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The Role of Health Extension Workers in Combating Hypertension in Ethiopia

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Editorial

Ethiopia faces a triple disease burden of communicable diseases, non-communicable diseases (NCDs), and injuries (1), with hypertension affecting nearly one in four adults (2). Hypertension is the major modifiable risk factor for cardiovascular disease (CVD) morbidity and mortality, accounting for more than half CVD-related deaths (3). Several community-based studies in Ethiopian cities revealed a high prevalence of hypertension, ranging from 25.1% to 31.9% in the Amhara region (4, 5), 25% to 32.3% in Addis Ababa (6, 7), and 19.7% to 35.2% in southern Ethiopia (8, 9). In rural areas, nearly one in five adults also suffers from hypertension (2), highlighting its growing public health significance.

Early detection and management of hypertension are critical for improving the care cascade (10), preventing complications (11), and saving lives (12). However, hypertension remains largely underdiagnosed and poorly managed, making hypertension an iceberg disease. The 2018 Ethiopian NCDI Commission summary report showed that less than 40% of hypertensive patients were diagnosed, 28% of those diagnosed patients received treatment, and only 26% of those treated had their blood pressure adequately controlled (13). A study in Ethiopia also showed that 77% of the population had never undergone blood pressure measurement (14), and 60% were unaware of their hypertension status (5). Another study in the rural districts of northwest Ethiopia also identified 84% of adults with hypertension were unaware of their condition (15), underscoring the urgent need for community-based interventions to improve early detection, treatment, and care.

Even though the Ministry of Health Ethiopia sets a goal in its second health sector transformation plan to increase the proportion of individuals with controlled blood pressure from 26% to 60% by 2025 (16), challenges such as a shortage of

health care providers and limited access to healthcare remain the most significant barriers to providing care at the primary health care level (17). One strategy to bridge the gap between the community and the health system in other contexts is task-sharing, in which specific tasks are shared from more qualified healthcare providers to a less trained cadre, such as community health workers (18). This approach reduces time and transportation costs for patients and brings healthcare services closer to the community. A study in northwest Ethiopia indicated that community-based hypertension screening led by HEWs can improve awareness, treatment, and control of hypertension in the community (19). Health extension workers-led home-based multicomponent interventions, which provided home health education, behavioural counseling, and referral to a nearby health facility, have been shown to enhance linkage to hypertension care and lead to a significant reduction of high blood pressure, with a higher proportion of patients achieving optimal blood pressure control (20).

To implement this strategy, integrating it into primary healthcare services at the village and health post level in rural areas is essential. However, successful implementation of the strategy requires scaling up of hypertension training programs for health extension workers and their supervisors, provision of standardized protocols, provision of adequate blood pressure measuring equipment, and regular supportive supervision.

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Factors Associated with Magnitude of Exchange of Sexually Explicit Contents among High School Students: A Cross Sectional Study

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Abstract

Background: *"Exchange of sexually explicit content" refers to behaviors such as sending or receiving nude or partially nude images, and sexually suggestive texts and calls via cell phones or other electronic media. As mobile technology is increasingly used to form and maintain social relationships, sexual content-sharing practices are becoming common among young people, contributing to technology-driven sexual risks. Despite this prevalence, there is a paucity of evidence on the prevalence of sexually explicit content-sharing among high school students.*

Objective: *This study aims to assess the magnitude of exchange of sexually explicit materials and associated risk factors among high school students.*

Method: *A cross-sectional study design using a stratified sampling technique was employed applied to 590 students from April 18, 2022 to May 03, 2022. Data was collected through structured, self-administered questionnaire. Data were coded and entered into Epi-Data version 3.1 and exported to SPSS version 25 for analysis. The degree of association between dependent and independent variables was assessed using bivariable and multivariable logistic regression analysis. Variables with p-value of less than 0.05 were considered significant.*

Result: *Overall about 220(38.4%) (95% CI 34.4-42.5) of high school students were actively engaged in exchange of sexually explicit contents. Associated factors were being male (AOR=2.08, 95%CI 1.37, 3.16), being in grade 12 (AOR=3.29, 95%CI1.84, 5.89), living with mother (AOR=7.49, 95%CI 4.01, 14.01), living with father (AOR= 7.06,95% CI2.99,16.66), having a social media account (AOR=3.35, 95%CI1.87, 6.07), free internet access (AOR=2.29,95%CI1.49,3.49) and having a low religiosity scale (AOR=1.67, 95% CI1.10, 2.54).*

Conclusion: *This study indicated that being male, having a low religiosity scale, living with a single parent, and visiting variety of social media were the major predictors associated with exchange of sexually explicit contents in Debre Markos high school students. There is a vital need to inform students of the consequences of this behavior on sexual health. Guardians or parents should strengthen their child's religious faith and parent their children together instead of individually. The purpose of information communication technology (ICT) materials in schools should be clearly explained to the students as being for the sole purpose of information gathering and not for illicit purpose.*

Introduction

Exchange of sexually explicit content is the act of sending or receiving self-generated sexually suggestive materials such as photos, videos, messages, and audio via Mobile phones or other electronic media(1). It integrates the production, possession and distribution of self-exploiting sexual material in audio, visual and written form(2) and is a phenomenon that derives directly from the digital age and opportunities to share text messages, pictures, and videos fast and conveniently(3).

Exchange of sexually explicit material became an unforeseen use of technology when mobile phone developers created camera phones. Advanced technology in cell phones has contributed to an environment in which the practice of this behavior is now widespread(4).The initiation and rise in popularity of smart mobile phones, tablets, and communication technology devices, combined with the recent boom in internet access and use, has contributed to negative effects on the healthy growth and development of young people(2).

The instant access of social media such as Face book, Telegram, Imo, Instagram, instant messaging and the ubiquitous cell phone with its text messaging and still/video camera have dramatically changed when, how, and what adolescents learn about each other and the world. These devices and apps have also enabled or at least significantly promoted access to both commercial and amateur sexually explicit media and other sex -related sites by young people(5). High School students often initiate and develop many types of relationships through text messages, such as dating and sexual relationships(6).

Exchange of sexually explicit content is considered a globalized social phenomenon, and student exchange has received much media attention in recent years(7). It is considered a deviant behavior that is closely linked to mental health, and may be a marker of adolescent involvement in risky sexual behavior, cyber bullying and substance abuse(8).Five years of global academic collaboration on sexual and reproductive health and rights policies showed that in Belgium,4.3% of boys and 0.5% of girls reported ever sending a sexual picture of themselves to someone (sexting)(1). The National Campaign to Prevent Teen and Unplanned Pregnancy (2008) survey reported that 33% of young adults had sent nude or semi-nude images of themselves, while 64% had received sexually suggestive messages(9). As demonstrated by a recent meta-analysis, the prevalence of exchange of sexually explicit contents was 14.8%(10).

Increasing access to digital technology to young people in low -income countries also has influenced their pornography viewing and receiving or sending of sexual explicit materials via electronic devices and change the sexual communication and behavior of the young populations(11).

In Ethiopia, findings show young people use smart phones and social media increasingly in their daily life. There is a consensus that social media and some networking sites may have both benefits and risks for students' sexual health and academic affairs(12).

Method

Study area: This study was conducted at Debre Markos town high schools. Debre Markos town is located 300km from Addis Ababa, the capital city of Ethiopia, and 265 km from Bihar Dar, the capital city of Amhara regional state. In Debre Markos town there are four public high schools managed through the city administration: Debre Markos higher secondary school (1282 students), Menkorer higher secondary school (1815students),Nigus Teklehaymanot higher secondary school(2204students) and Ethio Japan (Jaika) higher secondary school (1917 students).

Selection Criteria: The selected participants were all high school students from Debre Markos town during the study period. The sample size was determined using single population proportion and double proportion for the secondary objectives, using a 95% confidence interval with 4% marginal error, and by adding a 10% non-response rate, taking the identified single proportion as 33.7% from the previous study conducted in the Northern part of Ethiopia(11).

A stratified sampling technique was used. The strata were classified as grade 9, grade10, grade 11 and grade 12, with sampling units selected with proportional allocation to each stratum (grade). The sapling frame was the mark list or roster of the students obtained from each school. The sample size was selected using a computer-generated method in each grade, based on the number of students in each grade and the sample size for each of the four schools.

Sample size calculation for the second objective was calculated by double population proportion of significant variables

using Epi Info version 7.2.2.6 statistical software as follows below. Finally, the maximum sample size was taken.

Table 1: Sample size for second objectives by using double proportion formulas from the previous study:

Factors	CI	P(1-β)	Ratio	Proportion of exchange sexually explicit contents among exposed	Proportion of exchange sexually explicit contents among non exposed	Sample size		References
						N	N+non response (10%)	
Sex	95%	80%	1	83.6	70.3	342	342+35=377	(13)
Alcohol	95%	80%	1	89.9	63.2	90	90+9=99	(13)

The sample size for double proportion is 377, so the final sample size for the study was 590.

Data collection procedures and quality assurance: Data was collected using a self-administered structured questionnaire focusing on the exchange of sexually explicit content among high school students, and factors contributing to the frequency and prevalence of this exchange. This questionnaire was adopted from the literature and modified for this study (3, 13-19). The data collection tool addressed socio-demographic characteristics, behavioral factors, religiosity, and technology-related factors as they contribute to the magnitude of exchange. The questionnaire was first prepared in English, then translated to Amharic, and back again to English by another translator to check the accuracy and consistency of the translation in Amharic. After the final translation of the tool was reviewed, the Amharic version was used to collect data. A pre-test was conducted on 30 high school students at Gozzamin high school (5%of the total sample size) and the results used for a final revision of the questionnaire. For the data collection process, three BSC nurses were employed for the data collection and one health officer was assigned a supervising role. Training was given for a day on the objectives and relevance of the study. A reliability test of the religiosity scales was done using Cronbach's Alpha with a value of 0.83. The data collected was evaluated for completeness and problems with data collection were addressed daily. Lastly, all the collected data was checked by investigators for its completeness and consistency during data management, data storage, and analysis.

Data processing and analysis: Data was entered into epi-data 3.1 versions and then exported to SPSS version 25 for analysis. Descriptive statistics including percentages, ratios, frequency distribution, and measures of central tendency were used to describe different variables based on the nature of the variables. Results were presented in tables and graphs. Model fitness and multicollinearity assumptions were checked before analysis. The association between dependent and independent variables was assessed using bivariate and multivariate analysis. Variables with a p-value less than 0.25 in the binary logistic regression were considered for multivariable logistic regression analyses. Finally, p-value <0.05 and adjusted odds ratio together with their corresponding 95% confidence intervals were considered to conclude a result as statistically significant.

Result

Socio-demographic characteristics of participants: A total of 573 students participated out of 590 in the study with a response rate of 97.1%. The mean age of respondents was 18.27 (SD ± 1.674) years and the majority of respondents 361(63%) were in the age range of 18-20. About 318(55.5%) of respondents were male and the majority of respondents (432 (75.4%)) were living with both parents. Most (546 (95.3%)) respondents were orthodox Christian and nearly 486 (85%) of respondents were from urban areas (Table 2).

Table 2: Socio-demographic characteristics of Debre Markos high school students, 2022(N=573)

Variables		Frequency	Percentage (%)
Sex	Male	318	55.5
	Female	255	44.5
Age	15-17	174	30.4
	18-20	361	63
	21-24	38	6.6
Grade	9	208	36.3
	10	146	25.5
	11	113	19.7
	12	106	18.5
Religion	Orthodox	546	95.3
	Muslim	11	1.9
	Protestant	10	1.8
	Catholic	6	1.04
Residence	Urban	486	84.8
	Rural	87	15.2
Family structure	Both parents	432	75.4
	With mother	78	13.6
	With father	40	7.0
	Alone	9	1.6
	With friend	7	1.2
	With other relatives	7	1.2
Educational level/father	Can't read and write	91	15.9
	Primary	88	15.4
	Secondary	129	22.5
	Degree	231	40.3
	MSC and above	34	5.9
Educational level/mother	Can't read and write	147	25.7
	Primary	130	22.7
	Secondary	104	18.2
	Degree	175	30.5
	Above	17	3.0
Father occupation	Employee	291	50.8
	Farmer	132	23.0
	Daily laborer	41	7.1
	Merchant	109	19.0
Mother occupation	Employee	172	30.0
	House wife	249	43.5
	Daily laborer	65	11.3
	Merchant	87	15.2

In addition to religious identity, high school students' religiosity was assessed in this study. More than half 331(57.8%) had high faith on the religiosity scale **(Figure 1).**

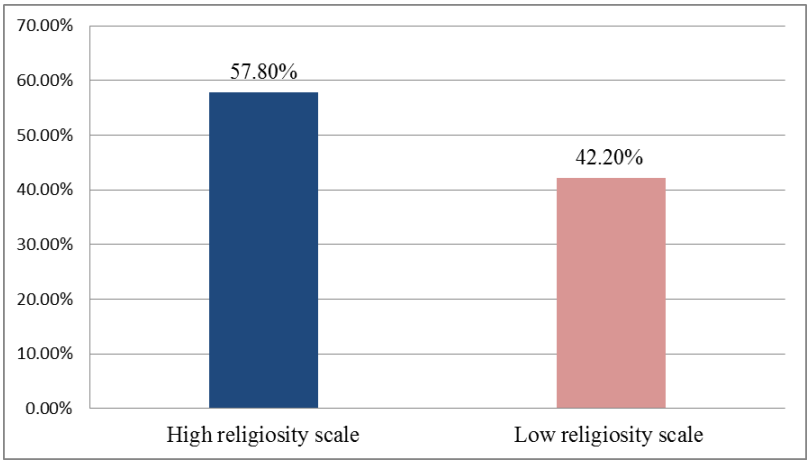

Figure 1: *Religiosity scale among high school students at Debre Markos town in 2022(N=573)*

High school students and technology: About 560(97.7%) of school youths had access to information technology. Among these, the majority (509 (88.8%))used mobile phones. In this study about 252(43.9%) students were able to watch television programs and 206 (36%) of respondents had free internet access at their house or schools **(Table 3).**

Table 3: Utilization of technologies among Debre Markos high school students 2022

Variables		Frequency	Percent (%)
Mostly use of Information Communication Technology materials			
Mobile		509	88.8
Laptop		32	5.6
Tablet		11	3.7
Desktop		8	1.9
Type of TV programs mostly watched			
Music videos		52	9.1
Foreign movies		82	14.3
Amharic movies		64	11.2
Romantic movies		46	8.0
Documentary		8	1.3
Free internet access	Yes	206	36.0
	No	367	64.0

This study indicated that about 441(77%) of youths used social media; among these, the majority of them (about 308 (53.80%)) had a Facebook account (**Figure 2).**

Sexuality and other behavioral characteristics reported: About 112(19.5%) of respondents had a boy/girlfriend, and 41(7.2%) of respondents had previously had sexual intercourse. About 52(9.1%) of respondents consumed various types of alcohol including local beverages **(Table 4).**

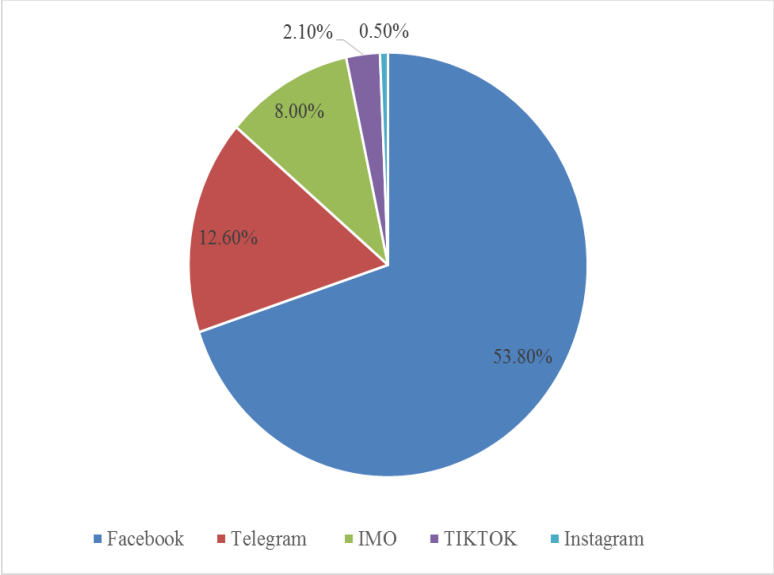

Figure 2: *Percent of social media account usage of high school students at Debre Markos town, 2022*

Table 4: Sexuality and other related characteristics reported among high school students in Debre Markos town, 2022(N=573)

Variables	Categories	Frequency	Percent (%)
Had boy/girlfriend	Yes	112	19.5
	No	461	80.5
Ever had sex	Yes	41	7.2
	No	532	92.8
Multiple sexual partners	Yes	38	6.6
	No	535	93.4
Pornography watching	Yes	99	17.3
	No	474	82.7
Alcohol consumption	Yes	52	9.1
	No	521	90.9

Prevalence of exchange of sexually explicit materials: From the total of 573 high School students surveyed, about 220 (38.4%) (95% CI 34.4 - 42.5)reported having exchanged sexually explicit materials in the past year. In this study, 177 (30.9%) of respondents were senders, 171 (29.8%) of respondents were receivers, and about 128 (22.34%) of students both sent and received different types of sexually explicit contents. Regarding the type of sexually explicit materials, text messaging was the most common while videos were the least common **(Figure 3).**

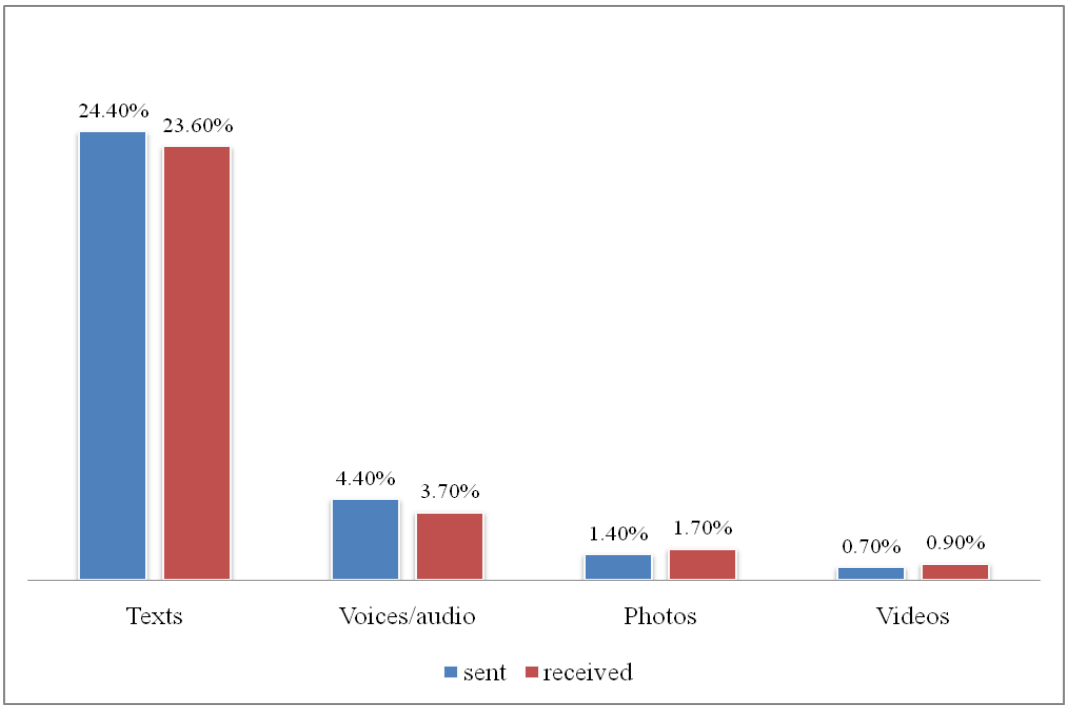

Figure 3: *Types of exchanged sexually explicit materials among high school students in Debre Markos town 2022*

Factors significantly associated with exchange of sexually explicit materials: Bivariate and multivariate analysis was conducted to determine factors associated with exchange of sexually explicit contents. Variables such as sex, grade level, living arrangements, mother's occupation, internet access, having a social media account, having a romantic relationship, having multiple sexual partners and religiosity were variables with p-value less than 0.25 in bivariable analysis. Then these variables were analyzed by a multivariable logistic regression model. Variables having p-value less than 0.05 in the multivariable model were considered significantly associated. Among these, students' sex, grade level, living arrangement (with one or two parents or a guardian), internet accessibility, having a social media account, and religiosity were factors associated with exchange of sexually explicit materials.

Model fitness was checked with Hosmer and Lemeshow goodness of fit test and fit with value = 0.141. There is no problem of multicollinearity among independent variables with variance inflation factors less than 2.

In this study, males were about 2times more likely to practice exchange of sexually explicit materials than females (AOR = 2.08, 95%CI 1.37, 3.16). Grade level of students was a socio-demographic predictor: students who were in grade 12 were 3.29 times (AOR=3.29, 95%CI 1.84, 5.89) more likely to exchange sexually explicit content than those who were in grade 9. High school students who were living with a single mother were 7.49times (AOR= 7.49, 95%CI 4.01, 14.01) more likely to engage in exchange of sexually explicit content than students who were living with both parents. Students who were living only with their father were 7 times (AOR=7.06, 95%CI 2.99, 16.67) more likely to exercise exchange of sexually explicit content than those living with both parents.

The odds of exchanging sexually explicit content among students who had free internet access were 2.29 times (AOR=2.29, 95%CI 1.49, 3.49) more likely than among those who had no free internet services. The likelihood of exchanging sexually explicit material among high school students were 3.35 times higher among those who had social media accounts when compared to students who had no social media accounts (AOR=3.35, 95%CI 1.87, 6.07).

Regarding religiosity; high school students who reported a low religiosity scale were 1.67 times (AOR=1.67, 95%CI 1.10, 2.54) more likely to engage in exchange of sexually explicit content those who claimed a high religiosity scale **(Table 5).**

Table 5: Factors associated with exchange sexually explicit contents among Debre Markos high school students, 2022(N=573)

Variables	Category	Exchange of sexually explicit contents		COR(95%CI)	AOR(95%CI)	P-value
		Yes	No			
Sex	Male	150	168	2.36(1.66,3.36)	2.08(1.37,3.16)	0.001*
	Female	70	185	1	1	
Grade	9	59	149	1.0		
	10	41	105	0.99(0.62,1.58)	0.84(0.49,1.44)	0.519
	11	42	66	1.79(1.11,2.91)	1.07(0.61,1.89)	0.809
	12	73	33	5.59(3.36,9.30)	3.29(1.84,5.89)	<0.001*
Family structure	Both parents	120	312	1	1	
	Mother	60	18	8.67(4.92,15.28)	7.49(4.01,14.01)	<0.001*
	Father	31	9	8.96(4.14,19.37)	7.06(2.99,16.66)	<0.001*
	Other guardians	9	14	1.67(0.71,3.96)	0.89(0.33,2.42)	0.827
Mother's occupation	Employed	68	104	1		
	Housewife	79	170	0.91(0.47,1.07)	0.82(0.49,1.34)	0.419
	Day laborer	33	32	1.58(0.89,2.80)	1.19(0.56,2.55)	0.640
	Merchant	40	47	1.31(0.78,2.19)	1.17(0.62,2.23)	0.629
Free Internet access	Yes	103	103	2.34(1.51,3.03)	2.29(1.49,3.49)	<0.001*
	No	117	250	1	1	
Access to Social media	Yes	201	237	5.18(3.08,8.71)	3.35(1.87,6.07)	<0.001*
	No	19	116	1	1	
Sexual intercourse	Yes	21	20	1.76(0.93,3.32)	1.69(0.79,3.62)	0.174
	No	119	333	1	1	
Have multiple sexual partners	Yes	25	13	3.35(1.68,6.71)	1.32(0.59,2.98)	0.498
	No	195	340	1	1	
Religiosity	Low faith	123	119	2.49(1.77,3.52)	1.67(1.10,2.54)	0.016*
	High faith	97	234	1	1	

NB: *Variables having a ($p < 0.25$) in bivariable (crude) analysis included in the multivariable logistic regression (adjusted) analysis.*

** Statistically significant at P-value < 0.05 and 1= reference.*

Discussion

Summary of main findings: This study investigated the magnitude of exchange of sexually explicit material and associated factors among high school students.

In this study, the prevalenceof exchange of sexually explicit contents among high school students in Debre Markos town was found to be 38.4%(95% CI 34.4 -42.5).

Comparison with other Reviews: The finding of this study was in line with a study conducted in Arizona, USA (38%) (20). But our results show higher rate of exchange than a previous study conducted in Tigray (33.7%)likely due to study population differences and rural high schools were included Tigray(11). Our data also show a higher rate of exchange than a meta-analysis and systematic review study on exchange of sexually explicit contents among youth(14.8%)(10) as well as other studies conducted in Rhode Island, USA, (22%)(21) and Zimbabwe(13%)(22). These variations were likely due to differences in study populations (starting with middle school age in the study conducted USA) and possibly variation in the amount of time to exposed digital technologies. However, our findings are lower than studies conducted in Kenya (57%) (23), Spain (58%)(24), and the Netherlands (71%)(25). This could be due to differences in availability and accessibility of free internet, early adoption of technology, and differences in cultural and social norms.

In our study, male gender was more frequently associated with exchange of sexually explicit contents than female gender. This result is similar to studies from Zimbabwe(22), Botswana(26) and Spain(24)on exchange of sexually explicit material. This might be due to socio cultural influences and/or gender differences in exposure to electronic materials. In our country, Ethiopia, it is a taboo for a female to clearly engage in such behaviors, and even if they engage they are less likely to report it as they know it is taboo(27).

According to the study conducted in USA, students in grade 12 were more likely to have engaged in exchange of sexually explicit content(28),consistent with the finding of this study. The possible explanation for this could be the effect of developmental age or grade level. This correspondence suggests that internet searching habits and use of a variety of technologies may increase with age/grade level.

High school students who live with single parent were more likely to exchange explicit contents than students living with both parents. This finding agrees with a similar study conducted in Spain(24). This may be because students who live with a single parent have less parental guidance and support, the family environment may be poor, and there may be little discussion of issues such as sexual intimacy, dangerous activities, and self-management of sexual relationships.

Our study also suggests that high school students with social media accounts are more likely to be exposed to sexually explicit materials than students who lack social media accounts. This is consistent with findings in a study conducted in Ecuador(29)..

Internet access was one of the significant factors contributing to exchange of sexually explicit material in this study. Students who had free internet (wifi) access were more likely to exchange sexually explicit content than those who had not wifi access. This result is supported by a study conducted in Netherland(25);however, wifi access was not found significant in a previous study in Belgium(30). A possible explanation for this difference may be due to differences in internet availability and accessibility: most developed and some Western countries have access to free internet easily and relatively cheaply, so they may be unaffected by the availability of the internet. However countries like Ethiopia take advantage of free internet to practice such kinds of behaviors(31).

Lastly, this study investigated the role of religiosity or religious faith; high school students who had a low religiosity scale were more likely to exchange sexually explicit content than those who had high religiosity scale. This finding was also agreed by the study conducted in New York(32). The reason is likely because religiosity lowers sexually permissive attitudes toward non-marital sex. In Ethiopia, teachings of the religious belief systems and customs are one mechanism of social control because they socialize members to adopt organizational norms and values(33).

Limitations:

- Since this study examines personal and sensitive issues, it may have been difficult to get an honest answer about sexually-related data from high school students.
- This data might have prone to response bias.
- The direction of causal relationships cannot be determined since this study was based on cross-sectional data.

Conclusion

Exchange of sexually explicit contents among high school students in Debre Markos town was found to be high. Sex, grade level of students, family structure, and use of social media, internet access, and religiosity were found to have significant or effect on the magnitude of exchange of sexually explicit contents among high school students. The most common mode for exchanging explicit content was text messages, while video was the least common. Most participants had access to information communication technologies.

Recommendation

- Guardians or parents should strengthen their child's religious faith with good follow up. This may be more effective when children are living with two parents rather than one.
- The purpose of ICT materials in schools should be adequately explained as being for purposes of information gathering and not for illicit activities. Free internets (wifi) should be restricted or limited with in school compounds beyond academic purposes.
- Strategies should be designed to control the use of technologies and to restrict creating social media accounts at early ages. Viewing illicit content from the social sites should be limited by laws for some smart phone applications and high risk programs.
- The risks of exchanging sexually explicit content should be incorporated into school curriculum during ICT lessons, including risks involved with inappropriate internet use.
- While this study was a cross-sectional design, future research should consider a qualitative study since the issue focuses on sensitive and privacy matter.

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Predictors of neonatal mortality in Tigray Regional State, Northern Ethiopia: a comparison of parametric survival models' approaches

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Abstract

Background: *The neonatal age is the most vulnerable time for survival in which children appeare at the highest risk of dying in their lives. Ethiopia has pledged to lower under-five child mortality rates since 2015 despite being one of the SSA nations to have achieved the fourth Millennium Development Goal (MDG4). The neonatal mortality rate (NMR) is still a significant public health issue in Ethiopia, and it is getting worse in the Tigray region. Neonatal mortality dataset from retrospective cross-sectional study research is also scarce. The objective of this study was to assess the predictors of neonatal mortality in the Tigray region of northern Ethiopia.*

Method: *A retrospective cross-sectional study design was conducted from 18, January, 2016 to 27, June 2016. In this study a total of 716 neonates were selected. Neonatal mortality risk factors include predictor variables such as neonate and mother demographics, health, and environmental factors. The study used descriptive statistics, Kaplan-Meier comparisons, and parametric survival models, and comparisons were also performed to select suitable forecasting model analyses.*

Result: *The overall NMR experienced was 4.3 neonatal deaths per 100 total live births. The estimated mean follow-up time of neonates was 10.0 days [95% CI: 9.67, 10.30] in the Tigray region. The multivariable Weibull-regression model analysis revealed that predictors being multiple birth type (AHR = 10.9, 95% CI: 3.4, 35.5) and home delivery (AHR = 10.5, 95% CI: 3.0, 36.6) were critically important risk predictors associated with a higher NMR.*

Conclusion: *The prevalence of NMR showed that the NMR in the Tigray region was greater than the national average.The current study identified the multiple birth type and home delivery of the neonates as crucial predictor factors for NMR. Interventions should be improved to these factors that significantly decrease the NMR problem among neonates.*

Introduction

Neonatal Mortality Rate (NMR) is the risk that a newborn will die within the first 28 days of life, or the first 4 weeks of life (1). It is given as the number of neonatal fatalities per 1,000 live births. The period of neonatal starts at birth and ends at 28 completed days after birth. It is the time when a neonate's survival status is most vulnerable (2).

According to (3), 2.9 million newborns globally perished within their first month of life each year, with the majority of these deaths taking place in underdeveloped nations. Preterm neonates have an extremely low survival rate in impoverished nations (3).

According to the 2022 Global Report, central and southern Asia had the second-highest NMR of 23 deaths per 1000 total live births, accounting for 36% of all newborn deaths worldwide, after Sub-Saharan Africa (SSA), with 27 deaths per 1000 live births and 43% of all newborn deaths worldwide. In addition, a child born in SSA has a ten-fold higher risk of dying than a child born in a high-income nation (4).

To effectively manage neonatal and maternal mortality, as well as to significantly enhance public health, it is crucial to understand the primary causes of child's death rates. Therefore, policymakers and designers have produced guidelines to address these linked predictor factors with appropriate intervention in order to enhance the public health status of mothers and neonates. The sustainability of reducing the early neonatal mortality rate will be protected by developing appropriate guidelines and regulations (5). According to (6), Ethiopia is one of the top NMR contributors, ranking sixth overall and second in the SSA after Nigeria.

Some of the most predictor factors associated with neonatal mortality are sex of the neonate (7), Antenatal Care (ANC) visit(8, 9), birth weight (low birth weight) (8, 9), preterm birth, fetal growth restriction and congenital abnormalities (10). Therefore, professional delivery assistance, high-quality antenatal care, and postnatal care follow-up should be used to reduce the highest NMR of children and incidence of difficulties during the initial neonatal period and to ensure the survival of neonatal babies.

The baby and under-five mortality rates in Ethiopia show a consistent downward trend over the preceding 15 years. On the other hand, despite the fact that the NMR slightly dropped from 39 fatalities per 1000 total live births in 2005 to 29 total live births in 2016. As a result, this report demonstrates that it has continued to be a stable high. In comparison to the national average mortality rate of 30 deaths per 1000 pregnancies (11, 12), the Tigray national regional State has a higher NMR of 34 total deaths per 1000 pregnancies, according to the Ethiopia Demographic and Health Surveys (EDHS) 2016 data.

Ethiopia is one of the SSA nations that, as of 2015, had fulfilled the fourth Millennium Development Goal (MDG4) commitment to reduce the mortality rate of children under the age of five. Even if the death rate for children has significantly decreased. NMR, though, is still high across the nation. Therefore, a significant decrease in NMR is essential to further achieving this objective in the future. According to earlier research, early NMR has been declining more slowly than late NMR during the past three decades.

It is important to control the present health programs and establish policies on improving the current situation for mother and neonate health status, which is why interventions to reduce neonatal mortality are a major concern and belong to enhancing maternal public health care. Additionally, understanding the risk factors for newborn mortality is crucial for tracking the effectiveness of intense, scientifically supported public health measures to prevent neonatal deaths (13).

There have been numerous investigations into the risk factors for the mortality of children under the age of five in Ethiopia. There are, however, few researches that examine the NMR and the risk factors that go along with it. The majority of these studies are nation-level investigations. As the country result may not accurately reflect the situation at regional levels, such studies omit a crucial point for policymakers and designers (14, 15). We conducted an all-inclusive retrospective cross-sectional study design analysis of the most recent EDHS 2016 to address the aforementioned gap and identify the key risk factors for NMR in the Tigray Regional State, taking into account a variety of socioeconomic, demographic, and environmental factors (11). Therefore, the objective of this study was to assess the predictors of neonatal mortality in the Tigray region of northern Ethiopia.

Method

Source of data, study design, and period: On the basis of the EDHS 2016 dataset, a retrospective cross-sectional study

design was used to perform this investigation. Between January and June of 2016, the Ethiopian Public Health Institute (EPHI), Central Statistics Agency, and Ministry of Health (MOH) performed the survey. It was sponsored from the United States Agency for International Development (USAID). This survey report's main goal is to provide policymakers and designers with comprehensive data on fertility, adult, newborn, child, and maternal mortality, maternal and child health status, nutrition, and knowledge of HIV/AIDS and other sexually transmitted illnesses.

Sample size determination technique and study population: Two stages of sample selection were used to implement this survey report's study design. There are 9 Regional States and 2 administrative cities in the nation. In the initial round, 645 enumeration areas 443 in rural and 202 in urban areas had been chosen with probability inversely correlated to size. In the second stage, the freshly constructed household list was systematically selected, with 28 households per cluster being selected with equal probability. All reproductive women between the ages of 15 and 49 who were stable residents of the chosen households and had spent at least one night there prior to the survey were eligible for the interview. Since the 2016 EDHS, a total of 15,683 women of reproductive age (15-49), 12,688 males of reproductive age (15-59), and 16,650 families have been questioned. 1,682 of these households came from the northern Ethiopian region of Tigray. In the five years before to the study, 4,428 live births were registered in the Tigray Regional State. The source population consisted of all neonates reported in the Tigray Regional State of Northern Ethiopia over the five years prior to the survey who were less than or equal to 28 days old. Next, using a sample selection procedure that is illustrated in Figure 1, newborns with completed records of information on neonatal death within the previous five years were found (11). Finally, samples of a total of 716 neonates who had full disclosure of all the risk factors taken into consideration were included.

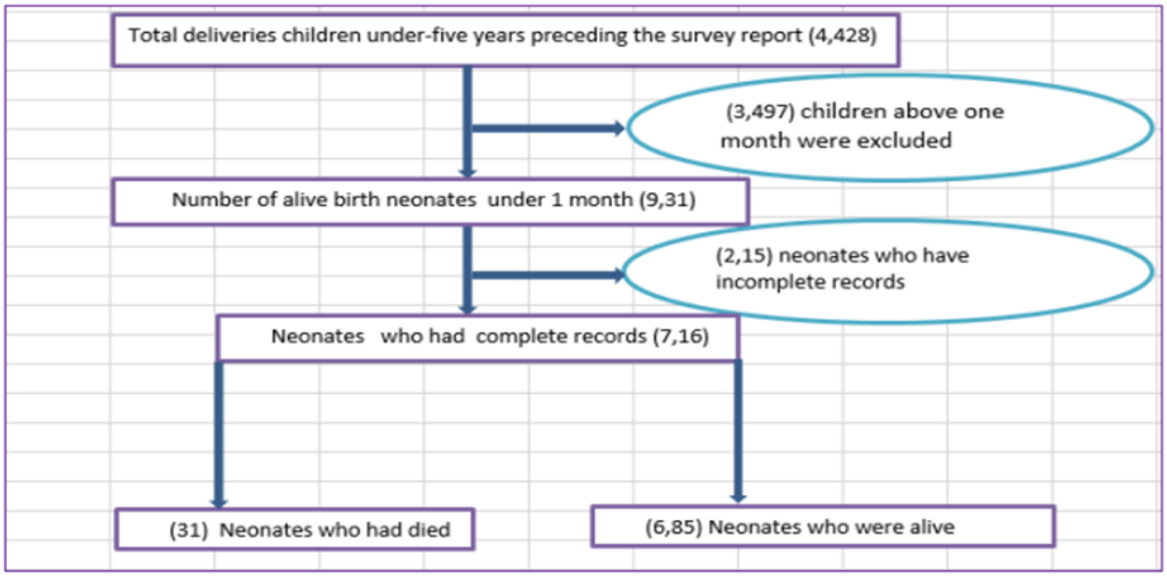

Figure. 1 Diagrammatic presentation of sample selection among neonates included in Tigray Regional State, Northern Ethiopia, 2016.

Study area: Tigray Region State is located between 36 and 40 degrees' East longitude North of Ethiopia bounded in the North with Eritrea, in the South Amhara Regional State, Sudan in the West and in the East Afar Regional State. According to the 2007 Ethiopian population and housing census survey, there were 3,136,267 people living in the Tigray Regional State, of which 1,542,165 were men. Around 2,667,789 people (or 85%) of the population lived in rural areas (16).

Variables of the study

Response variable: The response variable of this study was time to neonatal mortality of neonates which measured in days. In this study, "death" refers to a neonate who has passed away, whereas "censored" refers to neonate who is still living. The time from initial of observation until the occurrence of outcome of observation (death and censored i.e., assumed as right-censored). Then, neonatal mortality

will be obtained from the death of live birth within 28 days of life (i.e., death of neonates between 1–28 days). Therefore, the outcome variable for the neonate is dichotomous, represented by a random variable that takes the value "1" with probability of success (had neonatal death) and the value "0" with probability of failure (were neonatal alive), such that

$$\mathbf{Y}_i = \begin{cases} 1, \text{if } i^{th} \text{ neonate's had experinced with neonatal mortality (had died).} \\ 0, \text{if } i^{th} \text{ neonate's had not experinced with neonatal mortality (were censored).} \end{cases}$$

Independent variable: The explanatory variables were included in this study: mother's age (35 and above, 20-34, 19 and below), birth type of neonate (singletons, multiple), ANC visit (no, yes), sex of neonate (female, male), toilet facility using of mother's (with facility, no facility), place of delivery of neonate (health facility, home), residence place of neonates (rural, urban), drinking water source of mother's (protected, piped, unprotected), and exclusive breastfeeding (no, yes).

Statistical data analysis: Statistical analyses were performed using STATA version 14 statistical software (Appendix 1). For categorical predictor variables, Kaplan-Meier estimators were employed to show participant survival across time. The percentage and frequency distribution of the individuals in relation to all factors were described using descriptive statistics. Additionally, tables and figures were employed to present the data. In this study, five parametric survival models (i.e., Exponential, Weibull, Log-logistic, Lognormal and Gompertz) were fitted to identify the risk predictor factors of neonatal mortality. Using the Akaike Information Criteria (AIC), Bayesian Information Criteria (BIC), and Log-likelihood Information Criteria, the best model was chosen. The Wald test and Cox-Snell residual test were used to evaluate the goodness of fit test. Variables having P-value < 0.05 in the multivariable model were considered significantly associated with the response variable. To demonstrate the strength of the link, the adjusted hazard ratio (AHR) and its 95% confidence interval (CI) were computed.

Kaplan-Meier estimation: The Kaplan-Meier (K-M) curve is a nonparametric method used to estimate the survival experience. The survival experience of two or more groups of between-subjects factor can be compared for equality. It expressed as the survivor function of $S_{(t)}$.

$$S_{(t)} = \begin{cases} \prod_{t_j \le t} \left(1 - \frac{d_j}{n_j}\right), & t \ge t_1, \\ 1, & 0 < t < t_1, \end{cases} \quad (1).$$

Where; , is the number of participants who experience the event at a time , and, is the number of participants.

Weibull regression survival model: The Weibull distribution provides as one of the most commonly used parametric survival models. It plays a central role in the analysis of survival time dataset. The probability density function of the Weibull distribution with scale parameter and shape parameter γ,W(λ, γ), can be expressed as W(λ, γ) = . The survivor and hazard functions of a W (λ, γ) distribution are given by the following respectively;

$$s(\lambda,\gamma) = exp\left[-(\lambda t)^{\gamma}\right] \quad (2).$$

$$h(\lambda,\gamma) = \lambda\gamma t^{\gamma-1} \quad (3).$$

Where; is denotes the hazard for an event for neonates, is denoted the survival of patients. This hazard model was used to investigate and to check the impact on each independent variable on mortality rate. If γ = 1, the hazard will be constant over time and hence is equivalent with the exponential survival time. If γ >1, the hazard increases with time and if γ < 1 the hazard decreases as time increases. The method of maximum likelihood estimator is used to find estimators of the parameters λ and γ.

Model selection criteria: In this study, some evaluation factors will be taken into account in order to choose the optimum parametric model for simulating participant survival. To have an appropriate model selection for the bi-variable and multivariable parametric survival models most commonly known model selection criterions; AIC and BIC were considered for this study.

$$AIC = -2 * ln(likelihood) + 2 * k \quad (4).$$

$$BIC = -2 * ln(likelihood) + ln(N) * k \quad (5).$$

Where; k is number of parameters estimated, N is total number of observations used to fit the model. The smallest statistic values of AIC and BIC reflect an overall best fit.

Result

Descriptive characteristics of study participants: In the cross-sectional study, there were 716 participants, and 31 (4.3%) of them died. 357 (49.9%) of the total participants were male, and 396 (55%) were born in a hospital or medical facility. Moreover, the majority of participants 697 (97%) of them were singleton type of births. From all, 435 (61%) of mother's age were 35 years and above. On the subject of education level, 93 (13%) of them were primary education complete, 236 (33%) of them were illiterate, and 387 (54%) were secondary and above education level. On the other hand, majority of participants 595 (83%) were done ANC visit (**Table 1**).

Table 1: Socio-demographic characteristics, health and environmental predictors of mothers and neonates in Tigray Regional State, Northern Ethiopia, 2016 (N = 716).

Variables	Categories	Frequency (N)	(%)
Mother's age	19 and below	36	5
	20-34	245	34
	35 and above	435	61
Birth type	Multiple	19	2.7
	Singletons	697	97
Sex of neonate	Male	357	50
	Female	359	50
ANC visit	Yes	595	83
	No	121	17
Toilet facility	No facility	372	52
	With facility	344	48
Mother's education level	Secondary and above	387	54
	Primary	93	13
	Illiterate	236	33
Residence	Urban	22	3.1
	Rural	694	97
Drinking water source	Unprotected	135	19
	Piped	179	25
	Protected	402	56
Place of delivery	Health facility	396	55
	Home	320	45
Exclusive breastfeeding	No	193	27
	Yes	523	73
	Total neonates	716	100

Neonatal mortality rate and time-to-death of neonates in Tigray Regional State, Northern Ethiopia: The neonates were followed up time for a minimum of 1 day to a maximum of 28 days. The cohort contributed a total of 7159 neonate-days. Study neonates were followed for an overall estimated mean follow up time of 10.0 days [95% CI: (9.67, 10.3)]. During this follow up time the mortality rate of neonates was found to be 4.3 neonatal death (95% CI: 2.8, 5.8) per 100 total live births which is equivalent to the NMR of 43 per 1000 total neonates with [95% CI: (28, 58)].

Comparison of the survival ability of participants: From the K-M survivor estimate, singletons birth type children and public health place of delivery had shortened survival time to mortality as compared to its counter parts (**Figures 2).**

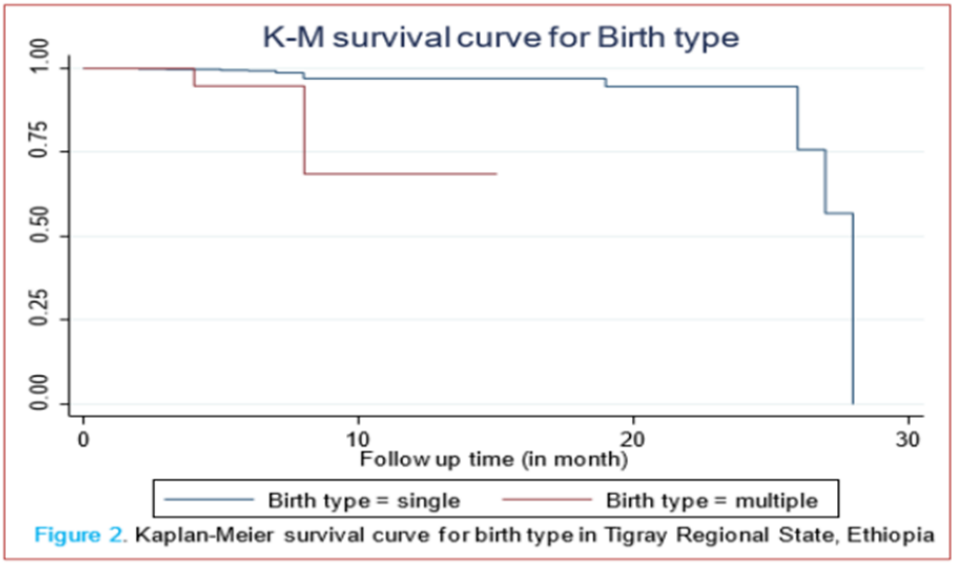

Figure 2. Kaplan-Meier survival curve for birth type in Tigray Regional State, Ethiopia

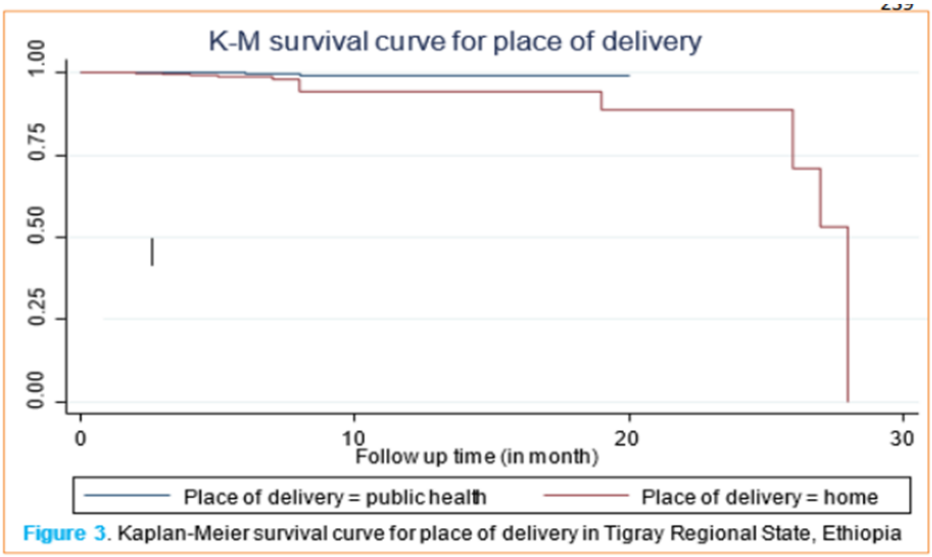

Figure 3. Kaplan-Meier survival curve for place of delivery in Tigray Regional State, Ethiopia

Model selection information criteria and goodness of fit model analysis results: The study compared various parametric survival models using the information criterion. The researchers employed the AIC and BIC model selection techniques for each model study. The value of AIC and BIC are computed as;

$AIC = -2*\ln(likelihood) + 2*k$ and $BIC = -2*\ln(likelihood) + \ln(N)*k$

Where; k = number of parameters estimated, N = number of observations.

According to the following statistics result of the AIC, BIC, and Log likelihood criteria the Weibull-regression parametric survival model was preferable for modelling since the lowest value is preferable. Therefore, the Weibull-regression model was done for a more accurate identification of the major risk predictors for neonates. This indicates that in terms of relative efficiency and parameterization the Weibull model is the best efficient for predicting survival of neonates (Table 2). Similarly, the survival probability plot of the five parametric survival

models stated indicates that the Weibull distribution implements better because it displays a clear step function than the other distributions and this also justifies the result value of AIC and BIC (**Figure 4**). Moreover, the authors checked the overall goodness of fit model done by the Wald test and Cox -Snell residual test. Therefore, the Wald test provided a chi-square value of 188.6 with 13 degrees of freedom and p-value < 0.001, which would imply that a good fit for the model (**Table 3**). Correspondingly, Cox-Snell residual test was used to check the goodness of model fitness. This graph shows that the hazard function follows the 45° closed to the baseline (**Figure 5**).

Table 2: Selection of the best fitted models for neonatal mortality data in Tigray Regional State, Northern Ethiopia, 2016.

	Models			
Information Criteria	**Weibull**	Gombertz	Log logistic	Lognormal
AIC	**199.04**	201.8	203.3	210.3
BIC	**267.6**	270.4	271.9	278.9
Log-likehood	**-84.5**	-85.9	-86.7	-90.16

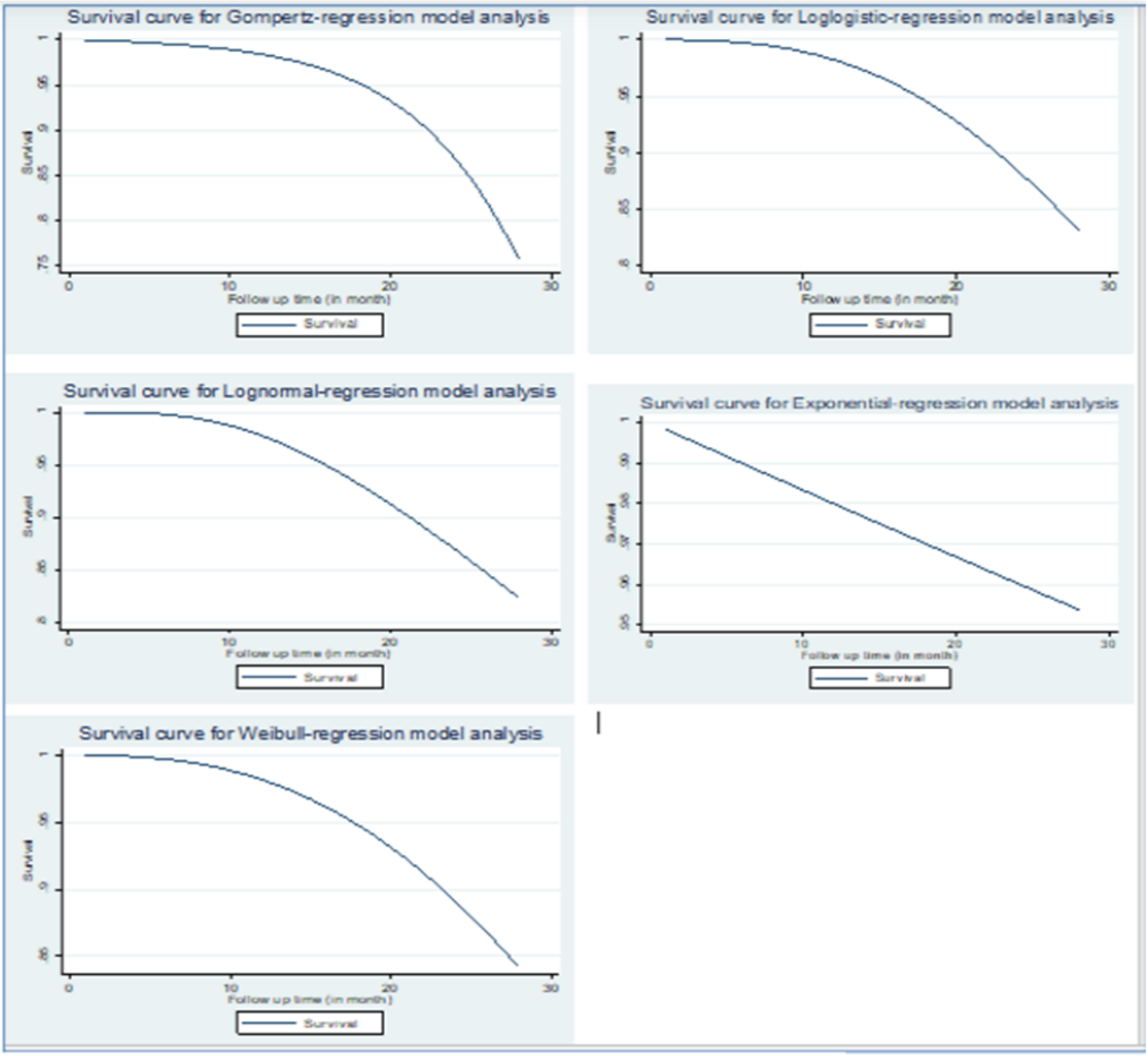

Figure 4. ***Survival plot of the five parametric survival models***

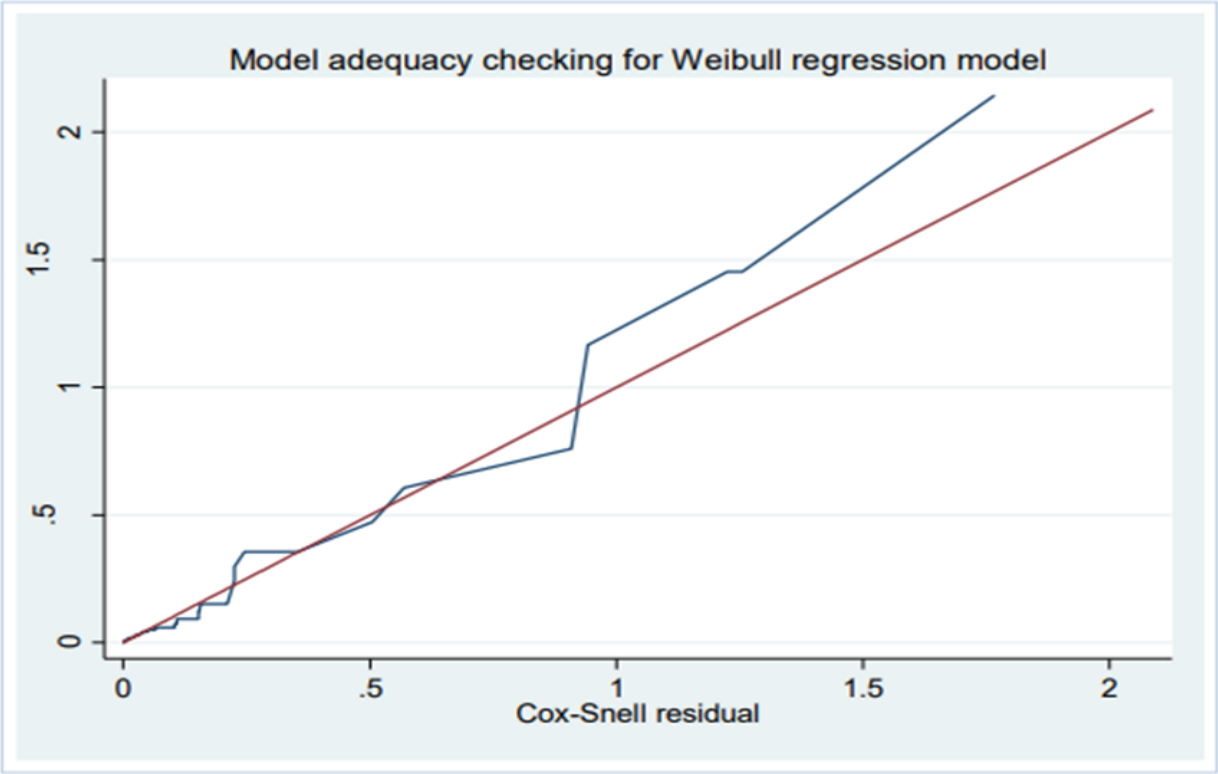

Figure 5: Cox-Snell residual Nelson-Aalen cumulative plots to assess model fitness of the Weibull regression model in Tigray Regional State, Northern Ethiopia.

Predictor factors of neonatal mortality in the Tigray Regional State, Northern Ethiopia

Weibull regression model analysis: Weibull-regression model analysis was done to identify the effect of each predictor variables on the neonatal mortality.

Predictor of neonatal mortality rate: Both bi-variable and multivariable Weibull-regression model analysis of risk factors associated with neonatal mortality was presented in **Table 3**. From the bi-variable model analyses; birth type, sex of neonate, residence, exclusive breastfeeding, and place of delivery were significant predictors of neonatal mortality among neonates in the Tigray Regional State. After adjusting for other predictor variables the result showed that; birth type and place of delivery were statistically significant predictors of neonatal mortality. However; mother's age, exclusive breastfeeding, sex of neonate, ANC visit, toilet facility, mother's education level, residence, and drinking water source were not statistically significant. According to the results from **Table 3**, the hazards of neonatal mortality rate were higher among neonates that were multiple (AHR = 10.9, 95% CI: 3.4, 35.5) than those in singletons births.

Concerning place of delivery, the hazards of neonatal mortality rates were higher among neonates with those who did not used health facility during birth (at home) (AHR = 10.5, 95% CI: 3.0, 36.6) compared to that of with health facility. The scale parameter of the Weibull-regression model was found to be $\gamma = 2.6$[95% CI: (2.1, 3.4)]. This interval doesn't include $\gamma = 1.0$ suggesting that the Weibull-regression model analysis is more appropriate than the other parametric survival models. Since $\gamma = 2.6$ which is greater than 1, the hazard of experiencing neonatal mortality decreases as survival time increases (see **Table 3**).

Table 3: Predictors of neonatal mortality using Weibull-regression model analysis in the Tigray Regional State, Northern Ethiopia, 2016 (N = 716).

Variables	Survival status		Bivariable analysis	Multivariable analysis
	Died (death=1)	Censored (censored=0)	CHR (95% CI)	AHR (95% CI)
Mother's age (ref.= 19 and below)	1	35		
20-34	21	224	5.1 (0.68, 37.7)	2.17 (0.28, 17.1)
35 and above	9	426	0.76 (0.1, 6)	0.48 (0.06, 3.9)
Birth type (ref.= singletons)	25	672		
Multiple	6	13	14.8 (5.9, 36.9)*	10.9 (3.4, 35.5)*
Sex of neonate (ref.= female)	7	352		
Male	24	333	2.9 (1.25, 6.76)*	2.2 (0.89, 5.2)
ANC visit (ref.= no)	9	111		
Yes	22	574	0.74 (0.34, 1.6)	1.7 (0.45, 6.1)
Toilet facility (ref.= with facility)	14	330		
No facility	17	355	1.2 (0.58, 2.4)	1.6 (0.54, 4.6)
Mother's education level (ref.= illiteracy)	15	221		
Primary	1	92	0.23 (0.03, 1.7)	0.18 (0.02, 1.6)
Secondary and above	15	372	0.8 (0.39, 1.6)	0.38 (0.13, 1.1)
Residence (ref.= rural)	29	665		
Urban	2	20	4.8 (1.10, 20.6)*	0.77 (0.13, 4.5)
Drinking water source (ref.= protected)	18	384		
Piped	9	170	0.82 (0.37, 1.8)	
Unprotected	4	131	0.66 (0.22, 1.9)	1.3 (0.42, 4.1)
Place of delivery (ref.= health facility)	3	317		
Home	28	368	10.1 (10.1, 33.1)*	10.5 (3.0, 36.6)*
Exclusive breastfeeding (ref.= no)	17	179		
Yes	14	506	2.4 (1.2, 4.8)*	1.3 (0.59, 2.8)
Cons			----------	0 (0, 0.0002)*
/ln_p			----------	0.97 (0.73, 1.2)
P = γ			----------	2.6 (2.1, 3.4)*
1/p = □			----------	0.38 (0.299, 0.48)*

Discussion

This study was conducted to assess predictor factors of NMR among neonates in the Tigray regional state, northern Ethiopia. The 2016 EDHS indicated that NMR is still one of the leading causes of illness and mortality among neonates. The magnitude of NMR is greater than the national average, and the early neonatal period has been associated with the highest chance of newborn mortality. Neonates whose mothers gave birth at home and who belonged to the child multiple birth type had a higher risk of NMR. In the current study, the overall neonatal mortality rate among neonate children was 4.3% which is equivalent to the NMR of 43 per 1000 live birth neonates with [95% CI: (28, 58)]. This finding confirms with the study done in Indonesia, 5.2% (17), Nigeria, 4.1% (8), Somali region of Ethiopia, Jimma Zone, 3.55% (18), and Ethiopia, 3.67% (19).

The outcome of this study, however, was less favorable than that of the research carried out at the University of Gondar Comprehensive Specialized Hospital in Northwest Ethiopia, 17.3% (6), WolaitaSodo Referral Hospital in southern Ethiopia, 17.3% (20), Debre Markos Referral Hospital in Northwest Ethiopia, 21.3% (21), and Amhara Regional State Referral Hospitals, Ethiopia, 18.6% (6).

On the other hand, it was more than the study done in China, 1.2% (22), and rural area of Eastern Ethiopia, 2.84% (23). This difference might be attributed to variation in study design, study settings, follow-up period, population sample size of the study, and socio-demographic characteristics of study participants.

The mother's age was identified as a significant risk factor for newborn mortality in a number of published publications. This study, however, demonstrated that the mother's age had little bearing on infant death. This is inconsistent with findings from other studies (2). Unlike other studies, male sex of neonate, not ANC visit and not initiating exclusive breastfeeding, and rural place of residence weren't responsible risk factors of neonatal mortality (2, 6, 7, 24).

Place of delivery was discovered to be a significant risk factor for neonatal mortality, meaning that babies born at home had higher risks of dying than babies who received care in health institutions. Prior, studies also reported that neonates who born in health facilities had better access to delivery services and better health care services for health service utilization for their newborn (6; 25).

One of the risk variables affecting a newborn's chance of survival is their birth type, which might vary depending on their socio-demographic parameters. Multiple births have a higher risk of infant mortality than single births. This study was similar with the previous studies done in Ethiopia (2). The cause may be explained by the fact that neonates from multiple births are more likely to have low birth weight and biological immaturity.

Limitation and strength of the study: This inquiry pinpointed the NMR issue inside the research domain. However, it is important to consider some of the restrictions. The authors were unable to include some of the significant predictor variables that have been identified as linked risk predictors in this analysis because of the secondary retrospective nature of the dataset and the high rates of missing datasets for predictor variables. It's unclear how useful these results are (given the omission of some of the historically significant datasets) and that the associated predictors examined were a convenience sample of the dataset gathered as part of the DHS. Also, the study was completed eight years ago. Therefore it is unlikely to accurately reflect the most recent developments about NMR in the region. Additionally, it was predicated on a suitable statistical model technique (parametric analytic comparison) to forecast the majority of risk factors for newborn mortality. Besides, because the study is according to the regional survey information, it may provide insight into how policymakers and program planners should develop effective regional intervention methods.

Conclusion

The prevalence of NMR showed that the NMR in the Tigray region was greater than the national average. The current study identified the multiple birth type and home delivery of the neonates as crucial predictor factors for NMR. Interventions should be improved to these modifiable major predictor factors that significantly decrease the NMR problem among neonates.

Abbreviations:

ANC; **A**ntenatal **C**are; AHR: **A**djusted **Hazard**s **R**atio; CI: **C**onfidence **I**nterval; CSA: **C**entral **S**tatistical **A**gency; EDHS: **E**thiopian **D**emographic **H**ealth **S**urvey; EPHI; **E**thiopian **P**ublic **H**ealth **I**nstitute;MDG4: **M**illennium **D**evelopment **G**oal; MOH: **M**inistry of **H**ealth; NMR: **N**eonatal **M**ortality **R**ate; UNICEF: **U**nited **N**ations **I**nternational **C**hildren's **E**mergency **F**und; USAID: **U**nited **S**tates **A**gency for **I**nternational **D**evelopment; SSA: **S**ub-**S**aharan **A**frica.

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Enhancing Adolescent Nutritional Behaviour through School Food Club Interventions

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Abstract

Background: *There is a growing concern over the rising prevalence of malnutrition among adolescents in Africa. This issue is largely attributed to the decline in dietary quality during this crucial stage, which compromises the ability to meet nutritional needs and increases vulnerability to various illnesses and nutrition-related diseases. Understanding the factors that can enhance adolescent nutritional behavior is essential to addressing this public health challenge.*

Objective: *This study aimed to investigate the impact of adopting School Food Clubs (SFC) on the nutritional behavior (NB) of adolescents in private secondary schools in Ibadan, Oyo State, Nigeria.*

Method: *With a quasi-experimental design, two Local Government Areas (LGAs) were randomly assigned as the Intervention Group (IG; Ibadan South West) and Comparison Group (CG; Ibadan North). Three private secondary schools with existing SFCs were randomly selected from each group. A total of 162 adolescents (IG=85, CG=77) interested in SFC were recruited. Quantitative assessments were performed using a semi-structured questionnaire at baseline and post-intervention.*

Result: *Knowledge, attitude, self-efficacy, and practice scores significantly increased in the IG post-intervention compared to the CG. The SFC adoption positively influenced knowledge (21.7±3.1), attitude (22.3±2.8), self-efficacy (24.4±3.1), and practice (22.2±5.0) scores at the 3-month follow-up. The study revealed consistent improvements across these variables, indicating a significant positive relationship between SFC adoption and NB promotion.*

Conclusion: *The School Food Club demonstrated effectiveness in promoting the nutritional behavior of adolescents in Ibadan. The study suggests that SFCs have the potential for sustainable positive nutritional behavior changes among the target population and recommends their encouragement in other schools. This research contributes valuable insights into addressing the increasing prevalence of malnutrition among adolescents, emphasizing the need for interventions that focus on holistic nutritional behavior improvements through innovative and sustainable platforms like SFCs.*

Introduction

There is an increasing prevalence of malnutrition among adolescents in developing countries. A major factor contributing to this is the decline in the quality of the diet of adolescents [1]. Eating behaviour is of high significance at this stage because adequate nutrition is vital to meet the requirements of rapid growth and development, increased physiological activities, cognitive growth and development, and prevention of illnesses and nutrition-related diseases [2]. There seems to be a unique relationship between the adolescence stage and their capacity for healthy food choices [3]. This is evident as peer acceptance is critical and can exert social pressure on their food choice [4]. Peers, for example, can influence their decision to skip meals and diet by indirectly bolstering the image of the "ideal" slender body form. Adolescents may also copy their classmates' poor eating habits, such as eating high-calorie items and drinking little water, which can lead to micronutrient deficiencies [5]. When nutrition demands are not met, adolescents become malnourished and consequently, have devastating effects on their development into productive adults [6].

A study among adolescents in the middle and high socioeconomic ladder showed a significant amount of underweight as the study recorded poor intake of fast food, sweets, and sugary beverages [7]. Another study among this group of adolescents also showed inadequate intake of fruits, vegetables, and fish over high-calorie meals, sweets, and snacks [8]. A crossectional survey of 172 students aged 10 to 16 in private schools in Port Harcourt found that 47% were of normal weight, 46.2% were underweight, and 6.6% were overweight [9]. Poor nutritional behaviour among adolescents is related to low knowledge, attitude, self-efficacy, and practices of nutrition [10,11].

Some examples of school-based nutrition education strategies for adolescents include School-based nutrition education for 3 months, for girls aged 15 to 19 years. Strategies included the use of lectures, movies, leaflets, and brochures to teach about the food pyramid, adequate eating, iron absorption stimulants and inhibitors, iron sources, anemia, and iron deficiency [12]. A different study used graphical materials with food models, images, and a packaging style [13]. For these strategies to be effective, factors determining adolescents eating preferences need to be considered, due to the wide disparity in the eating lifestyle of urban and rural adolescents [14]. Socio-economic factor plays a significant role in determining the variation between urban and rural adolescents. For instance, a high percentage of urban adolescents are from the high or middle socioeconomic income class and mostly attend private schools [15]. These adolescents usually have extra cash to spend which could be an advantage for healthy food choices. However, having access to food does not guarantee good nutritional status [16]. A good nutritional status is only built if the right food choices are constantly made. Right food choice is dependent on the presence of life skills in enhancing healthy eating behaviour.

Despite these intervention programmes, nutritional behaviour, especially among adolescents in private schools, has been poor [14]. While school nutrition intervention programmes remain an effective strategy that has been successfully used to promote nutrition knowledge, attitude, self-efficacy, and practice of adolescents [17]. Further strategies should incorporate the needs of adolescents from middle and high socioeconomic status, while also considering an engaging platform that can also be sustainable in promoting nutritional behaviour. One approach of interest is the adoption of school food clubs, which relies on an existing platform in the school for socialization, engaging, and educative approaches in providing nutrition education to adolescents. For instance, the strategy has been employed successfully in the past to provide free breakfast at vocational schools to decrease breakfast skipping [18], however, sustainability was an issue. Also, its practicability among adolescents of middle and high social-economic status in Nigeria has not received enough attention.

Although, private secondary schools in Nigeria operate on school curricula that have incorporated basic knowledge of nutrition into the context of health-based subjects such as home economics for the junior classes and food and nutrition for the senior classes. This will probably not be enough as the scheme focuses only on the Introductory context of healthy eating such as; basic food nutrients, condiments, seasoning, digestive system, food safety, and storage of foods to mention a few. Also, the classroom nutrition education approach, do not usually consider the use of the enter-education method, which is an essential method of teaching among adolescents [19] in other to promote nutritional behaviour among

adolescent. This could leave a major gap in the development of healthy nutritional behaviour among students which is a concern as the prevalence of malnutrition among adolescents is on the increase.

Also, while some secondary schools in Nigeria have included school food clubs as a part of their extracurricular club activity, formative research shows that lessons taught focused more on the art of cookery and recipe development of local and intercontinental dishes and have failed to include education and activities with potentials to develop their knowledge and skills capable of promoting healthy nutritional behaviour. The scope of learning might create major gaps in their knowledge of nutrition and healthy lifestyle.

A sustainable platform such as a school food club has proven to be an effective health-promoting setting. This study intends to adopt the existing school food club to fill the void in the lack of adequate nutrition education by providing peer-targeted nutrition education interventions. Since in-school adolescents spend most of their time in school, the platform is capable of promoting their knowledge, attitude, self-efficacy, and practices of nutritional behaviour. Also, very few studies have used school food clubs as interventions around the world. School food clubs, for example, had a substantial impact on students' knowledge and dietary diversity in research conducted among Somali primary school students. There was a 0.8 standard deviation increase in knowledge compared to the adolescents in the Comparison group, a 14 % higher value of Dietary Diversity Score [DDS] in the last 24 hours, and a 15 % age point drop in the rate of underweight [20]. Another study done in Ethiopia among primary school pupils promoted awareness of nutrition and equipped the pupils to take the messages to the community and raise awareness among peers [21]. These two studies although able to improve knowledge and nutritional behaviour was not done among adolescents, it also has not been able to maximize the strength of existing food clubs in the school to enrich their knowledge of nutrition lastly, previous interventions had not incorporated the influence of school environment and policy on their nutritional behaviour.

Adopting an existing food club can provide a peer-targeted intervention capable of producing good nutrition peer ambassadors who could have a positive influence on their peers. This is crucial since adolescents primarily get their information from peers, who may have been misinformed, and could lead to a cycle of poor food habits. This underscores the need for nutrition programmes that can engage in-school adolescents since many young people need to be educated in other to make proper food choices and also become positive peer influences in developing good nutritional behaviour. Therefore, the present study aimed to evaluate the effect of adopting a school food club as an intervention tool to promote a peer-acceptable and sustainable strategy, capable of improving adolescents' knowledge, attitude, self-efficacy, and practice toward healthy nutritional behaviour among adolescents in private schools in Ibadan, Oyo state, Nigeria.

Method

The study adopted a quasi-experimental design. The study adhered to the moral principles that govern studies involving human participants. The Oyo State Research Ethical Review Committee, Ministry of Health Secretariat, Ibadan, approved the research ethically and assigned reference number AD 13/479:1647A to it. Participants were informed that their involvement in the study was entirely voluntary, and the objectives of the investigation were thoroughly explained in English. Every ethical issue was handled with care. Additionally, before the adolescents' enrolment, written informed consent was collected from their parents and legal guardian, stating their permission to allow their children to participate in the study. Visits were made to the selected schools in each LGA, the principals of the schools were contacted and informed of the objective of the study, and permission was obtained. Permission was also obtained from, the coordinator of the school food club, who was also the home economics and food and nutrition teacher in all the schools, and lastly, student representatives of members of the school food club in each school. All stakeholders were met to brief them on terms of study goals and also to garner their support in the facilitation and implementation of the study.

The study was conducted among in-school adolescents in two Local Government Areas (LGAs) -Ibadan South West Local Government Area and Ibadan North Local Government Area. The Intervention and Comparison sites were selected due to the presence of established school food clubs located in the existing private schools. All intervention activities were carried out in the school food club. This was done

using already established and structured school food clubs with due permission from the participating schools. Also, JSS 3 and SS3 students were excluded from the study because of preparation for final exams which might interfere with their commitment to the research.

The sample size was calculated considering the prediction of a 50% increase in nutritional behaviour after the intervention. A significance level of 0.05 and a power of 80% were considered. Under this condition, the minimum sample size was a total of 62 participants per group. With the inclusion of percentage loss, the participants were increased to 85 for the Intervention and 77 for the Comparison group, with a total of 162 participants in the two groups. A 5-stage random sampling was adopted in selecting study participants**.** Using the state profiling data, stratification into urban and rural areas from the 11 LGAs present in Ibadan, Oyo state, according to the amount of industrial concentration and commercialization [22]. From the five urban LGAs in Ibadan Metropolis, a random selection of Ibadan South West LGA and Ibadan North LGAs was done and allocated into Intervention and Comparison sites, respectively using simple random sampling. The total number of private schools in each local Government Area was collected from the Ministry of Education. Ibadan South West LGA comprised one hundred and twenty-four (124), while Ibadan North comprised one hundred and seventy-nine (179). A list of schools with school food clubs in the selected LGAs was collected from the chairman of the private secondary school proprietor. Purposive selection of five schools in IBSW and six in IBN based on the presence of school food clubs. 6 out of 11 schools (3 from each LGA) consented to participate in the study.

Desk reviews of all six school food club curricula were conducted and the standard nutrition manual by UNICEF [23] was used as a guide. The instrument used was secondary data from the school food club curriculum, collected from the school principals. The process included a review of the school food club curricula. Findings from the desk review showed the knowledge gap that could promote healthy nutritional behaviour in the school food club manuals. Activities in the school food club focused on improving their knowledge of local and continental dishes recipe development with very little emphasis on educational activities that could promote their healthy nutritional behaviour. Monthly activities included the preparation of meals and at times, competition for the best chef. The gaps observed including, poor knowledge, attitude, self-efficacy, and practice of nutritional behaviour were documented and presented to stakeholders in the Intervention schools. The Comparison group was provided with a placebo, and information on knowledge of reproductive health.

A meeting date with two coordinating teachers (one food and nutrition teacher and one home-economics teacher) per school and four representatives of the adolescents in the school food club (a male and female from each of the upper and lower classes, respectively) was scheduled, to reveal the gaps accessed in the school club curricular in promoting nutritional behaviour among adolescents and for the development of a modified school food club manual with the tendency of bridging the gaps. The adopted school food club sessions were done once weekly during their extra-curricular activities time for 8 weeks. The duration for each session lasted from 45 minutes to 1 hour. The sessions were held in the school hall in some schools and the home economics lab in others. A pre-testing evaluation exercise was conducted to measure the adolescents' prior knowledge of nutritional behaviour before the weekly training started and a post-testing evaluation at the end of the weekly training, to test the effectiveness of the programme on them.

At the commencement of each session with adolescents, the modified school food club curriculum was given to the school teachers coordinating the school food club. An overview of the concept behind the adopted school food club and the expectations of the adolescents during the sessions were discussed. There were opportunities for the adolescents to ask questions concerning the adopted school food club programme as feedback and answers were provided. The training employed a participatory and enter-educative workshop approach. As a session begins, attendance was taken, followed by feedback and a recap on the previous topic discussed. Then, the topic of the present session was introduced and an interactive session followed, in which the activity book served as a guide. These activities were aimed at encouraging them to apply lessons learned before the next session. Feedback on previous session activities was given before the start of another session. The presentations were done in English and the session was guided by the nutritionist who is also the student researcher and assisted by the school's food club coordinator. Adolescents in the Compari-

son group attended a reproductive health education class at least once a week. As the study concluded, they received adopted school foods club modules and educational materials. (See Appendix for content of the SFC intervention/ curriculum)

A semi-structured questionnaire was used to conduct a quantitative analysis of adolescents' knowledge, attitudes, self-efficacy, and practice of nutritional behaviour to determine the effect of the intervention based on the developed manual. In a prior study, which was not included in the current study, the questionnaire was pilot tested with adolescents from private schools in a different urban local Government area from the study. The questionnaire has four sections concentrating on socio-demographic features, adolescents' level of nutrition knowledge, attitude toward nutritional behaviour, self-efficacy of adolescents' nutritional behaviour, and practices of adolescents' nutritional behaviour,. The validated questionnaire is a 39-item at pre-intervention (including additional 3 questions to check for confounders) and 36-item at post-Intervention which was adapted from two tools; Questionnaire for Nutritional behaviour [13]. Respondents in the Intervention and Comparison groups completed the same questionnaires at baseline and immediate post-Intervention and 3 months follow-up. The topics addressed include; Healthy eating, Timing of meals, Personal Hygiene/ Hand washing, and Deworming.

Knowledge Scale*:* A dichotomous knowledge scale was developed to quantify the knowledge of the study respondents. This was done to allow for comparison at the pre-test, and post-test both for the Intervention and Comparison group. The total number of test items in the knowledge section of the questionnaire was documented. A right answer was scored as 2 while a wrong answer scored 0. The total scores on the knowledge section were measured on a 12-item scale. The weight of the scale is 24 points. Centile was used for categorization of the scores. A score ≥ 12 was categorised as good knowledge of nutritional behaviour while a score < 12 was classified as poor knowledge.

Attitude Scale: An 8-item and 24-point attitude scale (Agree and Disagree) was developed. The total number of test items in the attitude section of the questionnaire was documented. The responses were also assigned scores. The right score is 3, while the wrong score is 0 using the 50th percentile for categorization of the scores, every respondent's attitude score ≥ 12 was categorized as having a positive attitude while respondents who scored < 12 were categorized as having a negative attitude.

The self-efficacy scale: A 9-item self-efficacy scale. Also, based on centile dichotomization, a 27-point self-efficacy scale (Confident, Not-confident) was developed. The total number of test items in the attitude section of the questionnaire was documented. The responses were assigned scores of 3 points per question. The total number of test items in the self-efficacy section of the questionnaire was documented. Categorization of the respondents' self-efficacy was done using the 50th percentile. Every adolescent self-efficacy score ≥ 13.5 was categorized as positive self-efficacy while participants who score < 13.5 were categorized as having poor self-efficacy.

Practice scale: A 7-item practice scale. The weight of the scale is 28. Based on a centile dichotomization, a dichotomous scale was developed. For the dichotomous scale, the right answer was scored 4, while the wrong answer was 0. The total number of test items in the questionnaire's practice section was noted. Using the 50th percentile for categorization of the scores, every respondent's practice score ≥ 14 was categorized as good practice while respondents who score < 14 were categorized as poor practice.

Statistical Package for Social Sciences (SPSS) version 20.0 was used for survey data entry and analysis. Descriptive statistics were employed to describe the categorical data about the sample of students in the selected private secondary schools in terms of gender, age groups, class, and other socio-demographic questions, and to summarize the data regarding adolescents' knowledge, attitude, self-efficacy, and practice towards nutritional behaviour. The differences between the two groups at baseline and post-Intervention were compared using the independent sample t-test. The p-value was used to conclude whether the results were merely coincidental or accurately reflective of the population. To predict a significant difference between the Intervention and Comparison group in terms of the (a) level of knowledge of nutritional behaviour, and (b) attitudes of adolescents towards nutritional behaviour. (c) self-efficacy of adolescents towards nutritional behaviour, (d) practices of nutritional behaviour among adolescents. Cohen-D test of significance was used to measure the connotation difference with effect size at baseline and post-Intervention for all study variables.

Result

A total of one hundred and sixty-two (162) in-school adolescents (respondents) including both males and females participated in the study. The number of adolescents in the Intervention group was eighty-five (85) and seventy-seven (77) in the Comparison group. The adolescents that participated were 39.0% of Male Adolescents in the Intervention group and 36.0% in the Comparison group. While 61.2% were female in the Intervention group and 64.0% in the Comparison group. Information on socio-demographic characteristics, level of knowledge, attitude, self-efficacy, and practices of Nutritional behaviour were obtained. The mean age of the participant was 13.8±1.1 for the intervention and 13.8±1.6 for the comparison. Table 1 shows the mean scores for nutritional knowledge from baseline to follow-up. At immediate post-intervention and three-month follow-up (p=0.001), the mean scores nutritional knowledge scores were significantly higher than baseline scores. Similar results occurred with nutrition attitudinal scores (Table 2), nutritional self-efficacy (Table 3), and nutritional practice (Table 4)

Table 1: Mean Nutritional Knowledge Scores of Intervention Vs Comparison from Baseline To Post-Intervention And Follow-Up

Knowledge	Intervention			Comparison			F	t	df	P-value
	N	Mean	SD	N	Mean	SD				
Baseline	85	9.1	3.5	77	8.8	3.8	0.0	0.5	160	0.7
Immediate PI	85	18.2	4.6	77	8.9	4.1	0.3	13.5	160	0.0
1st month PI	85	20.6	3.8	77	8.9	3.9	0.9	19.1	160	0.0
2nd month PI	85	20.7	3.1	77	9.2	4.0	2.9	20.4	160	0.0
3rd month PI	85	21.6	3.1	77	9.9	3.8	9.8	21.6	160	0.0

Table 2: Mean Nutritional Attitudinal Scores of Intervention Vs Comparison Group from Baseline to Post-Intervention And Follow-Up

Attitude	Intervention			Comparison			F	t	df	P-value
	N	Mean	SD	N	Mean	SD				
Baseline	85	6.4	3.8	77	6.9	4.4	1.8	-0.7	160	0.5
Immediate PI	85	18.5	4.9	77	7.6	4.8	0.0	14.3	160	0.0
1st month PI	85	20.1	4.6	77	7.9	4.6	0.3	16.8	160	0.0
2nd month PI	85	21.0	4.0	77	7.8	4.5	3.6	19.7	160	0.0
3rd month PI	85	22.3	2.9	77	8.2	4.7	27.0	23.2	160	0.0

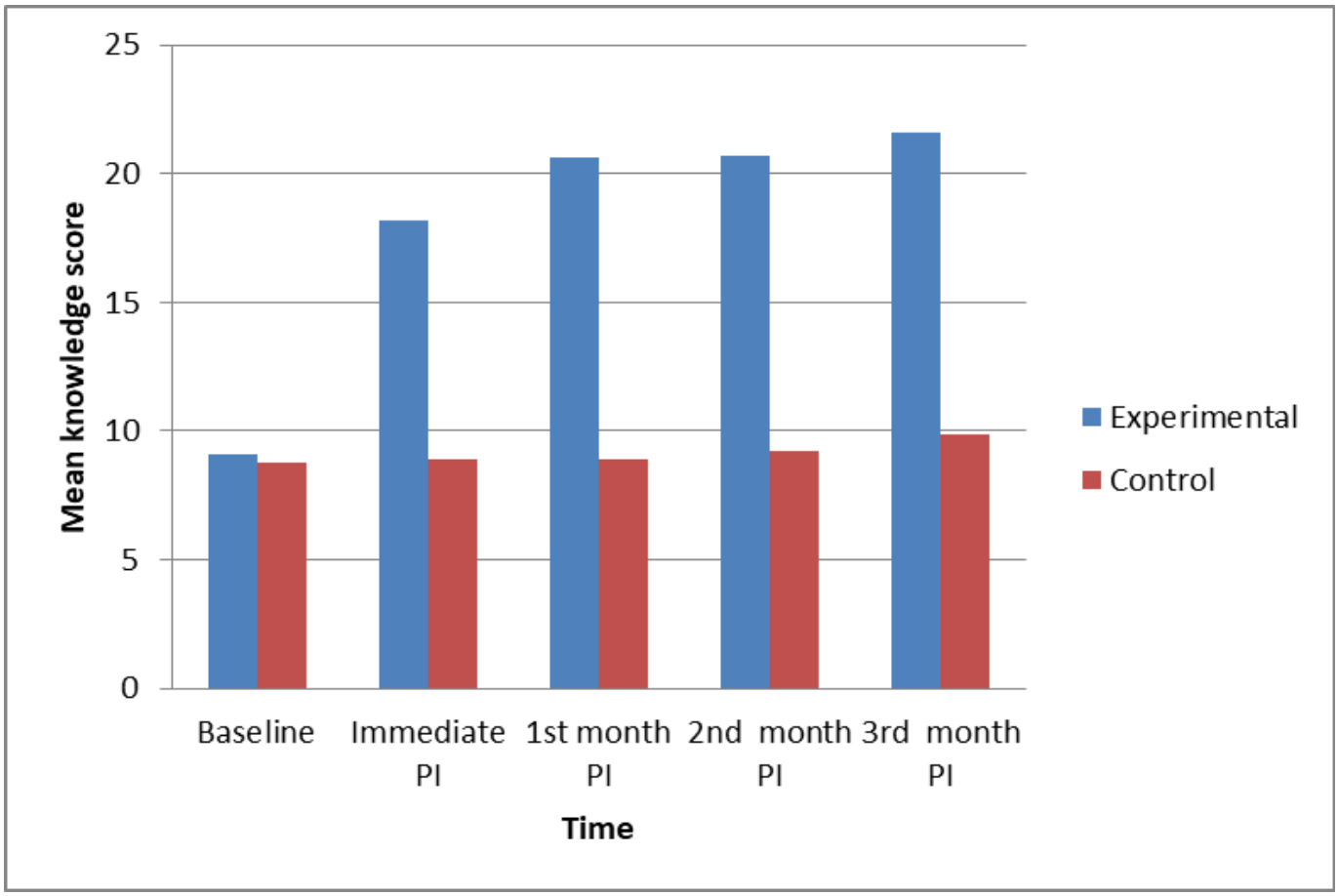
Table 3: Mean Nutritional Self-Efficacy Scores of Intervention Vs Comparison Group from Baseline to Post-Intervention and Follow-Up

Self-efficacy	Intervention			Comparison			F	t	df	P-value
	N	Mean	SD	N	Mean	SD				
Baseline	85	10.7	4.2	77	9.7	5.0	2.9	1.5	160	0.1
Immediate PI	85	17.5	4.7	77	10.0	5.7	1.8	9.2	160	0.0
1st month PI	85	20.8	3.9	77	10.9	5.4	8.5	13.4	160	0.0
2nd month PI	85	22.7	3.3	77	11.1	5.5	19.4	16.4	160	0.0
3rd month PI	85	24.4	3.1	77	11.1	5.5	28.4	19.3	160	0.0

Table 4: Mean Nutritional Practice Scores of Intervention Vs Comparison From Baseline to Post-Intervention and Follow-Up

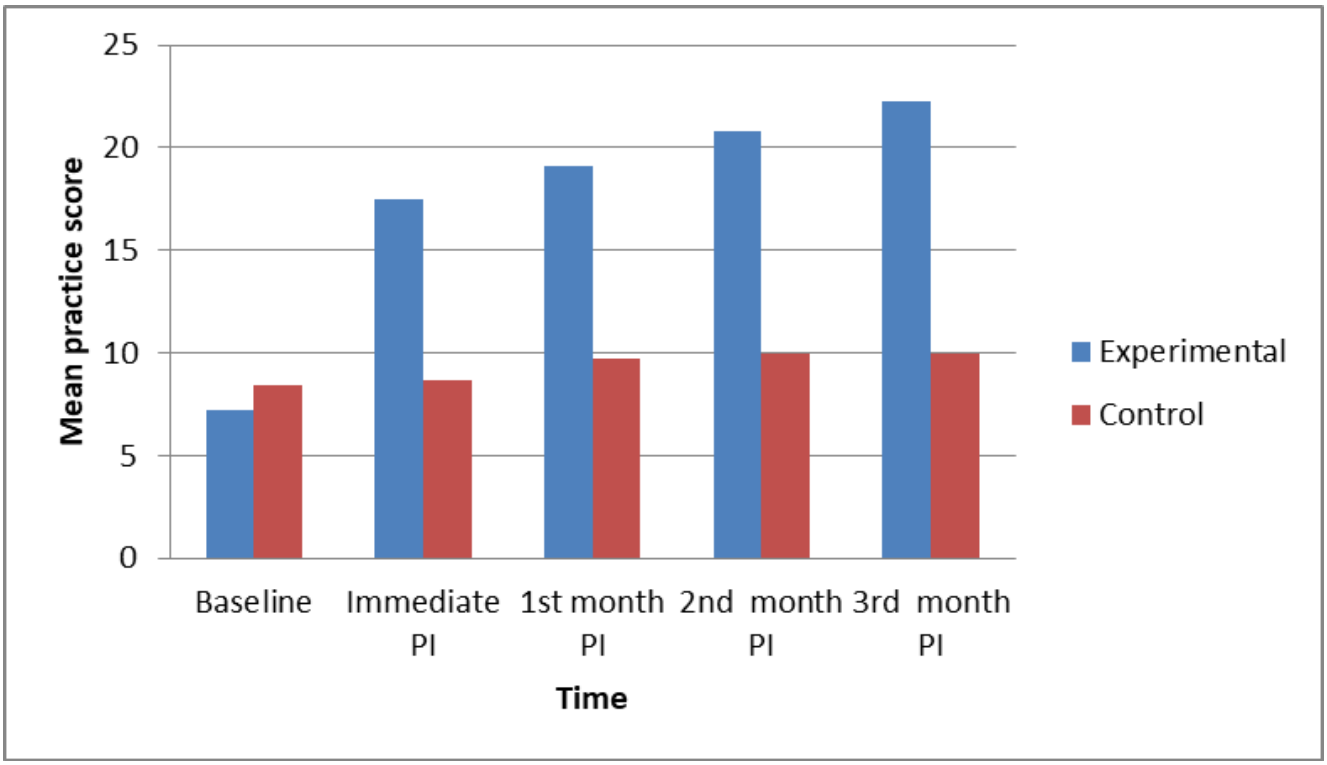
Practice	Intervention			Comparison			F	t	df	P-value
	N	Mean	SD	N	Mean	SD				
Baseline	85	7.2	5.1	77	8.4	5.0	0.5	-1.5	160	0.1
Immediate PI	85	17.5	6.1	77	8.7	5.5	1.9	9.7	160	0.0
1st month PI	85	19.1	5.7	77	9.7	5.4	0.1	10.8	160	0.0
2nd month PI	85	20.8	5.0	77	10.0	5.5	3.2	13.1	160	0.0
3rd month PI	85	22.3	5.0	77	10.0	5.4	1.9	14.9	160	0.0

Results in Figure 1 and Figure 2 showed that as intervention progressed through the months, adolescents were able to increase their knowledge and practice of nutritional behaviour. This was also consistent with the other study variables. Also, The Cohen-D test of significance for all study variables shows that there was a connotation difference with negligible effect size at baseline. At Immediate post-Intervention, First-month post-Intervention, Second-month post-Intervention and third-month post-Intervention, result shows a huge effect size which increases steadily from immediate post-intervention to third post-Intervention. This suggests a huge effect size which increases steadily from immediate post-intervention to third post-Intervention



PI*= Post Intervention*

Figure 1: *Baseline, Immediate post-intervention, First-month post-intervention, Second-month post-intervention, and Third-month post-intervention of mean nutritional knowledge for Intervention and Comparison*



PI *= Post Intervention*

Figure 2: *Baseline, Immediate post-intervention, First-month post-intervention, Second-month post-intervention and Third-month post-intervention of mean nutritional practice for Intervention and Comparison*

Discussion

This study aimed to evaluate the effect of adopting a school food club as an intervention tool to promote a peer-acceptable and sustainable strategy, capable of improving adolescents' knowledge, attitude, self-efficacy, and practice towards healthy nutritional behaviour among adolescents in private schools in Ibadan, Oyo state, Nigeria.

At the baseline of this study, the Intervention and Comparison groups did not differ significantly in their knowledge of nutritional behaviour. Findings showed poor knowledge of nutritional behaviour among adolescents. This implies that adolescents in private schools may have poor knowledge and understanding of healthy eating, proper meal timing, hand washing, and deworming. This shows a gap in the curriculum of school food clubs in the selected schools, which could serve as a platform to promote positive nutritional behaviour among adolescents.

In contrast, a study conducted among private school adolescents in Lagos showed moderate dietary knowledge, implying an understanding of healthy food choices, food nutritional values, and nutrition-related diseases [25]. Additionally, the result of knowledge of nutrition among adolescents in a secondary school in Ibadan showed positive knowledge [26]. Although Fatikhani and Setiawan [27] also reported good knowledge among adolescents, it showed no relationship between improved knowledge and adolescent nutritional status. On the other hand, a study revealed a significant relationship between knowledge and eating behaviour among adolescents, also showing poor food choices due to poor knowledge [28]. The baseline finding of this study is, however, similar to those of a similar study [33] where it was found that poor nutritional knowledge significantly increased at post-Intervention but does not indicate good nutrition eating habits.

In post-Intervention, the current study reports an increase in knowledge score in the Intervention group. Adolescents are now able to understand how to make healthy food choices, also, how to properly wash their hands and the benefits of deworming. This is similar to an intervention conducted by Ezezika, Oh, Edeagu, and Boyo [29], in Nigeria among adolescents which reported that nutrition education increased their knowledge leading them to alter their behaviour by incorporating more nutritious foods (such as fruits and vegetables) into their diet and engaging in more physical activity. Five themes

emerged from the analyses: increased knowledge, improved eating behaviour; increased physical and influencing others. Similarly, a study among adolescents in secondary school in Ibadan, Nigeria showed that Nutrition education through innovative strategies such as songs is effective in improving knowledge of healthy eating among adolescents [30].

The improvement of adolescents' knowledge at 8 weeks post-Intervention indicates that when appropriate knowledge of nutrition is included in the curriculum of the school food club, it has the potential of promoting their understanding of nutritional behaviour. The adopted school food club was able to provide a platform for an enter-educative approach to promote adolescents, knowledge of nutritional behaviour. Also, the nutritional behaviour of adolescents was seen to improve steadily at the 3-month post-Intervention, as the nutrition education continued. This implies that, when adolescents have good nutritional knowledge, it influences their decision to eat healthily and also has a major determining effect on the dietary patterns of adolescents. For instance, the intake of vegetables among adolescents was seen to be higher with an increased level of nutrition knowledge [31].

The current study's findings revealed no notable difference in the attitudinal disposition of participants in both the Intervention and Comparison groups at baseline. Both groups had a negative attitude toward nutritional behaviour, with (96.5%) in the Intervention (92.1%) in the Comparison group. These results can be attributed to the inadequate knowledge of participants about nutritional behaviour which might have a huge influence on their attitude towards it [32]. Similarly, a study by Salvy et al. [5] showed that a poor attitude towards healthy foods usually results in unhealthy nutritional behaviour. This corroborates finding among adolescent girls showing negative attitudes toward nutrition and majorly poor nutritional practice [33]. Adolescents who reported consuming a lot of fast food had similar opinions about eating nutritious meals, such as that they do not like the taste, do not have time to consume them, and also do not care about healthy food.

However, at Immediate Post-Intervention, there was an increase in the percentage of participants in the Intervention group with positive attitudes compared to the baseline. The attitudinal mean score was found to be statistically significant between the Intervention and Comparison groups. This is consistent with a study among adolescents in India that showed an increase in the attitude of adolescents by 7.4% from pre- to post-Intervention [34]. Attitude is an important indicator of food preference [35] and is also directly and indirectly associated with self-control [36]. This suggests that adolescents possessing a positive attitude will also have good intentions to choose healthy foods and also likely overcome peer influencing negatively promoting poor dietary habits [10]. A positive attitude towards nutrition in adolescents contributes immensely to adopting healthy nutritional behaviour. This corroborates a finding by Jayaveloo, Daud, and Rahman [37] that attitude has a positive correlation with dietary practices.

The adopted school food club served as a platform that reinforced adolescents' attitudes toward positive nutritional behaviour. Adolescents developed the attitude of choosing their food, not just for the taste but also the nutrient content by reading the nutritional label. Also, more adolescents preferred the intake of water to carbonated drinks, have a positive mindset about eating their meals at appropriate times, properly washing their hands before and after every meal, and lastly, deworming at appropriate times. The attitude of adolescents' nutritional behaviour was seen to steadily improve at 3 months post-intervention, indicating that their continuous exposure to the intervention promotes a positive mindset of nutritional behaviour.

At baseline, self-efficacy of nutritional behaviour in this study was found to be weak. The result showed that most adolescents in the Intervention (75.6%) and Comparison group (77.6%) had weak self-efficacy. This implies that adolescents do not have confidence in choosing to eat healthily, especially when it is not a tradition in the school environment or not widely acceptable among their peers. None of the schools enrolled in the study had positive variables that could promote the self-efficacy of participants in the adoption of nutritional behaviour. Examples of the positive variables include, sales of healthy foods in school tuck shops and nutritional behaviour reinforcing programs in the school food club. A study associated low self-efficacy for healthy eating and higher peer influence for unhealthy eating with poor eating habits [3]. This inferred that adolescents with low self-efficacy will most likely also have poor eating habits. A similar study showed a positive correlation between self-efficacy and intake of fruits and vegetables [38]. Indicating that when adolescents develop good self-efficacy, it impacts on intake of healthy foods [39].

As pointed out by Fitzgerald, Fitzgerald, Heary, Kelly, Nixon, and Shevlin [40] in a study of 483 adolescents aged 13-18, it was found that self-efficacy for eating and peer support for unhealthy eating are both associated with food intake patterns. Higher self-efficacy opinions were linked to eating healthy foods, while lower self-efficacy beliefs were linked to eating unhealthy foods, according to a study. A study among Nigerian adolescents confirms this [30]

In the post-Intervention group, adolescents in the Intervention group experienced an increase in self-efficacy in nutritional behaviour. This is consistent with a study that used Rango cards on food consumption, nutritional knowledge, and self-efficacy of healthy eating practices which showed that an increase in self-efficacy at post-Intervention had a positive significance on adolescents' adoption of nutritional behaviour [41]. This implies that the enter-educative approach in the development of the curriculum used for promoting nutritional behaviour in the adopted school food club was able to develop adolescents' confidence. The confidence of adolescents was seen to improve steadily at the 3-month post-Intervention to choose healthy foods, wash hands properly before and after meals and also deworm at appropriate times.

Practice disposition of adolescents at baseline in both Comparison and Intervention groups towards Nutritional behaviour was poor. This could be a result of the absence of a school food club curriculum that promotes their practice of nutritional behaviour. Such as teaching adolescents how to choose a variety of healthy meals and how to properly wash their hands.

Also, unhealthy snacks and soft drinks are comparably affordable and available in the school tuck shops and usually within budget, this could encourage adolescents to eat more snacks since they have some money available for daily spending. A study showed that students who ate at the school store in private schools more than three times a week were overweight. It also observed that high-fat-salt-sugar foods brought more sales to the store [42]. This confirms a study of an association between exposure of adolescents to food outlets in the school environment and its effect on their diet quality [43].

However, in post-Intervention, the practice of healthy nutritional behaviour of adolescents increased in the Intervention group but remained low in the Comparison group. This inferred that the adopted school food club intervention significantly influenced the decision to choose healthy foods. The dietary diversity of adolescents also increased. Adolescents steadily increased their intake of healthy food in varieties during the 3 months post-Intervention. In the study by Scaglioni, Cosmi, Ciappolino, Brambilla, and Agostoni [32], One of the most crucial aspects of satisfying the nutritional needs of adolescents is modeling healthy eating habits. Healthy eating habits are retained throughout adulthood, thus, lowering the chance of developing serious chronic diseases Christian and Smith [49], noted that there exists a direct relationship between poor nutrition practice during adolescents, development, and the prevalence of disease throughout the life cycle.

The findings in this study showed that the use of school food clubs as an Intervention increased the knowledge, attitude, self -efficacy, and practice of adolescents. This is consistent with a finding by Olowookere and Umukoro [50], that short-term nutrition intervention based on an active, participatory approach increased dietary knowledge and also influenced dietary intake of vegetables and reduced intake of carbonated drinks.

Also, a 3-month follow-up, a steady increase in the knowledge of nutritional behaviour among adolescents was seen in the first, second, and third-month follow-up. The increase in knowledge of nutritional behaviour among adolescents could be due to the nature of the delivery of the content in the modified school food training curriculum (MSFTC). The use of MSFTC was done with the use of methods such as; interactive discussions, hands-on demonstration, Information, Education and Communication (I.E.C) materials, and role-play. This nature of intervention has proved to be most effective in engaging and promoting knowledge among adolescents. A study by Moitra et al. [34] showed that nutrition education integrated into an intervention done 50 minutes weekly can have a positive effect on the knowledge, attitudes, and health behaviours of adolescents.

The steady increase can also be explained to be the positive influence of private schools on extracurricular activities in ensuring students adhered strictly to the requirements. Also, the activities of the curriculum took place at the school-stipulated time once every day. The advantage of constant exposure of adolescents to nutritional behaviour promoting materials and activities could serve as the reason for the steady increase in adolescents' knowledge of nutritional behaviour.

The change observed in the Intervention group could be attributed to the adopted school food club programme. There was no observable confounder among the independent variables of knowledge, attitude, self-efficacy, and practice which showed that the observable changes in the variables were not based on the influence of confounders. The broad objective of this study was to investigate the effectiveness of the adoption of school food clubs for change in nutritional behaviour among adolescents in private secondary schools. The mean difference in knowledge, attitude, self-efficacy, and practice of adolescents' nutritional behaviour at post-Intervention and 3 months follow-up, significant differences from the Intervention and Comparison group.

Baseline findings showed poor knowledge of nutritional behaviour among adolescents. This implies that adolescents in private schools may have poor knowledge and understanding of healthy eating, proper meal timing, hand washing, and deworming. In post-Intervention, the current study reports an increase in knowledge score in the Intervention group. Adolescents in the Intervention and Comparison groups had negative baseline attitudes toward reported nutritional behaviour. However, in post-Intervention adolescents experience a significant increase in attitude, while the Comparison group did not. Self-efficacy disposition of adolescents at the baseline, both the Comparison and Intervention groups had poor nutritional behaviour. In the post-Intervention group, adolescents in the Intervention group experienced an increase in self-efficacy in nutritional behaviour. The practice of adolescents' nutritional behaviour at baseline in the Comparison group and Intervention groups' dietary behaviour was subpar. However, in post-Intervention, the practice of healthy nutritional behaviour of adolescents increased in the Intervention group but remained low in the Comparison group.

The findings in this study showed that the use of school food clubs as an intervention increased the knowledge, attitude, self-efficacy, and practice of adolescents. Also, a 3-month follow-up, a steady increase in the knowledge of nutritional behaviour among adolescents was seen in the first, second, and third-month follow-up. The increase in knowledge of nutritional behaviour among adolescents could be due to the nature of the delivery of the content in the modified school food training curriculum (MSFTC).

Conclusion, Recommendation and Limitation

The use of adopted school food clubs in promoting nutritional behaviour is considered an effective nutrition intervention programme. The programme led to a positive change in the nutritional behaviour of adolescents over the study period. Therefore, a well-tailored intervention programme consisting of different educational strategies, targeted at promoting the knowledge, attitude, self-efficacy, and practice of nutritional behaviour such as; the use of role-playing, use of discussion, use of hands-on demonstration, use of posters and leaflets, use of games, and so on can play a major role in improving the nutritional behaviour of adolescents. It is also of note that, the current home economics curriculum (for junior classes) and food and nutrition curriculum (for senior classes) are inadequate in their capacity to promote the nutritional behaviour of adolescents. This is due to its deficiency in key healthy eating concepts and also the absence of engaging strategies in bringing the lessons to life. In conclusion, the outcome of this study provides significant insight into potential interventions through the development of an improved curriculum that promotes skills required for positive nutritional behaviour among adolescents in schools.

While the study yielded significant insights, several limitations must be acknowledged to contextualize the findings and suggest areas for future research improvements. One significant limitation is the sample size and its generalizability. Although the study involved 162 adolescents, the sample was limited to private secondary schools within two Local Government Areas in Ibadan. This limitation means the findings may not be representative of all adolescents in Ibadan or other regions of Nigeria, particularly those in public schools or rural areas where different socio-economic factors may influence nutritional behavior. The quasi-experimental design, while practical for this study, has inherent limitations. Unlike randomized controlled trials, quasi-experimental designs cannot fully control for all confounding variables, which may affect the internal validity of the results. For instance, other unmeasured factors such as socio-economic status, parental influence, and access to nutritional information outside school may have impacted the outcomes.

The use of an independent t-test in analyzing the data has limitations compared to more robust methods like difference-in-difference (DiD) analysis. While t-tests can compare means between two groups, they do not account for pre-existing differences between the groups before the intervention. DiD analysis, on the other hand, could better control for these baseline differences by comparing the changes in outcomes over time between the intervention and comparison groups. This approach provides a more accurate estimation of the intervention's effect by isolating the impact of the SFC from other time -related changes. The reliance on self-reported data through semi-structured questionnaires is another limitation. Self-reported data are subject to biases such as social desirability bias, where participants may provide answers they believe are socially acceptable rather than their true behaviors or attitudes. This could lead to an overestimation of the positive impact of SFCs on nutritional behavior. The follow-up period of three months is relatively short to assess the long-term sustainability of changes in nutritional behavior. Nutritional habits and behaviors often require longer periods to stabilize and become permanent. Future research should consider longer follow-up periods to evaluate the enduring impact of SFCs on adolescents' nutritional behavior.

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Appendix I

Description of topics, objectives, and activities that makes up the content of the School Food Club Curriculum used at each meeting of the nutrition intervention

S/N	OBJECTIVE	CONTENTS	METHODS	RESOURCES	EVALUATION
First week	Explain the meaning of Healthy eating	Definition of healthy eating Identification of the constituents of a healthy diet Differentiation between healthy and unhealthy diets Comparison between whole foods, minimally processed, and highly processed foods	Use of flip-chart to teach about healthy eating Interactive discussion on the concept of healthy eating Use of IEC materials to identify constituents of healthy eating Hands-on demonstration to differentiate between healthy and unhealthy diet Hands-on demonstration to identify whole foods, minimally processed foods, and highly processed foods.	Flip charts, models, Postals, and food models for demonstration, discussion	Question and answer pre and post discussion Return demonstration
Second week	Discuss the benefits of healthy food	Discuss the benefits of healthy eating Mention examples of Healthy foods Identify the disadvantages of eating an unhealthy diet Highlight processed Food Components to Avoid	Interactive discussion on the benefit of healthy eating Use of food models to demonstrate locally available healthy foods Use of IEC materials to discuss the disadvantages of an unhealthy diet Use of IEC materials to identify the processed food components to limit and avoid	Flip charts, Postals, and food cards for demonstration	Questions and answers, pre- and post-discussion Return demonstration of locally available healthy foods
Third week	Understanding of Dietary Diversity	Definition of dietary diversity Explanation of the concept of MyPlate Description of how dietary diversity can be achieved with MyPlate	Interactive discussion on the definition of dietary diversity Hands-on demonstration of the concept of MyPlate using MyPlate cards Discussion of how dietary diversity is achieved with MyPlate	Postal, MyPlate cards game IEC materials	Question and answer pre- and post-discussion, Return- demonstration

Content of School Food Club Curriculum (Continued)

S/N	OBJECTIVE	CONTENTS	METHODS	RESOURCES	EVALUATION
Fourth week	Identification of determinants of food choice	Explain the determinants of food choice Understand how nutrient quality can determine food choice Identify how nutrition fact label helps to make healthy food choices Define how to increase access to healthy food	Interactive discussion on determinants of food choice Interactive discussion on nutrient quality in determining food choice Role play on the use of nutrition fact label Interactive discussion on how to increase access to healthy food	Postal, Flip charts, Food models for role play	Questions and answers pre- and post-discussion Return demonstration
Fifth week	Discuss the best meal timing	Define meal timing and the best meal timing Understand the advantages of proper meal times	Interactive discussion on best meal timing Interactive discussion on the advantages of proper meal timing	Postal Flip charts.	Questions and answers pre and post-discussion
Sixth week	Demonstrate personal hygiene and its benefits	Meaning of personal hygiene Explain ways to ensure proper personal hygiene Demonstrate proper hand-washing steps Identify the frequency of hand washing	Interactive discussion on the meaning and importance of personal hygiene Interactive discussion on proper steps to hand washing Hands-on demonstration on proper steps of hand washing	Postal, hands-on demonstration with soap and running water	Questions and answers pre and post discussion Return-demonstration
Seventh week	Describe deworming and its benefits	Definition of deworming Explain the benefits of deworming How you become infected How often to deworm	Interactive discussions on the definition of deworming and |how we become infected and how often to deworm	Teaching Interactive discussion Role-play Postal, flip-chart	Question and answer pre and post-discussion
Eight week	**RECAP/ EVALUATION**	Evaluation			

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The association between ABO blood groups and norovirus infections among patients suffering from diarrheal disease in Northwest Ethiopia

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Abstract

Background: *Norovirus (NoV) infection is a significant cause of diarrhea worldwide. However, all individuals are not equally affected due to environmental, viral, and host factors, particularly ABO blood groups. Indeed, data that describes the association between NoV infection and the ABO blood group is limited in Ethiopia, and this needs to be investigated.*

Objective: *This study aimed to assess the relationship between ABO blood groups and NoV infection in Northwest Ethiopia.*

Method: *A health-facility-based cross-sectional study was conducted from May 2021 to November 2021 by enrolling 550 participants with diarrhea. Fecal samples were collected and analyzed by reverse transcription PCR to identify NoVs. To further genotype the positive samples, a viral protein-1-coding gene was sequenced. In addition, blood samples were collected and tested to identify blood groupsby using the tube hemagglutination technique. The data were analyzed using SPSS version 23. Logistic regression analysis was done to assess the association between NoV infection and the independent variables.*

Result: *Among the 550 enrolled participants, 519 (94% response rate) provided the required clinical samples and epidemiological data. The majority of the study participants (249/519; 48%) had O blood group.Among the NoV-positive study subjects, the majority (34/46, 74%) were in blood group O, followed by blood group A individuals (9/46, 19.6%).The risk of NoV infection was higher for patients with blood group O than for blood group B (AOR = 1.5, 95%CI = 2–15, P= 0.01), but there was no association for other blood groups.At least one NoV-GII was identified in each of the blood groups, while NoV-GI affected individuals with blood groups O and A. Besides, GII.3 and GII.21 genotypes were common among blood group O individuals, while most (75%) blood group A individuals were susceptible to GII.17 infections.*

Conclusion: *The positivity rate of NoV infection was considerably high among individuals with blood group O. Norovirus-GII can infect all blood groups, while NoV-GI selectively affects blood groups A and O. Further large-scale studies are warranted to assess the relevance of this observation and other genetic factors.*

Introduction

Diarrheal diseases are among the most common causes of morbidity and mortality, responsible for more than 1.5 million deaths globally(1). In developing countries, particularly, diarrhea is the second most common cause of death (2), with the highest burden resting in sub-Saharan Africa and south Asia (3). As a sub-Saharan African country, diarrheal disease is also an important public health concern in Ethiopia (4). More than 25% of under-5 children are affected by diarrhea(5, 6).Viruses are the leading etiological agents of diarrhea in both high-and low-income countries(7). Norovirus(NoV) infections pose a significant burden of diarrheal diseases among all age groups globally, with variable distributions across different settings(8, 9). These viruses are responsible for about 20% of all episodes of diarrheal disease globally (1).The estimated burden is 699 million cases and 219,000 deaths annually, where 97% of mortality is attributed to lower and middle-income countries (1, 10).

Human NoVs are genetically diverse groups of viruses under the family *Caliciviridae*. The virion contains a non-enveloped single-stranded (+sense) RNA genome (11). Based on the partial viral protein 1 (VP1) sequence analysis, they are classified into 10 genogroups (GI to GII) and 49 genotypes. Of these genogroups, GI,GII, and GIV are known to infect humans. These NoV genogroups are further divided into multiple genotypes (9 GI, 27 GII, and 2 GIV) (12). Norovirus GII is by far the predominant genogroup (13), and NoV-GII, genotype-4 (GII.4), is reported as the predominant genotype globally(9, 14). However, a predominance of non-GII.4 genotypes (GII.3, GII.17, and GII.2) over GII.4 was reported in the past five years (15, 16). This might be related to their rapid evolution and a change in their binding profiles (17).

Noroviruses are highly contagious, with an estimated infectious dose of as few as 18 viral particles and prolonged shedding over an average of 8–60 days (18, 19). The main route of transmission is direct contact with an infected person, and it can also be transmitted via contaminated food and water (20, 21). Despite the high infectivity and rapid transmission, not all individuals are affected and develop symptomatic disease (22).

The association between ABO blood groups and NoV infection was reported previously, but with a conflicting result (23, 24). One previous study demonstrated that NoV recombinant virus-like particles strongly agglutinated red blood cells from group O, A, and AB donors but were less likely to do so from group B individuals (25). Another study also reported that among NoV-positive individuals, all symptomatic infections were among blood group O and group A individuals (26). In another study, genogroup-specific susceptibility was reported with NoV-GI, which mainly targets individuals with blood groups O and A (27), while NoV-GII infected all individuals irrespective of their ABO blood group status (28). In contrast, a partial or total absence of correlation between different blood group (A, B, AB, and O) antigens and NoV infection was reported (29-31).

The distribution of ABO blood groups and other host genetic factors is strongly dependent on ethnicity (32, 33). Besides, the molecular epidemiology of NoV differs between different areas or countries due to different environmental, viral (34-36), and host factors (22, 37, 38). However, studies addressing the association of host factors, especially ABO blood groups, with NoV infection are limited in Africa and have not yet been conducted in Ethiopia. Therefore, this study aimed to assess the relationship between ABO blood groups and NoV infection in Northwest Ethiopia.

Method

Study design, study period, and setting: From May 2021 to November 2021, a health-facility-based cross-sectional study was conducted to collect clinical and epidemiological data. Four data collection sites (Debre Markos, Bahir Dar, Gondar, and Debre Tabor), all of which are found in Northwest Ethiopia, were considered. In each of the study sites, one comprehensive specialized hospital and two health centers were included. The health institutions included in Debre Tabor were Debre Tabor Comprehensive Specialized Hospital, Liul Alemayehu Health Center, and Debre Tabor Health Center. In the second study site, Bahir Dar, Felege Hiwot Comprehensive Specialized Hospital, Shimbit Health Center, and Abay Health Center were included. Similarly, Gondar consists of the University of Gondar Comprehensive Specialized Hospital, Azezo Health Center, and Gondar Health Center. Lastly, in Debre Markos, Debre Markos Comprehensive Specialized Hospital, Debre Markos Health Center, and Gozamen Health Center were considered.

Sample size determination and sampling technique: A single population proportion formula was used to calculate the sample size (n = Z α/22*P (1-P)/d2). By considering the following assumptions: Zα/2 is taken as 1.96 at a 95% confidence interval (CI); P is the proportion taken from the previous study (13.3%)(39); d is the desired level of precision (3%). Finally, a 10% non-response rate was added, and the total sample size was calculated at 550. Based on the previous year's diarrheal disease case flow, the total sample size was proportionally allocated as 100, 120, 152, and 178 for each of the Debre Tabor, Debre Markos, Gondar, and Bahir Dar sites, respectively. A systematic random sampling technique was used to select the study participants from each health facility.

Data collection: Socio-demographic data were collected by trained healthcare professionals working in each of the health facilities. Once a clinical diagnosis was made based on the inclusion criteria, a pre-tested, semi-structured questionnaire was administered to each participant.

Fecal sample collection, processing, and molecular characterization: Five mL diarrheic fecal samples were collected using sterile containers from individuals of all age groups with diarrhea and self-reported to the health facilities during the study period. These fecal samples were stored at -20 °C or lower in each of the health facilities until transported to the Amhara Public Health Institute (APHI) for molecular investigation. Besides, peripheral blood samples were also collected to assess the blood group status of study participants. Once the fecal samples were taken to the APHI, they were stored at -70 °C until processed. There, ten percent (weight/volume) of fecal suspensions were prepared with nuclease-free water or 1% phosphate-buffered saline as available, vortexed, and centrifuged. Viral ribonucleic acid (RNA) was extracted from 300 uL fecal suspensions using MagaBio Plus Virus RNA Purification Kit II (Hangzhou, China). The details for the detection and sequencing or genotyping protocols, list of primers and probes that used for screening and genotyping as well as all PCR conditions are available in our recent publication (40).

Blood sample processing and ABO blood grouping: The assigned and trained health care worker in each ward of the health facilities informed the patient that he had received permission to collect epidemiological data and sent him with a request paper to a laboratory room for blood group analysis. The trained laboratory professional, in the laboratory room, instructs the client and collects 5 mL of blood. Then blood typing was done on-site at each of the study sites with a tube hemagglutination technique as previously done(41). Briefly, a forward grouping protocol was applied to assess the presence or absence of A, B, and D antigens in the red blood cells using commercially prepared antisera (Cypress Diagnostics, Langdorp, Belgium). Blood cells were placed in the three test tubes to prepare a 5% suspension of red blood cells to be tested in isotonic saline. Then one drop of each RBC suspension in each tube was mixed with a drop of anti-A, anti-B, and anti -D. These tubes were subjected to centrifugation for 3 minutes to ensure enhanced chemical interactions, particularly for weaker antibodies to react and agglutinate. The resultant matrix was gently shaken and examined macroscopically for agglutination. The tubes were categorized according to the extent of blood clumping as A+, A-, B+, B-, AB+, AB-, O+, and O-.

Statistical analysis: Data were entered and analyzed using SPSS version 23 software. Descriptive statistics were used for frequencies and percentages. The association between the outcome variables and factors was assessed using a logistic regression analysis. Those variables with *P*values < 0.05 and an adjusted odds ratio (AOR) in a 95% CI were considered statistically significant. The assumption is that the AOR within the 95% CI should not include 1. The result was interpreted and presented in a summary or displayed by using tables and figures.

Result

Socio-demographic characteristics: Among the total 550 study participants enrolled, 519 (with a 94.4% response rate) provided the required clinical samples and socio-demographic information. The age of the study participants ranged from 3 months to 85 years. More than half (51.3%) of the participants were female. From the four study sites, one-third (178/519; 34.3%) of the study participants were recruited from Bahir Dar, followed by Gondar (142/519; 27.4%). Three-fourths of the study participants were came from urban areas. In addition to this, about two-thirds (330/519; 63.6%) of our study participants and/or their parents were married. Besides, the majority (407/519; 78.4%) of the study participants were literate (they were at least able to read and write).

ABO blood groups and Rh types: We identified four blood groups (A, B, AB, and O) and assessed the Rh factor status. Nearly half (249/519; 48%) of the study participants had the O blood group, followed by blood groups A (143/519; 27.5%) and B (103/519; 19.8%). More specifically, the majority (216/519; 41.6%) were identified as blood group O with an Rh factor (O+), which was followed by A+ (119/519; 22.9%) and B+ (88/519; 17%) (**Fig. 1).**

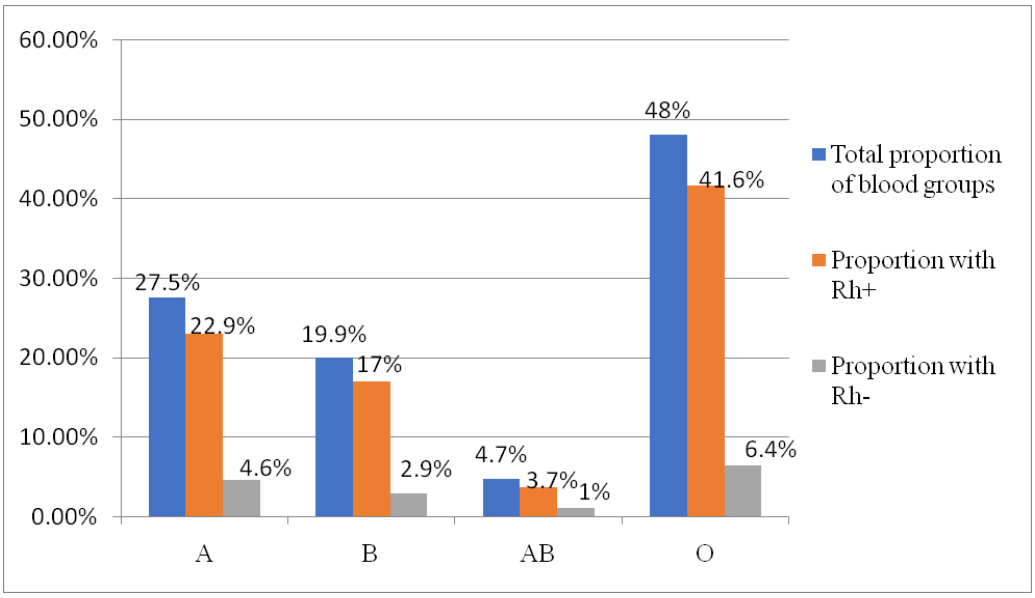

Figure 1: *The proportion of ABO blood groups and Rh status among patients with diarrhea in Northwest Ethiopia; May 2021 to November 2021*

Association between ABO blood groups and norovirus infection: Norovirus was identified in 8.9% (46/519) of the fecal samples of individuals with diarrhea. Both NoV-GI and GII were identified, with GII being predominant (38/46; 82.6%). The identified NoV genotypes were GI.3, GI.5, GII.3, GII.6, GII.10, GII.17, and GII.21. Of all the 29 successfully genotyped NoVs, genotype GII.3 was the predominant (13/29; 44.8%), followed by GII.21 (6/29; 20.7%) and GII.17 (4/29; 13.8%). In addition to this, GII.21 was identified for the first time in Ethiopia. Study participants with blood group O had the highest proportion of NoV infection (34/249; 13.7%), followed by blood group A (9/143; 6.3%), AB (1/24; 4.2%), and B 1/46 (2/103; 1.9%)(**Table 1**).

Table 1: The distribution of noroviruses across ABO blood groups of study participants in Northwest Ethiopia; from May 2021 to November 2021

NoV positivity, genogroups, and genotypes		**ABO blood groups (%)**			
		O	**A**	**B**	**AB**
Status of NoV infection	Positive	34 (13.7)	9 (6.3)	2 (1.9)	1 (4.2)
	Negative	215 (86.3)	134 (93.7)	101 (98)	23(95.8)
Genogroups	GI	6 (75)	2 (25)	0	0
	GII	28 (73.7)	7 (18.4)	2 (5.3)	1 (2.6)
Genotypes	GI.3	0	1	0	0
	GI.5	3	0	0	0
	GII.3	9	2	1	1
	GII.6	1	0	0	0
	GII.10	1	0	0	0
	GII.17	1	3	0	0
	GII.21	4	1	1	0

Among the NoV-positive study subjects, the majority (34/46, 74%) were blood group O, followed by blood group A individuals (9/46, 19.6%). Norovirus-GII was detected across participants with O, A, B, and AB blood groups, with the highest proportion (28/38; 73.7%) among blood group O participants. Based on the multiple logistic regressions analysis, the probability of NoV infection was increased amongunder-5 children (AOR = 1.4, 95% CI: 2.7–18, P = 0.02), the elderly (AOR = 5, 95% CI: 1.7–16, P = 0.015), individuals living in the Bahir Dar area (AOR = 1.5, 95% CI: 1.6–22, P = 0.014), and Debre Tabor (AOR = 2.5, 95% CI: 1.8–23, P = 0.001).Besides, the odds of NoV infection among blood group O individuals were 1.5 times higher than B blood groups (AOR: 1.5, 95%CI: 2–15, *P* = 0.001). Norovirus-GI was detected only in participants with blood groups O and A. Except for GI.3, all the other NoV genotypes were detected in participants with blood group O. The GII.3 genotype was detected across the four blood groups. Similarly, GII.21 was identified in participants with blood groups A, B, and O. In addition to this, three-fourths (3/4; 75%) of the GII.17 genotypes were detected in participants with blood group A. However, the difference was not statistically significant (*P*value > 0.05)(**Table 2**).

Table 2: The association of ABO blood groups and other variables with norovirus infection among patients with diarrhea in Northwest Ethiopia; May 2021 to November 2021

Variable	Categories	Norovirus status		COR (95% CI)	*P*value	AOR (95% CI)	*P*value
		Positive	Negative				
		N (%)	N (%)				
Sex	Male	25 (10)	228 (90)	1.3 (0.7-2.3)	0.4		
	Female	21(8)	245 (92)	1			
Age group in years	<5	20 (12.5)	160 (87.5)	5.6 (1.9-16.7)	0.002	1.4 (2.7-18)	***0.02**
	5 to 17	9 (8.2)	110 (91.8)	3.5 (1.3-9)	0.011	1.1 (0.2-17)	0.11
	18 - 64	9 (4)	225 (96)	1	1		
	> 64	8 (33.3)	24 (66.7)	12 (4-35)	0.000	5 (1.7-16)	***0.015**
Blood groups	O	34 (13.7)	215 (86.3)	2.7 (3.6-12)	0.02	1.5 (2-15)	***0.01**
	A	9 (6.3)	134 (93.7)	0.9 (0.08-5.3)	0.6	0.7 (0.5-8)	0.25
	AB	1 (4.2)	23 (95.8)	0.8 (0.2-25)	0.8	0.4 (0.2-14)	0.7
	B	2 (1.9)	101 (98)	1		1	
Study area	Debre Tabor	17 (17.2)	82 (82.8)	5 (1.6-15.4)	0.005	2.5 (1.8-23)	***0.001**
	Bahir Dar	15 (8.4)	163 (31.4)	2.7 (1.2-6.25)	0.017	1.5 (1.6-22)	***0.014**
	Gondar	10 (7)	132 (25.4)	2.25 (1.01-4.7)	0.032	2.8 (0.9-20)	0.13
	Debre Markos	4 (4)	96 (18.5)	1		1	

***AOR**, Adjusted odds ratio; **COR**, Crude odds ratio; *statistically significant*

Discussion

In the present study, we tried to demonstrate the association between the ABO blood group and NoV infections by analyzing blood and fecal samples collected from diarrheal patients recruited from the four major and proximate cities located in Northwest Ethiopia. In this study, NoV was predominantly identified in the participants with blood group O (13.7%) followed by blood group A (6.3%). Despite a significant number of participants, with blood group B involved, only about 2% of them were positive for NoV infection.

Three-fourths of the study participants who were positive for NoV infection had O blood group, while blood groups B and AB were less likely to be infected with NoV. Our findings are in agreement with different studies (24, 31, 42). Besides, in the present study, at least one NoV-GII was identified in each of the four blood groups, while infection with NoV-GI was observed among individuals with blood groups O and A. This is in agreement with a few previous studies (27, 31). Protection of individuals with blood groups B and AB for both genogroups was also reported previously, which supports our finding(22, 24).

Our findings also showed that at least one genotype of NoV-

GII was found among individuals with O blood groups. Besides, the predominant genotype (GII.3) was identified in all of the blood groups, more commonly among blood group O and blood group A individuals. This finding is in agreement with a study conducted in China(43).Although it was difficult to compare as it was a systematic review and meta-analysis, significant susceptibility patterns of O blood groups were also reported in China, which supported our finding (24).An absence of correlation among all blood groups (A, B, AB, and O) with NoV infection was also reported (29-31). This might be due to the existence of different factors other than the ABO blood group system that play a great role in the susceptibility of NoVs (11, 44).

In the present study, GII.21 was identified among all blood groups except AB blood groups. However, this justification requires further investigation. In addition to this, GII.17 genotypes were identified among individuals with blood groups A and O. In contrast to this, one previous study reported that one GII.17 infection was found in an individual with blood group O (31).The difference might be explained by host factors other than the ABO blood group, including the secretory antigen status of the individuals. Most individuals, termed secretors (having an active fucosyltransferase (FUT2) gene), express the histoblood group antigens in different body fluids that commonly act as receptors for NoV. Hence, they are commonly sensitive to some NoV infections, while others with inactivated or mutated FUT2 genes, termed non-secretors, are resistant to NoV(11). It might also be due to the host microbiota (like Enterobacter cloacae and Escherichia coli) that can mediated NoV attachment to the host via HBGA-like carbohydrates expressed on the surface of these bacteria(44). Moreover, the previous studies, the presence of Lewis^{b} antigen among secretors(45), and Lewis^{a} antigen among non-secretors (46)might play a role in NoV attachment.

In our study, there was a significant difference in the positivity rates of NoV across the different age groups, with the extreme age groups being significantly affected. Our finding is in agreement with some studies (47, 48). The possible explanation for the increased susceptibility of these age groups might be either due to their increased environmental exposure (49)or their weakened immune system (50). Similarly, our findings varied with study sites, where a significant increase was reported at the Debre Tabor and Bahir Dar sites. This might be explained either due to the increased diversity of the population and contact-mediated infection in Bahir Dar sites and/or due to the variability of weather conditions (relatively lower temperature, increased humidity, and increased rainfall) in the case of Debre Tabor sites that favor this virus replication (51, 52).

This is the first study conducted to assess the association between ABO blood groups and NoV infection in Ethiopia by considering multiple sites across all age groups. However, other host genetic factors, including secretory antigens and Lewis antigens, that might have a relationship are not assessed.

Conclusion and recommendation

The positivity rate of NoV was significantly higher among individuals with O blood groups compared to others. Norovirus-GII infected individuals of all blood groups, while NoV-GI affected blood groups A and O. This study might provide an input for viral-host interaction studies and vaccine design programs for NoV. Further large-scale studies are warranted to assess the relevance of this observation and identify other genetic factors that might affect the susceptibility of individuals to the different NoV genotypes.

Abbreviations:

AOR— Adjusted odds ratio
APHI— Amhara Public Health Institute
FUT2— Fucosyltransferase 2
NoVs— Noroviruses
NoV-GII— Norovirus-genogroup II
NoV-GI— Norovirus-genogroup I
ORF— Open reading frame
PCR— Polymerase chain reaction
RNA— Ribonucleic acid
RT-PCR— Real-time reverse transcription polymerase chain reaction

Declarations:

Ethical approval and consent to participate: The project was approved by the University of Gondar institutional review board with reference number V/P/RCS/05//765/2021. Written informed consent/assent was obtained either directly from the participants and/or their parents for children. The study was conducted according to the rules and regulations of the Helsinki Declarations. To maintain confidentiality, the data was recorded with a special code. The study participants were free not to participate or withdraw at any time.

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Data availability: The datasets supporting the conclusions are included within the manuscript. However, upon a reasonable quest, the data are available from the corresponding author [DT].

Competing interests: The authors declare that they have no conflict of interest.

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Physicochemical and bacteriological quality of water in public outdoor swimming pools in South Nations Nationalities People Regional State, Southern Ethiopia: Cross-sectional study

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Abstract

Background: *Swimming is a fashionable and wonderful form of recreational activity, sport, rehabilitative treatment and is generally considered to be healthy exercise for both young and old people. However, the risk of infection has been linked to faecal contamination of the swimming pool due to faeces released by bathers, contaminated source water or as the result of direct animal contamination. Swimmers are infected when they swallow contaminated pool water.*

Objective: *This study was aimedto assess the physicochemical and microbiological quality of water in public swimming pools in South Nations Nationalities People Regional State, Southern Ethiopia.*

Method: *A cross-sectional study was carried out to determine quality of water in swimming pool from July, 2018 to November, 2018. A purposive sampling technique was used to select swimming pools. Physicochemical and microbiological tests were made on water sample from selected pools. Descriptive statistics were performed to construct tables for physical parameters, chemical parameters, total plate counts (TPC), thermotolerant coliform (fecal coliform), and E. coli.*

Result: *A total of 12 swimming pools were included in this study and 54 water samples were collected. All the swimming pool water samples were beyond World Health Organization's (WHO) recommendation for both PH level and conductivity. Almost all, 91.7% (11/12) of the swimming pools were violated the WHO Standard of Heterotrophic Plate Count (HPC). Five out of twelve swimming pools) were not comply with the WHO limit (<1/100ml) for thermotolerant (faecal) coliform count. Four of the total swimming pools were confirmed for the presence of thermotolerant Escherichia coli (E. coli).*

Conclusion: *All the participated swimming pools violate the WHO recommendation for PH value and conductivity. In addition, all water samples were contaminated with mold. Half of the outdoor swimming pools violate for the lower limit value of WHO for thermotolerant (faecal) coliform count. No parasites were detected in all the swimming pools.*

Introduction

Swimming is a fashionable and wonderful form of the recreational activity and is generally considered to be a healthy exercise for both the young and old (1).The increasing attractiveness of swimming for sport, fitness, therapy or just pleasurable recreation has led to the increased use of swimming pools and the establishment of a variety of specific-use pools such as spa pools, waterslides, and more recently, hydrotherapy and wave pools. Swimming pools may be filled with fresh, marine or thermal water. Swimming pools may be classified as indoors, outdoors or both; they may be heated or unheated (2).

Different studies in the world reported that different gastrointestinal and upper respiratory infection of bathers related with unsafe swimming pools (3–5). Swimming pool waters may be contaminated by direct human contact and by waterborne pollutants from external sources (e.g., sewage, storm water, and agricultural runoff) (6). The pollution in swimming pools can be categorized in to physical, chemical and microbiological contamination (7). In many cases, the risk of illness or infection has been linked to faecal contamination of the swimming pool due to faeces, a contaminated source water oras the result of direct animal contamination (8).

Worldwide, unsafe WASH was responsible for 69% of diarrhoea cases, 14% of ARIs, and 10% of undernutrition disease burden. Additionally, it was estimated that all disease burden from STHs could be attributed to unsafe WASH(9).In Ethiopia, a significant portion of health issues, ranging from 60% to 80%, stem from communicable diseases caused by inadequate water supply, poor hygiene practices, and improper waste management (10).

If there is no regular cleaning and maintenance and proper water treatment, contamination swimming pool water may lead to different diseases outbreaks such as gastroenteritis, conjunctivitis, keratitis, trachoma, otitis, cholera, dysentery, eczema, skin rashes, typhoid, dysentery, giardiasis, cryptosporidiosis, helminthiasis, cholera, hepatitis, rotavirus infection, salmonellosis, and central nervous systems associated diseases (11).

A number of outbreaks were occurred related with *Shigella spp*., *E. coli* O157:H7, *Pseudomonas aeruginosa*, *Leptospira spp*., *Giardia lamblia*, *Cryptosporidiumparvum*, *Adenoviruses*, and *Norwalk-like viruses*, in swimming pools and recreational waters (12). The presence of *Escherichia coli* in water is indicators of fecal pollution of swimming pool (13).. In Ethiopia, there is lack of data on physicochemical and microbiological quality of outdoor swimming pools. Therefore, this study aimed at assessing the physicochemical and microbiological quality of public swimming pools in South Nations Nationalities People Regional State, Southern Ethiopia.

Method

Description of the study area: This study was carried out in selected area of South Nations Nationalities People Regional State (SNNPR) such as Dilla, Wendo Genet, Hawassa and Arbaminch town. These towns are frequently visited by local and international tourists.

Study subject: Study subject is all outdoor swimming pools located in South Nations, Nationalities and Regional States (SNNPR). The participated pools were purposively selected outdoor swimming pools from Hawassa (8 swimming pools), Wondo Genet (2 swimming pools), Dilla (1 swimming pool), and Arbaminch town (swimming pool) based on their customer frequency.

Study design: A cross-sectional study was carried out to determine physicochemical and bacteriological quality of swimming pool from July, 2018 to November, 2018.

Sample size and Sampling Procedure: A purposive sampling technique was used to select swimming pools considering bathers number. A total of 12 swimming pools were included in this study and 54 water samples were collected. Six water samples were collected from each pool of six refill swimming pools and three water samples from each pool of six recycling pool. In the case of refill pool, samples were collected at time of filling of pool, in mid time and before discarding of water from pool. In the case of recycling pool, water samples were collected three times per week. 500ml of swimming water sample collected from each pool using sterile continuer.

Methods of data collection: After obtaining permission from the owner of the swimming pool, the necessary information was collected. Furthermore, physicochemical and microbiological analysis were conducted to determine chemical and microbial quality of swimming pools.

Laboratory testing:

Water sampling: For swimming pool water sampling, a sterile bottle was immersed in the water up to the elbow, then inverted to gather the sample directly into the water about 8 inches (20 cm) beneath the surface. To obtain tap water, started by igniting the faucet and opened it completely. Let the water flow for 2-3 minutes, and then lowered the flow to fill the bottle without causing splashes. Lastly, sealed the bottle tightly with the cap. Finally the water samples were kept in cold box and transported to microbiology laboratory of Hawassa University, College of Medicine and Health Science, School of Medical Laboratory Science.

Physicochemical analysis: Physical parameters such as conductivity, and temperature, total dissolved solids (TDS) were analyzed at site of outdoor swimming pools using portable conductivity meter (JENWAY 4150). PH was also taken using portable PH-meter. Moreover, turbidity measurement was carried out at chemistry laboratory of Hawassa University using Hach-2100Q. The swimming pool water sample's turbidity was assessed using a nephlometer or turbidometer. Prior to and after incubation at 20 o C for five days, the sealed water sample's dissolved oxygen (DO), biological oxygen demand (BOD), and chemical oxygen demand (COD) were measured. The hardness was determined through colorimetric titration with an EDTA solution. The chlorine concentration in the swimming pool water was determined by observing the color change strength following the addition of diethyl-p-phenylenediamine (DPD) tablets.

Heterotrophic plate counts: Heterotrophic Plate Count (HPC) was carried out by counting the number of viable heterotrophic bacteria by inoculating pool water samples on Plate Count Agar (Oxoid, England) through pour plate technique. By using one ml of swimming water sample and nine ml of sterile distilled water, pool water samples were diluted serially into 10^{-1}, 10^{-2}, 10^{-3} and 10^{-4} dilution. One mlof each diluted water sample was placed and 12-15ml of molten plate count agar. In order to assure complete mixing of culture media with water sample, clockwise and anti-clockwise rotation and back and forth, left and right movement was made. The plates were left until it solidified and incubated in inverted position at 37 ^{0}C for 24 hours. After the incubation period, number of colonies were counted and reported as cfu/ml(14,15).

Determination of thermotolerant (faecal) coliform: Three sets of five tubes each, containing Durham tubes, were organized in a test-tube rack. The first row's tubes held 10 ml of double-strength Mackonkey (Oxoid, England) broth, while the second and third rows' tubes contained 10ml of single-strength Mackonkey broth. A sterile pipette was used to add 10 ml of sample to each of the five tubes with Mackonkey broth. Additionally, 1ml of sample was added to each of the five tubes in the second row, and 0.1ml of sample was added to each of the five tubes in the third row. After gently mixing the contents, the rack with the 15 tubes was incubated at 37°C for 24 hours. Following incubation, each tube was observed for the presence of gas. Negative tubes were reincubated for a further 24-hour period, and then rechecked for the presence of gas. A confirmative test was conducted by taking a loopful of culture from the positive test tube and incubating it at 44°C for 24 hours. The presence of thermotolerant coliforms was confirmed if gas was present in the confirmatory broth after 24 hours at 44°C. The Most Probable Number (MPN) was determined from a statistical table. Finally, the identification of *E.coli* was made by adding kovacs reagent in positive tryptone water and observing for the formation of a red ring to indicate indole production (15).

Pathogenic isolation and identification: The 24 hr growth suspension from Mackonkey broth was inoculated on Mackonkey agar and Manitol salt agar and incubated aerobically at 35-37 ^{o}C for 24 hours. Next day the growth of the organisms were examined for Colony morphology and Gram reaction. In addition, biochemical tests were processed for identification of the organism at genus and species level.

Mold and yeast count: Swimming pool water samples underwent serial dilution using a tenfold dilution series. Initially, 10ml of water sample was mixed with 90ml of sterile distilled water to achieve a 1:10 dilution, which was then further diluted up to 1:10000. Subsequently, 1ml of the diluted sample was carefully transferred to properly labeled duplicate sterile Petri dishes. Molten potato dextrose agar, cooled to 45°C, was poured into each Petri dish. Following swirling and solidification, the plates were inverted and placed in an incubator set at 32°C. After a 72-hour incubation period, the colonies were enumerated and the colony count per 100ml was reported (16).

Direct wet smear for parasitological analysis: In order to undertake parasitological analysis for the presence of protozoan parasites; *Giardia lamblia*, *Entamoeba histolytic*a and *Cryptosporidium parvum*, water samples were concentrated

according to WHO guideline. Samples were transferred in to 15ml of conical centrifuge tube and centrifuged at 5000 RPM at 4°c for 15 minutes. The sediments were analyzed based on microscopically. By tilting conical tube, a small portion of 2-3 cm diameter of the preserved sediment was taken on clean slide. The sediment was spread over an area of approximately 2cm×1cm and covered with a cover slip. Finally, the smear was examined under the microscope using 10× and 40× objectives for parasitological water quality (occurrence of *Cryptosporidium* oocyst, *Giardia* cysts, amoeba cyst)(17).

Data quality: Trained data collectors were recruited for interview and sample collection. A standard operational procedure was followed during Swimming water samples and laboratory analysis. To ensure sterility, a test was conducted on 5% of the prepared media by incubating it for 1 day, depending on the type of media. Performance of the culture media was checked using quality control strains (*Escherichia coli*ATCC25922 and *Staphylococcus aureus* ,ATCC43300)

Data Management and Analysis: The results were recorded in a laboratory format prepared for report and later entered into Microsoft Excel. The data were then double entered in Excel for quality control purposes. Descriptive statistics were performed to construct tables for physical parameters, chemical parameters, total plate counts (TPC), thermotolerant coliform (fecal coliform) and *E. coli*.

Ethical Considerations: Support letter to different organizations was written from Hawassa University. Permission was obtained from the owners prior to specimen collection. The owners were briefed about the objective of the study. Voluntary based participation was employed during data collection.

Result

A total of 12 swimming pools were included in this study. All are concrete swimming pools and had lifeguards. Out of 12 swimming pools half were using recycling water whereas the rest refill new water for swimming (Table 3 and Table 4).Almost all of the swimming pools (11/12) provide service for both adult and children baser. All participated swimming pools provide shower service for bathers before swimming. Only one pool had facility for disinfection of bather's feet before stepping into the swimming pool. Except one, all swimming pools were using chlorination as disinfection and mode of chlorination was manual powder. Only one of swimming pool had habit of using copper sulfate as an algicidal agent.

The swimming pools water were assessed for five physical parameters: PH, Temperature (^{0}c), Conductivity (µs/cm), TDS (mg/L), and Turbidity (FTU). All the swimming pools water samples were showed PH level above the WHO recommended PH value (7.2-7.8). Among swimming pools water samples assed for total dissolved solids (TDS), two are not comply with WHO recommendation. Moreover, two of the swimming pool water samples violated the WHO cut-off value for Turbidity (FTU). However, all of the swimming pool water samples beyond (above) WHO recommendation (not exceeded 400 µS/cm) for electrical conductivity **(Table-1)**.

Table 1: Physical parameters analysis of selected swimming pools from South Nations Nationalities and Regional State (SNNPR) from July, 2018 to November, 2018.

Sample Site	Physical Parameters				
	PH	Temperature(^{0}c)	Conductivity (µs/cm)	TDS (mg/L)	Turbidity (NTU)
WS1	8.37	27.9	2250	1125	1.55
WS2	8.49	28.6	831	416	3.79
WS3	8.4	25.1	1711	856	2.85
WS4	8.67	29.5	799	400	2.99
WS5	8.7	28.8	1578	789	2.28
WS6	8.21	24.7	2904	1452	2.79
WS7	8.5	26.2	1474	737	1.57
WS8	8.35	26.2	1670	835	2.00
WS9	8.3	27.8	526	263	8.9
WS10	8.2	47.9	3827	1914	10.3
WS11	8.9	34.7	930	465	0
WS12	8.3	35.7	942	471	0
WHO	(7.2-7.8)*	35	(not exceeded 400 µS/cm)	1200	5

**WHO, 2006, WS; Water sample*

Regarding of chemical analysis two of the swimming pools violated the WHO limit for Total Hardness (mg/L as CaCO3). In addition, five of the swimming pools analyzed for Total Alkalinity (mg/L as CaCO3) were not satisfy with WHO recommendation (**Table-2**).

Related to determination of thermotolerant (faecal) coliform and *E. coli* in recycling swimming pools, two of six swimming pool did not comply to WHO limit (<1/100ml) for thermotolerant (faecal) coliform count. From these confirmed positive swimming pools, one is positive for thermotolerant *Escherichia coli (E. coli).* However no pathogenic bacteria were identified from swimming pools (**Table 3.**). On the other hand determination of thermotolerant (faecal) coliform and *E.coli* in refill Swimming pools showed that half (3/6) of swimming pools and their corresponding sources were also violet the WHO threshold for thermotolerant (faecal) coliform count and from these positive swimming pools all are also positive for thermotolerant *Escherichia coli.* But none of water samples from swimming pools and their corresponding sources were positive for pathogenic bacteria (**Table 4**).

Concerting to Heterotrophic Plate Count (HPC), almost all swimming pools (11/12) are violet the WHO limit (<200 cfu/ml). In addition, five of the total swimming pools were positive for *Staphylococcus aureus*. However, all swimming pools had no positive result for parasitological analysis. Regarding to mold and yeast count, all swimming pools water sample positive for mold count with range of 3 to 30 CFU/ 200ml. but the yeast count was positive only in three of the swimming pools. (**Table 5**).

Table-2: Chemical parameters analysis of selected swimming Pools from South Nations Nationalities and Regional State (SNNPR) from July, 2018 to November, 2018.

Sample Site	Chemical Parameters							
	DO	COD	BOD5	Total Chlorine (mg/L)	Total Hardness (mg/L as CaCO3)	Total Alkalinity (mg/L as CaCO3)	Bicarbonate Alkalinity (mg/L as CaCO3)	Dissolved NH_3 (mg/L)
WS1	4.83 ± 0.10	21.88± 0.80	18.27 ±2.00	1.36	150	700	700	0.59
WS2	6.70 ± 0.20	22.35± 0.58	49.20 ± 6.32	2.12	240	700	700	.35
WS3	12.71 ± 0.95	25.80 ± 0.80	188.93 ± 4.83	0.13	200	500	500	0.68
WS4	11.03± 0. 20	23.88± 0.40	156.13 ± 0.12	0.00	200	500	500	0.21
WS5	10.74 ± 0.99	16.15 ± 0.61	152.20 ± 4.00	2	540	130	130	0.27
WS6	17.24 ± 0.99	16.95± 0.61	274.33 ± 3.35	3	480	160	160	0.22
WS7	11.85 ±0.15	25.88 ± 0.80	177.13 ± 6.11	0.83	440	260	260	0.52
WS8	8.47 ± 0. 20	17.88 ± 0.80	67.53 ±3.41	0.04	140	640	640	0.38
WS9	26.27 ± 0.57	38.01 ± 0.61	653.67 ±14..34	0.05	240	170	170	0.44
WS10	14.18 ± 3.37	30.28 ± 0.400	521.40 ± 8.00	0.04	50	1200	1200	0.23
WS11	9.92 ±4.63	15.08 ± 0.40	140.40 ± 100.70	0.01	45	530	530	0.05
WS12	17.73 ± 0.99	23.08 ±0.400	287.53 ± 37.28	0.02	50	480	480	0.49

Key: WS: *Water Sample,* ***BOD:*** *Biological oxygen demand,* ***COD:*** *chemical oxygen demand,* ***DO:*** *dissolved oxygen*

Table 3: . Determination of thermotolerant (faecal) coliform and *E.coli* in recycling swimming pools in SNNPR, Ethiopia.

Pool	MPN count/100ml			Confirmatory test		
	Sample 1	Sample 2	Sample 3	thermotolerant coliforms	*E. coli*	Pathogen
WS5	4	23	<2	Negative	Negative	Negative
WS6	<2	<2	<2	Negative	Negative	Negative
WS3	23	8	27	**Positive**	**Positive**	Negative
WS8	4	23	<2	**Positive**	Negative	Negative
WS9	<2	<2	<2	Negative	Negative	Negative
WS7	<2	<2	<2	Negative	Negative	Negative

Key: WS: *Water Sample.* ***MPN:*** *most probable number*

Table 4. Determination of thermotolerant (faecal) coliform and *E.coli* in refill Swimming pools in SNNPR, Ethiopia.

Pool	MPN count/100ml						Confirmatory test					
	Before swimming		Mid-weak		Before discarding		Thermotolerant coliforms		*E. coli*		Pathogen	
	Source	Pool	Source	Pool	Source	Pool	Source	Pool	Source	Pool	Source	pool
WS4	46	130	49	5	49	17	Positive	Positive	Positive	Positive	Negative	Negative
WS2	<2	17	<2	<2	<2	110	Negative	Negative	Negative	Negative	Negative	Negative
WS1	5	8	46	350	49	920	Positive	Positive	Positive	Positive	Negative	Negative
WS10	<2	22	<2	26	<2	33	Positive	Positive	Positive	Positive	Negative	Negative
WS12	<2	17	<2	110	<2	920	Negative	Negative	Negative	Negative	Negative	Negative
WS11	<2	130	<2	240	<2	1800	Negative	Negative	Negative	Negative	Negative	Negative

Key: WS: *Water Sample*

Table 5: Determination of Heterotrophic plate count (HPC), and Mycological count **of** Swimming pools in SNNPR, Ethiopia.

Pool	Heterotrophic plate count (HPC)	Staphylococcus aureus	Mould count (CFU)	Yeast count (CFU)
WS5	$2.2x10^6$ cfu/ml	Negative	9 CFU /200ml	6 CFU/200ml
WS6	$7.4x10^5$cfu/ml	Negative	3 CFU /200ml	0
WS3	$1.9x10^5$cfu/ml	Negative	2 CFU /200ml	3 CFU /200ml
WS8	$9.7x10^2$cfu/ml	Negative	30CFU/200ml	0
WS9	$1.7x10^4$cfu/ml	Negative	5 CFU /200ml	0
WS4	$3.1x10^6$cfu/ml	Positive	15CFU/200ml	0
WS2	$9.4x10^4$cfu/ml	Negative	8 CFU /200ml	13 CFU /200ml
WS1	$3.1x10^2$cfu/ml	Positive	20CFU/200ml	0
WS10	$2.1x10^4$cfu/ml	Positive	15CFU/200ml	0
WS12	$6.6x10^6$cfu/ml	Positive	9 CFU /200ml	0
WS11	$6.7x10^7$cfu/ml	Positive	20CFU/200ml	0
WS7	$1.6x10^2$cfu/ml	Negative	7 CFU /200ml	0
WHO	<200 cfu/ml			

Key: WS: *Water Sample*

Discussion

Even though the swimming pool water is not potable for drinking purpose, its quality has to meet the standards of drinking water since the individual who use it may accidentally drink it(18). Therefore, our study made assessment of water quality interims of physical, chemical, microbiological and parasitological analysis of the outdoor swimming pools found in South nation's nationalities people regional state. The indicators organisms (thermotolerant Coliform and *Ercherchia coli*) are used to check for the potential occurrence of fecal contamination(1). However, the absence of these organisms does not guarantee safety, as some pathogens are more resistant to treatment than the indicators (19).

In this study the physical parameter assessed for outdoor pools' water quality were PH, Temperature (^{0}c), Conductivity (µs/cm), TDS (mg/L), Turbidity (FTU) and Conductivity (µs/cm). Of total assessed for PH, all swimming pools indicated PH value above the WHO standard threshold (7.2-7.8). As the PH of pool waters increase scaling, chlorine inefficiency, cloudy poolsthus eye and skin irritation of the swimmers can be resulted (2,9). In addition, among swimming pools water samples assed for total dissolved solids (TDS), two are not comply with WHO recommendation.

Our study also assessed outdoor swimming pools for Heterotrophic Plate Count (HPC). As the result almost all of the swimming pools 91.7% (11/12) were violated for WHO standard Heterotrophic Plate Count (HPC). It gives an indication of the overall bacterial population within the pools. This might be because of deficiency of treatment processes. The finding of this study was higher than study conducted in Addis Ababa, Ethiopia (73.3%) (13). However similar study conducted in Ghana demonstrated that all of outdoor swimming pool water samples collected for Heterotrophic Plate Count (HPC) (26-90cfu/100ml) conforms to WHO standard (18).

The finding of thermotolerant (faecal) coliform in these swimming pools is indicator of fecal contamination and they are risks to swimmers. The current study showed that 41.7% (five out of twelve swimming pool) were not comply with WHO limit (<1/100ml) for thermotolerant (faecal) coliform count. Similar study conducted in Bahr Dar, Ethiopia reported higher result (75%) (20). However similar study conducted in Ghana reported that all swimming pools were violated the WHO standard(18). On the other another report from Port Harcourt, Nigeria and in Kampala City, Uganda indicated that none of the swimming pools were positive for fecal coliform (11,21). The presence of thermotolerant (faecal)

coliform might be as result of possible contamination of pools by bather or animal (22). The presence of these organisms indicates that current contamination of pool water and the presence of inefficient treatment system (23).

In addition, four of the total swimming pools were confirmed for presence thermotolerant *Escherichia coli (E. coli).* This also strengthens risks of swimming pools to pose infectious disease among swimmers. Similar study conducted in Addis Ababa, Ethiopia also reported that 33.3% of swimming pools water did not meet the standard. But this study did not notified whether the *Escherichia coli* was thermogenic or not (13).

The presence of *Staphylococcus aureus* in swimming pools can be used to determine non-fecal shedding. This indicates the quality of swimming pools water. Among assessed outdoor swimming pools; five (41.7%) were contaminated with *Staphylococcus aurous*. Another study conducted in Nigeria reported as two of ten (20%) swimming pools were contaminated with *Staphylococcus aureus* (21). However study conducted in Egypt reported higher finding (94.04%) (24).

This study also was performed parasitological analysis in outdoor swimming pool water. Based on investigation, none of the water samples had parasites. Similar study conducted in Greece reported that no *Cryptosporidium* and *Giardia* cyst were isolated (8). However another similar research conducted in Paris, France reported that one sample of swimming pools was positive for *Cryptosporidium* (25). The probably reason for this variation could be attributed to the diagnostic method of the water sample from swimming pools.

The presence of fungal agents may result skin infection among swimmers. Regarding to recovery of mold and yeast, all swimming pools water samples were contaminated with mold whereas only three of the swimming pools were contaminated with yeast. Different study also indicated in world that different species of fungus were also detected from swimming pool water (7,26–29).

Conclusion and recommendation

All of the swimming pool water samples were showed pH level above the WHO recommended pH value. Above one-third of the swimming pools analyzed for total alkalinity (mg/L as CaCO3) were not satisfy with WHO recommendation. Almost all swimming pools water samples (11/12) wereviolet the WHO limit for total aerobic count. Five out of twelve swimming pools water) were not comply with WHO limit (<1/100ml) for thermotolerant (faecal) coliform count. Five of the total swimming pools water samples were positive for *Staphylococcus aureus*. All swimming pools water samples had no positive result for parasitological analysis. All swimming pools water samples were contaminated with mold whereas only three of the swimming pools were contaminated with yeast. Therefore, the government and other concerned bodies should apply close supervision on swimming pools. . Training should be given on infectious prevention and adherence to quality criteria set by WHO .

Abbreviations: SHPC: Standard Heterotrophic Plate Count, WHO: World Health Organization, HPC: Heterotrophic Plate Count, TCC: Total Coliform Count FCC: Fecal Coliform Count, SNNPR: South Nations, Nationalities and Regional States, RPM: Revolution Per Minute. WS: Water Sample.

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