



Relationship between Pesticide Exposure and Type 2 Diabetes Mellitus in Farmers: Systematic Review

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ABSTRACT: A metabolic disorder known as diabetes mellitus is brought on when the pancreas is unable to produce enough insulin. Diabetes mellitus has a multifactorial pathogenesis, one of which is environmental pollution caused by agricultural chemicals such as pesticides. Pollutants contained in pesticides can act as endocrine-disrupting chemicals which can disrupt the endocrine system in the body. EDC into the body through exposure to pesticides through the respiratory, skin, and digestive systems. In the next process, it enters the organs of the body, namely, the pancreas. The absorbed EDC affects beta cells in producing insulin hormones. Insulin deficiency leads to high blood sugar levels, resulting in type 2 diabetes mellitus. This study aimed to determine the relationship between pesticide exposure and the incidence of type 2 diabetes mellitus among farmers. This study was conducted using a systematic review of the research method. The keywords used in the journal search were "pesticide and diabetes mellitus and farmers". Eight articles met our inclusion criteria. Based on the results of a literature study, the working period, spraying frequency, physical activity, amount of pesticides, and use of personal protective equipment were related to the incidence of type 2 diabetes mellitus in farmers. From the eight articles reviewed, it can be concluded that there is a relationship between exposure to pesticides and the incidence of type 2 diabetes mellitus in farmers.

KEYWORDS: "Pesticide and diabetes mellitus and farmers".

INTRODUCTION

According to the International Diabetes Federation (IDF), in 2019, at least 463 million people aged 20–79 years worldwide suffered from diabetes mellitus or 9.3% of the entire population. This figure is expected to continue to increase to 578 million in 2030 and 700 million in 2045. Countries in the Arab-North Africa and West Pacific regions rank first and second in terms of diabetes prevalence in the age range of 20–79 years. Indonesia ranks third in Southeast Asia with a prevalence of 11.3%, with 10.7 million people having diabetes mellitus. According to the results of the 2018 Basic Health Research (Riskesdas), the percentage of people with diabetes mellitus was 10.9%, an increase in the number of sufferers compared to the results of the 2013 Riskesdas, which was 8.5%. Based on these data, it was concluded that diabetes mellitus is a very important health problem (Kementerian Kesehatan RI., 2020).

Specifically, the eyes, kidneys, nerves, heart, and blood arteries can all become dysfunctional as a result of the metabolic disease diabetes mellitus, which develops over a lengthy period of time. The pancreas in diabetics is not able to produce insulin in sufficient quantities in other words the body of a person with diabetes mellitus is unable to use insulin effectively which results in excess sugar in the blood causing complications of other diseases. In general, people with diabetes mellitus will experience complaints of polyuria (frequent urination, especially at night), polydipsia, frequent thirst), polyphagia (often hungry), and experience drastic weight loss in a relatively short period of time, even though they are not on a diet (Saputri et al., 2018).

Diabetes mellitus has multifactorial pathogenesis: heredity, environmental influences, obesity, and lifestyle (Vitianoza et al., 2021). Recent research has suggested that environmental pollution caused by agricultural chemicals is a causative factor. The suspected compounds were arsenic, mercury, bisphenol A (BPA), and persistent organic pollutants (POP), especially polychlorinated biphenyls (PCB), dioxins, and pesticides. With more than 2.3 billion kg used globally in 2001, pesticides are currently the most widely used substances. A major cohort study involving 33,457 pesticide applicators as part of the Agricultural Health Research (AHS) project in the US found a link between diabetes and seven organochlorine pesticides, including aldrin, chlordane, heptachlor, dichlorvos, trichlorfon, alachlor, and cyanazine (Juntarawijit et al., 2018). Indonesia is an agrarian country, with a population that makes agriculture a livelihood. In the agricultural sector, pesticides are used in the hope of eradicating pests so that agricultural produce is good, abundant, and of good quality (Suhartono et al., 2018)



Based on the Regulation of the Minister of Agriculture No. 7 of 2007, pesticides are all chemical substances or other materials as well as microorganisms and viruses that are used to destroy or prevent pests and diseases that have the potential to destroy plants, plant components, or agricultural products, destroy grass, kill leaves, and preventing unwanted growth, causing plant growth or plant parts (but not part of the fertilizer class) (Menteri Pertanian, 2007). The effect of pesticides on the body is determined by the class of pesticides, how often they are exposed, what the mechanism is, and how the type of pesticide is prepared. The use of pesticides that are not by safety rules will result in acute and chronic poisoning by farmers, as observed from the impacts that arise. Pesticide poisoning can be diagnosed by examining blood AChE levels.

Pollutants contained in pesticides can act as endocrine-disrupting chemicals that disturb the endocrine system in the body. EDC (Endocrine Disrupting Chemical) is an exogenous substance from the external environment or a chemical mixture that changes the function of the endocrine system causing adverse effects on an organism on its offspring or its population. DC allows the attacking of all of the hormonal systems and can control the development of hormonal systems and functions in the body's tissues. The impacts caused by damage to the endocrine system include obesity or overweight, infertility or can reduce fertility, reduce intelligence in learning and memory storage in the brain, diabetes, cardiovascular, disease, and various other diseases. The way for EDC to enter the body is through the entry of pesticide exposure either through breathing, the skin surface, or the digestive system, which will then enter the blood circulation. In the next process, it will enter the organs, one of which is the pancreas organ. The absorbed EDC will affect the beta cells in producing the insulin hormone. When the body experiences a deficiency of insulin so that blood sugar levels become high, type diabetes mellitus will occur (Saputri et al., 2018).

Therefore, researchers are interested in knowing the relationship between exposure to pesticides and the incidence of diabetes mellitus in farmers.

METHOD

This article was made using a research method which is a systematic review. Searching for articles is based on the PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analysis) protocol. The process of searching for articles or journals uses four databases, namely Pubmed, research gate, science direct, and google scholar. The keywords entered are Pesticides, diabetes mellitus, and farmers. The articles used are limited to articles published in the last 5 years, namely 2018-2023. The selection of articles is based on the purpose of writing, namely the relationship between exposure to pesticides and the incidence of type 2 diabetes mellitus in farmers. An initial search from the Pubmed database found 26 articles, science direct 218 articles, research gate 10 articles, and Google Scholar identified 254 articles. From these results, a screening stage was then carried out in the form of articles that were not literature reviews, not meta-analyses, or systematic reviews and articles must be full text. After the screening process, articles that were not relevant to the purpose of making the article, not exposure to pesticides with the incidence of diabetes mellitus, and not the research results of the article being issued. The results of the feasibility assessment issued articles that did not fit the purpose of writing so only eight articles were included in this literature. Then, the writer analyzes the article and interprets it so that the results are obtained which will be discussed later.

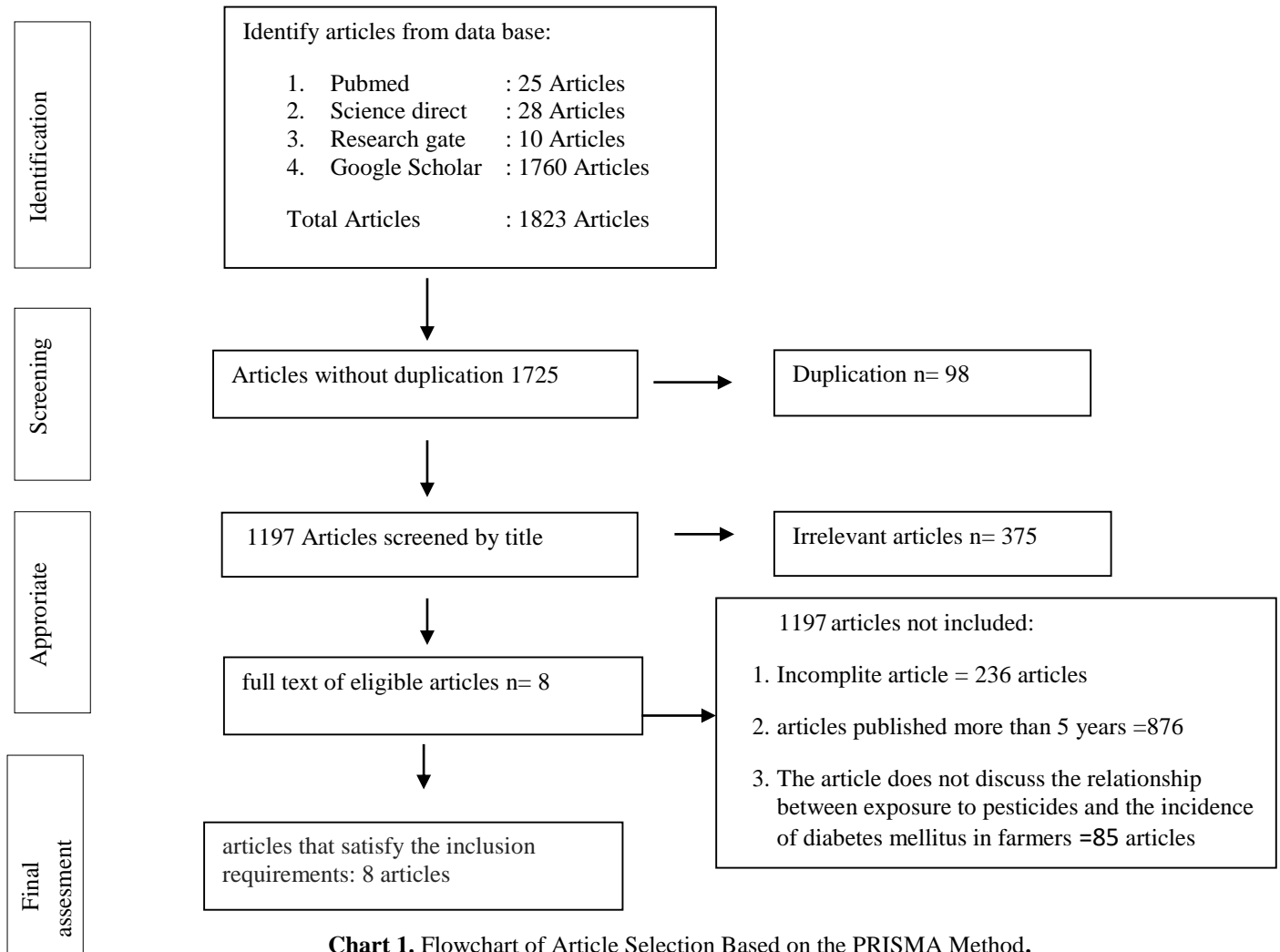


Chart 1. Flowchart of Article Selection Based on the PRISMA Method.

RESULT

From the results of the search selection of the articles described in the method above. There were 8 articles regarding various variables that are related to pesticide exposure and the incidence of diabetes mellitus.

Table 1. List of Systematic Review Articles

No	Author	Theme	Study Type	Target responded	variables	Study result
1.	(Juntarawijit et al., 2018)	Association between diabetes and pesticides: a case-control study among Thai farmers	Cross-sectional	sample of 1887 consisting of 866 cases, 1021 control.	Independent: Pesticide type	According to the study, Farmers in Thailand who use pesticides are at a higher risk of developing type 2 diabetes. Endosulfan, mevinphos, carbaryl/Sevin, and Ben late were found to have a statistically significant higher risk of diabetes among the 35 individual pesticides examined. P value 0.05



2.	(Saftarina et al., 2023)	Determinants of Type 2 diabetes mellitus in the agricultural community	Case-control	Farmers with type 2 DM (cases) and farmers without type 2 DM (controls) made up the samples. with a total of 41 individuals in each group	Independent: Number of pesticides, family history, and physical activity	The findings indicated that factors influencing the prevalence of type 2 DM included family history, physical activity, and the amount of pesticides present. In comparison to farmers who only used one type of pesticide, those who used more than two types of pesticide had a score of 2.7 times the chance of developing type 2 diabetes mellitus (95% CI: 1.109-6.615). Farmers who have been diagnosed with type 2 DM are 16.0 times more likely to develop the condition than other farmers who have no family history of the disease (95%: 4.77 - 53.85). Farmers who are less physically active have a 4.2 times higher chance of acquiring type 2 diabetes (95% CI: 2.587-6.671) compared to more active farmers.
3.	(Park et al., 2019)	Exposure to Pesticides and the Prevalence of Diabetes in a rural population in Korea	Cross-sectional	Using a sample from the farmer's cohort study with 2559 participants	Independent variables: Years of service	The study's findings revealed a significant association between farmers' working hours and the likelihood of developing diabetes mellitus (p-value = 0.001; OR = 2.00; 95% CI = 1.20 - 3.34)
4.	(Vitianoza et al., 2021)	Relationship between Body Mass Index and Duration of Spraying with Diabetes Mellitus among Farmers in Juhar Ginting Sadanioga Village, Karo District in 2018	Cross-sectional	60 farmers sprayers in Juhar Ginting Sadanioga Village	Independent variables: Body mass index, and frequency of spraying	According to the study's findings, there is a connection between body mass index and diabetes mellitus (p = 0.024) and between the length of time spent spraying and diabetes mellitus (p = 0.023).
5.	(Saputri et al., 2018)	Correlation between History of Pesticide Exposure and Type 2 Diabetes Mellitus in Spraying Farmers in Ngablak	Case-Control	The population of farmers with a total of 41 cases	Independent variables: Period of work, frequency of spraying, use of personal protective	The findings of the study showed that the factors years of service, frequency of pesticide spraying, use of personal protective equipment, and pesticide dosages had p-values less than 0.05. The length of employment, frequency of pesticide application, use of personal



		District, Magelang Regency			equipment, and dose of pesticides	protective equipment, and doses of pesticides are all substantially connected with the occurrence of type 2 diabetes mellitus.
6	(Rachmawati et al., 2019)	Study on Type 2 Diabetes Prevalence among Women Farmworkers in Bandung, Semarang Regency, Indonesia	Cross-sectional	52 respondents	Independent variables: years of service, frequency of spraying, use of personal protective equipment.	The research results show that there is a significant relationship between years of service, frequency of spraying crops, and use of personal protective equipment (PPE) with the incidence of type 2 diabetes. No There is a relationship between the length of work and the incidence of type 2 DM.
7.	(Rune et al., 2019)	A cross-sectional study in a semi-urban Nepali population identified a correlation between pesticide use and type 2 diabetes mellitus.	Cross-sectional	a Nepalese population-based cohort of 2310 respondents who attended	Independent variables: frequency of spraying	The research result showed that there is a relationship significant between frequencies spraying with incident diabetes mellitus
8.	(Jaacks et al., 2019)	Metabolite of the pesticide DDT and incident type 2 diabetes mellitus in urban	Case-control	193 participants with enough plasma samples and who fit the case criteria from Delhi and Chennai	Independent variables: educational status, age, employment status, family history, history of alcohol consumption, smoking history, body	The study's findings suggest that Delhi had exceptionally high levels of p,p'-DDE (dichlorodiphenyldichloroethylene), but no meaningful correlation was found. Type 2 diabetes mellitus incidence and p,p-DDE are significantly correlated.

DISCUSSION

Diabetes is a chronic condition brought on by insufficient insulin production by the pancreas or inadequate utilization of insulin by the body. A hormone called insulin controls blood sugar levels. Increased blood sugar, also known as hyperglycemia, is a side consequence of uncontrolled diabetes, which over time seriously harms numerous bodily systems, particularly the nerves and blood vessels. (WHO, 2023). From the articles obtained and then analyzed, it was explained that type 2 diabetes mellitus in farmers can be caused by the use of pesticides. Although the articles analyzed differed in terms of research locations, variables studied, and research results, the articles analyzed showed that pesticides increased blood glucose levels.

The lengthy hours that farmers put in at labor lead to a large buildup of pesticide exposure. The use of pesticides in large quantities and agricultural activities carried out, such as mixing pesticides and spraying on plants, cause the accumulation of pesticides in the farmers' bodies, which disrupts the function of organs, one of which is the insulin hormone. Exposure to pesticides for a long time on the farmer's body causes many harmful substances derived from these pesticides to enter the body through



breathing and the skin. These chemicals can cause poisoning and impaired body function, and the worst risk is death. Based on Permenaker No. 3 of 1986, states that to minimize the risk of exposure to pesticides, the use of pesticides should not be more than 5 hours a day or more than 20 hours a week (Peraturan Menteri Tenaga Kerja Republik Indonesia Nomor: Per-03/Men/1986).

Based on research that one of the factors that causes diabetes mellitus is a family history of heredity. Someone will be more at risk of developing diabetes mellitus if that person has a mother who has diabetes, and if a father and mother have diabetes mellitus, the risk of having diabetes mellitus will be higher. This is predicted because there is a combination of genes carrying the trait of diabetes mellitus from the father and mother, therefore the age at which diabetes mellitus is diagnosed becomes faster. If someone has one or more family members, both father and mother, siblings, or children who have diabetes, they are 2 to 6 times more likely to suffer from diabetes mellitus when compared to people who do not have family members who suffer from diabetes. Sry et al., (2020). Farmers who have a history of diabetes mellitus in the family are more likely to experience diabetes mellitus compared to farmers who do not have a history of diabetes mellitus in the family. This is evidenced by research conducted on farming communities, in Gedong Tataan, Tanggamus, Indonesia. The study was conducted using a case-control study design showing that family history is a determining factor for the occurrence of type 2 DM. Farmers with a family history of type 2 DM have a 16.0 times chance of suffering from type 2 diabetes mellitus compared to those without a family history of type 2 DM. 2 (95%: 4.77 - 53.85)(Saftarina et al., 2023).

Pest attacks that occur during the rainy season make farmers spray more frequently. Pesticides that have been sprayed previously are not useful because they are carried away by rainwater, which causes farmers to spray pesticides again. The accumulation of residues in the soil due to repeated spraying has an impact on environmental pollution. Repeated application frequency will make resistance faster and make pesticides more exposed to the body (Djojsumarto, 2008). Research conducted on farmers in the Bang Rakam region of Phitsanulok Province in Thailand indicates that diabetes mellitus suffered by farming communities is affected by many different kinds of pesticides, such insecticides, herbicides, fungicides, rodenticides, molluscicides.(Juntarawijit et al., 2018); therefore, the frequency of spraying with this type The pesticides used can increase blood glucose levels, which leads to diabetes mellitus in farmers. Based on another study conducted in the horticulture area, Semarang, it was found that there was a significant relationship between the frequency of spraying plants and the incidence of type 2 diabetes mellitus with a statistical test result of p-value <0.05.

Farmers in ancient times always walked to go to work in the fields, but because at this time there are many types of transportation used, for example, motorbikes, the community, and farmers are reluctant to walk. Physical activity such as walking is one of the factors that can affect blood sugar levels. Physical activity has a role in regulating blood sugar levels in the body. When individuals have diabetes mellitus do physical activities such as walking, the increased use of glucose by active muscles can directly lower blood sugar. (I Made Sundayana et al., 2021). Apart from lowering blood sugar levels in the body, the benefits of physical activity include being able to lose weight, improve cardiovascular function, and improve respiration (Alza et al., 2020).

The use of more than one pesticide allows for interactions between these substances so that the toxicity of these pesticides can increase. This is due to the synergistic reaction of several pesticides, which can harm human health. (WHO, 2005) This is also evidenced by research (Saftarina et al., 2023) conducted in Gedong Tataan District, Pesawaran Regency, Lampung Province, Indonesia, According to the study, farmers who use more than two types of pesticides run a 2.7 greater probability of acquiring type 2 diabetes mellitus than farmers who only use one type of pesticide (95% CI = 1.11-6.62). The study's findings are consistent with previous research. (Saputri et al., 2018), This involved farmers in Magelang Regency's Ngablak District. There was a significant connection between farmers who used more than two types of pesticides and pesticides (OR = 2.03; 95% CI: 1.58-2.61). The results of the study (Juntarawijit et al., 2018) In the Bang Rakam District of Phitsanulok Province in Thailand, where diabetes prevalence was connected to exposure to more than two types of pesticides, farmers who used endosulfan, mevinphos, carbaryl/Sevin, and ben late had a statistically significant increase in their chance of acquiring diabetes.

The use of PPE, or personal protective equipment, consisting of masks, goggles, rubber gloves, and only long-sleeved shirts, boots, and hats when using pesticides minimizes the risk of exposure to pesticides. In research (Saputri et al., 2018) on farmers in Ngablak District, it is known that most farmers do not use PPE properly because they feel they are not free. The test results show p-value of $0.00 < 0.05$ OR = 0.09 with a 95% CI of 0.03–0.34, so it can be concluded that the use of PPE has a significant relationship and is a protective factor for the incidence of type 2 diabetes mellitus. The current supervision of the use of pesticides is not by the Regulation of the Minister of Agriculture of the Republic of Indonesia Number 107/Permentan/SR.140/9/2014 concerning the



control of pesticides, which emphasizes that supervision must also be carried out on occupational safety and health so that user does not interfere with human health and safety or environmental sustainability (Peraturan Menteri Pertanian Republik Indonesia Nomor 107/Permentan/Sr.140/9/2014, 2014).

CONCLUSION

Diabetes Mellitus is a disorder of metabolism that develops over a long period, years, and causes continual damage and can cause dysfunction of various components of the body, including the eyes, kidneys, nerves, heart and blood vessels. The results of a systematic review show, it can be concluded that work period, spraying frequency, physical activity, amount of pesticides, and use of PPE has an association with the frequency of type 2 diabetes mellitus among farmers. Thus, to avoid the effects caused by pesticides, it is necessary to make preventive efforts to minimize the risk of exposure to pesticides for farmers. It is hoped that the supervision of the use of pesticides will be further enhanced by involving community leaders who have previously been given knowledge about the dangers of using pesticides to facilitate the socialization of the impact of pesticides on all levels of society, especially to every farmer in their area.

REFERENCES

1. Alza, Y., Arsil, Y., Marlina, Y., Novita, L., & Agustin, N. D. (2020). Aktivitas Fisik, Durasi Penyakit Dan Kadar Gula. *Gizido*, 12(1), 18–26.
2. Djojsumarto, P. (2008). *Panduan Lengkap Pestisida & Aplikasinya*.
3. I Made Sundayana, I Dewa Ayu Rismayanti, I. A. P. D. C. D. (2021). Penurunan Kadar Gula Darah Pasien DM Tipe 2 Dengan Aktivitas Fisik. *Jurnal Keperawatan Silampari*, 5, 27–34.
4. Jaacks, L. M., Yadav, S., Panuwet, P., Kumar, S., Rajacharya, G. H., Johnson, C., Rawal, I., Mohan, D., Mohan, V., Tandon, N., Barr, D. B., Narayan, K. M. V., & Prabhakaran, D. (2019). Metabolite of the pesticide DDT and incident type 2 diabetes in urban India. *Environment International*, 133(May), 105089. <https://doi.org/10.1016/j.envint.2019.105089>
5. Juntarawijit, C. J. and Y. (2018). *Association between diabetes and pesticides : a case-control study among Thai farmers*. 1–10. <https://doi.org/10.1186/s12199-018-0692-5>
6. Kementerian Kesehatan RI. (2020). Infodatin tetap produktif, cegah, dan atasi Diabetes Melitus 2020. In *Pusat Data dan Informasi Kementerian Kesehatan RI* (pp. 1–10). <https://pusdatin.kemkes.go.id/resources/download/pusdatin/infodatin/Infodatin-2020-Diabetes-Melitus.pdf>
7. Menteri Pertanian. (2007). Peraturan Menteri Pertanian Nomor : 07/Permentan/Sr.140/2/2007. *Syarat Dan Tatacara Pendaftaran Pestisida*.
8. Park, S., Kim, S. K., Kim, J. Y., Lee, K., Choi, J. R., Chang, S. J., Chung, C. H., Park, K. S., Oh, S. S., & Koh, S. B. (2019). Exposure to pesticides and the prevalence of diabetes in a rural population in Korea. *NeuroToxicology*, 70, 12–18. <https://doi.org/10.1016/J.Neuro.2018.10.007>
9. Peraturan Menteri Pertanian Republik Indonesia Nomor 107/Permentan/Sr.140/9/2014. (2014). *Pengawasan Pestisida*. 1–16.
10. Peraturan Menteri Tenaga Kerja Republik Indonesia Nomor: Per-03/Men/1986. (1986). *Syarat-Syarat Keselamatan Dan Kesehatan Di Tempat Kerja Yang Mengelola Pestisida*.
11. Rachmawati, S., & Setiani, O. (2019). Prevalence of Type 2 Diabetes in Women Farm Worker : Study in Horticulture Area, Bandungan, Semarang Regency, Indonesia. *International Journal for Research In Applied Science & Engineering Technology (IJRASET)*. <https://doi.org/http://doi.org/10.22214/ijraset.2019.2109>
12. Rune, M., Hansen, H., Gyawali, B., Neupane, D., Jørs, E., & Sandbæk, A. (2019). Pesticide exposure and diabetes mellitus in a semi-urban Nepali population : a cross-sectional study. *International Archives of Occupational and Environmental Health*, 92. <https://doi.org/10.1007/s00420-019-01508-2>
13. Saftarina, F., Angraini, D. I., & Mayasari, D. (2023). *Determinants of type 2 diabetes mellitus in the agricultural community*. 11(1), 40–46.
14. Saputri, E. G., Setiani, O., YD, N. A., & Budiyo. (2018). Hubungan Riwayat Paparan Pestisida dengan Kejadian Diabetes Mellitus Tipe 2 pada Petani Penyemprot di Kecamatan Ngablak Kabupaten Magelang. *Jurnal Kesehatan Masyarakat (e-Journal)*, 6(1), 645–653.



15. Sry, A., Nababan, V., Pinem, M. M., Mini, Y., Hertati, T., Program, P., Fakultas, S. G., Masyarakat, K., Kesehatan Helvetia, I., & Korespondensi, P. (2020). Faktor Yang Memengaruhi Kadar Gula Darah Penderita Diabetes Mellitus (DM) Tipe II Factors Affecting The Blood Sugar Content Of Diabetas Mellitus (DM) Type II. *Jurnal Dunia Gizi*, 3(1), 23–31. <https://ejournal.helvetia.ac.id/jdg>
16. Suhartono, E., Edyson, Budianto, W. Y., Sekartaji, H. L., Fahira, N. S., & Cahyadi, H. (2018). Hubungan Kadar Enzim Asetilkolinesterase terhadap Kadar Glukosa Petani yang Terpajan Pestisida. *Jurnal Publikasi Kesehatan Masyarakat Indonesia*, 5(1), 12–15.
17. Vitianoza, N., Nurmaini, N., & Ashar, T. (2021). (2021). Hubungan Indeks Massa Tubuh dan Lama Penyemprotan dengan Diabetes Mellitus pada Petani di Desa Juhar Ginting Sadanioga Kabupaten Karo Tahun 2018. *Fakultas Kesehatan Masyarakat Universitas Sumatera Utara, Jl. Universitas No. 21 Kampus USU, Medan 20155, Indonesia*, 1(1).
18. WHO. (2005). *Bahaya Bahan Kimia Pada Kesehatan Manusia Dan Lingkungan*. (E. Widyastuti P (ed.)). Edisi Baha.
19. WHO. (2023). Diabetes Mellitus. *Home/ Newsroom/ Fact Sheets/ Detail/ Diabetes*. <https://www.who.int/news-room/fact-sheets/detail/diabetes>

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