E-ISSN: 3025-6437
International Journal of Health Sciences
Vol. 3 Issue 2 (2026) January

Determinants of Hypertension Among Farmers: A Literature Review

Alfid Tri Afandi[1 *], Vrischa Nurkhalisah Putri[2], Dina Octavia[3], Nuria Rahma Wirajaya[4], Enggal Hadi Kurniyawan[5], Kholid Rosyidi Muhammad Nur[6], Dicky Endrian Kurniawan[7]

[1-7]Faculty of Nursing, Universitas Jember (alfid@unej.ac.id)

** Corresponding Author: Alfid Tri Afandi (alfid@unej.ac.id/)*

Submission date: 19/01/2025; Date received: 27/01/2026

Abstract

Hypertension among agricultural workers is a complex public health issue driven by a synergy of lifestyle choices, occupational hazards, and environmental exposures. Despite its prevalence, the specific interplay between farming-related risk factors and high blood pressure remains under-synthesized. This study aims to comprehensively analyze the key determinants, ranging from sociodemographic to occupational factorsthat contribute to the risk of hypertension among farmers. A comprehensive literature review was conducted using ProQuest, Springer, and Science Direct databases. The search strategy utilized keywords such as “Hypertension,” “Farmers,” and “Blood Pressure.” Inclusion criteria focused on original research articles published between 2020 and 2025 that assessed risk factors in agricultural populations. A total of ten articles met the eligibility criteria and were analyzed. The review identified significant determinants categorized into occupational and behavioral factors. Key risk factors included age (>30 years), farming duration exceeding 8 years, and inadequate use of Personal Protective Equipment (PPE), suggesting a link to chemical exposure. Behavioral determinants included smoking, high sodium consumption, and psychological stress. Furthermore, the review highlights that non-pharmacological interventions, specifically health education and community-based promotion, effectively improve blood pressure control. Hypertension in farmers is associated with distinct occupational exposures (duration of work, PPE non-compliance) alongside traditional lifestyle risks. An integrated preventive strategy combining occupational safety education with lifestyle modification programs is essential for sustainable health management in agricultural communities.

Keywords: Agricultural Workers; Hypertension Determinants; Occupational Health; Risk Factors; Pesticide Exposure.

Introduction

Hypertension remains the leading preventable risk factor for cardiovascular disease (CVD) and premature death worldwide. According to recent estimates by the World Health Organization (WHO), approximately 1.28 billion adults aged 30–79 years have hypertension, with two-thirds living in low- and middle-income countries [1]. While historically perceived as a disease of affluence or urban lifestyle, the epidemiological transition has shifted the burden of hypertension significantly toward rural and agricultural populations. In many developing nations, the prevalence of hypertension in rural areas has risen sharply, often matching or exceeding that of urban centers [2]. This shift is particularly alarming for the agricultural workforce, a population segment critical to global food security but often marginalized in terms of occupational health protection and access to healthcare services.

Farmers represent a unique occupational group exposed to a complex interplay of risk factors that differ substantially from the general population [3]. Traditionally, farming was associated with high levels of physical activity, which was thought to be protective against cardiovascular metabolic disorders [4]. However, the modernization of agriculture has introduced a "health paradox." While mechanization has reduced the intensity of physical labor, it has increased sedentary behavior during machinery operation. Furthermore, the agricultural environment exposes workers to a distinct set of hazards chemical, physical, and psychosocial that may act synergistically to elevate blood pressure [5]. Despite this, occupational health studies have disproportionately focused on industrial and office workers, leaving the specific determinants of hypertension among farmers underexplored [6,7].

One of the most significant and debatable determinants in this population is chronic exposure to agrochemicals. Farmers are routinely exposed to pesticides, including organophosphates, carbamates, and neonicotinoids. Emerging toxicological evidence suggests that these chemicals are not merely neurotoxic but also cardiotoxic [8]. Chronic exposure to organophosphates, for instance, has been linked to the inhibition of acetylcholinesterase, leading to an accumulation of acetylcholine and subsequent overstimulation of the autonomic nervous system, which can induce sustained hypertension [9, 10]. Additionally, oxidative stress and systemic inflammation caused by pesticide toxicity can impair endothelial function, leading to arterial stiffness.

However, the use of Personal Protective Equipment (PPE) among farmers, particularly in developing countries, remains critically low due to discomfort, cost, and lack of safety education [11, 12]. This gap in protection exacerbates the chemical risk, creating a direct pathway between occupational practices and cardiovascular pathology.

Beyond chemical hazards, lifestyle and behavioral factors among farmers contribute significantly to the hypertensive profile [13]. Contrary to the image of a healthy rural diet, many agricultural communities rely on diets high in sodium, often due to the consumption of preserved foods (salted fish, pickles) and a cultural preference for salty seasonings [14]. Smoking is another prevalent risk factor; in many agrarian societies, tobacco use is deeply ingrained in the social fabric and is often used as a coping mechanism for fatigue and hunger during long working hours [15,16]. These behavioral risks are compounded by the "healthy worker effect" mentality, where farmers often ignore early symptoms of illness, viewing them as a weakness that interferes with their ability to work. Consequently, hypertension in this group is frequently undiagnosed until it manifests as a catastrophic event, such as a stroke or myocardial infarction.

Psychosocial stress is an often-overlooked determinant in the agricultural sector. Farming is an inherently high-stress occupation, characterized by factors beyond the worker's control, such as climate change, unpredictable weather patterns, fluctuating market prices, and crop failures [17]. This chronic "agricultural stress" triggers the hypothalamic-pituitary-adrenal (HPA) axis, leading to elevated cortisol levels and long-term hemodynamic dysregulation. Unlike urban stress, which may be tied to deadlines or traffic, agricultural stress is tied to survival and livelihood, potentially having a more profound impact on cardiovascular health [18,19]. Furthermore, the aging farming workforce presents a demographic challenge. As younger generations migrate to cities, the average age of farmers has increased globally. Since age is an independent risk factor for arterial stiffening, the intersection of an aging workforce with occupational hazards creates a "perfect storm" for high hypertension incidence [20].

Despite the growing body of literature on rural health, studies specifically analyzing the determinants of hypertension among farmers remain fragmented. Most existing research focuses on isolated variables either solely on pesticide toxicology or solely on lifestyle factors without integrating them into a comprehensive risk model.

Moreover, there is a scarcity of systematic synthesis that evaluates the relative weight of occupational hazards (duration of farming, PPE use) versus traditional risk factors (diet, smoking) in this specific demographic [21]. Understanding these determinants is crucial for designing targeted interventions. Standard hypertension guidelines, which focus on generic lifestyle modifications, may be insufficient for farmers if occupational drivers like chemical exposure and work-related stress are not addressed [22, 23, 24].

Therefore, this study aims to systematically review and analyze the determinants of hypertension among farmers. By synthesizing evidence from recent studies, this review seeks to identify the key modifiable and non-modifiable factors driving the high incidence of hypertension in the agricultural sector. Specifically, it examines the associations between sociodemographic characteristics, behavioral practices, and occupational exposures including farming duration and PPE compliance and blood pressure outcomes. The findings of this review are intended to inform public health policymakers and occupational health practitioners in developing integrated, evidence-based strategies to mitigate cardiovascular risk in the agricultural workforce.

Method

Study Design This study employed a Literature Review design following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to identify, screen, and synthesize evidence regarding the determinants of hypertension among farmers. Search Strategy and Data Sources A comprehensive literature search was conducted across four major electronic databases: PubMed, ProQuest, SpringerLink, and ScienceDirect. The search period was restricted to articles published within the last five years, from January 2020 to August 2025, to ensure the relevance of the data.

The search strategy utilized Boolean operators (AND, OR) to combine keywords related to the outcome and population. The primary search string used was: ("Hypertension" OR "High Blood Pressure") AND ("Farmers" OR "Agricultural Workers" OR "Farmworkers"). Keywords in both English and Indonesian were used to maximize the retrieval of relevant regional studies. Inclusion and Exclusion Criteria To ensure the quality and eligibility of the selected studies, specific inclusion and exclusion criteria were established based on the PICOS framework (Population,

Intervention/Exposure, Comparator, Outcomes, Study design):

Inclusion Criteria:

1. Population: Farmers, agricultural workers, or plantation workers.
2. Outcome: Measured blood pressure, prevalence of hypertension, or identified risk factors for hypertension.
3. Study Type: Original research articles (cross-sectional, cohort, or case-control studies).
4. Language: Articles published in English or Indonesian.
5. Full Text: Articles with full-text accessibility.

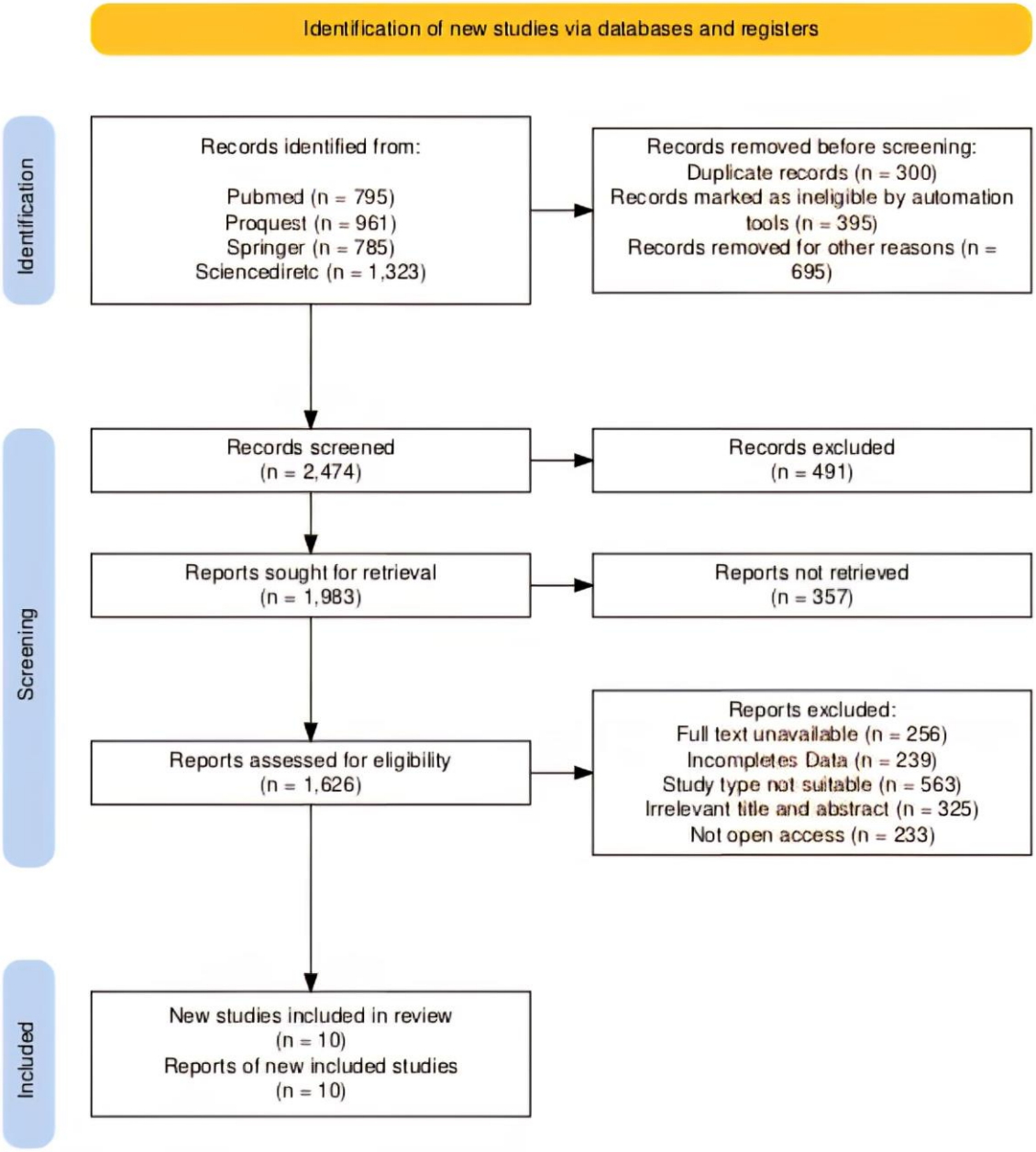
Exclusion Criteria:

1. Review articles (systematic reviews, meta-analyses), editorials, commentaries, and book chapters.
2. Studies conducted on non-agricultural populations.
3. Studies with incomplete data or unclear methodology.
4. Duplicate articles across databases.

Study Selection Process (PRISMA Flow) The selection process was conducted in three stages: identification, screening, and eligibility. Identification: The initial search yielded a total of 3,864 articles (PubMed: n=795; ScienceDirect: n=1,323; Springer: n=785; ProQuest: n=961). Screening: After removing duplicates and filtering by publication year (2020–2025), 1,626 articles remained. These articles underwent title and abstract screening to assess relevance to the research objectives.

Eligibility: Articles that appeared relevant were retrieved for full-text review. During this phase, articles were excluded due to incompatibility of the population, lack of specific hypertension data, or inaccessible full text. Final Inclusion: A total of 10 articles met all criteria and were included in the final review. Data Extraction from the included studies were extracted using a standardized format, which included: author(s), year of publication, country of study, study design, sample size, and key findings regarding risk factors (occupational and behavioral) associated with hypertension. The following is the PRISMA flowchart in this literature review:

E-ISSN: 3025-6437
International Journal of Health Sciences
Vol. 3 Issue 2 (2026) January



Picture 1.Prisma Flowchart

Results

From the database search, a total of 10 articles met the inclusion criteria and were analyzed. These studies utilized cross-sectional and quasi-experimental designs to evaluate the determinants of hypertension in agricultural populations. The prevalence of hypertension varied significantly across regions. For instance, a study by Salaroli et al. in Brazil reported a prevalence of 35.8% among farmers, with a higher incidence observed in men (36.6%) compared to women. The study identified that low education

levels, abdominal obesity, and specific working conditions were independent predictors of elevated blood pressure in this demographic [25].

Occupational hazards emerged as a primary driver of hypertension. Exposure to agrochemicals, particularly without adequate protection, showed a strong positive association with hypertension. Solehah et al. found that 64.7% of farmers in Bali exposed to pesticides suffered from hypertension. The risk was significantly elevated among those aged ≥30 years, with a farming duration of >8 years, and daily working hours exceeding 8 hours [26]. This is consistent with findings by Mostafalou et al., which highlighted that 83.6% of farmers did not use Personal Protective Equipment (PPE) according to standards. The study concluded that a working tenure of more than 21 years combined with poor PPE compliance significantly increased the odds of developing hypertension [27].

Beyond chemical risks, environmental physics plays a crucial role. Prihartono et al. demonstrated that farmers working in areas with a high heat index faced a greater risk of hypertension compared to those in cooler environments. The mechanism proposed involves thermal stress, which triggers increased heart rate, vasodilation, and chronic dehydration, collectively contributing to sustained blood pressure elevation [28].

Lifestyle and Behavioral Factors Behavioral patterns significantly exacerbate occupational risks. Pangestu et al. identified that the majority of hypertensive farmers in Jember District exhibited poor lifestyle habits, including smoking, high sodium consumption, and working more than five days a week [29]. These behaviors were found to have a detrimental impact not only on blood pressure control but also on overall quality of life. Conversely, Rachmawati et al. highlighted the protective role of healthy behaviors; farmers with moderate-to-heavy physical activity levels, good sleep quality, and low psychological stress levels tended to maintain more controlled blood pressure compared to their sedentary and high-stress counterparts [30].

The review also synthesized evidence regarding intervention strategies. Community-based approaches were found to be effective. Susanto et al. reported that the implementation of the Community-Based Occupational Health Promotion (COHP) program for 24 weeks resulted in a significant reduction in blood pressure among participating farmers [31]. Additionally, relaxation techniques proved beneficial; an earlier study by Susanto et al.demonstrated that a combination of Progressive Muscle

Relaxation and stretching exercises performed over three months significantly lowered both systolic and diastolic blood pressure, suggesting these are viable, low-cost adjunctive therapies for this population [32]. The following table presents the results of the literature review.

Table 1. Results of Literatur

No	Author/ Year	Article Title	Sample	Method	Result	Limitation
1	Salaroli et al. (2020)	Prevalence and Factors Associated with Arterial Hypertension in a Brazilian Rural Working Population	790 farmers (ages 18–59) from Santa Maria de Jetibá, Espírito Santo, Brazil	Cross-sectional study with interviews, anthropometric and blood pressure measurements	Hypertension prevalence: 35.8% (higher in men: 36.6%). Associated factors in men: low education, short working hours, abdominal obesity. In women: age, low education, abdominal obesity. 44.2% of hypertensives were untreated. High prehypertension in men (43.8%)	Cross-sectional design: cannot infer causality. Possible reverse causation (e.g., behavior change after diagnosis). Reliance on self-reported data (e.g., alcohol, smoking). BP measured at one point only. Lack of dietary/sodium intake data. Generalizability is limited to similar rural communities, especially of Pomeranian descent
2	Christian et al. (2025)	Household food insecurity, sociodemographic and lifestyle risk factors associated with high blood	430 women aged 18+ from 4 rural/peri-urban Ghanaian communities	Cross-sectional survey; 2-stage random sampling; blood pressure measured; structured	26% of households were food-insecure. 19% of women self-reported hypertension, and 22% had elevated BP at measurement. Food insecurity was **not** significantly associated with	Cross-sectional design limits causal inference; potential recall bias on food insecurity and hypertension diagnosis; did not distinguish between women solely in agriculture and those in multiple

		pressure among women in farming communities in Ghana		interviews; Household Food Insecurity Access Scale (HFIAS); Logit regression analysis	hypertension. Risk was higher in peri-urban communities and among older women. Dangbe ethnicity was associated with **lower** BP risk. Alcohol consumption was higher in food-insecure households. Mobility (physical activity proxy) slightly reduced BP odds among food-insecure women.	occupations; dietary diversity assessed via 24-hour recall may not reflect habitual intake; more robust longitudinal studies recommended.
3	Li, et al. (2022)	Association of AGTR1 Gene Methylation and Its Genetic Variant in Chinese Farmer with Hypertension: A Case-Control Study	386 farmers with hypertension cases subject.	This study used a case-control study. Data were collected through interviews.	No significant difference was found in the distribution of AGTR1 rs275653 polymorphism between hypertensive and control groups. However, AGTR1 promoter methylation was significantly negatively associated with hypertension (OP: 0.946; 95% Cl: 0.896-0.999; P = 0.047)	Some potential confounding factors (e.g., antihypertensive medication classifications) were not fully adjusted. The study population was limited to Chinese farmers, which may affect generalizability. The study was observational ad thus cannot determine causal mechanisms.
4	Rachma	Association	265	Cross	Approximately	The limitation in this

wati et al.(2024)	Between Lifestyle Factors And Hypertension Control In Indonesian Primary Healthcare Settings: A Cross-Sectional Study / Malaysian Family Physician / 19:18	patients with hypertension from the Pusat Kesehatan Masyarakat	Sectional	72.2% of the participants had uncontrolled hypertension. The majority of them showed the following characteristics: low physical activity (PA) level (46%), normal stress level (94.7%), good sleep quality (80%), low caloric intake (95.5%), neutral food habits (55.5%), and low emotional eating (93.2%). Several factors were found to significantly influence hypertension control, including sex (P=0.030), age (P=0.018), PA level (P=0.011), sleep quality (P=0.032), and stress level (P=0.030). Specifically, moderate (odds ratio [OR] = 5.868; 95% confidence interval [CI] = 3.024–11.798; P=0.000) and vigorous PA levels	study is (1) the response rate fell short of the minimum required for an ideal sample in this type of research; (2) the study duration was relatively insufficient; (3) the research location was limited to Puskesmas Batu and Junrejo; (4) a cross-sectional design was used, which could not establish a causal relationship; (5) there was potential for information bias; (6) convenience sampling was conducted, rendering the P-values and confidence intervals (CIs) uninterpretable and subjecting all estimates to selection bias; and (7) the AFHC, which is intended for adolescents, was used despite the target population consisting of adults and older adults.

					(OR = 2.188; 95% CI = 1.026–4.678; P=0.042) were significantly associated with better hypertension control.	
5	Susanto et al. (2021)	Effects Of Progressive Muscular Relaxation And Stretching Exercises Combination On Blood Pressure Among Farmers In Rural Areas Of Indonesia: A Randomized Study / Frontiers Of Nursing / 8(4)	130 participants were allocated randomly to intervention group (n=65) and control group (n=65)	Randomized Controlled Trial (RCT)	No significant changes in SBP and DBP were found in the control group. In contrast, the intervention group receiving PMR and Ses showed significant reductions in both SBP and DBP (P < 0.001). After three months, the control group's blood pressure remained unchanged, while the intervention group showed more participants with normal or prehypertensive levels and fewer in hypertension stage I.	The limitation in this study is (1) the sample size and demographic details were not explicitly stated, limiting the generalizability of the findings; (2) the duration of the intervention was not clearly described, raising questions about its feasibility in real-world settings; (3) the study did not include a long-term follow-up to assess the sustainability of the intervention's effects; (4) potential biases such as selection bias, performance bias, and attrition bias were not addressed in detail; (5) the study focused exclusively on farmers, which may limit the applicability of the findings to other

populations.

6	Susanto et al.(2024)	Community-Based Occupational Health Promotion For Reducing Blood Pressure: A Randomized Control Trial Of Agricultural Health Program / Journal Of Occupational Health And Epidemiology /	135 farmer participants in an agricultural area	Randomized Controlled Trial (RCT)	After 24 weeks of COHP, there were significant differences in SBP between the intervention and control groups (126.81 ± 14.52 vs. 146.65 ± 16.38; $p < 0.001$). Similarly, there were significant differences in DBP between the two groups (83.03 ± 8.31 vs. 86.91 ± 7.73; $p = 0.003$). Furthermore, COHP was found to be effective in reducing both SBP and DBP among farmers ($p < 0.001$).	This study is limited by its use of categorical data to assess the program's impact on hypertension. Including quantitative blood pressure data would better capture changes in systolic and diastolic levels. Sociodemographic factors, which may influence blood pressure, should also be analyzed and considered in future efforts to support lifestyle changes among farmers.

		13(4):252-60				
7	Priharto no et al.(2021)	Determinants Of Hypertension Amongst Rice Farmers In West Java, Indonesia	The total sample used in this study was 354 farmers, with an age range of 20 - 65 years.	Questionnaire and Multivariate Analysis	Among the 354 farmers in this study, 46.6% had hypertension with a mean systolic blood pressure of 156.3 mmHg and a mean diastolic blood pressure of 92.1 mmHg. There were 72% cases of hypertension in farmers aged 45 years, and 47.3% of hypertension occurred in farmers who already had a spouse. Farmers who sprayed pesticides had a higher prevalence of hypertension of 48.8%, farmers who used modern methods had a higher prevalence of 60.5%.	The main weakness of this journal is the use of a cross-sectional study design, which cannot determine cause-and-effect relationships. In addition, dietary measurements were taken only once, making them susceptible to misclassification, and the low variation in respondent characteristics such as BMI and education also limited the ability to perform statistical analysis. Pesticide exposure was also not specifically described, making it difficult to associate specific types of pesticides with hypertension.
8	Astuti et al. (2024)	Identification Of Risk Factors For The High Prevalence Of	64 Farm laborers in the Mumbulsari area who	Observational Analytical Research	The statistical test results of the salt intake variable state that there is a relationship between the hypertension	This study did not include more specific variables such as "pesticide use" and "duration of work" because the

		Hypertension Among Farm Workers In The Agro Industry Area Jember	suffer from hypertension and have met the inclusion criteria.		variable and the knowledge variable with a p-value (0.027). Knowledge factors can determine respondents' behavior in preventing hypertension, including controlling blood pressure and regulating diet.	respondents used in this study have a variety of agricultural products, so the duration and types of pesticides used also vary
9	Pertiwi et al. /(2022)	Hypertension Prevention Education Through Training in Making Herbal Teas in Talango Village, Talango District, Sumenep Regency	20 farmers and fishermen who are members of the Jala Tani Pertiwi Foundation.	Educational approach and training	Participants' understanding of hypertension prevention and treatment increased from 43% to 77%, and participants also learned how to make antihypertensive herbal tea, with the expected outcome that participants can sell herbal tea as a local economic potential.	This study is only descriptive education, so there is no direct measurement of the effect of herbal tea on lowering blood pressure on farmers and fishermen who are participants, and there is no measurement of blood pressure before and after the intervention, so it relies only on questionnaires.
10	Susanto et al. /2023	Management Of Hypertension Using A Plant-Based Diet Among	The total sample used in this study was 389 participants, with	Sequential mixed methods approach, including qualitative and	The weakness of this journal is that it is still a research protocol, so it does not present final results or empirical data that can be	The weakness of this journal is that it is still a research protocol, so it does not present final results or empirical data that can be thoroughly

	Farmers: Protocol For A Mixed Methods Study	details of 30 participants in the qualitative phase, 263 participants in the quantitative phase, and 96 participants in the intervention phase.	quantitative studies	thoroughly evaluated. In addition, the success of the intervention is highly dependent on participants' adherence to a plant-based diet (PBD), which can be variable and difficult to control. Blood pressure measurements also have the potential for discrepancies because they are taken by different health workers using equipment that may not be consistent.	evaluated. In addition, the success of the intervention is highly dependent on participants' adherence to a plant-based diet (PBD), which can be variable and difficult to control. Blood pressure measurements also have the potential for discrepancies because they are performed by different health workers using equipment that may not be consistent.

Discussion

This litetature review synthesizes recent evidence to highlight that hypertension among farmers is not merely a consequence of aging, but the result of a complex "syndemic" a synergistic interaction between occupational hazards, environmental stressors, and sociodemographic transitions. The aggregate findings reveal that agricultural workers face a double burden of disease: they are exposed to traditional lifestyle risks (sodium, smoking) while simultaneously battling unique occupational determinants such as pesticide toxicity and thermal stress. The prevalence rates reported in the reviewed studies, ranging from 19% in Ghana [33] to 64.7% in pesticide-exposed groups in Indonesia [34], suggest that the agricultural sector remains a high-risk environment for cardiovascular pathology, often exceeding national averages.

A critical finding of this review is the strong association between chronic pesticide exposure and elevated blood pressure, as evidenced [33, 34]. Unlike general population studies where diet is the primary driver, this review suggests that for farmers, chemical exposure is an independent and potent risk factor. The mechanism underlying this association is biologically plausible. Organophosphates and carbamates, commonly used in developing nations, are known cholinesterase inhibitors. Chronic inhibition of this enzyme leads to the accumulation of acetylcholine, overstimulating the autonomic nervous system and inducing sustained vasoconstriction. Furthermore, pesticide exposure induces systemic oxidative stress and inflammation, which damage the endothelial lining of blood vessels, leading to arterial stiffness over time.

The risk is exacerbated by the alarming rate of PPE non-compliance, which reached 83.6% in the study by Mostafalou et al. [27]. This highlights a critical gap between safety policy and field reality. In tropical agricultural settings, the non-use of PPE is often driven by "thermal discomfort"—wearing impermeable suits in high humidity is physically unbearable. This creates a vicious cycle: farmers avoid PPE to prevent heat exhaustion, thereby exposing themselves to chemical absorption through the skin, which in turn elevates cardiovascular risk.

Beyond chemical toxicity, this review uncovers the role of physical environmental stressors. Prihartono et al. provided compelling evidence that heat stress (measured by WBGT) is significantly associated with hypertension [28]. As climate change intensifies, farmers are increasingly working in conditions that exceed physiological thermal limits. Heat stress triggers a compensatory hemodynamic response, increasing heart rate and cardiac output to facilitate cooling. Chronic exposure, coupled with dehydration often seen in field workers, can lead to kidney strain and long-term upregulation of the renin-angiotensin-aldosterone system (RAAS), resulting in permanent hypertension.

Adding a layer of biological depth, the study by Li et al. (2022) introduces a novel dimension: the role of epigenetics. Their finding that lower methylation levels of the AGTR1 gene promoter are associated with hypertension in farmers suggests that environmental exposures may alter gene expression [34]. This implies that the stressors farmers face—whether chemical or environmentalvmight be leaving a "molecular scar" on their DNA, predisposing them to hypertension at a genetic level. This interaction

between environment and genetics (epigenetics) offers a powerful explanation for why some farmers develop hypertension despite having similar lifestyles to non-farmers

The review also elucidates the "rural health paradox." Historically, rural life was associated with healthier, active lifestyles. However, findings from Salaroli et al.vand Pangestu et al. contradict this, showing high rates of abdominal obesity, smoking, and sodium consumption [25, 29]. The modernization of agriculture has reduced physical labor intensity through mechanization, yet dietary habits have shifted toward processed foods high in sodium and preservatives.

Interestingly, Christian et al. noted that in Ghana, hypertension risk was higher in peri-urban communities compared to strictly rural ones, and food insecurity was not a direct driver of hypertension [33]. This suggests that "urbanization of the countryside" where rural areas adopt urban dietary risks without acquiring urban healthcare access is a major driver. Furthermore, the high prevalence of smoking identified by Pangestu et al. acts synergistically with pesticide exposure. Smoking damages the endothelial lining, making blood vessels more susceptible to the toxic effects of agrochemicals, essentially doubling the cardiovascular risk.

Psychosocial stress remains an under-addressed determinant. Farming is an occupation fraught with uncertainty crop failure, fluctuating market prices, and climate unpredictability create a state of chronic low-grade stress. Rachmawati et al. highlighted that poor sleep quality and high stress were significant predictors of hypertension [30]. Chronic stress dysregulates the hypothalamic-pituitary-adrenal (HPA) axis, leading to cortisol overproduction, which promotes salt retention and vasoconstriction.

Moreover, the study by Salaroli et al. emphasized that a significant portion of hypertensive farmers (44.2%) were untreated or undiagnosed [25]. This reflects the "healthy worker effect" mentality common in agrarian cultures, where seeking medical help is often viewed as a weakness or a disruption to productivity. Consequently, hypertension in farmers is often a "silent killer," remaining detecting until catastrophic cardiovascular events occur. The evidence overwhelmingly supports the efficacy of non-pharmacological, community-based interventions over purely clinical ones. Susanto et al. demonstrated the success of the Community-Based Occupational Health Promotion (COHP) model [31]. In rural areas with limited access to hospitals,

empowering the community to monitor their own health is the most sustainable strategy [35,36].

Similarly, the success of Progressive Muscle Relaxation (PMR) and stretching exercises shown by Susanto et al. offers a pragmatic solution [37]. These interventions are low-cost, require no equipment, and can be integrated into the farmers' daily routine (e.g., stretching before field work). Unlike complex medication regimens which may be financially burdensome or confusing, physical relaxation addresses both the physiological tension and the psychological stress inherent in farming.This review has several strengths, including the synthesis of diverse determinants ranging from molecular (epigenetics) to behavioral factors. However, limitations must be acknowledged. The majority of included studies employed cross-sectional designs [25-29], which precludes the establishment of temporal causality. For instance, it is difficult to determine if stress causes hypertension or if living with a chronic condition increases stress. Additionally, exposure data (such as pesticide use) often relied on self-reporting rather than biological monitoring (e.g., measuring blood cholinesterase levels), which introduces recall bias. Future research should prioritize longitudinal cohort studies to track the progression of blood pressure in relation to cumulative pesticide exposure over time.

Conclusion

Hypertension among farmers is a multifaceted pathology driven by a collision of occupational toxicity, environmental extremes, and shifting lifestyle patterns. The evidence suggests that standard hypertension prevention programs are insufficient for this population if they fail to address occupational drivers like pesticide safety and heat stress. Therefore, a paradigm shift is needed: occupational health and safety must be integrated into primary healthcare for rural communities. Interventions should be holistic—combining strict regulation of agrochemicals, ergonomic education (PPE and hydration), and community-based stress management programs—to safeguard the cardiovascular health of the workforce that feeds the world.

Conflict of Interest

No conflict of interest

References

1) World Health Organization. Hypertension [Internet]. Geneva: World Health

Organization; 2023 [cited 2024 Jan 10]. Available from: https://www.who.int/news-room/fact-sheets/detail/hypertension

2) Ranzani OT, Kalra A, Di Girolamo C, Curto A, Valerio F, Halonen JI, Basagaña X, Tonne C. Urban-rural differences in hypertension prevalence in low-income and middle-income countries, 1990–2020: A systematic review and meta-analysis. PLoS medicine. 2022 Aug 25;19(8):e1004079.
3) Berman JD, Ramirez MR, Bell JE, Bilotta R, Gerr F, Fethke NB. The association between drought conditions and increased occupational psychosocial stress among US farmers: An occupational cohort study. Science of The Total Environment. 2021 Dec 1;798:149245.
4) Du L, Hong F, Luo P, Wang Z, Zeng Q, Guan H, Liu H, Yuan Z, Xu D, Nie F, Wang J. The relationship between occupational physical activity and dyslipidaemia in farmers with varying working modes in southwest China: the China multi-ethnic cohort study. BMC Public Health. 2022 Apr 27;22(1):840.
5) Kim MJ, Park KS, Park S, Song H, Yoo SJ, Park WJ, Yoon SY, Choi DP, Sung JH. Occupational Hazardous Factors and Health Impacts among Agricultural Workers: a Mechanism-Based Review. Journal of agricultural medicine and community health. 2024;49(4):322-39.
6) Wells A, Previtera M, Markey M, Brunst KJ, Rao M, Adkins EA, Wu T, Rodner J, Bhattacharya A. Work as a social determinant of health on cardiovascular and musculoskeletal diseases: A literature review. Work. 2025 Oct;82(2):578-93.
7) Kurniyawan EH, Iswatiningtyas NF, Cahyarani FB, Sholihah NL, Wati DY, Sapitri RD, Afandi AT. Overview Of Reproductive Health In Women In Agricultural Areas Due To Exposure To Pesticides. Malang Journal Of Midwifery (MAJORY). 2024 Apr 30;6(1):1-3.
8) Botnaru AA, Lupu A, Morariu PC, Jităreanu A, Nedelcu AH, Morariu BA, Anton E, Di Gioia ML, Lupu VV, Dragostin OM, Vieriu M. Neurotoxic Effects of Pesticides: Implications for Neurodegenerative and Neurobehavioral Disorders. Journal of Xenobiotics. 2025 Jun 1;15(3):83.
9) Pulkrabkova L, Svobodova B, Konecny J, Kobrlova T, Muckova L, Janousek J, Pejchal J, Korabecny J, Soukup O. Neurotoxicity evoked by organophosphates and available countermeasures. Archives of toxicology. 2023 Jan;97(1):39-72.

10) Chen Y, Yang Z, Nian B, Yu C, Maimaiti D, Chai M, Yang X, Zang X, Xu D. Mechanisms of neurotoxicity of organophosphate pesticides and their relation to neurological disorders. Neuropsychiatric Disease and Treatment. 2024 Dec 31:2237-54.
11) Sookhtanlou M, Allahyari MS. Farmers' health risk and the use of personal protective equipment (PPE) during pesticide application. Environmental Science and Pollution Research. 2021 Jun;28(22):28168-78.
12) Afandi A, Ardiana A. The Use of Personal Protective Equipment to Prevent Work Accidents among Vegetable Farmers in the Tengger Tribe. International Journal of Community Services. 2024 Feb 21;1(2):42-8.
13) Kumar D, Sinha SN, Rajendra S, Sharma K. Assessing farmer's exposure to pesticides and the risk for non-communicable diseases: A biomonitoring study. Science of the Total Environment. 2023 Sep 15;891:164429.
14) Blanco-Metzler A, Núñez-Rivas H, Vega-Solano J, Montero-Campos MA, Benavides-Aguilar K, Cubillo-Rodríguez N. Household cooking and eating out: Food practices and perceptions of salt/sodium consumption in costa rica. International Journal of Environmental Research and Public Health. 2021 Feb;18(3):1208.
15) Khoso AR, Jintu G, Suyuhan W, Bhutto S, Akhtar F. Exploring the Role of Smoking as a Coping Mechanism for Stress Relief among Residents of Larkana, Sindh, Pakistan. Zakariya Journal of Social Science. 2024 Oct 14;3(1):35-47.
16) Padaallah AP, Wuryaningsih EW, Afandi AT. Description of Stress and Coping Mechanism Farmer in Kalisat District Jember Regency Indonesia. Nursing and Health Science Journal. 2021;1(1):54-6.
17) Croom DB, Scheyett AM, Yoo KB. Factors that contribute to extraordinary stress in farmers. Advancements in Agricultural Development. 2024 Mar 18;5(1):5-15.
18) Eskdale A, Tholth M, Paul JD, Desphande J, Cole J. Climate stress impacts on livestock health: Implications for farming livelihoods and animal disease in Karnataka, India. CABI One Health. 2022 Dec 7(2022).
19) Fadhilla AA, Salsabila YN, Susanti NI, Kurniyawan EH, Nur KR, Afandi AT, Kurniawan DE. Coping Strategies in Overcoming Stress in Farmers After Crop

Failure. International Health Sciences Journal. 2025 May 31;2(3):1-7.

20) Taweh O, Moreira JD. Proposed mechanisms of hypertension and risk of adverse cardiovascular outcomes in LGBT communities. American Journal of Physiology-Heart and Circulatory Physiology. 2023 Sep 1;325(3):H522-8.

21) Kangavari M, Sarvi M, Afshari M, Maleki S. Understanding determinants related to farmers' protective measures towards pesticide exposure: A systematic review. PLoS one. 2024 Feb 15;19(2):e0298450.

22) Nivetha R, Angelin RG, Muhammed K, Arun S. Respiratory & hypersensitivity profiling among farmers with pesticide exposure: field-based, cross-sectional study. Indian Journal of Occupational and Environmental Medicine. 2022 Jan;26(1):35.

23) Kurniyawan EH, Nurfatekha ED, Aisyah RD, Putri CA, Nur KR, Kurniawan DE, Afandi AT. Stress Coping Strategies In Farmers As An Effort To Overcome Psychosocial Problems. International Journal of Midwifery and Health Sciences. 2024 Jul 31;2(2):176-86.

24) Kurniyawan EH, Asmaningrum N, Dewi EI, Afandi AT. Work Stress Mapping of Farmers in Jember Regency. Jurnal Penelitian Pendidikan IPA. 2025 Nov 25;11(11):755-64.

25) Salaroli LB, Cattafesta M, Petarli GB, Ribeiro SAV, Soares ACO, Zandonade E, et al. Prevalence and factors associated with arterial hypertension in a Brazilian rural working population. *Clinics (Sao Paulo)*. 2020;75:e1605. doi: 10.6061/clinics/2020/e1605.

26) Solehah EL, Saputra IKDA, Ariantini NS. Factors related to the event hypertension in farmers. *J Lang Health*. 2024;5(1):145–50. doi: 10.37287/jlh.v5i1.3273.

27) Mostafalou S, Abdollahi M. Pesticides and human chronic diseases: evidences, mechanisms, and perspectives. *Toxicol Appl Pharmacol*. 2020;409:115303. doi: 10.1016/j.taap.2020.115303.

28) Prihartono NA, Fitria L, Ramdhan DH, Fitriyani F, Fauzia S, Woskie S. Determinants of hypertension amongst rice farmers in West Java, Indonesia. *Int J Environ Res Public Health*. 2022;19(3):1152. doi: 10.3390/ijerph19031152.

29) Pangestu AW, Kurdi F, Rasni H. The relation between life style and quality of

life in hypertension farmers in Panti District, Jember Regency. *J Rural Community Nurs Pract*. 2024;2(1):97–111. doi: 10.58545/jrcnp.v2i1.226.

30) Rachmawati E, Riskiyah, Novindra QA, Syarifah NA, Aisy NR. Association between lifestyle factors and hypertension control in Indonesian primary healthcare settings: a cross-sectional study. *Malays Fam Physician*. 2024;19(1):6. doi: 10.51866/oa.409.

31) Susanto T, Indriana T, Adi Yunanto R, Rahmawati I, Nistiandani A, Fauziah W. Community-based occupational health promotion for reducing blood pressure: a randomized control trial of agricultural health program. *J Occup Health Epidemiol*. 2024;13(4):252–60. doi: 10.61186/johe.13.4.252.

32) Susanto T, Purwandari R, Wuryaningsih EW, Watanabe H, Kazawa K, Moriyama M. Effects of progressive muscular relaxation and stretching exercises combination on blood pressure among farmers in rural areas of Indonesia: a randomized study. *Front Nurs*. 2021;8(4):365–74. doi: 10.2478/fon-2021-0036.

33) Christian AK, Owu RT, Kretchy IA. Household food insecurity, sociodemographic and lifestyle risk factors associated with high blood pressure among women in farming communities in Ghana. BMC Women's Health. 2025 Apr 15;25(1):181.

34) Li Z, Ma Q, Li X, Yu S, Zuo J, Wang C, et al. Association of AGTR1 gene methylation and its genetic variant in Chinese farmer with hypertension: a case-control study. *Medicine (Baltimore)*. 2022;101(29):e29712. doi: 10.1097/md.0000000000029712.

35) Astuti IS, Raharjo AM, Hakiim A, Nurmaida E, Oktadianto L. Identification of Risk Factors for the High Prevalence of Hypertension Among Farm Workers in the Agro Industry Area Jember. Malaysian Journal of Medicine & Health Sciences. 2024 Nov 2;20.

36) Pertiwi MK, Rubiah Rosyadahan A, Maat S, Nugroho Prasetyo E. Hypertension prevention education through training in making herbal teas in Talango Village, Talango District, Sumenep Regency. *J Health Community Serv*. 2022;2(2):120–8. doi: 10.33086/jhcs.v2i2.2758.

37) Susanto T, Rasny H, Kurdi F, Yunanto RA, Rahmawati I. Management of

hypertension using a plant-based diet among farmers: protocol for a mixed methods study. *JMIR Res Protoc*. 2023;12:e41146. doi: 10.2196/41146.