



# Knowledge and Practice of pregnant women on Anaemia prevention and control in the Bamenda Health District- North West Region of Cameroon

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## Abstract

**Background:** Evidence from World Health Organization (WHO) document shows that, about 38.6% (32 million) of pregnant women are anaemic in the world. Out of this, 46.3% (9.2 million) of them are in Africa. It constitutes a major Public Health concern with studies indicating that anaemia in pregnancy has been related to adverse pregnancy outcome and fetal growth. Cameroon as one of the middle-income countries reported a prevalence of 39.7% in 202. **Objective:** To assess the knowledge, and practices of pregnant women on anaemia, its prevention and control strategies in the Bamenda Health District. **Materials and Methods:** A cross-sectional, descriptive study design carried out involving all registered pregnant women at the antenatal clinic within the Bamenda Health District. Questionnaire with close ended questions was used to collect data from the participants. Ethical clearance, administrative authorization and informed consent from participants were obtained. Data analysis was done with statistical package for social sciences (SPSS) for Windows version 25.0, set at 5% ( $p=0.05$ ) CI. Chi-square ( $\chi^2$ ) analyses were conducted to determine any existing relationship between anaemia and various factors for quantitative data. **Results:** Belonging to the younger age group (15-19) increased the odds (OR 1.1.CI 0.6-2.2) of poor knowledge on causes of anaemia when compared with women of the older group (35-49 years). The result in terms of knowledge and age group showed that the age group 25-29 knew more about anaemia than other age groups ( $p=0.030$ ), as well as signs and symptoms of anaemia ( $p < 0.001$ ). The differences in level of education were statistically significant ( $p=0.012$ ). Practice in terms of marital status was higher with married women than with unmarried women ( $p=0.046$ ). **Conclusion:** Pregnant women had good knowledge on anaemia prevention but poor

practices. Current anaemia prevention practices have some gaps, which have been linked to barriers. Ministry of Public Health should formulate an independent policy on anaemia prevention in the health sector strategy.

**Key Words:** Pregnancy, Anaemia, Knowledge, Practice, Prevention, Control

## Introduction

Anaemia is one of the topmost causes of death globally and has been of a grave public health worry for both developing and developed countries affecting people of different age groups [1]. However, it is more prevalent in pregnant women, and other women in reproductive age [2]. Globally, anaemia prevalence is about 38% in pregnant women, with the highest prevalence in South Asia and Central and West Africa [3]. The commonest cause of anaemia is iron deficiency with evidence suggesting that up to 90% of maternal anaemia are due to inadequate intake of dietary iron. However, worm infestations (hookworm and schistosomiasis), bleeding haemorrhoids, vitamin B6 and B12 deficiencies, human immunodeficiency virus (HIV) infection, and genetic disorders such as sickle cell anaemia are other factors that cause anaemia in pregnancy [4, 5].

Knowledge on anaemia control amongst pregnant women seem to be limited as shown by studies carried out in Ghana as only 13.5% of the women had adequate knowledge on prevention while 58.4% and 28.1% had fair knowledge [6]. Anaemia in pregnancy usually increases the demand for iron used in blood formation. When the body is unable to meet these demands, due to either malnutrition or infection such as malaria, anaemia will occur [7]. Despite increased iron requirements, pregnancy is also a period of increased risk for anaemia.

In the study, the literacy rate was 68%, and the illiteracy rate was 32%. The majority of the women (72%) and the mean age of 20–29 years, teenage pregnancies (30 years) were 10%. Many of the patients registered were in the 1st trimester. Hb level less than 11 g is taken as anaemia. Out of 600 women, 459 (76.5%) are aware of anaemia and 47% knows anaemia is more common in pregnant women. About 53.5% of the women know about its complications and role of iron therapy (75.5%) sociodemographic factors, such as literacy rate, socioeconomic status, and iron consumption, are highly significant factors, which affect the Hb status of the study group. A baseline survey was conducted by Dwumfour-Asare and Kwapong [8] on 28 pregnant women randomly selected from the first 100 consistent antenatal attendees from August to October 2011 at Brosankro Health Centre, Ghana. The results show high anaemia consciousness with few respondents claiming no knowledge of the causes (3%) and effects (14%). The easily known cause of anaemia is poor diet (63%), followed by malaria (26%), worms (5%), and others (6%). Meanwhile, food sources that can fight anaemia are poorly known (18%). Cultural and religious beliefs in food restrictions exist and fairly a significant number of women (38%) are denied potential dietary nutrients. This was result of a study conducted on the knowledge and practice regarding prevention of anaemia among pregnant mothers attending ANC in Governmental hospitals at west Shoa zone, Ethiopia [8]. Results showed that 286 pregnant women participated in the study. Among them, only 57.3% and 50% were found to have good knowledge and poor practice, respectively, regarding the prevention of anaemia during pregnancy.

Crude and adjusted odds ratio calculated revealed that educational status, living in urban, having a nuclear family type, previous history of anaemia, and good practice were significantly associated with knowledge, while

educational status and having good knowledge also found to be significantly associated with the prevention of anaemia.

The study conducted by Yesufu *et al.*, [9] to determine the knowledge, attitude, and practices of the prevention of anaemia in pregnancy amongst 220 pregnant women attending Antenatal Clinic at Ifako-Ijaiye General Hospital in Lagos, found that a majority (95%) of the respondents were aware of anaemia in pregnancy but the mean knowledge score was 56.5%. Only 31.8% were compliant with the use of iron supplements. About one third (33.2%) did not combine drinking tea with meals, while 47.3% of the respondents did not use iron supplements with milk products. The study showed that most of the respondents had a moderate level of knowledge, and positive attitude toward contraceptive use but a high proportion were not compliant with the daily use of iron supplements [10].

It has been noted that, in developed countries women are not able to meet this iron during pregnancy requirement with a diet that is low in available iron and without iron supplements. For these reasons, nutrition education and iron supplementation must be paramount during pregnancy to control this condition [11]. World Health Organization has developed a safe motherhood strategy with the major objective of reducing anaemia during pregnancy. Evidence has also shown different interventions for the reduction of anaemia such as enhancement of dietary intake, food fortification and food diversification, supplementation of micronutrient specifically iron, common disease control, and health education [12].

## Materials and methods

The cross-sectional quantitative study was conducted in the Bamenda Health District of the North West Region of Cameroon; made up of 13 health areas. The target population included all pregnant women within ages of 15-49 years who had registered for antenatal care within the Bamenda Health District during the study period. The research population was distributed into all the 13 health areas of the Bamenda Health District and for each health area, the health units were randomly selected. The sample size using the formula by Kasiulevicius *et al.*, for a single population was then sampled by purposive sampling. The main instrument was a semi-structured questionnaire with closed ended questions in English language, to gather information on socio-demography and the objective of the study such as knowledge on the definition of anaemia, causes of anaemia, prevention, attitudes and practices; and practice of anaemia prevention and control. The questionnaire was checked by the supervisors. To be sure of the quality of data collected, the questionnaires were pretested on 20 participants in the Nkwen Health District on a similar sample. In each of the selected health units, self-introduction and topic, informed consent was obtained from all pregnant women recruited. Questionnaires were self-administered to pregnant women who could read and write and they were collected at the end of the ANC activities; Interviews for those could neither read nor write conducted on the spot. Prior to data entry, a data coding guide was prepared with each variable assigned a specific code to facilitate data entry and reduce errors. Data entry was done using unique identifiers and cross-checked for entry errors and range checks. Data analysis was done using the Statistical Package for Social Science (SPSS) for

Windows version 25.0. Frequency distribution tables were used to present categorical variables. Chi-square ( $\chi^2$ ) analyses was also conducted to test all research questions to determine any existing relationship with the socio-demographic and other variables. A cut off point for statistical significance was set at 5% ( $p=0.05$ ) confidence interval. Ethical clearance number 2022/0716H/UBa/IRB was gotten from the University of Bamenda Institutional Review Board. Administrative clearance was obtained from the Regional Delegate of Public Health for the North West Region. Information sheet about the research and the informed consent form was obtained and signed by participants.

## RESULTS

A total of 600 pregnant women were involved in this study with age groups ranging from 15 to 49 years with mean age 26.86years, gravity 2.64, Majority of the participants were within the age group of 25-39 year 289(48.2%), followed by those within the ages of 15-24 years 233(38.8%). The least age group 35 to 49 years was 78(13%).

For education, majority of the participants had reached the secondary school level 230(38.3%), closely followed by those with university level of education 222(37.0%). Majority of the participants were unemployed 390(65%), and up to 495(34%) of them were single parents. Majority of the participants came from a monogamous home 334(55.7%) and in terms of marital status, 361(60.2%) of them were married and 231(38.5%) were not married or single.

Gestational age of the pregnancy ranges from 0-42, with most of the pregnant women at 21-30 weeks 189(31.4%), followed by those at 31-40 weeks 169(28.3%). Majority of the pregnant women were primigravidae 139(32.2%). This was followed by those with at least one child 156(26%). Majority of the women were in the second trimester 249(41.5%) followed by those in the third 224(37.3%) trimester of their pregnancy. Many of them had attended ANC for 3 or more times 243(40.5%). See table 1 below

**Table 1: Distribution of pregnant women's demographic information**

Variable (n=600)	Frequency	Percent
<b>Age Group</b>		
15-19	79	13.2
20-24	154	25.7
25-29	184	30.7
30-34	105	17.5
35-39	34	9.0
40-49	24	4.0
<b>Education</b>		
None	49	8.2
Primary	99	16.5
Secondary	230	38.3
University	222	37.0
<b>Employment category</b>		
Employed	196	33.7



unemployed	404	67.3
<b>Type of household</b>		
Single parent	209	34.8
Monogamy	342	57.0
Polygamy	49	8.2
<b>Marital status</b>		
Married	366	61.0
Unmarried	234	39.0
<b>Types of pregnancy</b>		
Singleton	516	86.0
Multiple	81	14
<b>Number of children</b>		
0	182	30.3
1-3	324	54.0
4-5	94	15.7
<b>Average monthly income</b>		
Less than 25,000	312	52.0
25000 - 50000	171	28.5
>50,000	117	19.5
<b>Stage of pregnancy</b>		
First trimester	123	20.5
Second trimester	250	41.7
Third trimester	227	37.8
<b>Number of visits to ANC</b>		
One time	170	28.3
Two times	188	31.3
Three times plus	242	40.3

### Knowledge on Anaemia in pregnancy by pregnant women

Anaemia in pregnancy according to their knowledge is the condition in which the blood doesn't have enough health red blood cells 384(64.0%) and that they can identify anaemia through pale skin, lips nails palms of hand, underside of eyelids 484(80.7%), though majority did not know the stage of pregnancy at which anaemia occurs 186(31.0%). The pregnant women identified pregnancy with twins as those most affected by anaemia 305 (50.8%) and those with little or no iron in their diet 181(30.2%). The participants identified two main ways of preventing anaemia such as taking iron supplements 396 (66.0%) and eating dark green leafy vegetables 204((34.0%). Result of the assessment of their knowledge on the signs and symptoms of anaemia shows that they had some knowledge about the signs and symptoms of anaemia such as the presence of pale palm 473(78.8%), pale conjunctival 457(76.2%), pale palm and conjunctival 461(76.8%), paleness of face 366(60.7%), pallor of tongue 317(52.8%), pallor of nails 353(58.8%), dizziness 430(71.7%), palpitation 264(44.0%), shortness of breath 290(48.3%), headache 328(54.7%), loss of appetite 269(44.8%) and tiredness/weakness 455(75.8%).

### Association between women's knowledge of anaemia and socio-demographic characteristics

The result of the relationship between general knowledge of anaemia and age group shows that the age group 25-29 knows more about anaemia than other age groups, followed by those aged 20-24 years old. The difference was statistically significant for the definition of anaemia ( $p=0.030$ ), signs and symptoms of anaemia ( $p=0.000$ ), but it was not statistically significant in terms of those mostly affected and knowledge on anaemia prevention ( $p>0.05$ ).

According to our results, knowledge increases with increased level of education. Higher education had higher knowledge about anaemia than lower level of education. The difference was statistically significant for the definition of anaemia ( $p=0.018$ ), but it was not significant for other knowledge variables ( $p>0.05$ ).

For marital status, those married were more knowledgeable than those unmarried. The difference was statistically significant for definition of anaemia ( $p=0.007$ ) and for those mostly affected by anaemia ( $p=0.017$ ). The difference in terms of signs and symptoms and anaemia prevention was not statistically significant ( $p>0.05$ ).

According to the knowledge of pregnant women, there are several causes of anaemia that were identified such as repeated pregnancy at short interval, i.e., <2 years 297(49.5%), poor diet 501(83.5%), malaria 464(77.3%), worm infection 286(47.7%), and age 220(36.7%).

A number of complications of anaemia were identified such as death 454(75.7%), low birth weight 433(72.2%), miscarriage 480(80.0%) and preterm/premature birth 368(61.3%) with 230(38.5%) not knowing.

### **Association between women's knowledge of causes and complications of anaemia**

For causes and complications of anaemia, level of knowledge ranges from 19(3.8%) 40-45 years) to 32.6% (25-29 years). The age groups that knew much about the causes and complications of anaemia were the age group of 25-29, followed by age group of 20-24. The difference was statistically significant ( $p<0.05$ ) for all variables poor diet  $p=0.029$ , Malaria  $p=0.015$ , risk of miscarriage  $P=0.03$  and low birth weight  $p=0.018$  except for death as a complication of anaemia ( $p>0.05$ ).

According to the result, knowledge increases with a higher level of education. Those with university education were more knowledgeable than those with little or no education. The differences were all statistically significant for poor diet ( $p=0.009$ ) and malaria ( $p=0.002$ ) for causes of anaemia and low birth weight ( $p=0.007$ ) and risk of miscarriage ( $p=0.001$ ) for consequences of anaemia except for death ( $p>0.05$ ).

In terms of marital status, shows that those married were more knowledgeable than those unmarried. According to the result, the differences were statistically significant for malaria ( $p=0.010$ ) as cause of anaemia, dead ( $p=0.004$ ) and risk of miscarriage ( $p=0.034$ ) as complications or consequences of anaemia. other variables were not statistically significant ( $p>0.05$ ).

### **Knowledge on prevention and treatment of anaemia**

Regarding treatment and prevention, 91.7% of the participants reported that well-balanced diet during pregnancy prevent anaemia as well as eating more of green leafy vegetable and sprouted grains are rich in iron (86%). They also knew that meat, especially the liver is a rich source of iron (70.2%). Majority of them (53.8%) did not know that excess consumption of tea/coffee can lead to Iron Deficiency Anaemia (IDA). They knew that regular antenatal visit is necessary during pregnancy (90.8%) and that daily intake of iron and folic acid is necessary for treatment and prevention of anaemia (85%).

Concerning treatment of anaemia, the respondents were not very much aware of the treatment modalities. Only 39.3% of them knew about vitamin C tablet being taken along with iron tablet. However, up to 54.5% of them did not know. Also, only 56.5% of them knew that iron table sold during pregnancy in the hospital.

Knowledge increases as educational level increases. University level of education has the highest knowledge compared to lower education. the differences were statistically significant in most variables, where  $p$  value was greater than 0.05, but for some variables, the difference was not statistically significant ( $p>0.05$ ). Statistical significance  $p=0004$  for knowing that green leafy vegetables are rich in iron. Know that daily intake of iron and folic acid is necessary  $p=0.036$  know that vitamin C tablet is taken along with iron tablets  $p<0.001$ .

The difference between the married and unmarried women was statistically significant ( $p<0.05$ ) for most variables as the married women had the greatest knowledge value, compared to the unmarried women. Exception of knowledge on intake of iron daily ( $p=0.075$ )

### **Odd ratios for the relationship between knowledge of causes of anaemia and demography**

The results for multivariate logistic regression show that belonging to the younger age group (15-19 years) increases the odds OR1.1, CI 0.6 to 2.2) of poor knowledge on causes of anaemia when compared with women of the older group (35-49years). However, this was not statistically significant  $P=0.0486$ .

Having no education significantly increases the odds of poor knowledge on causes of anaemia when compared with women who attended university education. This result was statistically significant  $p=0.036$

**Table 2: Odd ratios for the relationship between knowledge of causes of anaemia and demography**

Variable	Knowledge on main causes of anaemia		OR	95 %CI		P value
	Good knowledge = 501(83.5)	Poor knowledge = 37(34)		Low	High	
<b>Age group (Years)</b>						
<b>15-19</b>	63(79.7)	11(13.9)	1.1	0.6	2.2	0.486
<b>20-24</b>	125(81.2)	15(9.7)	1.0	0.5	1.9	
<b>25-29</b>	152(82.6)	21(11.4)	1.0	0.5	1.8	
<b>30-34</b>	95(90.5)	8(7.6)	0.8	0.3	1.4	
<b>35-49</b>	47(87)	4(7.4)	ref			
<b>Education</b>						
<b>None</b>	41(83.7)	3(6.1)	1.6	0.9	2.6	0.036*
<b>Primary</b>	78(78.8)	8(8.1)	1.8	1.2	2.7	
<b>Secondary</b>	183(79.6)	13(5.7)	1.9	1.3	2.6	
<b>University</b>	199(89.6)	13(5.9)	ref			
<b>Marital status</b>						
<b>Unmarried</b>	301(82.2)	41(11.2)	1.1	0.9	1.5	0.609
<b>Married</b>	200(85.5)	20(8.5)	ref			

### **Practice on anaemia prevention in pregnancy**

According to the result on practice, majority of pregnant women 516(86%) were taking iron supplements during pregnancy. Not up to half of the pregnant women 251(41.8%) took the iron supplement during the first trimester of their pregnancy, while only about one quarter of the pregnant women 164(27.3%) and only 17(2.8%) at second and third trimesters respectively. About one quarter of the pregnant women did not sleep under a mosquito net 144(24%) majority of them also use the mosquito net 456(76%). Only 172(28.7%) reported a likelihood of getting malaria. Not up to half the number of pregnant women 260(43.3%) reported a very likelihood of getting malaria at any stage of their pregnancy.

### Relationship between practice on anaemia prevention and demographic characteristics

There were differences between age groups in terms of practice on the management and prevention of anaemia during pregnancy. The age group 25-29 years was the highest in terms of practice though the difference was not statistically significant ( $p>0.05$ ) except for taking iron supplement daily ( $p=0.002$ ).

Educational wise, the trend in terms of practice increases with increase education as those with higher level of education had higher level of preventive practice than those with lower education. The differences in level of education were statistically significant ( $p=0.005$ ,  $p=0.004$ ), but for the use of mosquito net to prevent malaria, the difference was not statistically significant ( $p=0.167$ ).

### Association between women's practice on anaemia prevention and demographic characteristic

The results for multivariate logistic regression show that belonging to the younger age group (15-99 years) increases the odds OR1.7, CI 0.5 to 6.3) of poor practice on anaemia prevention when compared with women of the older group (35-49years). However, this was not statistically significant  $P= 0.934$

Having a primary educational level significantly increases the odds (OR 3.4, CI 1.2 to 9.8) of poor prevention practice of anaemia when compared with women who attended university education. This result was statistically significant at  $p=0.0012$ . Being unmarried significantly increases the odds (OR 0.7, CI 0.4 - 1.0) of poor prevention practice of anaemia when compared with women who are married.

**Table 3: Association between women's practice on anaemia prevention and socio-demographic characteristics**

Variable	Practice on anaemia prevention		OR	95 %CI		p value
	Good practice = 525(87.5%)	Poor practice = 74(12.3%)		Low	High	
Age group (Years)						
15-19	71(89.9)	8(10.1)	1.7	0.5	6.3	0.934
20-24	133(86.4)	21(13.6)	1.3	0.4	3.9	
25-29	160(87)	23(12.5)	1.3	0.4	3.9	
30-34	93(88.6)	12(11.4)	1.5	0.5	5.1	
35-49	48(88.9)	6(11.1)	ref			
Education						



None	42(85.7)	7(14.3)	0.9	0.4	2.1	
Primary	95(96)	4(35)	3.4	1.2	9.8	0.012*
Secondary	194(84.3)	35(15.2)	0.8	0.5	1.3	
University	194(87.4)	28(12.6)	ref			
Marital status						
Married	327(89.3)	38(10.4)	ref			0.046*
Unmarried	198(84.6)	36(15.4)	0.7	0.4	1.0	

\*Statistically significant

## DISCUSSION

The study on community-based intervention strategy on anaemia prevention and control during pregnancy was carried out in the Bamenda Health District - North West Region of Cameroon. It brings out pertinent information on knowledge and practice in an urban and semi-urban area in an underserved Sub-Saharan African country where anaemia in pregnancy remains a public health challenge. Data was collected using standard methods. This study as well as any other cross-sectional study has limitations that cannot be overlooked.

Majority of the pregnant women were within 25-29 age group. This result is different from that carried out with majority in the age group 20-29 years [13]. This result is different from a study conducted in Cote d'Ivoire in 2023 in which a majority of the age group 20-29. This disparity could be because of the difference in age grouping. In our study most of the pregnant women had a good knowledge of anaemia treatment in pregnancy. These results are in line with a study conducted by Yesufu *et al.*, [9] to determine the knowledge, and of the prevention of anaemia in pregnancy amongst 220 pregnant women attending Antenatal Clinic at Ifako-Ijaiye General Hospital in Lagos; It was reported, that a majority of the respondents were aware of anaemia in pregnancy while this result is different in a study conducted in Ethiopia in 2018 on socio-demographic practices characteristics of pregnant women attending antenatal care in public health facilities. This difference could be as a result of the sample sizes.

In this study, pregnant women also found no resistance to medication during pregnancy. This agreed with another study [14] conducted to explore perceptions of women about anaemia in Bangladesh, [15] which revealed the respondents believed that by taking iron and folic acid tablets, their chances of getting anaemia was reduced. This study revealed that anaemia could be prevented by improving of pregnant women's diet and good practice of sanitation to prevent diseases such as malaria. Most of them suggested vegetable or leafy soup as the best food source for iron supplement during pregnancy.

Majority of the pregnant women identified two main ways of preventing anaemia such as taking iron supplements and eating leafy, dark green vegetables in this study. These results are similar to a study conducted on 600 pregnant women [13]. Our result was higher, compared to another study carried out in Ghana where knowledge on anaemia control amongst pregnant women was limited as only about one fifth of the women had adequate knowledge on prevention while one quarter had fair knowledge [6]. According to the knowledge of pregnant women, there are several causes of anaemia that were identified such as repeated pregnancy at short interval, i.e., <2 years poor diet, malaria, worm infection, and age [13].

Regarding treatment and prevention almost all of the pregnant women reported that well-balanced diet during pregnancy prevent anaemia as well as eating more of green leafy vegetable and sprouted grains are rich in iron. These results were different from that carried out in Ghana in 2020 showed that only slightly above a quarter of the pregnant women knew about eating dark green vegetables to prevent anaemia [6]. They also knew that meat, especially the liver is a rich source of iron. For these reasons, nutrition education and iron supplementation must be paramount during pregnancy to control this condition [11]. Majority of them did not know that excess consumption of tea/coffee can lead to Iron Deficiency Anaemia (IDA). They knew that regular antenatal visit is necessary during pregnancy and that daily intake of iron and folic acid is necessary for treatment and prevention of anaemia (85%). This is in line with other evidence which has also shown different interventions for the reduction of anaemia such as enhancement of dietary intake, food fortification and food diversification, supplementation of micronutrient specifically iron, common disease control, and health education [12].

According to the result on practice, majority of them women are taking iron supplements during as they are pregnant. Majority of them (41.8%) took the iron supplement during the first trimester of their pregnancy, while 27.3% and 2.8% took it at second and third trimesters respectively. Majority of the pregnant women reported taking the iron supplement on daily basis and majority of them also use the mosquito net. These policies in some countries like Nicaragua, where Integrated control strategy (IACS) has been developed by the Ministry of Health and it can be used as an important strategy to combat anaemia among women of reproductive age [14]. Here this strategy has significantly improved the haemoglobin level in women. It involves provision of iron and folic acid supplementation for pregnant women; fortification of flour with iron; anti-worm medication; Vitamin A supplementation; communication for behavioural change; comprehensive training of health service personnel, community health volunteers (CHVs), as well as nongovernmental organizations. They also take into consideration a program for monitoring and evaluation system [15].

### **Conclusion**

There was good knowledge in anaemia prevention by pregnant women in our study.

Current practices have some gaps, which have been linked to barriers encountered by the pregnant woman

### **Recommendation**

Education on anaemia prevention strategy should be intensified to improve on the pregnant woman's Knowledge.

There should be active involvement of male partners into antenatal care of pregnant women to reinforce practice of anaemia prevention during pregnancy. It is of paramount importance that a community-based intervention strategy should be put in place to ensure that the pregnant women comply to anaemia prevention and control strategies.

### **Contribution of authors**

KTOL conceived study design, instrument, data collection, analysis and interpretation of results. Wrote first draft.

AMBS principal supervisor and LKN co-supervisor. All authors read and approved the final manuscript.

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