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# Mental health among the sugar cane industry farmers and non-farmers in Peru: an occupational health study



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# Mental health among the sugar cane industry farmers and non-farmers in Peru: an occupational health study

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## Abstract

***Objective:*** We compared the prevalence rates of mental disorder symptoms among farmers and non-farmers workers in the sugarcane industry and investigated the role of relevant occupational factors.

***Design:*** A cross-sectional study

***Setting:*** This study was developed in Centro Poblado San Jacinto, a small village in the north of Peru.

***Participants:*** We recruited 281 male participants, among farmers and non-farmers, all active workers of the sugar cane industry and aged 18 to 60 years.

***Outcome:*** Mental disorder symptoms were evaluated through the local validated version of the General Health Questionnaire (GHQ-12).

***Results:*** Negative binomial regression models were fitted, and 95% confidence intervals (95% CI) were calculated. We assessed 281 workers between December 2019 and February 2020. 106 (37.7%) of 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: 1.48–3.01). The heavy workload increased the mean number of mental disorder symptoms by 68% (95% CI: 21%–133%), and each additional working hour per day increased the mean number of mental disorder symptoms by 13% (95% CI: 1%–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 programs and early interventions tailored to sugarcane industrial mill workers in the Latin American context.


***Keywords:*** Occupational hazard; occupational health; mental disorders; GHQ-1; sugarcane work; farmers; low and middle-income countries.

## The strengths and limitations of this study

- Our study explores a critical yet postponed issue amongst one of the main task forces in Peru and other LMICs.
- Our sample size was relatively small to draw conclusions regarding pesticide exposure, occupational heat stress, and shaded work breaks as risk factors for mental disorders.
- Our findings highlight the importance of including mental health within occupational programs and early interventions tailored to sugarcane industrial mill workers in the Latin American context.

## 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). 75% of people affected by mental disorders live in low-and-middle-income countries (LMIC), 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).

Here, we evaluate critical occupational risk factors for mental disorders in farmers of the sugarcane industry in Peru. We aim to 1) describe occupational characteristics of farmers and non-farmers, 2) determine differences in mental health status screening between these groups, and 3) identify occupational risk factors associated with mental disorders. We hypothesised that farmers are more at risk to develop 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. The primary data were collected for the study "Evaluating the effects of exposure to sugarcane industry work on kidney function in farmers" (9) that 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 is located in the Nepeña Valley at 328 meters above sea level, has a population of 12,000 inhabitants, of which approximately 70% have worked or currently work in agriculture-related activities, and 80%

of households meet basic sanitation needs. The sugar industry has more than 9,000 cultivated acres between 21 and 429 meters above sea level.

Although the sugar industry provides primary occupational health care by law (10), most of the worker's health care in San Jacinto is provided through EsSalud and MINSA health centres. The Peruvian social security runs EsSalud health centres for insured current and former workers, and MINSA's facilities operate under the Peruvian Ministry of Health administration. Typically, EsSalud health centres provide slightly better health care than MINSA health centres, mainly due to having more economic resources. However, in both cases, mental health care is minimal or practically inexistent in rural places such as San Jacinto. Only a tiny fraction of workers (commonly non-farmers) has access to private health care.

***Participants***

We recruited 281 male participants, all active workers of the sugar cane industry and aged 18 to 60 years. They were habitual residents of the study area for at least 12 months and agreed to participate in the study. We excluded participants with a diabetes mellitus diagnosis (defined as fasting blood glucose ≥126 mg/dl or self-reported diagnosis with the use of diabetic medications), hypertension (defined as systolic blood pressure (SBP) ≥140 mm Hg, diastolic blood pressure (DBP) ≥90 mm Hg or self-reported diagnosis with the use of antihypertensive medications), or self-reported chronic kidney disease. Participants working in more than one job at the same time were also excluded (Supplementary 1).

***Variables***

**Main Outcome**

Mental disorder symptoms were measured using a locally validated version of the General Health Questionnaire (GHQ-12) (11). This tool assesses the worker's mental health status by asking twelve 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 (Supplementary 2). 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 zero (0) for the first two options and a score equal to one (1) for the latter two. Thus, GHQ-12 ranged from 0 to 12 symptoms, for which a threshold score ≥5 would mean that the worker is at risk of having depression (12).

**Occupational groups**

The work activity (i.e., 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 vs>7 years of education), monthly salary (low = <USD 480, high = ≥USD 480), civil status (without union: divorced, separated, single; with union: cohabiting, married). *Occupational risk factors*, the occupational heat stress index (was calculated using the following formula: 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), 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 / m2.), self-rated health (poor, good).

***Data collection***

Questionnaires: After a pre-screening 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: During 15 calendar days (between February 03 to February 21, 2021), we recorded the air temperature and relative humidity every fifteen minutes between 08:00 to 14:00 across the sugar cane fields at 1.25 meters above the ground, using a wet-bulb balloon temperature (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 (HI) following the US Occupational Safety and Health Administration (OSHA) assessments and indications (13).

Clinical measurements: The participant's weight was measured using a TANITA Body composition analyzer model TBF-400 calibrated single frequency (50 kHz). Height was assessed using a folding stadiometer and reported in centimetres.

***Statistical analyses***

The baseline characteristics of the study population were tabulated overall and according to work activity (i.e., farmers and non-farmers). To describe data, we used percentages for categorical variables such as level of education, marital status, monthly salary, type of contract, heavy workload, shaded work break, exposure to pesticides, tobacco and alcohol consumption, body mass index, self-rated health. Time of work in the sugar cane industry,

occupational heat stress index, working hours per day, rest time in the working day, and working hours per week were treated as a continuous variable and summarized with the median and interquartile range.

Mental disorders symptoms were treated as a count variable (0 to 12 symptoms) and summarized by showing the mean and standard deviation 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 over-dispersed count data, 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, analyzing the full sample (independently of the work activity). Similar negative binomial regression models were fitted with socio-demographics, lifestyle, and occupational risk factors as predictors and mental disorders symptoms as the outcome (i.e., one unadjusted model per factor). Then, we jointed 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% confidence intervals and considered p-values<0.05 as significant. The statistical analysis was performed with Stata 16.1 for Windows (Stata Corporation, College Station, Texas).

### *Patient and public involvement*

As part of the study process, the parent study engaged farmers and non-farmer workers of the sugarcane industry to compare the prevalence rates of mental disorder symptoms.

## Results

### *Characteristics of farmer and non-farmer participants*

We surveyed 281 male workers between December 2019 and February 2020. 106 (37.7%) respondents were identified as farmers, while 172 (62.3%) were non-farmers. The farmer's

group was slightly older (mean: 42 years) compared to 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 sugar cane industry. One out of every four farmers had a fixed-term contract/service lease, compared to 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 to 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**).

**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 |

Abbreviations: GHQ-12, 12-Item General Health Questionnaire; SD, Standard Deviation; IQR, Interquartile Range.

*Body mass index, 116 people with measurements (73 non-farmers; 43 farmers).

***Differences in mental disorders symptoms between farmers and non-farmers***

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

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

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

Abbreviations: RM, Ratio of means; CI, Confidence interval; GHQ-12, 12-Item General Health Questionnaire.

*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.

***Occupational risk factors and mental disorders symptoms***

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

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

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

| | | |
|---|---|---|
| ***Lifestyle variables*** | | |
| Tobacco consumption | | |
| No | reference | |
| Yes | 1.00 (0.73-1.38) | 0.976 |
| Alcohol consumption | | |
| Low | reference | |
| High | 0.90 (0.67-1.20) | 0.458 |
| Body mass index* | | |
| Normal | reference | |
| Overweight / Obesity | 0.64 (0.40-1.02) | 0.062 |
| Self-rated health | | |
| Poor | reference | |
| Good | 1.31 (0.98-1.76) | 0.071 |

Abbreviations: RM, Ratio of means; CI, Confidence interval; GHQ-12, 12-Item General Health Questionnaire.
*Adjusted for the level of education, working hours per day, heavy workload, and shaded work break.

## Discussion

We assessed mental disorders symptoms and potential risk factors on farmers and non-farmers from the industrial sugarcane mill in a rural Peruvian context. We found that the farmers had more mental disorders symptoms compared to 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 disorders 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 sugar cane industry workers and compared the occupational characteristics among the farmers and non-farmers groups. Our farmers' sample was younger (42.5 years) 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). Our younger sample can be explained because around 25% of the farmers in San Jacinto were young migrants from the Peruvian highlands. We also found that many farmers worked under a fixed-term contract/service lease with lesser benefits. Insecurity related to future employment can negatively affect workers' health (4). A previous Norwegian study from the Health Survey of Hordaland found that male agricultural workers had the highest HADS-D level of all occupational groups in their study, and job insecurity may be a possible explanation (21). Due to their labour instability, farmers tend to overwork many more hours than are legally allowed (Law 27671 that rules

the Working day, hours, and overtime, 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, *e.g.*, psychological distress, depression, and less satisfaction with life, particularly in those settings where agriculture represents the main source of income (23). Also, farmers will hold heavier workloads compared to 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 the crops, and sugar cane 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, heat waves are common in summer and immediately affect the prevalence and severity of farmers' mental health (24). This exposure factor is expected to continue increasing with the current climate emergency. Higher ambient temperatures, heatwaves, and temperature variations are risk factors for worse mental health outcomes (26), potentially leading to a greater impact on the farmer's mental health.

Additionally, in the last 20 years, the average environmental temperature in Peru has increased due to global warming (Supplementary 3) (25). This increase has been linked to an increase in depression, bipolar disorder, bulimia, and post-traumatic stress disorder cases. These trends are likely due, in part, 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 (26). This phenomenon is called acclimatization, which may explain the -potentially- protective effect of having a shaded work break against mental disorders symptoms, which we also found in our study.

Farmers presented more symptoms of mental disorders given the nature of their extremely demanding physical activities and their working conditions. Numerous studies on mental illness and mental symptoms among farmers support our claim (27). For example, a study carried out by Hounsome et al. in the United Kingdom found a difference of 1.21 in the GHQ-12 score between farmers and non-farmers (28). We believe that 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 (29), 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 (30). 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 (31). Similar results have been found across seasonal farmers in Ethiopia, where was reported a higher prevalence of common mental disorders (32).

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 (33). 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 (34). 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 (29). 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**

Our study explores a critical yet postponed issue amongst 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 (35). We used other validated questionnaires to avoid social desirability bias. For example, the WHO STEPS survey on noncommunicable disease risk factors (36) and pesticide exposure in the DEGREE Study protocol for measuring population patterns of estimated Glomerular Filtration Rate (37) with independent measures for data and process quality, both of which were carried out by the same experienced and trained research team members.

As with most studies conducted on this topic, our study has some limitations that must be considered. The sample size was based on a pre-study power calculation of 80% to detect a 14% difference between farmers and non-farmers with a significance level of 0.05. Likewise, our study shows the same effect direction found in other studies (3). However, the sample size was relatively small for our third objective. 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.

## 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 specialized care for people with mental health disorders (38). In theory, farmers can and should be referred for specialized 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 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; involving employees in decision making; conveying a sense of control and participation; organizational practices that support a healthy work-life balance; and employee professional development programs.

## Conclusion

Sugar cane 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 programs and early interventions tailored to sugarcane industrial mill workers in the Latin American context.

## Declarations

### Data availability statement

All data relevant to the study are included in the article or uploaded as supplementary information.

### Competing interests

The authors declare no conflict of interest.

### Authors' contributions

JCB-A and JB-P conceived, designed and supervised the overall study. JB-P, ECF, JB and JCB-A developed the idea for this manuscript. JB-P and JCB-A led the statistical analysis. JB-P drafted the first version of the paper. All authors participated in writing the manuscript, provided important intellectual content and gave their final approval of the submitted version.

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### *Ethics*

This study was approved by the Institutional Review Board of the Universidad Peruana Cayetano Heredia (ID code 19018). All data analyzed for this study were de-identified and stored in one encrypted device.

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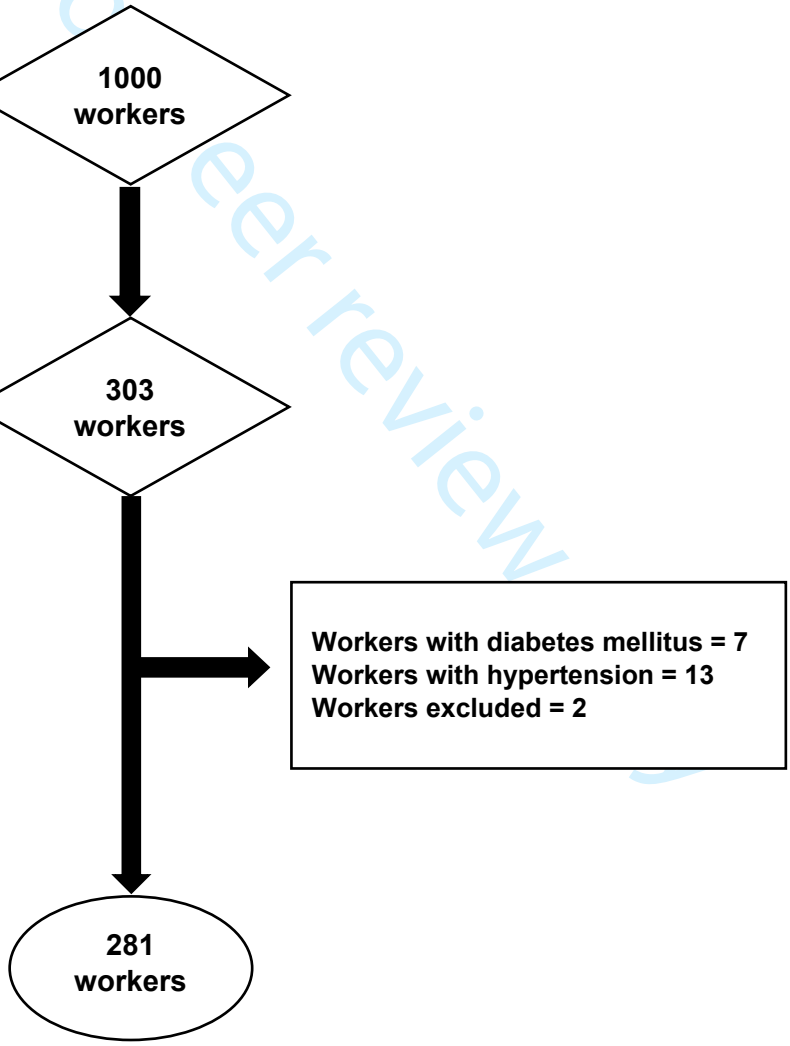
# Mental health among the sugar cane industry farmers and non-farmers in Peru: an occupational health study

**Supplementary material**

Supplementary 1: Study sample flowchart



Supplementary 2: Questionnaire of GHQ-12

| GHQ-12 Items | Answers | | | |
|---|---|---|---|---|
| 01. Have you recently been able to concentrate on whatever you're doing? | Better than usual | Same as usual | Less than usual | Much less than usual |
| 02. Have you recently lost much sleep due to worry? | Not at all | No more than usual | Rather more than usual | Much more than usual |
| 03. Have you recently felt that you were playing a useful part in things? | More so than usual | Same as usual | Less useful than usual | Much less than usual |
| 04. Have you recently felt capable of making decisions about things? | More so than usual | Same as usual | Less so than usual | Much less than usual |
| 05. Have you recently felt under constant strain? | Not at all | No more than usual | Rather more than usual | Much more than usual |
| 06. Have you recently felt you couldn't overcome your difficulties? | Not at all | No more than usual | Rather more than usual | Much more than usual |
| 07. Have you recently been able to enjoy your normal day-to-day activities? | More so than usual | Same as usual | Less so than usual | Much less than usual |
| 08. Have you recently been able to face your problems? | More so than usual | Same as usual | Less so than usual | Much less than usual |
| 09. Have you recently been feeling unhappy or depressed? | Not at all | No more than usual | Rather more than usual | Much more than usual |
| 10. Have you recently been losing confidence in yourself? | Not at all | No more than usual | Rather more than usual | Much more than usual |
| 11. Have you recently been thinking of yourself as a worthless person? | Not at all | No more than usual | Rather more than usual | Much more than usual |
| 12. Have you recently been feeling reasonably happy, all things considered? | More so than usual | Same as usual | Less so than usual | Much less than usual |

Supplementary 3: According to the National Service of Meteorology and Hydrology, environmental temperature records by department during the period 1999–2020 in Peru.

1. Temperatura promedio anual, según departamento 1999-2020
(Grado Celsius)

| Departamento | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Amazonas | 14,5 | 14,6 | 14,7 | 14,9 | 15,0 | 14,9 | 15,2 | 15,0 | 14,7 | 14,8 | 14,8 | 15,4 | 14,9 | 14,7 | 15,0 | 14,9 | 15,1 | 15,6 | 15,2 | 14,9 | 15,0 | 15,3 |
| Áncash | 11,9 | 11,9 | 12,0 | 12,6 | 12,6 | 12,1 | 12,5 | 14,2 | 12,6 | 12,4 | 12,5 | 12,7 | 12,2 | 12,4 | 12,5 | 12,5 | 12,8 | 13,1 | 12,3 | 12,0 | 12,5 | a/ |
| Apurimac | 14,8 | 14,6 | 14,8 | 14,8 | 15,3 | 14,8 | 16,2 | 15,7 | 15,8 | 16,2 | 16,0 | 16,2 | 15,7 | 14,0 | 14,1 | 14,1 | 14,5 | 14,9 | 14,3 | 14,2 | 14,6 | a/ |
| Arequipa | 16,0 | 15,2 | 15,8 | 16,3 | 16,3 | 15,8 | 16,0 | 15,9 | 15,9 | 15,0 | 16,4 | 16,4 | 15,6 | 15,6 | 15,6 | 16,1 | 17,1 | 17,3 | 16,6 | 16,6 | 17,0 | a/ |
| Ayacucho | 18,0 | 17,2 | 17,7 | 18,3 | 18,0 | 16,8 | 17,8 | 17,7 | 18,1 | 19,4 | 19,0 | 18,8 | 18,0 | 18,0 | 18,2 | 18,4 | 18,3 | 18,8 | 18,1 | 17,1 | 17,0 | 18,2 |
| Cajamarca | 14,2 | 14,0 | 14,4 | 14,7 | 14,8 | 14,6 | 14,6 | 14,5 | 14,4 | 14,4 | 14,7 | 14,9 | 14,4 | 14,6 | 14,9 | 15,0 | 15,4 | 15,6 | 15,0 | 14,9 | 15,0 | 15,5 |
| Cusco | 12,0 | 11,9 | 12,0 | 11,9 | 12,1 | 12,1 | 11,9 | 11,8 | 12,4 | 12,3 | 12,4 | 12,6 | 12,1 | 12,3 | 12,3 | 12,5 | 12,6 | 13,3 | 13,0 | 12,6 | 12,9 | 14,0 |
| Huancavelica | 9,8 | 10,0 | 9,9 | 10,5 | 10,4 | 10,5 | 10,5 | 10,1 | 10,3 | 10,0 | 10,6 | 10,4 | 9,5 | 9,6 | 10,3 | 10,3 | 10,4 | 10,8 | 10,4 | 10,4 | 10,7 | 11,1 |
| Huánuco | 19,9 | 19,9 | 20,2 | 20,5 | 20,6 | 20,2 | 20,7 | 20,4 | 20,5 | 20,4 | 20,5 | 20,9 | 20,2 | 20,3 | 20,7 | 20,6 | 20,8 | 21,4 | 20,9 | 20,2 | 20,4 | 21,1 |
| Ica | 20,8 | 20,9 | 22,1 | 21,6 | 21,0 | 20,9 | 20,7 | 21,2 | 20,6 | 21,6 | 21,8 | 21,4 | 22,2 | 20,7 | 21,5 | 21,0 | 21,6 | 22,9 | 22,7 | 22,4 | 22,1 | 22,7 |
| Junín | 11,9 | 12,0 | 12,0 | 12,3 | 12,2 | 12,2 | 12,4 | 12,0 | 12,4 | 12,1 | 12,4 | 12,7 | 12,1 | 12,1 | 12,4 | 12,4 | 12,6 | 13,0 | 12,8 | 12,3 | 12,3 | 13,3 |
| La Libertad | 19,7 | 20,2 | 19,7 | 20,6 | 20,1 | 17,9 | 20,1 | 20,1 | 18,9 | 20,8 | 20,5 | 19,8 | 19,9 | 21,2 | 19,3 | 21,0 | 22,2 | 21,2 | 20,9 | 20,0 | 20,6 | 20,2 |
| Lambayeque | 20,7 | 21,0 | 20,8 | 21,8 | 20,9 | 21,6 | 21,6 | 22,5 | 19,9 | 21,5 | 21,2 | 20,5 | 20,7 | 22,0 | 20,2 | 21,7 | 22,8 | 22,4 | 22,0 | 20,9 | 21,5 | 20,8 |
| Lima | 18,9 | 19,1 | 18,7 | 19,2 | 19,0 | 19,0 | 18,7 | 19,4 | 18,1 | 19,5 | 19,5 | 18,8 | 19,1 | 19,8 | 18,7 | 19,5 | 20,8 | 20,3 | 20,1 | 19,5 | 19,6 | a/ |
| Loreto | 26,8 | 26,8 | 26,7 | 27,6 | 26,7 | 27,5 | 28,1 | 27,4 | 27,4 | 27,3 | 27,4 | 27,6 | 27,5 | 26,8 | 27,4 | 26,9 | 27,3 | 27,5 | 27,5 | 27,2 | 27,4 | 27,6 |
| Madre de Dios | 26,3 | 26,4 | 26,5 | 27,0 | 27,1 | 26,8 | 27,8 | 27,4 | 27,1 | 26,5 | 26,1 | ... | 26,6 | 26,9 | 26,6 | 26,5 | 27,1 | 27,0 | 27,0 | 26,2 | 26,6 | 27,5 |
| Moquegua | 16,7 | 19,4 | 19,9 | 19,8 | 20,0 | 19,2 | 19,7 | 20,0 | 19,7 | 18,8 | 19,8 | 19,2 | 19,4 | 19,7 | 19,3 | 19,4 | 19,9 | ... | ... | 20,1 | 20,0 | a/ |
| Pasco | 4,6 | 4,6 | 4,6 | 4,9 | 5,0 | 4,7 | 5,1 | 4,8 | 5,0 | 5,3 | 5,2 | 5,7 | 5,2 | 5,0 | 5,3 | 5,2 | 5,5 | 6,0 | 5,5 | 5,2 | 5,5 | a/ |
| Piura | 23,8 | 24,1 | 23,8 | 24,7 | 24,5 | 24,5 | 24,1 | 24,8 | 24,0 | 24,8 | 24,8 | 24,2 | 24,6 | 25,2 | 23,9 | 25,3 | 26,1 | 26,0 | 25,0 | 25,0 | 25,4 | a/ |
| Puno | 10,1 | 9,7 | 9,8 | 10,2 | 10,2 | 10,3 | 10,2 | 10,2 | 10,7 | 9,4 | 10,9 | 11,5 | 10,8 | 10,5 | 10,2 | 10,5 | 10,3 | 10,9 | 10,6 | 10,4 | 10,7 | a/ |
| San Martín | 22,2 | 22,5 | 22,4 | 22,5 | 22,3 | 22,7 | 22,9 | 22,7 | 22,6 | 23,2 | 22,7 | 23,4 | 23,1 | 22,8 | 23,0 | 22,8 | 22,9 | 23,6 | 23,1 | 22,8 | 23,0 | a/ |
| Tacna | 17,3 | 17,5 | 17,6 | 17,8 | 17,7 | 17,0 | 17,2 | 18,0 | 16,7 | 18,3 | 18,1 | 17,5 | 17,6 | 18,2 | 17,7 | 18,0 | 18,8 | 18,8 | 18,5 | 18,5 | 18,2 | 18,8 |
| Tumbes | 25,0 | 24,6 | 24,6 | 25,6 | 25,3 | 25,1 | 24,9 | 25,3 | 24,9 | 26,2 | 25,7 | 25,5 | 25,5 | 25,6 | 25,1 | 26,0 | 27,2 | 26,9 | 25,8 | 26,0 | 26,3 | a/ |
| Ucayali | 26,8 | 26,9 | 26,3 | 25,6 | 25,5 | 25,2 | 25,9 | 25,7 | 26,2 | 26,1 | 25,7 | 26,1 | 25,5 | 25,5 | 25,6 | 25,5 | 26,0 | 26,0 | 25,9 | 25,5 | 25,7 | a/ |

a/ En el año 2020 no se registró información, debido a restricciones por la emergencia sanitaria ocasionada por la pandemia (COVID-19).

**Fuente: Servicio Nacional de Meteorología e Hidrología (SENAMHI).**

3. Temperatura máxima promedio, anual, según departamento, 1999 - 2020
(Grado Celsius)

| Departamento | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Amazonas | 19,5 | 19,4 | 20,2 | 19,7 | 20,0 | 20,2 | 20,8 | 20,2 | 20,0 | 20,4 | 19,9 | 20,9 | 20,3 | 19,9 | 20,2 | 20,0 | 20,0 | 20,9 | 20,3 | 20,1 | 20,0 | 20,5 |
| Áncash | 19,9 | ... | 20,1 | 20,4 | 21,2 | 20,6 | 21,1 | 21,9 | 20,8 | 20,5 | 20,1 | 21,5 | 20,5 | ... | 20,9 | 20,9 | 21,7 | 21,8 | 20,8 | 20,6 | 21,1 | a/ |
| Apurimac | 20,7 | 20,6 | 20,7 | 20,4 | 21,2 | 20,8 | 22,5 | 21,6 | 22,0 | 22,4 | 22,3 | 22,6 | 21,6 | 21,3 | 20,8 | 21,4 | 21,1 | 22,3 | 20,9 | 20,9 | 21,3 | a/ |
| Arequipa | 21,8 | 21,5 | 22,3 | 22,5 | 22,6 | 22,2 | 22,4 | 22,4 | 22,4 | 22,0 | 23,0 | 22,9 | 22,1 | 22,5 | 23,2 | 23,1 | 24,1 | 25,0 | 23,5 | 23,6 | 24,4 | a/ |
| Ayacucho | 26,2 | 26,0 | 26,7 | 24,2 | 24,7 | 25,6 | 26,7 | 24,5 | 24,7 | 27,1 | 27,2 | 28,1 | 26,3 | 26,2 | 26,6 | 27,4 | 26,5 | 28,2 | 26,8 | 25,6 | 26,4 | 27,6 |
| Cajamarca | 20,9 | 21,2 | 21,3 | 21,6 | 22,0 | 21,7 | 21,9 | 21,5 | 21,2 | 21,0 | 21,5 | 22,1 | 21,3 | 21,5 | 21,9 | 22,0 | 22,0 | 22,7 | 21,8 | 21,6 | 21,7 | 22,6 |
| Cusco | 20,8 | 20,9 | 20,4 | 20,5 | 21,3 | 21,1 | 21,4 | 20,8 | 21,1 | 21,1 | 21,7 | 22,1 | 21,2 | 21,8 | 21,8 | 21,5 | 21,2 | 22,0 | 21,2 | 20,7 | 21,1 | 21,7 |
| Huancavelica | 16,9 | 17,2 | 16,8 | 17,1 | 17,2 | 17,2 | 17,4 | 17,1 | 17,3 | 17,5 | 17,8 | 17,9 | 16,4 | 16,2 | 17,1 | 16,5 | 16,8 | 18,0 | 16,8 | 16,8 | 17,2 | 16,7 |
| Huánuco | 25,7 | 25,7 | 26,5 | 26,6 | 26,9 | 26,4 | 27,1 | 26,4 | 26,9 | 26,3 | 26,5 | 27,1 | 26,1 | 26,2 | 26,5 | 26,5 | 26,8 | 27,6 | 26,9 | 26,3 | 26,8 | 27,4 |
| Ica | 29,4 | 29,5 | 29,7 | 29,7 | 30,0 | 29,8 | 29,4 | 29,7 | 29,4 | 29,2 | 29,6 | 29,4 | 29,7 | 29,4 | 30,0 | 29,9 | 29,8 | 30,6 | 30,0 | 29,7 | 30,1 | 30,3 |
| Junín | 18,0 | ... | 19,5 | 19,7 | 20,0 | 20,0 | 20,6 | 19,7 | 20,2 | 19,9 | 20,0 | 21,0 | 19,9 | 20,1 | 20,6 | 20,5 | 20,7 | 21,5 | 20,4 | 20,4 | 20,3 | 21,1 |
| La Libertad | 23,8 | 24,4 | 23,8 | 25,0 | 24,4 | ... | 23,2 | 24,0 | 22,4 | 23,9 | 23,8 | 23,3 | 23,6 | 24,8 | 22,8 | 24,6 | 26,1 | 25,2 | 24,9 | 23,7 | 24,2 | 24,1 |
| Lambayeque | 25,3 | 25,5 | 25,1 | 26,5 | 25,5 | 26,7 | 27,8 | 28,8 | 23,9 | ... | 25,1 | 24,5 | 25,1 | 26,5 | 24,7 | 26,2 | 27,1 | 27,0 | 26,3 | 25,3 | 25,7 | 25,2 |
| Lima | 25,1 | ... | 21,0 | 21,5 | 21,3 | 21,6 | 20,9 | 21,7 | 20,4 | 21,6 | 21,9 | 21,3 | 21,6 | 22,3 | 21,3 | 22,1 | 23,4 | 23,3 | 23,1 | 22,4 | 22,5 | a/ |
| Loreto | 31,5 | 31,6 | 31,7 | 31,9 | 32,1 | 32,3 | 32,5 | 32,0 | 32,4 | 32,2 | 32,3 | 32,4 | 31,8 | 31,8 | 32,1 | 31,8 | 32,2 | 32,2 | 32,0 | 31,7 | 31,7 | 32,2 |
| Madre de Dios | 32,3 | 31,6 | 31,4 | 32,8 | 32,6 | 32,8 | 31,5 | 32,9 | 33,2 | 33,8 | 32,7 | ... | 32,2 | 31,7 | 31,3 | 31,2 | 31,6 | 31,7 | 31,6 | 31,0 | 31,2 | 32,5 |
| Moquegua | 25,6 | 26,2 | 27,1 | 26,9 | 27,3 | 27,0 | 26,9 | 27,1 | 26,8 | 26,6 | 27,0 | 26,8 | 26,8 | 27,4 | 27,4 | 27,2 | 27,6 | 27,9 | 27,3 | 27,6 | 27,7 | a/ |
| Pasco | 10,1 | 11,2 | 10,1 | 10,1 | 10,6 | 10,3 | 11,5 | 10,8 | 10,8 | 10,8 | 10,6 | 11,7 | 10,7 | 10,7 | 10,7 | 10,7 | 11,2 | 12,1 | 11,0 | 11,0 | 11,4 | a/ |
| Piura | 29,9 | 30,4 | 29,7 | 30,7 | 30,8 | 31,1 | 30,5 | 30,8 | 30,3 | 30,0 | 30,6 | 30,3 | 30,8 | 31,0 | 30,0 | 31,3 | 31,7 | 32,3 | 30,6 | 31,3 | 31,8 | a/ |
| Puno | 16,4 | 16,1 | 15,3 | 15,4 | 15,8 | 15,6 | 16,3 | 16,0 | 16,2 | 16,3 | 16,6 | 17,5 | 16,1 | 15,6 | 15,6 | 16,0 | 16,1 | 16,9 | 16,3 | 16,0 | 16,6 | a/ |
| San Martín | 27,7 | 27,8 | 27,8 | 27,9 | 28,2 | 28,4 | 28,8 | 28,7 | 28,4 | 28,3 | 28,5 | 29,4 | 28,8 | 28,6 | 29,3 | 28,4 | 28,7 | 29,4 | 28,6 | 28,2 | 28,6 | a/ |
| Tacna | 22,7 | 22,9 | 23,2 | 23,3 | 23,6 | 23,5 | 23,2 | 23,9 | 22,4 | 23,5 | 24,1 | 23,2 | 23,3 | 24,0 | 23,7 | 23,6 | 24,4 | 24,8 | 24,3 | 24,1 | 23,7 | 24,3 |
| Tumbes | 28,8 | 28,4 | 28,4 | 29,9 | 29,8 | 29,8 | 29,7 | 30,1 | 29,6 | 30,0 | 28,8 | 29,9 | 29,9 | 29,9 | 29,4 | 30,3 | 32,0 | 31,6 | 30,5 | 30,6 | 30,0 | a/ |
| Ucayali | 30,9 | 30,9 | 31,1 | 31,2 | 31,5 | 30,2 | 31,9 | 32,1 | 31,8 | 31,5 | 31,8 | 32,3 | 31,3 | 31,8 | 31,6 | 31,3 | 31,9 | 32,0 | 31,7 | 31,7 | 32,0 | a/ |

a/ En el año 2020 no se registró información, debido a restricciones por la emergencia sanitaria ocasionada por la pandemia (COVID-19).

**Fuente: Servicio Nacional de Meteorología e Hidrología (SENAMHI).**

# Mental health among the sugar cane industry farmers and non-farmers in Peru: an occupational health study

Research Checklist with STROBE

| | Item No | Recommendation | Page |
|---|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract<br>Title | 1 |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found<br>Abstract | 2 |
| **Introduction** | | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported<br>Introduction: paragraph 1 and 2. | 4 |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses<br>Introduction, paragraph 3. | 4 |
| **Methods** | | | |
| Study design | 4 | Present key elements of study design early in the paper<br>Methods: Study design | 4 |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection<br>Methods: Setting and data collection | 4 |
| Participants | 6 | (*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up<br>Methods: Participants | 5 |
| | | (*b*) For matched studies, give matching criteria and number of exposed and unexposed<br>NA | - |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable<br>Methods: Variables | 5 |
| Data sources/ measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group<br>Methods: Variables and data collection. | *5, 6* |
| Bias | 9 | Describe any efforts to address potential sources of bias<br>Methods: Strengths and limitations | 10 |
| Study size | 10 | Explain how the study size was arrived at<br>Results: Participants and Supplementary 1. | 7 |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why<br>Methods: Variables | 5 |

| | | | |
|---|---|---|---|
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding<br>Methods: Statistical Analysis section. | 7 |
| | | (*b*) Describe any methods used to examine subgroups and interactions<br>Methods: Statistical Analysis | 7 |
| | | (*c*) Explain how missing data were addressed<br>Methods: Statistical Analysis | 7 |
| | | (*d*) If applicable, explain how loss to follow-up was addressed<br>Methods: Statistical Analysis | 7 |
| | | (*e*) Describe any sensitivity analyses<br>NA | - |
| **Results** | | | |
| Participants | 13* | (a) Report numbers of individuals at each stage of study—e.g., numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed<br>Participants and Supplementary 1. | 7, 8 |
| | | (b) Give reasons for non-participation at each stage<br>Participants and Supplementary 1. | 7, 8 |
| | | (c) Consider use of a flow diagram<br>Participants and Supplementary 1. | 7, 8 |
| Descriptive data | 14* | (a) Give characteristics of study participants (e.g., demographic, clinical, social) and information on exposures and potential confounders<br>Table 1. | 8 |
| | | (b) Indicate number of participants with missing data for each variable of interest<br>Table 1 and Supplementary 1. | 8 |
| | | (c) Summarise follow-up time (e.g., average, and total amount)<br>NA | - |
| Outcome data | 15* | Report numbers of outcome events or summary measures over time<br>Table 1 and 2. | 8 |
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g., 95% confidence interval). Make clear which confounders were adjusted for and why they were included<br>Methods: Statistical Analysis section and Table 3. | 7, 8 |
| | | (*b*) Report category boundaries when continuous variables were categorized<br>Methods: measures section. | 5, 6 |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period<br>NA | - |
| Other analyses | 17 | Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses<br>NA | - |
| **Discussion** | | | |
| Key results | 18 | Summarise key results with reference to study objectives<br>Discussion: first paragraph. | 8 |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias<br>Discussion: second last paragraph. | 10 |

| | | | |
|---|---|---|---|
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence<br>Discussion: final paragraph. | 11 |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results<br>Discussion: final paragraph. | 11 |
| **Other information** | | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based<br>Statement provided during web-based submission. | 11 |

5

BMJ Open

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

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# Mental health among the sugar cane 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 farmers and non-farmers workers and investigate critical occupational risk factors for mental disorders in sugarcane farmers in Peru.

***Methods:*** 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 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% confidence intervals (95% CI) were calculated.

***Results:*** We assessed 281 workers between December 2019 and February 2020. 106 (37.7%) of 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: 1.48–3.01). The heavy workload increased the mean number of mental disorder symptoms by 68% (95% CI: 21%–133%), and each additional working hour per day increased the mean number of mental disorder symptoms by 13% (95% CI: 1%–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 programs and early interventions tailored to sugarcane industrial mill workers in the Latin American context.


***Keywords:*** Occupational hazard; occupational health; mental disorders; GHQ-1; sugarcane work; farmers; low and middle-income countries.

## Strengths and limitations of this study

- We discussed a critical but unresolved issue with one of the main task forces in Peru and other LMICs.
- We used a validated version of the GHQ-12 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). 75% of people affected by mental disorders live in low-and-middle-income countries (LMIC), 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 hypothesized that farmers are more at risk of developing mental disorders than non-farmers in this population.

## Methods

### *Study design*

We analyzed 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 9,000 cultivated acres between 21 and 429 meters above sea level. Although the sugar industry provides primary occupational health care by law (10), most of the workers' health care in San Jacinto is provided through EsSalud and MINSA health centers. However, in both centres, mental health care is minimal or practically nonexistent in rural places such as San Jacinto.

***Participants***

We detail the sample size calculations and sampling procedures for the main study in **Supplementary 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 (**Supplementary 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 sugar cane 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 General Health Questionnaire (GHQ-12) (11). This tool assesses the worker's mental health status by asking twelve 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 zero (0) for the first two options and a score equal to one (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 (i.e., 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 <USD 480, high ≥USD 480), civil status (without union, with union). *Occupational risk factors*, the occupational heat stress index (formula: 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) (15), use of shade during work break (no, yes), 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/m2), self-rated health (poor, good).

***Data collection***

Questionnaires: After a pre-screening 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 (16). The questionnaire sections included: demographics, employment, work history (17), and mental disorders.

Ambient measurements: Between February 3 and February 21, 2021, we recorded the air temperature and relative humidity every fifteen minutes between 08:00 and 14:00 across the sugar cane fields at 1.25 meters above the ground, using a wet-bulb balloon temperature (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 disorders symptoms were treated as a count variable (0 to 12 symptoms) and summarized by showing the mean and standard deviation 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 (18). 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 over-dispersed count data (**Supplementary 3**), as in this case (19). 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, analyzing the full sample (independently of the work activity). Similar negative binomial regression models were fitted with socio-demographics, lifestyle, and occupational risk factors as predictors and mental disorders symptoms as the outcome (i.e., one unadjusted model per factor). Then, we jointed 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% confidence intervals and considered p-values<0.05 as significant. The statistical analysis was performed with Stata 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. 106 (37.7%) respondents were identified as farmers, while 172 (62.3%) were non-farmers. The farmer's group was slightly older (mean: 42 years) compared to 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 sugar cane industry. One out of every four farmers had a fixed-term contract/service lease, compared to 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 to 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**).

**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 |

Abbreviations: GHQ-12, 12-Item General Health Questionnaire; SD, Standard Deviation; IQR, Interquartile Range.

*Body mass index, 116 people with measurements (73 non-farmers; 43 farmers).

***Differences in mental disorders symptoms between farmers and non-farmers***

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

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

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

Abbreviations: RM, Ratio of means; CI, Confidence interval; GHQ-12, 12-Item General Health Questionnaire.

*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.

***Occupational risk factors and mental disorders symptoms***

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

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

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

| | | |
|---|---|---|
| ***Lifestyle variables*** | | |
| Tobacco consumption | | |
| No | reference | |
| Yes | 1.00 (0.73-1.38) | 0.976 |
| Alcohol consumption | | |
| Low | reference | |
| High | 0.90 (0.67-1.20) | 0.458 |
| Body mass index* | | |
| Normal | reference | |
| Overweight / Obesity | 0.64 (0.40-1.02) | 0.062 |
| Self-rated health | | |
| Poor | reference | |
| Good | 1.31 (0.98-1.76) | 0.071 |

Abbreviations: RM, Ratio of means; CI, Confidence interval; GHQ-12, 12-Item General Health Questionnaire.
*Adjusted for the level of education, working hours per day, heavy workload, and shaded work break.

## Discussion

We assessed mental disorders symptoms and potential risk factors on farmers and non-farmers from the industrial sugarcane mill in a rural Peruvian context. We found that the farmers had more mental disorders symptoms compared to 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 disorders 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 sugar cane 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 (20). According to Wang et al., younger farmers experienced higher stress-related symptoms, while elderly farmers experienced more mental disabilities (21). 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 level of all occupational groups, and job insecurity may be a possible explanation (22). Due to their labor instability, farmers tend to overwork many more hours than is legally allowed (Law 27671 rules the working day, hours, and over time, established by the Peruvian government) (23). Despite this, farmers have a lower average monthly salary than non-farmers, as it is considered unskilled labor where the only requirement is previous experience. Financial challenges negatively impact farmers'

mental health, e.g., psychological distress, depression, and less satisfaction with life, particularly in those settings where agriculture represents the main source of income (24). Also, farmers had heavier workloads compared to non-farmer workers. Kallioniemi et al. found that stressors related to workload were associated with stress and burnout symptoms in Finland's farmers (15). These results support our study findings.

In our setting, farmers were responsible for the planting, harvesting of the crops, and sugar cane 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 (25). 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 (26). This phenomenon is called acclimatization, and it can explain the protective effect of having a shaded work break against mental disorder symptoms.

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 United Kingdom found a difference of 1.21 in the GHQ-12 score between farmers and non-farmers (27). 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 (28), 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 (29). 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 (30). Similar results have been found across seasonal farmers in Ethiopia, where was reported a higher prevalence of common mental disorders (31).

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 (32). 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 (33). 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 (28). 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 amongst 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 (34). 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 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 (35), 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 specialized care for people with mental health disorders (36). In theory, farmers can and should be referred for specialized 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 organizational practices that support a healthy work-life balance.

**Conclusion**

Sugar cane 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 programs and early interventions tailored to sugarcane industrial mill workers in the Latin American context.

**Acknowledgements**

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**Contributorship**

JCB-A and JB-P conceived and designed the overall study. JB-P and JB supervised the overall study. JB-P and JCB-A developed the idea for this manuscript, led the statistical analysis, and drafted the first version of the paper. EF provided important intellectual content and, with JB-P, JCB-A, EF and JB, drafted the manuscript. All authors participated in giving final approval of the submitted version.

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**Competing of interests**

None declared.

**Ethics approval**

This study was approved by the Institutional Review Board of the Universidad Peruana Cayetano Heredia (ID code 19018). All data analyzed for this study were de-identified and stored in one encrypted device.

**Data sharing**

No data are available.

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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.

**References:**

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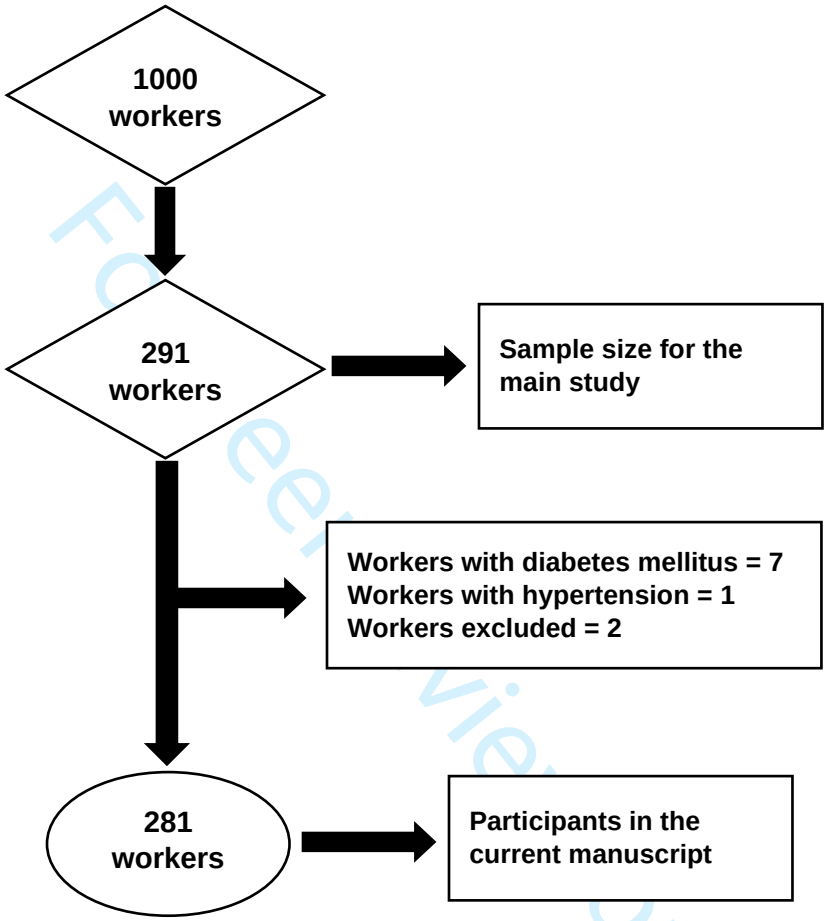
**Supplementary 2:** Flowchart based on the sample agreed upon

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.

# Mental health among the sugar cane industry farmers and non-farmers in Peru: an occupational health study

Research Checklist with STROBE

| | Item No | Recommendation | Page |
|---|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract<br>Title | 1 |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found<br>Abstract | 2 |
| **Introduction** | | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported<br>Introduction: paragraph 1 and 2. | 4 |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses<br>Introduction, paragraph 3. | 4 |
| **Methods** | | | |
| Study design | 4 | Present key elements of study design early in the paper<br>Methods: Study design | 4 |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection<br>Methods: Setting and data collection | 4, 5 |
| Participants | 6 | (*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up<br>Methods: Participants | 5 |
| | | (*b*) For matched studies, give matching criteria and number of exposed and unexposed<br>NA | - |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable<br>Methods: Variables | 5 |
| Data sources/ measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group<br>Methods: Variables and data collection. | *5, 6* |
| Bias | 9 | Describe any efforts to address potential sources of bias<br>Methods: Strengths and limitations | 10 |
| Study size | 10 | Explain how the study size was arrived at<br>Methods: Participants and Supplementary 1. | 5 |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why<br>Methods: Variables | 5 |

| | | | |
|---|---|---|---|
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding<br>Methods: Statistical Analysis section. | 7 |
| | | (*b*) Describe any methods used to examine subgroups and interactions<br>Methods: Statistical Analysis | 6, 7 |
| | | (*c*) Explain how missing data were addressed<br>Methods: Statistical Analysis | 6, 7 |
| | | (*d*) If applicable, explain how loss to follow-up was addressed<br>Methods: Statistical Analysis | 6, 7 |
| | | (*e*) Describe any sensitivity analyses<br>NA | - |
| **Results** | | | |
| Participants | 13* | (a) Report numbers of individuals at each stage of study—e.g., numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed<br>Participants and Supplementary 1. | 7, 8 |
| | | (b) Give reasons for non-participation at each stage<br>Participants and Supplementary 1. | 7, 8 |
| | | (c) Consider use of a flow diagram<br>Participants and Supplementary 1. | 7, 8 |
| Descriptive data | 14* | (a) Give characteristics of study participants (e.g., demographic, clinical, social) and information on exposures and potential confounders<br>Table 1. | 8 |
| | | (b) Indicate number of participants with missing data for each variable of interest<br>Table 1 and Supplementary 1. | 8 |
| | | (c) Summarise follow-up time (e.g., average, and total amount)<br>NA | - |
| Outcome data | 15* | Report numbers of outcome events or summary measures over time<br>Table 1 and 2. | 8 |
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g., 95% confidence interval). Make clear which confounders were adjusted for and why they were included<br>Methods: Statistical Analysis section and Table 3. | 7, 8 |
| | | (*b*) Report category boundaries when continuous variables were categorized<br>Methods: measures section. | 5, 6 |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period<br>NA | - |
| Other analyses | 17 | Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses<br>NA | - |
| **Discussion** | | | |
| Key results | 18 | Summarise key results with reference to study objectives<br>Discussion: first paragraph. | 12 |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias<br>Discussion: second last paragraph. | 14 |

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|---|---|---|---|
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence<br>Discussion: final paragraph. | 14, 15 |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results<br>Discussion: final paragraph. | 14, 15 |
| **Other information** | | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based<br>Statement provided during web-based submission. | 15 |

5