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Risk of Vitamin D Deficiency in Smokers: Mix-Method

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ABSTRACT
Cigarettes are one of the leading causes of death in the world and Indonesia. Cigarettes emit cigarette smoke, which contains toxins and has pro-inflammatory properties that interfere the metabolism of vitamin D in the lungs. The study aimed to determine the risk of vitamin D deficiency in active smokers in Rungkut Village, Surabaya City. This research method is a mix-method with a Convergent Parallel Design type strategy, which is a way of collecting quantitative (cross-sectional) and qualitative data (interpretative phenomenological analysis) simultaneously, with purposive sampling technique. The variable was the risk of vitamin D deficiency and vitamin D level. Subjects were active smokers aged ≥19 years in the Rungkut Subdistrict. The number of samples involved in this research was 125 samples in the quantitative phase, and 15 people in the qualitative phase. The highest level of smoking severity was light smokers (45.60%). Most of respondents had normal vitamin D levels (≥20 μg/mL) of 73.33%, averaging of 37.66 ± 5.89 μg/mL. Most active smokers are at risk of vitamin D deficiency. Risk factors for deficiency in heavy smokers are not consuming foods containing vitamin D (such as fish, eggs, and milk), not consuming fish oil supplements and vitamins, and not sunbathing. However, the level of physical activity tended to be moderate-heavy. The conclusion is that smokers must pay attention to their intake of foods containing vitamin D and exposure to sunlight to achieve sufficient vitamin D levels.

INTRODUCTION

Indonesia is in third place with the most significant number of smokers in the world after the People's Republic of China (PRC) and India. It is estimated that by 2030 the number of smokers in the world and the death rate will reach up to 10 million, of which 70% will come from developing countries. Currently, 50% of the death rate among smokers in the world has come from developing countries.[1] The number of deaths due to smoking is predicted to continue to increase every year because the main ingredient in cigarettes is tobacco.[2] The main substance in tobacco, namely nicotine, has a relaxing effect, making it addictive for users. The chemical poisons contained in cigarette smoke can be easily transferred from the lungs to the bloodstream and even spread to almost every organ of the human body.[3]

Systemically, exposure to cigarette smoke can disrupt vitamin D metabolism and damage tubules in the kidneys and liver. Cigarette exposure reduces 25(OH)D and 1,25(OH)2D levels by 10%.4 Cigarettes can also cause dryness and shrinkage of the skin, where skin synthesis is the primary source of vitamin D in humans.[4] Cigarette smoke contains toxic aldehydes that can influence the inflammatory response by increasing the production of pro-inflammatory cytokines.[5] Additionally, it has pro-inflammatory properties that can weaken host cells in the human body and disrupt the metabolism of vitamin D in the lungs,[6,7] leading to an accelerated decline in lung function.[8]

In recent years, research has shown an increase in the prevalence of vitamin D deficiency in countries near the equator, where there is abundant exposure to sunlight.[9]

Sun exposure is the most sustainable solution to the widespread issue of vitamin D deficiency, particularly in tropical regions. Despite the abundant sunlight in countries considered a paradox,[9] like Indonesia, there is a high prevalence of vitamin D deficiency.[10,11] A Hartung-Knapp-Sidik-Jonkman method meta-analysis revealed that vitamin D deficiency is a significant public health concern in Indonesia.[12] Research by Suryadinata and Lorensia in Indonesia demonstrated a link between vitamin D deficiency and smoking habits.[13] Respiratory diseases are commonly associated with vitamin D deficiency. This study aimed to assess the risk of vitamin D deficiency among active smokers in the Rungkut District of Surabaya City, located in the eastern part of Surabaya, with a large population of 833,426 people. Rungkut District is densely populated and includes worker residential areas, such as cigarette factories.[14]

MATERIAL AND METHOD

This research is a mixed-methods study that combines quantitative and qualitative data. The design strategy employed is convergent parallel design. The quantitative aspect involves descriptive analysis using a Cross-Sectional Study approach, while the qualitative aspect utilizes Interpretative Phenomenological Analysis (IPA) techniques for data analysis. The study was conducted in Rungkut Village, Surabaya City, from April to July 2023. The research adhered to the code of ethics with No. 160/KE/VI/2023 by Universitas Surabaya, Surabaya.

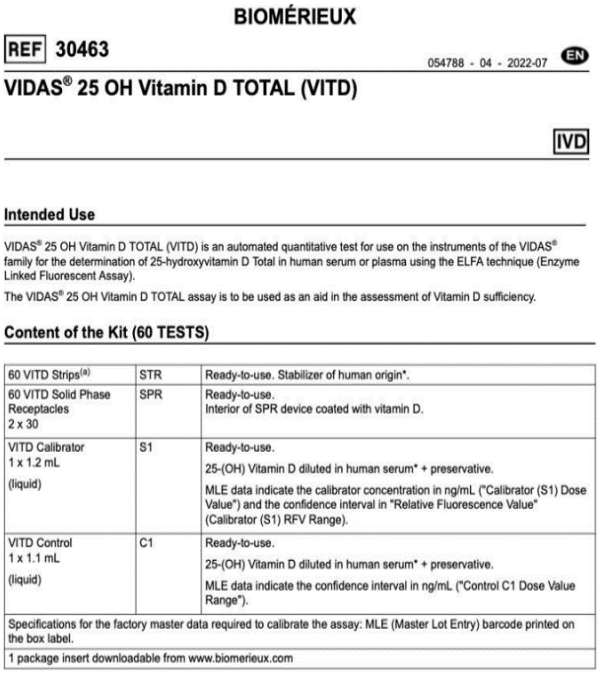
Smokers are adults who have smoked at least 100 cigarettes in their lifetime and currently smoke every day.[15] Smoking classification based on the Brinkman Index is divided into three categories: light smokers (0-199), moderate smokers (200-599), and heavy smokers (≥600). The Brinkman index formula is calculated by multiplying the number of cigarettes smoked daily (sticks) by the number of years of smoking (years).[16,17] Vitamin D deficiency occurs when the body lacks sufficient vitamin D intake. Most experts consider a 25(OH)D concentration below 25 or 30 nmol/L indicating an increased risk of vitamin D deficiency. A concentration of 50 nmol/L or higher is considered within the normal health range.[18,19] The study population was adult male active smokers in Rungkut Subdistrict, Surabaya City. The sample included male active smokers aged 19-60 years, with no chronic lung disease, who had been smoking for the last 5 years, and were willing to participate in the research. The total number of active adult smokers in the Rungkut Subdistrict was 125 respondents. Data was collected from residents who attended a health education session at the RW hall facilitated by the local RT head in April 2023. For this quantitative study, the minimum sample size was calculated using the Slovin formula, n=N/[1+Ne2] with a sampling error (e) of 5%. The minimum sample size (n) for this research was 95 respondents. The sampling method used was purposive sampling. In the

qualitative phase, data collection continued until data saturation was achieved.

The method used in this research is Mixed-Method, which can simultaneously collect quantitative and qualitative data. The qualitative phase of the mix-method aims to produce a more complete and in-depth picture of the phenomenon. In the initial stage, quantitative methods were used to measure active smokers' vitamin D deficiency risk. These risk factors were described from domains, including smoking history, diet, vitamin/supplement intake, sun exposure, frequency of gadget screens, and physical activity. Data collection began based on adapting the Vitamin D Deficiency Risk Questionnaire.[4,10,20,21] This research used a questionnaire consisting of 12 closed questions and several open questions. Questions in the vitamin D deficiency risk questionnaire included cigarette use, consumption of foods containing vitamin D (consumption of food from fish, eggs, and milk, which was assessed from the question points in the questionnaire, including the frequency and method of serving food), vitamin D supplements, exposure to sunlight, exposure to gadget radiation, and physical activity. The validity test in this questionnaire only extends to the development of sentences and language because each question item only contains short (closed) questions. In filling out the questionnaire in this study, respondents can fill in each question that has been provided.

Measurement of Vitamin D (25(OH)D) levels in human serum uses VIDAS® 25 OH Vitamin D TOTAL (VIT D), an automated quantitative test employing the ELFA (Enzyme-Linked Fluorescent Assay) technique (Figure 1). VIDAS® 25 OH Vitamin D TOTAL is employed to evaluate Vitamin D sufficiency. A certified laboratory collected 3 ml blood samples from respondents, followed by a blood sample taken at a standardized laboratory in Surabaya.

Quantitative methods are used to obtain measurable data that can be descriptive. The quantitative data in this research is for descriptive analysis. Measuring the percentage value of respondents regarding the risk of deficiency involves using simple statistical data, with the resulting percentage value calculated using the Statistical Package for Social Science (SPSS) program. After the quantitative data collection is complete, qualitative data is gathered in the form of an in-depth examination of the risk factors for vitamin D deficiency in various domains, including cigarette smoking, intake of foods containing vitamin D (such as fish, eggs, milk, and fish oil supplements), vitamin intake, skin exposure to sunlight, screen time on gadgets, and physical activity. Qualitative data is obtained through interviews conducted with the help of an interview guide instrument.



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VIDAS® 25 OH Vitamin D TOTAL (VITD)

IVD

Intended Use

VIDAS® 25 OH Vitamin D TOTAL (VITD) is an automated quantitative test for use on the instruments of the VIDAS® family for the determination of 25-hydroxyvitamin D Total in human serum or plasma using the ELFA technique (Enzyme Linked Fluorescent Assay).

The VIDAS® 25 OH Vitamin D TOTAL assay is to be used as an aid in the assessment of Vitamin D sufficiency.

Content of the Kit (60 TESTS)

60 VITD Strips[a]	STR	Ready-to-use. Stabilizer of human origin*.
60 VITD Solid Phase Receptacles 2 x 30	SPR	Ready-to-use. Interior of SPR device coated with vitamin D.
VITD Calibrator 1 x 1.2 mL (liquid)	S1	Ready-to-use. 25-(OH) Vitamin D diluted in human serum* + preservative. MLE data indicate the calibrator concentration in ng/mL ("Calibrator (S1) Dose Value") and the confidence interval in "Relative Fluorescence Value" (Calibrator (S1) RFV Range).
VITD Control 1 x 1.1 mL (liquid)	C1	Ready-to-use. 25-(OH) Vitamin D diluted in human serum* + preservative. MLE data indicate the confidence interval in ng/mL ("Control C1 Dose Value Range").
Specifications for the factory master data required to calibrate the assay: MLE (Master Lot Entry) barcode printed on the box label.		
1 package insert downloadable from www.biomerieux.com		

Source: Primary Data, 2023

Figure 1. VIDAS® 25 OH Vitamin D TOTAL (VIT-D) Procedure

RESULTS

This research and data collection was conducted from April 2023 to July 2023 in Rungkut Village. Data were collected by filling in questionnaire questions and conducting interviews with respondents included in the research sample. The number of samples involved in this research was 125. All active smokers were willing to fill out a questionnaire and have their vitamin D levels measured (n=125). However, in the qualitative phase, only 15 respondents were able to be followed up and were willing to continue with in-depth interviews. Based on Table 1, 125 respondents were active smokers, with 65 respondents (52%) starting smoking in adulthood, 22 (40%) having an average normal body weight, and the highest percentage of respondents (92%) having no history of the disease.

Based on Table 1 it showed that 85 respondents (68%) were active smokers with an average of ≥10 years of smoking.23 The maximum number of cigarettes smoked per day was 11-24, with 69 respondents (55.20%). Additionally, 99 respondents (79.20%) smoked filter cigarettes. The Brinkman Index categorized 57 respondents (45.50%) as light smokers.

Based on Table 2, there were 21 respondents (16.80%) who smoked tobacco through direct smoking. Additionally, 108 respondents (86.40%) consumed fish, with 100 respondents (80%) frying it. Moreover, 117 respondents (93.60%) consumed eggs, out of which 115 respondents (92%) used chicken eggs and fried them, as reported by 94 respondents (75.20%). Furthermore, 79 respondents consumed milk (63.20%), and 25 respondents (20.00%) used packaged liquid milk. The highest frequency of respondents who did not consume fish oil supplements was 118 respondents (94.40%). Similarly, the highest frequency of respondents who did not consume vitamins was 73 respondents (58.40%). The main reason respondents consumed vitamins was due to the health benefits, with 45 respondents (36%) citing this reason. The highest frequency of respondents who often looked at gadget screens was 118 respondents (94.40%), with 49 respondents (39.20%) spending more than 7 hours on this activity. Additionally, 98 respondents (78%) were unaware of the ideal time to look at monitor screens (40%). The highest frequency of respondents who rarely engaged in physical activity was 96 respondents (76.80%), with 49 respondents (39.20%) spending more than 7 hours inactive and 96 respondents (76.80%) falling into the moderate activity category (Table 2).

Table 1. Frequency Distribution of Respondents Based on Age, BMI, and Smoking Profiles

Characteristics	n = 125	%
Age (Years)		
19-44 (Adult)	65	52
45-59 (Pre-elderly)	48	38.40
60 (Seniors)	12	9.60
Body Mass Index (BMI)[24]		
Underweight (<18.5)	12	9.60
Normal (18.5-22.9)	50	40
Overweight with risks (23- 24.9)	25	20
Obesity 1 (25-29.9)	31	24.80
Obesity 2 (≥30)	7	5.60
Disease History		
Hypertension	3	2.40
Dyslipidemia	3	2.40
Diabetes Mellitus Type 2	3	2.40
Rheumatoid Arthritis	1	0.80
No History of Illness	115	92
Long Time Smoking Cigarettes (Years)		
< 10	40	32
≥ 10	85	68
Number of Cigarettes Smoked		
1-10 cigarettes per day	47	37.60
11-24 cigarettes per day	69	55.20
≥24 cigarettes per day	9	7.20
Types of Cigarettes		
Filter	99	79.20
Kretek	20	16.00
Mixture	6	4.80
Brinkman Index		
Light smoker (0-199)	57	45.60
Medium smoker (200-600)	52	41.60
Heavy smoker (>600)	16	12.80

Source: Primary Data, 2023

Table 2. Distribution Profile of Respondents' Answers

Domain	Question	Respondent's Answer	n = 125	%
Cigarette	Have you ever consumed tobacco directly?	No	104	83.20
		Yes	21	16.80
	How do you use this tobacco?	No	104	83.20
		Inhale directly	21	16.80
		Chewed	0	0
	How do you know this?	Don't know	104	83.20
		Friends/family	13	10.40
		Environment	8	6.40
Fish	Have you ever consumed fish?	Consume	108	86.40
		Do not consume	17	13.60
	What fish do you usually eat?	Mackarel tuna	35	28
		Pindang fish	32	25.60
		Salted fish	25	20
		Milkfish	7	5.60
		Catfish	5	4
		Mujaer fish	4	3.20
	How do you serve the fish you eat?	Fried	100	80
		Burned	5	4
		Steamed	3	2.40
	What is your reason for consuming fish?	Kitchen dishes	40	32
		Love the taste	32	25.60
		Get health benefits	21	16.80
		Do not like	16	12.80
		Affordable prices	10	8
		Diet	5	4
		Allergy	1	0.80
Egg	Have you ever consumed eggs?	Consume	117	93.60
		Do not consume	8	6.40
	What eggs do you usually eat?	Chicken	115	92
		Duck	2	1.60
	How do you serve the eggs you consume?	Fried	94	75.20
		Boiled	23	18.40
	What is the reason you consume eggs?	Love the taste	82	65.60
		Get health benefits	23	18.40
		Kitchen dishes	9	7.20
		Don't consume	7	5.60
		Cheap/affordable prices	3	2.40
		Diet	1	0.80
Milk	Do you consume milk?	Consume	79	63.20
		Do not consume	46	36.80
	What milk do you usually consume?	Packaging (liquid)	25	20
		Condensed milk (sachet)	22	17.60
		Real milk	20	16
		Powder	12	9.60
	What is the reason you consume milk?	Health benefits	50	40
		Love the taste	29	23.20
Fish Oil Supplements	Do you take fish oil supplements?	Do not consume	118	94.40
		Consume	7	5.60
	What type and brand of fish oil supplement do you consume?	Omega-3	4	3.20
		Forgot the brand	3	2.40
	How many fish oil supplements do you consume?	Capsule	7	5.60
		Teaspoon	0	0
		Tablespoon	0	0

Table 2. Distribution Profile of Respondents' Answers

Domain	Question	Respondent's Answer	n = 125	%
	Why do you take fish oil supplements?	Not accustomed to	63	50.40
		Stench	40	32
		Expensive price	15	12
		Health benefits	7	5.60
Vitamin	Do you take vitamins?	Do not consume	73	58.40
		Consume	52	41.60
	What type and brand of vitamins do you consume?	Vitacimin®	27	21.60
		Enervon-C®	7	5.60
		Hemaviton®	5	4
		Vitamin D (1000 IU)	5	4
		Imbost®	4	3.20
	The reason you take vitamins?	Don't know	73	58.40
		Health benefits	45	36
		Recommended	4	3.20
		friend/doctor	3	2.40
Changes in Skin Color	Does your skin color change when exposed to direct sunlight?	No	68	54.40
		Yes	57	45.60
	What changes does your skin color look like when exposed to sunlight?	No	40	32
		Blackish red	20	16
		Red	8	6.40
Sunbathe	Do you take free time to sunbathe directly?	No	67	53.60
		Yes (eg, tanned)	58	46.40
	What time are you usually exposed to sunlight (sunbathing)?	07.00-09.00	60	48
		10.00-11.00	32	25.60
		12.00-14.00	26	20.80
		15.00-17.00	7	5.60
	Do you sunbathe using personal protective equipment?	Hat	58	46.40
		Jacket	40	32
		Without personal protection	19	15.20
		Sunscreen/sunscreen	6	4.80
		Umbrella	2	1.60
	Do you wear closed clothes?	Shirt and trousers	82	65.60
		Short t-shirt	43	34.40
Gadget Screen	Are you staring at a gadget screen such as a cellphone, laptop or tablet?	Often	118	94.40
		Rarely/not at all	7	5.60
	How long (per day) do you stare at a monitor screen such as a cellphone, laptop or tablet?	≥7 hours	49	39.20
		0-1.5 hours	32	25.60
		4-6 hours	20	16
		2-3 hours	17	13.60
	In your opinion, how long is the ideal time to stare at a monitor screen?	Don't know	98	78.40
		1-2 hours	18	14.40
		20-30 minutes	9	7.20
Physical Activity	Do you often do physical activity?	Seldom	96	76.80
		Often	29	23.20
	How often do you do physical activity?	Light	0	0
		Moderate	96	76.80
		Heavy	29	23.20

Source: Primary Data, 2023

Most of respondents had normal vitamin D levels (sufficiency) of 73.33%, with an average vitamin D level of 37.66±5.89 mg/mL. The results of the cross-tabulation between the description of vitamin D risk factors and vitamin D levels can be seen in Table 3.

When conducting interviews regarding the risk of vitamin D deficiency, 15 respondents out of 125 respondents were willing to conduct further interviews. The researcher then made interview transcripts and summarized them in table form as well as interview excerpts to further understand the interview themes so that they were in accordance with the research title (Table 4).

Table 3. Cross Tabulation Between the Risk of Vitamin D Deficiency and Vitamin D Levels

Risk of Vitamin D Deficiency		Vitamin D Serum Category (μg/mL)[31]			Total
	Domain	Deficiency (<12μg/mL) (n = 7)	Insufficiency (12-20 μg/mL) (n = 26)	Sufficiency (>20 μg/mL) (n = 92)	
Cigarette (Brinkman Index)[24]	Light smoker (0-199)	0	4	53	57
	Medium smoker (200-600)	2	12	38	52
	Heavy smoker (>600)	5	10	1	16
Fish	Consume fish that contain high levels of vitamin D	3	10	52	65
	Consume fish that do not contain high levels of vitamin D	2	7	34	43
	Do not consume fish	3	9	5	17
Egg	Consume egg	1	25	91	117
	Do not consume egg	6	1	1	8
Milk	Consume milk	2	9	68	79
	Do not consume milk	5	17	24	46
Fish Oil Supplements	Consume fish oil	4	24	90	118
	Do not consume fish oil	3	2	2	7
Vitamin	Vitamin C	0	1	36	37
	Vitamin D	0	0	5	5
	Immunomodulator	0	2	2	4
	Not taking any vitamins	7	23	49	79
Changes in Skin Color	Yes	3	13	41	57
	No	4	13	51	68
Sunbathe	Yes	4	11	43	58
	No	3	15	49	67
Gadget Screen	Often	4	24	90	118
	Rarely/not at all	3	2	2	7
Physical Activity	Light	0	0	0	0
	Moderate	4	14	78	96
	Heavy	3	12	14	29

Source: Primary Data, 2023

Table 4. In-depth Interview Results

Domain	Findings	Answer Findings	Quotes From The Interview	Source
Smoke	Respondents knew the severity of smoking	Frequency of cigarette use by respondents	"I've been smoking for more than 15 years, so what's strange is that I can't really stop. Just stop when you cough, then try again with one cigarette, if you cough, throw it away and change to another brand of cigarette, and so on, sis."	Respondent 7
			"Usually I use official cigarettes from factories such as salt warehouses and every day I use up more than 20 cigarettes. I've been smoking for more than 15 years."	Respondent 1
			"I use cigarettes and the brand varies depending on the price, but I usually use 1 pack of solar a day, and I smoked when I was single, around 25 years after graduating from high school, sis."	Respondent 9
			"You don't know how to smoke, sis, sometimes Surya sometimes uses DJI Samsoe. "I've been smoking since I was 18 years old, sis, and now I'm 52 years old."	Respondent 11
	Respondents' views on cigarette use	Views of cigarettes on health by respondents	"For example, if I don't smoke, sis, I'm stressed because my job is uncertain. So, if I smoke, it just feels calmer in my mind, sis."	Respondent 2
			"I don't smoke, or if I just stop for a day, I'll get a headache, but if I smoke just one cigarette, my body will immediately feel better, sis, so I think that smoking isn't completely dangerous because according to my father, cigarettes are medicine."	Respondent 4
Tobacco	Respondents know their knowledge and behavior regarding tobacco use	Tobacco use by respondents	"Previously, I used to smoke tobacco straight away, sis, because in the past tobacco was cheaper than cigarettes, and I knew how to do it when my friends told me to use tobacco."	Respondent 13
			“In the past, I used tobacco directly, sis, by smoking it. "I knew about tobacco because I was told by a friend and forced by a friend to try it. After a while, I became addicted to it and then I tried to replace it with cigarettes."	Respondent 8
			"When I'm in a crisis, I usually use tobacco, sis, because it's cheaper and the way to do it is to smoke it directly. I know that method, I was given tips from my father for using tobacco too."	Respondent 5
Fish	Respondents know the behavior and amount of fish consumed	Respondents explained their fish consumption habits	"I like fish but I don't know how to eat it, sis, sometimes once a week, often twice at most. "I like it when the fish is fried, but more often I like to eat fish steamed in banana leaves."	Respondent 6

Table 4. In-depth Interview Results

Domain	Findings	Answer Findings	Quotes From The Interview	Source
			"I like to eat fish, but I can't guarantee that it will be every day depending on my wife's business in the kitchen, sis, usually once a week."	Respondent 8
	Respondents know their views on fish consumption habits	Respondents explained the benefits of consuming fish	"Actually, there is no benefit from fish, it's just a complement to food and just increases your appetite, sis."	Respondent 15
			"I like fish, sis, because the benefits of fish are that it is delicious as a complement to food and makes you full, sis."	Respondent 13
			"Because you really like eating fish because the benefits are actually good for your health, sis."	Respondent 11
Egg	Respondents' views on behavior and habits of consuming eggs	Respondents explained their egg consumption habits and views on eggs	“I like eggs, sis, but they contain diabetes, so at my age I cut back on them, sis. So I just eat boiled egg whites and discard the yolks and I eat them often every day, usually mixed with vegetables, because my wife makes that menu, sis."	Respondent 7
			"I like eggs, but I usually eat salted eggs when they are served because I like them. Eggs are good for the strength of your voice and are good for your health."	Respondent 3
			“I also often eat fried eggs, usually twice a week, and now I've switched to salted eggs, sis. "The reason is that I like eggs and they have good health benefits, but if the portion is too big, it's not good, sis."	Respondent 11
	Respondents found out their views on the habit of consuming eggs	Respondents explained the benefits of consuming fish	"Eggs are just a food supplement, so they have no health benefits."	Respondent 2
Milk	Respondents understand the behavior and benefits of milk	Respondents explained their milk drinking habits and views on the benefits of milk	"Sometimes I drink Frisian flag milk twice a week and if I drink too much I'm afraid because it contains sugar, sis. I actually prefer whole milk but I don't buy it because it's more expensive, sis. And I think the benefits of milk are good for health and increase energy."	Respondent 5
			"I also drink Anlene milk 3x a week because of its benefits for bones and usually relieves fatigue."	Respondent 11
	Respondents' views on milk consumption behavior		“I consume milk almost every day, sis, and usually I consume canned milk. "Drinking milk is just for warming the body and the benefits are only for warming the body, sis."	Respondent 12
	Respondents understand the	Respondents explained the	"I also consume the milk from Indomaret, usually it's the Frisian flag	Respondent 9

Table 4. In-depth Interview Results

Domain	Findings	Answer Findings	Quotes From The Interview	Source
	behavior and benefits of milk	behavior and benefits of consuming milk	brand which is low fat, but that's rare, sis, especially if you want it, sis. "It has good health benefits because it contains lots of vitamins."	
Supplement oil fish	Respondents knew the behavior and benefits of fish oil supplements	Views on fish oil supplements by respondents	"I don't take supplements because I don't know the benefits and I don't have the time, sis, because I think I already get enough vitamins from vegetables and fruit."	Respondent 8
		Views on the taste and benefits of oil supplements by respondents	"I don't like drinking fish oil because it tastes fishy even though it has benefits for increasing appetite."	Respondent 1
			"I know that it is useful for stamina, but I don't like taking fish oil supplements because I don't like the fishy taste."	Respondent 5
			"I don't take fish oil supplements because I have a stomach ailment, sis, so I don't like anything strange, especially fish oil supplements because it's fishy and makes me nauseous, even though the benefits are actually good for the body, the effect is only short-lived, sis."	Respondent 7

Source: Primary Data, 2023

DISCUSSION

The results obtained from filling out a questionnaire by 125 respondents were followed by interviews with 15 respondents regarding the risk of vitamin D deficiency in active smokers. This research focuses on exploring and exploring the risk of vitamin D deficiency, starting with the domain regarding smoking, the domain regarding sources of vitamin D, the sunlight exposure domain, the radiation domain, and the physical activity domain.

Based on the data obtained, 125 respondents were active smokers, most of whom smoked for more than 10 years, with the highest number of cigarettes smoked in a day ranging from 11-24 cigarettes, so it can be seen that active smokers in Rungkut Village can be categorized as light smokers, with a respondent frequency of 57 respondents. This relatively high number of smokers is in line with previous research by Salsabila et al.25, Central Java, Yogyakarta, East Java, Bali, NTB, South Kalimantan and South Sulawesi), there were 12,591 research subjects. Based on age, smokers in Indonesia have a median of 38 years. Based on gender, the majority of smokers in Indonesia are men, namely 11,908 people (95%). The type of cigarette most frequently used is filtered kretek cigarettes with an average of 12 cigarettes/day. Indonesia is the country with the highest number of smokers in ASEAN. In South Asia, smoking tobacco (25.2%) and smokeless tobacco (24.7%) is a widespread habit among men. Data from a nationally representative cross-sectional study (Demographic and Health Survey) conducted in Afghanistan, India, Maldives, Nepal and Pakistan from 2015–2018. The subjects were men between 15 and 49 years old. Results found that higher age, lower education, lower wealth status, and involvement in any occupation were strongly associated with smoking (p-value <0.001).[26]

Cigarette smoke has pro-inflammatory properties which can weaken host cells in the body and can interfere with the metabolism of vitamin D in the lungs. This is supported by previous research which shows that cigarette smoke can disrupt the potential pathways of the endocrine system so that it can trigger vitamin D deficiency.[6] Previous research by Yang et al., shows smokers have lower vitamin D

concentrations than non-smokers. So, smokers can trigger a more significant vitamin D deficiency than non-smokers.[4] Based on interviews conducted, respondents were asked for their reasons for smoking cigarettes. As for respondents who said that cigarettes are something that can relieve and reduce pain or have a calming effect on users (Table 4). From the results of the quote above, several respondents experience stress and even dizziness if they do not smoke and think that cigarettes can relieve stress or dizziness. This is supported by previous research that cigarettes can have a positive impact by eliminating stress and dizziness and providing a sense of calm against disturbing thoughts. The nicotine content in cigarettes gives users peace of mind.[27]

In general, conventional tobacco can be used as smoked tobacco or smokeless tobacco. Apart from cigarettes, tobacco is consumed in other forms such as loosely chewed tobacco leaves, snus, naswar, gutka tobacco, and tobacco paste. Scientific analysis of these smokeless tobacco products has revealed more than 20 chemical compounds known to be cancer-causing agents, which include tobacco-specific nitrosamines, N-nitrosamine acids, volatile N-nitrosamines, polycyclic triggering hydrocarbons, and aldehydes.[28] There are several interview quotes above that the price of using tobacco is cheaper than the price of cigarettes from the factory. Based on previous research, tobacco prices are more affordable because the weather makes tobacco production in Indonesia uncertain. If the quality of the tobacco is not good, the price of the tobacco will be sold cheaper.[29] Besides the price of tobacco being cheaper than factory cigarettes, rising cigarette prices will influence the high prevalence in Indonesia. This is because cigarette consumption, especially among adults, is greatly influenced by cigarette prices. The increase in cigarette prices is a preventative effort carried out by the government to reduce cigarette consumption, which currently has the highest number of smokers in the Asian region.[22]

The results showed most respondents consumed fish such as tuna, pindang fish, salted fish, milkfish, catfish, and tilapia fish. The most common way of serving fish is by frying rather than grilling or steaming. It can be seen from the interview excerpt above that respondents 6, 8, 15, 13, and 11 mostly consume fish even though some respondents have inconsistent views regarding the benefits of consuming fish (Table 4). Fish is one of the biggest contributors to vitamin D intake, such as catfish, milkfish, and snapper, which contain around 400 IU per 85 grams of fish. The frequency of fish consumption can affect the concentration of vitamin D, so frequent fish consumption can be recommended to prevent vitamin D deficiency. The process of cooking fish does not affect the vitamin D content in food products because vitamin D is resistant to heat, such as by grilling. However, the amount of vitamin D will decrease by 50% if frying uses cooking oil due to the fat-soluble nature of vitamin D.[30] Different cooking processes (fried, boiled, grilled) will affect the contents of the fish. Changes in the amount of vitamins and protein are significantly higher when fried. The change in the amount of fat will be higher in frying fish than in boiling or grilling. It was stated in this research that the cooking method by boiling is the best for healthy food.[31] A previous study by Sridonpai et al., determined the vitamin D content of commonly consumed fish in Thailand and the effect of different cooking methods on vitamin D retention.[32] The results showed that vitamin D3 was the only form of vitamin D detected in fish. The vitamin D content of raw freshwater fish ranges from 2.42 to 48.5 μg per 100 g Edible Portion (EP), higher than that of raw sea fish (2.94 to 4.69 μg per 100 g EP).32 Previous research by Andrade et al., a cross-sectional online study, was conducted among 1,637 adults.[33] Participants were considered vitamin D deficient and consumed an average of 347.05 ± 307.8 IUs of vitamin D through foods/beverages. Overall, though, participants, on average, did not meet the vitamin D RDAs (Recommended Daily Allowances) for healthy people. This is mainly related to participants rarely or never consuming foods high in vitamin D such as fish and dairy products.

The results show that most respondents consume eggs such as chicken and duck. The most common way of serving fish is frying compared to boiling (Table 4). On average, respondents consume eggs and are aware of their habits regarding egg consumption. Additionally, respondents understand the benefits of consuming eggs. Eggs are a rich source of protein containing ample amounts of

vitamin D and antioxidants, which help prevent aging by aiding in cell degradation. Vitamin D-rich eggs are found in egg yolks at 20 IU per yolk. The cooking process significantly affects the vitamin D content in eggs. According to USDA data from 2015, raw and boiled eggs contain 41 IU/50 grams of vitamin D3, while fried eggs contain 40 IU/46 grams of vitamin D3.[34] Eggs are among the few rich dietary sources of vitamin D. The results of the study by Vičič et al., revealed that fortifying eggs and milk (including yogurt) could effectively increase vitamin D intake in Slovenian women aged 44 to 65 by almost fivefold, thereby reducing the prevalence of vitamin D deficiency.[34] However, a previous study by Daly et al., evaluated the dose-response effect of consuming 2, 7, or 12 commercially available eggs per week on serum 25(OH)D concentrations. The results indicated that consuming 7 eggs per week for 12 weeks effectively reduced the decline in circulating vitamin D concentrations during winter in young Australian adults, with 12 eggs per week not providing any additional benefit.[35]

Based on the results of the questionnaire answered by respondents, it was found that 79 respondents consumed milk most frequently, using liquid packaged milk (ready to eat) and condensed milk (sachets) (Table 4). Respondents consume milk such as ready-to-eat packaged milk. Milk is a fortified product containing vitamin D. Fortified milk must contain 400 IU of vitamin D per litre, whereas pure cow's milk only has 40 IU per litre. Therefore, the best milk is milk with vitamin D fortification in the form of ready-to-eat liquid packaged milk. This research is also similar to other research by Lorensia et al., who analyzed the intake of foods containing vitamin D in 100 adults, showing that eggs and milk contain vitamin D that are most consumed almost every day (98.50%). The incidence of vitamin D deficiency is widespread worldwide, affecting individuals of all ages, including young and healthy subjects, as well as pregnant and elderly women, due to various factors such as inadequate sun exposure, skin pigmentation, adiposity, lifestyle, and low food intake.[30] To address this issue, fortification of daily consumed foods, such as milk, is highly recommended.[36] A theoretical model applied vitamin D3 fortifications of 1 µg, 1.5 µg and 2 µg/100g to simulate improvements in vitamin D intakes. Mean ± SD vitamin D3 in whole milk was 0.06 ± 0.02 µg/100g.[37] Previous research by Zhang et al., explored interaction between passive smoking and dietary undernutrition on the risk of vitamin D deficiency. The interaction between passive smoking and inadequate nutrition influences vitamin D risk D deficiency.[38] Passive smoking may amplify the effect of poor nutrition on the risk of vitamin D deficiency. The more often cigarettes one consumes, nicotine content enters CNS and CNS, putting an individual's food intake.[39] Research has been conducted on consuming foods containing vitamin D on vitamin to prevent deficiency,[30] but there has been no research linking the impact of active on the population and population, and no research no assessed that influences influencing levels through the intake of foods containing vitamin D.

Based on the results obtained, the highest frequency of respondents was found among those who did not consume fish oil supplements. Some reasons for not consuming fish oil supplements included being unaccustomed to them and disliking the fishy smell or taste associated with them (Table 4). Respondents elaborated on their reasons for not taking fish oil supplements, leading to most of respondents not taking supplements containing vitamin D. According to the results, the highest frequency of respondents was among those who did not consume vitamins (Table 4). The majority of respondents, as per the interview excerpt, do not take vitamins, despite some being aware of the benefits they offer to the body. Previous research by Lorensia and Suryadinata,[40] indicated that many individuals are hesitant to use fish oil supplements independently due to the large size of the soft capsules, which can be uncomfortable to swallow, and the fishy odor. However, this research also demonstrates that fish oil supplements are effective in enhancing lung function in smokers.[40]

The questionnaire results showed that as many as 68 respondents experienced color changes when exposed to sunlight, with the most frequent color changes occurring in blackish red. From the interview excerpts of the two respondents above, the respondents experienced changes in skin color when exposed to sunlight. This is supported by research

conducted by Carlberg,[41] skin color will change to pink or even black if the skin has received enough vitamin D. As for several other respondents who experienced something different from the previous respondents, respondents 3 and 9 did not experience changes in skin color when exposed to sunlight (Table 4). The respondent did not experience changes in skin color. The darker a person's skin color, the longer it takes to form vitamin D in the skin. According to Raymond-Lezman and Riskin,[42] in their research, they explain that someone with dark skin has large amounts of melanin in the epidermis, which will make melanin oppose vitamin D receptors in the skin. Melanin will absorb UVB light exposure, reducing the absorption of UVB light exposure for vitamin D receptors in the skin. A person with dark skin takes 10-50 times more exposure to sunlight than a person with light skin to produce the same amount of vitamin D.[42]

The results of the questionnaire showed that 67 respondents who took the time to sunbathe directly, which was mostly found at 07.00-09.00 WIB and by using personal protective equipment such as hats/jackets and long clothes (Table 4). Many respondents spend time sunbathing, but when the intensity of sun exposure is low, many respondents also use personal protective equipment and long clothing, which is at risk of experiencing a a deficiency. Respondents took time to sunbathe between 07.00-09.00 WIB and wore personal protective equipment and closed clothing. Previous research explained that the UVB intensity of sunlight is low at 07.00-08.00 WIB, while at 09.00 WIB, the intensity achieved increases, but it takes a long time of around 25 minutes to sunbathe directly. A good time to be exposed to sunlight is from 10 AM to 2 PM, because at that time UVB rays are more than UVA with a relatively stable and high intensity. However, to be able to see the adequacy of sun exposure not only at the time of exposure, the use of long clothing and personal protection also has an influence. So, it can be concluded that someone who has insufficient sun exposure and has body protection such as sunscreen, hats, jackets and long clothes will be at risk of vitamin D deficiency or vitamin D deficiency.[43]

From the results obtained, almost all respondents use gadget screens frequently (Table 4). Respondents use gadget screens for a long time, up to 7 hours or more. In the research of Shan et al.[44] the use of gadget screens is associated with physical activity on vitamin D concentrations. The time of gadget screen use has a significant relationship with a person's level of physical activity. So, screen use and physical activity are both markers of exposure to UVB rays. This is also supported by research by Rocka et al.[45] that there is a significant relationship between gadget screen use and physical activity on a person's vitamin status. A good duration of time to stare at a gadget screen is ≤2 hours/per day.

Based on the results obtained, the highest frequency of respondents was 96 respondents who carried out moderate levels of physical activity (Table 4). Respondents carried out moderate levels of physical activity such as doing housework as explained by respondents 10, 3, 13, and 14, while respondents 4 and 8 carried out heavy levels of physical activity. Vitamin D levels in the blood are related to muscles and bones and play a role in energy metabolism, oxidative stress, maintenance and increasing physical fitness.[46] The measurement of physical activity in this study only assessed physical activity from respondents' confessions but did not measure in quantitative detail the level of physical activity. Measuring physical activity quantitatively generally uses the IPAQ (International Physical Activity Questionnaire) questionnaire which was used in Indonesia by Lorensia et al.[47,48] Previous research by Lorensia et al., determine differences in lung function and levels of physical activity between smokers and non-smokers. The results show that a significant difference in lung function values was observed between smokers and non-smokers (p=0.00).[48]

CONCLUSION AND RECOMMENDATION

Most of the respondents were light smokers with normal blood levels of vitamin D. Most respondents often consume mackerel and pindang fish, even though they are served fried. Most respondents also consumed a lot of fried chicken eggs and drank bottled cow's milk. Smokers with vitamin D deficiency and insufficiency tend to have a low intake of foods containing vitamin D, such as fish, eggs and milk. Intake of fish oil and vitamin supplements is still rare. Most respondents rarely sunbathe and are

only exposed to sunlight in the morning. Respondents also use gadgets a lot and the frequency of physical activity tends to be rare and moderate.

Therefore, to reduce the risk of vitamin D deficiency, a smoker needs to improve his lifestyle by reducing the frequency of smoking, increasing his intake of foods high in vitamin D (fish, eggs, milk), increasing the frequency of exposure to sunlight, reducing the frequency of using gadgets and increasing activity physique.

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AUTHOR CONTRIBUTIONS

From the research process until the writing of this article, all authors played a role in this research. The correspondent author plays a role in compiling and designing research, the2nd acts as a data analyzer, the 3rd author acts as data collection in the field, and 4th author acts as an examiner of the clinical condition of each respondent in the field.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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