BMJ Open

Iodine concentration level, availability of adequately iodised salt and proper utilisation, and its influencing factors among households in Eastern Ethiopia: a community-based cross-sectional study

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To cite: Kebebew E, Derese T, Bogale G, *et al*. Iodine concentration level, availability of adequately iodised salt and proper utilisation, and its influencing factors among households in Eastern Ethiopia: a community-based cross-sectional study. *BMJ Open* 2023;**13**:e064041. doi:10.1136/bmjopen-2022-064041

► Prepublication history for this paper is available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2022-064041).

Received 20 April 2022
Accepted 01 December 2022

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ABSTRACT

Objective The availability of iodine concentration in iodised salt at the household level does not guarantee the prevention of iodine deficiency disorders, but it can be significantly assured through proper utilisation. In eastern Ethiopia, there are no data on the use of iodised salt at the household level. The purpose of this study was to determine the iodine concentration, the coverage of adequately iodised salt and the factors that influencing the proper iodised salt utilisation in households.

Design A community-based cross-sectional study was conducted. Data were collected through face-to-face interviews and iodine concentration was determined using the WYD Checker iodine test. We used the logistic generalised estimating equation statistical analysis method to assess the factors that affect proper iodised salt utilisation at a household level.

Setting The study was conducted in Dire Dawa City Administration, Eastern Ethiopia.

Participants A total of 473 households were selected using one-stage sampling technique.

Primary measures Iodine concentration, availability of adequately iodised salt and proper utilisation were primary outcomes of this study.

Results Only 37% of households found sufficient iodine concentration in iodised salt, while only 25.2% of households used iodised salt properly. College or above education (adjusted OR=5.1, 95% CI: 1.2 to 21.6, p=0.024), good knowledge (adjusted OR=5.3, 95% CI: 4.3 to 13.4, p<0.0001), good attitude (adjusted OR=4.2, 95% CI: 2.5 to 7.0, p<0.0001) and household with family size >5 (adjusted OR=0.39, 95% CI: 0.23 to 0.7) were significantly associated with proper utilisation of iodised salt.

Conclusions Adequate coverage and iodised salt utilisation were low. The proper use of iodised salt is associated with educational status, family size, knowledge and attitudes. Raising public awareness, health promotion and continuous regulation of iodine concentration at all levels by regulatory bodies are important strategies for addressing the public health problems of iodine deficiency and related diseases.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ Iodine concentration in salt was determined by the WYD test.
⇒ Statistical analysis and modelling were done by logistic generalised estimating equation, which can handle intraclass correlation within the clustered data, and this study used a combination of household practice and quantitative concentration of iodine in salt as the outcome variable.
⇒ The study was done in one region, and the findings may not be generalisable to national levels.
⇒ The cross-sectional study design limits the factors to establish temporal relationship; hence, causal inference is not possible.

INTRODUCTION

Iodine is a trace micronutrient element that is sparsely distributed across the earth's surface and is required for the synthesis of thyroid hormones, which are involved in human growth, brain development and the regulation of metabolic processes.[1] Iodine deficiency-related disease is still a major public health concern that affects all segments of the population. Pregnant and lactating women are especially vulnerable to iodine deficiency-related diseases, putting their children at risk of developing irreversible intellectual disability.[2] Iodine deficiency has been linked to abortion, stillbirths, congenital abnormalities, cretinism, goitre, squinting, hypothyroidism and stunting.[3 4]

Iodine deficiency affects 38% of the world's population.[5] Overall, it is clear that the use of sufficient iodine concentrations in iodised salt by both individuals and households is the primary strategy for controlling iodine deficiency disorders (IDDs).[6–8] Universal

salt iodisation (USI) is recommended as the most cost-effective, safe and long-term strategy for eliminating iodine deficiency-related disease, and it has been successfully implemented in 120 countries.[2 9 10] Recent data showed that 76% of households in the world consume enough iodised salt[10]; however, utilisation varies by country, with studies indicating a range of 10%–90%.[11] The pool prevalence of iodine deficiency among pregnant women in Ethiopia is 68.79%, and 50 000 prenatal deaths are reported each year.[12–15] This high prevalence indicates that it is still a significant public health issue. Cognisant of the high prevalence of iodine deficiency-related diseases, Ethiopia implemented a mandatory USI programme in 2011, resulting in a significant increase in the use of adequate iodine concentrations in iodised salt by households.[16–18] Nonetheless, according to a national survey conducted in 2014 by the Ethiopian Public Health Institute, only 53.9% of households had sufficient iodine concentration in iodised salt.[18] Another meta-analysis and systematic review study found that in Ethiopia, the pooled prevalence of adequate iodine levels in iodised salt was 44.37%.[19] However, due to the sensitive and volatile nature of iodine as a result of various factors, the availability of adequate iodine concentration in iodised salt at a household level could not significantly reduce IDDs and related diseases, but practising proper utilisation of iodised salt could.[7 20] The proper use of iodised salt was beneficial for the long-term elimination of IDDs and related diseases. Similarly, it is clear that improper utilisation or insufficient iodine concentration in iodised salt at the household level is the major impediment to controlling IDDs and related diseases in a given community. As a result, proper use of iodised salt is a critical step in reducing this problem.[21]

Various studies show that households in Dire Dawa City Administration and other Ethiopian regions use inadequately iodised salt.[16 22] Despite the fact that various studies on iodine concentration levels in iodised salt at the household level have been conducted at the national and regional levels, there were limited and inconsistent data on iodised salt utilisation at the household level, including the study area.

Therefore, the aims of this study were to determine the iodine concentration in collected salt samples, coverage of adequately iodised salt consumption, and identify factors that influence the proper iodised salt utilisation among households in Dire Dawa City Administration, Eastern Ethiopia. As a result, this finding will aid for concerned bodies and policymakers in their efforts to reduce morbidity associated with IDDs in the country using the existing healthcare system that reaches out to communities.

METHODS AND MATERIALS

Study design and setting

A community-based cross-sectional study was conducted at the household level in Dire Dawa City Administration, Eastern Ethiopia. The city administration was founded with 9 urban kebeles and 38 rural kebeles. The current population of Dire Dawa City Administration is 445 000, a 4.46% increase from 2021. Various nations and nationalities live in Dire Dawa City Administration, and a number of Ethiopian languages are widely spoken by residents.

Participants

The study included all randomly selected urban kebeles (the smallest administrative structure), and housewives or household heads who had lived for at least 6 months and above. Individuals who were severely ill or unable to communicate effectively were excluded from the study. Those who are unable to prepare food at home were also excluded from the study.

Sample size determination

The sample size was calculated using the single population proportion formula, taking into account the following assumptions: the previous study's prevalence of insufficient iodine intake at the household level was 26.5%,[23] 5% margin of error, 95% confidence level of certainty (α=0.05) and 1.5 as design effect, 5% of the sample was added to account for non-respondents, and finally a sample size of 473 was obtained.

Sampling procedure

A one-stage cluster sampling technique was used to select representative household samples. Initially, 4 kebeles were chosen at random from among the existing urban kebeles, and 10 clusters were chosen from among the kebeles. The sample was drawn in proportion to the size of the cluster's households. Then, using systematic random sampling, the participant households were chosen. The sampling interval was calculated by dividing the total number of households in the chosen cluster by the sample size assigned to that cluster. When a compound has more than one household, a simple random sampling technique was used to identify the participant household. A person who was a household member responsible for cooking most of the time was interviewed using the prepared questions.

Data collection tool and measurements

Data were gathered using validated and pretested questionnaires administered by interviewers. The questionnaire asked about sociodemographics, knowledge of iodised salt and iodine deficiency-related diseases, and attitudes and practices toward iodised salt. The knowledge and attitude questions included: 'What benefit does it have over the other types of salt?'; 'What are your methods to prevent IDD in the family?'; 'In your opinion, do all types of salt have iodine?'; In your opinion, does iodine change the taste of the salt?'. The English questionnaire was prepared, translated into the local language and then translated back to English. We pretested our questionnaire with 5% of the total study participants in a similar set-up to validate, standardise and rule out any ambiguities and discrepancies. The reliability of the

Table 1 Descriptive data of sociodemographic characteristics of the participants (n=473)

Variable	n	%
Sex of household head		
Male	58	12.2
Female	415	87.8
Age (years)		
18–24	8	1.7
25–34	260	55.0
35–44	205	43.3
Marital status		
Single	45	9.5
Married	341	72.1
Widowed	57	12.1
Divorced	30	6.3
Educational status of the respondent		
Non-formal education	33	7.0
Primary school	72	15.2
Secondary school	166	35.1
College and above	202	42.7
Educational status of partner		
Non-formal education	61	12.9
Primary school	87	18.4
Secondary school	200	42.3
College and above	125	26.4
Occupational status of partner		
Government	182	38.5
NGO	8	1.7
Private	208	44
Daily worker	51	10.8
Other	24	5.1
Occupational status of the respondent		
Government	85	18
Private	188	39.7
Daily worker	41	8.7
Housewife	143	30.2
Other	11	2.3
Family size		
<5	326	83.6
>5	64	16.4

NGO, non-governmental organisation.

questionnaire was measured using Cronbach's α test, and it was 0.72. Six well-trained health extension workers collected the data, and a laboratory technologist was tested the collected iodised salt sample on a daily basis. The data were collected under close supervision, and the principal investigator performed a daily double-check for completeness before saving the collected data.

Table 2 Level of proper utilisation, iodine concentration knowledge and attitude of participating households

Variables	n	%
Utilisation of iodised salt		
Improper utilisation	354	74.8
Proper utilisation	119	25.2
Iodine concentration (ppm)		
<15	298	63
>15	175	37
Level of knowledge		
Poor	279	59
Good	194	41
Level of attitude		
Poor	227	48
Good	246	52
	Mean (±SD)	
Mean (±SD) of iodine concentration (ppm)	11.8±5.48	

Salt sample collection and laboratory analysis

Each eligible household was given one medium-sized teaspoon of iodised salt (approximately 20 g), which was packaged in airtight plastic bags and transported to the eastern branch of Ethiopia Food and Drug Authority's food laboratory for analysis. To determine the iodine content, the WYD Iodine Checker (National Salt Research Center, Tianjin, China) was used.[24] The sample's iodine concentration was determined by taking the average of the two readings, and the Westgard rules with Levey-Jennings charts were used for internal bench quality control for daily routine monitoring of the WYD Iodine Checker performance characteristics. Throughout the analysis, the percentage coefficient of variation ranges from 2.5 to 5.0.

Operational definition

Adequate iodised salt

It is defined as iodised salt with an iodine concentration greater than or equal to 15 ppm.

Knowledge

Subjects were graded by asking and marking correct answers to a series of questions about iodised salt and iodine deficiency-related diseases. A dichotomous scale was used to assess the study participants' knowledge level. A total of nine knowledge questions were posed to the participants. A participant receives 1 point if he or she correctly answers one or more of the questions. Then, for those who responded, a correct answer was marked as 'yes' or 1, while an incorrect answer was marked as 'no' or 0. Knowledge was then assessed by calculating the mean of the nine items and determining whether participants scored more than or equal to 4 points, categorised as having good knowledge, while a participant who scored equal or less than 3 points was categorised as having poor knowledge.[25]

Table 3 Pearson's correlation between proper utilisation of iodised salt and sociodemographic variables

Variables	Level of practice		P value
	Improper utilisation	Proper utilisation	
	n (%)	n (%)	
Age			0.77
18–24	3 (1.5)	5 (1.8)	
25–34	112 (56.9)	148 (53.6)	
35–44	82 (41.6)	123 (44.6)	
Marital status			0.043*
Single	21 (10.7)	24 (8.7)	
Married	131 (66.5)	210 (76.1)	
Widowed	33 (16.8)	24 (8.7)	
Divorced	12 (6.1)	18 (6.5)	
Educational status of the respondent			<0.001*
Non-formal education	24 (12.2)	9 (3.3)	
Primary education	45 (22.8)	27 (9.8)	
Secondary education	87 (44.2)	79 (28.6)	
College and above	41 (20.8)	161 (58.3)	
Partner's educational status			<0.0001*
Non-formal education	37 (18.8)	24 (8.7)	
Primary education	56 (28.4)	31 (11.2)	
Secondary education	83 (42.1)	117 (42.4)	
College and above	21 (10.7)	104 (37.7)	
Partner's occupational status			<0.0001*
Government	41 (20.8)	14 (51.1)	
NGO	2 (1)	6 (2.8)	
Private	104 (52.8)	104 (37.7)	
Daily worker	35 (17.8)	16 (5.6)	
Other	15 (7.6)	9 (3.3)	
Occupational status of the respondent			<0.0001*
Government	20 (10.2)	65 (23.6)	
NGO	1 (0.5)	4 (1.4)	
Private	73 (37.1)	115 (41.7)	
Daily worker	30 (15.2)	11 (4)	
Housewife	66 (33.5)	77 (27.9)	
Other	7 (3.6)	4 (1.4)	
Family size			<0.0001*
<5	130 (66)	244 (88.4)	
>5	67 (34)	32 (11.6)	
Knowledge status			<0.0001*
Poor	170 (86.3)	109 (39.5)	
Good	27 (13.7)	167 (60.5)	
Attitude status			<0.0001*
Poor	126 (64)	101 (36.6)	
Good	71 (36)	175 (63.4)	

*Significant at p<0.05.
NGO, non-governmental organisation.

Attitude

There were a total of eight attitude questions about iodised salt. A Likert scale is used to assess attitude, with five possible responses: strongly agree, agree, uncertain, disagree and strongly disagree. The responses were labelled with three response categories: 'agree', 'neither agree nor disagree', and 'disagree'. Each positive response (agree) received a score of '1', while each negative response received a score of '0'. The maximum possible score for the eight attitude-related questions was '8', and the minimum possible score was '0'. If the average attitude score is lower than the mean, the attitude is considered poor attitude; if it is higher than the mean, the attitude is considered good attitude.

Proper utilisation

A total of eight practice questions were included to assess proper utilisation. Scores on iodised salt utilisation ranged from 0 to 1. When the respondent did not at all practise using iodised salt, '0' was assigned as a score. If their response was 'no', the score was '0', but if they answer 'yes' and 'practice', the score was '1', whereas improper utilisation was defined as practising at least one time that reduces the iodine content or concentration of 15 ppm in the salt, or when respondents did not use adequately iodised salt.

Data management and analysis

Data were collected with the KoBoTool software and entered into Microsoft Excel before being transferred and analysed with the SPSS V.25. Basic descriptive statistics such as frequencies, means, medians and percentages were calculated and presented for categorical and continuous variables. Pearson's $\chi 2$ test was employed to assess the statistical significant association between proper utilisation of iodised salt and sociodemographic variables. Iodine concentration is expressed as mean and SD (mean±SD). The outcome variable yielded a binary result (1=proper iodised salt utilisation and 0=improper iodised salt utilisation). Because of the cluster classification of households, the logistic generalised estimating equation was used to identify the factors for proper iodised salt utilisation. However, because the cluster method is prone to higher sampling error, it had an impact on statistical analysis. The probability distribution was binomial with a logit-link function, and the working correlation matrix structure was interchangeable (with a small quasi-likelihood under the independent criterion).[26] The covariance matrix served as a robust estimator, and the scale parameter was the individual's $\chi 2$. Bivariate logistic regression was used to identify the important independent variables. ORs were calculated to determine the strength of associations of the independent variable with the outcome variable at a 95% CI. Furthermore, variable interactions were evaluated at a p value of 0.05, and confounding variable was assessed using a backward and forward elimination procedure, and each variable causing a >20% change in the coefficient of the parameters between the reduced and full model was considered confusion.[26] Collinearity was tested using the variance inflation factor (VIF), and if the VIF was greater than 10,

Table 4 Multivariable logistic regression analysis predicting the probability of having a proper practice

Variables	Iodised salt utilisation		P value	AOR (95% CI)
	Improper utilisation n (%)	Proper utilisation n (%)		
Educational status of mothers				
Non-formal education	24 (12.2)	9 (3.3)	0.1	1.00
Primary education	45 (22.8)	27 (9.8)	0.043	3.8 (1.08 to 14.1)
Secondary education	87 (44.2)	79 (28.6)	0.1	2.8 (0.8 to 10.2)
College and above	41 (20.8)	161 (58.3)	0.024	5.1 (1.2 to 21.6)
Family size				
<5	130 (66)	244 (88.4)		1.00
>5	67 (34)	32 (11.6)	0.008	0.4 (0.2 to 0.7)
Knowledge status				
Poor	170 (86.3)	109 (39.5)		1.00
Good	27 (13.7)	167 (60.5)	<0.0001	5.3 (4.3 to 13.4)
Attitude status				
Poor	126 (64)	101 (36.6)		1.00
Good	71 (36)	175 (63.4)	<0.0001	4.2 (2.5 to 7.0)

Maximum SE=1.25.
*Significant at p<0.05.
AOR, adjusted OR.

the predictive variables were considered collinear and dropped from the model.

Patient and public involvement

Participants or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

RESULT

The study included 473 subjects in total. The participants' mean age was 32.4 years, with an SD of 32.4 (+5.1 SD). The majority were married, 42.7% (n=202) had higher education and 44% (n=208) were employed in the private sector. Exactly 16.4% (n=64) of households had more than five families (table 1).

Level of utilisation and iodine concentration

Only 25.2% (n=119) of participants used iodised salt properly. The mean (±SD) iodine content in salt from the households was 11.8±5.48 ppm (mg/kg), the range was 0.0–21.3 ppm and the median was 13.6 ppm. The majority of households (63%, n=298) consumed iodine with a concentration of <15 ppm. In addition, 41% (n=194) had good knowledge of iodised salt and 52% (n=246) had a positive attitude toward iodised salt (table 2).

Pearson's $\chi 2$ of the association of proper utilisation of iodised salt with sociodemographic variables

Pearson's $\chi 2$ showed that there was not statistically significant association between proper utilisation of iodised salt and age (p>0.05); however, other variables found a statistically significant (p<0.001) association with proper utilisation of iodised salt. The results are summarised in table 3.

Factors associated with proper utilisation of iodised salt at the household level

Multivariable logistic regression analysis showed that the respondents who had attained college and above education were 5.1 (adjusted OR (AOR)=5.1, 95% CI: 1.2 to 21.6, p=0.024) times more likely to use iodised salt properly compared with those who had not attained any formal education or were illiterate. Respondents who had good knowledge were 5.3 (AOR=5.3, 95% CI: 4.3 to 13.4, p<0.0001) times more likely to use iodised salt properly than those with poor knowledge. Similarly, the odds of having a good attitude toward iodised salt were 4.2 (AOR=4.2, 95% CI: 2.5 to 7.0, p<0.0001) times higher among respondents who use iodised salt properly compared with their counterparts. Respondents who had less than five family members were 60% (AOR=0.39, 95% CI: 0.23 to 0.7) times less likely to use iodised salt properly compared with those who had greater than five family members (table 4).

DISCUSSION

The main aims of this study were to assess iodine concentration in iodised salt and coverage of adequately iodised salt consumption; and identify factors affecting the proper utilisation of iodised salt among the households in Dire Dawa City Administration, Eastern Ethiopia.

This community-based study showed that only 25.2% (n=119) of households were using iodised salt properly. This was substantially below and provided a huge gap from the expected level.[9] This might be due to poor community awareness on the benefits of iodised salt to prevent IDDs. Thus, iodine education initiatives through health promotion via different communication platforms, such as using

the existing health extension programme, television and local radio, are crucial and could increase the level of household iodised salt utilisation.

Our finding was lower than the findings from studies conducted in Somali region of Jijiga town, Ethiopia (26.6%),[23] in Debre Tabor, Ethiopia (55.6%),[27] in Hetosa, Oromia, Ethiopia (38.4%),[28] in Addis Ababa, Ethiopia (78%),[29] and in Asella, Ethiopia (76.8%).[30] Moreover, this was higher than a study conducted in Alfom Tigray, Ethiopia (8.9%).[31] The possible reasons for this difference in the current study include the nature of the study setting and difference in the study population.

The coverage of adequately iodised salt among the households based on the test was 37%. This result is still lower than the national goal of reaching >90% of households with sufficient iodine concentration in iodised salt,[5] and alerts the concerned public authorities. The possible reasons might be due to poor enforcement by regulatory agencies, infrequent monitoring and evaluation at the site of production, and wholesaler and retail shops at the household level. Just because a certain target is achieved in one evaluation does not mean that future results will be consistent. Hence, continuous programme monitoring and cooperation of regulatory enforcement agencies are essential to ensure the appropriate use of iodine at different levels. This could have an influence on the decreased coverage of adequately iodised dietary salt at the household level and might have its own impact on the elimination or reduction of iodine deficiency-linked diseases in the country.

Similarly, this coverage was also considerably higher as compared with the studies conducted in Dire Dawa City, Ethiopia,[22] Oromia, Lalo Assabi, Ethiopia,[32] and Gondar, Ethiopia,[33] which showed that 7.5%, 8.7% and 33% of the households used adequately iodised salt, respectively.

Our finding showed that the respondents who had attained college and above education were 5.1 times more likely to use iodised salt properly compared with those who had not attained any formal education or were illiterate. This might be due to the fact that higher levels of education provided better nutritional awareness about the benefits of iodine, increased awareness on the health benefits of iodine in diets and increased the use of iodised salt. In addition, women who had the highest educational status had good employment opportunities, which might be indicative of better socioeconomic status. This could relate to women who were better educated and had the purchasing power to buy good-quality food appropriate for salt iodisation practice.[34] Moreover, mothers who were less educated and had less resources had the least knowledge about the importance of iodised salt.[35] This finding is supported by those studies done in Addis Ababa, Ethiopia,[29] Wolaita, Ethiopia[36] and Arsi, Ethiopia.[30]

In this study, respondents who had good knowledge were 5.3 times more likely to use iodised salt properly than those with poor knowledge because of the fact that proper utilisation of iodised salt decreased iodine deficiency and IDD. In addition, this could be because households with good knowledge can change their attitude and can easily put the changed attitude into practice. This study was supported by the studies conducted in Oromia, Ethiopia,[30] in Gondar, Ethiopia,[33] and Zuway, Ethiopia.[37]

The household with a good attitude was one of the factors associated with proper utilisation of iodised salt, confirming the fact that better utilisation of iodised salt properly by households has a relationship with the level of attitudes toward the benefits and health consequences of iodine. This study was supported by studies conducted in Dire Dawa, Ethiopia,[22] in Axum Tigray, and in Addis Ababa, Ethiopia.[38 39]

This study has its own limitations, including the fact that this study was conducted only on households from urban kebeles, not from rural areas. Additionally, due to resource constraints, we used the WYD test, which is not the gold-standard iodine test checker like iodiometric titration test and it implies, the WYD test checker does not show an accurate iodine concentrations in the iodized salt. In addition, this study did not triangulate with qualitative research.

Strengths and limitations of this study

The strengths of this study were as follows: iodine concentration in salt was determined by WYD test checker, rather than rapid test kit (RTK) checker, statistical analysis and modelling were done by logistic generalised estimating equation, which can handle intraclass correlation within the clustered data, the use of both household practice and quantitative concentration of iodine in salt as the outcome variable. However, this study was not without limitation. The study was done in one region and the findings may not be generalisable to national levels. In addition the cross-sectional study design limits the factors to establish temporal relationship; hence, causal inference is not possible.

Conclusion

The proportion of people in the study area who properly used iodised salt in their homes and coverage of adequately iodised salt still remains low. The proper use of iodised salt is associated with educational status, family size, knowledge and attitudes toward the benefits and health consequences of iodine. As a result, various media outlets and existing health extension workers are important strategy tools for improving the proper utilisation of iodised salt and maintaining the level of iodine in iodised salt at households. Furthermore, continuous programme monitoring and cooperation of regulatory enforcement authorities are essential to ensure the appropriate iodine at various levels. These strategies have the potential to prevent the community's public health problems caused by iodine deficiency-related diseases.

Acknowledgements The authors would like to express their gratitude to all of the study participants, data collectors and supervisors who took part in the study, as well as the kind and cooperative staff. The authors would also like to thank the Ethiopia Food and Drug Administration eastern branch food laboratory workers in particular for their assistance in testing the sample in the laboratory.

Contributors EK and AB contributed to the study conception, designed the study, performed the analyses, wrote the first version of the manuscript, read and commented on the manuscript and approved the final version of the manuscript. TD and GB wrote, read and commented on the manuscript.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not required.

Ethics approval This study's methods were all carried out in accordance with the Declaration of Helsinki-ethical principle for medical research involving human subjects. Before beginning data collection, ethical approval was obtained from the Institutional Review Board of Dire Dawa University's Public Health Department, with the reference number IRB/289/21. After participants and legally authorised representatives 'of minors under the age of 18 years and illiterates' provided written informed consent to participate, their privacy and confidentiality were maintained. All personal identifiers were removed, and data were kept confidential and used only for the proposed study.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement All data relevant to the study are included in the article or uploaded as supplemental information.

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