Association between Alcohol Consumption and Pre-Diabetes among 383,442 Thai Population Aged 15 Years and Older in Ubon Ratchathani: Analytical Cross-Sectional Study

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Background: *Alcohol consumption has been reported to be associated with the risk of diabetes. However, few studies have examined alcohol consumption as a risk factor for pre-diabetes in Asian populations.*
Material and Method: *This study is an analytical cross-sectional study aimed at determining the relationship between alcoholic consumption and pre-diabetes. This study used data on 383,442 men and women participating in the Health Checks Ubon Ratchathani (HCUR) project in 2007. Pre-diabetes was defined as a fasting blood glucose of >100-125 mg%. Data on alcohol consumption was questioned and categorized into six groups: never, occasionally, 1-2 times/month, 1-2 times/week, 3-4 times/week and every day. Multivariable logistic regression was performed to estimate the association between self-reported alcohol consumption and pre-diabetes.*
Results: *The prevalence of pre-diabetes was 10.5% (11.2% and 9.7% in men and women, respectively). After adjusting for other risk factors, alcohol consumption was independently associated with pre-diabetes, with dose response relationship (adjusted odds ratio (OR_{adj} of 1.80, 95% CI 1.53-2.11, p<0.001 and 1.47, 95% CI 1.28-1.68, p<0.001) for those who drank every day and 3-4 times a week, as compared to no consumption), but who drank 1-2 times/month is decreased risk of pre-diabetes (OR_{adj} = 0.89, 95% CI, 0.82-0.97, p = 0.006). Similar findings were observed for men. Women who drank occasionally had a significantly decreased risk of pre-diabetes, compared with non-drinker in women (OR_{adj} 0.95, 95% CI 0.91-0.99, p = 0.039). There was no interaction between alcohol consumption with other potential covariates.*
Conclusion: *Alcohol consumption was independently associated with the risk of pre-diabetes in a possibly dose response fashion. Mild-moderate alcohol consumption appeared to be related with a decreased risk.*

Keywords: *Alcohol consumption, Pre-diabetes, Analytical cross-sectional study*

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As an upper-middle income country, Thailand has achieved significant economic, social and health improvement over the past few decades. In Thailand, non-communicable diseases are estimated to account for 73% of all deaths, with cardiovascular disease, cancer and diabetes representing 44%, 8% and 3% of all causes[1]. Type 2 diabetes mellitus is a disorder that affects the body's ability to produce or respond to insulin, and has been associated with atherosclerosis and increased risk of cardiovascular events[2,3]. The prevalence of diabetes in Thai adults was 9.6% (2.4 million people), with approximately half being previously undiagnosed. The prevalence of impaired fasting glucose (pre-diabetes) was 5.4% (1.4 million people)[4]. Diabetes and pre-diabetes have significant burden on individuals, families and society[5,6]. There have been many previous studies examining the association of alcohol consumption with the risk of diabetes, with varying results from deleterious, to protective and no effect[7-11]. A few studies have reported the association between alcohol consumption and pre-diabetes, most in White populations[14]. Little evidence exists to document the association between alcohol consumption and pre-diabetes in Asian

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populations. Therefore, the present study was aimed to examine the association between alcohol consumption and pre-diabetes in a Thai population aged 15 years and older in Ubon Ratchathani, Thailand.

Material and Method

This study used data on 383,442 men and women participating in the Health Checks Ubon Ratchathani (HCUR) project, a large population-based health examination of a Thai general population residing in Ubon Ratchathani. This project was initiated and commissioned by the Public Health Office of Ubon Ratchathani. It was primarily aimed to provide a population of Ubon Ratchathani with annual health examination with an emphasis on the identification of individuals with metabolic diseases and cancers as well as those at risk. In 2007, 25 health checks teams carried out health examination for men and women aged 15 years and older in 25 districts of Ubon Ratchathani. Each health check team was comprised of two nurses and six health check workers, who were trained for necessary skills and procedures used for health examination and data collection.

Participants were questioned about their general and medical history, health behaviors (physical activity, diet, smoking and alcohol consumption) and physical examination was taken, including body weight, height and waist circumference. Blood tests for fasting blood sugar and total cholesterol were also taken for those who met the pre-defined criteria reflecting potentially high metabolic risk. A total of 768,002 individuals participated in the health check project between 2006-2007. We included in this analysis only those with complete data on fasting blood sugar, alcohol consumption and other potential risk factors for diabetes. We excluded those with biochemically diagnosed diabetes from this study (15,861 subjects with a fasting blood sugar level of >125 mg/dL), leaving 383,442 individuals as a final study population.

Classification of pre-diabetes

Pre-diabetes was defined as a Fasting blood sugar (FBS) of >100-125 mg/dL(12). Fasting blood sugar was measured using point-of-care glucometers, which were standardized and annually calibrated for all health check teams.

Classification of exposure

Age was defined as age at the date of participating in the HCUR project. Body mass index (BMI) was divided in to 3 groups: <25 kg/m^2, 25 ≤BMI <30 kg/m^2 and ≥30 kg/m^2. Systolic blood pressure was measured using a standard sphygmomanometer. Waist circumference was measured using non-stretch measuring tape. Family history of diabetes was dichotomized as either having a first degree family member with diabetes or not. Data on self-reported alcohol consumption was questioned and categorized into six groups: never, occasionally, 1-2 times/month, 1-2 times/week, 3-4 times/week and every day. Physical exercise was categorized into 4 groups: no exercise, <3 days/week, 3-5 days/week, >5 days/week. Smoking was categorized into three groups: non-smokers, occasional smokers, regular smokers.

Data analysis

Participant characteristics were analyzed and presented as mean Standard deviation (SD) and number (%) for continuous and categorical variables respectively. Student t-test and Chi-squared test were used to compare continuous and categorical variables across two groups, with *p*-value of <0.05 considered a statistically significant difference. Univariable and multivariable logistic regression was performed to estimate the association between self-reported alcohol consumption and pre-diabetes, and odds ratios (OR) with 95% confidence intervals (CIs) were calculated. In multivariable regression, we adjusted for potential conventional risk factors, namely age, sex, a family history of diabetes, physical exercise, smoking, self-rated sweetened diet, BMI, systolic blood pressure (SBP), waist circumference, and blood cholesterol. We also did a sensitivity analysis to examine if the results might be altered by a different definition of pre-diabetes (FBS = 110-125 mg/dL)[13].

As the HCUR project was initiated as part of health care service for residents of Ubon Ratchathani, the participants were invited and participated based on their own decision, and no written informed consent was given. This analysis was approved by Ubon Ratchathani University Ethics committee. Number UBU-EC-5/2557.

Results

Characteristics of 383,442 HCUR participants are presented in Table 1. The mean (SD) age of study participants was 48.61 (15.27) years, with 47.3% being males. They are fairly slim with the mean (SD) BMI of 22.5 kg/m^2. The majority of the participants did not smoke cigarette and drink alcohol. Compared to those with normal glucose tolerance, individuals with pre-diabetes appeared to be older, more obese and had a

Table 1. Characteristics of 383,442 participants in the HCUR study by pre-diabetes status

	All participants	Pre-diabetes status		*p*-value*
		Yes	No	
	n = 383,442	n = 40,272	n = 343,170	
Male sex, n (%)	181,359 (47.3)	17,652 (43.8)	163,707 (47.7)	<0.001
Age (mean ± SD, years)	48.61±15.27	51.19±15.02	48.31±15.27	<0.001
BMI (mean ± SD, kg/m^2)	22.55±3.25	23.26±3.84	22.46±3.17	<0.001
BMI category, n (%)				<0.001
BMI <25	315,596 (82.3)	29,489 (73.2)	286,107 (83.4)	
25 ≤BMI <30	56,695 (14.8)	8,596 (21.3)	48,099 (14.0)	
BMI ≥30	11,151 (2.9)	2,187 (5.4)	8,964 (2.9)	
SBP (mean ± SD, mmHg)	119.23±13.57	124.21±16.38	118.65±13.09	<0.001
Waist circumference (mean ± SD, cm)	77.12±8.11	80.29±9.04	76.76±7.91	<0.001
Central obesity, n (%)	77,102 (20.1)	11,522 (28.6)	65,580 (19.1)	<0.001
Family history of diabetes, n (%)	19,915 (5.2)	4,120 (10.2)	15,795 (4.6)	<0.001
Smoking status, n (%)				<0.001
Non-smokers	331,637 (86.5)	132,952 (73.3)	198,685 (98.3)	
Occasional smokers	26,851 (7.0)	24,585 (13.6)	2,266 (1.1)	
Regular smokers	24,952 (6.5)	23,821 (13.1)	1,131 (0.6)	
Alcohol drinking status, N (%)				<0.001
Never	290,632 (75.8)	30,088 (74.7)	260,544 (75.9)	
Occasionally	78,648 (20.5)	8,553 (21.2)	70,095 (20.4)	
1-2 times/month	8,427 (2.2)	828 (2.1)	7,599 (2.2)	
1-2 times/week	3,116 (0.8)	338 (0.8)	2,778 (0.8)	
3-4 times/week	1,655 (0.4)	263 (0.7)	1,392 (0.4)	
Drink every day	964 (0.3)	202 (0.5)	762 (0.2)	
Exercise, n (%)				<0.001
No exercise	58,734 (15.3)	4,675 (11.6)	54,059 (15.8)	
<3 days/week	54,793 (14.3)	6,222 (15.4)	48,571 (14.2)	
3-5 days/week	232,451 (60.7)	25,220 (62.6)	207,231 (60.4)	
>5 days/week	37,159 (9.7)	4,132 (10.3)	33,027 (9.6)	
High sugar diet, n (%)	7,360 (1.9)	1,143 (2.8)	6,217 (2.1)	<0.001
Blood cholesterol (mg/dL), mean ± SD	124.10±69.37	142.65±67.93	121.97±69.36	<0.001
Fasting blood sugar (mg/dL), mean ± SD	88.69±10.47	107.63±7.31	86.51±8.38	<0.001

* Student t-test and Chi-square test were used to compare characteristics across groups for continuous and categorical variables respectively

higher SBP and total blood cholesterol. They were more likely to have a family history of diabetes. They were also more likely to be regular cigarette smokers and alcohol drinkers.

The overall mean fasting plasma glucose of this non-diabetic population was 88.69±10.47 mg/dL, with the estimates of 88.89±10.13 mg/dL and 88.62± 10.83 mg/dL in males and females respectively. The prevalence of pre-diabetes was 10.5%, with a higher prevalence in women than men (11.2% vs. 9.7%).

Fig. 1 shows the prevalence of pre-diabetes by age group and sex. Generally, the prevalence of pre-diabetes rose with increasing age and was higher in women than men. The prevalence of pre-diabetes differed across different levels of alcohol consumption (Chi-2 for trend *p*-value <0.05), as shown in Fig. 2. The prevalence of pre-diabetes for individuals who drank 3-4 time/week (15.9%) and drank every day (21.0%) was significantly higher than for individuals who never drank (10.4%) (*p*<0.001).

Association between alcohol consumption and pre-diabetes

After adjusting for age, sex, BMI, SBP, waist

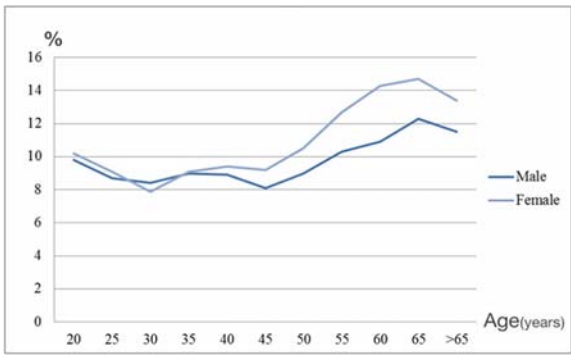

Fig. 1 Prevalence (%) of pre-diabetes by age and sex in 383,442 participants in the HCUR study.

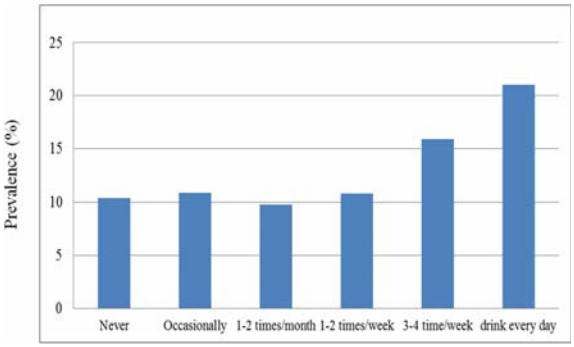

Fig. 2 Prevalence (%) of pre-diabetes by alcohol consumption in 383,442 participants in the HCUR study.

circumference, a family history of diabetes, smoking, physical exercise, self-rated consumption of high-sugar diet and blood cholesterol, there was a significant positive association between alcohol consumption and pre-diabetes. Individuals with more frequent consumption had higher odds of having pre-diabetes than those with less frequent consumption (Chi-2 for trend *p*-value <0.05) (Table 2). For example, those who drank every day and drank 3-4 times/week had an 80% and 47% higher risk of having pre-diabetes, compared to non-drinkers (OR_{adj} 1.80, 95% CI 1.53-2.11 and 1.47, 95% CI 1.28-1.68, respectively). However, those who consumed alcohol less than twice a week had a similar risk of having pre-diabetes to non-drinkers. There was no interaction between alcohol consumption and other risk factors concerning the risk of pre-diabetes.

Similar findings were observed in men. Although there seemed to be a positive trend in risk of having pre-diabetes with increasing consumption of alcohol in women, the associations were not statistically significant (Table 2). Noteworthy, women who drank occasionally seemed to have a decreased risk, as compared with non-drinkers (OR_{adj} 0.95, 95% CI 0.91-0.99, p = 0.039). Sensitivity analyses using different pre-diabetes criteria of fasting blood sugar of 110-125 mg/dL show similar results concerning the association between alcohol consumption and pre-diabetes.

Discussion

Using data on a large health examination project, the present study shows that the prevalence of pre-diabetes in this Thai general population was fairly low. There was a positive association between alcohol consumption and pre-diabetes, with a more pronounced association in men than in women.

Our study suggests a positive association between alcohol consumption and pre-diabetes in men, with a more complex relationship in women. This is similar to the results from a prospective study in a Swedish population by Cullmann et al[14]. The authors found that medium and high alcohol consumption increased the risk of pre-diabetes in men by 42% and 76%, respectively, while no association was observed in women. When considering types of alcohol and beverages, they found that high consumption of wine decreased pre-diabetes risk in women by 46%, which differs from our results. The authors reported the associations between different types of alcohols and risk of pre-diabetes, while our study had no data on different types of alcohol consumption. This might underline the importance of alcohol consumption to the risk of pre-diabetes in different ethnics and populations, and highlight the differential impact of different alcoholic beverages on the risk of pre-diabetes and diabetes.

Many previous studies suggest that low-moderate consumption of alcohol might be beneficial concerning diabetes risk[7-11], and our study further suggests that the benefits may also be true for the risk of pre-diabetes. This is supported by the evidence that alcohol ingestion may have significant effect on glucose tolerance and insulin secretion in non-diabetic populations[15]. As the diagnostic criteria to define diabetes and pre-diabetes are somewhat arbitrary, the patterns of the association between alcohol consumption and blood glucose levels in a high normoglycemic range might merit further study. As the risk of macro- and micro-vascular complications is continuous and linear across the whole range of blood sugar[16-19], the prevention of pre-diabetes through interventions addressing alcohol consumption might possibly help

Table 2. Association between alcohol consumption and pre-diabetes using multivariable logistic regression

Alcohol consumption	Pre-diabetes status		Crude OR (95% CI)	Adjusted OR+ (95% CI)
	Yes (%)	No (%)		
All participants				
Never	30,088 (74.7)	260,544 (75.9)	1	1
Occasionally	8,553 (21.2)	70,095 (20.4)	1.05 (1.03-1.08)	0.99 (0.96-1.02)
1-2 times/month	828 (2.1)	7,599 (2.2)	0.94 (0.87-1.01)	0.89 (0.82-0.97)*
1-2 times/week	338 (0.8)	2,778 (0.8)	1.05 (0.94-1.18)	1.00 (0.89-1.13)
3-4 times/week	263 (0.7)	1,392 (0.4)	1.63 (1.43-1.86)	1.47 (1.28-1.68)*
Drink every day	202 (0.5)	762 (0.2)	2.29 (1.96-2.68)	1.80 (1.53-2.11)*
Male				
Never	10,501 (59.5)	104,683 (63.9)	1	1
Occasionally	5,476 (32.6)	48,344 (29.5)	1.18 (1.14-1.22)	1.02 (0.99-1.07)
1-2 times/month	700 (4.0)	6,445 (3.9)	1.08 (0.99-1.17)	0.92 (0.84-1.00)
1-2 times/week	303 (1.7)	2,436 (1.5)	1.24 (1.09-1.40)*	1.06 (0.93-1.20)
3-4 times/week	225 (1.3)	1,153 (0.7)	1.94 (1.68-2.24)*	1.55 (1.33-1.80)*
Drink every day	177 (1.0)	646 (0.4)	2.73 (2.31-3.22)*	1.87 (1.57-2.24)*
Female				
Never	19,587 (86.6)	155,861 (86.8)	1	1
Occasionally	2,807 (12.4)	21,751 (12.1)	1.02 (0.98-1.07)	0.95 (0.91-0.99)*
1-2 times/month	128 (0.6)	1,154 (0.6)	0.88 (0.73-1.06)	0.86 (0.71-1.04)
1-2 times/week	35 (0.2)	342 (0.2)	0.81 (0.57-1.15)	0.74 (0.51-1.06)
3-4 times/week	38 (0.2)	139 (0.1)	1.26 (0.89-1.78)	1.15 (0.81-1.64)
Drink every day	25 (0.1)	116 (0.1)	1.71 (1.11-2.64)	1.31 (0.83-2.05)

* *p*-value <0.05

+ Odds ratios was adjusted for age, sex, BMI, SBP, waist circumference, family history of diabetes, exercise, smoking, high sugar food and blood cholestero

reduce the risk of such complications.

Strengths and limitations

Our study was among the first to describe the prevalence of pre-diabetes and the association between alcohol consumption and pre-diabetes in Asian general populations. This was a large population-based health examination of individuals in Ubon Ratchathani, with standardized measurements and outcome ascertainment. A large study of almost 400 thousands men and women allows a sufficiently high power to detect small associations between the exposures and outcomes. The associations reported in this study were controlled for several traditional risk factors for diabetes and pre-diabetes. However, our study has a number of limitations. First, alcohol consumption was self-reported. Therefore, under-reporting of true alcohol consumption is possible, and this might alter the true association between alcohol consumption and risk of pre-diabetes. Second, this analysis was based on cross-sectional data; hence, the possibility of reverse causality should be concerned. Third, we used a single fasting blood sugar to define diabetes and pre-diabetes.

There might, therefore, be the possibility of misclassification and regression to normal glucose tolerance. Lastly, this study was done in the general population of Ubon Ratchathani, the generalizability to Thailand's general population might be concerned. However, the study participants were fairly similar to a national representative sample in the Thailand National Health Examination Survey III, regarding body mass index, waist circumference, and systolic blood pressure, despite a lower prevalence of cigarette smoking[20].

Implications

The differential association between alcohol consumption and pre-diabetes across sex highlights the importance of development of recommendations on preventive measures specific to sexes. Our study also suggests groups/individuals at high risk to

which preventive interventions could be targeted. In addition, research on the prospective association between overall and different types of alcohol consumption and risk of pre-diabetes is needed.

Conclusion

In this large population-based health examination survey, alcohol consumption had a continuous and positive relationship with risk of pre-diabetes, with different associations between men and women. This underlines the importance of gender-specific recommendations on preventive interventions. Prospective research to examine temporal relationship between alcohol consumption and the risk of pre-diabetes is needed.

What is already known on this topic?

Most studies have been examined association between alcohol consumption and type 2 diabetes mellitus. The U-shaped relationship between alcohol consumption and diabetes mellitus was observed among western populations. A report from studies in Sweden found total alcohol consumption and binge drinking increased the risk of pre-diabetes and type 2 diabetes mellitus in men and women, while low consumption decreased diabetes risk in women. In China, found population who drank moderate alcohol intake around 1-3 drinks/day was inversely related to type 2 diabetes mellitus risk. A few studies have been examined association between alcohol consumption and pre-diabetes mellitus in Asian general populations and Thai population.

What this study adds?

This study was among the first reports to describe the prevalence of pre-diabetes and the association between alcohol consumption and pre-diabetes. We found the differential association between alcohol consumption and pre-diabetes across sex in Thai population and Asian general populations. Our study suggests that the benefits may also true for the risk of pre-diabetes. This is supported by the evidence that alcohol ingestion may have significant effect on glucose tolerance and insulin secretion in non-diabetic populations.

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Potential conflicts of interest

None.

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ความสัมพันธ์ระหว่างการดื่มเครื่องดื่มผสมแอลกอฮอล์กับภาวะเบาหวานแฝงในประชาชนอายุ 15 ปีขึ้นไป จำนวน 383,442 คน ในจังหวัดอุบลราชธานี

พลากร สืบสำราญ, หรรษา ชื่นชูผล, สุวิทย์ โรจนศักดิ์โสธร, สุรพร ลอยหา, ปริญญา ชำนาญ

ภูมิหลัง: *จากรายงานการศึกษาที่ผ่านมาพบว่า การดื่มเครื่องดื่มผสมแอลกอฮอล์มีความสัมพันธ์กับการเกิดโรคเบาหวานแต่ยังมีข้อมูลค่อนข้างน้อยเกี่ยวกับความสัมพันธ์ระหว่างการดื่มเครื่องดื่มผสมแอลกอฮอล์กับการมีภาวะเบาหวานแฝงในประชากรในภูมิภาคเอเชีย*

วัสดุและวิธีการ: *การศึกษาครั้งนี้เป็นการศึกษาเชิงวิเคราะห์แบบภาคตัดขวางเพื่อศึกษาความสัมพันธ์ระหว่างการดื่มเครื่องดื่มผสมแอลกอฮอล์กับการมีภาวะเบาหวานแฝงในประชาชนอายุ 15 ปี ขึ้นไป จำนวน 383,442 คน ที่ร่วมโครงการการตรวจสุขภาพประชาชนทั่วไปในจังหวัดอุบลราชธานี (Health Checks Ubon Ratchathani (HCUR) project) ในปี พ.ศ. 2549 โดยภาวะเบาหวานแฝงหมายถึงผู้ที่มีระดับน้ำตาลในเลือดระหว่าง 100-125 มิลลิกรัมต่อเดซิลิตร และการดื่มเครื่องดื่มผสมแอลกอฮอล์แบ่งออกเป็น 6 กลุ่ม คือ ไม่ดื่ม ดื่มนานๆ ครั้ง 1-2 ครั้งต่อเดือน 1-2 ครั้งต่อสัปดาห์ 3-4 ครั้งต่อสัปดาห์ และดื่มทุกวัน โดยวิเคราะห์หาความสัมพันธ์ของการดื่มเครื่องดื่มผสมแอลกอฮอล์กับการมีภาวะเบาหวานแฝง โดยการวิเคราะห์ถดถอยเชิงพหุแบบลอจิสติก*

ผลการศึกษา: *ความชุกของภาวะเบาหวานแฝงในประชาชนที่ศึกษาเท่ากับร้อยละ 10.5 โดยมีความชุกในเพศหญิงร้อยละ 11.2 และเพศชายร้อยละ 9.7 เมื่อวิเคราะห์ข้อมูลเชิงซ้อนเพื่อควบคุมอิทธิพลของตัวแปรอื่นพบว่า การดื่มเครื่องดื่มผสมแอลกอฮอล์มีความสัมพันธ์กับการมีภาวะเบาหวานแฝง ได้แก่ ดื่มทุกวัน (OR_{adj} = 1.80, 95% CI, 1.53-2.11), ดื่ม 3-4 ครั้งต่อสัปดาห์ (OR_{adj} = 1.47, 95% CI, 1.28-2.68) และคนที่ดื่ม 1-2 ครั้งต่อเดือน ลดโอกาสเสี่ยงเมื่อเทียบกับคนที่ไม่ดื่ม (OR_{adj} = 0.89, 95% CI, 8.82-0.97) ส่วนในเพศชายให้ผลการศึกษาคล้ายคลึงกับที่กล่าวมาในเพศหญิง พบว่าคนที่ดื่มเล็กน้อยลดโอกาสเสี่ยงเมื่อเทียบกับคนที่ไม่ดื่ม (OR_{adj} = 0.95, 95% CI, 0.91-0.99) ไม่พบผลจากปฏิสัมพันธ์ของการดื่มเครื่องดื่มผสมแอลกอฮอล์กับปัจจัยเสี่ยงอื่นๆ ต่อความเสี่ยงของการมีภาวะเบาหวานแฝง*

สรุป: *การดื่มเครื่องดื่มผสมแอลกอฮอล์เป็นปัจจัยเสี่ยงที่สำคัญต่อการเกิดภาวะเบาหวานแฝง แต่การดื่มในปริมาณไม่มากเป็นการลดโอกาสเสี่ยงต่อการมีภาวะเบาหวานแฝง*