Remoundou K, Brennan M, Sacchettini G, Panzone L, Butler-Ellis MC, Capri E, Charistou A, Chaideftou E, Gerritsen-Ebben MG, Machera K, Spanoghe P, Glass R, Marchis K, Doanngo K, Hart A, Frewer LJ. **Perceptions of pesticides exposure risks by operators, workers, residents and bystanders in Greece, Italy and the UK**. *Science of the Total Environment* **2015, 505, 1082-1092.**

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Abstract

The EU Directive on the sustainable use of pesticides (EU128/2009/EC) requires European Member States to develop training activities targeting occupational exposure to pesticides, and communication material aimed at residents and bystanders. Risk perceptions, knowledge and attitudes associated with passive and occupational exposure to pesticide potentially influence the extent to which different stakeholders adopt self-protective behaviour. A methodology for assessing the link between attitudes, adoption of self-protective behaviours and exposure was developed and tested. A survey was implemented in the Greece, Italy and the UK, and targeted stakeholders associated with pesticide exposure linked to orchards, greenhouse crops and arable crops respectively. The results indicated that the adoption of protective measures is low for residents and bystanders, with the exception of residents in Greece, when compared to operators and workers, who tend to follow recommended safety practices. A regression analysis was used to examine the factors affecting the probability of adopting protective measures as well the as the level of exposure in the case of operators and workers where data are available. The results indicate that the likelihood of engaging in self-protective behaviour is not significantly affected by perceptions of own health being affected by pesticides for residents and bystanders. However, operators who perceive that their heath has been negatively affected by the use of pesticides are found to be more likely to adopt self-protective behaviours. Gender and country differences, in perceptions, attitudes and self-protection are also observed. Recommendations for improved communication, in particular for vulnerable groups, are provided.

Keywords: Worker; Operator; Resident; Bystander; Exposure; Pesticide; Agriculture; Risk Perceptions.

Running Head: Perceived pesticide exposure risk

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1. Introduction

The recently revised EU Directive on the Sustainable Use of Pesticides (EU128/2009/EC) requires European Member States to develop training activities targeting occupational exposure to pesticides, as well as communication material aimed at residents and bystanders (EC, 2009). To accomplish this, it is important to develop an understanding of the perceptions and attitudes of different stakeholders' regarding risks from pesticide exposure, and how these perceptions translate into adoption of protective behaviours (see, *inter alia*, Koh and Jeyaratnam,1996; Palis *et al*., 2006; Yasin *et al*., 2002). However, there is little empirical evidence available to link risk perceptions and attitudes of European workers and operators to their adoption of protective behaviours (Remoundou *et al*., 2014). Even less is known about residents and bystanders in this regard. In the research presented here, "workers" are defined as a person who, as part of his/her employment, enters an area that has previously been treated with pesticides or who handles a crop that has been treated with pesticides, in line with the EFSA (2010) definition. The same source defines "operators" as those individuals employed in pesticide application. "Residents" are defined as individuals living or working in areas adjacent to those where pesticides are applied, and "bystanders" as individuals who are inadvertently exposed to agricultural pesticides through non-agricultural activities, for example through engagement in leisure activity in areas which have recently been sprayed. Risks to residents and bystanders may include inadvertent dermal and inhalation exposure from sprayed fields, contact with treated crops during amenity visits (Butler-Ellis, van den Berg and Kennedy 2013). A recent review of the literature located only three studies conducted in Europe examining perceptions and attitudes of operators and residents, although there is a literature drawing on data collected in developing countries and the US (Remoundou *et al*., 2014). However, the existing evidence is not conclusive with regard to the association between risk perceptions and adoption of protective behaviours. High levels of risk perception associated with pesticide exposure, and levels of knowledge about the associated risks, are often observed, but these do not always translate into better use of, and adherence to, advice about self-protective behaviour and equipment use (Remoundou *et al*, 2014). Other factors, such as economic and employment pressures, and those related to peer group influences and culture, appear to influence risk-related behaviours.

Illiteracy may result in difficulties in understanding labels on pesticide containers, or written risk communications about how to avoid exposure. There is evidence that illiteracy is an important barrier to the adoption of self-protective behaviours in the developing world, including agricultural workers (e.g. see Kimani and Mwabthi, 1995; Pasiani *et al*., 2012; Stadlinger *et al*., 2011; Salameh *et al*., 2004; Karunamoorthi *et al*., 2011; Blanco-Muñoz and Lacasaña, 2011).

For workers and operators in particular, difficulties in implementing appropriate protection may also exist in relation to access and use of protective clothing (e.g. Flocks *et al*, 2012). Perceived or actual work pressures may also result in inappropriate behaviours in these stakeholder groups (Acury *et al*., 2002; Austin *et al*., 2001). Peer pressure (Heong *et al.*, 2012) may also influence the behaviours of workers and operators. Lack of knowledge, for example, in relation to when treatments should be applied, or regarding the extent to which pesticides represent a hazard, may also discourage adoption of self-protective behaviours (Obopile *et al*., 2008). Similarly, the perception that resistance to pesticide risks will occur after years of exposure, or that a person's ability to control their own exposure to pesticides is limited, is likely to result in lower adoption of protective behaviour (Flocks *et al.*, 2007; Arcury *et al.*, 2002; Cabrera, 2009). Finally, adoption of heavy protective clothing may be uncomfortable in warmer climates or conditions, indicating the need to compare perceptions and the adoption of self-protective behaviours across countries in different climatic regions (e.g. Berg *et al*, 2001; De Almeida *et al*, 2012).

Furthermore, in the majority of the available studies, data have been collected in the developing world, and may be influenced by local cultural factors (Remoundou *et al.*, 2014). The results may not, as a consequence, directly translate to the European context. Furthermore, there is a paucity of data relating to the link between the risk perceptions and adoption of self-protective behaviours *of residents* and *bystanders*. Lack of knowledge of, for example, the extent to which pesticides represent a hazard may also militate against the adoption of self-protective behaviours (Barraza *et al.*, 2011; Ntow *et al.*, 2006).

The need for further research into the relationship between risk perceptions and attitudes, and adoption of self-protective behaviours, is thus often stressed (Remoundou *et al.*, 2014; Emery *et al* , accepted). The research presented here addresses this gap by assessing the risk perceptions and related attitudes held by operators, workers, residents, and bystanders in 3 European countries (Greece, Italy and the UK). Data were collected as part of a wider survey aiming to measure and model pesticide exposure and inform the revision of the risk assessment models in Europe. An important aim of the research was to demonstrate the utility of the methodologies applied, and to assess differences between *stakeholder groups* and *countries*. To our knowledge, this is the first study presenting European evidence regarding the potential link between risk perceptions, attitudes and protective behaviours related to pesticide exposure for residents and bystanders. The methodological approach represents, therefore, a valuable tool in developing understanding of the drivers of pesticide exposure in the stakeholder groups included in the research. Information of relevance to the design of training materials which build on existing perceptions, attitudes, and behaviours of different stakeholder groups has also been identified.

2. Methodological Approach and Empirical Research Hypotheses

Various factors may potentially influence the adoption of safety behaviours and thus the degree of pesticide exposure. The research presented here aims to present a methodology for assessing the link between perceptions and attitudes regarding self-protective behaviours associated with pesticide exposure, which can be replicated in other regions, countries and national contexts, facilitating the targeting of risk communication to the needs of different stakeholder groups. It is predicted that the extent to which individuals will adopt protective measures regarding pesticide exposure will increase if they perceive more personal health risks to have been associated with pesticide exposure, and are more worried about the future. Demographic differences were also taken into account in the analysis, as individual differences have been reported in the literature (for example, in relation to gender). The empirical analysis applies multivariate regression to modelling adoption of protective behaviours, A, for individual i as a function of demographic characteristics D, perception of personal health being affected by pesticides H, and worry about the future, F as;

$$A_i = f(D_i, H_i, F_i) + \varepsilon_i \qquad (1)$$

where ε is a normally distributed residual. H and F refer specifically to stated agreement to the following two statements:

- *I think that my health has been affected by exposure to pesticides (H)*
- *I do not spend a big part of my time worrying about the future (F)*

It is predicted that higher perceptions of health damage due to exposure to pesticides will result in greater protective behaviour (i.e. higher A), (Lichtenberg and Zimmerman, 1999). Similarly, greater concern to the future (a low F) should result in more frequent adoption of protective behaviours. Similarly, F is treated as a proxy for time preferences and it is expected that greater concern about the future (a low F) will result in more frequent adoption of protective behaviours and therefore lower exposure risk. This hypothesis is consistent with previous evidence suggesting that time preferences are likely to influence individual behaviour in general, and behaviour related to health outcomes in particular. More future-oriented individuals are less likely to engage in risky health behaviours such as smoking, drinking, drug use or unhealthy dietary habits (Conell-Price and Jamison, 2012). Time preferences are also found to be associated with adoption of protective behaviours. Individuals who greatly discount the future and show little regard for future health consequences are less likely to engage in protective behaviours (Lawless *et al*., 2013). There is, however, no research examining the importance of time preferences in the context of the risks associated with pesticide exposure. Nevertheless, the existence of a *present bias* may explain low adoption of protective behaviours designed to protect against pesticide exposure since such behaviours require people to sacrifice present pleasure for future benefits.

These working hypotheses are tested using primary data collected from 3 European countries. Data are collected from the general public (residents and bystanders), operators applying pesticides in agricultural production, and workers performing tasks in crops treated with pesticides. H and F in equation (1) are a series of dummy variables taking a value $k = 1, \ldots, 5$, leading to the estimable equation

$$A_i = \beta_0 + \beta_1 D_i + \sum_{k=1}^{5} \gamma_k H_i^k + \sum_{n=1}^{5} \alpha_n F_i^n + \varepsilon_i \qquad (2)$$

For residents, bystanders and operators equation (2) is first estimated, with A being the likelihood of adoption of protective behaviours. A is therefore modelled as a binary indicator that observes whether an individual adopts protective behaviours. For residents and bystanders, this refers to whether individuals do anything to protect themselves from exposure. For operators, A refers to whether they use Personal Protective Equipment (PPE) when mixing/loading and applying pesticides and cleaning equipment used for pesticide application. A question on the use of PPE was not asked for workers and therefore the likelihood of adopting PPE for this group is not modelled.

For operators and workers, information regarding exposure risks is also available. Exposure risks are calculated for each individual using the BROWSE Exposure Assessment Software.

The software uses new exposure models for operators and workers developed by the BROWSE project. The user can specify the exposure scenario and input values for several parameters (factors influencing exposure eg. normal work clothing, working time) to get exposure estimates. More information on the BROWSE Exposure Assessment Software, the underlying models, a trial version and initial comparisons with existing models can be found at https://secure.fera.defra.gov.uk/browse/software/

In this case, *A* is a continuous variable showing the level of exposure (workers) or exposure reduction (operators). The dependent variables are explained in the following subsections.

2.1 Adoption of protective behaviours

Adoption of protective behaviours can be intended as a latent variable A_i^* mirroring a continuous scale of use. Specifically, individuals with a positive propensity for adopting protective behaviours are assigned a value of adoption of one, and zero otherwise, as:

$$\begin{aligned} A_i &= 1 \quad if \quad A_i^* \geq 0 \\ A_i &= 0 \quad if \quad A_i^* < 0 \end{aligned} \qquad (3)$$

This approach allows an unobservable continuous measure of adoption to be dealt with by associating a probability to the occurrence of a positive outcome. The relation between a covariate and an outcome probabilistically, given that specific factors may increase or decrease the probability of adoption, can then be observed.

For the residents and bystanders, the question aiming to assess adoption of protective measures was framed as: '*Do you do anything to reduce your exposure to pesticides while in, or adjacent to, farmland, orchards or greenhouses?'* Respondents could reply by indicating either "yes" or "no". The binary indicator then takes the value of 1 if the respondent replies yes and 0 otherwise.

In the case of operators, adoption has been measured with respect to self-protective behaviours associated with mixing and loading; application; and cleaning. Operators were asked whether they always, when specified in the Plant Protection Product label or never use PPE during the above activities. The binary indicator then takes the value of 1 if the operator reports using PPE during the relevant activity (either always or when specified in the label) and 0 otherwise. In this case, marginal effects for F_i^1 (the same applies to all dummies) in equation (1') correspond to:

$$\frac{\partial \Pr(A_i \mid D_i, H_i, F_i^k)}{\partial F_i^k} = \phi(\delta_i, F_i^1 = 1) \cdot \alpha_1 - \phi(\delta_i, F_i^1 = 0) \cdot \alpha_1 \qquad (4)$$

where $\delta_i = \beta_0 + \beta_1 D_i + \sum_{k=1}^{5} \gamma_k H_i^k + \sum_{n=2}^{5} \alpha_n F_i^n + \varepsilon_i$. (5)

Since almost all operators indicated that they use protection for mixing and loading, the analysis was focused on pesticide application and cleaning of equipment.

2.2 Exposure indicators

The approach highlighted above provides an indication of whether individuals adopt or do not adopt specific protective behaviours. For operators and workers, information regarding exposure risks is calculated for each individual using the BROWSE software. The use of a proxy variable may introduce a measurement error in the dependent variable, with a consequent reduction in the efficiency of the estimator, but with no impact on its consistency (see e.g. Hausman, 2001). This approach follows a truncated dependent variable in the form:

$$\begin{aligned} E_i &= 1 && \text{if} \quad E_i^* > 1 \\ E_i &= E_i^* && \text{if} \quad 0 \geq E_i^* \geq 1 \\ E_i &= 0 && \text{if} \quad E_i^* < 0 \end{aligned} \qquad (6)$$

where *E* represents exposure, and marginal effects are calculated using equation (4).

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2.2.1 Operators

For operators, the level of exposure has been measured through an *"Exposure Reduction Index"* (ERI) calculated as

$$\text{ERI} = 100 \cdot \frac{(\text{Potential exposure - Actual exposure})}{\text{Potential exposure}} \qquad (7)$$

The index was calculated at the individual level using the BROWSE software assuming a common scenario for all individuals and allowing variations in the use of PPE, clothing and the use of the cabin for arable crops (https://secure.fera.defra.gov.uk/browse/software/, BROWSE, 2013a).

2.2.2 Workers

The level of exposure for workers uses a *"Migration Index"* (MI) calculated as:

$$MI = \sum_j (\text{Body part surface area} \cdot \text{Migration factor} \cdot \%\ \text{working time}) \qquad (8)$$

where j refers to different activities. MI was again measured at individual level, and separately for cold season and warm season using the BROWSE Worker model (BROWSE, 2013b; 2013c) on the basis of self-reported behaviours in relation to working clothes and PPE worn during working activities.

3. The survey

The survey was developed in collaboration with pesticide exposure modellers working on the BROWSE FP7 project. Part of the survey included items on risk perceptions and attitudes, the focus of the current analysis. Four different versions of the survey were developed, each targeting a different stakeholder group (namely, Operators, Workers, Residents, and Bystanders). The structure of all four versions was similar with the questionnaire consisting 3 parts. The first part aimed to assess the level of actual exposure, and involved questions about the channels and frequency of pesticide exposure, as well as about which measures were adopted by respondents in order to reduce their personal exposure. It is important to note that the questions differed between different versions of the questionnaire, as different stakeholder groups were being surveyed. The second part aimed to assess risk perceptions associated with pesticides exposure, and their participants' general attitudes towards pesticides[1].

Data about risk perceptions and attitudes were collected by means of statements that the respondent had to indicate the extent of their agreement or disagreement on a five-point Likert scale, anchored by 1 (strongly agree) and 5 (strongly disagree). The statements were: 1: *"There are benefits from the use of pesticides relating to crop quality, appearance and food safety"*; 2: *"I think that my health has been affected by exposure to pesticides";* 3: *"I consider myself to be more at risk from pesticides than other people";* 4: *"I think the use of pesticides in food production reduces the safety of food";* 5: *"The health risks associated*

[1] Questions were also asked about their preferred information sources for pesticide risk communication, and the extent to which they trusted different sources. The results will be reported elsewhere. A copy of the survey instrument is available from the corresponding author on request.

with pesticides are well understood by scientists"; 6: *"I do not spend a big part of my time worrying about the future";* 7: *"I would financially contribute, through higher taxes, to research and activities aimed at mitigating the adverse health effects of pesticides".* Statements 2 and 6 are used to formulate our hypotheses and estimate equation (1).

The last part of the questionnaire collected information on the socio-demographic characteristics of the participants including age, gender, income, occupational status, presence of children (under 16) in the family and health satisfaction.

3.1 Participants

Data collection took place between March and December 2012 in Greece, Italy and the UK using primarily face-to-face interviews. The choice of the different countries aimed to cover both the Northern and Southern regions of Europe. These regions differ considerably in climatically conditions, which potentially affects exposure (for example, regarding the extent to which wearing protective clothing is comfortable, or the type of crop being treated). Cultural variables may also be influential, for example in relation to the size of farms, proximity of housing, and behaviours regarding adoption of protective measures. Residents and bystanders were randomly selected in high streets[2]. Operators and workers were interviewed on the farm after permission from the farm owner. The exception to face-to-face interviewing occurred in the UK, additional data from operators and workers were collected *via* a web survey developed using survey-monkey software. The web survey was deemed suitable for operators and workers in the UK given the intensive nature of UK farming, in particular during the summer when data collection took place, and because of the general familiarity of UK farmers with web technologies as a consequence of the need to provide internet data to DEFRA (Department of Environment, Food and Rural Affairs). An advertisement with a link to the survey was placed in the Farmers Weekly magazine, a nationally distributed UK magazine on farming issues with the highest circulation.

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[2] It should be noted that individuals living or working further than 20 meters from farmland, orchards or greenhouses (as the EFSA definition for residents requires) were included in the resident category. This decision was taken when participants firmly insisted that they were of the belief that they were a member of the resident category and they justified this by declaring that they were able to see machinery operating close to where they live.

The implementation of the survey resulted in 186 completed questionnaires the UK, 207 in Italy and 223 in Greece. The number of participants in each country and each stakeholder group are summarised in Table 1.

[Table 1 around here]

Interviews were conducted by researchers from the BROWSE project, following an agreed protocol. Recruitment into stakeholder groups was based on the definitions of residents, bystanders, operators, and workers adopted by the European Food Safety Authority, (EFSA), the European risk assessment body for food and feed safety. The protocol clarified the sampling and survey implementation principles for each stakeholder group on the basis of maximizing the representativeness of the sample and of ensuring consistency of data collection across the 3 different countries. Finally, one operator and five workers *per* farm enterprise were interviewed (or the contractor in case that the farm contracted an operator).

In Italy and the UK, an incentive in the form of a small gift or a charitable donation was used respectively. No incentive was used in Greece[3]. The questionnaires were initially developed in English and were translated and back translated into Greek and Italian by the researchers, who also trained the interviewers. Targeted operator and worker groups differed between the 3 countries to reflect the priority crops, as identified by the exposure modellers within the BROWSE project. It was therefore decided to interview and model exposure and risk perceptions of Operators, Workers, Residents and Bystanders associated with pesticide application to arable crops in the UK, wine grapes and greenhouses in Italy and greenhouse vegetables and olives in Greece (Table 2).

[Table 2 around here]

Types of crops are also included in this table. Note that types of crops utilised match those selected for the Browse modelling activities, and are representative of the countries included in the study. Note that residents and bystanders were surveyed in the same areas in each country.

4. Results

4.1 Descriptive Statistics

[3] Different incentives were used given the different cultural contexts in the sampled countries. Although we cannot exclude some self-selection of the participants we are not expecting this to be linked with views on pesticides.

Table 3a summarises selected characteristics of respondents in the bystander and resident category across the different countries, including all covariates included in the regression. Table 3b reports similar statistics for workers and operators. For the later information on the illiteracy rates is also gathered and reported in the tables.

[Table 3a around here]

[Table 3b around here]

4.2 Adoption of protective behaviours

Summary statistics indicate variability in the characteristics of the sample between countries. An immediate empirical question is whether the observed differences in the adoption of protective behaviours and exposure presented in Tables 3a and 3b are significantly different between countries. ANOVA was applied to test for main effects, and pairwise comparisons conducted using the Fisher-Hayter (FH) test; differences in variance were tested using a Bartlett's test. The tests compared both the adoption variable (Table 4a) and the exposure indicators (Table 4b). Results detect no significant differences in the likelihood of bystanders adopting protective behaviours between the 3 countries (FH_{UK} vs Greece: 1.8, FH_{UK} vs Italy: 1.33, $FH_{Italy\ vs\ Greece}$: 0.43). However, the adoption of protective behaviours differed significantly among groups: adoption is significantly higher in the UK for both residents (FH_{UK} vs Greece: 9.64, FH_{UK} vs Italy: 3.38) and operators at the application (FH_{UK} vs Greece: 7.98, FH_{UK} vs Italy: 6.43) and cleaning stage (FH_{UK} vs Greece: 9.18). Adoption in Italy is better than in Greece for residents ($FH_{Italy\ vs\ Greece}$: 6.25) and operators at the cleaning stage ($FH_{Italy\ vs\ Greece}$: 9.05). No differences in operator exposure reduction were observed between countries (FH_{UK} vs Greece: 2.14, FH_{UK} vs Italy: 2.69, $FH_{Italy\ vs\ Greece}$: 0.11). However, the migration coefficient is higher for workers in Italy compared to Greece in the warm period ($FH_{Italy\ vs\ Greece}$: 3.35). Moreover, exposure is higher in the UK compared to Greece (warm period, FH_{UK} vs Greece: 4.73) and Italy (cold period, FH_{UK} vs Italy: 2.99). Finally, the samples tend to have similar variances across all countries. The only exception is for operators both in terms of adoption of protective behaviours (at application, $p<0.000$) and in terms of the exposure index, which have greater variance in the UK sample compared to both Italy and Greece ($p < 0.000$).

[Table 4a around here]

[Table 4b around here]

4.3 Adoption of protective behaviours: Regression analysis

The results indicate a substantial amount of national variation in the adoption of protective behaviours designed to reduce risks of exposure to pesticides. To explore the sources of this heterogeneity, regression analysis was used to examine the relationship between adoption of protective behaviours, socioeconomic characteristics, country of residence as well as perceptions and attitudes towards pesticides.

The results presented in Table 5 refer to the use of the binary adoption indicator described in Section 2.1, which measures the likelihood of adopting protective behaviours for residents and bystanders and probability of using PPE while applying pesticides or cleaning equipment for operators. Given the binary nature of the dependent variable, probit models are estimated. Table 5 reports the estimated parameters of the probit regression while the marginal effects for the health and future variables are provided in figure 1, together with the bootstrapped standard errors. The analysis specifies that all variables and observations are retained in the maximization process. This option is typically not specified, and may introduce numerical instability. Marginal effects are estimated forcing the retention of perfect predictor variables, to avoid any observations from being dropped (the index relates to application). The coefficients of the probit regressions indicate changes in the cumulative distribution function of the probability and thus are only informative in terms of their sign, but not in their size (see e.g. Greene, 2008). Furthermore, as specified above, participant responses to Likert scales are included as a series of dummies. Thus the marginal effect is allowed to vary without imposing any *a priori* relation between variables, e.g. they could show a linear as well as a quadratic relation. The results are presented separately by group.

[Table 5 around here]

[Figure 1 around here]

4.3.1 Residents and Bystanders

Due to the low number of observations and the presence of several missing observations in demographics, the model for the residents and bystanders shows parsimony by using only the gender of the respondent (where male equals 1) and age (in years), which enters the regression linearly. The model also includes country dummies, where UK is the baseline. The results (Table 5) indicate that the likelihood of adopting protective behaviours is lower among male residents ($p<0.000$), and significantly higher among Greek ($p<0.000$) and Italian

($p<0.087$) residents relative to UK. Figure 1 further suggests that the “future” variable negatively impacts on the likelihood of adoption for both residents and bystanders. Conforming to expectations, individuals caring less about the future tend not to adopt protective behaviours. The explanatory power is weak for the sample of bystanders, while the model is stronger for the sample of residents.

For both residents and bystanders, the perception that personal health was damaged by pesticides did not result in higher (stated) adoption of protective behaviours. In fact, adoption of protective behaviours is unresponsive to changes in perceived health damage from pesticide exposure (see figure 1). As a result, respondents did not view the adoption of protective behaviours as relevant, potentially because the damage to health was perceived to have already occurred (e.g. it was too late to intervene by adopting protective behaviours), or because respondents were unable to adjust their behaviours to be more protective despite being aware of the damage of pesticide exposure to health.

4.3.2 Operators

The methodological approach used for operators was similar to that used for residents and bystanders. As before, demographics played a minor role in influencing the behaviour of respondents (all males), but some country differences were identified. The Italian sample tended to perform significantly better than the UK in terms of adoption of PPE while applying pesticides ($p<0.020$). Greek operators were associated with a lower probability of adopting PPE while cleaning compared to their UK counterparts ($p<0.000$). However, problems of multicollinearity caused large standard errors to be associated with the estimated coefficients in some of the dummy variables in the model, limiting inference. The results further suggest that adoption of protective behaviours was not related to perceptions held by respondents about their own health, nor concerns about the future. This is confirmed by marginal effects. However, figure1 indicates that there may be a weakly positive relation between health and behaviour, particularly in relation to cleaning, as well as a higher level of adoption of protective behaviours by individuals who report low interest in the future. This lack of significance may be attributable to collinearity, but the present dataset does not allow further analysis regarding this issue.

4.4 Exposure indicator: Regression analysis

The analysis described in section 4.3 was re-conducted for the index measuring exposure to pesticides for operators and workers. This approach allows analysis of the data obtained from sample of workers at the expense of a reduced sample size in some of the samples due to missing observations. Regressions replicate the previous exercise, using the same covariates, but are adjusted because of the dependent variable: the dependent variable is truncated for both operators (ranging from 0 to 100) and workers (ranging from 0 to 1), and the estimation uses a Tobit regression with double truncations. The results are presented in Table 6, while marginal effects are displayed in Figure (2) together with bootstrapped standard errors (1,000 replications).

[Table 6 around here]

[Figure 2 around here]

4.4.1 Workers

To approximate for workers' exposure, a 'migration index' is calculated using the BROWSE software for the warm and the cold seasons. A higher migration index indicates a higher exposure. The regression results suggest that, in both seasons, demographics are not associated to a change in exposure. Country differences are only evident in warm periods, with Italian workers having a higher migration index compared to their UK counterparts ($p=0.077$). The results presented in figure 2 further suggest that an individual's perceptions of own health being negatively affected by pesticides does not significantly influence exposure. Finally, time preferences are not found to be a significant determinant of exposure. The models tend to have a low predictive power, a feature that can also be observed in the relatively low rate of success in the bootstrapping procedure of the marginal effects (around 87%).

4.4.2 Operators

As for 2.2.1, an 'Exposure Reduction Index' was developed using the BROWSE software to approximate operator exposure. This was used as the dependent variable in the regression analysis. Mirroring the results for workers, exposure did not vary with demographic characteristics of operators. However, exposure reduction was significantly lower (therefore exposure was higher) in Italy ($p<0.005$) and Greece ($p<0.05$) compared to the UK for this group. The results further indicate that the level of concern about the future does not relate to the level of exposure. Nevertheless, individuals who believed that their health had been negatively affected by exposure to pesticides had a lower reduction index and thus higher exposure to pesticides. This might imply that individuals who believe that there health has already been damaged by exposure to pesticides are less likely to adopt protective behaviours. Marginal effects (figure 2) confirm these relationships.

5. Discussion

Understanding the risk perceptions and risk attitudes of different stakeholders' regarding pesticide exposure is important if risk communication programs and policy responses aimed at reducing pesticide exposure through adoption of self-protective behaviours are to be effective in achieving public health goals. The need to optimise public health in relation to pesticide exposure has been the focus of recent policy documents. These documents reflect the observation that inappropriate stakeholder exposure to pesticides represents a significant source of mortality and morbidity worldwide (WHO 2003; Pimentel 1996). However, understanding *how* to tailor risk communication messages to the needs of *different* stakeholder groups must take account of (potential differences in) risk perceptions, which, as the results presented here have shown, tend to vary between individual groups of stakeholders in a predictable way.

The research presented here has built on the existing literature investigating how risk perceptions and attitudes held by stakeholder groups potentially affected exposure to pesticides. This literature has drawn heavily on data from developing countries or immigrant samples in the US where pesticide-related health effects are more pronounced. In addition, the focus of the research has been on agricultural workers or pesticide operators rather than residents and bystanders. As a consequence, evidence from European populations is required to inform the development and implementation of effective risk communication strategies as required by the EU Sustainable Use of Pesticides Directive. A methodology for so doing is presented. An important finding is that there are low levels of adoption of protective behaviours by residents and bystanders (with the exception of residents in Greece), who may therefore be particularly vulnerable to the negative effects of pesticide exposure. Against this, the majority of operators appear to engage in self-protective behaviours, and it may be broadly concluded that risk communication and training targeting operators in Europe regarding pesticide exposure is effective. None-the-less, differences within these groups were also observed. For example, operators who perceived that their heath was being negatively affected by the use of pesticides were found to be more likely to adopt self-protective behaviours (see also Lichtenberg and Zimmerman, 1999). The predicted relationship between an individual's concern about the future and increased likelihood of adoption of protective measures was not observed for operators. This might be because people's concerns about the future were not operationalised in terms of their health, but were related to other areas of concern (for example, fiscal or other socio-economic issues). Risk communication might usefully emphasis the potential long-term health impacts of exposure to pesticides. The provision of concrete and actionable recommendations regarding how exposure can be avoided, tailored to the needs and abilities of different stakeholder groups, would also provide the basis for behavioural changes regarding exposure. Other factors, however, may also influence the extent to which risk communication is effective. For example, the *drivers* of an individual's risk perceptions and tendency to adopt of protective behaviours may vary within a stakeholder group. For example, individuals who perceive that their health has already been affected by exposure to pesticides *may* also perceive that, because damage has already been done, that any further attempts to limit pesticide exposure through adoption of self-protective behaviours would have limited health benefit. Alternatively, these individuals may believe that exposure results in "immunity" to negative effects of exposure (Yasin *et al* , 2002) or that pesticide exposure only negatively effects vulnerable or weaker individuals (Salazar, 2004). Risk communication efforts may usefully, therefore, target these erroneous perceptions in order to encourage the adoption of self-protective behaviours. A focus for risk communication strategies might be, therefore, communication about the potentially negative effects of pesticides on human health following exposure, independent of whether previous exposure has taken place. This will address any potential stakeholder confusion about dose-response relationships and human health impacts associated with pesticide exposure. Furthermore, the content of risk communication should emphasise that adverse health effects associated with pesticide exposure are chronic rather than acute, with the aim of altering time preferences and ensuring people are more "future-oriented" regarding health impacts. Research has shown that training and educational activities can make people more willing to make investments (for example, in terms of behaviour changes) that involve short-term costs for long-term benefits (Cawley and Ruhm, 2011). However, illiteracy is an important barrier to the adoption of self-protective behaviours. Our study pointed to significant illiteracy rates in Southern Europe particularly among migrant workers in Greece. This represents a challenge in the design of appropriate training and communication material.

Awareness raising campaigns are particularly needed in order to inform residents and bystanders about the exposure risks associated with living in proximity to, or entering, fields which are being sprayed. An important element of such campaigns is the provision of information to residents and bystanders regarding concrete and actionable protective behaviours that they can take to reduce their exposure, given that there are greater limitations in behavioural responses. Health behaviour and adoption of protective behaviours has been found to be responsive to information for a number of health hazards (Dupas, 2011). However, provision of information is not always found to be enough to reduce risky behaviours. Research has indicated that different messages and message delivery may be effective in different contexts in order to convince people to adopt protective behaviours (Dupas 2011).

Some demographic differences were also observed. Female residents were found to have significantly higher risk perceptions and be more likely to engage in safety practices than male residents. Higher risk perceptions for women compared to men have been found for other areas of risk perception research (e.g. Flynn *et al*, 1994; Cabrera and Leckie, 2009). This finding supports the link between risk perception and adoption of self-protective behaviours, as well as confirming the tendency for women to have greater risk perception and adopt less risky behaviours when compared to men

The research presented here has provided a methodology which can be used to assess the links between perceptions, the tendency of an individual to adopt self-protective behaviours, and exposure to pesticides. Broadly, it can be concluded that a relationship between perceptions, associated attitudes, and exposure holds for most of the stakeholder groups included in the analysis, as well as the different countries in which data were collected. However, the existence of differences in absolute levels of (for example) adoption of protective behaviours between countries suggests that cultural variation in perceptions, attitudes and behaviours exists even within Europe, and thus it is recommended that further research is conducted within the different stakeholder groups at the national level, in order to facilitate the tailoring of risk communication efforts to the needs of national communities. It should be noted that the results are less helpful in addressing some potentially profound cultural and linguistic barriers to effective risk communication. For example, the problem of language remains, as many of those exposed to the risks associated with pesticides many not understand the dominant language used in a particular country (in particular migrant workers or tourists). Some intuitive solutions (for example, communication using pictograms) may also misinterpreted by stakeholders (Emery *et al*, in press). Thus, while the research has identified the need to develop effective communication, in particular that targeting residents and bystanders, the format (or formats) most suited to the needs of different stakeholder groups requires further consideration.

Some important limitation of the research can also be identified, and these may need to be addressed in the design of future research studies. The first relates to the risk perception measures utilised in the survey, which were limited for pragmatic reasons (the length of time needed to complete the survey needed to be as short as possible). However, it is arguable that other risk perceptions factors might also be efficacious predictors of protective behaviours.

Prominent among these is “optimistic bias”, or the extent to which an individual considers themselves to be less at risk from a particular hazard compared to the risk applicable to an average member of the society in which they live (Weinstein, 1980; Weinstein, 1996). Generally, the more people perceive that they have control over exposure to a hazard, the greater their optimistic bias (Klein and Helweg-Larsen, 2002). Factors which influence the extent to which people experience optimistic bias linked to personal risk estimates associated with different hazards include negative mood, dysphoria, trait and state anxiety, event severity, and proximity of feedback, and control related factors (e.g. perceived control over exposure to the hazard, and prior experience of the negative impacts of the hazard (Helweg-Larsen, and Shepperd, (2001). If the stakeholders addressed in this study are failing to adopt protective measures because of optimistic bias, risk communication is unlikely to be effective unless it builds on those psychological factors which will reduce it. Further examination of the potential impacts of optimistic bias on the efficacy of communication in relation to self-protection against pesticides is justified.

A second limitation relates to sample sizes across the different types of crops and stakeholder groups. The possibility remains that the lack of significant effects for some relationships may reflect sample size limitations rather than lack of relationship. Despite this, significant relationships suggest that the research has provided a methodology which can be used to assess the links between risk perceptions, associated relevant attitudes (for example, perceptions of health status and concerns about the future), the tendency of an individual to adopt self-protective behaviours, and exposure to pesticides.

A third limitation is the lack of exposure measures for residents and bystanders as the only available data relates to whether they adopt protective measures. Although the variable ‘adoption of protective measures’ has been studied in relation to risk perceptions (measured by agreement to the statement ‘I think that my health has been affected by exposure to pesticides’) and attitudes (measured by the statement ‘I do not spend a big part of my time worrying about the future’), further research examining the relationship between perceptions, and attitudes for residents and bystanders is needed.

A further limitation of this research is the lack of clarity regarding what measures would be the most appropriate to align the risk perception of residents and bystanders with exposure. This is in part a consequence of the sample size. However, the population of residents and bystanders is important considering both public health goals and the implementation of the sustainable use directive. First, we would recommend that training materials targeting residents and bystanders be developed and tested using changes in risk perceptions and risk-related behaviours as indicators of their effectiveness. It is also suggested that additional risk attitudes be incorporated into this research (for example, the extent to which such training materials influence optimistic biases about personal exposure to pesticides, which may represent an important barrier to effective risk communication or adoption of self protective behaviours). Second, the populations of residents and bystanders surveyed need to be increased both in numbers and in terms of geographical range, in order to generate information of direct relevance to the development of effective risk communication with all stakeholders following implementation the sustainable use directive, including the circumstances where adoption of protective measures are not required.

6. Conclusions

It can be concluded that a relationship between risk perceptions, associated attitudes, and exposure holds for most, but not all, of the stakeholder groups included in the analysis, as well as within the different countries included. However, further research is needed to understand the relation between risk perceptions and attitudes of residents and bystanders and their tendency to adopt self-protective behaviours. Risk communication and training for operators appears well understood, although some limitations regarding workers have been identified, not least in relation to the problems associated with researching migrant or illegal agricultural workers in Europe. The existence of differences in absolute levels of (for example) protective behaviours between countries suggests that cultural variations in perceptions, attitudes and behaviours exist even within Europe. It is recommended that further research be conducted within the different stakeholder groups at the national level, and that risk communication efforts are further tailored to the needs of national communities. Developing and testing effective risk communication strategies aimed at residents and bystanders represents an important priority.

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Tables

Table 1: Survey Participants

	Residents	Bystanders	Operators	Workers
Greece	55	59	52	57
UK	51	60	51	24
Italy	52	54	41	60
Total	158	173	144	141

Table 2. Areas of data collection for workers and operators in the three different countries included in the survey.

Country	Case study area	Crop
Greece	Messenia (Peloponnesus)	Olive trees
	Neapoli (Crete)	Olive trees
	Marathonas (Attica)	Greenhouse vegetables
	Messenia (Peloponnesus)	Greenhouse vegetables
	Tibaki (Crete)	Greenhouse vegetables
Italy	Emilia Romagna	Grapevine, Table grape
	Umbria	
	Piemonte	
	Puglia	
	Pistoia (Toscana)	Greenhouses
UK	Newcastle	Arable crops
	Alnwick	
	Hexham	
	Northallerton	
	Corbridge	
	Kent	
	East Anglia	

753 **Table 3a:** Summary statistics – Bystanders and residents

		Bystanders			Residents		
	Variable	N	Mean	S.D.	N	Mean	S.D.
UK	Adoption (binary)	60	0.22	0.42	51	0.22	0.42
	Gender (male =1)	60	0.43	0.50	51	0.41	0.50
	Age (years)	60	46.83	17.82	50	51.20	17.04
	Health (*H*)	53	2.25	0.83	47	2.21	0.88
	Future (*F*)	60	2.97	1.19	50	3.38	1.18
	Income	57	3.60	1.21	49	3.22	1.50
Greece	Adoption (binary)	59	0.32	0.47	55	0.8	0.40
	Gender (male =1)	59	0.53	0.50	54	0.72	0.45
	Age (years)	59	49.98	15.16	52	48.46	12.48
	Health	56	3.45	1.39	52	3.08	1.22
	Future	59	2.71	1.41	54	1.83	1.04
	Income	47	3.43	1.04	45	3.62	0.96
Italy	Adoption (binary)	54	0.30	0.46	52	0.42	0.50
	Gender (male =1)	54	0.48	0.50	52	0.42	0.50
	Age (years)	52	39.81	17.52	51	41	14.65
	Health	54	3.15	1.02	49	2.92	1.08

	Future	53	2.32	1.12	52	2.23	1.15
	Income	47	3.21	1.00	36	3.33	1.04

Notes: Income could take 5 levels: 1 corresponding to well above the mean income in the country, 2 above mean income, 3 equal to mean income, 4 below mean income and 5 well below mean income.

Table 3b: Summary statistics – Workers and Operators

		Workers			Operators		
		N	Mean	S. D.	N	Mean	S. D.
UK	Mixing/loading- PPE use	n/a			36	1.00	0.00
	Application – PPE use	n/a			34	0.65	0.49
	Cleaning – PPE use	n/a			36	0.83	0.38
	Exposure Reduction Index	n/a			33	87.32	9.7
	Migration Index Cold	21	0.38	0.19	n/a		
	Migration Index Warm	21	0.38	0.27	n/a		
	Gender (1=male)	24	0.83	0.38	33	1.00	0.00
	Age (years)	24	40.54	12.36	31	46.19	13.07
	Health	22	2.41	1.01	32	2.22	1.10
	Future	23	3.13	0.87	33	3.09	1.04
	Income	20	2.9	0.97	28	2.61	0.96
	Not at all/somewhat competent in reading	20	0	0	20	0	0
	Not at all/somewhat competent in writing	20	0	0	20	0.05	0.22
	Not at all/ somewhat competent in speaking	20	0	0	20	0	0

Greece	Mixing/loading PPE use	n/a			51	0.86	0.35
	Application –PPE use	n/a			51	1.00	0.00
	Cleaning – PPE use	n/a			51	0.25	0.44
	Exposure Reduction Index	n/a			52	77.07	28.31
	Migration Index Cold	20	0.50	0.19	n/a		
	Migration Index Warm	20	0.48	0.35	n/a		
	Gender (1=male)	57	0.88	0.33	52	1.00	0.00
	Age (years)	57	37.93	13.23	52	45.27	11.33
	Health	54	2.59	1.19	51	2.94	1.30
	Future	57	1.82	0.97	52	1.83	1.08
	Income	43	4.26	0.95	34	3.59	0.96
	Not at all/somewhat competent in reading	54	0.5	0.50	52	0.17	0.38
	Not at all/somewhat competent in writing	54	0.5	0.50	52	0.17	0.38
	Not at all/ somewhat competent in speaking	56	0.36	0.48	52	0.08	0.27
Italy	Mixing/ loading – PPE use	n/a			39	0.97	0.16
	Application –PPE use	n/a			39	0.95	0.22

	Cleaning – PPE use	n/a			38	0.82	0.39
	Exposure Reduction Index	n/a			25	77.92	29.11
	Migration Index Cold	35	0.41	0.14	n/a		
	Migration Index Warm	35	0.68	0.27	n/a		
	Gender (1=male)	59	0.59	0.50	41	1.00	0.00
	Age (years)	59	45.17	12.56	40	51.35	11.62
	Health	52	2.65	1.05	39	2.56	1.07
	Future	56	2.36	1.23	40	2.05	0.90
	Income	47	4.21	0.66	28	2.64	0.87
	Not at all/somewhat competent in reading	42	0.12	0.33	41	0	0
	Not at all/somewhat competent in writing	42	0.19	0.40	41	0	0
	Not at all/ somewhat competent in speaking	42	0.05	0.22	41	0.02	0.16

Notes: Income could take 5 levels: 1 corresponding to well above the mean income in the country, 2 above mean income, 3 equal to mean income, 4 below mean income and 5 well below mean income.

n/a stands for not applicable. PPE use while mixing, loading and cleaning is only relevant to operators. The exposure indicator is only calculated for operators whereas the migration index for workers.

Exposure reduction index for operators and migration indexes for workers are calculated using the BROWSE software.

Table 4a: Test of differences in means and variances across samples: adoption of protective measures

		Bystanders		Residents		Operators - Application		Operators – Cleaning	
	Source	**Parameter**	**Prob**	**Parameter**	**Prob.**	**Parameter**	**Prob.**	**Parameter**	**Prob.**
ANOVA	Model	0.89	0.414	24.07***	0.000	17.26***	0.000	29.29***	0.000
	Country	0.89	0.414	5.25**	0.000	17.26***	0.000	29.29***	0.000
Bartlett's test (equal variances)	chi^2	1.0227	0.600	2.8026	0.246	19.7505***	0.000	1.0843	0.581
Fisher-Hayter	Critical values (5%)	2.7917		2.7936		2.7998		2.7996	
pairwise comparisons	UK vs Greece	1.8087		9.6431*		7.9779*		9.1906*	
	UK vs Italy	1.3361		3.3761*		6.4342*		0.2609	
	Italy vs Greece	0.4301		6.2517*		1.2065		9.0526*	
Descriptive	N	173		158		124		125	

statistics					
	R^2	0.0103	0.2370	0.222	0.3244
	Adjusted R^2	-0.0013	0.2271	0.209	0.3134

Note: * indicates significance at 10%, **indicates significance at 5%, *** indicates significance at 1%.

Table 4b: Test of differences in means and variances across samples: exposure indicator

			Operators		Workers – cold		Workers - warm	
	Source		**Parameter**	**Prob**	**Parameter**	**Prob**	**Parameter**	**Prob**
ANOVA	Model		2.01	0.1395	2.70*	0.075	6.29***	0.003
	Country		2.01	0.1395	2.70*	0.075	6.29***	0.003
Bartlett's test (equal variances)	chi^2		34.5038***	0.000	2.2470	0.325	2.9567	0.228
Fisher-Hayter pairwise comparisons	Critical values (5%)		2.8044		2.8252		2.8252	
	UK vs Greece		2.1440		0.5895		4.7294*	
	UK vs Italy		2.6904		2.9957*		1.3041	
	Italy vs Greece		0.1123		2.7612		3.3462*	
Descriptive statistics	N		107		67		67	
	R^2 (ANOVA)		0.0372		0.0777		0.1642	
	Adjusted R^2		0.0187		0.0489		0.1381	

	(ANOVA)				

Note: *indicates significance at 10%, **indicates significance at 5%, *** indicates significance at 1%.

Table 5: Results of Multivariate regression analysis – Binary adoption (Probit model)

		Bystanders			Residents			Operators – application			Operators – cleaning		
		Coefficient	**S.E.**	**p-value**	**Coefficient**	**S.E.**	**p-value**	**Coefficient**	**S.E.**	**p-value**	**Coefficient**	**S.E.**	**p-value**
Intercept		-0.5533	0.5927	0.3510	-0.2875	0.6872	0.6760	-0.6881	0.9774	0.4810	1.3311*	0.8051	0.0980
Gender (male=1)		0.2293	0.2252	0.3090	-1.1613***	0.3000	0.0000	-			-		
Age (years)		-0.0090	0.0070	0.2010	0.0039	0.0091	0.6710	0.0059	0.0184	0.7490	-0.0162	0.0137	0.2360
Greece		0.3586	0.3074	0.2430	2.2517***	0.4284	0.0000				-1.7887***	0.4397	0.0000
Italy		0.0917	0.2974	0.7580	0.6154*	0.3596	0.0870	1.8229**	0.7851	0.0200	0.5708	0.5228	0.2750
UK		baseline			Baseline			Baseline			Baseline		
Health	**1**	Baseline			Baseline			Baseline			Baseline		
	2	0.7036	0.4776	0.1410	-0.0304	0.4181	0.9420	-0.4048	0.7479	0.5880	-0.4481	0.4783	0.3490
	3	0.3427	0.5063	0.4990	0.3757	0.4429	0.3960	0.8343	0.6614	0.2070	0.2065	0.5128	0.6870
	4	0.9079*	0.5006	0.0700	-0.0726	0.4639	0.8760	-			0.5898	0.5266	0.2630
	5	0.3212	0.5383	0.5510	-0.6813	0.6441	0.2900	-			1.5081**	0.7148	0.0350
Future	**1**	baseline			Baseline			Baseline			Baseline		
	2	-0.4755	0.3110	0.1260	-0.1098	0.3259	0.7360	0.4524	0.7194	0.5290	-0.0148	0.3945	0.9700
	3	-0.6771*	0.3824	0.0770	-0.6153	0.5666	0.2780	0.4212	0.8081	0.6020	0.1543*	0.5535	0.7800

4	-0.5905*	0.3377	0.0800	-0.4709	0.4151	0.2570	0.5692	0.8553	0.5060	1.3846*	0.7226	0.0550
5	-0.9105*	0.5142	0.0770	-0.8260	0.5164	0.1100	0.7581	1.4050	0.5890	1.2453*	0.7350	0.0900
Observations	160			143			50			114		
LR chi2	17.74		0.1238	63.17***		0.0000	11.44		0.1780	57.26***		0.0000
Log-likelihood	-87.1136			67.5036			-21.8345			-48.9617		
Pseudo R2	0.0924			0.3188			0.2076			0.3690		

Note: *, indicates significance at 10%, **indicates significance at 5%, *** indicates significance at 1%

Table 6: Results of Multivariate regression analysis – Exposure Indicators (Probit and Tobit models)

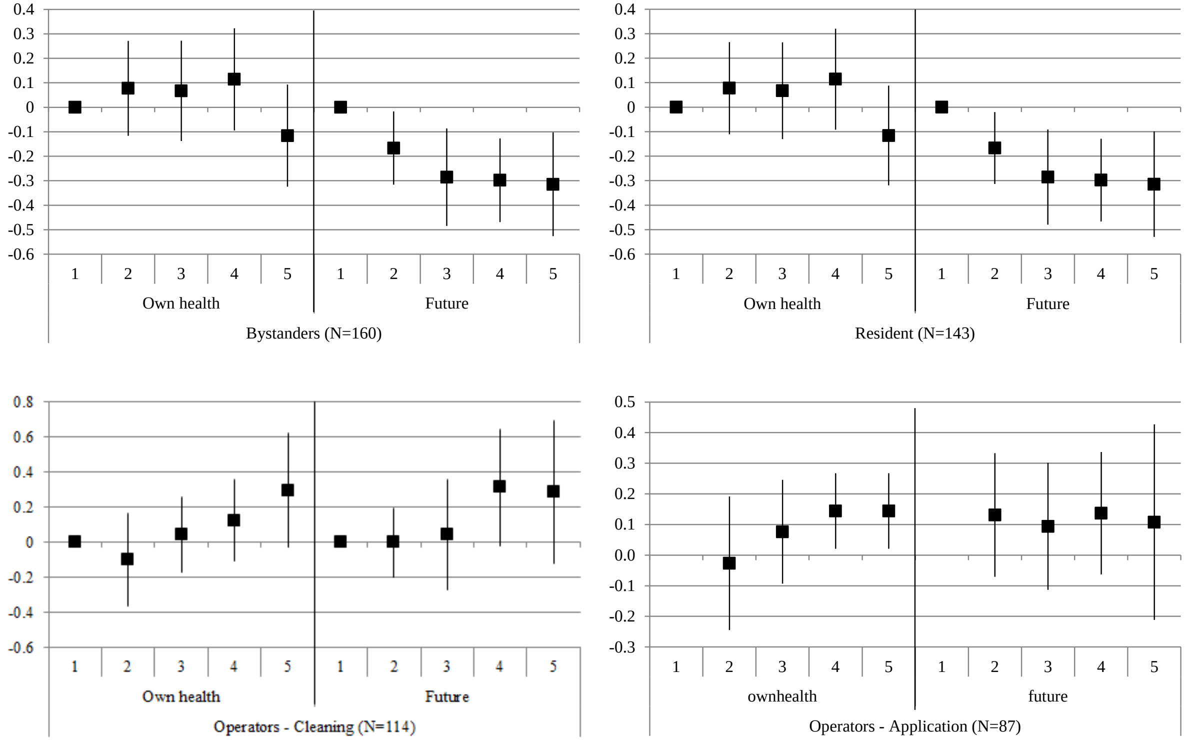
		Operators			Workers – cold			Workers - warm		
Model		**Tobit**			**Tobit**			**Tobit**		
		Coefficient	**S.E.**	**p-value**	**Coefficient**	**S.E.**	**p-value**	**Coefficient**	**S.E.**	**p-value**
Intercept		80.8083***	10.1410	0.0000	0.4385***	0.1540	0.0060	0.5976*	0.2995	0.0510
Gender (male=1)		-			0.0749	0.0549	0.1780	0.0453	0.1077	0.6760
Age (years)		0.1550	0.1814	0.3950	-0.0033	0.0023	0.1550	-0.0029	0.0045	0.5260
Greece		-12.1984**	5.8982	0.0410	0.0421	0.0828	0.6130	-0.0677	0.1639	0.6810
Italy		-20.6686***	6.8793	0.0030	0.0346	0.0700	0.6230	0.2497*	0.1384	0.0770
UK		Baseline			Baseline			Baseline		
Health	**1**	Baseline			Baseline			Baseline		
	2	12.7379*	6.5550	0.0550	0.1099	0.0694	0.1190	0.0094	0.1354	0.9450
	3	9.2351	6.6487	0.1680	-0.0413	0.0812	0.6130	-0.1691	0.1586	0.2910
	4	9.9859	6.6344	0.1360	0.0823	0.1039	0.4320	0.0965	0.2016	0.6340
	5	-29.1778***	9.3188	0.0020	0.1504	0.1034	0.1520	0.0554	0.2024	0.7850
Future	**1**	Baseline			Baseline			Baseline		
	2	-2.7002	5.5522	0.6280	0.0040	0.0612	0.9480	-0.0526	0.1200	0.6630
	3	-8.1966	7.8381	0.2980	-0.0492	0.0974	0.6150	-0.1138	0.1899	0.5510

4	7.8153	7.9422	0.3280	-0.0597	0.0802	0.4600	-0.1685	0.1566	0.2870
5	-32.2218***	10.3812	0.0030	-0.3332**	0.1569	0.0380	0.0358	0.2911	0.9030
Sigma	20.5686	1.4193		0.1757	0.0170		0.3390	0.0357	
Observations	105			66			66		
LR chi2	39.80***		0.0000	20.53*		0.0576	15.41		21.9800
Log-likelihood	-466.4837			8.1176			-33.4418		
Pseudo R2	0.0409			4.7772			0.1873		

Note: *, indicates significance at 10%, **indicates significance at 5%, *** indicates significance at 1%

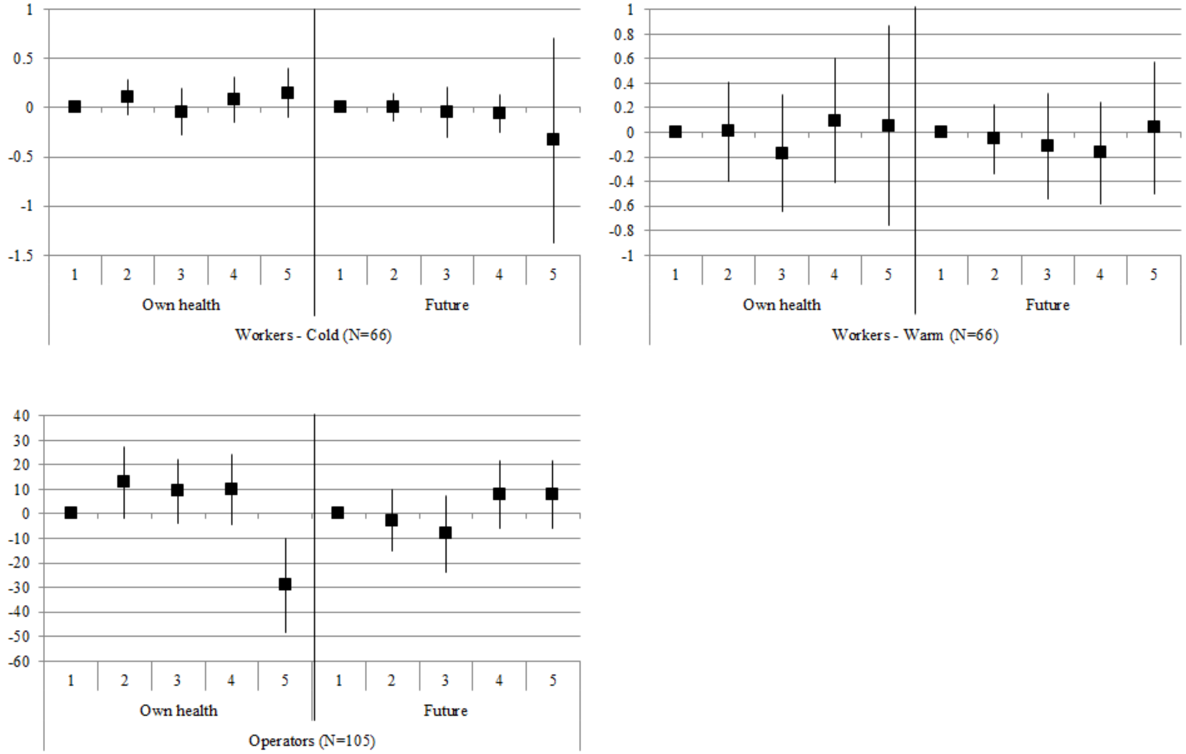
8. Figures

Figure 1: Marginal impact of Perceived Health and Future on adoption, by group



Note: standard errors estimated using 1,000 bootstrapping replications. Success rate: all sample = 100%.

Figure 2: Marginal impact of Perceived Health and Future on exposure, by group



Note: standard errors estimated using 1,000 bootstrapping replications. Success rate: Bystanders and residents: 100%; Workers (both samples): 86.9%; Operators: 99.7%