Title

Farming, pesticide exposure and respiratory health: a cross-sectional study in Thailand

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Key messages:

1. What is already known about this subject?

Farm work – including the use of pesticides – has been associated with adverse respiratory health effects. Few studies, however, have used spirometry to examine the risks of chronic airflow obstruction in the context of agricultural work in low- or middle-income countries.

2. What are the new findings?

In a rural community in Thailand, chronic airflow obstruction was uncommon; as with other studies in developing countries, villagers had a low prevalence of smoking. Most farmers applied pesticides regularly but neither this nor other farming practices is likely to be a major cause of chronic respiratory problems in this setting.

3. How might this impact on policy or clinical practice in the foreseeable future?

Agriculture plays a fundamental economic role in developing countries and the use of pesticides is crucial in modern farming practice. While the findings of this work are reassuring, health education and training in self-protection training for farming villagers remain important.

Abstract [239 words]

Objective To assess the association of lung function and respiratory symptoms with farming, particularly pesticide use in an agricultural province in Thailand.

Methods We undertook a cross-sectional survey of adults aged 40 to 65 in Nan province, Thailand, between May and August 2019. We randomly recruited 345 villagers and enriched the sample with 82 government employees. All participants performed post-bronchodilator spirometry and completed a questionnaire covering information on respiratory symptoms, farming activities, pesticide use and known risk factors for respiratory disease. Associations of respiratory outcomes with farming and pesticide exposures were examined by multivariable regression analysis.

Results The response rate was 94%. The prevalence of chronic airflow obstruction among villagers was 5.5%. Villagers had on average a lower percent predicted post-bronchodilator FEV₁/FVC than government employees (98.3% versus 100.3%; $p=0.04$). There was no evidence of association of lung function with farming activities, the use of specific herbicides (glyphosate and paraquat), insecticides (organophosphates and pyrethroids) or fungicides. The exceptions were poultry farming, associated with chronic cough and an increase of FEV₁/FVC, and atrazine, for which duration ($p\text{-trend}<0.01$), intensity ($p\text{-trend}<0.01$) and cumulative hours ($p\text{-trend}=0.01$) of use were all associated with higher FEV₁/FVC in an exposure-response manner. Cumulative hours (-280mL/hour), low duration (-270mL/year) and intensity (-270mL/hour/year) of atrazine use were associated with lower FVC.

Conclusions Chronic airflow obstruction is uncommon among villagers of an agricultural province in Nan, Thailand. Farming and pesticide use are unlikely to be major causes of respiratory problems there.

[Abstract 239/250 words] [Main Text 3378/3500 words] [5/5 tables]

[Supplemental material: 1 figure; 9 tables; 1 questionnaire]

Introduction

Worldwide, more than a billion people – about a third of the global workforce – work on farms. (1) Farmers are frequently exposed to organic and inorganic dusts and fumes, as well as pesticides, which may lead to respiratory tract inflammation and respiratory disease. (2, 3) Two systematic reviews of the literature on chronic respiratory disease in farmers have been published recently. Guillien *et al.* reported that both chronic obstructive pulmonary disease (COPD) and airflow limitation associated with several farming activities (e.g. livestock, crop and mixed farming). Similarly, Fontana *et al.* reported that COPD associated with several farm categories (i.e. greenhouse, pesticides, dairy and multiple exposures). (4) Both reviews suggested further epidemiological studies of different farm types and practices, specific agents and factors, particularly in crop farmers. Farming is a common occupation in low- and middle-income countries (LMICs) and any adverse effects are likely to have a high impact on public health and economic growth. Yet in these reviews there were only six studies from LMICs, (three in North Macedonia, one in China, one in Nigeria and one in India). Whether farming has a role in COPD remains unclear in developing countries. (5)

Thailand is one of the largest rice exporters in the world and 31% (11.6 of 37.9 million) of its working population is in the agricultural sector (6), accounting for 11% of gross domestic product. The poorer, lower 40% of the population, are more likely to work in agriculture. (7) Due to the rapid development of intensive agriculture for commercialisation, Thailand is among the highest users of complex pesticides per unit area in the world. (8) Occupational pesticide exposure associates with chronic respiratory symptoms, chronic bronchitis and asthma, but data on the relationships between pesticide exposures and COPD and lung function impairment are limited. (9) A recent systematic review reported tentative evidence that exposure to cholinesterase (ChE) inhibiting pesticides is associated with reduced FEV₁/FVC. (10), perhaps reflecting their activity on the muscarinic cholinergic receptors, resulting in increased respiratory tract bronchial secretions and bronchoconstriction. (11)

In order to assess the association of lung function and respiratory symptoms with farming, particularly pesticide use, we conducted a survey in Nan – one of the largest agricultural provinces in Thailand – which recently reported the highest number of chronic bronchitis, emphysema and COPD deaths (52.7 per 100,000) and hospital admission rates in the country. (12) The published literature on farming and adverse respiratory health effects in Thailand is very limited and there has been no study in Nan province before.

1 **Methods**

2 *Study setting and population*

3 We undertook a survey in Nan province, Thailand, between May and August 2019. This district
 4 was selected as, according to a recent census, 47% of its population were farmers. (13) Based
 5 on Pothirat *et al.*, a previous survey in Chiangmai province in which 34% of rural villagers aged
 6 over 40 were farmers (14), we calculated a sample size of three hundred and forty-five
 7 potential participants. We sampled using a cluster random method in three villages (villages
 8 no. 3, 11 and 13 in the Tha Wang Pha district, Nan province), from a pool of adults aged 40 to
 9 65 years old in the provincial Public Health database and invited them to the study. Having
 10 surveyed the first two villages, we made a preliminary check of the data collected and found
 11 that the large majority of villagers (185 of 218 who participated in the study; 84.9%) reported
 12 'farming' as their longest held jobs. To increase exposure contrast for the association analysis,
 13 we additionally sampled local government employees in Tha Wang Pha district (including
 14 school teachers, municipality officers, monks, police officers, nurses and public health
 15 officers) aged 40 to 65, who worked full-time in the same area, but who were not included
 16 on the database as local villagers (n=82). In this way, a total of 427 subjects were invited to
 17 participate. (figure S1) This study was approved by the Chulalongkorn University Institutional
 18 Review Board (MedChula IRB no.766/61) and the Imperial College Research Ethics Committee
 19 (ICREC:19IC5098); all participants provided written informed consent.

20 *Data collection*

21 We used a structured questionnaire from the Burden of Obstructive Lung Disease (BOLD)
 22 study to obtain information on sociodemographic variables and respiratory health and
 23 symptoms. (15) The BOLD questionnaire has been widely used across several countries,
 24 including LMICs in Asia. (16) To assess farming and pesticide activities, practices and
 25 exposures, we developed a questionnaire appropriate for developing countries such as
 26 Thailand. This questionnaire covered 1) the farming environment and activities; 2) crops
 27 grown and animals raised; 3) pesticide use; and 4) crop burning (see details in the
 28 supplemental material). This questionnaire contained photos of all pesticides available in the
 29 local marketplaces. All questionnaires were translated into Thai, piloted among 19 villagers
 30 in another subdistrict and applied using Open Data Kit (ODK) electronic forms
 31 (<https://opendatakit.org>). In addition, participants had their height, weight, pulse rate, blood
 32 pressure, and lung function measured.

33 *Assessment of respiratory symptoms*

34 We collected data on respiratory symptoms including chronic cough, chronic phlegm,
 35 dyspnoea and wheeze. Chronic cough was defined by cough on most days for at least three
 36 months per year. Similarly, chronic phlegm was defined by the production of sputum on most
 37 days for at least three months per year. Dyspnoea was defined as breathlessness at least
 38 when walking more slowly than people of the same age or having to stop walking due to
 39 shortness of breath, according to the modified Medical Research Council (MRC) dyspnoea
 40 scale. Wheeze was defined as having had any whistling in the chest at any time in the last 12
 41 months.

1 *Assessment of lung function*

2 We conducted spirometry on all participants using the ndd EasyOne™ spirometer, (ndd
3 Medizintechnik; Zurich, Switzerland). Participants were tested before and 20 minutes after
4 200µg of salbutamol administered via a spacer. Each spirogram was reviewed and scored
5 using the American Thoracic Society (ATS) and European Respiratory Society (ERS) criteria.
6 (17) Usable spirometry was defined as two or more acceptable trials, with FEV₁ and FVC
7 repeatability within 200mL. At the beginning of each day the spirometer was calibrated using
8 a 3L syringe.

9 A post-bronchodilator forced expiratory volume in one second (FEV₁) to forced vital capacity
10 (FVC) ratio below the lower limit of normal (LLN) was considered chronic airflow obstruction,
11 and an FVC less than the LLN was considered spirometric restriction. The LLNs were calculated
12 using the Global Lung Initiative (GLI) 2012 equations for South East Asia, which were based
13 on data from the region, including Thailand. (18) Reversibility was defined as a increase >12%
14 (and 200 ml) of the pre-bronchodilator FEV₁ (19)

15 *Data analysis*

16 Age, sex, socioeconomic status (household assets, education), body mass index (BMI) using a
17 classification for Asian populations: underweight (<18.5 kg/m²); normal (18.5 to <23.0 kg/m²);
18 overweight (23.0 to <25.0 kg/m²); obese level 1 (25.0 to <30.0 kg/m²) and obese level 2 (≥30.0
19 kg/m²) (20), smoking status, farming and pesticide exposure data were described. Farming
20 exposure variables including years of living on a farm, farm size and types of crops were
21 included in the analyses; farming practices comprised crop farming, livestock farming and
22 pesticide spraying. Farming activities such as ploughing, harvesting, chemical protection of
23 crops, fertilizer use and crop burning were analysed as potential risk factors. Pesticide
24 exposure variables included mixing pesticides, time of the last exposure to pesticides.
25 Pesticide exposures were also classified by specific types of pesticide. An assessment of the
26 level of pesticide exposure was estimated by 1) cumulative hours of exposure in a lifetime; 2)
27 duration, as years of exposure; and 3) intensity, as estimated hours of exposure per year.
28 Respiratory symptoms, spirometry data, both raw and percent predicted values, were
29 analysed.

30 We assumed that the data followed a normal distribution and analysed differences between
31 villagers and government employees using the Student's t-test for continuous variables and
32 the chi-squared test or Fisher's exact test (for n<5) for categorical variables, as appropriate.
33 To assess the association of lung function (i.e. FEV₁, FVC and FEV₁/FVC) with farming and
34 pesticide exposure, we used multivariable linear regression; when the dependent variable
35 was respiratory symptoms, we used multivariable logistic regression. All regression models
36 were adjusted for age, sex and smoking status based on a priori knowledge. We additionally
37 adjusted for subject group (villagers or government employees) to account for unmeasured
38 confounders that may be characteristic of each group. Models with FVC and FEV₁ as outcomes
39 were further adjusted for height, and models with dyspnoea and wheeze further adjusted for
40 BMI.

Pesticide exposure-response relations were examined after categorisation of the distributions of lifetime cumulative hours, duration and intensity of exposure. The median number of each measure of exposure was used as the cut-off value. We analysed exposure-response effects comparing high and low levels of exposure by testing for trend (p-trend). Statistical significance was set at $p < 0.05$. We performed all analyses using Stata 16 (Stata Corp., College Station, TX, USA).

Results

Demographic characteristics

Four hundred men and women (94% of those eligible) took part in the study and completed all questionnaires. Table 1 summarises some characteristics of the study population. Almost two thirds had never smoked. Compared with the group of government employees, villagers were 3.4 years older ($p < 0.001$), 3.3 centimetres shorter in males ($p < 0.001$) and 2.3 centimetres shorter in females ($p = 0.03$). Most villagers had only primary school education (68.5%) while most government employees had a university degree. Based on household assets ownership, villagers were worse off than government employees ($p < 0.001$). Among the villagers, 86.6% reported farming as their longest-held occupation. There were significant differences in measures of pesticide exposure (i.e. cumulative hours, duration (year) and intensity (hour/year)) between the two subject groups.

Respiratory symptoms and farming practice

After adjustment for age, sex, smoking and study subject, chronic cough was positively associated with poultry farming (OR=2.07, 95%CI 1.08 to 3.96). There were no associations between respiratory symptoms and other farming practices or pesticide use. (table 2)

Lung function and farming

Among villagers, the prevalence of chronic airflow obstruction was 5.5% and the prevalence of restriction was 10.3%. (table 3) We found no evidence of association of lung function with any of the considered farming exposure variables (i.e. harvesting, threshing, ploughing, the application of fertilizers and the burning of crop-residues), except for rearing poultry, which was associated with a small increase in FEV₁/FVC. (table 4)

Lung function and pesticides

Lung function was not associated with the way farmers applied pesticides. (table S1) There were 304 regular pesticide sprayers (76% of all participants). Pesticides were classified into three main types: herbicides, insecticides and fungicides. Specifically, pesticide sprayers used: glyphosate (91%); paraquat (69%); atrazine (13%); organophosphates (34%); pyrethroids (69%); mancozeb (17%) or pyraclostrobin (23%).

Table 5 is a summary of the associations between lifetime cumulative hours of use for each pesticide and spirometric parameters. Tables S2 and S3 show the relationships between all spirometric parameters and duration (year) and intensity (hours/year) of pesticide exposure. There were no significant associations between the use of specific herbicides (glyphosate and paraquat), insecticides (organophosphates and pyrethroids) or fungicides (mancozeb and pyraclostrobin) and lung function. The exception was atrazine, for which cumulative hours (p-trend=0.01), duration (p-trend<0.01) and intensity (p-trend<0.01) of use were all associated

with higher FEV₁/FVC in an exposure-response relationship. Low duration, low intensity and low cumulative hours of atrazine use were associated with lower FVC.

Thirteen of 339 (3.8%) subjects with acceptable pre-bronchodilator spirometry showed lung function reversibility after administration of the bronchodilator. We re-ran all analyses using pre-bronchodilator spirometric parameters as outcomes. Villagers had significantly lower percent predicted pre-bronchodilator FEV₁/FVC than government employees. The prevalence of pre-bronchodilator airflow obstruction and spirometric restriction were higher compared to the results from post-bronchodilator spirometry. (table S4) However, after adjustment for confounding factors, multivariable analyses showed that the relationships between farming and pesticide variables and pre-bronchodilator spirometry were similar to those using post-bronchodilator values. (tables S5 to S9)

Discussion

In this community-based survey in Nan, an agricultural province in northern Thailand, we found that chronic airflow obstruction was uncommon, suggesting that farming and pesticide use are unlikely to be a major cause of respiratory problems there.

In this study, villagers (86.6% of whom defined themselves as farmers) had a low prevalence of chronic respiratory symptoms and chronic airflow obstruction, which was no higher than would be expected in a healthy population. This figure is at the lower end of those reported from previous studies of the association between farming and COPD, where the prevalence of airflow obstruction varied between 3% and 68% (4). A similar study in Thailand reported a similar prevalence of COPD (5.5%) among adult farmers. (21) The prevalence of COPD is generally low (4.5% to 9.4%) in South East Asians, perhaps reflecting the low smoking prevalence in these populations. (22) Moreover, farming in Nan province is mainly crop farming conducted in open fields. A cross-sectional survey in France found that only 2.9% of crop farmers had COPD (23), a figure much lower than those from other studies in European farmers mainly working on livestock farms where the reported COPD prevalence ranged between 10.7% and 30.2%. (24) It is also interesting that our findings suggest a relatively high prevalence of a restrictive spirometric pattern (10.3%) among villagers. Currently, the determinants of restrictive spirometry pattern remain poorly understood; explanations might include genetic factors or some adverse early life exposures impacting on childhood development. (25)

We found no association of organic dust exposure variables, including harvesting and threshing cereals, with significant changes in spirometry, although we found an association between poultry farming and chronic cough. Our findings are in agreement with a recent nationwide study in Denmark which indicated no association of cumulative occupational organic dust exposure and an increased risk of COPD. (26) However, we did find an association between rearing poultry and a small increase in FEV₁/FVC with no significant change of FVC, whereas another recent study in the USA concluded that there was no association between raising animals, including poultry, and COPD. (27) The apparently contradictory finding from our study might have occurred by chance or in reflection of a 'healthy worker' effect. (28) For inorganic soil dust exposure, we found no association between ploughing and lung function. One explanation might be due to open air farmland with high humidity, which is typical in the study region and results in relatively low exposure intensities (29) Ambient air

pollution in agricultural areas, as a result of crop-residue burning, has given rise to widespread concern over its health consequences. Studies in India found a decline in local subjects' lung function parameters during the period of intense agricultural burning (30, 31); in contrast, we found no such association among villagers in Nan. These differences might be explained by our focus on the long-term exposure effect of burning exposures, while others focused on short-term changes. We found no significant associations between the use of fertilizers and lung function.

We found no associations between respiratory symptoms and spraying pesticides. These findings are in contrast with the Lifelines Cohort study in the Netherlands, which reported that high occupational exposure to pesticides increases the odds of all respiratory symptoms. (32) Further, a study similar to ours of Ethiopian farmers found a significant association between applying pesticides and reductions in both FEV₁ and FEV₁/FVC. (33) Two of five villages in that study undertook greenhouse farming with probably high intensities of pesticide exposure intensity, while all villagers in our study worked on open farms.

As in a previous meta-analysis, (10) we found no significant association of paraquat exposure with FEV₁/FVC. An explanation is the low volatility of paraquat whereby the risk of damage, mainly via an inhalation route, is low. (34) Nor did we find an association between glyphosate exposure and reduction in lung function. There were significant associations of atrazine exposure (duration, intensity and cumulative lifetime hours) and a higher FEV₁/FVC consistent with a lower FVC; these associations could reflect early lung restriction. To the best of our knowledge, there are no previous reports of such a. In the USA, a study of male sprayers reported significant relationships between wheezing (no measurement of lung function) and both glyphosate and atrazine exposures. (35) Organophosphate and pyrethroid were common insecticides used by farmers in Nan. While we found that participants with higher cumulative exposures to organophosphates had lower values of FEV₁/FVC, FVC and FEV₁, these were not statistically different from those of non-exposed participants. This is in contrast with a study in Uganda farmers, which reported a significant association between lower FEV₁ and high exposure to organophosphate and carbamate. (36) That, however, was a 'panel' study with individual comparison across seasons and pesticide exposure data based on biological monitoring. We found weak exposure-response associations of pyrethroid exposure (intensity and cumulative hours) with an increase in FEV₁/FVC but a decrease in FVC, despite no statistical significance. A study in Canada reported an association between pyrethroid exposure and higher FEV₁/FVC and lower FVC. (37) Nan sprayers mainly used mancozeb and pyraclostrobin as fungicides of choice. A recent meta-analysis included articles reporting an association of unspecified fungicide exposures with obstructive lung disease; (38) our study did not replicate these findings.

Our study has several strengths. First, the response rate was high compared with a range between 42% and 92% in previous similar cross-sectional studies included in recent systematic reviews. (4, 5) This was achieved in part because in the study villages, the local public health volunteer system helped our research team to communicate with eligible participants before and during the fieldwork. Second, the study questionnaire focusing on farming and pesticide use considered the local context, including local crops and best-selling pesticides, so that the farming exposure data reflected local participants' exposures. Although this questionnaire was not formally validated, it was piloted in similar villagers outside the sampling area before its use in this study. Moreover, this study has filled a gap in that most previous studies did not examine associations with specific farming activities and

1 types of pesticides. Third, the study had very few missing data due to the use of an electronic
2 data collection system. Fourth, we undertook high quality post-bronchodilator spirometry;
3 the majority of previous studies identified abnormalities of respiratory outcomes only from
4 either self-reported questionnaires or pre-bronchodilator spirometry. (4, 5)

5 A limitation of this cross-sectional study is its inability to assess the direction of any potentially
6 causal relationship. Furthermore, the self-reported information might be open to recall bias.
7 Exposure misclassification might have occurred and, if at random, would bias the study
8 findings towards the null. National data indicated that farmers in Tha Wang Pha, Nan province
9 represented about half of the adult population. However, when collecting the data from the
10 cluster randomly sampled villagers, we found that the true figure was much higher. To
11 increase exposure contrast (i.e. to avoid having only farmers), we enriched our sample with
12 government employees. To limit the potential for selection bias due to this sampling
13 approach, we adjusted our analyses for study subject. Also, we were unable to measure
14 quantitatively individual exposures to pesticides, but we estimated cumulative metrics that
15 allowed us to test for exposure-response trends. We calculated exposure-response
16 relationships based on job titles and length and frequency of exposures, although these may
17 not accurately reflect true 'doses' of each farming and pesticide variable. The lack of evidence
18 of association between farming practices or pesticide exposures and spirometric parameters
19 might be due to a healthy worker effect, as previously found in a recent large population-
20 based study where only by analysing lifetime job-histories agriculture-related jobs emerged
21 at increased COPD risk (39) whereby farmers affected by farming practices and/or pesticides
22 would have quit farming and only healthier farmers would stay in the job, work longer and
23 accept riskier farming tasks. In this study, having conducted around a hundred tests increased
24 the probability of finding false positives, perhaps an explanation for the positive relationship
25 between rearing poultry and FEV₁/FVC we report.

26
27 Although we found no evidence of increased risk of abnormal respiratory outcomes with
28 farming, particularly pesticide exposures, it does not necessarily mean that such exposures
29 have no serious effects on other aspects of health. There is growing evidence, for example,
30 examining the associations of pesticide exposures and health effects such as cancer,
31 reproductive and nervous system abnormalities. (40)

32
33 In conclusion, chronic airflow obstruction was uncommon among villagers in Nan, Thailand.
34 A high proportion of Nan farmers were pesticide applicators but farming and pesticide use
35 seem unlikely to be a major cause of respiratory problems in this setting.

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Contributors

JR, AFSA, SDM, PC and PB were engaged in the initial design of the study. JR was responsible for data collection and spirometry testing. PB conducted the quality control of the spirometry data. JR analysed all data and drafted the initial manuscript, and all authors contributed to its development and approved the final version.

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Competing Interests

None declared.

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Tables [5 tables]

Table 1 Demographic characteristics and respiratory symptoms of the study participants

Study variables	Villagers (n=322)		Government employees (n=78)		p-value†
	Mean	SD	Mean	SD	
Age (year)	53.8	0.4	50.4	0.7	<0.001
Height (cm), male	163.4	0.4	166.7	0.9	<0.001
Height (cm), female	154.7	0.4	157.0	0.9	0.03
Working hours (hour/week)	43.4	0.9	39.9	1.2	0.09
Study variables	n	Percent	n	Percent	p-value††
Sex					1.00
Male	156	48.5%	41	52.6%	
Female	166	51.5%	37	47.4%	
Education					<0.001
None	13	4.1%	0	0.0%	
Primary school	220	68.5%	4	5.1%	
Secondary/high/vocational school	78	24.3%	18	23.1%	
University	10	3.1%	56	71.8%	
Household asset score					<0.001
≥12	175	54.4%	69	88.5%	
Smoking status					0.15
Never	200	62.1%	49	62.3%	
Ex	90	28.0%	16	26.5%	
Current	32	9.9%	13	11.2%	
Body Mass Index (Asian)					0.15
Underweight	39	12.1%	3	3.8%	
Normal	128	39.8%	30	38.5%	
Overweight	69	21.4%	17	21.8%	
Obese level 1	73	22.7%	23	29.5%	
Obese level 2	13	4.0%	5	6.4%	
Longest held job in lifetime					<0.001
Farming	278	86.6%	2	2.6%	
Pesticide exposure					<0.001
Ever	286	88.8%	18	23.1%	
Cumulative lifetime hours					<0.001
<320	139	43.2%	12	15.4%	
≥320	147	45.6%	6	7.7%	
Duration (years)					<0.001
<11.5	142	44.1%	10	12.8%	
≥11.5	144	44.7%	8	10.3%	
Intensity (hours/year)					<0.001
<30	136	42.2%	11	14.1%	
≥30	150	46.6%	7	9.0%	
Respiratory symptoms	n	Percent	n	Percent	p-value††
Chronic cough	37	11.5%	6	7.7%	0.41
Chronic phlegm	25	7.8%	3	3.9%	0.32
Dyspnoea	9	2.8%	0	0.0%	0.22
Wheezing	20	6.2%	4	5.3%	1.00

†Analysing differences between subject groups by Student's t-test; ††Analysing differences between subject groups by chi-squared test or Fisher's exact test (for n<5).

Table 2 Respiratory symptoms and farming practices

Farming practice (n=400)	Chronic cough (n=43)			Chronic phlegm (n=28)			Dyspnoea (n=9)			Wheeze (n=24)		
	n	OR	95% CI	n	OR	95% CI	n	OR	95% CI	n	OR	95% CI
Crop farming												
No (n=111)	11	ref		6	ref		1	ref		7	ref	
Yes (n=289)	32	0.93	0.42 to 2.09	22	1.11	0.40 to 3.10	8	3.44	0.24 to 48.92	17	0.83	0.30 to 2.30
Poultry farming												
No (n=240)	19	ref		16	ref		4	ref		13	ref	
Yes (n=160)	24	2.07*	1.08 to 3.96	12	1.11	0.51 to 2.43	5	2.72	0.53 to 14.05	11	1.30	0.56 to 3.01
Pesticide spraying												
No (n=96)	8	ref		5	ref		0	ref		4	ref	
Yes (n=304)	35	1.22	0.45 to 3.32	23	0.90	0.27 to 3.04	9	-	-	20	1.77	0.44 to 7.22
Herbicide												
No (n=103)	8	ref		5	ref		0	ref		5	ref	
Yes (n=297)	35	1.43	0.53 to 3.81	23	1.10	0.34 to 3.63	9	-	-	19	1.30	0.37 to 4.61
Insecticide												
No (n=123)	11	ref		6	ref		2	ref		4	ref	
Yes (n=277)	32	1.16	0.48 to 2.79	22	1.17	0.39 to 3.53	7	1.13	0.16 to 8.10	20	3.14	0.78 to 12.65
Fungicide												
No (n=242)	21	ref		11	ref		5	ref		9	ref	
Yes (n=158)	22	1.53	0.77 to 3.05	17	2.27	0.99 to 5.23	4	1.80	0.36 to 8.87	15	3.02	1.18 to 7.74

Chronic cough and chronic phlegm odd ratios (OR) and 95% CIs were calculated by using a multivariable regression model adjusted for age, sex, smoking status and study subject (villagers vs government employees).

Dyspnoea and wheeze odd ratios (OR) and 95% CIs were calculated by using a multivariable regression model adjusted for age, sex, BMI, smoking status and study subject (villagers vs government employees).

ref. reference; *p<0.05

Table 3 Percent predicted values of post-bronchodilator spirometric parameters and prevalence of abnormal spirometric patterns among study participants

Spirometric parameter	Villagers (n=290)		Government employees (n=68)		p-value†
	Mean	SD	Mean	SD	
FEV ₁ /FVC (%predicted)	98.34	7.51	100.32	3.99	0.04
FVC (%predicted)	92.88	13.28	90.93	11.83	0.26
FEV ₁ (%predicted)	91.41	14.04	90.93	11.91	0.80
Spirometric patterns	<i>n</i>	Percent	<i>n</i>	Percent	p-value††
Chronic airflow obstruction	16	5.5%	0	0.0%	0.05
Spirometric restriction	30	10.3%	9	13.0%	0.51

Chronic airflow obstruction: FEV₁/FVC<LLN; spirometric restriction: FVC<LLN.

LLN, lower limit of normal based on GLI2012 reference equations.

†Analysing differences between subject groups by Student's t-test.; ††Analysing differences between subject groups by chi-squared test or Fisher's exact test (for n<5).

Table 4 Post-bronchodilator spirometric parameters and farming variables

Farming variables (n=358)	n	FEV ₁ /FVC (%)				FVC (L)				FEV ₁ (L)			
		β	95% CI			β	95% CI			β	95% CI		
Years of living on a farm													
Never	32	ref				ref				ref			
<33 years	162	-0.48	-2.88	to	1.93	0.05	-0.12	to	0.22	0.03	-0.12	to	0.18
≥33 years	164	-0.21	-2.75	to	2.33	0.04	-0.14	to	0.22	0.02	-0.13	to	0.18
Farmland size													
<18.5 rai (7.3 acre)	199	ref				ref				ref			
≥18.5 rai (7.3 acre)	159	0.57	-0.79	to	1.93	0.02	-0.07	to	0.12	0.04	-0.05	to	0.12
Growing rice													
No	148	ref				ref				ref			
Yes	210	0.64	-0.62	to	1.91	0.02	-0.07	to	0.11	0.04	-0.03	to	0.12
Growing maize/corn													
No	175	ref				ref				ref			
Yes	183	0.00	-1.30	to	1.30	-0.05	-0.15	to	0.04	-0.05	-0.13	to	0.03
Growing longan													
No	90	ref				ref				ref			
Yes	268	1.07	-0.46	to	2.59	0.03	-0.08	to	0.14	0.06	-0.03	to	0.15
Keeping poultry													
No	216	ref				ref				ref			
Yes	142	1.38*	0.17	to	2.59	-0.02	-0.11	to	0.06	0.01	-0.06	to	0.09
Harvesting cereal													
No	167	ref				ref				ref			
Yes	191	1.15	-0.43	to	2.73	0.00	-0.12	to	0.11	0.03	-0.06	to	0.13
Threshing cereal													
No	284	ref				ref				ref			
Yes	74	1.77	-0.16	to	3.69	-0.02	-0.15	to	0.12	0.03	-0.08	to	0.15
Ploughing													
No	189	ref				ref				ref			
Yes	169	0.36	-0.96	to	1.67	-0.05	-0.14	to	0.05	-0.02	-0.10	to	0.06
Applying natural fertilizer													
No	130	ref				ref				ref			
Yes	228	0.40	-0.89	to	1.68	0.06	-0.03	to	0.15	0.07	-0.01	to	0.14
Applying chemical fertilizer													
No	94	ref				ref				ref			
Yes	264	0.11	-1.41	to	1.63	0.03	-0.07	to	0.14	0.05	-0.04	to	0.14
Burning crop-residue smoke exposure													
No	282	ref				ref				ref			
Yes	76	0.73	-0.78	to	2.23	0.02	-0.09	to	0.13	0.03	-0.06	to	0.12
Converting an arable land by burning													
No	228	ref				ref				ref			
Yes	130	1.20	-0.05	to	2.44	0.00	-0.09	to	0.09	0.03	-0.04	to	0.11

FEV₁/FVC ratio coefficients (β) and 95% CIs were calculated by using a multivariable regression model adjusted for age, sex, smoking status and study subject (villagers vs government employees).

FVC and FEV₁ coefficients (β) and 95% CIs were calculated by using a multivariable regression model adjusted for age, height, sex, smoking status and study subject (villagers vs government employees).

ref. means a reference representing an unexposed group of each variable.; *p<0.05

Table 5 Post-bronchodilator spirometric parameters by lifetime cumulative hours of pesticide exposure classified by pesticide type

Cumulative exposure (total hours in lifetime) (n=358)	n	FEV ₁ /FVC (%)				FVC (L)				FEV ₁ (L)			
		β	95% CI			β	95% CI			β	95% CI		
<i>Herbicide</i>													
Glyphosate unexposed	108	ref				ref				ref			
<240 hours	117	-0.06	-1.71	to	1.59	0.06	-0.06	to	0.17	0.05	-0.05	to	0.15
≥240 hours	133	0.44	-1.23	to	2.12	-0.05	-0.17	to	0.07	-0.01	-0.11	to	0.09
Paraquat unexposed	172	ref				ref				ref			
<240 hours	83	0.30	-1.27	to	1.86	0.01	-0.10	to	0.12	0.01	-0.08	to	0.11
≥240 hours	103	-0.75	-2.27	to	0.77	0.00	-0.11	to	0.10	0.00	-0.10	to	0.09
Atrazine unexposed	319	ref†				ref				ref			
<240 hours	19	2.91*	0.26	to	5.56	-0.28**	-0.46	to	-0.09	-0.15	-0.32	to	0.01
≥240 hours	20	3.13*	0.49	to	5.78	-0.02	-0.21	to	0.17	0.08	-0.09	to	0.24
<i>Insecticide</i>													
Organophosphate unexposed	265	ref				ref				ref			
<144 hours	44	0.70	-1.15	to	2.56	0.01	-0.12	to	0.14	0.06	-0.06	to	0.17
≥144 hours	49	-0.87	-2.64	to	0.90	-0.04	-0.16	to	0.09	-0.04	-0.15	to	0.07
Pyrethroid unexposed	165	ref				ref				ref			
<128 hours	98	-0.04	-1.60	to	1.53	-0.02	-0.13	to	0.09	-0.03	-0.12	to	0.07
≥128 hours	95	1.17	-0.42	to	2.76	-0.07	-0.18	to	0.05	-0.03	-0.13	to	0.07
<i>Fungicide</i>													
Mancozeb unexposed	313	ref				ref				ref			
<120 hours	18	-0.06	-2.83	to	2.70	-0.03	-2.78	to	2.72	0.06	-0.10	to	0.23
≥120 hours	27	-1.14	-3.41	to	1.14	-1.23	-3.50	to	1.03	0.06	-0.08	to	0.19
Pyraclostrobin unexposed	299	ref				ref				ref			
<24 hours	27	-0.09	-2.37	to	2.20	0.01	-2.27	to	2.28	0.04	-0.10	to	0.18
≥24 hours	32	-0.02	-2.12	to	2.08	0.08	-2.01	to	2.17	0.07	-0.06	to	0.20

FEV₁/FVC ratio coefficients (β) and 95% CIs were calculated by using a multivariable regression model adjusted for age, sex, smoking status and study subject (villagers vs government employees).

FVC and FEV₁ coefficients (β) and 95% CIs were calculated by using a multivariable regression model adjusted for age, height, sex, smoking status and study subject (villagers vs government employees).

ref. reference; *p<0.05, **p<0.01, †p-trend<0.05, ††p-trend<0.01

Supplemental material

Figure [1 figure]

Figure S1 Flowchart of the selection and the number of subjects

Table [9 tables]

Table S1 Post-bronchodilator spirometric parameters and pesticide practice

<i>Pesticide practice</i> (n=358)	<i>n</i>	FEV ₁ /FVC (%)				FVC (L)				FEV ₁ (L)			
		β	95% CI			β	95% CI			β	95% CI		
Spraying pesticide													
Never	84	ref				ref							
Ever	274	-0.25	-2.02	to	1.52	-0.02	-0.15	to	0.10	-0.02	-0.13	to	0.77
Mixing pesticide													
Never use pesticide	84	ref				ref				ref			
Not involved with	85	-0.68	-2.68	to	1.33	0.00	-0.14	to	0.14	0.00	-0.12	to	0.13
Involved with	189	0.00	-1.85	to	1.85	-0.04	-0.17	to	0.09	-0.03	-0.14	to	0.09
Part of body usually contact pesticide													
Never use pesticide	84	ref				ref				ref			
No contact	83	-0.98	-2.96	to	1.00	-0.06	-0.21	to	0.08	-0.06	-0.19	to	0.06
At least one part	191	0.25	-1.62	to	2.12	0.00	-0.13	to	0.14	0.02	-0.10	to	0.13
Last pesticide exposure													
Unexposed	84	ref				ref				ref			
More than 12 months	39	-0.90	-3.30	to	1.50	-0.02	-0.19	to	0.16	-0.04	-0.18	to	0.11
Within 12 months	109	-1.15	-3.09	to	0.79	-0.02	-0.16	to	0.11	-0.04	-0.16	to	0.08
Recent (within 1 week)	126	0.79	-1.12	to	2.71	-0.03	-0.16	to	0.11	0.01	-0.11	to	0.13

FEV₁/FVC ratio coefficients (β) and 95% CIs were calculated by using a multivariable regression model adjusted for age, sex, smoking status and study subject (villagers vs government employees).

FVC and FEV₁ coefficients (β) and 95% CIs were calculated by using a multivariable regression model adjusted for age, height, sex, smoking status and study subject (villagers vs government employees).

ref. means a reference representing an unexposed group of each variable.; *p<0.05

Table S2 Post-bronchodilator spirometric parameters by duration (years) of pesticide exposure

Years of exposure (years) (n=358)	n	FEV ₁ /FVC (%)				FVC (L)				FEV ₁ (L)			
		β	95% CI			β	95% CI			β	95% CI		
<i>Herbicide</i>													
Glyphosate unexposed	108	ref				ref				ref			
<11 years	123	0.23	-1.42	to	1.89	0.03	-0.11	to	0.17	0.04	-0.07	to	0.14
≥11 years	127	0.13	-1.54	to	1.80	0.00	-0.11	to	0.11	0.01	-0.09	to	0.11
<i>Paraquat</i>													
unexposed	172	ref				ref				ref			
<11 years	89	-0.13	-1.69	to	1.42	0.02	-0.09	to	0.13	0.02	-0.08	to	0.11
≥11 years	97	-0.37	-1.89	to	1.16	-0.01	-0.12	to	0.10	-0.01	-0.10	to	0.09
<i>Atrazine</i>													
unexposed	319	ref††				ref				ref			
<10 years	21	2.90*	0.35	to	5.45	-0.27**	-0.45	to	-0.09	-0.13	-0.29	to	0.03
≥10 years	18	3.16*	0.43	to	5.89	-0.01	-0.21	to	0.18	0.07	-0.10	to	0.24
<i>Insecticide</i>													
Organophosphate unexposed	265	ref				ref				ref			
<10 years	39	-0.07	-2.03	to	1.89	0.03	-0.11	to	0.17	0.06	-0.06	to	0.17
≥10 years	54	-0.17	-1.87	to	1.53	-0.05	-0.17	to	0.07	-0.03	-0.14	to	0.07
<i>Pyrethroid</i>													
unexposed	165	ref				ref				ref			
<10 years	91	0.59	-1.02	to	2.21	-0.01	-0.13	to	0.10	-0.01	-0.11	to	0.08
≥10 years	102	0.51	-1.04	to	2.06	-0.06	-0.17	to	0.05	-0.04	-0.14	to	0.05
<i>Fungicide</i>													
Mancozeb unexposed	313	ref				ref				ref			
<6 years	23	-0.76	-3.22	to	1.71	-0.77	-3.22	to	1.69	0.04	-0.10	to	0.19
≥6 years	22	-0.67	-3.17	to	1.83	-0.75	-3.23	to	1.74	0.07	-0.08	to	0.23
<i>Pyraclostrobin</i>													
unexposed	299	ref				ref				ref			
<4 years	31	-0.36	-2.51	to	1.77	-0.23	-2.37	to	1.90	0.05	-0.08	to	0.18
≥4 years	28	0.30	-1.93	to	2.54	0.36	-1.87	to	2.58	0.07	-0.07	to	0.20

FEV₁/FVC ratio coefficients (β) and 95% CIs were calculated by using a multivariable regression model adjusted for age, sex, smoking status and study subject (villagers vs government employees).

FVC and FEV₁ coefficients (β) and 95% CIs were calculated by using a multivariable regression model adjusted for age, height, sex, smoking status and study subject (villagers vs government employees).

ref. reference; *p<0.05, **p<0.01, †p-trend<0.05, ††p-trend<0.01

Table S3 Post-bronchodilator spirometric parameters by intensity (hours/year) of pesticide exposure

Intensity (hours/year) (n=358)	n	FEV ₁ /FVC (%)				FVC (L)				FEV ₁ (L)			
		β	95% CI			β	95% CI			β	95% CI		
<i>Herbicide</i>													
Glyphosate unexposed	108	ref				ref				ref			
<20 hours/year	120	0.44	-1.20	to	2.08	0.02	-0.10	to	0.14	0.04	-0.06	to	0.14
≥20 hours/year	130	-0.13	-1.82	to	1.56	-0.01	-0.13	to	0.11	0.01	-0.10	to	0.11
Paraquat unexposed	172	ref				ref				ref			
<17 hours/year	93	0.24	-1.28	to	1.76	0.00	-0.11	to	0.11	0.00	-0.10	to	0.09
≥17 hours/year	93	-0.81	-2.38	to	0.76	0.01	-0.10	to	0.12	0.01	-0.08	to	0.11
Atrazine unexposed	319	ref††				ref				ref			
<16 hours/year	17	2.90*	0.11	to	5.69	-0.27**	-0.46	to	-0.08	-0.14	-0.32	to	0.03
≥16 hours/year	22	3.12*	0.60	to	5.63	-0.05	-0.23	to	0.13	0.05	-0.11	to	0.21
<i>Insecticide</i>													
Organophosphate unexposed	265	ref				ref				ref			
<18 hours/year	43	-0.45	-2.33	to	1.43	-0.01	-0.14	to	0.12	0.01	-0.10	to	0.13
≥18 hours/year	50	0.14	-1.62	to	1.90	-0.02	-0.14	to	0.11	0.00	-0.11	to	0.10
Pyrethroid unexposed	165	ref				ref				ref			
<16 hours/year	89	-0.05	-1.64	to	1.55	-0.02	-0.14	to	0.09	-0.04	-0.13	to	0.06
≥16 hours/year	104	1.09	-0.46	to	2.65	-0.06	-0.17	to	0.06	-0.02	-0.12	to	0.07
<i>Fungicide</i>													
Mancozeb unexposed	313	ref				ref				ref			
<18 hours/year	20	0.25	-2.36	to	2.86	0.22	-2.38	to	2.82	0.06	-0.09	to	0.21
≥18 hours/year	25	-1.49	-3.86	to	0.87	-1.54	-3.90	to	0.81	0.06	-0.09	to	0.20
Pyraclostrobin unexposed	299	ref				ref				ref			
<8 hours/year	26	-0.08	-2.41	to	2.26	0.01	-2.31	to	2.34	0.02	-0.12	to	0.17
≥8 hours/year	33	-0.03	-2.10	to	2.04	0.07	-1.99	to	2.14	0.08	-0.04	to	0.21

FEV₁/FVC ratio coefficients (β) and 95% CIs were calculated by using a multivariable regression model adjusted for age, sex, smoking status and study subject (villagers vs government employees).

FVC and FEV₁ coefficients (β) and 95% CIs were calculated by using a multivariable regression model adjusted for age, height, sex, smoking status and study subject (villagers vs government employees).

ref. reference; *p<0.05, **p<0.01, †p-trend<0.05, ††p-trend<0.01

Table S4 Percent predicted values of pre-bronchodilator spirometric parameters and prevalence of abnormal spirometric patterns among study participants

Spirometric parameter	Villagers (n=290)		Government employees (n=68)		p-value [†]
	Mean	SD	Mean	SD	
FEV ₁ /FVC (%predicted)	95.73	0.46	98.03	0.51	0.02
FVC (%predicted)	94.34	0.91	90.98	1.47	0.10
FEV ₁ (%predicted)	90.13	0.81	89.20	1.44	0.63
Spirometric patterns	<i>n</i>	Percent	<i>n</i>	Percent	p-value ^{††}
Chronic airflow obstruction	29	10.7%	0	0.0%	0.004
Spirometric restriction	25	9.2%	8	13.3%	0.33

Chronic airflow obstruction: FEV₁/FVC<LLN; spirometric restriction: FVC<LLN.

LLN, lower limit of normal based on GLI2012 reference equations.

[†]Analysing differences between subject groups by Student's t-test.; ^{††}Analysing differences between subject groups by chi-squared test or Fisher's exact test (for n<5).

Table S5 Pre-bronchodilator spirometric parameters and farming variables

Farming variables (n=332)	n	FEV ₁ /FVC (%)				FVC (L)				FEV ₁ (L)			
		β	95% CI			β	95% CI			β	95% CI		
Years of living on a farm													
Never	27	ref				ref				ref			
<33 years	150	0.12	-2.59	to	2.84	0.02	-0.19	to	0.23	0.01	-0.14	to	0.17
≥33 years	155	0.83	-1.99	to	3.65	-0.02	-0.24	to	0.20	0.02	-0.13	to	0.18
Farmland size													
<18.5 rai (7.3 acre)	215	ref				ref				ref			
≥18.5 rai (7.3 acre)	143	0.21	-1.27	to	1.69	-0.01	-0.12	to	0.11	0.01	-0.08	to	0.09
Growing rice													
No	130	ref				ref				ref			
Yes	202	0.29	-1.07	to	1.65	0.04	-0.07	to	0.14	0.06	-0.02	to	0.13
Growing maize/corn													
No	160	ref				ref				ref			
Yes	172	-0.93	-2.29	to	0.44	-0.04	-0.14	to	0.07	-0.06	-0.14	to	0.01
Growing longan													
No	84	ref				ref				ref			
Yes	248	1.15	-0.49	to	2.78	-0.02	-0.15	to	0.10	0.02	-0.07	to	0.11
Keeping poultry													
No	200	ref				ref				ref			
Yes	132	0.46	-0.83	to	1.75	0.01	-0.09	to	0.11	0.00	-0.07	to	0.07
Harvesting cereal													
No	155	ref				ref				ref			
Yes	177	0.33	-1.37	to	2.03	0.04	-0.09	to	0.17	0.03	-0.06	to	0.13
Threshing cereal													
No	263	ref				ref				ref			
Yes	69	1.32	-0.72	to	3.36	0.01	-0.15	to	0.17	0.05	-0.07	to	0.16
Ploughing													
No	172	ref				ref				ref			
Yes	160	-0.01	-1.42	to	1.41	-0.04	-0.15	to	0.07	-0.02	-0.10	to	0.06
Applying natural fertilizer													
No	122	ref				ref				ref			
Yes	210	0.53	-0.83	to	1.90	0.03	-0.08	to	0.14	0.03	-0.05	to	0.11
Applying chemical fertilizer													
No	87	ref				ref				ref			
Yes	245	0.19	-1.45	to	1.82	0.07	-0.05	to	0.20	0.05	-0.04	to	0.14
Burning crop-residue smoke exposure													
No	258	ref				ref				ref			
Yes	74	-0.41	-1.99	to	1.17	0.07	-0.05	to	0.20	0.02	-0.07	to	0.11
Converting an arable land by burning													
No	215	ref				ref				ref			
Yes	117	1.04	-0.29	to	2.37	0.00	-0.11	to	0.10	0.03	-0.05	to	0.10

FEV₁/FVC ratio coefficients (β) and 95% CIs were calculated by using a multivariable regression model adjusted for age, sex, smoking status and study subject (villagers vs government employees).

FVC and FEV₁ coefficients (β) and 95% CIs were calculated by using a multivariable regression model adjusted for age, height, sex, smoking status and study subject (villagers vs government employees).

ref. means a reference representing an unexposed group of each variable.; *p<0.05

Table S6 Pre-bronchodilator spirometric parameters and pesticide practice

<i>Pesticide practice</i> (n=332)	<i>n</i>	FEV ₁ /FVC (%)				FVC (L)				FEV ₁ (L)			
		β	95% CI			β	95% CI			β	95% CI		
Spraying pesticide													
Never	75	ref				ref							
Ever	257	-0.14	-2.05	to	1.78	0.00	-0.14	to	0.15	-0.02	-0.15	to	0.10
Mixing pesticide													
Never use pesticide	75	ref				ref				ref			
Not involved with	75	-0.47	-2.66	to	1.72	0.06	-0.11	to	0.23	0.00	-0.14	to	0.14
Involved with	182	0.03	-1.96	to	2.02	-0.02	-0.18	to	0.13	-0.04	-0.17	to	0.09
Part of body usually contact pesticide													
Never use pesticide	75	ref				ref				ref			
No contact	72	-0.51	-2.70	to	1.67	-0.08	-0.25	to	0.09	-0.06	-0.21	to	0.08
At least one part	185	0.08	-1.93	to	2.09	0.05	-0.10	to	0.21	0.00	-0.13	to	0.14
Last pesticide exposure													
Unexposed	75	ref				ref				ref			
More than 12 months	41	-0.71	-3.20	to	1.78	0.00	-0.19	to	0.20	-0.02	-0.19	to	0.16
Within 12 months	99	-0.30	-2.44	to	1.84	-0.02	-0.19	to	0.14	-0.02	-0.16	to	0.11
Recent (within 1 week)	117	0.24	-1.84	to	2.32	0.03	-0.13	to	0.19	-0.03	-0.16	to	0.11

FEV₁/FVC ratio coefficients (β) and 95% CIs were calculated by using a multivariable regression model adjusted for age, sex, smoking status and study subject (villagers vs government employees).

FVC and FEV₁ coefficients (β) and 95% CIs were calculated by using a multivariable regression model adjusted for age, height, sex, smoking status and study subject (villagers vs government employees).

ref. means a reference representing an unexposed group of each variable.; *p<0.05

Table S7 Pre-bronchodilator spirometric parameters by lifetime cumulative hours of pesticide exposure classified by pesticide types

Cumulative exposure (total hours in lifetime) (n=332)	n	FEV ₁ /FVC (%)				FVC (L)				FEV ₁ (L)			
		β	95% CI			β	95% CI			β	95% CI		
<i>Herbicide</i>													
Glyphosate unexposed	97	ref				ref				ref			
<240 hours	107	1.04	-1.68	to	1.89	0.12	-0.02	to	0.25	0.07	-0.03	to	0.17
≥240 hours	128	-0.32	-2.12	to	1.48	0.00	-0.13	to	0.14	-0.01	-0.11	to	0.09
Paraquat unexposed	192	ref				ref				ref			
<240 hours	75	0.16	-1.53	to	1.85	0.06	-0.07	to	0.19	0.02	-0.07	to	0.12
≥240 hours	105	-0.74	-2.32	to	0.84	0.02	-0.10	to	0.14	0.01	-0.08	to	0.10
Atrazine unexposed	295	ref†				ref				ref			
<240 hours	18	3.72**	0.95	to	6.49	-0.23**	-0.45	to	-0.02	-0.10	-0.25	to	0.06
≥240 hours	19	3.17*	0.41	to	5.94	-0.07	-0.28	to	0.15	0.09	-0.07	to	0.25
<i>Insecticide</i>													
Organophosphate unexposed	244	ref				ref				ref			
<144 hours	42	-0.60	-2.55	to	1.34	0.09	-0.06	to	0.24	0.05	-0.06	to	0.16
≥144 hours	46	-0.36	-2.23	to	1.51	-0.01	-0.16	to	0.13	-0.01	-0.12	to	0.09
Pyrethroid unexposed	150	ref				ref				ref			
<128 hours	90	0.23	-1.44	to	1.90	-0.07	-0.20	to	0.06	-0.03	-0.12	to	0.06
≥128 hours	92	1.04	-0.64	to	2.71	-0.07	-0.20	to	0.06	-0.01	-0.11	to	0.08
<i>Fungicide</i>													
Mancozeb unexposed	285	ref				ref				ref			
<120 hours	18	0.16	-2.68	to	2.99	0.11	-0.11	to	0.33	0.12	-0.03	to	0.28
≥120 hours	29	-0.16	-2.42	to	2.10	0.09	-0.09	to	0.26	0.06	-0.07	to	0.19
Pyraclostrobin unexposed	281	ref				ref				ref			
<24 hours	20	-1.60	-4.28	to	1.08	0.08	-0.13	to	0.28	0.03	-0.12	to	0.17
≥24 hours	31	0.71	-1.46	to	2.88	0.09	-0.08	to	0.26	0.09	-0.04	to	0.21

FEV₁/FVC ratio coefficients (β) and 95% CIs were calculated by using a multivariable regression model adjusted for age, sex, smoking status and study subject (villagers vs government employees).

FVC and FEV₁ coefficients (β) and 95% CIs were calculated by using a multivariable regression model adjusted for age, height, sex, smoking status and study subject (villagers vs government employees).

ref. reference; *p<0.05, **p<0.01, †p-trend<0.05, ††p-trend<0.01

Table S8 Pre-bronchodilator spirometric parameters by duration (years) of pesticide exposure

Years of exposure (years) (n=332)	n	FEV ₁ /FVC (%)				FVC (L)				FEV ₁ (L)			
		β	95% CI			β	95% CI			β	95% CI		
<i>Herbicide</i>													
Glyphosate unexposed	97	ref				ref				ref			
<11 years	114	-0.33	-2.13	to	1.46	0.08	-0.05	to	0.22	0.04	-0.06	to	0.14
≥11 years	121	0.12	-1.67	to	1.91	0.04	-0.10	to	0.18	0.03	-0.07	to	0.13
<i>Paraquat</i>													
unexposed	152	ref				ref				ref			
<11 years	85	-0.49	-2.14	to	1.17	0.07	-0.06	to	0.20	0.02	-0.07	to	0.12
≥11 years	95	-0.21	-1.82	to	1.39	0.01	-0.12	to	0.13	0.01	-0.08	to	0.10
<i>Atrazine</i>													
unexposed	295	ref††				ref				ref			
<10 years	20	3.78**	1.13	to	6.43	-0.27*	-0.48	to	-0.06	-0.09	-0.24	to	0.07
≥10 years	17	3.05*	0.19	to	5.91	-0.01	-0.24	to	0.21	0.10	-0.07	to	0.26
<i>Insecticide</i>													
Organophosphate unexposed	244	ref				ref				ref			
<10 years	37	-1.21	-3.26	to	0.83	0.12	-0.04	to	0.28	0.05	-0.06	to	0.17
≥10 years	51	0.06	-1.73	to	1.84	-0.02	-0.16	to	0.12	-0.01	-0.11	to	0.09
<i>Pyrethroid</i>													
unexposed	150	ref				ref				ref			
<10 years	83	0.93	-0.79	to	2.66	-0.05	-0.18	to	0.08	-0.01	-0.10	to	0.09
≥10 years	99	0.39	-1.25	to	2.02	-0.09	-0.22	to	0.04	-0.03	-0.12	to	0.06
<i>Fungicide</i>													
Mancozeb unexposed	285	ref				ref				ref			
<6 years	24	-0.54	-3.01	to	1.94	0.09	-0.10	to	0.28	0.08	-0.06	to	0.22
≥6 years	23	0.47	-2.04	to	2.98	0.10	-0.09	to	0.29	0.09	-0.06	to	0.23
<i>Pyraclostrobin</i>													
unexposed	281	ref				ref				ref			
<4 years	25	-1.90	-4.29	to	0.49	0.10	-0.09	to	0.29	0.04	-0.10	to	0.17
≥4 years	26	1.47	-0.88	to	3.82	0.07	-0.11	to	0.25	0.08	-0.05	to	0.21

FEV₁/FVC ratio coefficients (β) and 95% CIs were calculated by using a multivariable regression model adjusted for age, sex, smoking status and study subject (villagers vs government employees).

FVC and FEV₁ coefficients (β) and 95% CIs were calculated by using a multivariable regression model adjusted for age, height, sex, smoking status and study subject (villagers vs government employees).

ref. reference; *p<0.05, **p<0.01, †p-trend<0.05, ††p-trend<0.01

Table S9 Pre-bronchodilator spirometric parameters by intensity (hours/year) of pesticide exposure

Intensity (hours/year) (n=332)	n	FEV ₁ /FVC (%)				FVC (L)				FEV ₁ (L)			
		β	95% CI			β	95% CI			β	95% CI		
<i>Herbicide</i>													
Glyphosate unexposed	97	ref				ref				ref			
<20 hours/year	111	0.55	-1.21	to	2.31	0.09	-0.05	to	0.22	0.06	-0.03	to	0.16
≥20 hours/year	124	-0.88	-2.69	to	0.94	0.03	-0.11	to	0.17	-0.01	-0.11	to	0.10
Paraquat unexposed	192	ref				ref				ref			
<17 hours/year	87	0.11	-1.51	to	1.73	0.05	-0.07	to	0.18	0.02	-0.07	to	0.11
≥17 hours/year	93	-0.82	-2.46	to	0.82	0.02	-0.10	to	0.15	0.01	-0.08	to	0.11
Atrazine unexposed	295	ref††				ref				ref			
<16 hours/year	16	3.54*	0.62	to	6.46	-0.20**	-0.43	to	0.03	-0.08	-0.25	to	0.09
≥16 hours/year	21	3.37*	0.75	to	5.99	-0.11	-0.31	to	0.10	0.06	-0.09	to	0.21
<i>Insecticide</i>													
Organophosphate unexposed	244	ref				ref				ref			
<18 hours/year	41	-1.23	-3.19	to	0.74	0.09	-0.06	to	0.24	0.04	-0.07	to	0.15
≥18 hours/year	47	0.17	-1.67	to	2.02	-0.01	-0.15	to	0.13	0.00	-0.11	to	0.10
Pyrethroid unexposed	150	ref				ref				ref			
<16 hours/year	83	0.26	-1.43	to	1.96	-0.07	-0.20	to	0.06	-0.03	-0.13	to	0.06
≥16 hours/year	99	0.97	-0.68	to	2.62	-0.07	-0.20	to	0.05	-0.01	-0.10	to	0.08
<i>Fungicide</i>													
Mancozeb unexposed	285	ref				ref				ref			
<18 hours/year	21	0.55	-2.06	to	3.17	0.10	-0.10	to	0.30	0.12	-0.02	to	0.27
≥18 hours/year	26	-0.52	-2.90	to	1.86	0.09	-0.09	to	0.27	0.05	-0.09	to	0.19
Pyraclostrobin unexposed	281	ref				ref				ref			
<8 hours/year	21	0.00	-2.64	to	2.64	0.01	-0.19	to	0.22	0.03	-0.11	to	0.17
≥8 hours/year	30	-0.31	-2.52	to	1.90	0.13	-0.04	to	0.30	0.08	-0.04	to	0.21

FEV₁/FVC ratio coefficients (β) and 95% CIs were calculated by using a multivariable regression model adjusted for age, sex, smoking status and study subject (villagers vs government employees).

FVC and FEV₁ coefficients (β) and 95% CIs were calculated by using a multivariable regression model adjusted for age, height, sex, smoking status and study subject (villagers vs government employees).

ref. reference; *p<0.05, **p<0.01, †p-trend<0.05, ††p-trend<0.01

Agricultural questionnaire

1.	Have you ever lived on a farm?	Yes	—
		No	—
	<i>[If “yes” ask question 1A., otherwise skip to question 2.]</i>		
	1A. Are you still living on a farm?	Yes	—
		No	—
	<i>[If “yes” ask question 1A.i., otherwise skip to question 1B.]</i>		
	1A.i. What size is the farm (in local unit)?	— — —	Rai — Ngan
		— — —	Tarang Wa (Wa ²)
	1B. How many years have you lived on a farm?	— —	years
2.	Have you ever ploughed the soil or prepared it for planting?	Yes	—
		No	—
	<i>[If “yes” ask all question 2A. to 2E., otherwise skip to question 3.]</i>		
	2A. How many years have you ploughed the soil or prepared it for planting?		— — years
	2B. In the years that you ploughed the soil or prepared it for planting, how many months of each year did you do it?		— — months
	2C. In the months that you ploughed the soil or prepared it for planting, how many days of each month did you do it?		— — days
	2D. On the days that you ploughed the soil or prepared it for planting, how many hours of each day did you do it?		— — hours
	2E. Are you still ploughing the soil or preparing it for planting?	Yes	—
		No	—
<u>Plants grown</u>			
3.	Do you grow plants?	Yes	—
		No	—
	<i>[If “yes” ask question all 3A. to 3O., otherwise skip to question 4.]</i>		
	3A. Cereal	Yes	—
		No	—
	<i>[If “yes” ask all question 3A.i to 3A.iii, otherwise skip to question 3B.]</i>		
	3A.i. Which cereal crop(s) do you grow? [SELECT ALL THAT APPLY]		
	— In-season rice		
	— Off-season rice		
	— Maize		
	— Sweet corn		
	— Wheat		
	— Other cereal		
	3A.i.i. If select “other cereal”, please specify: _____		
	3A.ii. Are you involved with harvesting the cereal crops?	Yes	—
		No	—
	3A.iii. Are you involved with threshing the cereal crops?	Yes	—
		No	—
	3B. Vegetables and melons	Yes	—
		No	—
	<i>[If “yes” ask all question 3B.i, otherwise skip to question 3C.]</i>		
	3B.i. Which vegetables and melons do you grow?[SELECT ALL THAT APPLY]		
	— Cauliflower		
	— Cabbage		
	— Chinese kale		
	— Pak Choi		
	— Coriander		
	— Chinese convolvulus		
	— Water convolvulus		
	— Chinese cabbage		
	— Mustard Green		
	— Lettuce		
	— Broccoli		
	— Courgette		
	— Cucumber		
	— Japanese Cucumber, Suhyo		
	— Watermelon		
	— Wax gourd		
	— Pumpkin		
	— Tomato		
	— Thai eggplant		
	— Aubergine		
	— Eggplant		

☐	Bitter melon		
☐	Garlic		
☐	Onion		
☐	Shallot		
☐	Indian Oyster		
☐	Other vegetable and melon		
3B.i.i. If select "other vegetable and melon", please specify: _____			
3C. Fruit and nuts		Yes	☐
		No	☐
<i>[If "yes" ask all question 3C.i, otherwise skip to question 3D.]</i>			
3C.i. Which fruit and nuts do you grow? [SELECT ALL THAT APPLY]			
☐	Pineapple		
☐	Santol		
☐	Banana		
☐	Rambutan		
☐	Durian		
☐	Guava		
☐	Monkey apple		
☐	Tamarind		
☐	Lime		
☐	Mango		
☐	Papaya		
☐	Langsat		
☐	Longan		
☐	Lychee		
☐	Strawberry		
☐	Mulberry		
☐	Tangerine		
☐	Pomelo		
☐	Passion fruit		
☐	Avocado		
☐	Tung oil, tree China wood-oil tree		
☐	Cashew tree		
☐	Other fruit and nut		
3C.i.i. If select "other fruit and nut", please specify: _____			
3D. Oilseed crops		Yes	☐
		No	☐
<i>[If "yes" ask all question 3D.i, otherwise skip to question 3E.]</i>			
3D.i. Which oilseed(s) do you grow? [SELECT ALL THAT APPLY]			
☐	Sesame		
☐	Peanut		
☐	Soybean		
☐	Oil Palm		
☐	Other oilseed		
3D.i.i. If select "other oilseed", please specify: _____			
3E. Root/tuber crops with high starch or inulin content		Yes	☐
		No	☐
<i>[If "yes" ask all question 3E.i, otherwise skip to question 3F.]</i>			
3E.i. Which root/tuber crops with high starch or inulin content do you grow?			
[SELECT ALL THAT APPLY]			
☐	Sweet potato		
☐	Potato		
☐	Cassava		
☐	Other root		
3E.i.i. If select "other root", please specify: _____			
3F. Beverage and spice crops		Yes	☐
		No	☐
<i>[If "yes" ask all question 3F.i, otherwise skip to question 3G.]</i>			
3F.i. Which beverage and spice crops do you grow?			
[SELECT ALL THAT APPLY]			
☐	Coffee bean		
☐	Tea		
☐	Ginger		
☐	Bird eye chili		
☐	Chilli pepper		
☐	Sweet pepper		
☐	Bell pepper		
☐	Makhwaen/Sichuan pepper		
☐	Other beverage/spice crop		
3F.i.i. If select "other beverage", please specify: _____			

3G. Leguminous crops	Yes	—
	No	—
<i>[If “yes” ask all question 3G.i, otherwise skip to question 3H.]</i>		
3G.i. Which leguminous crops do you grow? [SELECT ALL THAT APPLY]		
— Mung bean		
— Black gram, urad bean		
— Cow pea		
— Common bean		
— Asparagus bean		
— Pea		
— Other legume		
3G.i.i. If select “other legume”, please specify: _____		
3H. Sugar cane	Yes	—
	No	—
3I. Grasses and other fodder crops	Yes	—
	No	—
3J. Fibre crops	Yes	—
	No	—
<i>[If “yes” ask all question 3J.i, otherwise skip to question 3K.]</i>		
3J.i. Which fibre crops do you grow? [SELECT ALL THAT APPLY]		
— Cotton		
— Other fibre		
3J.i.i. If select “other fibre”, please specify: _____		
3K. Medicinal, aromatic, pesticidal, or similar crops	Yes	—
	No	—
<i>[If “yes” ask question 3K.i, otherwise skip to question 3L. and 3M.]</i>		
3K.i. Which medicinal, aromatic, pesticidal, or similar crops do you grow?, please specify: _____		
3L. Rubber	Yes	—
	No	—
3M. Flower crops	Yes	—
	No	—
<i>[If “yes” ask all question 3M.i, otherwise skip to question 3N.]</i>		
3M.i. Which flower crops do you grow?, please specify: _____		
3N. Tobacco	Yes	—
	No	—
3O. Other crops	Yes	—
	No	—
<i>[If “yes” ask all question 3O.i, otherwise skip to question 4.]</i>		
3O.i. Which other crops do you grow? [SELECT ALL THAT APPLY]		
— Teak		
— Calameae		
— Bamboo		
— Agarwood/Eagle wood		
— Other crop		
3O.i.i. If select “other crop”, please specify: _____		

Weedkillers

4. Have you ever used weedkillers to protect your plants?	Yes	—
	No	—
<i>[If “yes” ask question 4A., otherwise skip to question 5.]</i>		
4A. When did you start spraying weedkillers?	_____ (year in B.E.)	
4B. Over the past year, have you sprayed weedkillers?	Yes	—
	No	—
<i>[If “no” ask question 4C., otherwise skip to question 4B.1. then 4D.]</i>		
4B.1. Time since last weedkillers exposure	i. __ hours	
	ii. __ days	
	iii. __ months	
4C. When did you stop spraying weedkillers?	_____ (year in B.E.)	
<i>[Continue question 4D.]</i>		

4D. weedkillers

Now I am going to ask you about *weedkillers* that you have ever used. I would like you to tell me each *weedkiller* that you apply (or applied), and how long do (or did) you spray? If possible, please show the *weedkiller* package(s)/label(s). In case the name(s) of *weedkiller(s)* used is/are not in the lists below, please specify on question 4D.i. in the ‘other’ cell, and allow the interviewer to take a photo (by a device provided).

i. Which weedkillers have you ever used? [SELECT ALL THAT APPLY]	ii. How many years have you sprayed your crops with weedkillers?	iii. In the years that you sprayed weedkillers, how many months of each year did you spray?	iv. In the months that you sprayed weedkillers, how many days of each month did you spray?	v. On the days that you sprayed weedkillers, how many hours of each day did you spray?	vi. Over the past year, have you used this?	If applicable, take a photo of weedkiller package(s)/label(s). [Only 'other' selected]
_ 1. glyphosate <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 2. paraquat <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 3. 2,4-D-dimethylammonium <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 4. atrazine <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 5. acetochlor <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 6. alachlor <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 7. pendimethalin <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 8. metsulfuron-methyl <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 9. isoxaflutole <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 10. cyprosulfamide + isoxaflutole <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 11. 2,4-D sodium salt <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 12. quizalofop-P-tefuryl <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 13. fomesafen <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 14. glufosinate-ammonium <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ other: please specify..... <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	<i>Please record a photo no.</i>

4E. When you spray, which parts of your body usually come into contact with weedkillers? [SELECT ALL THAT APPLY]

- Face _____
- Hands _____
- Arms _____
- Trunk _____
- Legs _____
- None of the above _____

4F. Do you mix these weedkillers yourself?

- Yes _____
- No _____

[If "yes" ask question 4G., otherwise skip to question 4H.]

4G. Did you mix them inside home, outside home or both?

- Outside home _____
- Inside home _____
- Both outside and inside home _____

4H. Do you store the mixed chemicals in your home?

- Yes _____
- No _____

4I. When mixing, loading or applying these weedkillers what protective clothing do you wear? [SELECT ALL THAT APPLY]

- Boots _____
- Gloves _____
- Respirator _____
- Goggles/Safety glasses _____
- Mask _____
- Balaklavas or clothes wrapped around the face _____
- Hat _____
- Full face shield _____
- Apron _____
- None of the above _____

4J. After spraying the weedkillers do you...? [SELECT ALL THAT APPLY]

Wash your hands, in home	—
Wash your hands, outside home	—
Have a shower, in home	—
Have a shower, outside home	—
Change your clothes	—
None of the above	—

Insecticides

5. Have you ever used insecticides to protect your plants?

Yes	—
No	—

[If “yes” ask question 5A., otherwise skip to question 6.]

5A. When did you start spraying insecticides? — — — — (year in B.E.)

5B. Over the past year, have you sprayed insecticides?

Yes	—
No	—

[If “no” ask question 5C., otherwise skip to question 5B.1. then 5D.]

5B.1. Time since last insecticides exposure

i.	—_ hours
ii.	—_ days
iii.	—_ months

5C. When did you stop spraying insecticides?

— — — — (year in B.E.)

[Continue question 5D.]

5D. insecticides

Now I am going to ask you about *insecticides* that you have ever used. I would like you to tell me each *insecticide* that you apply (or applied), and how long do (or did) you spray? If possible, please show the *insecticide* package(s)/label(s). In case the name(s) of *insecticide(s)* used is/are not in the lists below, please specify on question 5D.i. in the ‘other’ cell, and allow the interviewer to take a photo (by a device provided).

i. Which insecticides have you ever used? [SELECT ALL THAT APPLY]	ii. How many years have you sprayed your crops with insecticides?	iii. In the years that you sprayed insecticides, how many months of each year did you spray?	iv. In the months that you sprayed insecticides, how many days of each month did you spray?	v. On the days that you sprayed insecticides, how many hours of each day did you spray?	vi. Over the past year, have you used this?	If applicable, take a photo of insecticide package(s)/label(s). [Only 'other' selected]
_ 1. chlorpyrifos <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 2. cartap hydrochloride <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 3. cypermethrin <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 4. acetamiprid <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 5. fipronil <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 6. chlorpyrifos + cypermethrin <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 7. pyridaben <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 8. imidacloprid <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 9. emamectin benzoate <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 10. chlorfenapyr <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 11. buprofezin <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 12. sulphur <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 13. carbaryl <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 14. abamectin <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 15. propargite <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 16. Petroleum oil <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 17. dinotefuran <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 18. <i>B Thuringiensis</i> <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 19. thiamethoxam <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 20. indoxacarb <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 21. lambda-cyhalothrin <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ other: please specify..... <i>If selected, answer ii. to vi..</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	Please record a photo no.

5E. When you spray, which parts of your body usually come into contact with insecticides? [SELECT ALL THAT APPLY]

- Face _____
 Hands _____
 Arms _____
 Trunk _____
 Legs _____
 None of the above _____

5F. Do you mix these insecticides yourself?

- Yes _____
 No _____

[If "yes" ask question 5G., otherwise skip to question 5H.]

5G. Did you mix them inside, outside home or both?

- Outside home _____
 Inside home _____
 Both outside and inside home _____

5H. Do you store the mixed chemicals in your home?	Yes	—
	No	—
5I. When mixing, loading or applying these insecticides what protective clothing do you wear? [SELECT ALL THAT APPLY]		
Boots	—	
Gloves	—	
Respirator	—	
Goggles/Safety glasses	—	—
Mask	—	
Balaklavas or clothes wrapped around the face	—	
Hat	—	
Full face shield	—	
Apron	—	
None of the above	—	
5J. After spraying the insecticides do you...? [SELECT ALL THAT APPLY]		
Wash your hands, in home	—	
Wash your hands, outside home	—	
Have a shower, in home	—	
Have a shower, outside home	—	
Change your clothes	—	
None of the above	—	

Fungicides

6. Have you ever used fungicides?	Yes	—
	No	—
<i>[If "yes" ask question 6A., otherwise skip to question 7.]</i>		
6A. When did you start spraying fungicides?	— — — — (year in B.E.)	
6B. Over the past year, have you sprayed fungicides?	Yes	—
	No	—
<i>[If "no" ask question 6C., otherwise skip to question 6B.1. then 6D.]</i>		
6B.1. Time since last fungicides exposure	i. — — hours	
	ii. — — days	
	iii. — — months	
6C. When did you stop spraying fungicides?	— — — — (year in B.E.)	
<i>[Continue question 6D.]</i>		

6D. fungicides

Now I am going to ask you about *fungicides* that you have ever used. I would like you to tell me each *fungicide* that you apply (or applied), and how long do (or did) you spray? If possible, please show the *fungicide* package(s)/label(s). In case the name(s) of *fungicide(s)* used is/are not in the lists below, please specify on question 6D.i. in the 'other' cell, and allow the interviewer to take a photo (by a device provided).

i. Which fungicides have you ever used? [SELECT ALL THAT APPLY]	ii. How many years have you sprayed your crops with fungicides?	iii. In the years that you sprayed fungicides, how many months of each year did you spray?	iv. In the months that you sprayed fungicides, how many days of each month did you spray?	v. On the days that you sprayed fungicides, how many hours of each day did you spray?	vi. Over the past year, have you used this?	If applicable, take a photo of insecticide package(s)/label(s). [Only 'other' selected]
_ 1. mancozeb <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 2. hexaconazole <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 3. carbendazim <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 4. thiram <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 5. copper II hydroxide <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 6. quintozone + Etridiazole <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 7. triforine <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 8. pyraclostrobin <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 9. dimethomorph <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 10. etridiazole <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 11. cuprous oxide <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 12. prochloraz <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 13. tetraconazole <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ other: please specify..... <i>If selected, answer ii. to vi..</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	<i>Please record a photo no.</i>

6E. When you spray, which parts of your body usually come into contact with fungicides? [SELECT ALL THAT APPLY]

- Face _____
- Hands _____
- Arms _____
- Trunk _____
- Legs _____
- None of the above _____

6F. Do you mix these fungicides yourself?

- Yes _____
- No _____

[If "yes" ask question 6G., otherwise skip to question 6H.]

6G. Did you mix them inside, outside home or both?

- Outside home _____
- Inside home _____
- Both outside and inside home _____

6H. Do you store the mixed chemicals in your home?

- Yes _____
- No _____

6I. When mixing, loading or applying these fungicides what protective clothing do you wear? [SELECT ALL THAT APPLY]

- Boots _____
- Gloves _____
- Respirator _____
- Goggles/Safety glasses _____
- Mask _____
- Balaklavas or clothes wrapped around the face _____
- Hat _____
- Full face shield _____
- Apron _____
- None of the above _____

6J. After spraying the fungicides do you...? [SELECT ALL THAT APPLY]

- Wash your hands, in home —
- Wash your hands, outside home —
- Have a shower, in home —
- Have a shower, outside home —
- Change your clothes —
- None of the above —

Storage of food crops

7. Have you ever used chemicals to protect food crops during storage? Yes —
No —

[If “yes” ask question 7A., otherwise skip to question 8.]

7A. Which chemicals do you apply to protect food crops during storage?

[SELECT ALL THAT APPLY]

- Rodenticide —
- Fumigant —

Animals

8. Do you keep animals? Yes —
No —

[If “yes” ask question 8A. and 9., otherwise skip to question 10.]

8A. Which of these animals do you keep? [SELECT ALL THAT APPLY]

- Insects (bees/silkworms/other worms or insects) —
- Large ruminants (Cattle/buffaloes/yaks) —
- Small ruminants (Sheep/goats) —
- Pigs or swine —
- Equines —
- Poultry: hens, ducks, geese etc. —
- Dogs and cats —
- Rabbits and hares —
- Other animal(s) —

8A.i. If select “other animal(s)”, please specify: _____

Insecticides protecting animals

9. Have you ever used insecticides to protect your animals? Yes —
No —

[If “yes” ask question 9A., otherwise skip to question 10.]

9A. When did you start dipping insecticides protecting animals? _____ (year in B.E.)

9B. Over the past year, have you dipped insecticides protecting animals?

Yes —
No —

[If “no” ask question 9C., otherwise skip to question 9B.1. then 9D.]

9B.1. Time since last insecticides protecting animal exposures

- i. ____ hours
- ii. ____ days
- iii. ____ months

9C. When did you stop spraying insecticides protecting animals? _____ (year in B.E.)

[Continue question 9D.]

9D. insecticides protecting animals

Now I am going to ask you about *insecticides* that you have ever used to protect your animals. I would like you to tell me each *insecticide* that you apply (or applied), and how long do (or did) you dip? If possible, please show the *insecticide* package(s)/label(s). In case the name(s) of *insecticide(s)* used is/are not in the lists below, please specify on question 9D.i. in the ‘other’ cell, and allow the interviewer to take a photo (by a device provided).

i. Which insecticides have you ever used? [SELECT ALL THAT APPLY]	ii. How many years have you dipped insecticides to protect animals?	iii. In the years that you dipped insecticides, how many months of each year did you dip?	iv. In the months that you dipped insecticides, how many days of each month did you dip?	v. On the days that you dipped insecticides, how many hours of each day did you dip?	vi. Over the past year, have you applied this?	If applicable, take a photo of insecticide protecting animals package(s)/label(s). [Only 'other' selected]
_ 1. chlorpyrifos <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 2. cartap hydrochloride <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 3. cypermethrin <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 4. acetamiprid <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 5. fipronil <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 6. chlorpyrifos + cypermethrin <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 7. pyridaben <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 8. imidacloprid <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 9. emamectin benzoate <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 10. chlorfenapyr <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 11. buprofezin <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 12. sulphur <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 13. carbaryl <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 14. abamectin <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 15. propargite <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 16. Petroleum oil <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 17. dinotefuran <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 18. <i>B Thuringiensis</i> <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 19. thiamethoxam <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 20. indoxacarb <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ 21. lambda-cyhalothrin <i>If selected, answer ii. to vi.</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	
_ other: please specify..... <i>If selected, answer ii. to vi..</i>	__ years	__ months	__ days	__ hours	_ Yes _ No	Please record a photo no.

9E. When you dip, which parts of your body usually come into contact with insecticides? [SELECT ALL THAT APPLY]

- Face _____
- Hands _____
- Arms _____
- Trunk _____
- Legs _____
- None of the above _____

9F. Do you mix these insecticides yourself?

- Yes _____
- No _____

[If "yes" ask question 9G., otherwise skip to question 9H.]

9G. Did you mix them inside, outside home or both?

- Outside home _____
- Inside home _____
- Both outside and inside home _____

9H. Do you store the mixed chemicals in your home?

- Yes _____

	No	—
9I. When mixing, loading or applying these insecticides what protective clothing do you wear? [SELECT ALL THAT APPLY]		
Boots	—	
Gloves	—	
Respirator	—	
Goggles/Safety glasses		—
Mask	—	
Balaklavas or clothes wrapped around the face	—	
Hat	—	
Full face shield	—	
Apron	—	
None of the above	—	
9J. After dipping the insecticides do you...? [SELECT ALL THAT APPLY]		
Wash your hands, in home	—	
Wash your hands, outside home	—	
Have a shower, in home	—	
Have a shower, outside home	—	
Change your clothes	—	
None of the above	—	
10. Have you ever worked in a barn/silo storing grain or fodder?		Yes —
		No —
[If "yes" ask question 10A. to 10E., otherwise skip to question 11.]		
10A. How many years have you worked in a barn/silo storing grain or fodder? __ years		
10B. In the years that you worked in a barn/silo storing grain or fodder, how many months of each year did you do it?		__ months
10C. In the months that you worked in a barn/silo storing grain or fodder, how many days of each month did you do it?		__ days
10D. On the days that you worked in a barn/silo storing grain or fodder, how many hours of each day did you do it?		__ hours
10E. Are you still working in a barn/silo storing grain or fodder?		Yes —
		No —
11. Have you ever driven farm machines?		Yes —
		No —

[If "yes" ask question 11A., otherwise skip to question 12.]

11A. farm machines

Now I am going to ask you about *farm machines and fuels* that you have ever used. I would like you to tell me each *farm machine* that you drive (or drove), how long do (or did) you use, and its fuel? The following are explanations for each *farm machine*. In case of 'other' selected, please specify a name of machine used.

- Farm trucks: Pick-ups, cargo vans, cars and other passenger vehicles used in farm business
- Tractors
- Tillage equipment: Moldboard plow; Disk plow; Subsoiler; Lister; Disk harrow; Spring tooth harrow; Spike; Land roller; Float
- Planting equipment: Spacing drill; Planters; Transplanters; Sugar cane planter
- Crop protection equipment: Water pumps; Sprats; Cultivator; Fertiliser distributors; Mowers
- Harvesting equipment: Combine harvester; Sugar harvester; Straw or fodder balers; Root or tuber harvesting; Threshing; Hullers and Mills
- Other: e.g. Livestock machine, Milking machines, Feeding stuffs, Poultry keeping, Crop processing equipment, Grading, Dryers, Conveyors

i. Which of these machines have you driven on the farm? [SELECT ALL THAT APPLY]	ii. How many years have you driven these farm machines	iii. In the years that you drove these farm machines, how many months of each year did you drive it?	iv. In the months that that you drove these farm machines, how many days of each month did you drive it?	v. On the days that that you drove these farm machines, how many hours of each day did you drive it?	vi. Which of these sources of fuel is used for driving your driving farm machinery? [SELECT ALL THAT APPLY]	vii. Over the past year, have you driven these farm machines?
☐ Farm trucks <i>If selected, answer ii. to vii.</i>	__ years	__ months	__ days	__ hours	☐ Diesel ☐ Petrol (gasoline) ☐ Biodiesel ☐ Gasohol ☐ Other fuel <i>specify:.....</i>	☐ Yes ☐ No
☐ Tractors <i>If selected, answer ii. to vii.</i>	__ years	__ months	__ days	__ hours	☐ Diesel ☐ Petrol (gasoline) ☐ Biodiesel ☐ Gasohol ☐ Other fuel <i>specify:.....</i>	☐ Yes ☐ No
☐ Tillage equipment <i>If selected, answer ii. to vii.</i>	__ years	__ months	__ days	__ hours	☐ Diesel ☐ Petrol (gasoline) ☐ Biodiesel ☐ Gasohol ☐ Other fuel <i>specify:.....</i>	☐ Yes ☐ No
☐ Planting equipment <i>If selected, answer ii. to vii.</i>	__ years	__ months	__ days	__ hours	☐ Diesel ☐ Petrol (gasoline) ☐ Biodiesel ☐ Gasohol ☐ Other fuel <i>specify:.....</i>	☐ Yes ☐ No
☐ Crop protection equipment <i>If selected, answer ii. to vii.</i>	__ years	__ months	__ days	__ hours	☐ Diesel ☐ Petrol (gasoline) ☐ Biodiesel ☐ Gasohol ☐ Other fuel <i>specify:.....</i>	☐ Yes ☐ No
☐ Harvesting equipment <i>If selected, answer ii. to vii.</i>	__ years	__ months	__ days	__ hours	☐ Diesel ☐ Petrol (gasoline) ☐ Biodiesel ☐ Gasohol ☐ Other fuel <i>specify:.....</i>	☐ Yes ☐ No
☐ Other: please specify..... <i>If selected, answer ii. to vii.</i>	__ years	__ months	__ days	__ hours	☐ Diesel ☐ Petrol (gasoline) ☐ Biodiesel ☐ Gasohol ☐ Other fuel <i>specify:.....</i>	☐ Yes ☐ No

12. Do you apply natural fertilizer?

Yes
No

13. Do you apply chemical fertilizer?

Yes
No

14. Do you burn forest/previous crops for converting to farm lands?

Yes
No

[If "yes" ask question 14A., otherwise finish this interview]

14A. Over the past year, have you burnt forest/previous crops for converting to farm lands?

Yes
No

[If "yes" ask question 14A.1., otherwise skip to question 14B.]

14A.1. Time since last burning forest/previous crops for converting to farm lands?

i. __ hours
ii. __ days
iii. __ months

14B. How long have you burnt forest/previous crops for converting to farm lands?

__ years

14C. How many times a year did you burn forest/previous crops for converting to farm lands?

__ times

Completed by: _____