UNIVERSITI PUTRA MALAYSIA

DERMAL EXPOSURE TO PESTICIDES AND HEALTH SYMPTOMS OF PADDY FARMERS IN SEBERANG PERAK, MALAYSIA

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By

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

DERMAL EXPOSURE TO PESTICIDES AND HEALTH SYMPTOMS OF PADDY FARMERS IN SEBERANG PERAK, MALAYSIA

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Pesticides are hazardous to the global public health since numerous studies had identified several problems related to occupational diseases, caused by the higher pesticide usage in the agricultural sectors. A cross-sectional study design was conducted on 179 paddy farmers in Seberang Perak, Malaysia. The aim of this study was to estimate actual dermal exposure to pesticides among paddy farmers using Dermal Exposure Assessment Method (DREAM). Apart from that, this study aimed to determine the socio-demographic, characteristics of pesticides, use of Personal Protective Equipment (PPE), duration of exposure, the prevalence of health symptoms experienced by paddy farmers, comparison between activities, use of PPE, and pesticides physical form with actual dermal exposure to pesticides, and relationship between socio-demographic characteristic, use of PPE and duration of exposure with prevalence of health symptoms experienced by paddy farmers.

These findings indicated no greater than moderate levels of risks during both activities. On the average, estimated potential dermal exposure ($Skin_W$-P_{TASK}) resulted higher than the actual dermal exposure ($Skin_W$-A_{TASK}) for both mixing/loading and spraying activities. Conversely, the $Skin_W$-A_{TASK} value of spraying was higher than that of the mixing/loading activities. The independent *t*-tests analysis showed there were a significant difference ($p < 0.001$) between the actual dermal exposure and activities, use of PPE during spraying activities, and pesticides physical form during the mixing/loading activities. Besides, the lower parts of the body contributed the most to the high $Skin_W$-A_{TASK} value during spraying, along with more than 50% prevalence of skin irritation. In contrast, hands received the greatest exposure to pesticides during the mixing/loading activities, as a result from 100% non-usage of gloves.

Apart from the actual dermal exposure, findings revealed several factors contributed to the health status of the paddy farmers, which includes the use of PPE, duration of exposure, and specific sociodemographic characteristics. A chi-square test analysis showed a significant relationship between health symptoms and the use of PPE for headache, dizziness, numbness, finger tingling, blurring of vision, skin rashes, skin irritation, and eye itchiness ($p < 0.05$). Moreover, a chi-square test analysis also showed a significant relationship between skin irritation on hands/wrists and the use of PPE ($p < 0.05$). Finally, this study revealed that there was statistically significant relationship ($p < 0.05$) between general health symptoms and the employment years, education level as well as duration of exposure. From those findings, it can be concluded that actual dermal exposure and the health status of the paddy farmers were highly dependent on the activities, use of PPE, pesticides physical form, sociodemographic characteristics, and duration of exposure. Due to the limitation of this study as there was no direct quantitative data taken, DREAM could serve as an alternative method in risk assessment.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Sarjana Sains

PENDEDAHAN RACUN PEROSAK MELALUI KULIT DAN SIMPTOM KESIHATAN PESAWAH PADI DI SEBERANG PERAK, MALAYSIA

Oleh

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Racun perosak adalah penting kepada kesihatan awam di peringkat antarabangsa memandangkan pelbagai kajian telah mengenal pasti beberapa masalah yang berkaitan dengan penyakit pekerjaan, disebabkan oleh penggunaan racun perosak dalam sektor pertanian. Reka bentuk kajian rentas telah dijalankan ke atas 179 pesawah padi di Seberang Perak, Malaysia. Tujuan kajian ini adalah untuk menganggar pendedahan racun perosak melalui kulit dalam kalangan pesawah padi menggunakan Kaedah Penilaian Pendedahan Dermal (DREAM). Selain itu, kajian ini bertujuan untuk menentukan sosio-demografi, ciri-ciri racun perosak, penggunaan Peralatan Perlindungan Peribadi (PPE), tempoh pendedahan, dan simptom kesihatan yang dialami oleh pesawah padi, perbandingan antara aktiviti, penggunaan PPE, dan bentuk fizikal racun perosak dengan pendedahan racun perosak melalui kulit, dan perbandingan antara ciri sosio-demografi, penggunaan PPE dan tempoh pendedahan dengan kelaziman simptom-simptom kesihatan yang dialami oleh pesawah padi.

Kajian ini menunjukkan tahap risiko tidak lebih dari paras risiko sederhana bagi kedua-dua aktiviti. Anggaran pendedahan racun perosak ke atas kulit yang berpotensi ($Skin_W$-P_{TASK}) didapati lebih tinggi daripada pendedahan ke atas kulit sebenar ($Skin_W$-A_{TASK}) untuk aktiviti pencampuran dan pemuatan, serta penyemburan racun perosak. Sebaliknya, $Skin_W$-A_{TASK} didapati lebih tinggi semasa semburan berbanding aktiviti pencampuran dan pemuatan.

Analisis *t*-ujian bebas menunjukkan terdapat perbezaan yang signifikan ($p < 0.001$) di antara anggaran sebenar pendedahan dan aktiviti racun perosak, penggunaan PPE semasa aktiviti penyemburan, dan bentuk fizikal racun perosak semasa aktiviti pencampuran/pemuatan. Selain itu, bahagian bawah badan menyumbang paling banyak kepada nilai $Skin_W$-A_{TASK} semasa

menyembur, selari dengan lebih 50 peratus kerengsaan kulit. Sebaliknya, tangan menunjukkan pendedahan yang paling ketara terhadap racun perosak semasa aktiviti pencampuran/pemuatan, hasil daripada ketidakgunaan sarung tangan 100%.

Malah, kajian juga menunjukkan beberapa faktor yang menyumbang kepada status kesihatan pesawah padi, termasuk penggunaan PPE, tempoh pendedahan, dan ciri-ciri sosiodemografi. Analisis ujian khi kuasa dua menunjukkan perbezaan yang signifikan antara simptom-simptom kesihatan dan penggunaan PPE untuk sakit kepala, pening, kebas, jari berdenyut, kabur penglihatan, ruam kulit, kerengsaan kulit, dan gatal mata ($p < 0.05$). Selain itu, analisis ujian khi kuasa dua juga menunjukkan perbezaan yang signifikan antara kerengsaan kulit pada tangan/pergelangan tangan dan penggunaan PPE ($p < 0.05$). Akhirnya, kajian ini mendedahkan bahawa terdapat perbezaan yang signifikan secara statistik ($p < 0.05$) antara gejala kesihatan dan tempoh tahun bekerja, tahap pendidikan serta tempoh pendedahan. Daripada penemuan ini, dapat disimpulkan bahawa pendedahan racun perosak melalui kulit dan status kesihatan pesawah padi bergantung pada aktiviti, penggunaan PPE, bentuk fizikal racun perosak, ciri-ciri sosiodemografi, dan tempoh pendedahan kepada racun perosak. Oleh kerana had kajian ini tidak mempunyai data kuantitatif langsung, maka DREAM boleh digunakan sebagai kaedah alternatif dalam penilaian risiko.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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LIST OF ABBREVIATIONS

ASTDR	Agency for Toxic Substances and Disease Registry
CLASS	Classification, Labelling and Safety Data Sheet of Hazardous Chemicals Regulations
CPL	Classification, Packaging, and Labelling of Hazardous Chemicals
CVI	Content Validity Index
DU	Dermal Unit
DDT	Dichlorodiphenyltrichloroethane
DERM	Dermal Exposure Ranking Method
DOA	Department of Agriculture
DOSH	Department of Occupational Safety and Health
DREAM	Dermal Exposure Assessment Method
FELCRA	Federal Land Consolidation and Rehabilitation Authority
IADA	Integrated Agriculture Development Area
MOH	Ministry of Health
OCPs	Organochlorine Pesticides
Ops	Organophosphate Pesticides
OSHA	Occupational Safety and Health Act
PANAP	Pesticide Action Network Asia and Pacific
PHED	Pesticide Handlers Exposure Database
POPs	Persistent Organic Pollutants
PPE	Personal Protective Equipment
RISKOFDERM	Risk Assessment of Occupational Dermal Exposure
SPSS	Statistical Package for the Social Sciences
UNEP	United Nations Environment Programme

USA	United States of America
USECHH	Use and Standards of exposure of Chemicals Hazardous to Health
USEPA	United States Environmental Protection Agency
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

This chapter represents the research background, problem statement and justification, significance of study, research questions, research objectives, research hypothesis, definition of terms, and conceptual framework.

1.1 Research background

In Malaysia, the agricultural sector is one of the most important sectors that contribute to economic growth. Paddy is the third most widely planted crop in Malaysia after palm oil and rubber. According to the Department of Agriculture Peninsular Malaysia (2015b, 2015a), 674,332 hectares were planted in 2013 with paddy twice a year. Despite its tropical wet climate, Malaysia is suitable for paddy plantation at Peninsular Malaysia and Borneo Islands. Paddy is an essential food for 32.3 million Malaysian citizens (Department of Statistics Malaysia, 2018). Regardless of its importance, this industry has received special attention from the government to sustain the nation's food security (Rosnani, 2015).

The agricultural sector in developing countries contributes to 20% of pesticide use for pest control purposes (Issa, Sham'a, Nijem, Bjertness, & Kristensen, 2010) to increase crop production and enhance the economic value for farmers (Ecobichon, 2001), hence, these numbers keep increasing. Upper-middle-income countries including Malaysia, Argentina, Brazil, and South Africa Uruguay also showed no positive results in reducing pesticide use (Schreinemachers & Tipraqsa, 2012). Generally, paddy farmers are likely to be exposed to pesticides while mixing/loading, application and cleaning activities. During these activities, paddy farmers or pesticide applicators are prone to pesticide exposure via inhalation, ingestion, and dermal route exposures. Among these three routes, dermal is the most common route for pesticide application (Macfarlane, Carey, Keegel, El-Zaemay, & Fritschi, 2013; Pierre et al., 2010; van Hemmen & Brouwer, 1995), as pesticides poisoning commonly occurs through skin contact (Damalas & Koutroubas, 2016).

Consequently, numerous studies have identified problems related to occupational diseases. This includes serious cases of mortality reported in the United States of America (USA), as pesticides proved toxic through skin absorption (van Hemmen, 2004). Yet, only a few studies have been published in relation to paddy farming in Malaysia (Mardiana Idayu, Nur Anis, Syahidah, & Norizan, 2014), with few cases on exposure level and the prevalence of

general health symptoms from the use of pesticides. Therefore, an extended research on exposure level and the prevalence of general health symptoms related to pesticide exposure is essential. The findings shed light on the different levels of risks exposed by paddy farmers, besides promoting safer pesticide application amongst paddy farmers in Seberang Perak, Malaysia.

1.2 Problem statement and justification

Apart from employees, protecting the public from safety and health risks associated with work activities is one of the main responsibilities of an employer and the self-employed under the Occupational Safety and Health Act 1974 (Department of Occupational Safety and Health Malaysia, 2006). This includes safe pesticide application in paddy farming. Extensive pesticide usage in developing countries including Malaysia is alarming as it poses risks to the safety and health of paddy farmers. A few studies reported inappropriate use of chemical pesticides by farmers which have been greatly discussed worldwide (Ngowi, Mbise, Ijani, London, & Ajayi, 2007a, 2007b).

Several cases of occupational diseases have been reported, either causing acute health effects such as skin irritation or nausea, or chronic health effects such as cancer. The number of occupational diseases is increasing among year. The statistics on occupational poisoning and diseases reported to the Department of Occupational Safety and Health, Malaysia comprised of 2,588 cases in 2013, 2,648 cases in 2014, 5,960 cases in 2015, 7,820 cases in 2016, 6,020 cases in 2017, and 5,139 cases until September 2018 (Department of Occupational Safety and Health Malaysia, 2018) (Table 1.1).

Table 1.1 : Statistics of occupational diseases from 2013 to 2018

Year	Case, *n*
2013	2,588
2014	2,648
2015	5,960
2016	7,820
2017	6,020
2018 (September)	5,139

Subsequently, in 2017, the agricultural sector was placed at the fourth rank after manufacturing, mining and quarry, and civil service at 108 (1.79%) from 6,020 total cases of occupational poisoning and diseases (Department of Occupational Safety and Health Malaysia, 2018). According to Jamal, Norhafezah, and Fadzli Shah (2018; as cited in Department of Occupational Safety and Health Malaysia, 2006), the Malaysian Trade Union Congress indicated that numerous cases of accidents which resulted from agricultural sectors were not reported, especially the minor accidents and chronic health effects due to pesticide usage.

Excessive and inappropriate use of pesticides is alarming as it poses risks to the safety and health of paddy farmers or pesticides applicators. Due to its ability to cause harm to human health, therefore, this research was carried out to estimate the dermal exposure to pesticides using Dermal Exposure Assessment Method (DREAM), a method with limited usage in Malaysia's research. In comparison to other methods as RISKOFDERM, DERM and PHED, DREAM posed the most appropriate use due to its good inter-observer agreement and assess more accurately (Lesmes Fabian, Teubl, & Binder, 2014). On top of that, limited studies on health symptoms of paddy farmers related to pesticide exposure also urge the needed to be determined through a self-reported questionnaire. This study revealed the different levels of risks experienced by farmers, along with their health conditions associated with the use of pesticides. The outcome of this study will assist the governments in improving the quality of life of people, in line with the aim of Shared Prosperity Vision 2030, to provide a decent standard of living for all Malaysians (Ministry of Economic Affairs, 2019).

1.3 Significance of study

This study was useful in providing measurement of the risks of dermal exposure to pesticides among paddy farmers in Malaysia, especially when it was not widely used in Malaysia. Through this study, it served as a medium to be applied in Malaysia, especially it is a low cost and easy to be used. A semi-quantitative method was used as an alternative to the direct quantitative measurement, which is low cost and easy to be used. The measurement also focused on transportation of pesticides from the source of exposure to the surface of the skin via emission, deposition, and transfer. It indirectly benefited the society in the aspect of protecting them from exposure to pesticides that potentially harms human health. Awareness of safe pesticides application was enhanced among paddy farmers, especially regarding the proper use of Personal Protective Equipment (PPE) during mixing/loading and spraying activities in order to protect their health from occupational diseases.

1.4 Research questions

1. What are the socio-demographic, characteristics of pesticides, use of Personal Protective Equipment (PPE), duration of exposure, and the prevalence of health symptoms usage during mixing/loading and spraying activities?
2. What are the level of actual dermal exposure to pesticides among paddy farmers?
3. Is there any differences between activities, use of PPE, and pesticides physical form with actual dermal exposure to pesticides?
4. Is there any relationship between socio-demographic characteristic, use of PPE and duration of exposure with prevalence of health symptoms experienced by paddy farmers?

1.5 Research objectives

The general objective of this study is to estimate dermal exposure to pesticides among paddy farmers in Seberang Perak, Malaysia using Dermal Exposure Assessment Method (DREAM).

The specific objectives of the study are:

1. To determine the socio-demographic, characteristics of pesticides, use of Personal Protective Equipment (PPE), duration of exposure, and the prevalence of health symptoms experienced by paddy farmers.
2. To estimate the actual dermal exposure to pesticides among paddy farmers.
3. To compare between activities, use of PPE, and pesticides physical form with actual dermal exposure to pesticides.
4. To determine the relationship between socio-demographic characteristic, use of PPE and duration of exposure with prevalence of health symptoms experienced by paddy farmers.

1.6 Research hypothesis

1. There is a significant difference between activities, use of PPE, and pesticides physical form with actual dermal exposure to pesticides.
2. There is a significant relationship between socio-demographic characteristic, use of PPE and duration of exposure with prevalence of health symptoms experienced by paddy farmers.

1.7 Definition of terms

1.7.1 Pesticides

Conceptual definition: Pesticides are chemicals that are designed to kill pests or unwanted living organisms that have the potential to cause an adverse effect on crop yield (Agency for Toxic Substances and Disease Registry, 2008). Pesticides can be classified based on their target groups: insecticides (insects), fungicides (fungi), herbicides (plants), molluscicides (slugs and snails), rodenticides (rodents), acaricides (mites), and nematicides (nematode worms) (Ballantyne & Marrs, 2003).

Operational definition: Observation was done on paddy farmers who used pesticides during mixing/loading and spraying activities.

1.7.2 Exposure

Conceptual definition: Humans can be exposed to pesticides via dermal, oral or inhalation routes. Among those three routes, dermal and inhalation are the most common routes for farmers' exposure to pesticides (Damalas & Koutroubas, 2016).

Operational definition: This study determined pesticides exposure through dermal (skin) as the dermal route is the most pertinent route for pesticide application (Macfarlane et al., 2013; Pierre et al., 2010; van Hemmen & Brouwer, 1995). Pesticides poisoning commonly occurs through the dermal route (Damalas & Koutroubas, 2016).

1.7.3 Assessment

Conceptual definition: Exposure assessment for a developing country, including Malaysia, should be economical and user-friendly (Blanco Romero, 2008). Therefore, modelling is a valuable approach to estimate exposure when direct measurement is not applicable due to expensiveness or unavailability of measurement during that time. According to World Health Organization [WHO] (2014), a "model" is defined as a mathematical formula resulting from an expert's assumption to represent the exposure, while "tools" is defined as a computer-based software or spreadsheet to simplify the estimation process and can be implemented for various models.

Operational definition: This study focuses on using the Dermal Exposure Assessment Method (DREAM) for dermal exposure assessment based on the conceptual model by Schneider et al. (1999), which describes the transportation of contaminant mass from exposure sources to the surface of the skin via three main routes: emission, deposition, and transfer.

1.7.4 Paddy farmers

Conceptual definition: Individuals who work in paddy farming including land preparation, paddy cultivation, and harvesting.

Operational definition: Paddy farmers involved in paddy cultivation and who uses pesticides during mixing/loading and spraying activities were selected to take part in this study.

1.7.5 Socio-demographic characteristics

Conceptual definition: The characteristics or background information of respondents.

Operational definition: The characteristics of paddy farmers involved in this study including age, race, marital status, education level, and duration of employment.

1.7.6 Characteristic of pesticides

Conceptual definition: The characteristics or background information of pesticides used.

Operational definition: The characteristics or background information of pesticides involved in this study covering type of pesticide, pesticide group, pesticide class, and pesticide formulation.

1.7.7 Duration of exposure

Conceptual definition: The duration of chemical exposure is one of the contributing factors to dermal absorption (Anderson & Meade, 2014).

Operational definition: This study determines the duration of pesticides exposure that measures how long paddy farmers were exposed to pesticides in a day.

1.7.8 Personal Protective Equipment (PPE)

Conceptual definition: Proper use of protective clothing and gloves during work activities is one of the contributing factors to the rate of dermal absorption (Fenske, 2005; Semple, 2004).

Operational definition: The use of complete Personal Protective Equipment (PPE) during mixing/loading and spraying activities were observed for each of the nine body parts: head, upper arm, lower arm, hands/wrists, torso front, torso back, lower body, lower leg, and feet.

1.7.9 Health status

Conceptual definition: Pesticides may cause harm to human health either through acute or chronic health effects.

Operational definition: Acute health effects were observed in this study to determine pesticides exposure onto human health comprising neurological symptoms (headache, dizziness, numbness, muscle cramps, lethargy, joint pain, and finger tingling), gastrointestinal symptoms (nausea, vomiting, diarrhoea, and abdominal pain), and dermatological symptoms (skin irritation, eye itchiness, blurring of vision, and skin rashes).

1.8 Conceptual framework

Pesticides are chemicals that are designed to kill pests or control unwanted living organisms that can reduce crop production in agricultural sectors. There are three routes of pesticide exposure, which are the dermal, oral or inhalation routes. Among these three routes, the dermal route is the most pertinent route for pesticide application (Macfarlane et al., 2013; Pierre et al., 2010; van Hemmen & Brouwer, 1995), as pesticide poisoning frequently occurs through the skin (Damalas & Koutroubas, 2016).

According to National Institute for Occupational Safety and Health (2013), dermal absorption can be described as the transportation of a chemical from the outer surface of the skin into the skin and body. Dermal absorption depends on various factors, such as the characteristics of pesticides (formulation), duration of exposure to pesticides, personal hygiene, and PPE application. However, there are four independent variables in this study: socio-demographics, characteristic of pesticides, PPE application during pesticide mixing/loading and spraying and duration of exposure to pesticides. Age, marital status, educational level and duration of employment were obtained to determine the socio-demographic characteristics of paddy farmers in Seberang Perak. Besides that, the characteristic of pesticides such as type, group, formulation, class, active ingredients, and product name was obtained from a self-reported questionnaire and Safety Data Sheet (SDS) of each pesticides. Mardiana Idayu et al. (2014) in their study mentioned that there were several types of pesticides used by paddy farmers in Permatang Keriang, Malaysia, such as insecticides, herbicides, fungicides and rodenticides to control major pests. However, insecticides were found to be the most common pesticide applied by farmers. Pesticides can also be categorised into different forms, such as solid (granule or powder) and liquid. Apart from that, PPE application during mixing/loading and spraying activities by paddy farmers somehow contribute to pesticide exposure. Proper use of PPE decreases the exposure to highly hazardous pesticides (Sapbamrer & Nata, 2014; Yassin, Abu Mourad, & Safi, 2002). The duration of exposure may also affect the human health, as prolonged exposure to pesticides increases its capacity to be absorbed through

the skin (Anderson & Meade, 2014). A self-reported questionnaire was filled to determine the background information of respondents including characteristics of pesticides, PPE application, and duration of exposure to pesticides.

Two dependent variables were measured in this study, which are the estimated dermal exposure to pesticides and prevalence of health symptoms of paddy farmers. There are various methods for pesticide exposure assessment, including qualitative, quantitative and semi-quantitative methods. According to WHO (2014), pesticides can be measured quantitatively, either through direct measurement as an interception technique (patches/whole body sampling method), removal technique (tape stripping/suction technique wiping/handwash/immersion), or biomonitoring of pesticides in urine or blood. Apart from that, a self-reported questionnaire can also be used to assess dermal exposure to pesticides. For a qualitative method, Schneider et al. (1999) in their research used a fluorescent tracer to assess the mass of a hazardous substance contaminant on the surface of the skin of a worker and the area of exposed skin. However, when direct measurement cannot be used or is unpractical, models are a suitable approach to assess dermal exposure to pesticides (WHO, 2014) such as using the Dermal Exposure Assessment Method (DREAM) and Dermal Exposure Ranking Method (DERM). Among all methods listed above, this study used a DREAM method, due to its good inter-observer agreement. DREAM consists of semi-quantitative inventory of processes of exposure, and it can be applied in any exposure condition in developing countries (Kromhout, van Wendel De Joode, & van Hemmen, 2008). This method is suitable for exposure processes, and an output of a rough category (zero, low, moderate, high, very high and extremely high) is sufficient as a first estimate to get an idea on the amount of pesticide exposure (WHO, 2014).

Finally, the prevalence of health symptoms of paddy farmers was be obtained by a self-reported questionnaire to determine the health symptoms of paddy farmers when exposed to pesticides. The symptoms were divided into three categories: neurological symptoms (headache, dizziness, numbness, muscle cramps, lethargy, joint pain, and finger tingling), gastrointestinal symptoms (nausea, vomiting, diarrhoea, and abdominal pain), and dermatological symptoms (skin irritation, eye itchiness, blurring of vision, and skin rashes).

The highlighted boxes are showing the variables within the scope of this study. This study focused on the difference between activities, use of PPE, and pesticides physical form with actual dermal exposure to pesticides. Besides that, this study also focused on the relationship between socio-demographic characteristic, use of PPE and duration of exposure with prevalence of health symptoms experienced by paddy farmers.

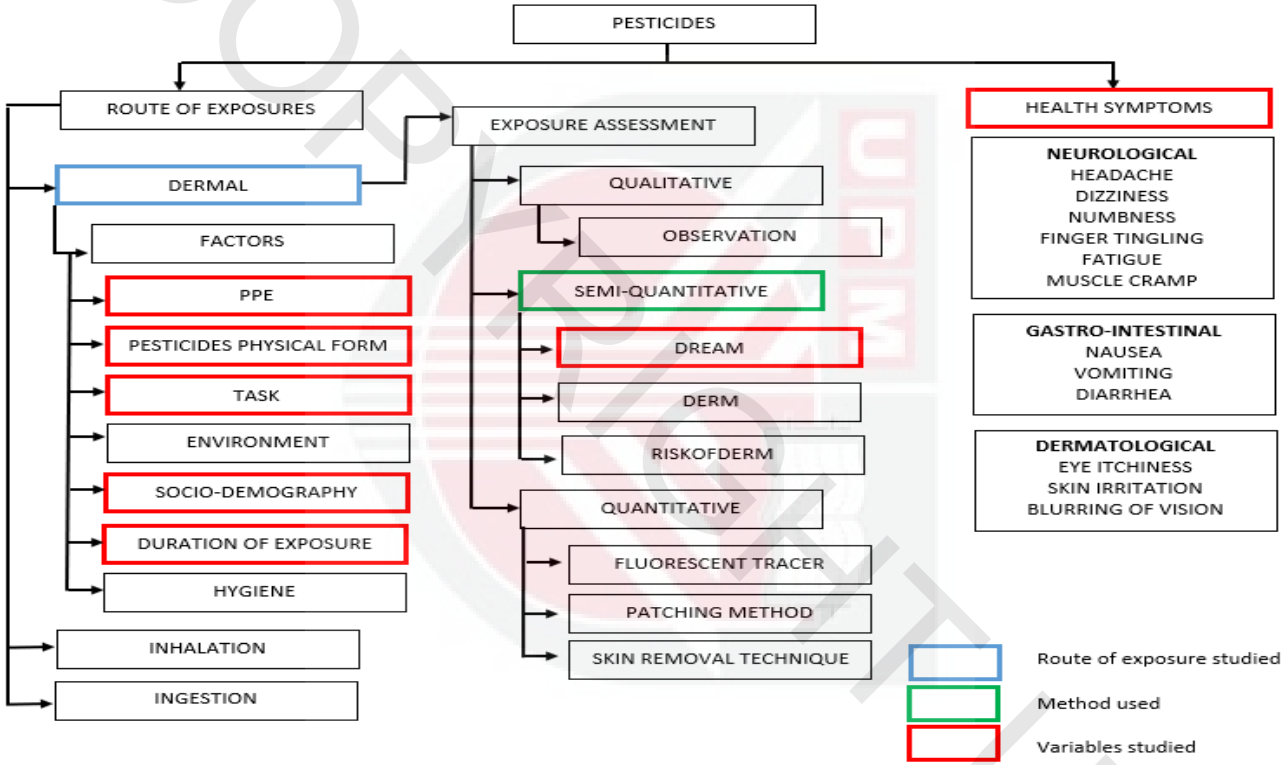

Figure 1.1 : Research Conceptual Framework

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