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Mental health among the sugarcane industry farmers and non-farmers in Peru: a cross-sectional study on occupational health

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ABSTRACT

Objective Describe the occupational characteristics of farmer and non-farmer workers and investigate critical occupational risk factors for mental disorders in sugarcane farmers in Peru.

Method We conducted a cross-sectional study with occupational health and safety focus among farmers and non-farmers. Mental disorder symptoms were evaluated through the local validated version of the 12-Item General Health Questionnaire (GHQ-12). We explored the association between mental disorder symptoms, work conditions and known occupational risk factors (weekly working hours, pesticide exposures, heat stress and heavy workload). Negative binomial regression models were fitted, and 95% CIs were calculated.

Results We assessed 281 workers between December 2019 and February 2020. One hundred and six (37.7%) respondents identified themselves as farmworkers. The mean GHQ-12 scores for farmers and non-farmers were 3.1 and 1.3, respectively. In the fully adjusted multivariable model, mental disorder symptom counts among farmers were more than twice as high as those of non-farmers (β: 2.11; 95% CI: 1.48 to 3.01). The heavy workload increased the mean number of mental disorder symptoms by 68% (95% CI: 21% to 133%), and each additional working hour per day increased the mean number of mental disorder symptoms by 13% (95% CI: 1% to 25%).

Conclusion Farmers have higher mental disorder symptoms than non-farmers. A heavy workload and more working hours per day are independently associated with more mental disorder symptoms. Our findings highlight the importance of including mental health within occupational programmes and early interventions tailored to sugarcane industrial mill workers in the Latin American context.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ We discussed a critical but unresolved issue with one of the main task forces in Peru and other low-income and middle-income countries.
⇒ We used a locally validated version of the 12-Item General Health Questionnaire as a screening instrument for mental disorders.
⇒ Our sample size was relatively small for detecting more occupational risk factors, but the statistical power was enough to support the main conclusions.

INTRODUCTION

Every year, more than 450 million people develop a mental disorder globally. Mental disorders represent a critical proportion of the global disease burden and disability-adjusted life years.[1] About 75% of people affected by mental disorders live in low-income and middle-income countries (LMICs), and most have no access to appropriate treatment.[2] Per a recent global review that included evidence from 27 countries, farmers have higher rates of suicide, depression and anxiety than the general population.[3] In many LMICs, agriculture and farming remain the principal source of income[4]; however, farmers' mental health usually receive poor attention from employers and limited care from health systems.[3]

Understanding the effects of occupational risk factors on farmers' mental health at an epidemiological level is essential to determine prevention strategies that may help to avoid long-term mental health issues. For example, farmers are disproportionately exposed to work-related health risk factors[4] such as lower salaries,[5] pesticides,[6] heat stress[7] and heavier workloads.[5] These factors can contribute to a higher risk of developing physical and mental diseases. Farmers can also be more likely to develop common mental disorders than non-farmers working in the same industry.[8] However, to our knowledge, the problem of mental disorders due to agricultural work conditions have been barely studied in LMICs and especially in a Latin American context.[3]

The available evidence on this topic, especially for this population group is lacking. Our study compared the prevalence of mental health disorders among sugar cane farmers and non-farm workers and explored

its relationship with sociodemographic and work characteristics. There is an urgent need to have an evidence-based understanding of mental health risk factors for high occupational exposure groups in farming communities to improve the prevention efforts. We aim to describe the occupational characteristics of farmers and non-farmers, determine differences in mental health status screening between these groups, and identify occupational risk factors associated with mental disorders. We hypothesised that farmers are more at risk of developing mental disorders than non-farmers in this population.

METHODS

Study design

We analysed the baseline data of a prospective cohort of Peruvian farmers and non-farmers from the cane industry. That study, 'Evaluating the effects of exposure to sugarcane industry work on kidney function in farmers',[9] compared the time trends of kidney damage biomarkers with three assessments over 12 months in both occupational groups.

Setting

This study was developed in Centro Poblado San Jacinto, a small village in the north of Peru, economically dependent on the local sugarcane industry. San Jacinto has a population of 12 000 inhabitants, of which approximately 70% have worked or are currently working in agriculture-related activities. The sugar industry has more than 9000 cultivated acres between 21 m and 429 m above sea level. Although the sugar industry provides primary occupational healthcare by law,[10] most of the workers' healthcare in San Jacinto is provided through EsSalud and MINSA health centres. However, in both centres, mental healthcare is minimal or practically non-existent in rural places such as San Jacinto.

Participants

We detail the sample size calculations and sampling procedures for the main study in online supplemental file 1. We included 281 out of 291, 175 farmers and 106 non-farmers, and this allowed us to achieve 100% power to detect a difference of 1.2 between farmers and non-farmers with a significance level of 0.05 online supplemental file 2.

According to the main study's selection criteria, male participants between the ages of 18 and 60 and habitual residents in the study area (last 12 months) were eligible participants. Participants with a diagnosis of high blood pressure, diabetes mellitus and chronic kidney disease were excluded from this analysis, as they are considered to have known causes of chronic kidney disease. Also, we excluded participants working on more than one job as the effect of specific occupational exposures could not be estimated.

Farmer workers are subcontracted by the sugar company; their wages depend on the amount of sugarcane they cut or plant and will usually work long hours. Non-farmer workers are contracted directly by the sugar company and do not have the same heavy workload as field workers. They perform management activities, logistic processes, product quality assessment, and supervise production team operations.

Variables

Main outcome

Mental disorder symptoms were measured using a locally validated version of the 12-Item General Health Questionnaire (GHQ-12).[11] This tool assesses the worker's mental health status by asking 12 questions about how they have felt during the past week on various symptoms. The symptoms include problems with sleep and appetite, subjective experiences of stress, tension or sadness, mastery of daily problems, taking decisions and self-esteem. For each symptom, the person can respond less than usual, no more than usual, more than usual and much more than usual. We assigned a score equal to 0 for the first two options and a score equal to 1 for the latter two. Thus, GHQ-12 ranged from 0 to 12 symptoms; a score ≥5 would mean that the worker is at risk of having depression.[12]

Occupational groups

The work activity (ie, farmer and non-farmer) was the studied exposure. The farmer roles included cane cutters, seeders and seed cutters (exposed group). The non-farmer roles were defined as performing a factory or administrative activity (non-exposed group).

Covariates and occupational risk factors

Sociodemographic variables collected included age (years), level of education (<7 years of education, >7 years of education), monthly salary (low <US$480, high ≥US$480) and civil status (without union, with union). *Occupational risk factors*: the occupational heat stress index (formula: wet-bulb balloon temperature (WBGT)=0.7 wet bulb temperature + 0.2 globe temperature + 0.1 dry bulb temperature),[13] hours of work per day,[14] type of contract (fixed-term contract, indefinite contract), time of work in the industry (years), rest time during the working day (minutes), working hours per week, heavy workload (no, yes),[5] use of shade during work break (no, yes) and exposure to pesticides (no, yes).[6] *Lifestyle covariates*: tobacco consumption (at least one cigarette per day), alcohol consumption (self-reported consumption of ≥6 beers or its equivalent in alcohol with other beverages on the same occasion at least once a month), body mass index (normal: BMI >18.5 kg/m^2 and <25 kg/m^2, overweight/obesity: BMI ≥25 kg/m^2) and self-rated health (poor, good).

Data collection

Questionnaires

After a prescreening and informed consent process, the participants were invited to participate in the study voluntarily. Once a written consent of participation was signed, the research staff surveyed them through an online

questionnaire on tablets. The research team was trained on questionnaire application by the principal investigator, and research bioethics and responsible conduct in research by QUIPU—Centro Andino de Investigación y Entrenamiento en Informática para la Salud Global.[15] The questionnaire sections included: demographics, employment, work history,[16] and mental disorders.

Ambient measurements

Between 3 February and 21 February 2021, we recorded the air temperature and relative humidity every 15 min between 08:00 and 14:00 across the sugarcane fields at 1.25 m above the ground, using a WBGT and two 800036 WBGT laptops (Sper Scientific, China) independently to ensure data quality. We reported the mean results of the two devices. We calculated the heat index following the US Occupational Safety and Health Administration assessments and indications.[13]

Statistical analyses

The baseline characteristics of the study population were tabulated overall and according to work activity. To describe the data, we used percentages for categorical variables and median and interquartile ranges for continuous variables.

Mental disorder symptoms were treated as a count variable (0–12 symptoms) and summarised by showing the mean and SD for farmers and non-farmers. We fitted a negative binomial regression to the model count of symptoms as an outcome, setting work activity as the unique predictor. This allowed to formally compare the expected number of symptoms (mean) in non-farmers over the expected number of symptoms in farmers. In other words, we estimated a ratio of means (RM) between both groups.[17] As with other ratio measures, RM >1 implies more risk of suffering depressive symptoms, RM <1 less risk and RM=1 equal risk. We preferred negative binomial regression instead of Poisson regression because the first can be used for overdispersed count data (online supplemental file 3), as in this case.[18] We also fitted two adjusted models. Model 1 included the most critical work-related factors identified in the literature: monthly salary, exposure to pesticides and working hours per week. In Model 2, we adjusted for the same factors plus the type of contract, time of work in the industry, occupational heat stress index and heavy workload. Both models were also adjusted for age and work activity, the latter because it could still include other inherent risk factors we did not measure (occupational and non-occupational).

We adopted an exploratory approach for the last objective, analysing the full sample (independently of the work activity). Similar negative binomial regression models were fitted with sociodemographics, lifestyle and occupational risk factors as predictors and mental disorders symptoms as the outcome (ie, one unadjusted model per factor). Then, we joined those factors with a significant unadjusted association with mental disorders symptoms in one multivariable model. The factor selection and last estimated association allowed us to detect the main factors.

We calculated 95% CIs and considered p values <0.05 as significant. The statistical analysis was performed with Stata V.16.1 for Windows (Stata Corporation, College Station, Texas).

Patient and public involvement

No patients were involved.

RESULTS

Characteristics of farmer and non-farmer participants

We surveyed 281 male workers between December 2019 and February 2020. A total of 106 (37.7%) respondents were identified as farmers, while 172 (62.3%) were non-farmers. The farmers group was slightly older (mean: 42 years) compared with non-farmers (mean: 40 years). Farmers had a lower monthly salary and had achieved fewer education levels than non-farmers.

Regarding occupational risk factors, the group of non-farmers had, on average, 11 years working in the sugarcane industry. One out of every four farmers had a fixed-term contract/service lease, compared with non-farmers who had permanent contracts/direct employment with the company. The farmers were exposed to a higher index of occupational heat stress (28.3°C, IQR±0.6), they worked 8.5 hours per day (IQR±1.5), they rested 12.9 fewer minutes in a workday, they worked +55 hours (IQR±8.0) during the week and had a heavier workload, compared with non-farmers.

Regarding lifestyle, the farmer's group had a lower prevalence of tobacco consumption, alcohol consumption and overweight/obesity than non-farmers. The mean GHQ-12 score for farmers was 3.1 and 1.3 for non-farmers (table 1).

Differences in mental disorder symptoms between farmers and non-farmers

Farmers got 2.3 (95% CI: 1.71 to 3.09) times the mean number of mental disorder symptoms than non-farmers. After adjusting for the variables described in the first model (RM: 2.27; 95% CI: 1.69 to 3.06) and the second model (RM: 2.11; 95% CI: 1.48 to 3.01), the mean number of mental disorders symptom for farmers compared with non-farmers were still more than double (table 2).

Occupational risk factors and mental disorder symptoms

We detected three factors associated with symptoms of mental disorders. Having a heavy workload increased 68% of the mean number of mental disorders symptoms (95% CI: 21% to 133%). On average, each extra working hour per day increased the same outcome by 13% (95% CI: 1% to 25%). We detected a marginally-protective effect of having a shaded work break against symptoms of mental disorders (27%, 95% CI: −47% to 0%) (table 3).

DISCUSSION

We assessed mental disorder symptoms and potential risk factors on farmers and non-farmers from the industrial

Table 1 Characteristics of the study participants (N=281)

Characteristics	Non-farmer n=175 (%)	Farmer n=106 (%)	Overall
Sociodemographic variables			
Age, mean±SD	40.7±11.2	42.5±11.1	41.4±11.2
Level of education			
<7 years of education	15 (8.6)	43 (40.6)	58 (20.6)
≥7 years of education	160 (91.4)	63 (59.4)	223 (79.4)
Marital status			
Without union: divorced, separated, single	61 (34.9)	24 (22.6)	85 (30.2)
With union: cohabiting, married	114 (65.1)	82 (77.4)	196 (69.8)
Monthly salary			
High	70 (40.0)	34 (32.1)	104 (37.0)
Low	105 (60.0)	72 (67.9)	177 (63.0)
Occupational risk factors			
Type of contract			
Indefinite contract	137 (78.3)	81 (76.4)	218 (77.6)
Fixed-term contract	38 (21.7)	25 (23.6)	63 (22.4)
Time of work in the industry (years), median±IQR	11.0±14.0	10.0±13.0	11.0±13.0
Occupational heat stress index, median±IQR	28.0±0.0	28.3±0.6	28.1±0.4
Working hours per day, median±IQR	7.8±1.4	8.5±1.4	8.0±1.4
Rest time in the working day (minutes), median±IQR	30.0±51.4	17.1±30.0	30.0±45.0
Working hours per week, median±IQR	51.0±8.0	56.0±8.0	51.0±8.0
Heavy workload			
No	112 (64.0)	16 (15.1)	128 (45.6)
Yes	63 (36.0)	90 (84.9)	153 (54.4)
Shaded work break			
No	49 (28.0)	79 (74.5)	128 (45.6)
Yes	126 (72.0)	27 (25.5)	153 (54.4)
Exposure to pesticides			
No	155 (88.6)	90 (84.9)	245 (87.2)
Yes	20 (11.4)	16 (15.1)	36 (12.8)
Lifestyle variables			
Tobacco consumption			
No	122 (69.7)	80 (75.5)	202 (71.9)
Yes	53 (30.3)	26 (24.5)	79 (28.1)
Alcohol consumption			
Low	87 (49.7)	66 (62.3)	153 (54.4)
High	88 (50.3)	40 (37.7)	128 (45.6)
Body mass index*			
Normal	16 (21.9)	18 (41.9)	34 (29.3)
Overweight/obesity	57 (78.1)	25 (58.1)	82 (70.7)
Self-rated health			
Poor	86 (49.4)	33 (31.1)	119 (42.5)
Good	88 (50.6)	73 (68.9)	161 (57.5)
Mental disorders symptoms (GHQ-12), mean±SD	1.3±1.9	3.1±1.6	2.0±2.0

*Body mass index, 116 people with measurements (73 non-farmers; 43 farmers).
GHQ-12, 12-Item General Health Questionnaire.

Table 2 Mental disorder symptoms (GHQ-12) among farmers and non-farmers (N=281)

Work activity	n	Mean and SD of the number of mental disorders symptoms	Unadjusted estimate RM (95% CI)	Unadjusted estimate P value	Model 1* RM (95% CI)	Model 1* P value	Model 2† RM (95% CI)	Model 2† P value
Non-farmer	175	1.34 (1.93)	Reference		Reference		Reference	
Farmer	106	3.08 (1.63)	2.30 (1.71 to 3.09)	<0.001	2.27 (1.69 to 3.06)	<0.001	2.11 (1.48 to 3.01)	<0.001

*Adjusted for age, monthly salary, exposure to pesticides, working hours per week.
†Adjusted for age, monthly salary, type of contract, time of work in the industry, exposure to pesticides, occupational heat stress index, working hours per week, heavy workload.
.GHQ-12, 12-Item General Health Questionnaire; RM, ratio of means.

sugarcane mill in a rural Peruvian context. We found that the farmers had more mental disorders symptoms compared with non-farmers and that for any worker in this study, having a heavy workload and working more hours per day was associated with a higher risk of having mental disorder symptoms. There was a lack of association between pesticides exposure and a higher scoring in the heat stress index with mental disorders symptoms, opposed to reported evidence of these factors in other studies.[6 7]

Our study focused on active sugarcane industry workers and compared the occupational characteristics among the farmers' and non-farmers' groups. Our farmers' sample was younger than the mean age of participants reported in other studies.[19] According to Wang *et al*, younger farmers experienced higher stress-related symptoms, while elderly farmers experienced more mental disabilities.[20] We also found that many farmers worked under a fixed-term contract/service lease with fewer benefits. Insecurity related to future employment can negatively affect workers' health.[4] A previous Norwegian study found that male agricultural workers had the highest HADS-D (Hospital Anxiety and Depression Scale) level of all occupational groups, and job insecurity may be a possible explanation.[21] Due to their labour instability, farmers tend to overwork many more hours than is legally allowed (Law 27 671 rules the working day, hours and over time, established by the Peruvian government).[22] Despite this, farmers have a lower average monthly salary than non-farmers, as it is considered unskilled labour where the only requirement is previous experience. Financial challenges negatively impact farmers' mental health, for example, psychological distress, depression and less satisfaction with life, particularly in those settings where agriculture represents the main source of income.[23] Also, farmers had heavier workloads compared with non-farmer workers. Kallioniemi *et al* found that stressors related to workload were associated with stress and burnout symptoms in Finland's farmers.[5] These results support our study findings.

In our setting, farmers were responsible for the planting, harvesting of the crops and sugarcane cutting. These activities involve a high physical and mental toll and are always carried out under the sun, often without choice or protection. Surprisingly, we did not observe an increased effect of heat stress on mental disorders. However, in the last 20 years, the average environmental temperature in Peru has increased due to global warming.[24] This increase has been linked to an increase in depression, bipolar disorder and post-traumatic stress disorder cases, which indicates the severity of farmers' mental health. These trends are likely due to seasonal variations in serotonin levels in the brain, which are affected by temperature and light. As constant sun exposure decreases, serotonin levels in the brain slowly return to baseline.[25] This phenomenon is called acclimatisation, and it can explain the protective effect of having a shaded work break against mental disorder symptoms.

Table 3 Sociodemographic, occupational and lifestyle risk factors associated with mental disorders symptoms (GHQ-12) (N=281)

	Unadjusted		Adjusted*	
Factors	**RM (95% CI)**	**P value**	**RM (95% CI)**	**P value**
Sociodemographic variables				
Age (years)	1.00 (0.99 to 1.02)	0.330		
Level of education				
<7 years of education	Reference		Reference	
≥7 years of education	**0.55 (0.39 to 0.78)**	**0.001**	0.82 (0.56 to 1.20)	0.302
Marital status				
Without union: divorced, separated, single	Reference			
With union: cohabiting, married	0.99 (0.73 to 1.34)	0.974		
Monthly salary				
High	Reference			
Low	1.35 (1.00 to 1.82)	0.052		
Occupational risk factors				
Type of contract				
Indefinite contract	Reference			
Fixed-term contract	1.03 (0.73 to 1.44)	0.886		
Time of work in the industry (years)	1.00 (0.98 to 1.01)	0.795		
Occupational heat stress index	1.23 (0.90 to 1.68)	0.191		
Working hours per day	**1.17 (1.05 to 1.30)**	**0.004**	**1.13 (1.01 to 1.25)**	**0.029**
Rest time in the working day (minutes)	1.00 (0.99 to 1.01)	0.780		
Working hours per week	1.01 (0.99 to 1.03)	0.069		
Heavy workload				
No	Reference			
Yes	**1.95 (1.45 to 2.63)**	**<0.001**	**1.68 (1.21 to 2.33)**	**0.002**
Shaded work break				
No	Reference			
Yes	**0.57 (0.43 to 0.76)**	**<0.001**	0.73 (0.53 to 1.00)	0.051
Exposure to pesticides				
No	Reference			
Yes	1.12 (0.73 to 1.71)	0.606		
Lifestyle variables				
Tobacco consumption				
No	Reference			
Yes	1.00 (0.73 to 1.38)	0.976		
Alcohol consumption				
Low	Reference			
High	0.90 (0.67 to 1.20)	0.458		
Body mass index*				
Normal	Reference			
Overweight/obesity	0.64 (0.40 to 1.02)	0.062		
Self-rated health				
Poor	Reference			
Good	1.31 (0.98 to 1.76)	0.071		

Values in bold are related to a p-value <0.05.
*Adjusted for the level of education, working hours per day, heavy workload and shaded work break.
GHQ-12, 12-Item General Health Questionnaire; RM, ratio of means.

Farmers presented more symptoms of mental disorders given the nature of their extremely demanding physical activities and their working conditions. In support of our claim, Hounsome *et al* in the UK found a difference of 1.21 in the GHQ-12 score between farmers and non-farmers.[26] The farmer's working conditions are a plausible explanation for our results. For instance, the intense, heavy-duty working shifts beyond the allowed legal limits are striking signs of precarious agricultural employment, especially in Peru. Although the agricultural sector in the country contributes to 9% of the gross domestic product and represents 24.7% of its economically active population,[27] the farmers' contract modality is notably diverse, and many times they are paid on a daily performance basis. Due to this and other factors, the agricultural sector has the highest poverty prevalence in Peru and, therefore, has poorer mental health consequences, as has been established elsewhere.[28] Farmers from our study also had limited access to work-related social security benefits. This happens because many farmers have temporary contracts or do not have formal contracts.[29] Similar results have been found across seasonal farmers in Ethiopia, where a higher prevalence of common mental disorders was reported .[30]

In our study, symptoms of mental disorders increased with additional hours of excessive work. This finding is consistent with the North American study reported by Kearney *et al*, where 60% of farmers who worked >40 hours per week reported being very stressed.[31] Excessive working hours in stressful environments and poor working conditions have been found associated with increased mental health disorder symptoms. In Brazil, it is highlighted that the heavy workload is a definite farmer's stressor.[32] The Occupational Health and Safety guidelines recommend that farmers should work 75% of the time and rest 25% of it when carrying out heavy load activities in high ambient temperatures to avoid adverse health effects. In Peru, agricultural work is ruled by the Special Labor Regime Law (Law 27360-Promotion of the Agrarian Sector), which holds up to a maximum of 48 hours the farmer's working week.[27] However, this limit is usually not followed by their employers, which will not be often audited for labour law compliance or receive any sanctions from the Government.

Strengths and limitations

We explored a critical yet postponed issue among one of the main task forces in Peru and other LMICs. We used a locally validated version of the GHQ-12 as a screening instrument for mental disorders in our study population due to its satisfactory reliability sensitivity and specificity.[33] Also, our study has some limitations that must be considered. The sample size was relatively small for our third objective. However, we tried to be conservative when fitting models related to this objective, for example, adjusting only for key potential confounders. Given the external evidence discussed above, we can be conclusive on the heavy workload and working hours per day. However, we cannot reach conclusions regarding pesticides exposure, occupational heat stress and shaded work breaks. Finally, we acknowledge that we did not use a random sampling and are aware of the possibility of sampling bias. However, the characteristics of age, level of education and low economic income described in our study are similar to those described in Peru's National Agricultural Census,[34] implying that our findings are representative of Peruvian farmers.

Occupational health implications

Good practices that protect and promote mental health in the workplace should bring together the implementation of social safety nets with health facilities to protect workers' mental health. The Peruvian government created community mental health centres in mental health reform (through Law 29889, in 2015) to ensure the provision of outpatient and specialised care for people with mental health disorders.[35] In theory, farmers can and should be referred for specialised care. However, in practice, access to the nearest health centre is complicated, there are no strategies for early detection of mental health symptoms by the industry's occupational health staff and farmers are afraid to report them due to fear of future repercussions. These will hold a serious barrier to access to timely treatment of mental disorders among agricultural workers.

Our results highlight that good practices for protecting and promoting mental health in the workplace should consider the following: the implementation and enforcement of health and safety policies and practices, including the identification of distress, drinking enough fluids, wearing appropriate clothing and scheduling work activities and breaks in the shade; informing staff that support is available; and organisational practices that support a healthy work–life balance.

Conclusion

Sugarcane farmers have higher mental disorder symptoms than their non-farmer peers. A heavy workload and more working hours per day are independently associated with more mental disorder symptoms. Our findings highlight the importance of including mental health within occupational programmes and early interventions tailored to sugarcane industrial mill workers in the Latin American context.

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Competing interests None declared.

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Patient consent for publication Consent obtained directly from patient(s).

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Mental health among the sugar cane industry farmers and non-farmers in Peru: a cross-sectional study on occupational health

Supplementary 1: Sample size and power analysis

Sample size for the main study:

On the main study, to determine the sample size required to detect differences in eGFR of -5 ml/min/1.73m2 or higher (1), we used a significance level of 5% ($\alpha = 0.05$) for a 2-tailed test with a statistical power of 80% ($1-\beta = 0.80$) and an estimated variance of 289 (2). With this information, assuming that the population is infinite, 81 people per group (exposed and unexposed) were obtained. Assuming a 20% loss to follow-up, a sample size of 97 was obtained at a ratio of 1:1 per group, 97 farmers to 97 non-farmers. However, to increase the power of this study, the inclusion ratio for this study was 2:1, for a total of 291 participants.

Also, random sampling stratified by age (18-30, 31-45, 46-60 years) and work activity was used in the main study. The list of workers was used as a sampling frame in our database. The farmers (exposed group) who met the study's inclusion and exclusion criteria were chosen, and non-farmer workers with similar characteristics (age) to each farmer.

Power analysis for the current manuscript:

Two-Sample T-Test Power Analysis: Numeric Results for Two-Sample T-Test

Null Hypothesis: Mean1=Mean2. Alternative Hypothesis: Mean1≠Mean2

The standard deviations were assumed to be unknown and unequal.

Allocation									
Power	N1	N2	Ratio	Alpha	Beta	Mean1	Mean2	S1	S2
1.00	175	106	0.606	0.05	0.00	10.7	9.5	0.3	0.2

Report Definitions

- Power is the probability of rejecting a false null hypothesis. Power should be close to one.
- N1 and N2 are the number of items sampled from each population. To conserve resources, they should be small.
- Alpha is the probability of rejecting a true null hypothesis. It should be small.
- Beta is the probability of accepting a false null hypothesis. It should be small.
- Mean1 is the mean of populations 1 and 2 under the null hypothesis of equality.

- Mean2 is the mean of population 2 under the alternative hypothesis. The mean of population 1 is unchanged.
- S1 and S2 are the population standard deviations. They represent the variability in the populations.

Summary Statements

Group sample sizes of 175 and 106 achieve 100% power to detect a difference of 1.2 between the null hypothesis that both group means are 10.7 and the alternative hypothesis that the mean of group 2 is 9.5 with estimated group standard deviations of 0.3 and 0.2 and with a significance level (alpha) of 0.05000 using a two-sided two-sample t-test.

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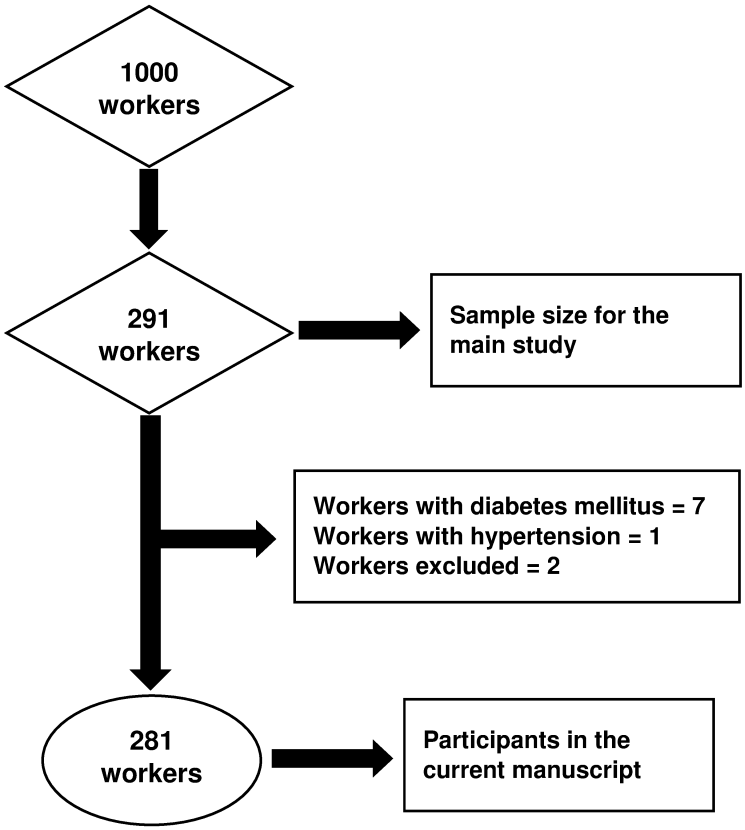
Supplementary 2: Flowchart based on the sample agreed upon

A total of 1000 workers participated in the study. We obtained a sample size of 291 workers from that total. Only 95.6% (281 workers) agreed to take part in the study.



Supplementary 3: Assumption's evaluation

Examine equidispersion

(i) Poisson goodness-of-fit test

```
poisgof
        Deviance goodness-of-fit =  538.2604
        Prob > chi2(279)         =    0.0000

        Pearson goodness-of-fit  =  575.6407
        Prob > chi2(279)         =    0.0000
```

```
display 538.2604/279
1.9292487
```

Conclusion: The Poisson goodness-of-fit test results indicate (p-value 0.05) that the Poisson model is inappropriate. Similarly, when the deviance was divided by the number of observations, the value was > 1, indicating overdispersion. Both results show that Negative Binomial Regression should be used instead of Poisson Regression.

(ii) The alpha parameter for overdispersion

```
xi:nbreg ghql2_num cond_labor

Negative binomial regression                    Number of obs     =        281
                                                LR chi2(1)        =      43.74
Dispersion     = mean                           Prob > chi2       =     0.0000
Log likelihood = -511.89239                     Pseudo R2         =     0.0410

------------------------------------------------------------------------------
   ghql2_num |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  cond_labor |   .8329231   .1196616     6.96   0.000     .5983908    1.067456
       _cons |   .2905351   .0831008     3.50   0.000     .1276606    .4534097
-------------+----------------------------------------------------------------
    /lnalpha |  -.7751364   .2216944                     -1.209649   -.3406233
-------------+----------------------------------------------------------------
       alpha |    .460641   .1021215                      .2983018    .7113268
------------------------------------------------------------------------------
LR test of alpha=0: chibar2(01) = 48.86                Prob >= chibar2 = 0.000
```

Conclusion: The overdispersion alpha parameter test results show that the alpha is significantly different from zero, reinforcing the position that the Poisson distribution is inappropriate.