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Original Article

Use of Pesticides and Health Risks to Chinese Water Chestnut Farmers in Suphanburi Province, Thailand

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Abstract

Background: We aimed to study the relationship between the use of pesticides and the health risks faced by Chinese water chestnut farmers in this country.

Methods: This cross-sectional survey was conducted among 425 farmers in Sriprachan district, Suphanburi Province, Thailand in 2021. Samples were recruited using the cluster sampling method, and data collection took place through questionnaires. The questionnaire consisted of 3 parts, 76 items, namely personal information of farmers (12 items checklist), the use of pesticides by chemical risk assessment was a 5-point rating scale (40 items), and health risk assessment exposure to pesticides was a 5-point rating scale (24 items). The content validity index for scale (S-CVI) was 0.963 and the reliability with Cronbach's alpha coefficient was 0.904. Data were analyzed using descriptive statistics, chi-square, relative risk, and 95% CI.

Results: The overall pesticide use among farmers was at a moderate level (Mean=3.26, SD=0.60). Farmers' signs and symptoms of exposure were compared to their use of pesticides. The pesticide use increased health risks by 15.57 (95% CI: 12.33 to 18.14). Hazard identification was 10.79 higher (95% CI: 8.19 to 13.40). Dose-response assessment was -16.23 higher (95% CI: -17.63 to -14.82). Exposure assessment was 11.49 higher (95% CI: 9.87 to 13.10) and the risk characteristic was -7.46 (95% CI: -8.49 to -6.44). It was statistically significant at <.001.

Conclusion: Careless and incorrect use of pesticides by Chinese water chestnut farmers can lead to health risks from exposure to toxic substances.

Keywords: Use of pesticides; Health risks; Farmers; Water chestnut farming

Introduction

Thailand has the largest cultivation area of Chinese water chestnuts, this practice is especially well-known in Sriprachan District, Suphanburi Province (1, 2). Pesticides are widely used in the

agricultural sector to protect yield and prevent pests such as weeds, insects, shellfish, rodents, fungi, and many plant diseases. Pesticides have impacts on health and the environment (3, 4) and even put farmers and consumers at risk of poisoning (5), but farmers using them fail to recognize these problems. Thailand has one of the top three pesticide use cases in ASEAN (6), with chemical insecticides and herbicides used for monocropping in large areas like rice fields, cornfields, and Chinese water chestnut fields (7,8).

Thailand's import data shows a year-on-year trend of increasing use of pesticides. In 2015, the country imported 149,458 tons of these substances; this increased to 160,667 and 197,646 tons in 2016 and 2017, respectively (9). This puts 64.1 million Thai people at risk of exposure to pesticides at a level of more than 2.6 kilograms per person per year) (10). The country's report data on occupational disease shows that pesticide use according to food group T600 (ICD-10) results in a 12.37 sickness rate per 100,000 population. In this respect, farmers are found most frequently (37.3%), followed by hired workers (28.8%) (11,12). The careless use of agricultural chemicals by farmers is both acutely toxic and chronically poisonous, affecting the nervous system and causing cancer (13,14). It is a serious health problem for farmers caused by the use of pesticides and incorrect preventive behavior of farmers (15). There are many factors related to the use of pesticides and impacts on health, such as gender, age, educational attainment, and congenital diseases (16). Factors related to the use of pesticides include chemical type, level of chemical consumption, method, period, frequency, and use of personal protective equipment (PPE) (17,18). There are additional factors regarding knowledge, attitude, and behavior regarding pesticide use (19). In addition, there is the toxicological risk assessment of chemicals such as hazard identification, assessment response to quantity, chemical exposure assessment, and risk characterization (20,21) (Fig. 1).

Given the importance of this topic, the researchers wish to conduct a study related to the use of pesticides and the health risks faced by Chinese water chestnut farmers in Suphanburi Province. In this study, principles of risk assessment for mixed chemicals applied to the use of health risks of farmers from signs and symptoms were outlined in the study (22).

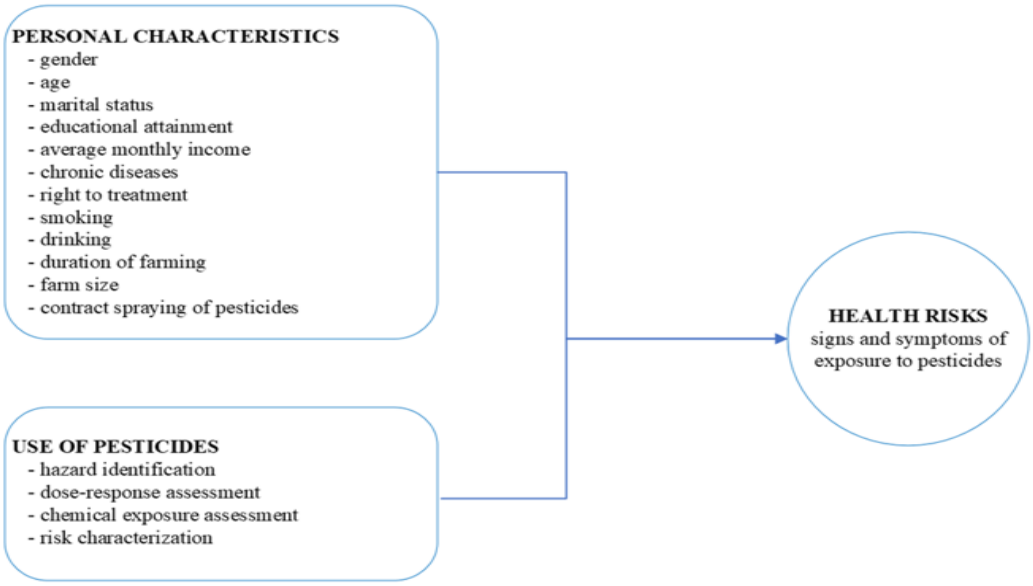

Fig. 1: The toxicological risk assessment of chemicals and health risks (20,21)

Methods

Population and Sample Group

Population - using purposive selection from 5 areas where Chinese water chestnuts are planted most from a total of 9 sub-districts in Siprachan District in 2021. Overall, 812 households was one representative each (1). The sample group size was obtained by using the Cochran formula (23).

$n = p(1-p)z^2/e^2$.

n = sample size

p = the population proportion

e = acceptable sampling error

The sample group consisted of 425 farmers in Siprachan District, Suphanburi Province (14°37'11"N 100°8'40"E) (Fig. 2).

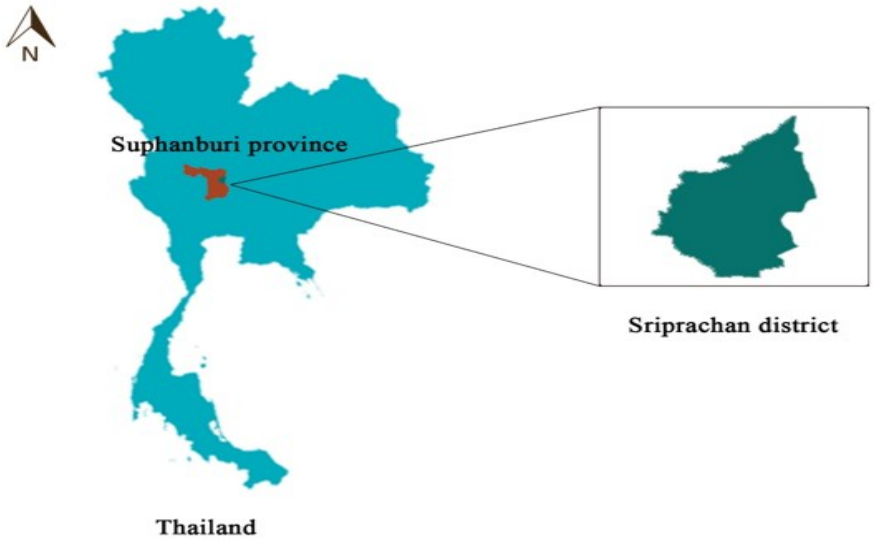

Fig. 2: Location of study area (Sriprachan district, Suphanburi Province)

Research Ethics

The participants filled out the questionnaires with their consent and cooperated with this research, and their personal information was given anonymously in the research.

Data Analysis

Data were analyzed by using SPSS software version 24.0 (IBM Corp., Armonk, NY, USA), with the statistical significance level set at .05. The following calculations were made:

1. Descriptive statistics - percentage, frequency, and standard deviation.
2. Chi-Square or Fisher's Exact Test, Relative Risk (RR), and 95% CI of RR using Multiple Linear Regression to analyze the relationship between the use of pesticides and health risks of the Chinese water chestnut farmers.

Results

Personal Characteristics

More than one-half of the respondents were males who were 28-74 yr old. The majority were married elementary school graduates. Their average monthly income range was 5,001-7,500 baht. Most of the respondents suffered from chronic disease, with high blood pressure being the most prevalent. Most had universal health insurance cards and did not smoke or drink. The farmers had been cultivating Chinese water chestnut for an average of 9.74 yr on an average farm size of 3.70 acres. Most of them did not hire workers to conduct pesticide spraying (Table 1).

Table 1: Personal characteristics of the respondents (n=425)

Personal characteristics	*N*	*%*
Gender		
Male	245	57.65
Female	180	42.35
Age (yr)		
Below 40	158	37.18
40 - 49	60	14.12
50 - 59	118	27.76
60 and above	89	20.94
Education attainment		
Elementary school (6 yr)	222	52.24
Secondary school or vocational certificate	91	21.41
Diploma or higher vocational certificate	88	20.70
Bachelor's degree or equivalent	24	5.65
Average monthly income (baht)		
Less than 5,000	112	26.35
5,001 - 7,500	122	28.70
7,501 - 10,000	81	19.06
10,001 - 12,500	71	16.71
More than 12,500	39	9.18
($\bar{X}$ = 8,717.18, SD = 2,829.18, Min = 2,400, Max = 25,000)		
Chronic disease		
No	162	38.12
Yes	263	61.88
- Diabetes Mellitus	84	31.94
- Hypertension	97	36.88
- Hyperlipidemia	40	15.21
- Chronic Obstructive Pulmonary Disease	18	6.84
- Osteoarthritis of Knee	20	7.61
- Heart Disease	4	1.52
Right to treatment		
Government official/State enterprise employee	81	19.6
Health insurance card	344	80.94
Smoking		
No	352	82.82
Yes	73	17.18
Drinking		
No	370	87.06
Yes	55	12.94
Duration of farming (years)		
Less than 5	168	39.53
5–9	48	11.30
10– 14	110	25.88
15 and above	99	23.29
($\bar{X}$ = 9.74 yr, SD = 6.054, Min = 2, Max = 27)		
Farm size (acres)		
Less than 1.98	158	37.18
1.99– 3.56	60	14.12
3.57–5.53	118	27.76
5.54 and above	89	20.94
($\bar{X}$ = 3.696 acres, SD = 5.078, Min = 0.79, Max = 8.70)		
Contracted pesticides spraying		
No	398	93.65
Yes	36	6.35

Use of Pesticides and Health Risks

According to Table 2, the respondents use pesticides at a moderate level ($\bar{X}$=3.26, SD=0.60). The following were also found at a moderate level: assessment of chemicals exposure/use of PPE ($\bar{X}$ = 3.56, SD=0.66); risk characterization/use of pesticides method ($\bar{X}$ =3.31, SD=0.77); hazard identification/type of pesticides ($\bar{X}$ =3.15, SD=0.20); and quantitative response assessment/amount, duration, and frequency of use of pesticides ($\bar{X}$=3.01, SD=0.93), respectively.

Table 2: Use of pesticides among the respondents (N = 425)

Use of pesticides	*Level of use of pesticides*		
	M	*SD*	*Description*
1. Hazardous identification - Type of pesticides	3.15	0.20	Moderate
1.1 Use of herbicides	4.82	0.47	High
1.2 Use of insecticides	4.89	0.33	High
1.3 Use of pesticides for shellfish and rodents	4.09	0.88	High
1.4 Use of fungicide and plant disease killer	4.85	0.47	High
1.5 Use of more than two types of pesticides each time	2.01	1.13	Low
1.6 Switched the types of pesticides used to prevent pesticide resistance	3.95	0.96	High
1.7 Mixing different pesticides are more effective than just one	2.14	0.89	Low
1.8 Use of natural or biological extracts instead of chemicals such as neem juice and biological fermentation	2.64	1.11	Moderate
1.9 Use of at least one of the following pesticides: paraquat (Grammoxone), glyphosate (Round Up), chlorpyrifos (Triazophos)	1.64	0.85	Low
1.10 Choose pesticides that match the type of pests	3.57	0.62	Moderate
2. Quantitative response assessment, e.g. quantity, period, and frequency of use of chemicals	3.01	0.93	Moderate
2.1 Strictly use the number of pesticides as specified on the package label	3.28	0.69	Moderate
2.2 Use of pesticides in the amount enough to spray out each time	3.01	0.90	Moderate
2.3 Use of pesticides based on one experience or habit	2.73	1.21	Moderate
2.4 Use of pesticides more than as specified by the package label for more effectiveness	2.87	1.12	Moderate
2.5 Immediately spray pesticides when plant disease and insects are found	3.67	1.43	High
2.6 Spray pesticides for not more than an hour	2.88	1.75	Moderate
2.7 Spraying pesticides for more than two hours per day on average	2.80	1.33	Moderate
2.8 Leave the time for spraying pesticides before harvesting as specified by the packaging label	2.90	1.53	Moderate
2.9 Spray pesticides often or twice a month to prevent insects and pests	2.48	1.15	Low
2.10 Spray pesticides immediately when learning that neighbor's Chinese water chestnut fields are spreading insects or disease	3.24	1.34	Moderate
3. Assessment of chemical exposure, e.g. use of personal protective equipment (PPE)	3.56	0.66	Moderate
3.1 Put on a complete set of PPE (hat, rubber gloves, face mask, apron skirt, chemical goggles, and boots)	4.27	0.73	High

3.2 Use a cloth to cover the nose and mouth instead of wearing a chemical mask when spraying pesticides	3.56	1.09	Moderate
3.3 Use chemical goggles when preparing or mixing chemicals or pesticides	3.31	0.74	Moderate
3.4 Wear rubber gloves to prevent chemical exposure when talking or pouring chemicals	3.31	0.74	Moderate
3.5 Check that PPE is in good condition before use	3.93	0.64	High
3.6 Wearing personal protective equipment is inconvenient for spraying pesticides	3.30	0.87	Moderate
3.7 Remove PPE immediately at the workplace after spraying pesticides	2.65	2.18	Moderate
3.8 Wash clothing or PPE separately from other clothing	3.40	0.56	Moderate
3.9 Wear a general mask instead of a chemical mask when spraying pesticide because it is more convenient	3.57	0.77	Moderate
3.10 Wash body with water for at least 15 min and take a soapy shower if exposed to spilled chemicals to prevent harm	3.24	0.72	Moderate
4. Risk characterization - use of pesticides method	3.31	0.77	Moderate
4.1 Read the package label carefully for instructions on how to use it, protect against danger, and cure poisoning before using	2.91	0.49	Moderate
4.2 Have been trained to use pesticides properly	2.89	1.53	Moderate
4.3 Strictly spray pesticides by the method as specified by the package label	3.20	1.43	Moderate
4.4 Blow or suck the spray nozzle when the sprayer is clogged or damaged	3.20	1.40	Moderate
4.5 Mix many kinds of pesticides in the same tank	2.31	1.35	Low
4.6 Spray pesticides in the morning or afternoon when there is no bright sunlight and always stand against the wind's direction	4.40	0.56	High
4.7 Spray pesticides in advance to prevent insects or pests	3.17	1.00	Moderate
4.8 Make an appointment to spray pesticides together with neighboring water chestnut fields to prevent or eliminate pests and plant diseases	3.29	0.65	Moderate
4.9 Do not smoke or drink alcohol while spraying pesticides	3.15	1.67	Moderate
4.10 Be careful not to let chemicals get into your mouth, nose, eyes, skin, and face while using it	4.01	0.93	High
Total	3.26	0.60	Moderate

Health risks

The respondents had a low level of health risks ($\bar{X}$=1.69, SD=0.40). Based on its details, the following was found: group I (mild), at moderate level ($\bar{X}$=2.60, SD =0.79), group II (moderate) at a moderate level ($\bar{X}$ = 1.44, SD = 0.40), and group III (severe) at a low level ($\bar{X}$ =1.05, SD=0.11).

Relationship between personal characteristics and health risks

The following variables had a statically significant relationship with health risks among the respondents: gender, age, right to treatment, smoking, drinking, duration of farming, and contracted pesticide spraying. However, marital status, educational attainment, average monthly income, chronic diseases, and farm size had no relationship with health risks (Table 3).

Table 3: Relationship between personal characteristics and health risks of the respondents (n=425)

Personal Characteristics	*Low level of health risks*	*Moderate level of health risks - High level of health risks*	x^2, *(P-value)*
	N (%)	**N (%)**	
Gender			x^2*(b)* = 45.009**
Male	175 (41.18)	70 (16.47)	*P*<0.001
Female	174 (40.94)	6 (1.41)	df = 1
Age (P_{50} = 56.00 yr)			x^2*(a)* = 4.684*
28 – 55	167 (63.77)	26 (36.17)	*P*=0.030
56 – 74	182 (36.23)	50 (63.83)	df = 1
Marital status (P_{50} = Single)			x^2*(b)* = 0.091
Single	41 (9.65)	8 (1.88)	*P*=0.846
Married, widowed, divorced, Separated	308 (72.47)	68 (16.00)	df = 1
Educational attainment (P_{50} = Elementary school)			x^2*(a)* = 2.550
Elementary school	176 (41.41)	46 (10.82)	*P*=0.110
Higher than elementary school	173 (40.71)	30 (7.06)	df = 1
Average monthly income (P_{50} = 8,500 baht)			x^2*(a)* = 2.086
1,500 – 8,500	161 (37.88)	42 (9.88)	*P*=0.149
8,501 – 25,000	188 (44.24)	34 (8.00)	df = 1
Chronic disease			x^2*(a)* = 1.644
No	166 (39.06)	30 (7.06)	*P*=0.200
Yes	183 (43.06)	46 (10.82)	df = 1
Right to treatment (P_{50} = Health insurance card)			x^2*(a)* = 7.532*
Health insurance card	291 (68.47)	53 (12.47)	*P*=0.006
Other rights	58 (13.65)	23 (5.41)	df = 1
Smoking (P_{50} = No smoking)			x^2*(b)* = 292.335**
No	340 (80.00)	12 (2.82)	*P*<0.001
Yes	9 (2.19)	64 (5.41)	df = 1
Drinking (P_{50} = No drinking)			x^2*(b)* = 240.998**
No	345 (81.18)	25 (5.88)	*P*<0.001
Yes	4 (0.94)	51 (12.00)	df = 1
Duration of water chestnut farming (P_{50} = 9.00 yr)			x^2*(a)* = 3.941*
2 - 9	177 (41.65)	29 (6.82)	*P* = 0.047
10 - 27	172 (40.47)	47 (11.06)	df = 1
Farm size (P_{50} = 2.77 acres)			x^2*(a)* = 0.601
0.79 - 2.77	162 (38.12)	39 (9.18)	*P*= 0.438
2.78 - 6.32	187 (44.00)	37 (8.70)	df = 1
Contracted pesticides spraying			x^2*(b)* = 50.053**
No	335 (78.82)	54 (12.71)	*P*< 0.001
Yes	14 (3.29)	22 (5.18)	df = 1

******P*-value < 0.01, **P*-value <) 0.05by Chi-Square test)

x^2)a) = Pearson Chi-Square, x^2)b) = Fisher's Exact Test

Relationship between use of pesticides and health risks of the respondents

The respondents were at risk who did not have health risks. Based on its details, the use of pesticides has positive health risks including hazard identification and exposure assessment. However, use of pesticides having health risks in the opposite direction included dose-response assessment and risk characterization with a statistical significance level (*P*-value<0.001) (Table 4).

Table 4: Relationships between the use of pesticides and health risks of the respondents

Use of pesticides	*Unstandardized Coefficients*		*Standardized Coefficients*	*t*	*Sig.*	*95% Interval for B*	*Confidence*
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant) Reference*	15.57	1.477		10.311	.000	12.33	18.14
• Hazard identification	10.79	1.325	.17	8.148	.000	8.19	13.40
• Dose-response assessment	-16.23	.716	-1.18	-22.677	.000	-17.63	-14.82
• Exposure assessment	11.49	.820	.59	14.006	.000	9.87	13.10
• Risk characterization	-7.46	.520	-.45	-14.36	.000	-8.49	-6.44

*Health risks of the respondents based on signs and symptoms due to exposure to pesticides

Discussion

The use of pesticides by Chinese water chestnut farmers in Sriprachan District, Suphanburi Province had a relationship with their health risks at a moderate level ($\bar{X}$ = 3.26, SD = 0.60) (10). Most of the farmers were at risk from the use of pesticides at a moderate level. As a whole, the health risks of the farmers in the Sriprachan District based on signs and symptoms due to exposure to pesticides were at risk 15.57 times those having no health risks with a statistical significance level (<0.001). This was consistent with the hypothesis of the set.

Use of pesticides on hazard identification: the type of pesticides had a positive relationship with health risks (10.79 times). This could be explained by the fact that most Chinese water chestnut farmers in Sriprachan District preferred the use of insecticide and herbicide. They used insecticide at a high level ($\bar{X}$ = 4.89, SD = 0.33) and followed by herbicide ($\bar{X}$ = 4.82, SD = 0.47) (15), which left most farmers at risk from exposure to insecticides and herbicides. Chemical toxicity depends on the chemical properties or comments of a particular chemical. Hence, it may affect health risks from signs and symptoms.

Quantitative response assessment included amount, times span, and frequency of use of pesticides having relationships with health risks in the opposite direction (-16.23 times). Health risks due to signs and symptoms caused by the use of pesticides of the farmers' group have fewer risk factors than those without risk factors. These are considered protective factors. In other words, the farmers using pesticides in customized quantities, not as specified by the package table and those spraying immediately when insects or plant diseases are found can be observed at a high level ($\bar{X}$ = 3.67, SD = 1.43). This is followed by those spraying pesticides immediately when finding that water chestnut fields of neighbors have an outbreak of diseases or insects ($\bar{X}$ = 3.24, SD = 1.34). This will be more health risks from using pesticides than farmers who use chemicals at the specified rate by the package level (10) which found that farmers are at risk of using pesticides in large quantities and having long exposure are at the greatest risk. This is particularly on the overuse of chemicals.

Assessment of chemical exposure including the use of PPE has a positive relationship with health risks (11.49 times). This can be explained that most farmers completely were PPE (i.e., hat, rubber gloves, mask face, chemical apron shirt, chemical goggles, and boots) when using pesticides and it is found at a high level ($\bar{X}$ = 4.27, SD = 0.73). This is followed by checking PPE before using it ($\bar{X}$ = 3.93, SD = 0.64). This results in a low level of risk of chemical exposure (10), found that inappropriate wearing of PPE is at risk most. Moreover, academic data indicate that

the nature of toxicity depends on the do received a period of exposure in areas exposed to chemicals, and little self-defense of farmers. Moreover, the pesticide prevention behaviors of the farmers are at the least average mean score ($\bar{X}$ = 1.86, SD = 0.41) (16).

Risk characterization - use of pesticide method has a relationship with health risk in the opposite direction (-7.46 times). The farmers have their use of pesticides method. They mostly spray pesticides in the morning or late afternoon when there is no bright sunlight (standing against the wind direction) and it is found at a high level ($\bar{X}$ = 4.40, SD = 0.56). This is followed by being careful not to let the chemical enter the mouth, nose, eyes, or sleep into the skin or face when using it ($\bar{X}$ = 4.01, SD = 0.93) (19) which found that farmers perceive the risks of pesticides while mixing them with bare hand and using more chemicals than the label says. More than 64.90% find that having a lot of pests is a high chance of getting the chemical into the body. They perceive this risk through shop suggestion, package label, and their self-practice method (12), found that the use of pesticides has a negative relationship with farming size and the period of farmers (r = -0.548). However, it does not conform to a study (10) which showed that the use of pesticide traits in the cultivation of farmers is very risky but in the positive direction 2.36 times of those not engaged in cultivation.

Conclusion

The overall use of pesticides among Chinese water chestnut farmers was at a moderate level. The use of pesticides compared to the health risk of farmers' exposure from signs and symptoms, and the overall pesticides use increased by 15.57 higher risk than that of the farmers who had no health risks. Therefore, health officials and related parties should be monitored for the impact on farmers' health with appropriate risk mitigation management to ensure the safety of using pesticides, especially for high-risk farmers.

Journalism Ethics considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Conflict of interest

The authors declare that they have no competing interests.

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