ISSN NO. 2320-5407

Journal homepage: http://www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

THE INFLUENCE OF RESIDENTS' AWARENESS AND DEMOGRAPHIC CHARACTERISTICS ON THEIR USE OF DEFLUORIDATED WATER IN NAKURU TOWN, KENYA

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Manuscript Info

Manuscript History:

Received: 14 November 2013
Final Accepted: 29 November 2013
Published Online: December 2013

Key words:
Influence, Residents Awareness, Personal Characteristics, Use, Defluoridated Water, Nakuru Town, Kenya

Abstract

This paper assesses the extent to which the level of awareness influences the use of defluoridated water and the influences of personal characteristics on use of defluoridated water. The study evaluated the performance of the CDN program since its inception to date. It sought to establish if the short term goals have been realized. The study was conducted in Nakuru Town. The study assessed the contribution of the CDN water quality program in providing safe fluoride free drinking water to the residents of Nakuru Town. To evaluate level of awareness, an exploratory survey was conducted in the project area. One hundred residents were randomly selected to fill the questionnaires. Three categories based on population density within the municipality were used in the survey. Each objective was analyzed using appropriate statistical tests like frequencies, percentages and means. The study established if the program has been able to increase awareness on fluorosis and promote use of defluoridated water among the residents. The major findings were that the CDN project has been unable to increase awareness on fluorosis and the program and promote use of defluoridated water in the target population. Therefore, the recommendations are that the CDN should embark on an aggressive campaign to increase awareness on fluorosis and their products.

Introduction

Chronic exposure to fluoride results in skeletal fluorosis. Fluoride accumulates in the bone to high levels leading to symptoms like stiffness and joint pains. Sometimes it leads to change in bone structure and calcification of ligaments which ultimately results in muscle impairment and pain. Some effects of acute high-level exposure may be immediate and include severe abdominal pain, vomiting, excessive salivation, muscle spasms and seizures (Mkongo, 1995).

It is rare for high level exposure to occur. When it occurs, it is mainly due to fires and explosions which contaminate drinking water. It is more common to get moderate chronic exposure of above 1.5 mg/litre of water. This is the WHO recommendation for water fluoride levels). Most people who suffer from fluorosis are usually exposed to more than one source of fluoride in the water, air, toothpaste and soil. The most significant source however, is drinking water. The ability of a person's body to dispose of fluoride as well as their dietary habits and general health all affect how the fluoride exposure is manifested in the individual (Mkongo, 1995).

Distribution of Fluoride

Distribution of Fluoride in water mainly follows a geological pattern. The highest fluoride levels are mainly found at the foot of high mountains and in geological deposits near the sea. Waters with high levels of fluoride content are mostly found at the foot of high mountains and in areas where the sea has made geological deposits. There are two main known fluoride belts on land. The first one stretches from Syria through Jordan, Egypt, Libya, Algeria, Sudan and Kenya, and another that stretches from Turkey through Iraq, Iran, Afghanistan, India, northern Thailand and China. Americas and Japan also has similar fluoride belts and these areas are associated with fluorosis (Chikte, 1997).

Distribution of Dental Fluorosis in Kenya

In Kenya, dental fluorosis has been endemic for many years (Akpabio, 1970; Bakshi, 1974; Bohdal *et al*., 1968; Munoz *et al*., 1964; Nair & Manji, 1982; Neville & Bras, 1953; Ockerse, 1953; Ongweny, 1973). It is considered a major public health problem. It occurs as a result of consuming a high amount of fluoride (Dean, 1936).The main source of fluoride is from drinking water especially in the areas that have volcanic rocks and hot springs in the Rift Valley (Williamson, 1953). Fluoride is also found in food, drinks and dust around the lake (Gitonga & Nair, 1982), the dust around Lake Nakuru has fluoride levels of between 2800 and 5600 ppm (Williamson, 1953).

Most of Kenya's rainfall goes through the surface and is stored as underground water. A major portion of the population uses underground water for cooking and drinking. Most of the rivers and streams available are seasonal and only contain water during rainy seasons (Ojany, 1974). Water treatment carried out is mainly chlorination especially in the urban areas. The rural water supply which is mainly underground, does not receive any treatment. The occurrence and distribution of fluoride in Kenyan waters was first studied by Williamson in 1953 in conjunction with the government chemists. He studied fluoride levels in some 200 boreholes across the country. Some regions reported very high fluoride concentrations like the highest levels in wells was 39.0 ppm in boreholes, 43.50 ppm, in Lake Elementaita 1640 ppm and in Lake Nakuru 2800 ppm (Williamson 1953)

Their findings for the Rift Valley Province in which the CDN project is operational are summarized in the table below.

Table 1: Number of Groundwater Samples in each District in Rift Valley containing various Levels of Fluoride (in ppm)

District	Level of fluoride in ppm from 6 water samples from each districts						Total
Baringo	1	1	1	-	-	1	**4**
Elgeyo Marakwet	1	1	-	-	-	-	**2**
Kajiado	10	12	32	9	1	2	**66**
Kericho	-	5	1	4	-	1	**11**
Laikipia	1	6	14	4	2	1	**28**
Nakuru	11	10	50	26	18	24	**139**
Narok	1	1	3	-	-	1	**6**
Samburu	-	2	8	-	1	-	**11**
Trans Nzoia	2	2	1	-	-	-	**5**
Turkana	9	5	6	-	1	-	**21**
Uasin Gishu	8	4	5	-	2	1	**20**
Nandi		-	-	-	-	-	**-**

Source: Williamson, 1953

Dental Fluorosis

Dental fluorosis is a condition that affects dental enamel leading to loss of shine and luster. It is characterized by discolorations which may range from brown, black, yellow or opaque white. It may appear as spots or as horizontal bands. It appears as bands following the incremental pattern in which enamel is laid down. Severity varies with the amount of fluoride ingested. Permanent incisors and molars are most commonly affected. The inner surfaces of teeth (dentine) are also affected but not as severely as the enamel. Mild fluoride levels ranging between 0.7-1.5 mg/L in drinking water have been shown to cause mottling and opaque white spot enamel lesions (Dean, 1936). Daily fluoride intake of 0.1 mg/kg body weight has been shown to result in mild fluorosis (Fawell *et al.*, 2006).

Loss of Teeth at Early Age

Once teeth have dental fluorosis, it cannot be reversed. Some treatments however, are available to improve the aesthetics of the teeth. These include; bleaching, masking with composite fillings, veneering and crowning with dental porcelain (Rajchagool, 1997). In very severe cases of dental fluorosis, the teeth become very brittle and invariably fracture leading to early tooth loss.

Skeletal Fluorosis

Excessive fluoride is also deposited in the skeleton. Most of the deposition will occur in cancellous bone. This leads to severe pain and rigidity of the joints in the body leading to restricted body movement and even severe deformity. Deformities include; deformed stiff spine and immobile pelvic, knee as well as shoulder joints. Severe deformity associated with crippling, scoliosis, kyphosis, paraplegia and quadriplegia have been known to occur (Mkongo, 1995).

Drug induced Fluorosis

Fluorosis can also occur as a result of long term use of sodium fluoride containing drugs. In 1982, two cases of drug induced skeletal fluorosis were reported from Switzerland on patients with arthritis who were on long term treatment with niflumic acid. They were on a daily dose of 3 250mg capsules of the drug (Nifluril, UPSA Laboratories, France). Excessive use of fluoridated mouthwashes and tooth paste may also lead to fluorosis especially in combination with high level fluoride drinking water. This occurs easily as the sublingual mucosa is very absorbent and easily absorbs the fluoride into the blood stream (Sharma & Parul, 2009).

Industrial Fluorosis

Some industries make use of fluoride and hydrofluoric acid in their day to day operations. These include the steel, pottery, aluminium, welding, plastic, oil refinery, glass, automobile, pharmaceutical, fertilizer and chemical industries. Their waste which contains high levels of fluoride invariably ends up in the air and water supply and may lead to fluorosis among the populace (Fawell *et al*., 2006).

Prevention and Control

Where it is not possible to get naturally occurring fluoride free water, we can prevent or even reduce the incidence of fluorosis by removing excess fluoride from drinking water or by finding alternative water sources.

Alternative Water Sources

Other water sources that can be used include; trapped rain water, surface water and low fluoride groundwater.

Surface Water

Surface water is often contaminated with pollutants therefore it must never be used for drinking without first carrying out the appropriate treatment (Gupta, Seth & Gavane, 1993). There are several effective methods available but most are expensive. Simpler cheaper methods like sand filtration, ultraviolet disinfection or chlorine treatment are also effective but not always. These are mainly use at the community level although sometimes they may be used at the house hold level especially chlorination.

Rainwater

Rainwater may offer the simplest and cleanest solution to fluoride free water. However, most communities lack the capacity to store it adequately during the rainy season. It may require the building and maintenance of high capacity reservoirs which is expensive and many people cannot afford them. Thus, a lot of the rain water is not trapped and goes to waste (Chinoy, 1991).

Low-fluoride Groundwater

The levels of fluoride in one area can vary greatly especially among different wells. This is dependent on the depth at which the water is drawn and the type of aquifer providing the water. Sometimes, by just deepening the well or sinking a new well may result in getting water with less fluoride. However, this may prove inadequate as fluoride is unevenly distributed both vertically and horizontally meaning that each well has to be tested on its own and results from one well cannot be adequately used as an indicator for the others (Gupta *et al.*, 1993).

Statement of the Problem

Fluorosis is a major problem affecting Kenyans today. Several governmental and non-governmental organizations have undertaken measures to try and curb the problem. One organization based in Nakuru known as the Catholic Diocese of Nakuru (CDN) has a water quality program that seeks to provide safe defluoridated water to residents of Nakuru and its environs and to promote knowledge and safe practices towards fluorosis. The study evaluated whether the organization has been able to achieve its objectives.

There are no studies that clearly outline the prevalence of fluorosis as a condition. It is however believed that millions of people worldwide are affected. The most frequently occurring forms of fluorosis are mild or moderate (Bregnhoj, 1997). It is difficult and expensive to remove fluoride from water therefore it's easier to find alternative water sources. However, in the absence of alternatives, defluoridation may be the only option. Methods of defluoridation include; contact precipitation, activated bone char and use of activated alumina (Nalgonda technique). Since they are expensive and produce sludge, not all water can be treated and only water for cooking and drinking is treated (Bregnhoj, 1997).

The Catholic Diocese of Nakuru (CDN) water quality program in Nakuru Municipality uses the activated bone char for defluoridation. This method makes use of locally available raw materials. They burn and crush animal bones in a high temperature furnace (500^0C). This removes all the organic matter leaving an inorganic content of calcium and phosphate which has the ability to adsorb fluoride from water. These are then supplied with filters to the residents.

The Water Quality Program has 3 types of filters suitable for different localities and users (household filters, community filters and institutional filters). They are currently working on a new "self-regenerating" filter which can increase the effectiveness of the bone char. This has been achieved by the development of calcium phosphate pellets which increase the lifespan of the filters when combined with bone char (CDN, 2009). The study evaluated whether the program has been able to improve awareness and promote safe practices towards fluorosis.

Limitations of the Study

The research only investigated the research problem based on one District in the Rift valley Province yet the CDN is operational in other Districts including Baringo, Koibatek and Naivasha. The study focused on assessing the contribution of the CDN water quality program in providing safe fluoride free drinking water to the residents of Nakuru Town. The study population was limited to Nakuru Town. Three sub-categories based on population density and social economic statuses were chosen. The three estates from which the study was conducted were: Shabab estate, Milimani estate and Ponda Mali estate. The findings therefore did not reflect the effectiveness of the program in the other areas of operation. Furthermore, the researcher was unable to find any other studies on people's knowledge and practices as regards dental fluorosis to make comparisons with.

Materials and Methods

The study was conducted in Nakuru town for the following reasons: the CDN water project is based in Nakuru; there are known incidences of fluorosis due its location in the Rift Valley which is a fluoride belt, and high concentration of fluoride in both surface and underground water in Nakuru. Nakuru is located in the Great Rift Valley. The geology of Nakuru area comprises mainly volcanic soils and rocks and this volcanic activity give rise to the high concentration of fluorides and other inorganic salts in water and soil. There is a major salt water lake, the Lake Nakuru, which is situated within the National park. Another major volcanic feature is the Menengai crater which is also as a result of volcanic activity. Nakuru experiences a hot and dry climate most times of the year (Muller, 2007).

The population of Nakuru Town was estimated to be 309,424 as per the 2009 census which was carried out by the Kenya Population Data Networks. The research was exploratory. It involved the use of questionnaires to measure various aspects of people's demographics and how it influenced their knowledge and practices towards fluorosis.

The exploratory design used both qualitative and quantitative analysis of the research variables. According to Yamane (1967), for populations greater than 10,000, sampling is done from 1,000 members of the group to be surveyed. In order to evaluate the awareness on fluorosis and the CDN program, and therefore using Yamane's sample size determination formula, a sample size of 100 respondents was selected to participate in the study. The 100 respondents were stratified into three sampling sub-units. In each sub-unit, 33 respondents were selected

randomly to participate in the study. The sub-units were based on socio-economic status and population density. These were low, medium and high population density areas.

The study collected data using questionnaires. This tool was used because it enabled the author to collect data from a large number of respondents within a short period of time. The questionnaires consisted of mostly closed-ended and a few open-ended items. Data collected was checked and edited for correctness. Each objective was then analyzed using appropriate statistical tests. Data was analyzed with the help of SPSS. Frequencies, percentages, means and mean difference were used for analysis. The data was then presented in the form of tables and figures.

Results

Demographic Details of Nakuru Town Residents

Gender

It was a gender based sample size where both male and female were sampled. The findings were; Female respondents (55%) were more than male respondents (45%).

Age

An examination of the respondents by age distribution was carried out. Those aged below 25 years were 18(18%), those aged between 26 and 30 years were 21(21%), those aged from 31-40 years were 35(35%) and those above 40 years of age were 26(26%). The study thus concluded that majority of the respondents were aged above 30 years. Very few household heads were aged below 25 years of age.

Education

The survey sought to establish the education level among the respondents. These results showed that 15% had secondary education, 45% had college level, 25% degree and 5% had attained master's degree level education. As such, most of the respondents have gone beyond secondary school level.

Income

The survey sought to establish the levels of income among the respondents. These results were as presented in Table 1 below.

Table 1: Income Levels among Respondents

Income level	Ponda Mali		Shabab		Milimani		Total % for each level
	F	**%**	**F**	**%**	**F**	**%**	
Less than 5000 Kshs	2	6.2	3	9.2	0	0	7
10,000-20,000 Kshs	18	54.5	4	12.2	1	3.0	23
20,000-50,000 Kshs	13	39.3	20	60.2	13	38.2	46
50,000-100,000 Kshs	0	0	4	12.2	11	32.3	15
Above 100,000 Kshs	0	0	2	6.2	9	26.5	11
Frequency	**33**		**33**		**34**		**100**
Total (%)	**100**		**100**		**100**		**100**

It was noted that majority of the respondents earned between Ksh 20,000-50,000 per month. Thus they can be considered middle income earners. Most of the respondents from Ponda Mali earned Below Ksh 20,000, most of the respondents in Shabab earned above Ksh 20, 000 while most of the residents of Milimani earned above Ksh 50, 000. From these results, we can conclude that Ponda Mali was a low income area; Shabab was a middle income area while Milimani was a high income area.

Awareness of Fluorosis

The study sought to find out the levels of awareness on fluorosis among residents of Nakuru town. Majority of the residents (75%) across the town were aware of what fluorosis was while 25% of them were totally unaware. They, however, mainly knew about dental fluorosis and did not know that the disease affects the skeletal system as well.

Where Residents Learnt about Fluorosis

The study sought to find out how the residents learnt about fluorosis. These findings were as presented in Table 2 below.

Table 2: Where Residents of Nakuru Learnt about Fluorosis

	Frequency	**Percentage**
From CDN	3	3

From other sources	97	97
Total	**100**	**100**

Very few (3%) of the residents had learnt about fluorosis from the CDN program. Majority of them (97%) learnt about it from other sources. This means that the CDN does not have much direct contribution to knowledge on fluorosis among the residents.

Factors that Contribute to Fluorosis

The respondents gave various reasons as to what they thought contribute to fluorosis. These included water, volcanic soil and high levels of fluoride in water while some did not know. This shows that the residents were adequately knowledgeable on the causes of fluorosis. The findings were as presented in Table 3 below.

Table 3: Factors Residents thought contribute to Fluorosis

Cause of fluorosis	**Ponda Mali**		**Shabab**		**Milimani**		**Total % for each estate**
	F	**%**	**F**	**%**	**F**	**%**	
Water	16	48.4	18	54.5	19	55.8	43
Volcanic soil	2	6.1	2	6.1	5	14.7	9
Borehole water	2	6.1	3	9.1	4	11.7	9
Levels of fluoride	2	6.1	3	9.1	3	8.8	8
Unaware	11	33.3	7	21.2	3	8.8	21
Frequency	**33**		**33**		**34**		**100**
Total	**100**		**100**		**100**		**100**

From these findings, we can see that most of the people who were unaware of factors that contribute to fluorosis came from the low income area. People from the middle and high income areas were more knowledgeable on the signs and causes of fluorosis.

Signs of Fluorosis

The study established what residents thought were the signs of fluorosis. These results are presented in the Table 4 below.

Table 4: What the Residents thought are the Signs of Fluorosis

Signs	**Frequency**	**Percentage**
Brown teeth	59	59
Decay teeth	3	3
Broken teeth	1	1
Yellow teeth	3	3
Bad odour	6	6
Weak bones	3	3
Unaware	25	25
Total	**100**	**100**

Most of the respondents were well versed with the common signs of fluorosis which they named. These included, brown teeth, decayed teeth, broken teeth, yellow teeth, bad odour and weak bones. Very few were totally unaware.

Awareness on the CDN Water Quality Program

The study sought to establish if the residents knew about the CDN program. Majority of the residents (75%) did not even know of the existence of the project. Only 25% of the respondents had ever heard about CDN. This shows that the CDN has not been able to penetrate the market effectively to offer the residents its products and services and also educate the residents on fluorosis.

Awareness on how the CDN Programme Operates

The study established level of awareness on the CDN program. The results showed that 81% were unaware, 16% said they were aware of fluoride removal buckets supplied by the program while 3% thought they just supply water.

As such, most of the residents were unaware on how the CDN project operates. The few who were aware thought they work by providing fluoride filters and free water.

Use of CDN Fluoride Filters

The study established how many residents use filters from CDN. Most of the residents (81%) had never used a fluoride filter from CDN or practiced any other form of fluoride filtration and did not know anybody who did. Only 19% had either used a fluoride filter or taken any other measures to filter the water. This points to the fact that most people are not taking measures to filter the fluoride out of their drinking water or they may be using other means apart from CDN filters.

Measures taken to prevent Fluorosis

Most of the residents took some steps to try and prevent fluorosis in their households. The measures taken included boiling water, using water guard to treat water, buying bottled water, brushing with tooth paste and using CDN filters. These findings are presented in the table below

Table 5: Measures taken by Residents to prevent Fluorosis

Measures	**Ponda Mali**		**Shabab**		**Milimani**		**Total (%)**
	F	**%**	**F**	**%**	**F**	**%**	
Boiled water	8	24.2	9	27.2	2	5.8	19
Using waterguard	4	12.2	7	21.2	5	14.7	16
Buying bottled water	0	0.0	1	3.1	14	41.2	15
Toothpaste	10	30.3	8	24.3	3	8.8	21
Using CDN filters	3	9.1	4	12.1	2	5.8	9
No measure taken	8	24.2	4	12.1	8	23.5	20
Frequency	**33**		**33**		**34**		**100**
Total	**100**		**100**		**100**		**100**

These results show that most of the residents had misconceptions about fluorosis for instance they thought that boiling water and brushing teeth may prevent fluorosis. This is untrue.

Rating Residents' Knowledge of Fluorosis

Using a Likert scale, the residents were asked to rate their knowledge on fluorosis from 0-10 with 0 being very poor and 10 being very good. The average rating was 4. Most of the residents rated their knowledge of fluorosis very poorly with majority of them rating themselves below average. This is inconsistent because according to the researcher their knowledge of fluorosis was acceptable for a non-expert in the field. As we have seen in earlier results, many of the residents were well aware of what fluorosis is, its causes, signs and preventive measures.

Rating of CDN Performance by Residents

Using a Likert scale, the residents were asked to rate the performance of the CDN program from 0-10 with 0 being very poor and 10 being very good. The average rating was 2. It is to be noted that majority of the respondents rated the program very poorly. This could be due to the fact that they don't even know of its existence and workings.

Discussion

The study sought to establish awareness on dental fluorosis, it was shown that majority of the respondents were aware of fluorosis and its causes and even how to prevent it, however, majority of the residents did not take any measures to try and protect their families from getting the condition. However, their awareness on the CDN program and its mode of operation was very poor. It also emerged that very few residents of Nakuru use the fluoride filters from CDN to filter water with majority of those taking measures to purify the water using other means like boiling water and buying bottled water. The residents also rated their knowledge of fluorosis very highly. This was true as most of them could identify the signs of fluorosis, the causes and the different treatment options.

On awareness on CDN program, it was shown that, they had limited knowledge on CDN program and also rated the performance of the CDN water quality program very poorly. This can be attributed to the fact that most of them were not even aware of its existence. The results further show that in as much as the residents know what causes the disease, they are in a dilemma as to where they could seek advice from where so that they are able to know how to treat and remove fluoride in water. Furthermore, the findings show that many residents do not use services provided by CDN.

Conclusion and Recommendations

Evidently, the program has not been able to create awareness on fluorosis in Nakuru town as most of the residents who were knowledgeable on fluorosis had not learnt about it from CDN but from other sources. The program has also not been able to increase awareness on their existence and their products and services.

The CDN programme should increase efforts to create awareness on fluorosis among the residents. This can be achieved by partnering with local institutions like schools and churches to have seminars on fluorosis and also use of electronic and print media. The CDN programme should increase efforts to create awareness on the programme itself, its products and services among the residents.

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