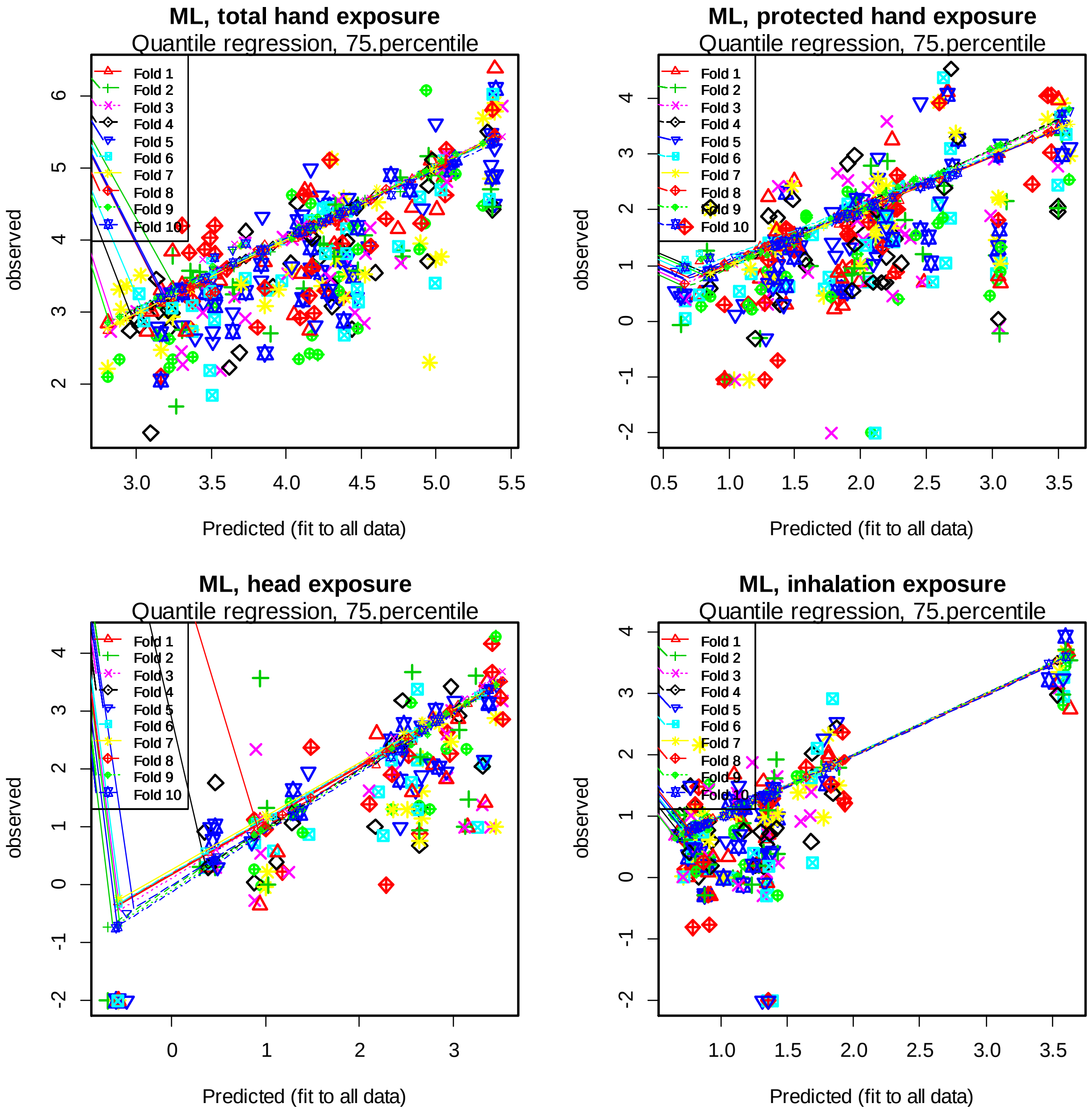

Figure 13: Cross validation of the revised tank mixing/loading model; shown are random subsets of the model (in different colours) together with the model prediction of the reduced datasets (line in same colour as the data subset)

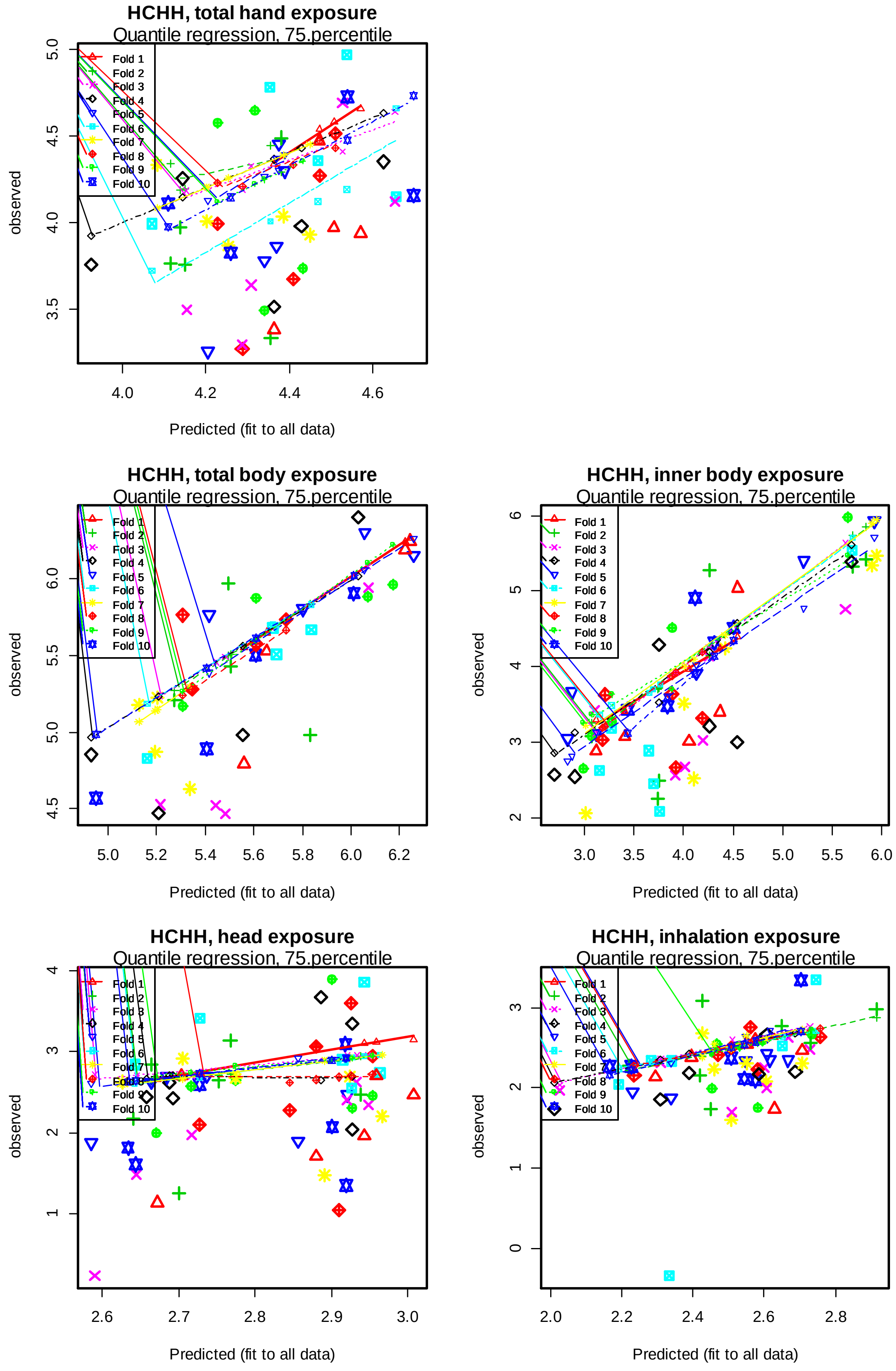

Figure 14: Cross validation of the greenhouse HCHH model; shown are random subsets of the model (in different colours) together with the model prediction of the reduced datasets (line in same colour as the data subset).

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.

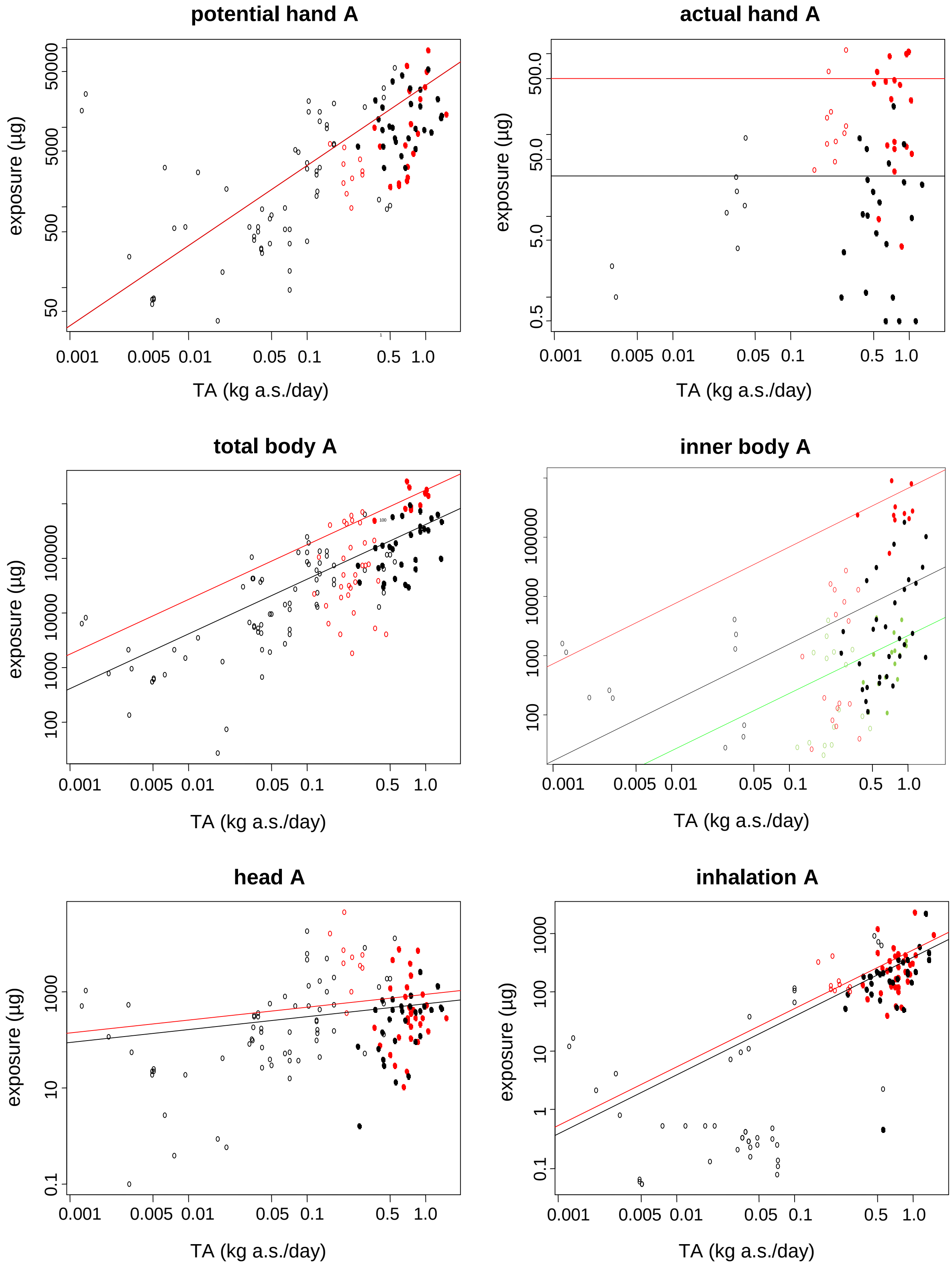

Figure 15: Validation data (empty circles) for high crop application in greenhouse in comparison to model data (filled circles) and model prediction (75th percentile; solid lines); black: normal culture, red: dense culture; green: dense culture with rain suits/water repellent clothing

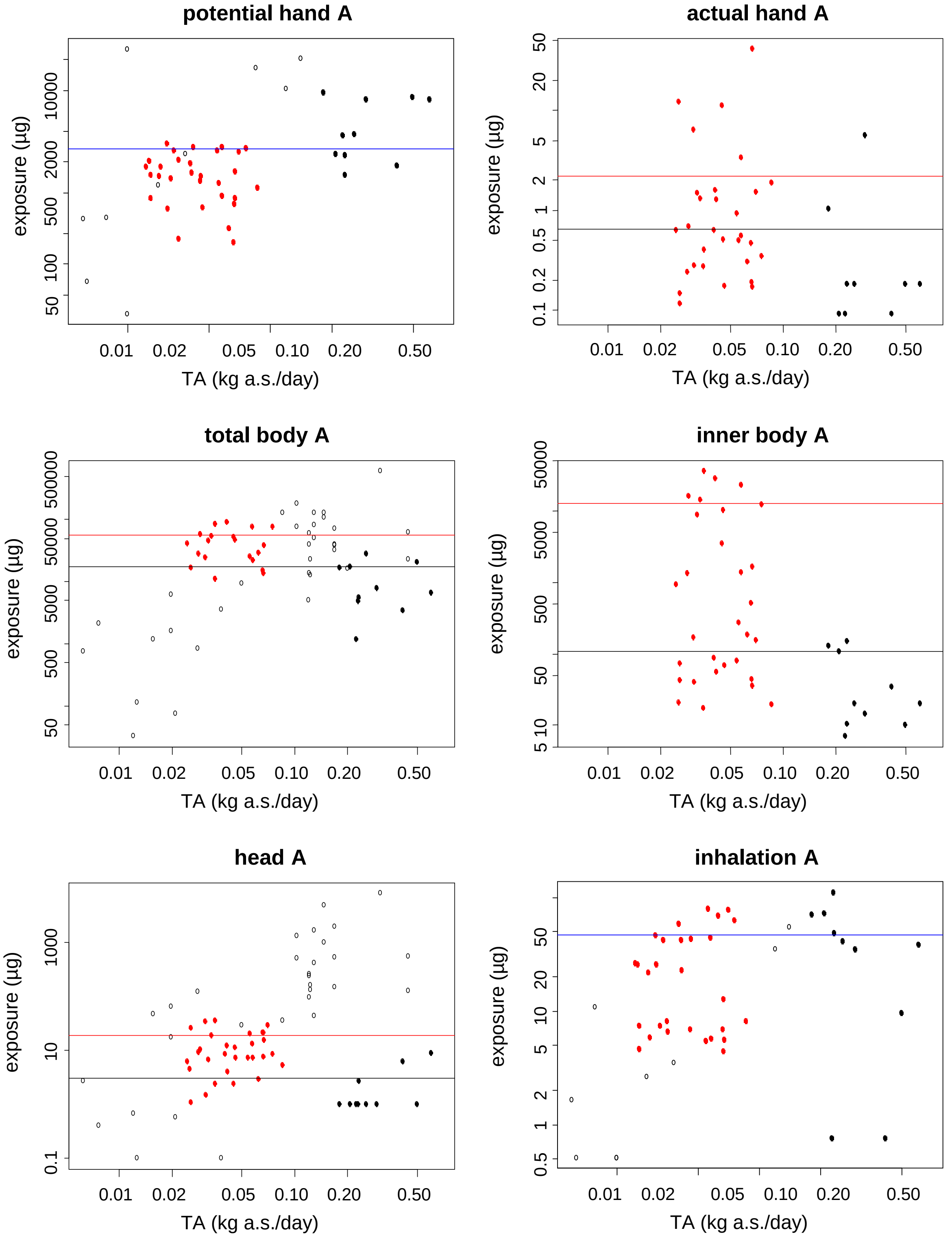

Figure 16: Validation data (empty circles) for low crop application in greenhouse in comparison to model data (filled circles); black: normal culture, red: dense culture; black line: 75th percentile for normal scenario; red line: 75th percentile for dense scenario; blue line: 75th percentile for normal 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 (75^{th} percentile level) and Table 3 (95^{th} 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 75^{th} percentile; in case no model could be derived the 75^{th} percentile was calculated (normal scenario/dense scenario/dense scenario with rain trousers); exposure is given in µg/person; * with or without face mask.

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

Tank ML		log exp = α log TA + [formulation type] + constant
	total hands	log $D_{ML(H)}$ = 0.79 log TA + 0.50 [liquid] + 1.15 [WP] + 1.59 [WP_S] - 0.79 [glove wash] + 3.73
	prot. hands	log $D_{ML(Hp)}$ = log TA + 0.08 [liquid] + 1.08 [WP] + 0.90 [WP_S] + 2.22
	total body	log $D_{ML(B)}$ = 0.29 log TA + 0.65 [liquid] + 1.25 [WP] + 4.21
	inner body	log $D_{ML(Bp)}$ = log TA + 0.37 [liquid] + 1.50 [WP] + 1.79
	head	log $D_{ML(C)}$ = 0.82 log TA + 0.54 [liquid] + 0.20 [WP] - 1.45 [face shield] + 2.23
	inhalation	log I_{ML} = 0.54 log TA - 0.88 [liquid] + 1.54 [WP] - 0.37 [WP_S] + 1.69
GH HCHH		log exp = α log TA + [dense] + constant
	total hands	log $D_{A(H)}$ = log TA + 0.10 [dense] + 4.84
	prot. hands	log $D_{A(Hp)}$ = log TA + 0.77 [dense] + 2.38
	total body	log $D_{A(B)}$ = 0.47 log TA + 0.58 [dense] + 5.89
	inner body	log $D_{A(Bp)}$ = log TA + 1.09 [dense] - 1.10 [rain suit] + 5.04
	head*	log $D_{A(C)}$ = 0.94 log TA + 0.75 [dense] + 3.18
	inhalation	log I_A = log TA + 0.62 [dense] + 2.72
GH LCHH		95th percentile (above 0.60 kg a.s./ 0.075 kg a.s. / 0.086 kg a.s. linear extrapolation)
	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/m^2). 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	75th perc.	median	CV%	n	75th 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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EFSA (European Food Safety Authority): EFSA Guidance Document on clustering and ranking of emissions of active substances of plant protection products and transformation of these active substances from protected crops (greenhouses and crops grown under cover) to relevant environmental compartments ; EFSA Journal 2014; 12(3):3615

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Machera, K., Tsakirakis, A., Charistou, A., Anastasiadou, P. and Glass, C.R.: Dermal exposure of pesticide applicators as a measure of coverall performance under field conditions; Ann. Occup. Hyg., Vol. 53, No. 6, pp. 573-584, 2009

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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 asses 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 m^3/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	*1967*			
2	1.50	21	9.4	19	*523*			
3	1.20	10	19.8	200	*15745*			
4	1.50	7	2.5	327	*2623*			
5	0.75	16	2.7	26	*104*			
6	0.75	14	37.1	6	*1298*			
7	0.90	14	1.3	46	*123*			
8	1.20	14	10.0	46	*142*			
9	0.75	7	8.7	13	*2007*			
10	1.20	5	8.6	22	*619*			

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	*92241*	294375	1121415	80
2	1.05	143	2253.1	270	*48749*	846244	913783	275
3	0.99	123	302.8	1083	*31310*	219191	1330735	250
4	0.70	174	402.4	277	*59805*	951656	1562003	625
5	0.75	140	267.7	481	*6472*	209289	667815	55
6	0.75	137	120.8	10877		346213	416389	100
7	0.68	139	566.4	950	*5075*	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 m^3/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 [µg]	Hands [µg]	Gloves [µg]	$Body_{inner}$ [µg]	$Body_{outer}$ [µg]	Face/ neck [µg]
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	*3048*	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 (this 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 m^3/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-lenght 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 m^3/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	*10.9*	28.3	1212			*117.1*
3	1.10	6	* *2.5*	25.6	856			*8.6*
7	0.70	6	* *2.5*	* 0.5	615			* *0.8*
9	1.43	4	*6.5*	153.4	3539			*3.8*
11	0.83	4	*10.1*	6.3	1950			* *0.8*
13	0.47	5	* *2.5*	7.1	638			* *0.8*
15	0.88	7	*14.9*	6.0	1066			*13.3*
17	0.35	6	*15.9*	3.4	2299			*108.2*
19	0.31	4	*13.7*	1.3	1097			*2.8*
21	0.91	6	*22.1*	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 form 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 acified 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 m^3/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 m^3/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 [µg]	Hands [µg]	Gloves [µg]	$Body_{inner}$ [µg]	$Body_{outer}$ [µg]	Face/ neck [µg]
21	0.038	9	3.1	2.3	*6423*			
22	0.068	12	7.9	3.5	*2286*			
23	0.059	14	5.9	1.9	*1601*			
24	0.068	9	6.1	3.1	*2584*			
25	0.075	19	33.2	99.4	*12957*			
26	0.075	10	4.1	111.7	*8880*			
27	0.075	10	27.7	3.9	*819*			
28	0.038	9	2.8	2.9	*1897*			
29	0.075	11	1.6	7.2	*1863*			
30	0.038	16	7.1	2.4	*15828*			
31	0.056	9	1.8	3.0	*2224*			
32	0.056	7	5.5	3.0	*983*			
33	0.038	5	2.9	9.3	*1201*			
34	0.034	12	0.2	2.8	*1941*			
35	0.075	12	0.2	2.8	*2976*			
36	0.038	9	15.7	50.1	*3304*			
37	0.029	10	2.6	3.5	*998*			
38	0.068	12	9.1	18.6	*2397*			
39	0.038	11	2.5	1.1	*794*			
40	0.034	9	3.1	0.9	*10590*			

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 quantivication 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 m^3/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

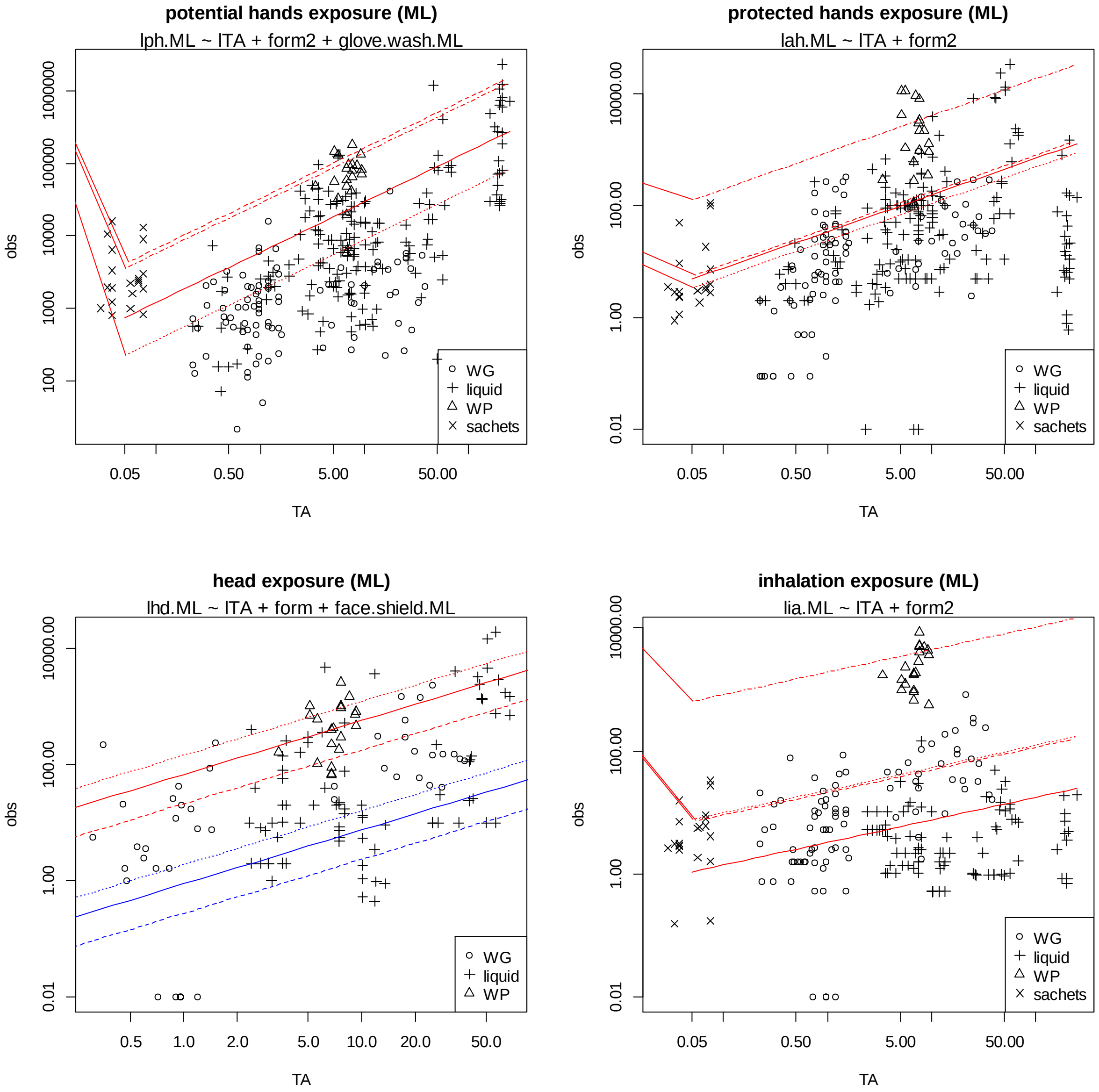
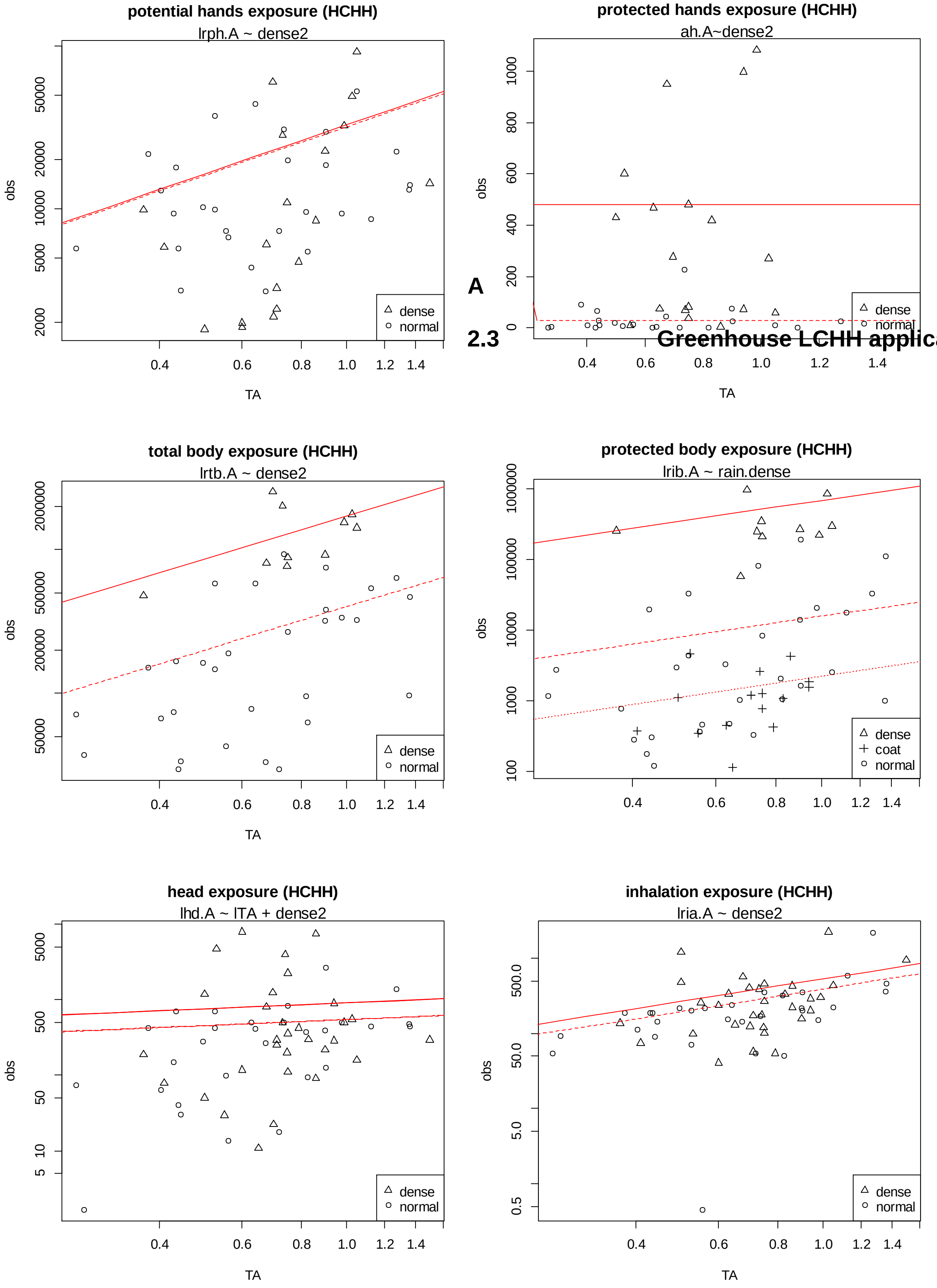


Figure A 1: Model prediction with quantile regression for tank mixing/loading (outdoor and greenhouse database); broken line: liquid formulations, broken/dotted line: sachets (WP), solid line: WG formulations, dotted line: WP formulations; blue lines: head exposure when using face shields.

A 2.2 Greenhouse HCHH application



A 2.3 Greenhouse LCHH 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.

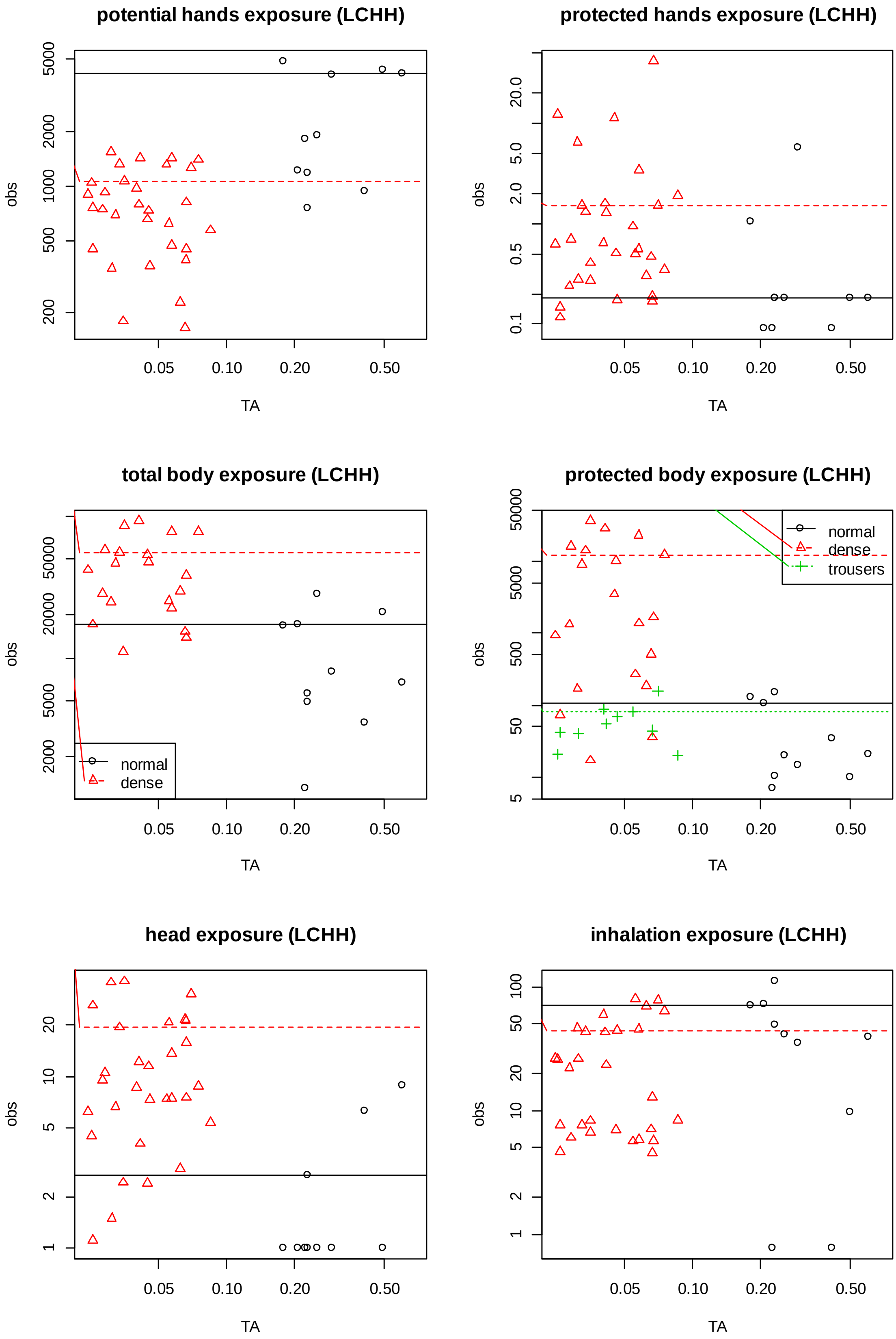


Figure A 3: Model prediction with quantile regression for greenhouse application on low crops; solid line: normal scenario, broken line: dense scenario, dotted line: dense scenario with rain trousers.

Appendix 3 Estimations of the 75th percentile

A 3.1 Greenhouse HCHH application (protected hand)

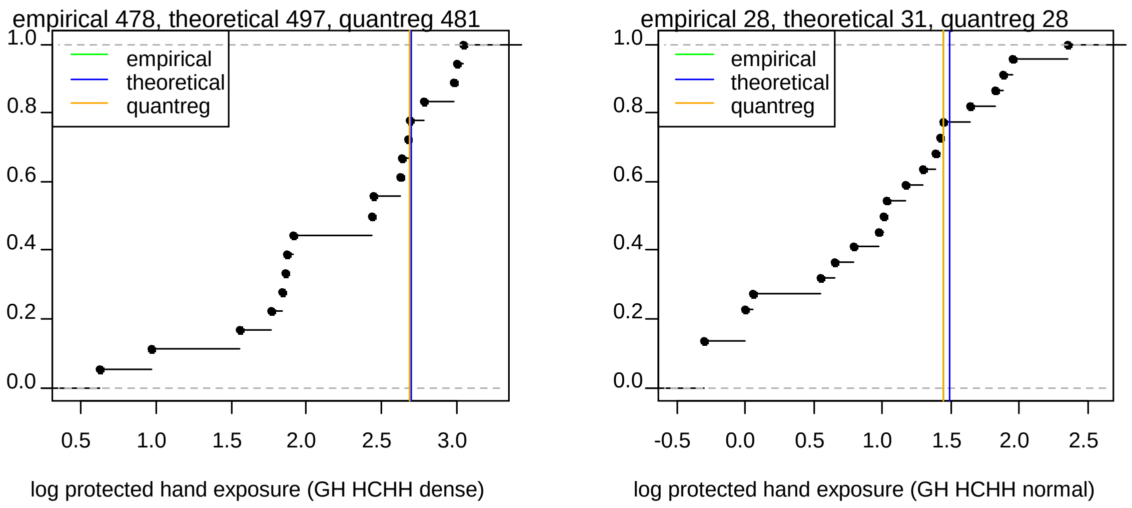


Figure A 4: Comparison of the empirical 75th percentile (green line) with the parametric estimate of the percentile calculated acc. to EFSA (blue line) and the 75th percentile obtained by quantile regression (orange line); the y-axis gives the proportion of data with values below a certain level of exposure.

A 3.2 Greenhouse LCHH application (normal scenario)

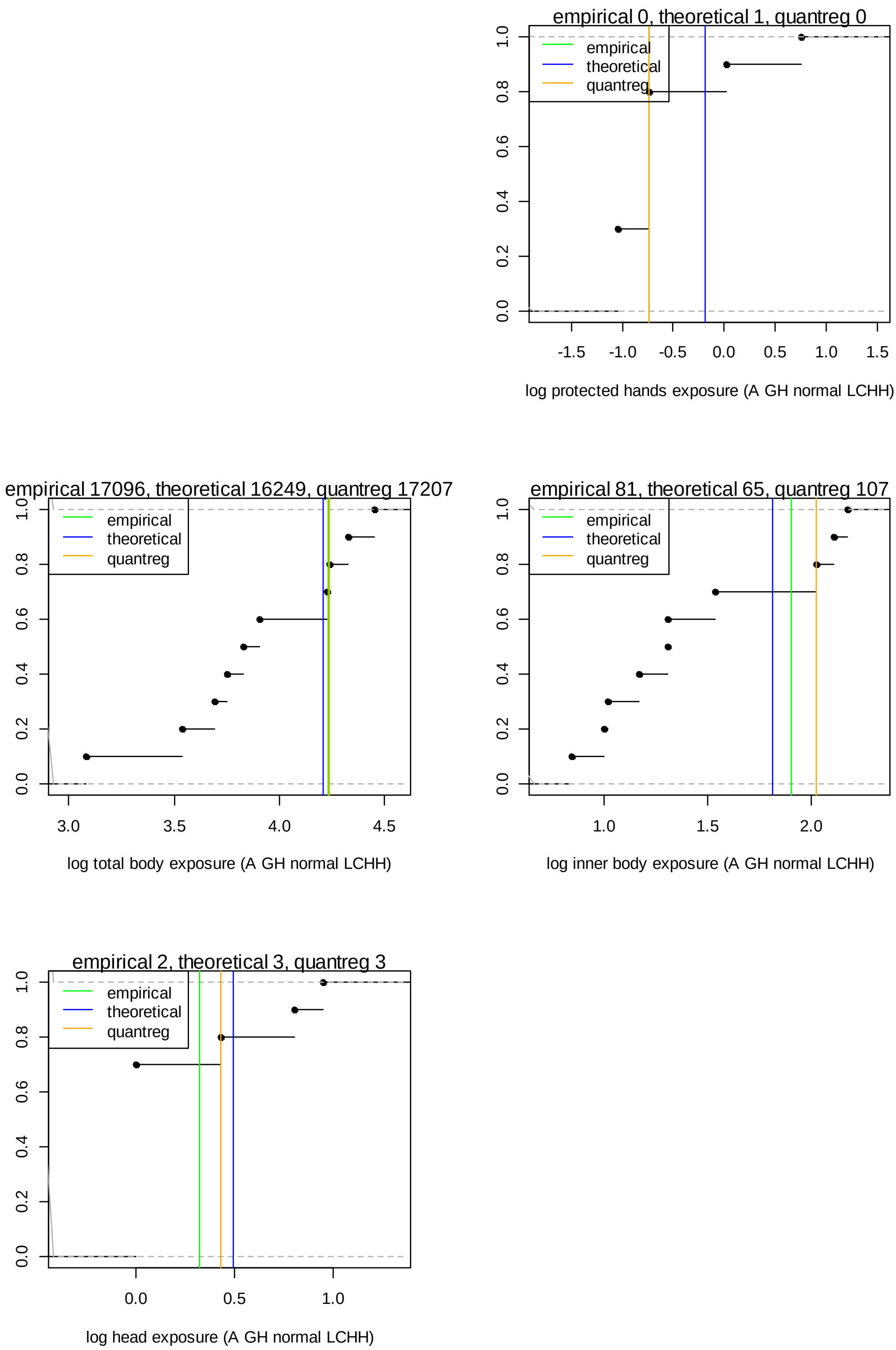


Figure A 5: Comparison of the empirical 75th percentile (green line) with the parametric estimate of the percentile calculated acc. to EFSA (blue line) and the 75th percentile obtained by quantile regression (orange line); the y-axis gives the proportion of data with values below a certain level of exposure.

A 3.3 Greenhouse LCHH application (dense scenario)

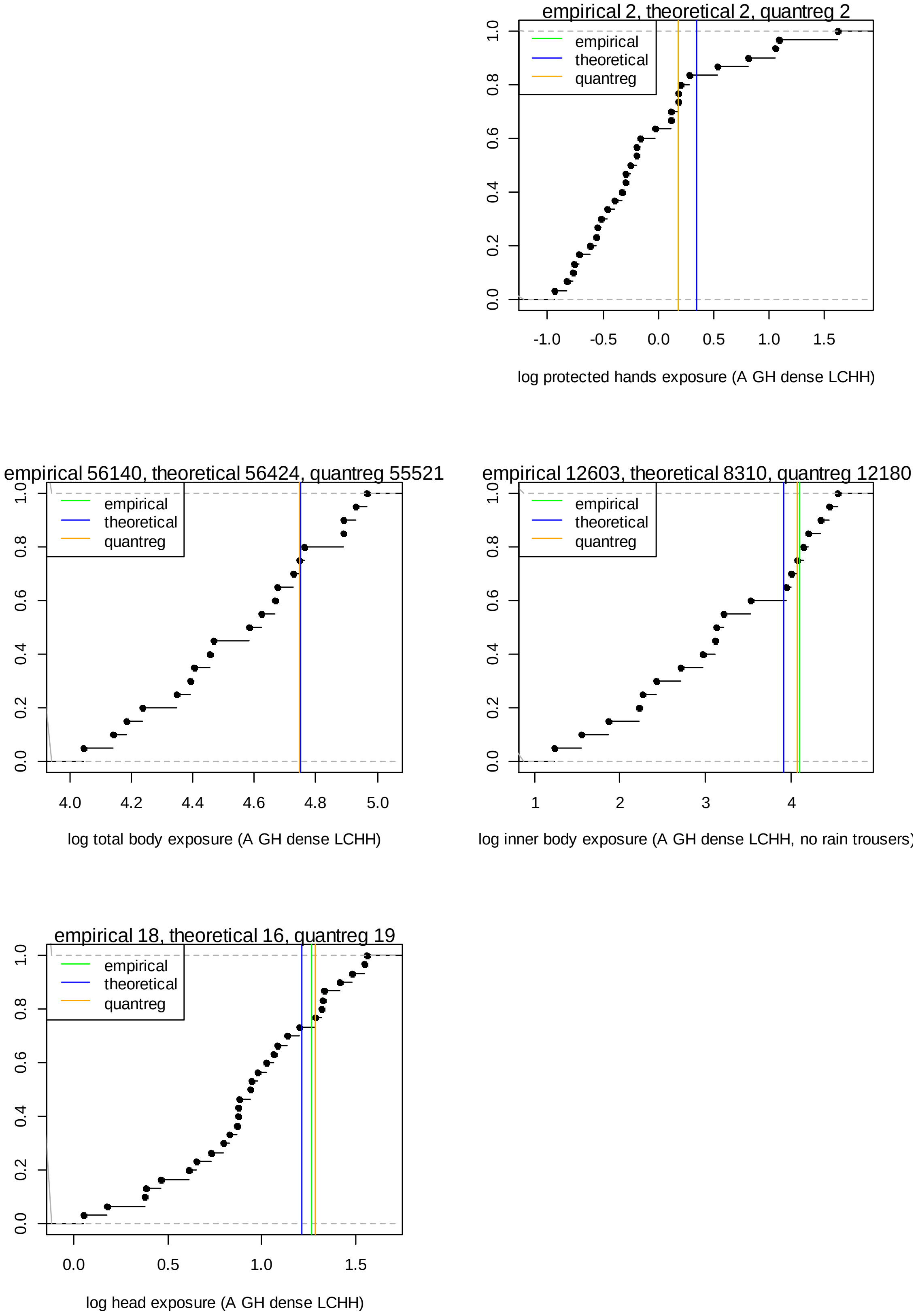


Figure A 6: Comparison of the empirical 75th percentile (green line) with the parametric estimate of the percentile calculated acc. to EFSA (blue line) and the 75th percentile obtained by quantile regression (orange line); the y-axis gives the proportion of data with values below a certain level of exposure.

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

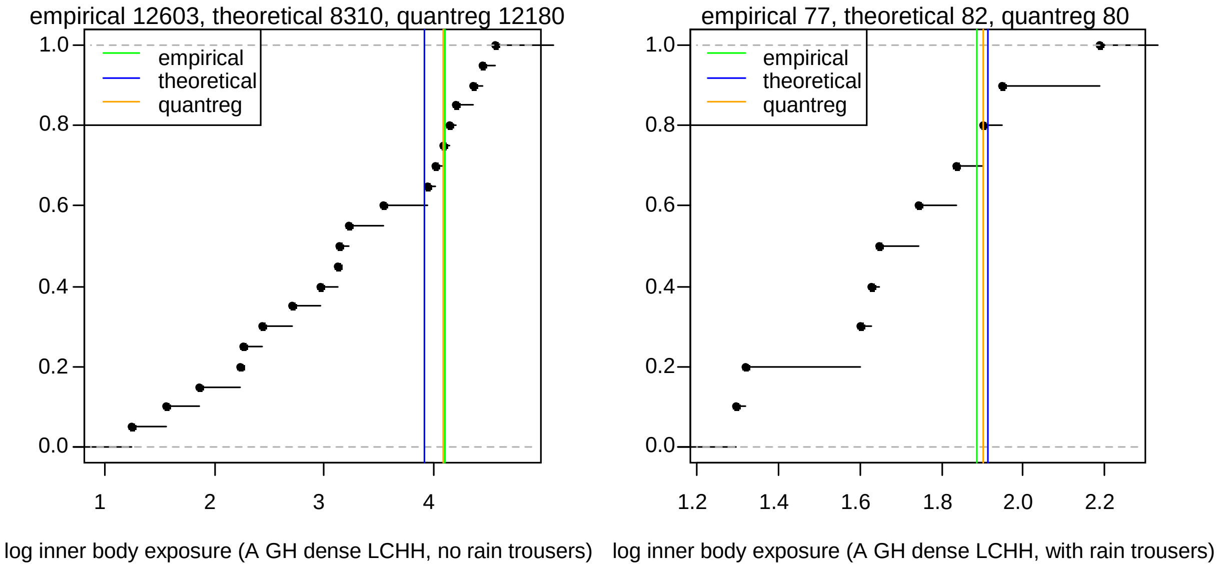


Figure A 7: Comparison of the empirical 75th percentile (green line) with the parametric estimate of the percentile calculated acc. to EFSA (blue line) and the 75th percentile obtained by quantile regression (orange line); the y-axis gives the proportion of data with values below a certain level of exposure.

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

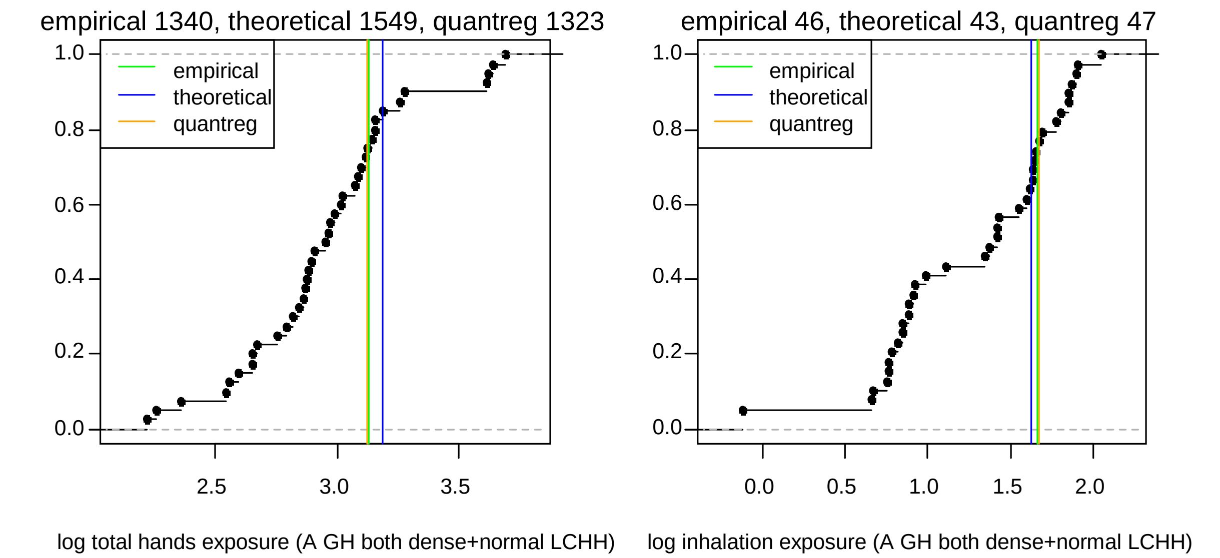


Figure A 8: Comparison of the empirical 75th percentile (green line) with the parametric estimate of the percentile calculated acc. to EFSA (blue line) and the 75th percentile obtained by quantile regression (orange line); the y-axis gives the proportion of data with values below a certain level of exposure.

Appendix 4 Model predictions (95th percentile)

A 4.1 ML tank

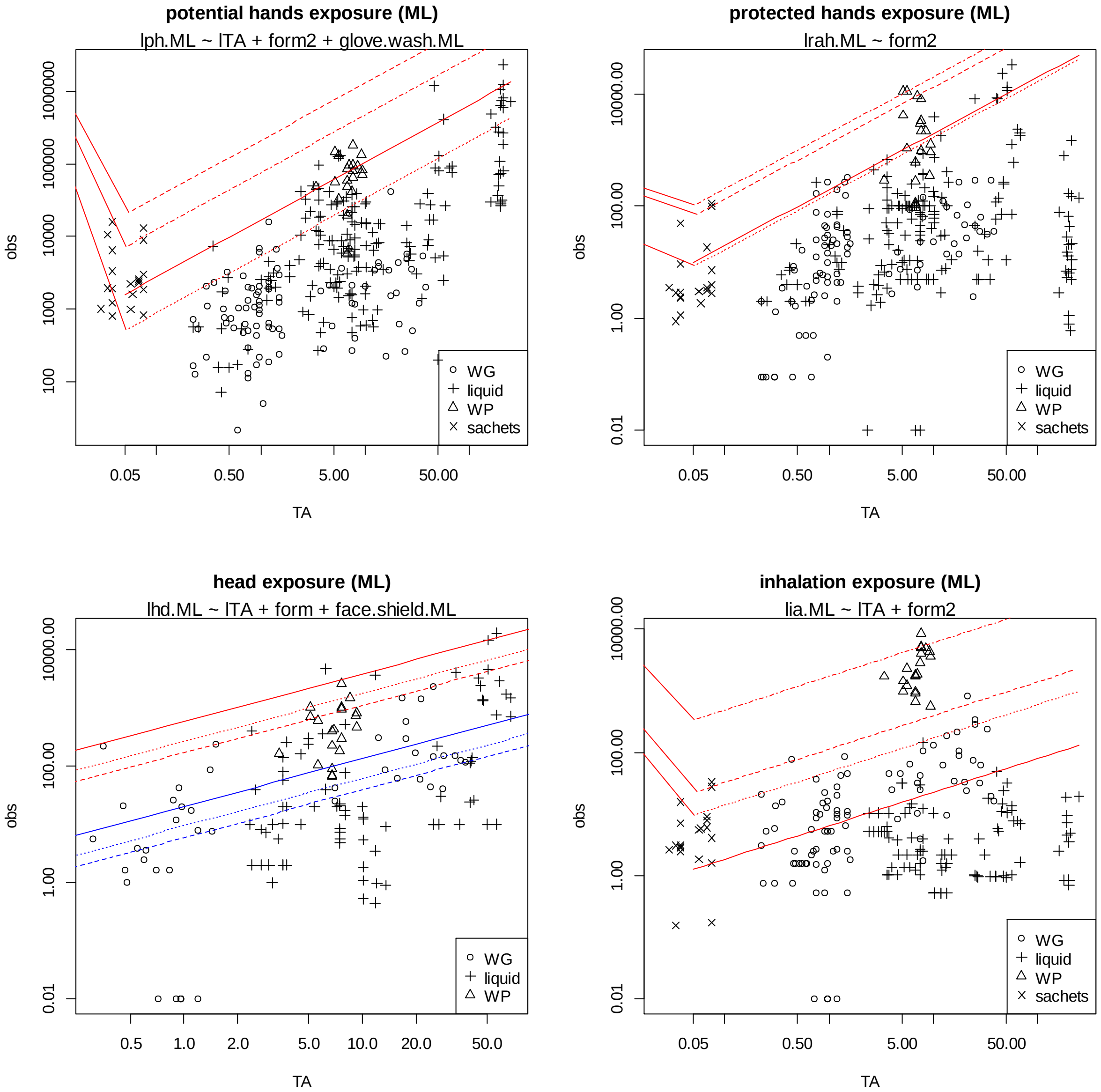


Figure A 9: Model prediction with quantile regression for tank mixing/loading (outdoor and greenhouse database); broken line: liquid formulations, broken/dotted line: sachets (WP), solid line: WG formulations, dotted line: WP formulations; blue lines: head exposure when using face shields.

A 4.2 Greenhouse HCHH application

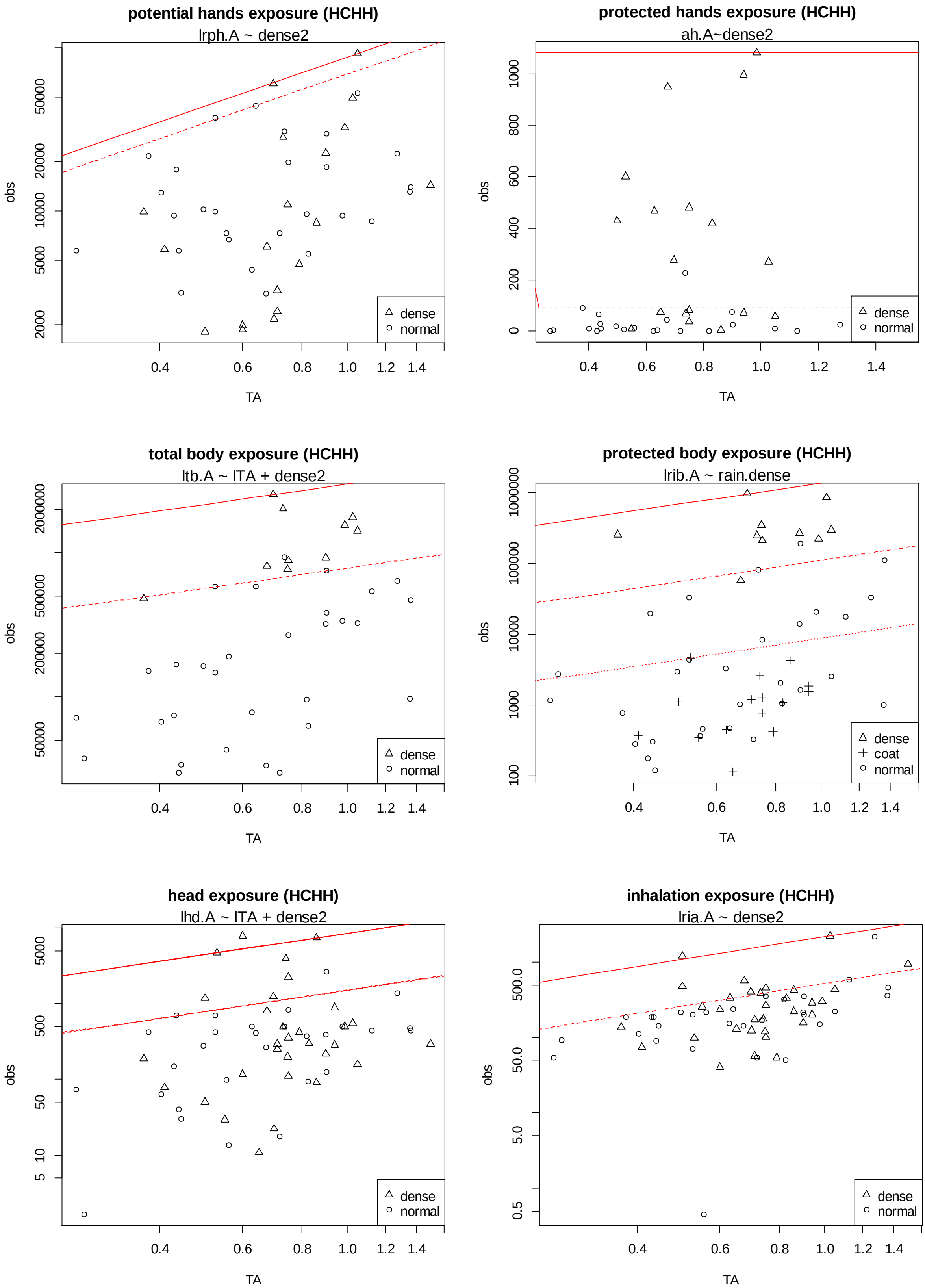


Figure A 10: Model prediction with quantile regression for greenhouse application on high crops; solid line: dense scenario, broken line: normal scenario, dotted line: dense scenario with rain suit.

A 4.3 Greenhouse LCHH application

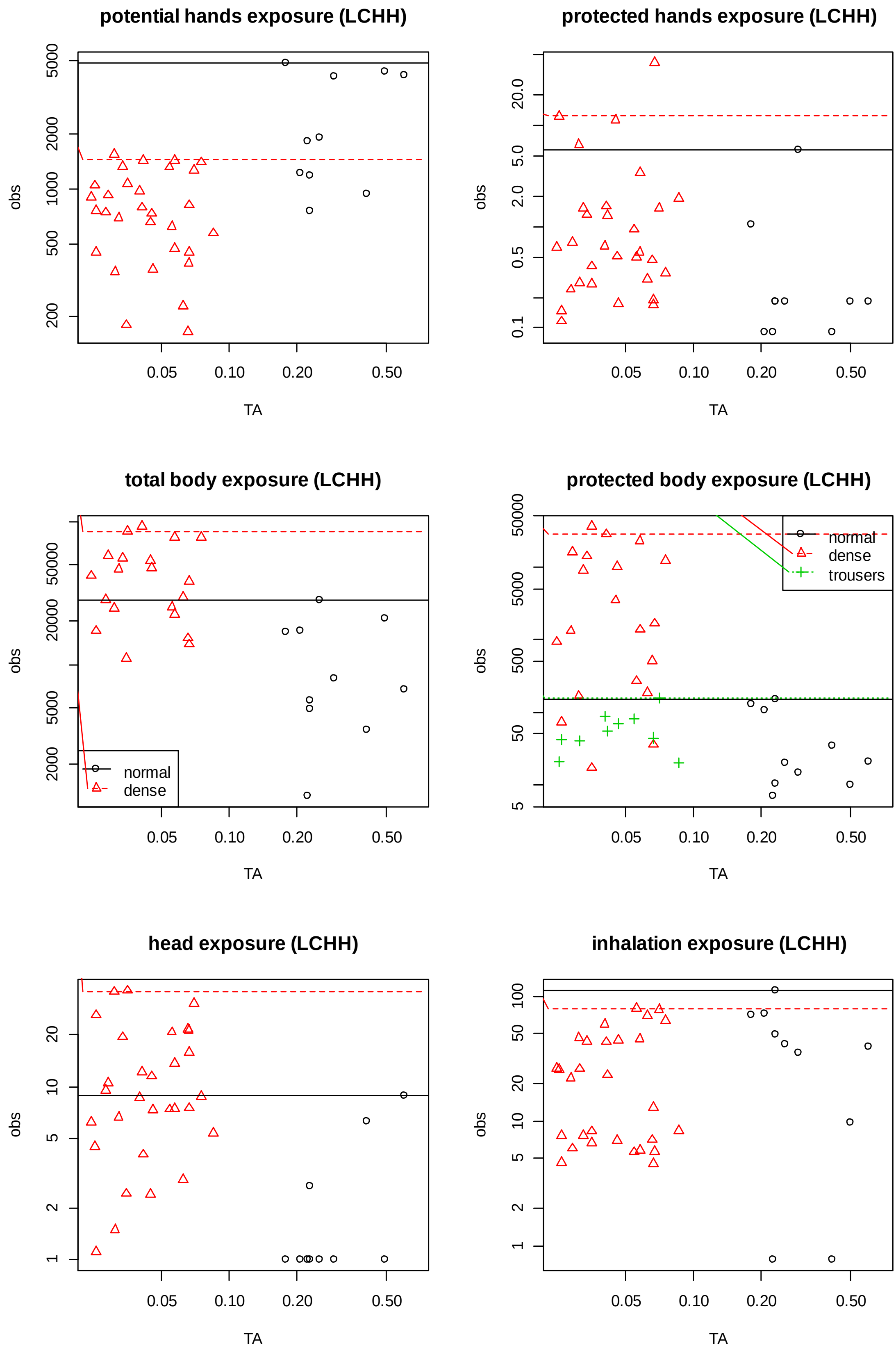


Figure A 11: Model prediction with quantile regression for greenhouse application on low crops; solid line: normal scenario, broken line: dense scenario, dotted line: dense scenario with rain trousers.

Appendix 5 Estimations of the 95th percentile

A 5.1 Greenhouse LCHH application (normal scenario)

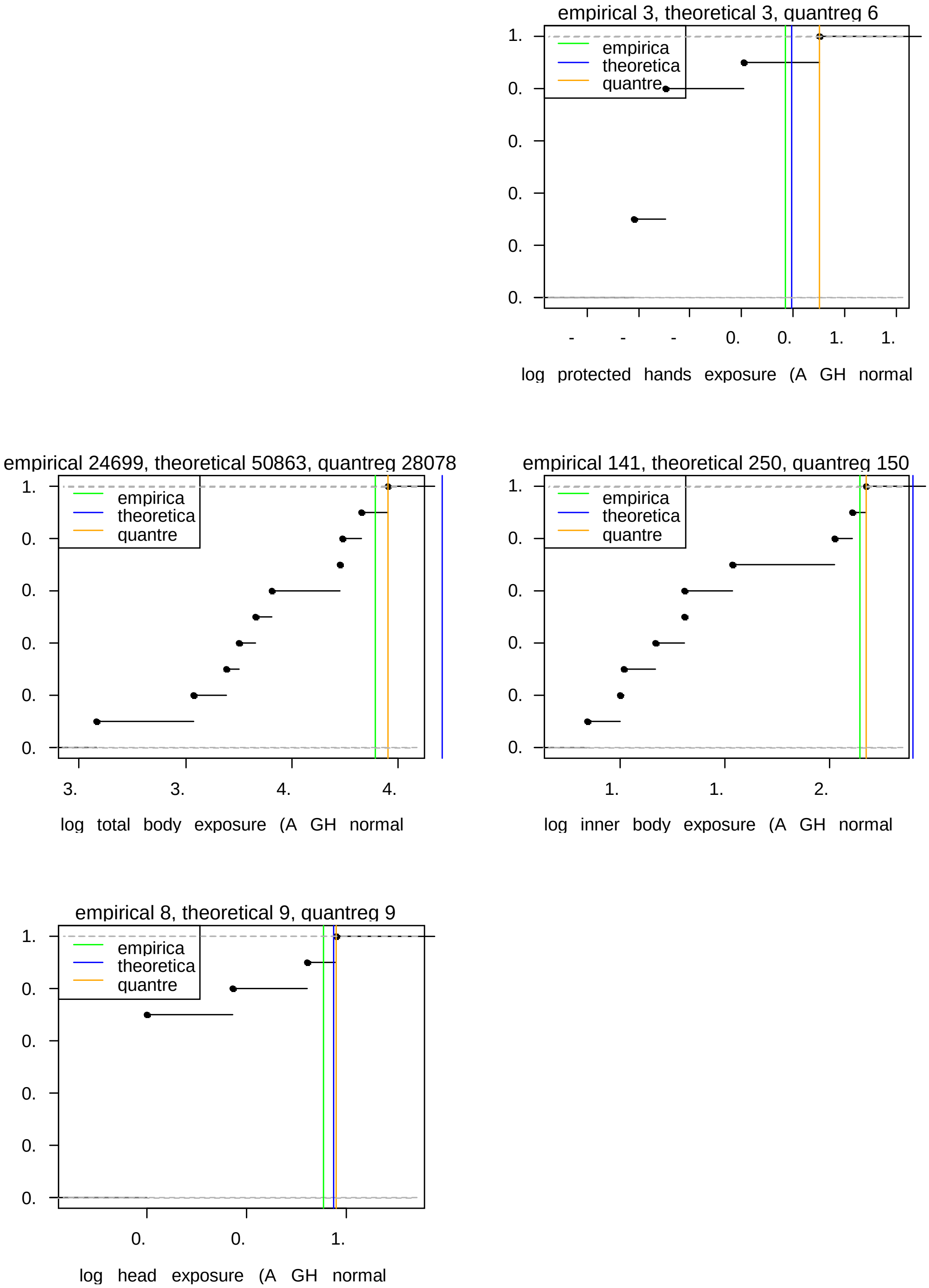


Figure A 12: Comparison of the empirical 95th percentile (green line) with the parametric estimate of the percentile calculated acc. to EFSA (blue line) and the 95th percentile obtained by quantile regression (orange line); the y-axis gives the proportion of data with values below a certain level of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

A 5.2 Greenhouse LCHH application (dense scenario)

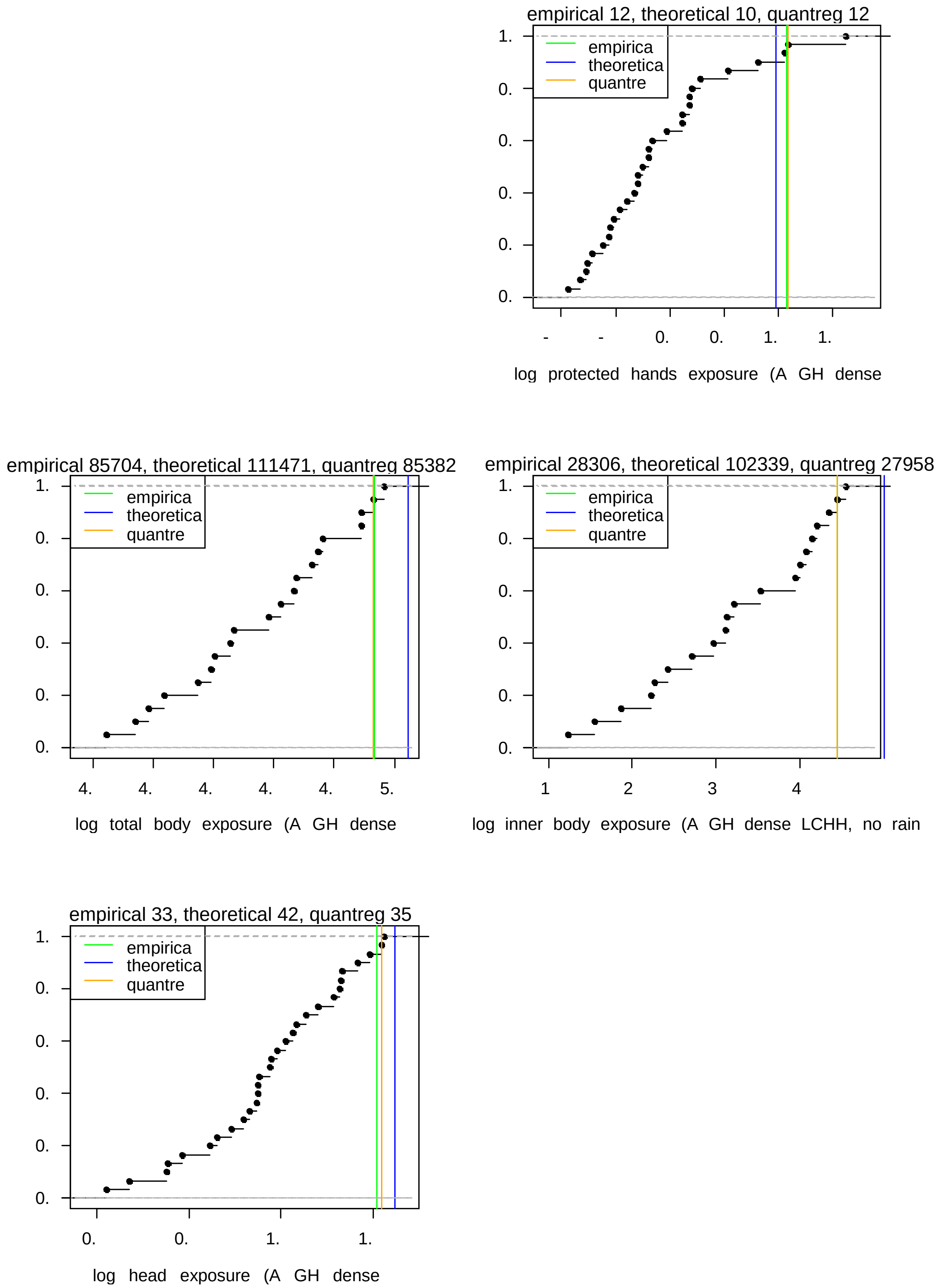


Figure A 13: Comparison of the empirical 95th percentile (green line) with the parametric estimate of the percentile calculated acc. to EFSA (blue line) and the 95th percentile obtained by quantile regression (orange line); the y-axis gives the proportion of data with values below a certain level of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

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

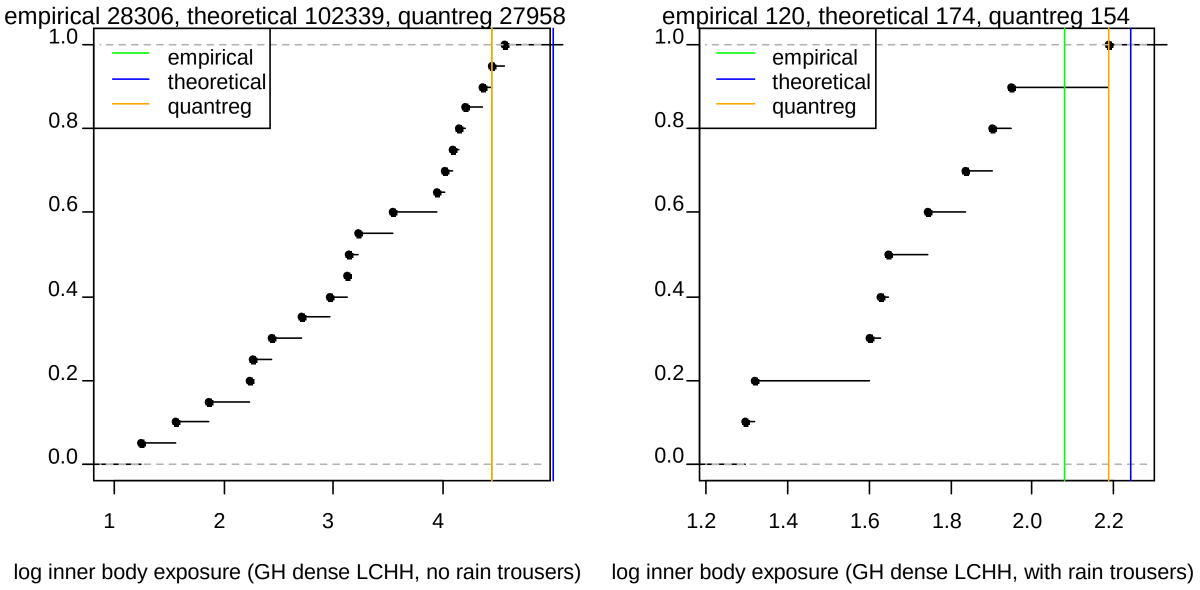


Figure A 14: Comparison of the empirical 95th percentile (green line) with the parametric estimate of the percentile calculated acc. to EFSA (blue line) and the 95th percentile obtained by quantile regression (orange line); the y-axis gives the proportion of data with values below a certain level of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

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

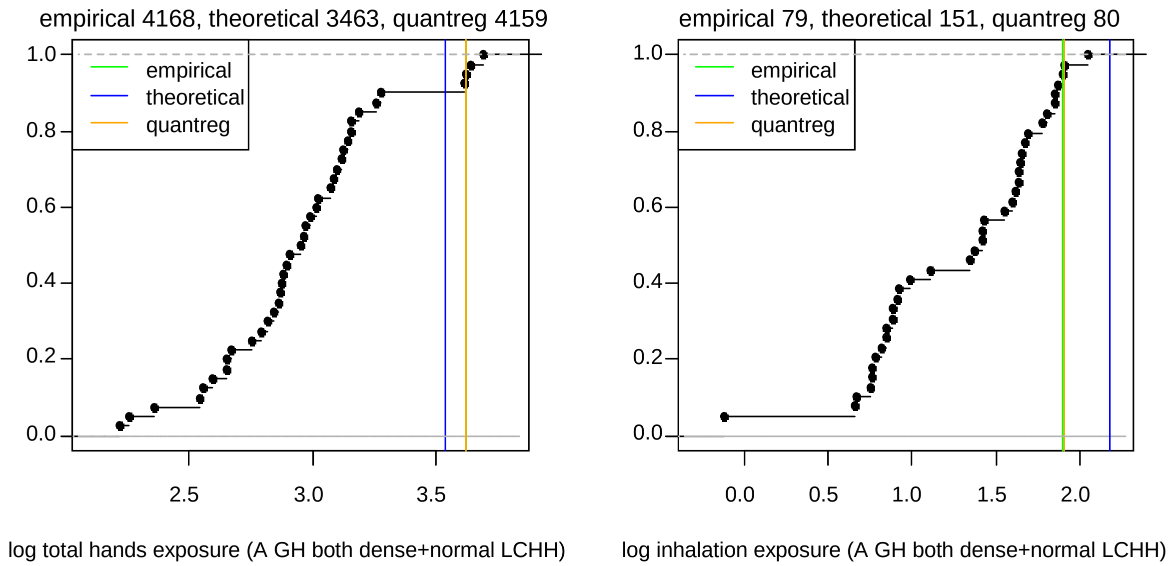


Figure A 15: Comparison of the empirical 95th percentile (green line) with the parametric estimate of the percentile calculated acc. to EFSA (blue line) and the 95th percentile obtained by quantile regression (orange line); the y-axis gives the proportion of data with values below a certain level of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

	n	min	50th perc.	75th perc.	90th perc.	95th 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 (µg/kg a.s.)

	n	min	50th perc.	75th perc.	90th perc.	95th 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 (µg/kg a.s.)

	n	min	50th perc.	75th perc.	90th perc.	95th 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 (µg/kg a.s.)

	n	min	50th perc.	75th perc.	90th perc.	95th 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 application

Total hand exposure (µg/kg a.s.)

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

Protected hand exposure (µg/kg a.s.)

	n	min	50th perc.	75th perc.	90th perc.	95th 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 (µg/kg a.s.)

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

Inner body exposure (µg/kg a.s.)

	n	min	50th perc.	75th perc.	90th perc.	95th 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 (µg/kg a.s.)

	n	min	50th perc.	75th perc.	90th perc.	95th 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 (µg/kg a.s.)

	n	min	50th perc.	75th perc.	90th perc.	95th 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 application

Total hand exposure (µg/kg a.s.)

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

Protected hand exposure (µg/kg a.s.)

	n	min	50th perc.	75th perc.	90th perc.	95th 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 (µg/kg a.s.)

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

Inner body exposure (µg/kg a.s.)

	n	min	50th perc.	75th perc.	90th perc.	95th 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 (µg/kg a.s.)

	n	min	50th perc.	75th perc.	90th perc.	95th 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 (µg/kg a.s.)

	n	min	50th perc.	75th perc.	90th perc.	95th 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 0.00000000000000
lTA                 0.6954309  0.5936785  0.8223129 0.07101780  9.792346 0.00000000000000
form2WP             1.2019432  1.0144665  1.4421394 0.12054292  9.971081 0.00000000000000
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(ph.ML) =  2.879  + 0.662 log(TA) + 1.449 form2WP + 0.471 form2liquid + 1.406
form2sachets + -0.383 glove.wash.MLyes
Formula for 75th percentile (based on quantile regression):
log(ph.ML) =  3.253  + 0.695 log(TA) + 1.202 form2WP + 0.524 form2liquid + 1.264
form2sachets + -0.373 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(ah.ML) = log(TA) + 0.753  + 1.496 form2WP + -0.182 form2liquid + 1.26
form2sachets
Formula for 75th percentile (based on quantile regression):
log(ah.ML) = log(TA) + 1.271  + 1.376 form2WP + 0.006 form2liquid + 0.809
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(ph.A) = log(TA) + 4.252  + -0.16 dense2dense
Formula for 75th percentile (based on quantile regression):
log(ph.A) = log(TA) + 4.505  + 0.011 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(ph.A) =  4.237  + 0.918 log(TA) + -0.156 dense2dense
Formula for 75th percentile (based on quantile regression):
log(ph.A) =  4.519  + 1.034 log(TA) + -0.002 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(ib.A) = log(TA) + 3.647  + 1.925 rain.densedense + -0.495 rain.densesuit
Formula for 75th percentile (based on quantile regression):
log(ib.A) = log(TA) + 4.196  + 1.638 rain.densedense + -0.851 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(ib.A) =  3.813  + 1.888 log(TA) + 1.862 rain.densedense + -0.517 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(tb.A) =  5.421  + 1.261 log(TA) + 0.792 dense2dense
Formula for 75th percentile (based on quantile regression):
log(tb.A) =  5.666  + 1.281 log(TA) + 0.565 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(ia.A) = log(TA) + 2.377  + 0.139 dense2dense
Formula for 75th percentile (based on quantile regression):
log(ia.A) = log(TA) + 2.594  + 0.134 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	0.00000000000000
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(ia.A) =  2.413  + 1.194 log(TA) + 0.13 dense2dense
Formula for 75th percentile (based on quantile regression):
log(ia.A) =  2.595  + 1.019 log(TA) + 0.139 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(ph.ML) =  2.879  + 0.662 log(TA) + 1.449 form2WP + 0.471 form2liquid + 1.406
form2sachets + -0.383 glove.wash.MLyes
Formula for 95th percentile (based on quantile regression):
log(ph.ML) =  3.734  + 0.79 log(TA) + 1.149 form2WP + 0.496 form2liquid + 1.593
form2sachets + -0.791 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(ah.ML) = log(TA) + 0.753  + 1.496 form2WP + -0.182 form2liquid + 1.26
form2sachets
Formula for 95th percentile (based on quantile regression):
log(ah.ML) = log(TA) + 2.221  + 1.084 form2WP + 0.076 form2liquid + 0.904
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(ah.A) = log(TA) + 1.164  + 1.163 dense2dense
Formula for 95th percentile (based on quantile regression):
log(ah.A) = log(TA) + 2.377  + 0.771 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(ah.A) =  0.954  + 0.09 log(TA) + 1.26 dense2dense
Formula for 95th percentile (based on quantile regression):
log(ah.A) =  2.538  + 1.383 log(TA) + 0.675 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(tb.A) = log(TA) + 5.372  + 0.811 dense2dense
Formula for 95th percentile (based on quantile regression):
log(tb.A) = log(TA) + 6.041  + 0.516 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(tb.A) =  5.421  + 1.261 log(TA) + 0.792 dense2dense
Formula for 95th percentile (based on quantile regression):
log(tb.A) =  5.892  + 0.466 log(TA) + 0.582 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(ib.A) = log(TA) + 3.647  + 1.925 rain.densedense + -0.495 rain.densesuit
Formula for 95th percentile (based on quantile regression):
log(ib.A) = log(TA) + 5.043  + 1.092 rain.densedense + -1.101 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: lhd.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(ia.A) = log(TA) + 2.377  + 0.139 dense2dense
Formula for 95th percentile (based on quantile regression):
log(ia.A) = log(TA) + 2.72  + 0.622 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(ia.A) =  2.413  + 1.194 log(TA) + 0.13 dense2dense
Formula for 95th percentile (based on quantile regression):
log(ia.A) =  3.13  + 2.041 log(TA) + 0.2 dense2dense

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