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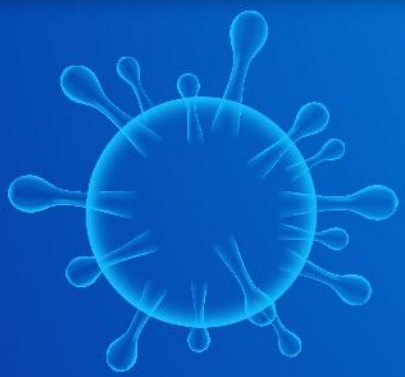

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The effect of atorvastatin on macular pigment optical density: experimental study

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ABSTRACT

Introduction: Low-density lipoprotein (LDL)- and high-density lipoprotein (HDL) cholesterol are serum lipoproteins involved in the transportation of lutein and zeaxanthin to the retina to serve as macular pigments (MPs). Atorvastatin, a serum cholesterol-lowering agent, can affect the MP distribution and reduce macular pigment optical density (MPOD). MPOD is one of the best indicators of retinal diseases such as age-related macular degeneration. **Objective:** To study the effect of atorvastatin on the level of MPOD in people taking atorvastatin 10 mg for more than 6 months. **Methodology:** An experimental study was conducted on 44 Asian men and women, aged between 30 and 60 years and residing in Thailand, who were recruited and divided into two equal groups. The first group was currently taking atorvastatin 10 mg for at least 6 months, whereas the control group did not receive atorvastatin. MPOD was measured in all participants using the macular pigment screener-II. Participants were required to sign an informed consent form and complete questionnaires regarding various factors that may influence the MPOD. Data were analyzed using the Kolmogorov–Smirnov test and t-test to compare the MPOD between groups. **Results:** The mean MPOD of the experiment group was 0.3295 ± 0.1311 DU, whereas that of the control group was 0.4686 ± 0.1491 DU. The mean MPOD of the experimental group was significantly lower than that of the control group (p-value = 0.002). **Conclusion:** Patients taking atorvastatin had a lower MPOD than those who did not.

Keywords: *Macular pigment optical density, Hypercholesterolemia, LDL cholesterol, Atorvastatin*

Introduction

Hypercholesterolemia is a form of dyslipidemia that indicates an increased level of low-density lipoprotein cholesterol (LDL-C) in the serum. Compared to other middle-income countries in Asia, Thailand is among the countries with the highest unawareness rate regarding hypercholesterolemia at 78.0% in 2004, with a low level of treatment and control [1]. The Third Adult Treatment Panel (ATP III) states that different people have different cutoff levels of serum cholesterol depending on their cardiovascular risk levels [2]. In 2018, approximately 28.5 million adults (≥20 years) had total cholesterol levels ≥240 mg/dL with an overall prevalence of 11.9% globally [3]. The diagnosis of hypercholesterolemia is mainly based on fasting blood cholesterol levels. The National Cholesterol Education Program (NCEP) stated in the ATP III that an LDL-C level <100 mg/dL should be classified as the optimal level. A serum LDL-C level of 160–189 mg/dL is considered high, and >190 mg/dL indicates very high or severe hypercholesterolemia [4]. Table 1 shows the classification of LDL, high-density lipoprotein (HDL), and total cholesterol levels.

Table 1 ATP III classification of LDL- and total cholesterol [5]

LDL cholesterol (mg/dL)	
<100	Optimal
100–129	Near optimal/above optimal
130–159	Borderline high
160–189	High
≥190	Very high
Total cholesterol (mg/dL)	
<200	Desirable
200–239	Borderline high
240	High
HDL cholesterol (mg/dL)	
<40	Low
>60	High

High cholesterol levels can lead to the dangerous accumulation of cholesterol and other deposits on arterial walls, resulting in atherosclerosis, which reduces blood flow and leads to serious

complications such as carotid artery disease, coronary artery disease including angina and heart attack, peripheral artery disease, and stroke. Studies have shown that serum cholesterol levels play a crucial role in cardiovascular disease-related mortality. It has also been claimed that a low dietary intake of fat and low serum cholesterol levels promote lower mortality from coronary heart disease and a lower risk for certain cancers [6]. According to the expert panel of various data analyses, clinical practice recommends the control of blood cholesterol levels to reduce the risk of atherosclerotic cardiovascular disease (ASCVD). Healthy diet and/or lifestyle modifications are recommended as standards of care in the management of blood cholesterol levels [7]. Controlling the related risk factors, such as hypertension and lifestyle changes, especially avoidance of smoking, should be adapted. The 2013 American Heart Association guideline on the treatment of blood cholesterol has classified statin therapy into high intensity, moderate intensity, and low intensity. One trial revealed that the crucial factor in reducing ASCVD events was the timely initiation of moderate-intensity therapy, which is targeted to lower LDL cholesterol by approximately 30.0% to <50.0%, or high-intensity statin therapy, which lowers LDL cholesterol by ≥50.0% [8].

Atorvastatin is one of the most commonly used statins, and its primary site of action is the liver, where the majority of both cholesterol synthesis and LDL clearance take place. It can effectively lower total cholesterol by 27.0%–37.9%, LDL cholesterol by 37.1%–51.7%, and triglycerides by 18.0%–28.3% when used within the recommended dosage range of 10–80 mg/day. The extent of LDL level reduction correlates with the dosage of atorvastatin used [9]. Atorvastatin has been proven to have higher efficacy and potency in lowering LDL cholesterol levels than simvastatin, which is commonly used in some countries [10].

The macular pigment (MP) protects the retina from oxidative damage by absorbing short-wavelength blue light, which is harmful to the eye [11]. It is mainly located in the fibers of Henle in the fovea and in the inner part of the parafoveal site [12-13]. The dietary hydroxy carotenoids lutein and zeaxanthin are the main components of MP [14]. The protective role of the MP in some ocular diseases, such as age-related macular degeneration, has been well studied [11, 15]. Several studies have investigated the influence of social factors such as age, sex, body mass index (BMI), eye color, and other environmental factors on the macular pigment optical density (MPOD) value. The study described that females tend to have higher MPOD values than that in men of the same age group [16-17]. Although the decline in MPOD with age is still questionable, older populations, particularly those aged ≥60 years, have been proven to have lower MPOD values than that in younger age populations [16]. A lower value was observed in people with a higher BMI [16-17]. Due to the lesser amount of melanin density present, the lighter iris color has a lower MPOD value [16-17].

MPOD measures the amount of blue light attenuation of the MP in the retina. It is directly related to the amount of integrated macular carotenoids, lutein and zeaxanthin, over the region of MP deposition. MPOD is usually described in optical density level or density units (DUs), and the normal range in the center of the macula is from 0 to 1 [19]. The central MPOD value >0.5 DU is considered high range; 0.5–0.25 DU, mid-range; and <0.25 DU, low range. The macular pigment screener-II (MPS-II), also known as MPS9000 (Figure 1), is a recently introduced device to measure MPOD for the screening and detection of ophthalmic diseases such as age-related macular degeneration [20].

Figure 1 The MPS-II device (L); the view through eyepiece (R)

The device has two test modes: (1) standard mode, which is a central test that estimates the MPOD value by comparing it with age normative data, and (2) detailed mode, which is a central plus peripheral test to determine the absolute MPOD value. The detailed mode is usually performed in patients who do not conform to age normative data, for example, patients with diabetes or those with other conditions that change the transmission of the ocular lens. In this study, only the standard mode was used in one eye.

Association of LDL cholesterol and transport of lutein and zeaxanthin

Circulating lipoproteins can be classified into six groups: very-low-density lipoproteins (VLDLs), intermediate-density lipoproteins (IDLs), LDLs, HDLs, chylomicrons, and chylomicron remnants. Lipoproteins are usually associated with high-affinity receptors on the cell surface to be transported in the body and regulate lipid metabolism [21]. Lipoproteins are responsible for the transport of plasma carotenoids into the body. Fifty-five percent of total carotenoids are transported on LDLs, whereas 33.0% are associated with HDLs and only 10.0%–19.0% with VLDLs [22]. This finding suggests that MP may be influenced by the delivery and distribution of carotenoids to the retina by an individual's lipoprotein and lipoprotein profile in the blood [23].

Since the main effect of statins is the reduction in the serum cholesterol level, which is one of the main

factors in transporting MPs to the retina, patients taking long-term statin therapy are believed affect the MP distribution and, in turn, lower the MPOD value. Several studies have investigated the relationship between statins and MPOD. One study on simvastatin stated that MPOD was significantly lower with a longer duration of statin use [24].

Methodology

Study design and study population

An experimental study was conducted to compare the mean MPOD. A total of 44 volunteers were divided into two groups—experimental and control—with 22 participants in each group. The experimental group included patients aged 30–60 years who were currently taking atorvastatin for >6 months. The control group included healthy individuals within the same age range. Those who were using lutein and zeaxanthin supplementation were excluded from the study. Patients with age-related macular degeneration and other related ocular diseases such as glaucoma, cataract, optic nerve atrophy, diabetic retinopathy, previous lasers or surgery to the retina, and previous eye trauma were also excluded. Furthermore, patients with serum blood cholesterol >190 mg/dL and those with other comorbidities such as diabetes mellitus, myocardial infarction, stroke, liver dysfunction or renal impairment, autoimmune disease, hyperthyroidism, hypothyroidism, or malignant tumors were excluded from the study. Patients with difficulties in performing the flicker sensitivity test of the MPS-II were allowed to withdraw from the study.

Research procedure

Participants were divided into two groups: the experimental group, who received atorvastatin 10 mg for >6 months, and the control group, who did not receive atorvastatin. They were given a complete questionnaire to rule out the exclusion criteria. Questions were developed based on the factors that were related to the level of MPOD, such as participant characteristics, lifestyle, dietary habits, and environmental factors. Before conducting the MPOD measurement, instructions on how to perform the test on the MPS-II were explained to all participants. Each participant took approximately 60–90 s for the test to be done.

Ethical consideration and statistics

This study was approved by the Mae Fah Luang University Committee on Human Research in compliance with international guidelines such as the Declaration of Helsinki, the Belmont Report, the council for international organizations and medical science (CIOMS) guidelines, and the International Council for Harmonization of Technical Requirements for Pharmaceuticals for Human Use–Good Clinical Practice (COA: 171/2020). The MPS-II device is approved by the Thai Food and Drug Administration and has been proven to have little or no danger to the user during or after measurement. The results of the study were only provided to the participants and kept confidential. The patients participated voluntarily without any payment or charge on the tests and instruments. All volunteers had an equal chance of testing their MPOD levels.

The test results were analyzed using the SPSS (2016, IBM Corp., Armonk, NY, USA) software. Data were reported using frequency for categorical variables and mean and standard deviation for continuous variables. The Kolmogorov–Smirnov test was used to test the normal distribution, and the t-test was used to compare the MPOD values between the case and control groups.

Results

General characteristic of participants

The general demographic data of the 44 participants were recorded and analyzed using descriptive statistics (Table 2).

Table 2 Participants' demographic characteristics

Demographic	Experimental (n=22)	Control (n=22)
Sex		
Male	12	9
Female	10	13
Age (years)		
Mean ± SD	44.00 ± 9.84	36.64 ± 6.49
Min–max	30–60	30–54
Smoking, n (%)		
Yes	8	3
No	14	19
Alcohol drinking, n (%)		
Yes	8	3
No	14	19
Physical activity, n (%)		
Yes	8	11
No	14	11
Drug allergy, n (%)		
Yes	1	0
No	21	22
Skin sensitivity		
Yes	2	0
No	20	22
Strong sunlight exposure		
Yes	0	0
No	22	22
Sunglass usage		
Yes	1	0
No	21	22
Screen usage (h/day)		
Mean ± SD	7.18 ± 2.11	8.36 ± 1.33
Min–max	4–10	6–10
Eye color, n (%)		
Dark Brown	12	13
Brown	10	9

The experimental group consisted of 12 males and 10 females with a mean age of 44.0 ± 9.8 years. Eight participants smoked, 8 participants used alcohol, and 8 participants engaged in physical activity. Furthermore, two participants had skin sensitivity, no participant was exposed to strong sunlight, and one participant regularly wore sunglasses. The mean screen use time was 7.1 ± 2.1 h/day. Most participants had dark brown color, and 10 had a brown color.

The control group consisted of 13 females and 9 males, with a mean age of 36.6 ± 6.4 years. Three participants smoked, 3 participants used alcohol, and 11 participants engaged in physical activity. None of the participants had skin sensitivity, was exposed to strong sunlight, and wore sunglasses regularly. The mean screen use time was 8.3 ± 1.3 h/day. Most participants had a dark brown color, and 9 were brown in color.

Table 3 Underlying disease and treatments apart from hyperlipidemia

Factor	Experimental	Control
Underlying disease, n (%)		
Hypertension	8 (36.4%)	1 (4.5%)
Diabetes mellitus	8 (36.4%)	7 (31.8%)
Heart disease	4 (18.2%)	0 (0.0%)
Metabolic syndrome	0 (0.0%)	0 (0.0%)
Gout	3 (13.6%)	0 (0.0%)
Osteoarthritis	1 (4.5%)	0 (0.0%)
Dementia/Alzheimer	0 (0.0%)	0 (0.0%)
Migraine	0 (0.0%)	0 (0.0%)
Glaucoma	0 (0.0%)	0 (0.0%)
Cataract	0 (0.0%)	0 (0.0%)
Eye trauma	0 (0.0%)	0 (0.0%)
AMD	0 (0.0%)	0 (0.0%)
Diabetic retinopathy	0 (0.0%)	0 (0.0%)
Diabetic macular edema	0 (0.0%)	0 (0.0%)
Operation/treatment to the eye, n (%)		
Other major operation	3 (13.6%)	0 (0.0%)
Other minor operation	3 (13.6%)	0 (0.0%)

A family history of hypertension (n = 8), diabetes mellitus (n = 8), and heart disease (n = 4) was noted; three participants had gout, and one had osteoarthritis. Other major operations (n = 3) and other minor operations (n = 3) were performed, and no surgery or treatment of the eye in any participant. For those in the control group, a family history of diabetes mellitus and hypertension in 7 and 1 participant, respectively. None of the participants underwent surgery or treatment of the eye or other major and minor operations (Table 3).

Sixteen participants eat fruits and veggies, 14 eat eggs, and 12 eat oily fish. The participants were found to take omega-3 fish oil (n = 13), vitamin C (n = 12), vitamin D (n = 8), astaxanthin (n = 6), CoQ10 (n = 5), multivitamins (n = 1), and other supplements (n = 1). An equal number of participants took medications for <12 months (n =11) and ≥12 months (n =11). In the control group, 17, 16, and 16 participants were found to eat oily fish, fruits and veggies, and eggs, respectively. The participants were found to take vitamin C (n = 14), omega-3 fish oil (n = 8), multivitamins (n = 7), vitamin D (n = 7), CoQ10 (n = 3), vitamin B (n = 2), and astaxanthin (n = 2) (Table 4).

Table 4 Supplements and medications

Factors	Experimental (n=22)	Control (n=22)
Fruits and veggies	16	16
Eggs	14	16
Oily fish intake	12	17
Lutein and zeaxanthin	0	0
Multivitamin	1	7
Vitamin B	0	2
Vitamin C	12	14
Vitamin D	8	7
Astaxanthin	6	2
Omega-3 fish oil	13	8
CoQ10	5	3
Other supplements	1	0
Duration of taking atorvastatin 10 mg/day		
<12 months	11	–
≥12 months	11	–

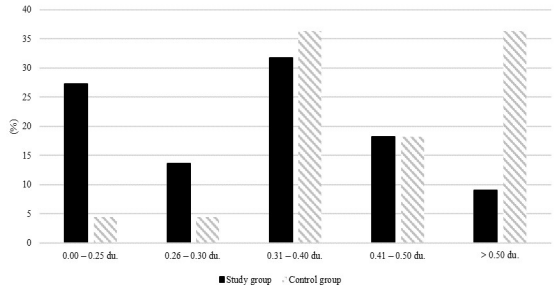

Figure 2 The comparison of MPOD values between groups

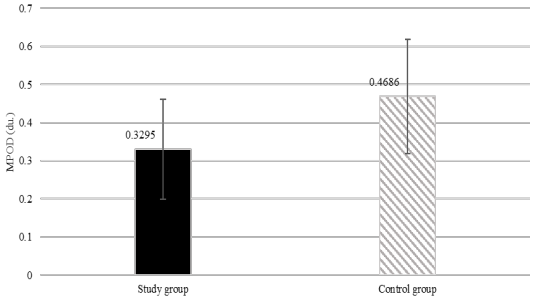

Figure 3 The comparison of MPOD values between groups

Figure 2 show the results of the MPOD comparisons of participants who received atorvastatin 10 mg for at least 6 months in the experimental and control groups.

In the experimental group, the MPOD level was 0.26–0.50 DU (mid-range) in 14 participants, followed by 0.00–0.25 DU (low-range) in 6 and >0.50 DU (high

range) in 2. In the control group, the MPOD level was 0.26–0.50 DU in 13 participants, followed by >0.50 DU in 8 and 0.00–0.25 DU in 1.

The mean MPOD in the experimental group was 0.32 ± 0.13 DU (min–max, 0.05–0.58). For the control group, it was 0.46 ± 0.14 DU (min–max, 0.24–0.86). Comparing the MPOD between the experimental and control groups, the mean MPOD in the experimental group was significantly lower than that in the control group (p-value = 0.002). A significant reduction in MPOD levels was observed in patients taking atorvastatin 10 mg for at least 6 months (Table 5 and Figure 3).

Table 5 Statistical analysis of MPOD between groups

Group	n	Mean	SD	Min–max	t	df	p-value
Experimental	22	0.32	0.13	0.05–0.58	−3.285	42	0.002*
Control	22	0.46	0.14	0.24–0.86			

p-values are determined using the independent t-test.

*p-values = 0.05 were considered statistically significant.

Discussion

Our findings were consistent with those of a previous study showing that MPOD was significantly lower in patients using statins for >1 year than that in non-statin users [25]. Moreover, one study revealed that patients using atorvastatin had lower MPOD values than that in simvastatin users, suggesting that the type of statin and the duration of treatment play a significant role in the MPOD values. This may explain the controversial point from a previous study conducted in patients receiving simvastatin, in which the results showed no significant difference in MPOD in patients taking simvastatin 10 mg for 6–12 months and normal patients [24].

A previous study showed that MPOD values were influenced by several physical and environmental factors such as age, sex, BMI, eye color, diet, physical activity, and amount of screen time or exposure to blue light [26]. MP density also showed correlations with lutein and zeaxanthin in relation to serum lipid levels [26].

Serum lipoproteins, especially LDL, are one of the main components of the transport of carotenoids to the retina as MPs. Atorvastatin, a lipid-lowering agent that can reduce LDL by 37.1% to 51.7% in the blood, possibly decreased the distribution of MPs, leading to a reduction in MPOD value. Decreased MPOD value can cause decreased visual acuity, less contrast sensitivity, slower glare recovery, and reduced light sensitivity and is an important risk factor for age-related macular degeneration, which can cause irreversible blindness. A comparative study between atorvastatin and simvastatin showed that atorvastatin is more potent and effective than simvastatin [10].

Therefore, it is advantageous for patients taking statin drugs to be aware of the risk of macular degeneration and blindness. Health education on eye care should be provided to all patients on long-term statins such as eating lutein- and zeaxanthin-rich foods, including green leafy vegetables, carrot, pumpkin, corn, and eggs, or taking lutein and zeaxanthin supplementations. Regular eye check-ups including MPOD measurements should be performed for the early detection of reduced MPOD values and prevention of age-related macular degeneration.

Conclusion

The mean MPOD in patients using atorvastatin 10 mg for at least 6 months (0.32 ± 0.13 DU) was significantly lower than that in the control group (0.46 ± 0.14 DU). The duration of medication administration in the experimental participants taking atorvastatin 10 mg varied from 6 months to 20 years. Assessment of the risk associated with long-term statin use will be beneficial, including a controlled, prospective clinical trial with exact dietary and/or lifestyle modifications and supplemental trials, and further investigations on the serial measurement of serum lutein and zeaxanthin and MPOD in patients taking statins are necessary.

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Deaths on shrimp farm from suspected hydrogen sulfide poisoning in the confined well: Experienced people also being at risk

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ABSTRACT

Introduction: On 6 September 2020, the joint investigation team of the Department of Disease Control, Thailand, was notified about the death of three informal workers in a water well on a shrimp farm in Prachuap Khiri Khan Province. **Objective:** The objectives were to verify the diagnosis of the event, to describe epidemiological characteristics of the cases, to identify risk factors of the event, and to assess knowledge, attitude and practice (KAP) on the risk of working in water wells among the villagers. **Methodology:** We conducted a cross-sectional questionnaire survey to identify the event's risk factors and assess KAP of the villagers concerning the experiences of working in water wells. Chi-square test was performed. **Results:** The index case's most likely cause of death was hydrogen sulfide (H_2S) poisoning, followed by drowning. The main fatality risk was a lack of knowledge and insufficient awareness of the danger of working in water wells, especially among those with prior experience of working in water wells. **Conclusion:** Occupational safety regulations and guidelines need to be developed and enforced to protect workers operating in the wells. Mitigation strategies included the avoidance of work in confined spaces as much as possible, and using proper engineering techniques for rescuing the victims if needed.

Keywords: *confined space, drowning, hydrogen sulfide, informal worker, shrimp farming*

Introduction

In Thailand, about one-third of the population working in the agricultural sector [1]. Shrimp farming causes a major export earning in Thailand, especially in the coastal provinces. It is estimated that Thailand supplies 20% of the world trade in shrimps and prawns [2]. Some shrimp farms in Thailand use polyethylene (PE) plastic to cover the pond areas to increase shrimp production [3]. This system comes with a specific waste-water well system that needs an ultra-deep water well. In this regard, the water well is identified as a 'confined space' in the farm. Confined spaces can create hazardous conditions such as asphyxia, sink, fall, trap to those inside the space. Asphyxiants are gases that displace oxygen from the air (simple asphyxiant), or interact with the body system (chemical asphyxiant) [4-5]. Serious occupational accidents in confined spaces have been reported from time to time. According to the Event-based Surveillance (EBS) database of the Department of Disease Control (DDC), the Ministry of Public Health (MOPH), during 2003-2018, of 62 events, two-third occurred in agriculture settings. The case fatality rate in confined spaces was extremely high (61.9%). Most events had secondary victims who went to help primary victims [6].

On 6 September 2020, the joint investigation team of the Division of Epidemiology, DDC, MOPH, Thailand, was notified by the Situation Awareness Team (SAT) about the deaths of three workers on a shrimp farm in Sam Roi Yod District, Prachuap Khiri Khan Province, Thailand. The objectives of this study were to verify the diagnosis of the victims, to describe epidemiological characteristics of the cases, to identify

risk factors of the event and to assess knowledge, attitude and reported practices related to the risk of working in a confined space among informal workers.

Deputy District Chief (for instance, those living further from the Hall or migrant workers who did not understand Thai message). Besides, although the summon of villagers by the Deputy District Chief was a practical approach, it hampered our attempt to perform probability sampling on the populations. Lastly, the answer in the questionnaire might not necessarily be the same as the actual practices of the villagers.

For recommendations, the foremost principle is to reduce the number of confined spaces as much as possible. If the water well needs to exist, limiting the exposure to the confined space is strongly recommended, for instance, prohibiting people entering the well by using a lever to operate the water valve from outside instead of manual operating. For personal level, a proactive health education should be conducted to enable the workers and the villagers to be aware of the danger of injury in confined spaces [24]. A preparation of proper rescue equipment for non-entry rescue technique is suggested. This needs to implement alongside the availability of trained rescue personnel. For the farm owner, flushing the water out of the well for evert 3-5 days is useful. Placing a warning sign and fencing the well opening also help prevent future events to some extent. In addition, the regulations and guidelines for occupational safety on the work in confined spaces (including agricultural well) among informal workers should be developed. The Division of Occupational and Environmental Diseases of the Thai DDC should take a lead in this proposal. Further studies that explore the KAP on the head-to-reach people including migrants are recommended

Methods

We conducted a cross-sectional study on 6-7 September and 27-29 October, 2020. A case was defined as any person working in a water well on the shrimp farm on 5 September 2020 and had at least one of the following symptoms: headache, syncope, dizziness, nausea, difficulty of breathing, or death. Medical records of the deaths were reviewed. We also interviewed with the medical staff and the event witnesses.

The environmental survey of the shrimp farm in which this event occurred was conducted. We observed the water pumping system on the farm. We conducted a gas measurement by QRAE-II diffusion multi-gas monitor at different depths of the well. The gas detector was able to measure oxygen (O_2), carbon monoxide (CO), hydrogen sulfide (H_2S), and the lowest explosive limit (LEL) of combustibles.

We then surveyed knowledge, attitudes, and practices (KAP) about work experience in agricultural wells among the villagers in Sam Roi Yod District. The survey was conducted during the public gathering called by the Deputy District Chief. We hypothesized that people who were used to working in the well might have different risk perceptions compared those without or with little experience. Therefore, we divided meeting participants into two groups – 1) experienced people: well owners or those having experience in entering the water wells and 2) non-experienced people: participants who were not well owners or those who had never entered the wells. We excluded health care workers or village health volunteers in the analysis. We tested the face validity of the questionnaire with a few villagers before the meeting date. The survey questionnaire consisted of four parts. The answers were “yes” or “no” in the first two parts. Part 1 aimed to evaluate knowledge of danger recognition (e.g., “the Are agricultural wells a confined place?”, and “Can a well that is less than 3-meters deep cause hypoxia?”). Part 2 measured knowledge on self-protection (e.g., “Well that never had an event/accident before is still dangerous,” and “If sewage is present, you should not enter the well.”). Part 3was an assessment of attitudes on self-protection strategies. The answers were “agree,” “disagree,” and “not sure” (e.g., Death in confined space is preventable). The last part (Part 4) examined practices or experiences of entering an agricultural well. The questions focused on symptoms that might occur while entering the well. The participants were recruited by convenience sampling during the meeting at the district hall 28 October 2020. We scored the answers of each participant and assessed the percentage of participants that showed the correct answers. A Chi-square test was used to compare the percentage of correct answers between the experienced and non-experienced participants.

Results

Description of the event

On 5 September 2020, the event occurred among five Myanmar males (Workers A-E). Three of these five cases died. The median age was 30 (min, max = 25, 33) years. Worker A went into the well to turn on a water valve. None of them wore respiratory protective devices. Then the water came out strongly and the sewage splashed. The witnesses reported that the victim rushed climbing up the ladder but soon became unconscious and fell into the water. Five minutes later, workers B and C climbed down to rescue the primary case but they were untrained rescuers. Workers B and C both fell into the water. They struggled for a while before drowning. Workers A, B and C were brought

out by workers D and E who went to rescue. An ambulance arrived 30 minutes later as the Myanmar witnesses could not remember the ambulance hotline until a Thai worker who could recall the hotline came to the scene. Workers A and C were declared dead on the scene by the emergency medics. Worker B was transferred to Sam Roi Yod Hospital. The physician at the emergency room declared worker B dead after cardiopulmonary resuscitation for half an hour. Chest radiography showed diffuse ground-glass and multifocal patchy opacities in both lungs. The doctor found that foul water came out from mouth and nose of worker B. The electrolyte test of the death cases showed acute metabolic acidosis and hyperkalaemia. Workers D and E informed that they experienced eye and nose irritation while entering the water well. The survived cases entered the well to help the victims while tying the rope around their body as a lifeline.

Environmental study

The victims worked in one of the costliest shrimp farms in the province. The farm contained 18 ponds, all of which were covered by PE plastics. The well that the event took place is used to circulate water from one shrimp pond to another every 8-10 weeks. The reuse of drained water from the pond bottom was designed to keep essential minerals in the water. Since there was no rain for a few months prior to the event, the water in the well became stagnant and consisted of composed of mud, sludge, and biofloc (plankton, protozoa, heterotrophic bacteria). The well was ten-meter deep and three-meter wide. There were two water valves at the bottom. To operate the valve, the worker needed to climb down to open the valves manually. The water system model is shown in Figure 1.

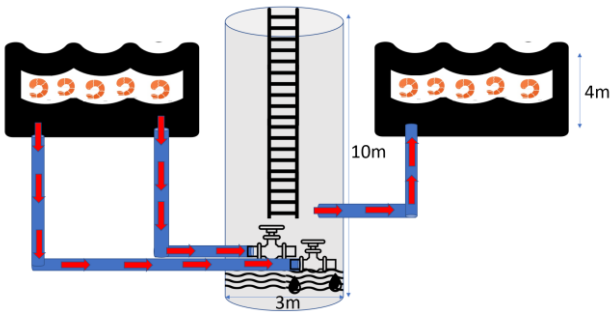

Figure 1 Water-circulating system in the shrimp farm

The dead victims had experience of entering the well before. On the event day, the witnesses mentioned that they noticed a foul smell and bubbling from the water inside the well and the scent became more robust once the index case opened the valve. In the nearby villages, the majority of occupations were agriculture and fisheries, so that most informal workers were Thai. The farm is only one PE shrimp farming in the district; most shrimp farming was non-intensive farming.

Laboratory study

We conducted gas measurements twice. The first attempt was on the following day after the event. The second attempt took place two months later as we tried to simulate the water condition of the event date. However, for the first attempt, the well owner had drained the water just before we arrived. In the second attempt, there was heavy rain a week prior to the measurement. This made the water become diluted and rose to the level of the well opening.

Survey on the residents in the community

Fifty-four participants attended the survey. All were Thais. Male to female ratio was 1:1.1. Most of them were farmers (76%). The median age was 46 years (P25, P75 = 38, 52). The low percentage of correct answers in both experienced and non-experienced people was found in certain questions: “combustible gas can cause injury or death in confined spaces”; “any accidents in confined spaces can cause injury or death”; “a well that is less than 3-meter deep can cause hypoxia”; and “confined space can be any space that has limited entrance/exit”. Experienced people appeared to misunderstand some issues. For instance, some experienced respondents answered that “an agricultural well was not a confined place” or “a well that had never had an event/accident before is safe”. Some experienced respondents reported that they would definitely enter a confined space to help the victims unconscious, Figures 2-3.

Figure 4 demonstrates that most of the respondents agreed that “death in confined spaces is preventable”. They concurred that feasible strategies in the community context were to prepare at least two helpers to be available at the entrance. However, only half of the experienced respondents agreed not to enter the confined space in any conditions.

Discussion

This study confirmed the presence of confined-space deaths in the well in a shrimp farm. Three Myanmar migrant workers died. The possible cause of death of the first case could be due to H_2S poisoning followed by drowning; while, the other two secondary victims died due to drowning. The main fatality risks of this event might be insufficient awareness, lack of knowledge, improper rescue technique, and unpreparedness of the protective equipment. The survey on KAP showed that experienced people were complacent about the dangers in the well. This study is probably the first reported outbreak in a shrimp farm. This event corresponded with the prior events reported

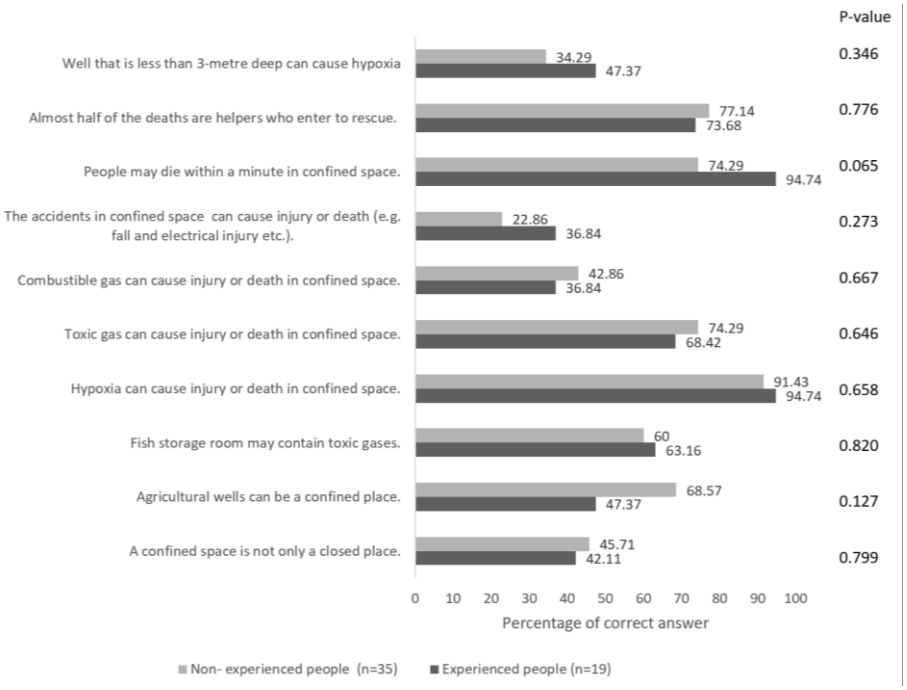

Figure 2 Percentage of correct answers between experienced and non-experienced people about the work in water wells

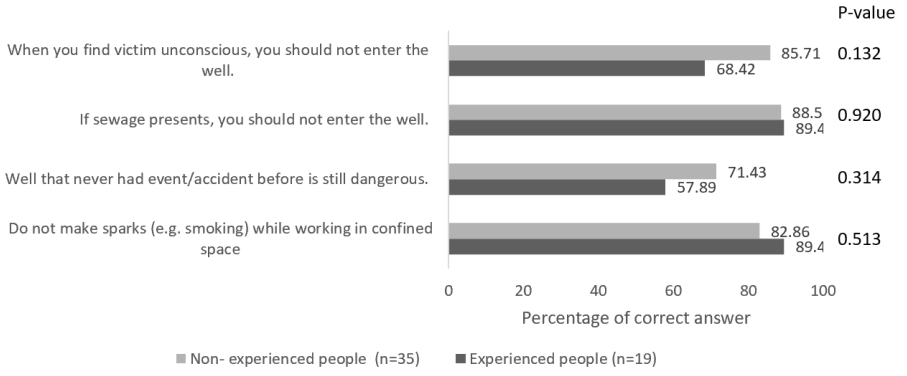

Figure 3 Percentage of correct answers between experienced and non-experienced people about knowledge of self-protection

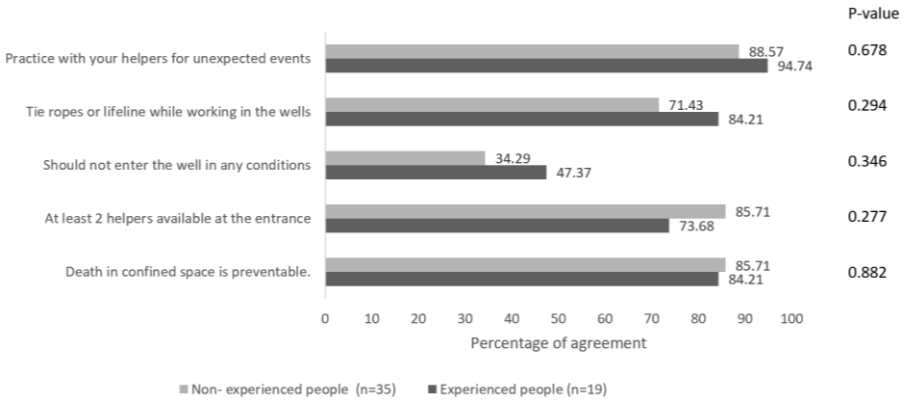

Figure 4 Percentage of agreement between experienced and non-experienced people about attitudes of self-protection strategies

in the EBS which informed that one-third of the events between 2003 and 2018 took place in agricultural areasand most of the victims were informal workers and were secondary victims [6-7].

Although we could not find strong evidence of the presence of H_2S in the well, we hypothesized that H_2S poisoning could be the cause of death of the primary case. The supporting reasons were as follows. Firstly, since H_2S is heavier than air and the witnesses reported that the index case became unconscious just a few seconds before drowning [8-9]. Secondly, the blood test showed acute metabolic acidosis with hyperkalaemia which can be found in chemical asphyxiants toxicity, not in hypoxia [10-11]. Thirdly, the witnesses reported nose and eye irritation while entering the well which is commonly found in areas covered with toxic gases [9]. Fourthly, shrimp farming is at high risk of H_2S generation since the moist soil was normally composed of iron and sulfur from pond [12-13], and the use of polyethylene liners facilitated anaerobic oxidation and H_2S production under the liner as supported by Soraphat et al. [14] and Nóbrega et al. [15]. Lastly, before the event occurred, the water had been stagnant for months without being diluted by the rain. This implied a likely accumulation of toxic gases.

The survey on KAP showed that experienced people seemed to be complacent with the dangers in the well. In addition, there were some misunderstanding points about the knowledge and attitudes of working in a water well. Some of them did not recognise the well as a confined place and some perceived that immediate entrance to help the victims in confined space was an appropriate approach. The findings also suggest that health education might not be effective to prevent further events because people might have a pre-emptive attitude that it is always safe to access a well. Therefore, we need additional strategies apart from health education to prevent further events. Fencing off confined space areas or covering the well entrances might be useful.

Knowledge and information that should be promoted to the villagers include: (1) combustible gas, drowning, fall and injury can occur in a confined space; (2) a shadow well can cause hypoxia just like a deep well; (3) a well that has never had a previous event is still dangerous; and (4) a confined space is not only a closed space, but also includes areas with limited openings.

Death among rescuers from improper rescuing techniques is very common [16-17]. According to National Institute of Occupational Safety and Health (NIOSH), approximately 60% of confined-space fatalities happen in rescuers [18]. Besides, some local rescuing teams do not have enough capacity or skill to rescue victims in a confined space [19-20]. Thus it is critical to make rescuers aware that they need proper preparation before entering the space to help others.

There were some worth-learning lessons from this event. Inadequate preparation before working in wells always enhance the risk of injury for the workers. The surviving rescuers used the lifeline and had an assistant standing by at the well opening while the deceased rescuers promptly jumped into the well to help the primary cases without proper preparation. This confirmed that the rescuers should be very well prepared before helping others. However, the best method to prevent injury is to avoid entering the well from the outset.

In this event, the rescuers conducted an entry-rescue technique, which is the riskiest choice. Those who survived used a rope tied around their body with assistants available at the well opening. Non-entry rescue technique is a safer choice according to the recommendation of the Occupational Safety and Health Administration (OSHA) [21]. It was the technique that use a retrieval system such as tripods to bring the employee out of the space. However, in many settings (like this event), it cannot be exercised in a timely manner.

In addition, there has been no guidance on occupational safety, health and environment management for confined space working for informal workers [22]. The available guidance is only for the factory context [4]. The farm owners and the employees in this event had never been trained for a safe rescuing before.

More importantly, most agricultural workers in Thailand are recognised as informal workers and are composed of both Thais and non-Thais. Therefore, the campaign to raise awareness of occupational safety for the informal workers need to account for the language and cultural barriers and should consider the outreach strategies to reach the hard-to-reach populations (like migrants) as much as possible [23].

There remained some limitations in this study. Firstly, we could not perform the gas measurement right on the scene. Even though we measured the gas in the well twice, the first attempt was not valid as the farm owner drained out the water from the well before we arrived and the second attempt was interfered by heavy raining. We did not take the third attempt because all recommendations to prevent gas forming in the well were already implemented. Secondly, the attendance of the participants for the KAP assessment was voluntary. This meant that we might miss the villagers who missed the gathering message from the Deputy District Chief (for instance, those living further from the Hall or migrant workers who did not understand Thai message). Besides, although the summon of villagers by the Deputy District Chief was

a practical approach, it hampered our attempt to perform probability sampling on the populations. Lastly, the answer in the questionnaire might not necessarily be the same as the actual practices of the villagers.

For recommendations, the foremost principle is to reduce the number of confined spaces as much as possible. If the water well needs to exist, limiting the exposure to the confined space is strongly recommended, for instance, prohibiting people entering the well by using a lever to operate the water valve from outside instead of manual operating. For personal level, a proactive health education should be conducted to enable the workers and the villagers to be aware of the danger of injury in confined spaces [24]. A preparation of proper rescue equipment for non-entry rescue technique is suggested. This needs to implement alongside the availability of trained rescue personnel. For the farm owner, flushing the water out of the well for evert 3-5 days is useful. Placing a warning sign and fencing the well opening also help prevent future events to some extent. In addition, the regulations and guidelines for occupational safety on the work in confined spaces (including agricultural well) among informal workers should be developed. The Division of Occupational and Environmental Diseases of the Thai DDC should take a lead in this proposal. Further studies that explore the KAP on the head-to-reach people including migrants are recommended

Conclusions

The study is probably one of the first reported shrimp-farming accidents. The most likely cause of death of the index case was due to H_2S poisoning, followed by drowning. All of the cases were Myanmar informal male workers on the shrimp farm. Rescuers were at risk of death, as was the primary victim. The lack of knowledge and insufficient awareness, especially among those who had prior experience of well entry, were amongst key risk factors of the accidents. Occupational safety guidelines for informal workers working in confined spaces should be developed and enforced. Mitigation strategies should highlight on avoiding to work in confined spaces as much as possible. A preparation of proper rescue equipment with available well-trained rescue staff is recommended.

Acknowledgements

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Effectiveness of the hill tribe audio computer assisted self interview versus self-administration questionnaires to assess sexual behaviors among the hill tribe youths

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ABSTRACT

Background: Human sexual behaviors are common, and some practices increase the risk contracting a diseass, however it is difficult to obtain accurate information from a particular population. The hill tribe audio computer-assisted self-interview (HACASI) was developed. The study aimed to compare its effectiveness with a paper-based questionnaire among hill tribe youths in assessing their sexual behaviors. **Methods:** Two different experimental assessments were performed to collect data from youths aged 15–24 years belonging to one of six main tribes: Akha, Lahu, Hmong, Yao, Karen, or Lisu. Purposive sampling was used to select sexually active participants. Questions regarding individuals' sexual behaviors were prepared and collected in two forms: paper-based questionnaires and HACASI. Chi-square and correlation tests were used to detect differences and correlations, respectively, at a significance level of α = 0.05. **Results**: A total of 600 participants were recruited for the study; 50.0% were male, 72.5% were aged 15–17 years (mean = 16.7, SD = 1.34), and 81.2% were Christian. Tribes were represented as follows: 20.0%, Akha; 16.7%, Lahu; 16.7%, Hmong; 16.7%, Yao; 16.7%, Karen; 13.3%, Lisu). A large proportion of the participants were students (84.0%). In the correlation test between the paper-based questionnaire and HACASI in classification by sex, answers to seven variables were found to be statistically significantly different in males (P-value<0.001): having sex experience, age at their first sexual intercourse, the number of partners, their first sexual intercourse, condom use, being MSM, being engaged in prostitution. Another seven variables were found to be statistically significantly different (P-value < 0.001) between the paper-based questionnaire and HACASI among female sexual behaviors on questions related to having sexual experience, age of their first sexual intercourse, the number of partners, with whom they had first sexual intercourse, condom use, past-year sexual intercourse with men, and being a prostitute. **Conclusion:** The HACASI is appropriate for gathering information on sexual behaviors among youths and should be promoted in surveillance systems to monitor sexual behaviors among hill tribe youths in the future.

Keywords: *Effectiveness, HACASI, Sexual behavior, Hill tribe, Youth*

Introduction

Sexual behavior is kept secret by individuals and is not usually made public [1]. Many sexual activities have been identified as routes to several diseases, such as hepatitis B [2], human immunodeficiency virus [3], syphilis [4], and gonorrhea [5]. However, obtaining information on sexual behavior in a particular population is very difficult; getting accurate data on the sexual behavior among those living in poor socioeconomic conditions is even more problematic [6]. In addition, most social norms in a community do not include sexual behaviors; thus, the accuracy of information is always doubtful, especially in some specific populations [7].

The hill tribe people in Thailand are classified as the minority population who have their own cultures

and norms, including expressing their sexual behaviors [8]. There are six main groups: Akha, Lahu, Hmong, Yao, Karen, and Lisu. The population of Thailand was more than 4.5 million in 2020, including 250,000–300,000 hill tribe people living in 749 hill tribe villages in Chiang Rai [9]. Those aged 15–24 years are classified as being sexually active and present a risk population for many sexually transmitted infetions (STIs) [10]. STIs have been reported to be highly prevalent in these populations [11]. Therefore, understanding sexual behaviors is critical and requires close monitoring. Since specific norms and cultures restrict expressing sexual behaviors, gathering this information requires a particular approach [12]. The hill tribe audio computer-assisted self-interview (HACASI) was developed by the team of the Center of Excellence, Hill Tribe Health Research from Mae Fah Luang University [13].

However, the effectiveness of HACASI has not yet been tested. HACASI has been created in six hill tribe languages: Akha, Lahu, Hmong, Yao, Karen, and Lisu. It is a computer program showing several icons on the screen. Each icon represents a specific question or answer relating to sexual behavior. The icon text is presented on the computer screen while participants hear the question through earphones. Participants select a response by pressing the button of the chosen icon that is transformed into a number form in Excel. The Excel sheet was used for further analysis. The specific feature of the HACASI is the method of gathering information on sensitive issues such as sexual behaviors (Figure 1).

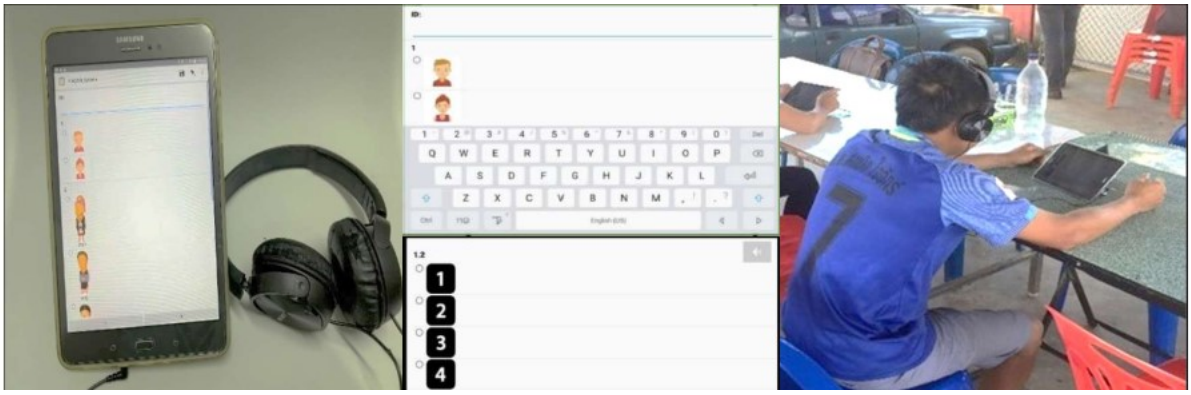

Figure 1 The hill tribe audio computer assisted self-interview (HACASI)

This study aimed to test the effectiveness of the HACASI compared to a paper-based questionnaire on sexual behaviors among hill tribe youths in northern Thailand.

Methods

Study design and participants

Two experimental assessments using two different approaches were performed to collect data on sexual behaviors in hill tribe youths.

Study population

The target populations were the hill tribe youths who belonged to six main tribes: Akha, Lahu, Hmong, Yao, Karen, or Lisu, and living in Chiang Rai province, Thailand.

Study sample

The study samples consisted of individuals aged 15–24 years. There are 749 hill-tribe villages in Chiang Rai province: 316 in Lahu, 243 in Akha, 63 in Yao, 56 in Hmong, 36 in Karen, and 35 in Lisu [14]. Purposive sampling was used to select two villages in each tribe in three districts: Muang District, Mae Chan, and Mae Fah Luang; participants lived in 12 selected villages. Those who could not provide all the essential information related to the study protocols were excluded from the study.

Research instruments

A questionnaire was developed by reviewing various literature sources of information. All the selected questions were validated using a small test group of 60 people from the six hill tribe groups who had similar characteristics to the targeted population of the study. The final set of questions prepared for data collection consisted of three parts. In part one, eight questions were used to collect the demographic characteristics of the participants. In part two, 16 questions were used to collect data regarding substance use. In part three, seven questions were used to collect data on sexual behaviors, with different questions for males and females.

The hill tribe audio computer-assisted self-interview (HACASI)

All questions were transformed into the six hill tribe languages and tested for accuracy by the forward and backward testing before use. Four people (two

males and two females) in each tribe who were able to use Thai and their own language fluently performed the testing. The HACASI was developed and used as previously mentioned.

Steps of data collection

The village headman granted access to each village for data collection. All village headmen were provided with all essential information regarding the study before the appointment was made. On the day of data collection, all participants, taking part voluntarily, were provided with information about the study.

All participants were asked to complete a paper-based questionnaire that lasted for 10 min. Then, two months later, all participants were asked the same questions again but in the HACASI format. The data collection was performed between April to June 2021.

Data analysis

Data were analyzed using SPSS version 24 (SPSS, Chicago, IL, USA), and are presented as percentages, means, and standard deviations depending on whether they were in the form of either categorical or continuous data. The chi-square test was used to test the proportions between the groups. In addition, Pearson correlation was used to assess the correlations between the information obtained from the paper-based and HACASI at a significance level of $\alpha = 0.05$.

Ethical consideration

All research protocols were approved by the Chiang Rai Provincial Public Health Office (CRPPHO No. 71/2563). All activities were performed following the relevant guidelines and regulations. Before implementation, all participants were provided with information about the study and asked to voluntarily provide their informed consent.

Results

General charcateristics of participants

Six hundred participants were recruited for the analysis; 50.0% were males, 72.5% were aged 15–17 years (mean = 16.7, SD = 1.34), and 81.2% were Christian. Tribe representation was 20.0% Akha, 16.7% Lahu, 16.7% Hmong, 16.7% Yao, 16.7% Karen, and 13.3% Lisu. A large proportion of the sample had vocational certificates (66.5%) and 84.0% were students (Table 1).

Comparisons of sexual behaviors between sexes in information obtained by HACASI approach

Comparing sexual behaviors between sexes in data collected by the HACASI method, three factors were found to be statistically different between males and females: having sexual experience (*P*-value = 0.022), the number of partners (*P*-value < 0.001), and a person they had their first sexual intercourse with (*P*-value = 0.025) (Table 2).

Table 1 Characteristics of participants

Characteristics	n	%
Total	**600**	**100.0**
Sex		
Male	300	42.0
Female	300	58.0
Age (years)		
15-17	435	72.5
18-21	165	27.5
Min=15, Max=21, Mean=16.7, SD=1.34		
Tribe		
Ahka	120	20.0
Lahu	100	16.7
Hmong	100	16.7
Yao	100	16.7
Karen	100	16.7
Lisu	80	13.3
Marital status		
Single	600	100.0
Religion		
Buddhist	113	18.8
Christian	487	81.2
Education		
Illiterate	13	2.2
High school	188	31.3
Vocational	399	66.5
Occupation		
Unemployed	96	16.0
Student	504	84.0
Health insurance		
Universal health Coverage	600	100.0

Comparisons of substance use behaviors by chracteristics in information obtained by HACASI approach

In responses to the HACASI program on substance use, two features were found to show a statistically significant difference: sex ($p < 0.001$) and occupation ($p = 0.007$) (Table 3).

Comparisons of sexual behaviors between information obtained by HACASI approach and paper-based

In the correlation analysis between answering paper-based questionnaire and in HACASI by sex, seven variables differed in giving answers to questions on sexual behaviors among males: sex experience ($r = 0.911$, *P*-value < 0.001), first sexual intercourse ($r = 0.964$, *P*-value < 0.001), number of partners ($r = 0.923$, *P*-value < 0.001), first sexual intercourse ($r = 0.909$, *P*-value < 0.001), condom use ($r = 0.911$, *P*-value < 0.001), sexual intercourse with men who have sex with men (MSM) ($r = 0.911$, *P*-value < 0.001), and prostitution ($r = 0.911$, *P*-value < 0.001). Seven

Table 2 Comparison between sexes and sexual behaviors in HACASI

Characteristics	Total		Sex				χ^2	*P*-value
			Male		Female			
	n	%	n	%	n	%		
Having sex experience								
Yes	127	21.6	75	59.1	52	40.9	5.28	0.022*
No	473	78.4	225	47.6	248	52.4		
Age at first sexual intercourse (years)								
≤15	88	69.3	48	54.5	40	45.5	2.41	0.121
>15	39	30.7	27	69.2	12	30.8		
Number of partners								
Only one	97	76.4	45	46.4	52	53.6	27.23	<0.001*
More than one	30	23.6	30	100.0	0	0.0		
Having first sexual intercourse with whom								
Boy/Girlfriend	116	91.3	72	62.1	44	37.9	5.03	0.025*
One night stand	11	8.7	3	27.3	8	72.7		
Condom use								
Yes	84	66.1	45	53.6	39	46.4	3.08	0.079
No	43	33.9	30	69.8	13	30.2		
Being prostitution								
Yes	0	0.0	0	0.0	0	0.0	NA	NA
No	127	100.0	75	59.1	52	40.9		

**Significant level at α= 0.05*
[a]Fisher's exact test

Table 3 Comparison between characteristics and substance use behaviors in HACASI

Characteristics	Smoking		Alcohol use		Other substance use		χ^2	*P*-value
	n	%	n	%	n	%		
Total	43	100.0	77	100.0	13	100.0	N/A	N/A
Sex								
Male	37	44.6	35	42.2	11	13.3	22.40	<0.001[a]*
Female	6	12.0	42	84.0	2	4.0		
Age (years)								
15-17	18	46.2	18	46.2	3	7.7	4.82	0.090
18-21	25	26.6	59	62.8	10	10.6		
Tribe								
Ahka	10	40.0	12	48.0	3	12.0	10.50	0.364[a]
Lahu	7	50.0	5	35.7	2	14.3		
Hmong	5	22.7	16	72.7	1	4.5		
Yao	6	50.0	5	41.7	1	8.3		
Karen	9	31.0	17	58.6	3	10.3		
Lisu	6	19.4	22	71.0	3	9.7		
Religion								
Buddhist	11	23.4	31	66.0	5	10.6	2.66	0.264
Christian	32	37.2	46	53.5	8	9.3		
Education								
Illiterate	6	60.0	3	30.0	1	10.0	9.10	0.055
High school	14	37.8	17	45.9	6	16.2		
Vocational	23	26.7	57	66.3	6	7.0		
Occupation								
Unemployed	15	25.0	34	56.7	11	18.3	10.03	0.007*
Student	28	38.4	43	58.9	2	2.7		

** Significant level at α= 0.05*
[a]Fisher's exact test

Table 4 Comparison between the answers in paper-based questionnaire and HACASI in males and females of their sexual behaviors

Sex	Items	Sexual behaviors	Correlation	
			r	*P-value*
Male	Paper-based questionnaire / HACASI	Sex experience	0.911	<0.001*
	Paper-based questionnaire / HACASI	Age at first sexual intercourse	0.964	<0.001*
	Paper-based questionnaire / HACASI	Number of partners	0.923	<0.001*
	Paper-based questionnaire / HACASI	Having first sexual intercourse with whom	0.909	<0.001*
	Paper-based questionnaire / HACASI	Condom use	0.911	<0.001*
	Paper-based questionnaire / HACASI	MSM	0.911	<0.001*
	Paper-based questionnaire / HACASI	Being prostitution	0.911	<0.001*
Female	Paper-based questionnaire / HACASI	Sex experience	0.869	<0.001*
	Paper-based questionnaire / HACASI	Age at first sexual intercourse	0.869	<0.001*
	Paper-based questionnaire / HACASI	Number of partners	0.869	<0.001*
	Paper-based questionnaire / HACASI	Having first sexual intercourse with whom	0.866	<0.001*
	Paper-based questionnaire / HACASI	Condom use	0.873	<0.001*
	Paper-based questionnaire / HACASI	Having sexual intercourse with men one year prior	0.866	<0.001*
	Paper-based questionnaire / HACASI	Being prostitution	0.869	<0.001*

** Significant level at α = 0.05*

variables differed in answers to questions on sexual behaviors among females: sex experience (r = 0.869, *P*-value < 0.001), first sexual intercourse (r = 0.869, *P*-value < 0.001), number of partners (r = 0.869, *P*-value < 0.001), first sexual intercourse (r = 0.866, *P*-value < 0.001), condom use (r = 0.873, *P*-value < 0.001), past one-year sexual intercourse with men (r = 0.866, *P*-value < 0.001), and prostitution (r = 0.869, *P*-value < 0.001) (Table 4).

In terms of male sexual experience, only 91.1% gave a consist responses in being MSM and being male prostitutes between the paper-based questionnaire and HACASI. Examining further the 8.9% who responded, the following was found: 60.0% were Lisu, 30.0% were Karen, and 10.0% were Lahu; 50.0% were 16–17 and 50.0% were 18–20 years of age; 90.0% were Buddhists and 10.0% were Christians; 80.0% possessed a vocational degree and 20.0% were at high school; 90.0% were students and 10.0 % were unemployed (Table 4).

When answering the question of "age at first sexual intercourse" in males, 96.4% gave consistent responses to the paper-based questionnaire and HACASI. Among those who did not respond (3.6%), 71.4% were Lisu, 14.3% were Karen, and 14.3% were Lahu; 57.1% were 17 years and 42.9.0% were 18–20 years; 85.7% were Buddhists and 14.3% were Christians; 71.4% had a vocational degree and 28.6% were at high school; 85.7% were students and 14.3% were unemployed (Table 4).

Regarding the "number of partners" in males, 92.3% gave consistent responses to the paper-based questionnaires and HACASI. Those who did not respond (7.7%), 33.3% were Lisu, 33.3% were Karen, and 33.3% were Lahu; 66.7% were 18 years and 33.3% were 20 years; 66.7% were Buddhists and 33.3% were Christians; 100.0% had a vocational degree; 66.7% were students and 33.3% were unemployed (Table 4).

Responding to the question on people they had their first sexual intercourse with, in males, 90.9%

gave consistent responses to the paper-based questionnaire and HACASI. Those who did not respond (9.1%), 60.0% were Lisu, 30.0% was Karen, and 10.0% was Lahu; 50.0% were 16–17 years and 50.0% were 18–20 years; 90.0% were Buddhists and 10.0% were Christians; 80.0% had a vocational degree and 20.0% were at high school; 90.0% were students and 10.0% were unemployed (Table 4).

When answering the question on "condom used while having sexual intercourse" in males, 91.1% gave consistent responses in the paper-based questionnaire and HACASI. Among those who did not respond (8.9%), 80.0% were Lisu, 10.0% was Karen, and 10.0% was Lahu; 40.0% were 17 years, 40% were 18 years, and 20.0% were 20 years; 80.0% were Buddhists and 20.0% were Christians; 60.0% had a vocational degree and 40.0% were at high school; 80.0% were students and 20. % were unemployed (Table 4).

Responding to questions on "having sexual experience," "age of first sexual intercourse," "number of partners," and "being prostitution, 86.9% of females gave a consist responses in the paper-based questionnaire and HACASI. Among those who did not respond (13.1%), 36.4% were Akha, 27.3% were Yao, 18.1% were Karen, 9.1% were Lahu, and 9.1% were Lisu; 63.6% were 15 years, 27.3% were 16 years, and 9.1% were 20 years of age; 90.9% were Buddhists and 9.1% were Christians; 54.5% were at high school and 45.5% had a vocational degrees; 90.9% were students and 9.1 % were unemployed (Table 4).

Responding to the question of "whom to have their first sexual intercourse with," and "having sexual intercourse with men in the past year," 86.6% gave consistent responses in the paper-based questionnaire and HACASI. Among those who did not respond (13.4%), 36.4% were Akha, 27.3% were Yao, 18.1% were Karen, 9.1% were Lahu, and 9.1% were Lisu; 63.6% were 15 years, 27.3% were 16 years, and 9.1% were 20 years of age; 90.9% were Buddhists, 9.1% were Christian; 54.5% were at high school and 45.5% had a vocational degree; 90.9% were students and 9.1 % were unemployed (Table 4).

Among females responding to the question of "condom use" in females, 87.3% gave consistent answers to the paper-based questionnaires and HACASI. Among those who did not respond (12.7%), 36.4% were Akha, 27.3% were Yao, 18.1% were Karen, 9.1% were Lahu, and 9.1% were Lisu; 63.6% were 15 years, 27.3% were 16 years, and 9.1% were 20 years of age; 90.9% were Buddhists and 9.1% were Christians; 54.5% were at high school and 45.5% had a vocational certification; 90.9% were students and 9.1 % were unemployed (Table 4).

Discussion

This study assessed the accuracy of responses to questions related to individuals' sexual behaviors using two methods:HACASI and paper-based questionnaires. Seven variables were found in different responses to the questions between the paper-based and HACASI in males: having sexual experience, age at first sexual intercourse, with whom they had their first sexual intercourse, condom use, the number of partners, being MSM, and being prostitutes. Seven variables were found in different responses to the questions between the paper-based and HACASI in females: having sexual experience, age at first sexual intercourse, the number of partners, being in prostitution, having sexual intercourse with men one year ago, and condom use.

The HACASI approach presented more accurate responses to the questions related to sexual behaviors among hill tribe youths. This might be because the HACASI used the hill tribe languages and also kept responses to questions private. The accuracy of the HACASI approach was confirmed by Jaranit et al. [15-16]. Moreover, in the context of norms and culture in not talking about sensitive issues, especially sexual behaviors, in public, gathering this information in the form of HACASI is much more accurate. A study in India in domestic violence was presented that using ACASI (Audio computer-assissted self-intervieweing) was presented in better accuracy compared to face-to-face interview [17].

One of the advantages of HACASI is that it can be used to gather information on sexual behavior by applying regular data collection. This could lead to the development of a proper sexual behavior surveillance system in the minority population, such as the hill tribe. This would greatly impact understanding the change in sexual behaviors among hill tribe youths. Information could also be used to develop a proper public health intervention to reduce the incidence of STIs. Previous dtudies [18-20] greatly supported the idea on the using the HACASI or ACASI (Audio computer-assissted self-intervieweing) to monitor sexual behaviors among young adults and obtained more accurate information. Moreover, it was found that gathering sensitive information from the participants using HACASI was more feasibility and acceptability than paper-based. This was supported by a study in Sudan and Ethiopia [21].

This study has some limitations. First, only those who could use Thai met the inclusion criteria because the participants were required to answer the question in both the paper-based and HACASI; the study accuracy did not include those who could not use Thai. Second, the gap between answering the paper-based and HACASI was a bit long. The reason for leaving two

months between testing the two approaches was to reduce the possibility that the participants simply repeated responses from the previous round. However, during the two-month gap, participants might have acquired knowledge and experience by learning from the question that might have made the two responses different. Last, with the norm and culture of not talking about sexual behaviors in public, the responders might not tell the truth; however, it was not the objective of the study.

Conclusion

With the norms and cultures of the hill tribe people, especially in response to sexual behaviors, HACASI is the better method to gather this information than responding to a paper-based questionnaire. Therefore, it should be encouraged that the HACASI instrument is used in health institutes for sexual behavior surveys and other purposes such as setting up surveillance systems for monitoring long-term sexual behaviors and STIs among the minorities with specific norms and cultures.

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Effectiveness of the hill tribe audio computer assisted self interview versus self-administration questionnaires to assess sexual behaviors among the hill tribe youths

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ABSTRACT

Background: Human sexual behaviors are common, and some practices increase the risk contracting a diseass, however it is difficult to obtain accurate information from a particular population. The hill tribe audio computer-assisted self-interview (HACASI) was developed. The study aimed to compare its effectiveness with a paper-based questionnaire among hill tribe youths in assessing their sexual behaviors. **Methods:** Two different experimental assessments were performed to collect data from youths aged 15–24 years belonging to one of six main tribes: Akha, Lahu, Hmong, Yao, Karen, or Lisu. Purposive sampling was used to select sexually active participants. Questions regarding individuals' sexual behaviors were prepared and collected in two forms: paper-based questionnaires and HACASI. Chi-square and correlation tests were used to detect differences and correlations, respectively, at a significance level of α = 0.05. **Results**: A total of 600 participants were recruited for the study; 50.0% were male, 72.5% were aged 15–17 years (mean = 16.7, SD = 1.34), and 81.2% were Christian. Tribes were represented as follows: 20.0%, Akha; 16.7%, Lahu; 16.7%, Hmong; 16.7%, Yao; 16.7%, Karen; 13.3%, Lisu). A large proportion of the participants were students (84.0%). In the correlation test between the paper-based questionnaire and HACASI in classification by sex, answers to seven variables were found to be statistically significantly different in males (P-value<0.001): having sex experience, age at their first sexual intercourse, the number of partners, their first sexual intercourse, condom use, being MSM, being engaged in prostitution. Another seven variables were found to be statistically significantly different (P-value < 0.001) between the paper-based questionnaire and HACASI among female sexual behaviors on questions related to having sexual experience, age of their first sexual intercourse, the number of partners, with whom they had first sexual intercourse, condom use, past-year sexual intercourse with men, and being a prostitute. **Conclusion:** The HACASI is appropriate for gathering information on sexual behaviors among youths and should be promoted in surveillance systems to monitor sexual behaviors among hill tribe youths in the future.

Keywords: *Effectiveness, HACASI, Sexual behavior, Hill tribe, Youth*

Introduction

Sexual behavior is kept secret by individuals and is not usually made public [1]. Many sexual activities have been identified as routes to several diseases, such as hepatitis B [2], human immunodeficiency virus [3], syphilis [4], and gonorrhea [5]. However, obtaining information on sexual behavior in a particular population is very difficult; getting accurate data on the sexual behavior among those living in poor socioeconomic conditions is even more problematic [6]. In addition, most social norms in a community do not include sexual behaviors; thus, the accuracy of information is always doubtful, especially in some specific populations [7].

The hill tribe people in Thailand are classified as the minority population who have their own cultures

and norms, including expressing their sexual behaviors [8]. There are six main groups: Akha, Lahu, Hmong, Yao, Karen, and Lisu. The population of Thailand was more than 4.5 million in 2020, including 250,000–300,000 hill tribe people living in 749 hill tribe villages in Chiang Rai [9]. Those aged 15–24 years are classified as being sexually active and present a risk population for many sexually transmitted infetions (STIs) [10]. STIs have been reported to be highly prevalent in these populations [11]. Therefore, understanding sexual behaviors is critical and requires close monitoring. Since specific norms and cultures restrict expressing sexual behaviors, gathering this information requires a particular approach [12]. The hill tribe audio computer-assisted self-interview (HACASI) was developed by the team of the Center of Excellence, Hill Tribe Health Research from Mae Fah Luang University [13].

However, the effectiveness of HACASI has not yet been tested. HACASI has been created in six hill tribe languages: Akha, Lahu, Hmong, Yao, Karen, and Lisu. It is a computer program showing several icons on the screen. Each icon represents a specific question or answer relating to sexual behavior. The icon text is presented on the computer screen while participants hear the question through earphones. Participants select a response by pressing the button of the chosen icon that is transformed into a number form in Excel. The Excel sheet was used for further analysis. The specific feature of the HACASI is the method of gathering information on sensitive issues such as sexual behaviors (Figure 1).

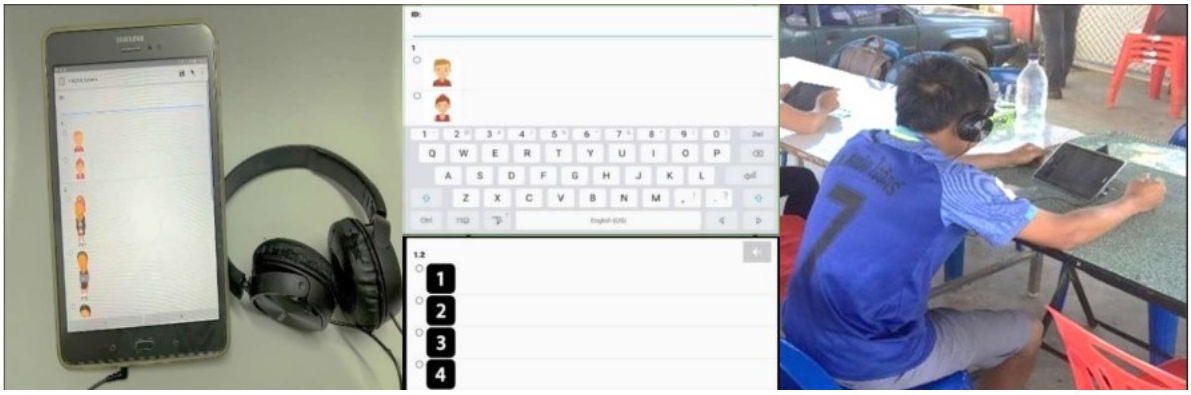

Figure 1 The hill tribe audio computer assisted self-interview (HACASI)

This study aimed to test the effectiveness of the HACASI compared to a paper-based questionnaire on sexual behaviors among hill tribe youths in northern Thailand.

Methods

Study design and participants

Two experimental assessments using two different approaches were performed to collect data on sexual behaviors in hill tribe youths.

Study population

The target populations were the hill tribe youths who belonged to six main tribes: Akha, Lahu, Hmong, Yao, Karen, or Lisu, and living in Chiang Rai province, Thailand.

Study sample

The study samples consisted of individuals aged 15–24 years. There are 749 hill-tribe villages in Chiang Rai province: 316 in Lahu, 243 in Akha, 63 in Yao, 56 in Hmong, 36 in Karen, and 35 in Lisu [14]. Purposive sampling was used to select two villages in each tribe in three districts: Muang District, Mae Chan, and Mae Fah Luang; participants lived in 12 selected villages. Those who could not provide all the essential information related to the study protocols were excluded from the study.

Research instruments

A questionnaire was developed by reviewing various literature sources of information. All the selected questions were validated using a small test group of 60 people from the six hill tribe groups who had similar characteristics to the targeted population of the study. The final set of questions prepared for data collection consisted of three parts. In part one, eight questions were used to collect the demographic characteristics of the participants. In part two, 16 questions were used to collect data regarding substance use. In part three, seven questions were used to collect data on sexual behaviors, with different questions for males and females.

The hill tribe audio computer-assisted self-interview (HACASI)

All questions were transformed into the six hill tribe languages and tested for accuracy by the forward and backward testing before use. Four people (two

males and two females) in each tribe who were able to use Thai and their own language fluently performed the testing. The HACASI was developed and used as previously mentioned.

Steps of data collection

The village headman granted access to each village for data collection. All village headmen were provided with all essential information regarding the study before the appointment was made. On the day of data collection, all participants, taking part voluntarily, were provided with information about the study.

All participants were asked to complete a paper-based questionnaire that lasted for 10 min. Then, two months later, all participants were asked the same questions again but in the HACASI format. The data collection was performed between April to June 2021.

Data analysis

Data were analyzed using SPSS version 24 (SPSS, Chicago, IL, USA), and are presented as percentages, means, and standard deviations depending on whether they were in the form of either categorical or continuous data. The chi-square test was used to test the proportions between the groups. In addition, Pearson correlation was used to assess the correlations between the information obtained from the paper-based and HACASI at a significance level of $\alpha = 0.05$.

Ethical consideration

All research protocols were approved by the Chiang Rai Provincial Public Health Office (CRPPHO No. 71/2563). All activities were performed following the relevant guidelines and regulations. Before implementation, all participants were provided with information about the study and asked to voluntarily provide their informed consent.

Results

General charcateristics of participants

Six hundred participants were recruited for the analysis; 50.0% were males, 72.5% were aged 15–17 years (mean = 16.7, SD = 1.34), and 81.2% were Christian. Tribe representation was 20.0% Akha, 16.7% Lahu, 16.7% Hmong, 16.7% Yao, 16.7% Karen, and 13.3% Lisu. A large proportion of the sample had vocational certificates (66.5%) and 84.0% were students (Table 1).

Comparisons of sexual behaviors between sexes in information obtained by HACASI approach

Comparing sexual behaviors between sexes in data collected by the HACASI method, three factors were found to be statistically different between males and females: having sexual experience (*P*-value = 0.022), the number of partners (*P*-value < 0.001), and a person they had their first sexual intercourse with (*P*-value = 0.025) (Table 2).

Table 1 Characteristics of participants

Characteristics	n	%
Total	**600**	**100.0**
Sex		
Male	300	42.0
Female	300	58.0
Age (years)		
15-17	435	72.5
18-21	165	27.5
Min=15, Max=21, Mean=16.7, SD=1.34		
Tribe		
Ahka	120	20.0
Lahu	100	16.7
Hmong	100	16.7
Yao	100	16.7
Karen	100	16.7
Lisu	80	13.3
Marital status		
Single	600	100.0
Religion		
Buddhist	113	18.8
Christian	487	81.2
Education		
Illiterate	13	2.2
High school	188	31.3
Vocational	399	66.5
Occupation		
Unemployed	96	16.0
Student	504	84.0
Health insurance		
Universal health Coverage	600	100.0

Comparisons of substance use behaviors by chracteristics in information obtained by HACASI approach

In responses to the HACASI program on substance use, two features were found to show a statistically significant difference: sex ($p < 0.001$) and occupation ($p = 0.007$) (Table 3).

Comparisons of sexual behaviors between information obtained by HACASI approach and paper-based

In the correlation analysis between answering paper-based questionnaire and in HACASI by sex, seven variables differed in giving answers to questions on sexual behaviors among males: sex experience ($r = 0.911$, *P*-value < 0.001), first sexual intercourse ($r = 0.964$, *P*-value < 0.001), number of partners ($r = 0.923$, *P*-value < 0.001), first sexual intercourse ($r = 0.909$, *P*-value < 0.001), condom use ($r = 0.911$, *P*-value < 0.001), sexual intercourse with men who have sex with men (MSM) ($r = 0.911$, *P*-value < 0.001), and prostitution ($r = 0.911$, *P*-value < 0.001). Seven

Table 2 Comparison between sexes and sexual behaviors in HACASI

Characteristics	Total		Sex				χ^2	*P*-value
			Male		Female			
	n	%	n	%	n	%		
Having sex experience								
Yes	127	21.6	75	59.1	52	40.9	5.28	0.022*
No	473	78.4	225	47.6	248	52.4		
Age at first sexual intercourse (years)								
≤15	88	69.3	48	54.5	40	45.5	2.41	0.121
>15	39	30.7	27	69.2	12	30.8		
Number of partners								
Only one	97	76.4	45	46.4	52	53.6	27.23	<0.001*
More than one	30	23.6	30	100.0	0	0.0		
Having first sexual intercourse with whom								
Boy/Girlfriend	116	91.3	72	62.1	44	37.9	5.03	0.025*
One night stand	11	8.7	3	27.3	8	72.7		
Condom use								
Yes	84	66.1	45	53.6	39	46.4	3.08	0.079
No	43	33.9	30	69.8	13	30.2		
Being prostitution								
Yes	0	0.0	0	0.0	0	0.0	NA	NA
No	127	100.0	75	59.1	52	40.9		

**Significant level at α= 0.05*
[a]Fisher's exact test

Table 3 Comparison between characteristics and substance use behaviors in HACASI

Characteristics	Smoking		Alcohol use		Other substance use		χ^2	*P*-value
	n	%	n	%	n	%		
Total	43	100.0	77	100.0	13	100.0	N/A	N/A
Sex								
Male	37	44.6	35	42.2	11	13.3	22.40	<0.001[a]*
Female	6	12.0	42	84.0	2	4.0		
Age (years)								
15-17	18	46.2	18	46.2	3	7.7	4.82	0.090
18-21	25	26.6	59	62.8	10	10.6		
Tribe								
Ahka	10	40.0	12	48.0	3	12.0	10.50	0.364[a]
Lahu	7	50.0	5	35.7	2	14.3		
Hmong	5	22.7	16	72.7	1	4.5		
Yao	6	50.0	5	41.7	1	8.3		
Karen	9	31.0	17	58.6	3	10.3		
Lisu	6	19.4	22	71.0	3	9.7		
Religion								
Buddhist	11	23.4	31	66.0	5	10.6	2.66	0.264
Christian	32	37.2	46	53.5	8	9.3		
Education								
Illiterate	6	60.0	3	30.0	1	10.0	9.10	0.055
High school	14	37.8	17	45.9	6	16.2		
Vocational	23	26.7	57	66.3	6	7.0		
Occupation								
Unemployed	15	25.0	34	56.7	11	18.3	10.03	0.007*
Student	28	38.4	43	58.9	2	2.7		

** Significant level at α= 0.05*
[a]Fisher's exact test

Table 4 Comparison between the answers in paper-based questionnaire and HACASI in males and females of their sexual behaviors

Sex	Items	Sexual behaviors	Correlation	
			r	*P-value*
Male	Paper-based questionnaire / HACASI	Sex experience	0.911	<0.001*
	Paper-based questionnaire / HACASI	Age at first sexual intercourse	0.964	<0.001*
	Paper-based questionnaire / HACASI	Number of partners	0.923	<0.001*
	Paper-based questionnaire / HACASI	Having first sexual intercourse with whom	0.909	<0.001*
	Paper-based questionnaire / HACASI	Condom use	0.911	<0.001*
	Paper-based questionnaire / HACASI	MSM	0.911	<0.001*
	Paper-based questionnaire / HACASI	Being prostitution	0.911	<0.001*
Female	Paper-based questionnaire / HACASI	Sex experience	0.869	<0.001*
	Paper-based questionnaire / HACASI	Age at first sexual intercourse	0.869	<0.001*
	Paper-based questionnaire / HACASI	Number of partners	0.869	<0.001*
	Paper-based questionnaire / HACASI	Having first sexual intercourse with whom	0.866	<0.001*
	Paper-based questionnaire / HACASI	Condom use	0.873	<0.001*
	Paper-based questionnaire / HACASI	Having sexual intercourse with men one year prior	0.866	<0.001*
	Paper-based questionnaire / HACASI	Being prostitution	0.869	<0.001*

** Significant level at α = 0.05*

variables differed in answers to questions on sexual behaviors among females: sex experience (r = 0.869, *P*-value < 0.001), first sexual intercourse (r = 0.869, *P*-value < 0.001), number of partners (r = 0.869, *P*-value < 0.001), first sexual intercourse (r = 0.866, *P*-value < 0.001), condom use (r = 0.873, *P*-value < 0.001), past one-year sexual intercourse with men (r = 0.866, *P*-value < 0.001), and prostitution (r = 0.869, *P*-value < 0.001) (Table 4).

In terms of male sexual experience, only 91.1% gave a consist responses in being MSM and being male prostitutes between the paper-based questionnaire and HACASI. Examining further the 8.9% who responded, the following was found: 60.0% were Lisu, 30.0% were Karen, and 10.0% were Lahu; 50.0% were 16–17 and 50.0% were 18–20 years of age; 90.0% were Buddhists and 10.0% were Christians; 80.0% possessed a vocational degree and 20.0% were at high school; 90.0% were students and 10.0 % were unemployed (Table 4).

When answering the question of "age at first sexual intercourse" in males, 96.4% gave consistent responses to the paper-based questionnaire and HACASI. Among those who did not respond (3.6%), 71.4% were Lisu, 14.3% were Karen, and 14.3% were Lahu; 57.1% were 17 years and 42.9.0% were 18–20 years; 85.7% were Buddhists and 14.3% were Christians; 71.4% had a vocational degree and 28.6% were at high school; 85.7% were students and 14.3% were unemployed (Table 4).

Regarding the "number of partners" in males, 92.3% gave consistent responses to the paper-based questionnaires and HACASI. Those who did not respond (7.7%), 33.3% were Lisu, 33.3% were Karen, and 33.3% were Lahu; 66.7% were 18 years and 33.3% were 20 years; 66.7% were Buddhists and 33.3% were Christians; 100.0% had a vocational degree; 66.7% were students and 33.3% were unemployed (Table 4).

Responding to the question on people they had their first sexual intercourse with, in males, 90.9%

gave consistent responses to the paper-based questionnaire and HACASI. Those who did not respond (9.1%), 60.0% were Lisu, 30.0% was Karen, and 10.0% was Lahu; 50.0% were 16–17 years and 50.0% were 18–20 years; 90.0% were Buddhists and 10.0% were Christians; 80.0% had a vocational degree and 20.0% were at high school; 90.0% were students and 10.0% were unemployed (Table 4).

When answering the question on "condom used while having sexual intercourse" in males, 91.1% gave consistent responses in the paper-based questionnaire and HACASI. Among those who did not respond (8.9%), 80.0% were Lisu, 10.0% was Karen, and 10.0% was Lahu; 40.0% were 17 years, 40% were 18 years, and 20.0% were 20 years; 80.0% were Buddhists and 20.0% were Christians; 60.0% had a vocational degree and 40.0% were at high school; 80.0% were students and 20. % were unemployed (Table 4).

Responding to questions on "having sexual experience," "age of first sexual intercourse," "number of partners," and "being prostitution, 86.9% of females gave a consist responses in the paper-based questionnaire and HACASI. Among those who did not respond (13.1%), 36.4% were Akha, 27.3% were Yao, 18.1% were Karen, 9.1% were Lahu, and 9.1% were Lisu; 63.6% were 15 years, 27.3% were 16 years, and 9.1% were 20 years of age; 90.9% were Buddhists and 9.1% were Christians; 54.5% were at high school and 45.5% had a vocational degrees; 90.9% were students and 9.1 % were unemployed (Table 4).

Responding to the question of "whom to have their first sexual intercourse with," and "having sexual intercourse with men in the past year," 86.6% gave consistent responses in the paper-based questionnaire and HACASI. Among those who did not respond (13.4%), 36.4% were Akha, 27.3% were Yao, 18.1% were Karen, 9.1% were Lahu, and 9.1% were Lisu; 63.6% were 15 years, 27.3% were 16 years, and 9.1% were 20 years of age; 90.9% were Buddhists, 9.1% were Christian; 54.5% were at high school and 45.5% had a vocational degree; 90.9% were students and 9.1 % were unemployed (Table 4).

Among females responding to the question of "condom use" in females, 87.3% gave consistent answers to the paper-based questionnaires and HACASI. Among those who did not respond (12.7%), 36.4% were Akha, 27.3% were Yao, 18.1% were Karen, 9.1% were Lahu, and 9.1% were Lisu; 63.6% were 15 years, 27.3% were 16 years, and 9.1% were 20 years of age; 90.9% were Buddhists and 9.1% were Christians; 54.5% were at high school and 45.5% had a vocational certification; 90.9% were students and 9.1 % were unemployed (Table 4).

Discussion

This study assessed the accuracy of responses to questions related to individuals' sexual behaviors using two methods:HACASI and paper-based questionnaires. Seven variables were found in different responses to the questions between the paper-based and HACASI in males: having sexual experience, age at first sexual intercourse, with whom they had their first sexual intercourse, condom use, the number of partners, being MSM, and being prostitutes. Seven variables were found in different responses to the questions between the paper-based and HACASI in females: having sexual experience, age at first sexual intercourse, the number of partners, being in prostitution, having sexual intercourse with men one year ago, and condom use.

The HACASI approach presented more accurate responses to the questions related to sexual behaviors among hill tribe youths. This might be because the HACASI used the hill tribe languages and also kept responses to questions private. The accuracy of the HACASI approach was confirmed by Jaranit et al. [15-16]. Moreover, in the context of norms and culture in not talking about sensitive issues, especially sexual behaviors, in public, gathering this information in the form of HACASI is much more accurate. A study in India in domestic violence was presented that using ACASI (Audio computer-assissted self-intervieweing) was presented in better accuracy compared to face-to-face interview [17].

One of the advantages of HACASI is that it can be used to gather information on sexual behavior by applying regular data collection. This could lead to the development of a proper sexual behavior surveillance system in the minority population, such as the hill tribe. This would greatly impact understanding the change in sexual behaviors among hill tribe youths. Information could also be used to develop a proper public health intervention to reduce the incidence of STIs. Previous dtudies [18-20] greatly supported the idea on the using the HACASI or ACASI (Audio computer-assissted self-intervieweing) to monitor sexual behaviors among young adults and obtained more accurate information. Moreover, it was found that gathering sensitive information from the participants using HACASI was more feasibility and acceptability than paper-based. This was supported by a study in Sudan and Ethiopia [21].

This study has some limitations. First, only those who could use Thai met the inclusion criteria because the participants were required to answer the question in both the paper-based and HACASI; the study accuracy did not include those who could not use Thai. Second, the gap between answering the paper-based and HACASI was a bit long. The reason for leaving two

months between testing the two approaches was to reduce the possibility that the participants simply repeated responses from the previous round. However, during the two-month gap, participants might have acquired knowledge and experience by learning from the question that might have made the two responses different. Last, with the norm and culture of not talking about sexual behaviors in public, the responders might not tell the truth; however, it was not the objective of the study.

Conclusion

With the norms and cultures of the hill tribe people, especially in response to sexual behaviors, HACASI is the better method to gather this information than responding to a paper-based questionnaire. Therefore, it should be encouraged that the HACASI instrument is used in health institutes for sexual behavior surveys and other purposes such as setting up surveillance systems for monitoring long-term sexual behaviors and STIs among the minorities with specific norms and cultures.

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Effectiveness of the NERSD program in reducing HbA1c levels in patients with uncontrolled diabetes in Northern Thailand

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ABSTRACT

Background: Uncontrolled diabetes mellitus (DM) is a public health problem that has a large impact on the economics of caring for individuals over the long term. This study aimed to evaluate the effectiveness of proper food consumption, regular exercise, Roy's adaptation model, stress management, and regular drug taking (NERSD) program to reduce HbA1c in patients with uncontrolled diabetes. **Methodology:** A randomized control trial was used to implement a NERSD program designed to control HbA1c levels among patients with diabetes in Wiang Chiang Rung District, Chiang Rai Province, Thailand. Intervention and control groups were assigned by a random allocation method after careful screening for uncontrolled blood glucose among 60 DM patients, indexed by HbA1c>7.0. The intervention program took 9 months to complete. A t-test and repeated measures analysis of variance was used to detect a significance level of α=0.05. **Results**: A total of 60 patients with uncontrolled diabetes were recruited for the study, with 30 patients each in the intervention and control groups. Among the interventions, 80.0% of the patients were female, 50.5% were aged between 50 and 59 years, 66.7% had graduated from primary school, 83.4% were farmers, 90.0% were paid 5,000 baht per month, and 43.4 were diagnosed with diabetes for 1–5 years. In the control group, 70.0% of the patients were female, 53.4% were aged between 50 and 59 years, 86.7% had graduated from primary school, 76.7% were farmers, 96.7% were paid 5,000 baht per month, and 73.3% were diagnosed as having diabetes for 1–5 years. At the end of the intervention, knowledge of the disease and drugs (*P*-value <0.001) and preventive skills (*P*-value = 0.004) were found to be different between the groups. HbA1c levels between the control and intervention groups were statistically significant (*P*-value <0.001). **Conclusion**: The NERSD program was found to be effective in reducing HbA1c levels among patients with uncontrolled diabetes in district hospitals of northern Thailand. This program should be promoted for use in other district hospitals that handle similar populations in Thailand.

Keywords: *Uncontrolled diabetes, Exercise, Nutrition, Stress, Drugs, Roy's model*

Introduction

Diabetes mellitus (DM) is a major health threat [1-2]. According to the World Health Organization (WHO),422 million patients have diabetes and 1.5 million die of diabetes each year globally [3]. It was found that 80% of these diabetes patients were living in low- and middle-income countries, including in Thailand [4]. Diabetes is clearly demonstrated as one of the major contributors to the reduction of a patient's quality of life (QOL) [1]. After being diagnosed with diabetes, patients and their families often face several adverse consequences, such as financial burden due to medical consultation and treatments [5], loss of daily income [6], reduction in the quality of life of [7], and complications [8].

Uncontrolled diabetes is defined as uncontrolled blood sugar after taking medicines, which is indicated by HbA1c levels >7% [9]. Poor control of blood glucose in patients with diabetes leads to life-threatening complications, such as diabetic ketoacidosis (DKA) [3], heart attack [4], and stroke [5]. Chronically high blood sugar levels lead to damage to the nerves, blood vessels, and vital organs [6]. In Thailand, more than half the patients with diabetes have uncontrolled blood glucose levels [10]. Therefore, the health system of Thailand is faced by challenges in terms of both an increased number of diabetes patients and health problems from the complications of uncontrolled blood glucose. Uncontrolled blood glucose in patients with diabetes is related to several factors such as improper quality and quantity of food consumption [7], no regular exercise [8], poor stress management [11], and poor knowledge regarding the prevention and control of diabetes [12]. According to Roy's model, setting up both physical and other essential information could positively address a health problem effectively [9-10].

District hospitals in Thailand have been designated as one of the important health institutes in the country [13]. A hospital's duty is to respond to all medical and public health missions to support people's health including medical care, prevention, and promotion [14]. Because of its scale and associated complications, diabetes consumes most of a hospital's resources [15]. A significant amount of hospital finance is spent on caring for non-communicable diseases, especially for diabetes [16]. Caring for diabetes patients has been the responsibility of the healthcare professionals, rather than integrating both health care professionals and patients for more effective results, as mentioned in Roy's model.

Chiang Rai is located in northernmost Thailand and a large proportion of people in this province work in the agricultural sector [17]. People living in this area have poor education and economic status [18-20]. In line with their occupation conditions, most people spend their time on farms and experience economic constraints, especially during the coronavirus disease 2019 (COVID-19) pandemic. During an epidemic, the challenges associated with accessing health institutes increase [21]. Considering the current COVID-19 pandemic and the need to improve the uncontrolled blood glucose condition in diabetes patients, it is necessary to develop a proper model to facilitate the minimization of the problem.

Therefore, this study aimed to examine the effectiveness of proper food (N), proper and regular exercise (E), modification of the environment in terms of improvement under the concept of Roy's model (R), stress management ability (S), and adherence to taking drugs (D) (NERSD Program) in controlling HbA1c among diabetes patients who were classified as having uncontrolled blood glucose at a district hospital in northern Thailand.

Methodology

Study setting

This study was conducted at a DM clinic in Wiang Chiang Rung Hospital, Chiang Rai Province, Thailand.

Study design

A randomized control trial was used to examine the effectiveness of the NERSD program.

Study sample and sample size calculation

The sample size was calculated using a standard formula for randomized control trials. The comparison between the two groups with the endpoint was done using quantitative data, and it was given as follows: $n = 2SD^2(Z_{\alpha/2}+Z_{\beta})^2/d^2$ [13], where standard deviation (SD) was used as the value from the previous study, which was 0.2 [14]; $Z_{\alpha/2}$ was a type-I error at the 95% confidence interval, which was 5.0%; $Z_{\alpha/2}$ was 0.84 at 80% power of the test; d was the effect side or the difference between means, which was 0.6 [14]. From the calculation, it was found that 30 participants were required for each group.

Intervention

The NERSD Program was designed and provided to the intervention group. The program focused on providing appropriate knowledge regarding nutrition, exercise, Roy's adaptation concept, stress management, and information regarding DM at the first session of the intervention, which was classified into three phases. In phase one, the intervention group was provided appropriate knowledge regarding nutrition, exercise, stress management, appropriate drug intake, and information regarding DM prevention control and care. In phase two, the intervention group was provided knowledge, information demonstrations for appropriate cooking practices, and introduced to nutrition profiles of several kinds of food. Finally, in phase three, the intervention group was provided information and given demonstrations for appropriate exercise. The intervention was performed between November 2020 and October 2021.

Measurements

Questionnaires were developed based on the literature review. This was validated before use. The final version of the questionnaire consisted of three parts. Part one consisted of 12 questions which were used to collect general characteristics of participants, such as age, sex, education, occupation, and so on. In part two, eight questions were provided to collect participants' knowledge regarding DM disease prevention and control. In part three, 42 questions were used to collect participant's knowledge about preventive practices on DM with respect to the NERSD program.

The item-objective congruence (IOC) method was used for the content validation of questionnaires. During the IOC, three experts (one internal medicine, one non-communicable disease expert, and one nutritionist) were invited to assess the quality of the questions. Each question was scored -1 if non-relevant to the context, 0 if a question presented as relevant but required some revision, and +1 if a question presented relevancy to the context.

Scores from the experts were pooled before final interpretation. Questions that scored 0.5 were deleted from a set of the questionnaire; questions that scored 0.60-0.70 were revised and put into the set of the questionnaire, while questions that scored 0.7 were pooled into the set of the questionnaire.

Afterwards, the questionnaire was administered to 15 selected people who had similar characteristics as the participants, with the purpose of testing the feasibility, understandability, and order or sequence of the questions. Finally, Cronbach's alpha was calculated to determine its reliability for parts two and three, which was found to be 0.81.

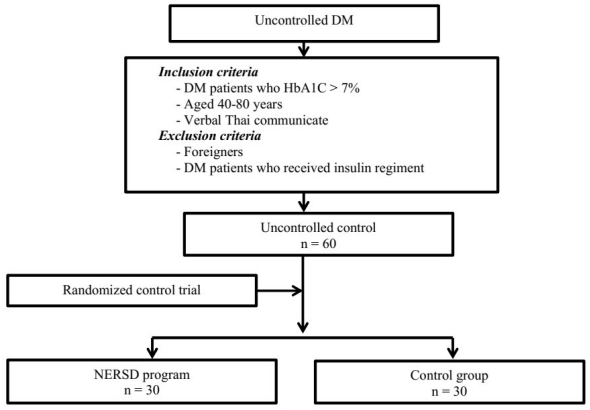

Figure 1 Experimental procedure

Procedure

Patients with uncontrolled DM were recruited from a hospital DM list. Participants were recruited according to the following inclusion criteria: 1) HbA1c level > 7%; 2) aged ≥40 years; and 3) able to use Thai. Those receiving an insulin regimen were excluded from the study (Figure 1).

According to the inclusion and exclusion criteria, 60 patients were invited to participate in the study and allocated into the intervention group (30 patients) and control group (30 patients).

The three phases were executed among those participants who were allocated to the intervention. During the intervention, knowledge and preventive practice according to diabetes prevention, control, and care were measured at baseline and 3, 6, and 9 months. The HbA1c level was also measured at these times.

The participants in the control group, were not provided any intervention, however all participants were assessed by the measurements used among the interventions. Furthermore, participants of this group were provided with all interventions as provided to the intervention group after completion of the final assessment. This was done to cooperate with ethical issues for intervention research to maintain the rights of participants in the control group.

Statistical analysis

Descriptive data analysis was performed accordingly. Categorical data were analyzed as percentages, while continuous data were presented as means and standard deviations. A chi-square was used to detect different proportion between groups. A t-test was used to detect means between groups at a significance level of 0.05. Two-way repeated measure analysis of variance was used to assess the different means within the group measured multiple times.

Ethical consideration

All study concepts and intervention protocols were approved by the Chiang Rai Provincial Public Health Research Ethics Committee on Human Research (CRPPHO No.67/2563). All participants were provided information regarding the study before obtaining their informed consent. All participants were interviewed accordingly.

Results

A total of 60 participants (30 each in the intervention and control groups) were recruited into the study. Of them, 50.0% were females, 51.7% were aged between 50 and 59 years (mean=57.5, SD=6.2), 88.3% were married, 76.7% had graduated from primary school, 80.0% worked in the agricultural sector, 93.3% were paid < 5,000 Thai Baht (THB)/month (median= 3,000, IQR=1,500), and 58.3% had been diagnosed with uncontrolled DM for 1–5 years (mean=5.5, SD=3.8) (Table 1).

In the intervention group, 80.0% of the patients were female, 50.5% were aged between 50 and 59 years (mean=58.8, SD=6.1), 88.3% were married, 66.7% had graduated from primary school, 83.4% worked in the agricultural sector, 90.0% were paid <5,000 THB/month (median= 3,000, IQR=1,500), and 43.4% had been diagnosed with uncontrolled DM for 1–5 years (mean=6.4, SD=4.3) (Table 1).

Of the patients in the control (30 participants) group, 70.0% were female, 53.4% were aged between 50 and 59 years (mean=56.2, SD=6.0); 93.3% were married; 86.7% had graduated from primary school; 76.7% worked in the agricultural sector; 96.7% were paid <5,000 THB (median= 3,000, IQR=1,500), and 73.3% were diagnosed with DM diagnosed for 1–5

years (mean=4.5, SD=2.9). The general characteristics of the two groups were found to be non-statistically significant (Table 1).

The scores on practicing diabetes drug taking, healthy food consumption, regular and proper exercise, and having individual stress management were found to be statistically significant in months 3, 6, and 9 (*P*-value < 0.001). Only drug taking was not found to be statistically significant at the 0 month between the groups (Table 2).

While looking closer into each group during the study period, we detected the statistical change of HbA1c: the decreased means in the intervention and fluctuation means in the control group. In the final model, repeated measures were compared between the two groups, and the results were statistically significant (Table 3).

Table 1 General characteristics of participants

Characteristics	Total n (%)	Intervention n (%)	Control n (%)	χ^2	*P*-value
Sex					
Male	15 (50%)	6 (20.0)	9 (30.0)	0.80	0.371
Female	45 (50%)	24 (80.0)	21 (70.0)		
Age (years)					
40-49	7 (11.6)	2 (6.6)	5 (16.6)	2.04	0.360
50-59	31 (51.7)	15 (50.5)	16 (53.4)		
≥60	22 (36.7)	13 (43.3)	9 (30.0)		
	Mean=57.5, SD= 6.2	***Mean=58.8, SD=6.1***	***Mean=56.2, SD=6.0***		
Marital status					
Married	53 (88.3)	25 (83.3)	28 (93.3)	1.45	0.228
Other	7 (11.7)	5 (16.7)	2 (6.7.0)		
Education					
Illiterate	6 (10.0)	4 (13.3)	2 (6.7)	3.45	0.178
Primary school	46 (76.7)	20 (66.7)	26 (86.7)		
≥High school	8 (13.3)	6 (20.0)	2 (6.6)		
Occupation					
Unemployment	2 (3.3)	0 (0.0)	2 (6.7)	1.76	0.643[a]
Employment	10 (16.7)	5 (16.6)	5 (16.6)		
Agriculture	48 (80.0)	25 (83.4)	23 (76.7)		
Income (THB)					
< 5000	56 (93.3)	27 (90.0)	29 (96.7)		
≥ 5000	4 (6.7)	3 (10.0)	1 (3.3)	1.12	0.612[a]
	Median= 3,000 IQR=1,500	***Median=3,000, IQR=1,500***	***Median=3,000, IQR=1,000***		
Length of having been DM diagnosed (years)					
1-5	35 (58.3)	(43.4)	22 (73.3)		
6-10	17 (28.4)	11 (36.6)	6 (20.0)		
11-15	8 (13.3)	6 (20.0)	2 (6.7)	5.61	0.069[a]
	Mean= 5.5, SD=3.8	***Mean=6.4, SD=4.3***	***Mean=4.5, SD=2.9***		

** Significant level at α=0.05*

[a] Fisher's exact test

Table 2 Preventive practices score on diabetes drug taking, proper food consuming, regularly exercise, and stress management

Characteristics	Intervention		Control		t-test	*P*-value
	mean	SD	mean	SD		
Drug						
0th day	10.7	2.1	10.4	1.9	*0.59*	*0.558*
3 months	12.3	0.9	4.8	1.9	*19.90*	*<0.001**
6 months	12.1	1.3	4.8	1.9	*17.54*	*<0.001**
9 months	12.4	0.9	5.7	2.0	*16.40*	*<0.001**
F= 11.21, *P*-value = <0.001*			F=73.86, *P*-value <0.001*			
F=76.34, *P*-value <0.001*						
Food						
0th day	38.7	4.7	42.0	2.8	*-3.33*	*0.002**
3 months	45.2	2.4	33.5	5.1	*11.42*	*<0.001**
6 months	41.8	3.5	33.5	5.1	*7.39*	*<0.001**
9 months	45.4	2.8	33.2	5.2	*11.33*	*<0.001**
F= 31.41, *P*-value <0.001*			F=33.99, *P*-value <0.001*			
F=60.28, *P*-value <0.001*						
Exercise						
0th day	5.7	1.7	4.1	1.6	3.83	<0.001*
3 months	7.3	1.5	4.1	1.6	8.13	<0.001*
6 months	6.3	1.2	4.1	1.6	6.11	<0.001*
9 months	7.5	1.5	4.3	1.5	8.42	<0.001*
F= 11.83, *P*-value <0.001*			F= 0.21, *P*-value = 0.801			
F=5.16, *P*-value = 0.003*						
Stress management						
0th day	23.0	4.8	16.9	0.8	*6.84*	*<0.001**
3 months	26.6	0.5	17.5	2.3	*21.19*	*<0.001**
6 months	18.8	2.0	17.5	2.3	*2.23*	*0.030**
9 months	22.2	2.7	16.7	1.6	*9.59*	*<0.001**
F= 35.43, *P*-value <0.001*			F= 1.43, *P*-value = 0.246			
F=25.19, *P*-value <0.001*						

** Significant level at α=0.05*

Table 3 Means of HbA1c of participants in different phases

Characteristics	Intervention		Control		t-test	*P*-value
	mean	SD	mean	SD		
HbA1c						
0th day	9.0	1.4	8.7	1.1	*0.76*	*0.451*
3 months	7.8	1.7	9.3	1.6	*-3.49*	*0.001**
6 months	8.6	1.5	9.7	1.4	*-3.15*	*0.003**
9 months	7.5	1.1	9.3	1.6	*-4.98*	*<0.001**
F= 8.99, *P*-value = 0.001*			F= 4.04, *P*-value = 0.016*			
F=8.51, *P*-value <0.001*						

** Significant level at α=0.05*

Discussion

The diabetes patients with uncontrolled blood glucose in Wiang Chiang Rung Hospital, Chiang Rai Province, Thailand tended to be female, older, and with poor socioeconomic status (SES) with an average year of diabetes diagnosis at 5.5 years. The NERSD Program significantly reduced the HbA1c levels in the intervention group compared to the control group after 9 months of intervention.

Our study showed that the NERSD program could improve the knowledge and skills of diabetes patients that are essential for blood glucose control, such as the knowledge of drug taking, healthy food consumption, regular exercise, and coping with individual stress appropriately under the environmental conditions of Roy's concept. These practices are essential to maintain the patients' blood glucose levels. Roy's concept of creating a friendly environment to support patients' learning to maintain desired behaviors is also important. Our findings are supported by a randomized

controlled trial on a web-based educational intervention to improve knowledge of healthy diet and lifestyle in women with diabetes conducted in Australia [15]. Another study in China [16] reported that educational intervention program in primary care can increase diabetes awareness among patients with type 2 DM. In Thailand, Ratipark et al. [17] also reported that community-based interventions could improve knowledge and attitudes toward diabetes prevention. Therefore, providing knowledge regarding diabetes disease and preventive care are key tools for improving diabetes patients' self-care.

The main challenge of this study was that all patients with uncontrolled blood glucose diabetes were with SES. This posed challenges in terms of how healthcare professionals could maintain healthy food among the patients given their socioeconomic conditions. Moreover, regular exercise was also a critical point because many studies in Thailand reported that people were living in a stage of poor regular exercise [22-24].

Stress has been defined as one of the contributing factors to health, especially in diabetes, particularly during the COVID-19 pandemic. With the integration of SES and COVID-19, people in northern Thailand have been suffering from stress. Northern Thailand has been reported as a crisis for COVID-19 [25]. Therefore, providing patients with knowledge and skills on personal stress coping was clearly shown in their integrated impact of the reduction of HbA1c.

This study has some limitations. First, some patients in the intervention could not completely adhere to the protocols, especially exercise, due to their old age. Second, with regard to having healthy food, it was found that some patients were unable to prepare food in daily life. Other family members prepared for some participants in their daily lives, and it was difficult to educate those individuals regarding healthy food preparation practices. Finally, although the study had two separate groups (intervention and control) and interventions to the control group was carefully avoided, some points of intervention, such as knowledge on having healthy food, exercise, stress coping, and taking drugs was regularly and commonly provided to all patients attending the clinic of the hospital. This may have interfered with the results.

Conclusion

The NERSD program is effective in reducing HbA1c levels in patients with uncontrolled diabetes after providing knowledge and skills on diabetes, drugs, food, exercise, and stress coping skills in Roy's environment. Nine months of intervention, including education and skill development, helped patients control their blood glucose. Motivating patients to be informed about these practices helps reduce HbA1c levels.

The NERSD program should be promoted in all district hospitals to address uncontrolled blood glucose levels in diabetes patients. This should be considered as one of the tools added to the standard care for diabetes patients, which might improve the patients' health and eventually reduce the health economics of a country.

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Effectiveness of the NERSD program in reducing HbA1c levels in patients with uncontrolled diabetes in Northern Thailand

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ABSTRACT

Background: Uncontrolled diabetes mellitus (DM) is a public health problem that has a large impact on the economics of caring for individuals over the long term. This study aimed to evaluate the effectiveness of proper food consumption, regular exercise, Roy's adaptation model, stress management, and regular drug taking (NERSD) program to reduce HbA1c in patients with uncontrolled diabetes. **Methodology:** A randomized control trial was used to implement a NERSD program designed to control HbA1c levels among patients with diabetes in Wiang Chiang Rung District, Chiang Rai Province, Thailand. Intervention and control groups were assigned by a random allocation method after careful screening for uncontrolled blood glucose among 60 DM patients, indexed by HbA1c>7.0. The intervention program took 9 months to complete. A t-test and repeated measures analysis of variance was used to detect a significance level of α=0.05. **Results**: A total of 60 patients with uncontrolled diabetes were recruited for the study, with 30 patients each in the intervention and control groups. Among the interventions, 80.0% of the patients were female, 50.5% were aged between 50 and 59 years, 66.7% had graduated from primary school, 83.4% were farmers, 90.0% were paid 5,000 baht per month, and 43.4 were diagnosed with diabetes for 1–5 years. In the control group, 70.0% of the patients were female, 53.4% were aged between 50 and 59 years, 86.7% had graduated from primary school, 76.7% were farmers, 96.7% were paid 5,000 baht per month, and 73.3% were diagnosed as having diabetes for 1–5 years. At the end of the intervention, knowledge of the disease and drugs (*P*-value <0.001) and preventive skills (*P*-value = 0.004) were found to be different between the groups. HbA1c levels between the control and intervention groups were statistically significant (*P*-value <0.001). **Conclusion**: The NERSD program was found to be effective in reducing HbA1c levels among patients with uncontrolled diabetes in district hospitals of northern Thailand. This program should be promoted for use in other district hospitals that handle similar populations in Thailand.

Keywords: *Uncontrolled diabetes, Exercise, Nutrition, Stress, Drugs, Roy's model*

Introduction

Diabetes mellitus (DM) is a major health threat [1-2]. According to the World Health Organization (WHO),422 million patients have diabetes and 1.5 million die of diabetes each year globally [3]. It was found that 80% of these diabetes patients were living in low- and middle-income countries, including in Thailand [4]. Diabetes is clearly demonstrated as one of the major contributors to the reduction of a patient's quality of life (QOL) [1]. After being diagnosed with diabetes, patients and their families often face several adverse consequences, such as financial burden due to medical consultation and treatments [5], loss of daily income [6], reduction in the quality of life of [7], and complications [8].

Uncontrolled diabetes is defined as uncontrolled blood sugar after taking medicines, which is indicated by HbA1c levels >7% [9]. Poor control of blood glucose in patients with diabetes leads to life-threatening complications, such as diabetic ketoacidosis (DKA) [3], heart attack [4], and stroke [5]. Chronically high blood sugar levels lead to damage to the nerves, blood vessels, and vital organs [6]. In Thailand, more than half the patients with diabetes have uncontrolled blood glucose levels [10]. Therefore, the health system of Thailand is faced by challenges in terms of both an increased number of diabetes patients and health problems from the complications of uncontrolled blood glucose. Uncontrolled blood glucose in patients with diabetes is related to several factors such as improper quality and quantity of food consumption [7], no regular exercise [8], poor stress management [11], and poor knowledge regarding the prevention and control of diabetes [12]. According to Roy's model, setting up both physical and other essential information could positively address a health problem effectively [9-10].

District hospitals in Thailand have been designated as one of the important health institutes in the country [13]. A hospital's duty is to respond to all medical and public health missions to support people's health including medical care, prevention, and promotion [14]. Because of its scale and associated complications, diabetes consumes most of a hospital's resources [15]. A significant amount of hospital finance is spent on caring for non-communicable diseases, especially for diabetes [16]. Caring for diabetes patients has been the responsibility of the healthcare professionals, rather than integrating both health care professionals and patients for more effective results, as mentioned in Roy's model.

Chiang Rai is located in northernmost Thailand and a large proportion of people in this province work in the agricultural sector [17]. People living in this area have poor education and economic status [18-20]. In line with their occupation conditions, most people spend their time on farms and experience economic constraints, especially during the coronavirus disease 2019 (COVID-19) pandemic. During an epidemic, the challenges associated with accessing health institutes increase [21]. Considering the current COVID-19 pandemic and the need to improve the uncontrolled blood glucose condition in diabetes patients, it is necessary to develop a proper model to facilitate the minimization of the problem.

Therefore, this study aimed to examine the effectiveness of proper food (N), proper and regular exercise (E), modification of the environment in terms of improvement under the concept of Roy's model (R), stress management ability (S), and adherence to taking drugs (D) (NERSD Program) in controlling HbA1c among diabetes patients who were classified as having uncontrolled blood glucose at a district hospital in northern Thailand.

Methodology

Study setting

This study was conducted at a DM clinic in Wiang Chiang Rung Hospital, Chiang Rai Province, Thailand.

Study design

A randomized control trial was used to examine the effectiveness of the NERSD program.

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The sample size was calculated using a standard formula for randomized control trials. The comparison between the two groups with the endpoint was done using quantitative data, and it was given as follows: $n = 2SD^2(Z_{\alpha/2}+Z_{\beta})^2/d^2$ [13], where standard deviation (SD) was used as the value from the previous study, which was 0.2 [14]; $Z_{\alpha/2}$ was a type-I error at the 95% confidence interval, which was 5.0%; $Z_{\alpha/2}$ was 0.84 at 80% power of the test; d was the effect side or the difference between means, which was 0.6 [14]. From the calculation, it was found that 30 participants were required for each group.

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The NERSD Program was designed and provided to the intervention group. The program focused on providing appropriate knowledge regarding nutrition, exercise, Roy's adaptation concept, stress management, and information regarding DM at the first session of the intervention, which was classified into three phases. In phase one, the intervention group was provided appropriate knowledge regarding nutrition, exercise, stress management, appropriate drug intake, and information regarding DM prevention control and care. In phase two, the intervention group was provided knowledge, information demonstrations for appropriate cooking practices, and introduced to nutrition profiles of several kinds of food. Finally, in phase three, the intervention group was provided information and given demonstrations for appropriate exercise. The intervention was performed between November 2020 and October 2021.

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Scores from the experts were pooled before final interpretation. Questions that scored 0.5 were deleted from a set of the questionnaire; questions that scored 0.60-0.70 were revised and put into the set of the questionnaire, while questions that scored 0.7 were pooled into the set of the questionnaire.

Afterwards, the questionnaire was administered to 15 selected people who had similar characteristics as the participants, with the purpose of testing the feasibility, understandability, and order or sequence of the questions. Finally, Cronbach's alpha was calculated to determine its reliability for parts two and three, which was found to be 0.81.

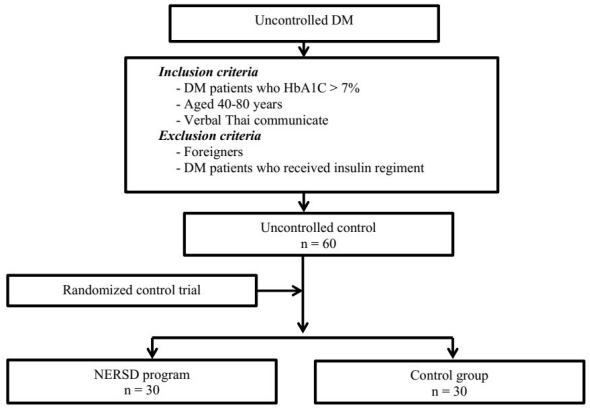

Figure 1 Experimental procedure

Procedure

Patients with uncontrolled DM were recruited from a hospital DM list. Participants were recruited according to the following inclusion criteria: 1) HbA1c level > 7%; 2) aged ≥40 years; and 3) able to use Thai. Those receiving an insulin regimen were excluded from the study (Figure 1).

According to the inclusion and exclusion criteria, 60 patients were invited to participate in the study and allocated into the intervention group (30 patients) and control group (30 patients).

The three phases were executed among those participants who were allocated to the intervention. During the intervention, knowledge and preventive practice according to diabetes prevention, control, and care were measured at baseline and 3, 6, and 9 months. The HbA1c level was also measured at these times.

The participants in the control group, were not provided any intervention, however all participants were assessed by the measurements used among the interventions. Furthermore, participants of this group were provided with all interventions as provided to the intervention group after completion of the final assessment. This was done to cooperate with ethical issues for intervention research to maintain the rights of participants in the control group.

Statistical analysis

Descriptive data analysis was performed accordingly. Categorical data were analyzed as percentages, while continuous data were presented as means and standard deviations. A chi-square was used to detect different proportion between groups. A t-test was used to detect means between groups at a significance level of 0.05. Two-way repeated measure analysis of variance was used to assess the different means within the group measured multiple times.

Ethical consideration

All study concepts and intervention protocols were approved by the Chiang Rai Provincial Public Health Research Ethics Committee on Human Research (CRPPHO No.67/2563). All participants were provided information regarding the study before obtaining their informed consent. All participants were interviewed accordingly.

Results

A total of 60 participants (30 each in the intervention and control groups) were recruited into the study. Of them, 50.0% were females, 51.7% were aged between 50 and 59 years (mean=57.5, SD=6.2), 88.3% were married, 76.7% had graduated from primary school, 80.0% worked in the agricultural sector, 93.3% were paid < 5,000 Thai Baht (THB)/month (median= 3,000, IQR=1,500), and 58.3% had been diagnosed with uncontrolled DM for 1–5 years (mean=5.5, SD=3.8) (Table 1).

In the intervention group, 80.0% of the patients were female, 50.5% were aged between 50 and 59 years (mean=58.8, SD=6.1), 88.3% were married, 66.7% had graduated from primary school, 83.4% worked in the agricultural sector, 90.0% were paid <5,000 THB/month (median= 3,000, IQR=1,500), and 43.4% had been diagnosed with uncontrolled DM for 1–5 years (mean=6.4, SD=4.3) (Table 1).

Of the patients in the control (30 participants) group, 70.0% were female, 53.4% were aged between 50 and 59 years (mean=56.2, SD=6.0); 93.3% were married; 86.7% had graduated from primary school; 76.7% worked in the agricultural sector; 96.7% were paid <5,000 THB (median= 3,000, IQR=1,500), and 73.3% were diagnosed with DM diagnosed for 1–5

years (mean=4.5, SD=2.9). The general characteristics of the two groups were found to be non-statistically significant (Table 1).

The scores on practicing diabetes drug taking, healthy food consumption, regular and proper exercise, and having individual stress management were found to be statistically significant in months 3, 6, and 9 (*P*-value < 0.001). Only drug taking was not found to be statistically significant at the 0 month between the groups (Table 2).

While looking closer into each group during the study period, we detected the statistical change of HbA1c: the decreased means in the intervention and fluctuation means in the control group. In the final model, repeated measures were compared between the two groups, and the results were statistically significant (Table 3).

Table 1 General characteristics of participants

Characteristics	Total n (%)	Intervention n (%)	Control n (%)	χ^2	*P*-value
Sex					
Male	15 (50%)	6 (20.0)	9 (30.0)	0.80	0.371
Female	45 (50%)	24 (80.0)	21 (70.0)		
Age (years)					
40-49	7 (11.6)	2 (6.6)	5 (16.6)	2.04	0.360
50-59	31 (51.7)	15 (50.5)	16 (53.4)		
≥60	22 (36.7)	13 (43.3)	9 (30.0)		
	Mean=57.5, SD= 6.2	***Mean=58.8, SD=6.1***	***Mean=56.2, SD=6.0***		
Marital status					
Married	53 (88.3)	25 (83.3)	28 (93.3)	1.45	0.228
Other	7 (11.7)	5 (16.7)	2 (6.7.0)		
Education					
Illiterate	6 (10.0)	4 (13.3)	2 (6.7)	3.45	0.178
Primary school	46 (76.7)	20 (66.7)	26 (86.7)		
≥High school	8 (13.3)	6 (20.0)	2 (6.6)		
Occupation					
Unemployment	2 (3.3)	0 (0.0)	2 (6.7)	1.76	0.643[a]
Employment	10 (16.7)	5 (16.6)	5 (16.6)		
Agriculture	48 (80.0)	25 (83.4)	23 (76.7)		
Income (THB)					
< 5000	56 (93.3)	27 (90.0)	29 (96.7)		
≥ 5000	4 (6.7)	3 (10.0)	1 (3.3)	1.12	0.612[a]
	Median= 3,000 IQR=1,500	***Median=3,000, IQR=1,500***	***Median=3,000, IQR=1,000***		
Length of having been DM diagnosed (years)					
1-5	35 (58.3)	(43.4)	22 (73.3)		
6-10	17 (28.4)	11 (36.6)	6 (20.0)		
11-15	8 (13.3)	6 (20.0)	2 (6.7)	5.61	0.069[a]
	Mean= 5.5, SD=3.8	***Mean=6.4, SD=4.3***	***Mean=4.5, SD=2.9***		

** Significant level at α=0.05*

[a] Fisher's exact test

Table 2 Preventive practices score on diabetes drug taking, proper food consuming, regularly exercise, and stress management

Characteristics	Intervention		Control		t-test	*P*-value
	mean	SD	mean	SD		
Drug						
0th day	10.7	2.1	10.4	1.9	*0.59*	*0.558*
3 months	12.3	0.9	4.8	1.9	*19.90*	*<0.001**
6 months	12.1	1.3	4.8	1.9	*17.54*	*<0.001**
9 months	12.4	0.9	5.7	2.0	*16.40*	*<0.001**
F= 11.21, *P*-value = <0.001*			F=73.86, *P*-value <0.001*			
F=76.34, *P*-value <0.001*						
Food						
0th day	38.7	4.7	42.0	2.8	*-3.33*	*0.002**
3 months	45.2	2.4	33.5	5.1	*11.42*	*<0.001**
6 months	41.8	3.5	33.5	5.1	*7.39*	*<0.001**
9 months	45.4	2.8	33.2	5.2	*11.33*	*<0.001**
F= 31.41, *P*-value <0.001*			F=33.99, *P*-value <0.001*			
F=60.28, *P*-value <0.001*						
Exercise						
0th day	5.7	1.7	4.1	1.6	3.83	<0.001*
3 months	7.3	1.5	4.1	1.6	8.13	<0.001*
6 months	6.3	1.2	4.1	1.6	6.11	<0.001*
9 months	7.5	1.5	4.3	1.5	8.42	<0.001*
F= 11.83, *P*-value <0.001*			F= 0.21, *P*-value = 0.801			
F=5.16, *P*-value = 0.003*						
Stress management						
0th day	23.0	4.8	16.9	0.8	*6.84*	*<0.001**
3 months	26.6	0.5	17.5	2.3	*21.19*	*<0.001**
6 months	18.8	2.0	17.5	2.3	*2.23*	*0.030**
9 months	22.2	2.7	16.7	1.6	*9.59*	*<0.001**
F= 35.43, *P*-value <0.001*			F= 1.43, *P*-value = 0.246			
F=25.19, *P*-value <0.001*						

** Significant level at α=0.05*

Table 3 Means of HbA1c of participants in different phases

Characteristics	Intervention		Control		t-test	*P*-value
	mean	SD	mean	SD		
HbA1c						
0th day	9.0	1.4	8.7	1.1	*0.76*	*0.451*
3 months	7.8	1.7	9.3	1.6	*-3.49*	*0.001**
6 months	8.6	1.5	9.7	1.4	*-3.15*	*0.003**
9 months	7.5	1.1	9.3	1.6	*-4.98*	*<0.001**
F= 8.99, *P*-value = 0.001*			F= 4.04, *P*-value = 0.016*			
F=8.51, *P*-value <0.001*						

** Significant level at α=0.05*

Discussion

The diabetes patients with uncontrolled blood glucose in Wiang Chiang Rung Hospital, Chiang Rai Province, Thailand tended to be female, older, and with poor socioeconomic status (SES) with an average year of diabetes diagnosis at 5.5 years. The NERSD Program significantly reduced the HbA1c levels in the intervention group compared to the control group after 9 months of intervention.

Our study showed that the NERSD program could improve the knowledge and skills of diabetes patients that are essential for blood glucose control, such as the knowledge of drug taking, healthy food consumption, regular exercise, and coping with individual stress appropriately under the environmental conditions of Roy's concept. These practices are essential to maintain the patients' blood glucose levels. Roy's concept of creating a friendly environment to support patients' learning to maintain desired behaviors is also important. Our findings are supported by a randomized

controlled trial on a web-based educational intervention to improve knowledge of healthy diet and lifestyle in women with diabetes conducted in Australia [15]. Another study in China [16] reported that educational intervention program in primary care can increase diabetes awareness among patients with type 2 DM. In Thailand, Ratipark et al. [17] also reported that community-based interventions could improve knowledge and attitudes toward diabetes prevention. Therefore, providing knowledge regarding diabetes disease and preventive care are key tools for improving diabetes patients' self-care.

The main challenge of this study was that all patients with uncontrolled blood glucose diabetes were with SES. This posed challenges in terms of how healthcare professionals could maintain healthy food among the patients given their socioeconomic conditions. Moreover, regular exercise was also a critical point because many studies in Thailand reported that people were living in a stage of poor regular exercise [22-24].

Stress has been defined as one of the contributing factors to health, especially in diabetes, particularly during the COVID-19 pandemic. With the integration of SES and COVID-19, people in northern Thailand have been suffering from stress. Northern Thailand has been reported as a crisis for COVID-19 [25]. Therefore, providing patients with knowledge and skills on personal stress coping was clearly shown in their integrated impact of the reduction of HbA1c.

This study has some limitations. First, some patients in the intervention could not completely adhere to the protocols, especially exercise, due to their old age. Second, with regard to having healthy food, it was found that some patients were unable to prepare food in daily life. Other family members prepared for some participants in their daily lives, and it was difficult to educate those individuals regarding healthy food preparation practices. Finally, although the study had two separate groups (intervention and control) and interventions to the control group was carefully avoided, some points of intervention, such as knowledge on having healthy food, exercise, stress coping, and taking drugs was regularly and commonly provided to all patients attending the clinic of the hospital. This may have interfered with the results.

Conclusion

The NERSD program is effective in reducing HbA1c levels in patients with uncontrolled diabetes after providing knowledge and skills on diabetes, drugs, food, exercise, and stress coping skills in Roy's environment. Nine months of intervention, including education and skill development, helped patients control their blood glucose. Motivating patients to be informed about these practices helps reduce HbA1c levels.

The NERSD program should be promoted in all district hospitals to address uncontrolled blood glucose levels in diabetes patients. This should be considered as one of the tools added to the standard care for diabetes patients, which might improve the patients' health and eventually reduce the health economics of a country.

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