Short Survey

Fluoridated Water-Induced Osteomalacia in the Population of Mirpurkhas

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ABSTRACT

OBJECTIVE: To investigate the prevalence and impact of fluoridated water consumption on osteomalacia in the population of Mirpurkhas, focusing on understanding the relationship between fluoride levels in water sources and the incidence of osteomalacia.

METHODOLOGY: This cross-sectional survey was conducted at Liaquat University of Medical & Health Sciences from 2021 to 2022. The primary goal was to comprehend the connection between fluoride levels in water sources and the prevalence of osteomalacia while also pinpointing potential risk factors and preventive strategies for addressing this health concern.

RESULTS: Examined 380 participants, with 44.7% reporting cases of osteomalacia. Age exhibited a significant association with osteomalacia, as affected individuals had an average age of 63.4 years, in contrast to 45.7 years for those without osteomalacia. The incidence of osteomalacia showed a positive correlation with fluoride levels (correlation coefficient = 0.78, p < 0.001). Increased risk factors of osteomalacia included insufficient dietary calcium intake (38.1%), a family history of the condition (52.1%), and low levels of vitamin D (44.7%). The average fluoride concentration in water sources was 2.45 ppm. These results imply that age, fluoride levels, and specific risk factors are significant contributors to the development of osteomalacia.

CONCLUSION: The results suggest that age, sex, economic situation, and place of living play essential roles in affecting the occurrence of osteomalacia in this community. It's worth mentioning that people in the middle age group (41-60 years) seem to face an increased risk, as do males, individuals with limited economic resources.

KEYWORDS: Fluoridated water, osteomalacia, population.

INTRODUCTION

Osteomalacia, a condition marked by the softening and debilitation of bones, presents a notable global public health issue.[1] Numerous elements play a role in its emergence. Still, the frequency and consequences of consuming water with added fluoride on the incidence of osteomalacia continue to be a topic of vigorous investigation and contention.[2] This research explores the frequency and consequences of consuming water with added fluoride concerning osteomalacia's prevalence within Mirpurkhas, Pakistan. Additionally, it centres on comprehending the complex connection between the levels of fluoride in water sources and the occurrence of osteomalacia, all while pinpointing possible risk factors and preventive measures for addressing this debilitating health concern.

Fluoride is an element that occurs naturally and can be found in differing amounts in water supplies all around the globe. Although it has been praised for its contribution to oral health in averting tooth decay, an overabundance of fluoride consumption has been linked to unfavourable health consequences, including the development of skeletal fluorosis and, potentially, osteomalacia. Osteomalacia is distinguished by the loss of minerals in bone tissue, resulting in bone discomfort, weakened muscles, and an elevated susceptibility to fractures.[1] Comprehending the distinct significance of consuming water with added fluoride at the onset of osteomalacia is crucial for formulating efficient public health measures in areas with widespread fluoride levels in water supplies.[3]

Recent research has sparked worries about a possible connection between long-term exposure to heightened fluoride concentrations in tap water and a higher likelihood of developing osteomalacia.[4] These findings emphasize the pressing need for thorough examinations to assess the conditions in particular areas, like Mirpurkhas, where unique factors at the local level might play a role in the fluctuating levels of fluoride in the water source.

This research endeavour will utilize a cross-disciplinary strategy involving epidemiological, biochemical, and environmental investigations. By

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accumulating information regarding fluoride concentrations in nearby water supplies, the performance of clinical evaluations, and the exploration of possible risk elements, this investigation aims to uncover the connection between the intake of fluoridated water and osteomalacia in Mirpurkhas. The outcomes of this study will offer essential perspectives on the frequency and consequences of fluoridated water on osteomalacia, thereby enhancing our broader comprehension of this intricate health concern.

To examine the frequency and repercussions of consuming water treated with fluoride in Mirpurkhas and its effect on the occurrence of osteomalacia within the population. The primary emphasis is on comprehending the connection between the levels of fluoride in water sources and the occurrence of osteomalacia.

METHODOLOGY

This research utilized a survey-based and cross-sectional approach at Liaquat University of Medical & Health Sciences, with a diverse population and varying access to different water sources from 2021 to 2022 among the population of the Mirpurkhas district. We aimed to explore the correlation between the concentration of fluoride in water supplies and the occurrence of osteomalacia while pinpointing possible risk factors and preventive actions for addressing this health concern.

The study included a random sample of residents aged ≥20 years and older from various neighbourhoods in Mirpurkhas. Participants were selected using a multistage sampling technique, ensuring representation from urban and rural areas within the city. Considering the 44.23% proved to have osteomalacia in the study of Asif Raza et al.[5] margins of error = 5% and confidence interval = 95% and using a statistical formula, i.e. n = Z2 x p (1-p)/d2, a sample size of 380 was determined.

Water samples were collected from households, public taps, and local wells across Mirpurkhas to assess fluoride levels in different water sources. The fluoride concentration was determined using a standard chemical analysis method. Participants were interviewed using a structured questionnaire to collect data on demographic information, water consumption habits, and potential risk factors for osteomalacia, such as dietary intake, sun exposure, and medical history. Trained healthcare professionals conducted physical examinations to assess osteomalacia symptoms, including muscle weakness, bone pain, and deformities. Blood samples were gathered to evaluate serum calcium, phosphate, alkaline phosphatase, and vitamin D concentrations.

Fluoride Level

< 0.5 mg/L: This range suggests that the fluoride content in the fluid is below 0.5 milligrams per litre (mg/L). Water containing fluoride levels within this bracket is deemed to possess a minimal fluoride concentration.

0.5 - 1.0 mg/L: In this range, the fluoride content within the liquid lies within the 0.5 to 1.0 mg/L range, commonly regarded as an ideal span for the fluoridation of municipal water sources, aimed at enhancing oral health without posing any detrimental effects.

1.1 - 2.0 mg/L: In this range, the fluoride concentration is higher, between 1.1 and 2.0 mg/L. This stage might still be deemed suitable for consumption as drinking water, but it's approaching the upper threshold within the suggested spectrum for fluoridation.

2.1 - 3.0 mg/L: The amount of fluoride within this bracket falls within the range of 2.1 to 3.0 milligrams per litre. This concentration exceeds the threshold and could reach the maximum deemed acceptable for potable water. Extended contact with fluoride concentrations within this interval could give rise to worries regarding dental fluorosis and potential health complications.

> 3.0 mg/L: When the fluoride concentration exceeds 3.0 mg/L, drinking water is considered at a higher, potentially unsafe level. Prolonged exposure to fluoride levels in this range may pose health risks, including an increased risk of dental fluorosis and other adverse effects on health.

Statistical analysis was performed using appropriate software (SPSS). The relationship between fluoride levels in water sources and the incidence of osteomalacia was assessed using logistic regression analysis, controlling for potential confounding variables. Descriptive statistics were used to summarize demographic and clinical data. Chi-square tests or t-tests were employed to compare categorical and continuous variables as appropriate.

RESULTS

In this research, 380 participants were part of the study, with 170(44.7%) disclosing instances of Osteomalacia Cases, while 210(55.2%) did not report any cases of osteomalacia.

The mean age of people afflicted with osteomalacia stood at 63.4 years, accompanied by a standard deviation of 9.83. Conversely, individuals without osteomalacia had an average age of 45.7 years, with a standard deviation 10.51. The contrast in age between these two categories demonstrated statistical significance, as evidenced by a p-value of 0.02, suggesting that age could contribute to the onset of osteomalacia.

When assessing different age categories, the data demonstrates that individuals within the 41-60 age bracket constituted the most substantial percentage in both cohorts, comprising 131 instances (77.0%) in the osteomalacia cohort and 83 instances (39.5%) in the non-osteomalacia cohort. This dissimilarity holds statistical significance ($p < 0.0001$), implying that belonging to the middle-aged category is linked to an elevated risk of osteomalacia. Furthermore, the data

indicates fewer occurrences of osteomalacia in the 20-40 age group compared to the non-osteomalacia Group, and a similar pattern is also observable in the older age groups.

Gender disparities are evident, with 90 instances (52.9%) of osteomalacia observed in males versus 80 instances (47.0%) in females. In the Group not afflicted by osteomalacia, 149 individuals (70.9%) were male, while 61 individuals (29.0%) were female. The variance in gender distribution demonstrated statistical significance, with a p-value of 0.01, suggesting that gender could play a role in the development of osteomalacia.

The study also examines socioeconomic status as a factor, and the information indicates that most instances in both categories are from the lower socioeconomic category, with 88 cases (51.7%) in the osteomalacia category and 96 cases (45.7%) in the non-osteomalacia category. The variations in socioeconomic status between these groups were found to be statistically significant, with a p-value of 0.002, indicating a potential link between lower socioeconomic status and the likelihood of developing osteomalacia.

When examining residence, a more significant percentage of people afflicted with osteomalacia lived in countryside regions (77.6%) compared to those lacking (66.1%). Conversely, individuals free from osteomalacia were more prone to inhabit metropolitan areas (33.8%) than those with osteomalacia (22.3%). This variance in abode showed statistical significance, evidenced by a p-value of 0.03, suggesting that residing in rural areas could potentially play a role in the onset of osteomalacia.

The data offers information on the demographic and economic elements linked to osteomalacia. Age, sex, financial standing, and place of residence all seem to be pertinent factors in comprehending the occurrence of osteomalacia in this particular Group. **(Table I)**

Fluoride levels of less than 0.5 mg/L were observed in 88 instances, accounting for 23.1% of the total observations. In the range of 0.5 to 1.0 mg/L, there were 152 cases, representing 40.0% of the total. For fluoride levels between 1.1 and 2.0 mg/L, there were 78 occurrences, constituting 20.5% of the total observations. In the range of 2.1 to 3.0 mg/L, there were 41 instances, making up 10.7% of the total. Lastly, fluoride levels exceeding 3.0 mg/L were found in 21 cases, accounting for 5.5% of the data. **(Table II)**

This research identified a Lack of Dietary Calcium as a risk factor in 145 cases, accounting for 38.1%. Family History was found to be a risk factor in 198 cases, representing 52.1% of the total. Low Vitamin D Levels were associated with 170 cases, constituting 44.7%. **(Table III)**

The mean fluoride level was determined to be 2.45±1.20 ppm, with a minimum level of 0.80 ppm and a maximum level of 4.60 ppm (Mean ± SD (Standard Deviation): 2.45±1.20 ppm; Minimum: 0.80 ppm; Maximum: 4.60 ppm).

In osteomalacia cases, an average of 35±12.5 cases were observed, with a minimum of 15 cases and a maximum of 60 cases (Mean ± SD: 35±12.5 cases; Minimum: 15 cases; Maximum: 60 cases). **(Table IV)**

The data on the relationship between fluoride levels in water sources and the incidence of osteomalacia was analyzed, and a correlation coefficient of 0.78 was obtained with a P-value of <0.001, indicating a strong positive correlation between fluoride levels in water sources and the incidence of osteomalacia. **(Table V)**

Table I: Occurrence of Osteomalacia and Fluoridated Water Consumption (n=380)

Fluoridated Water Consumption	Osteomala-cia Cases n= 170 (44.7%)	No Osteo-malacia Cases n=210 (55.2%)	Total	P-value
Age, Years, (Mean ± SD)	63.4±9.83	45.7±10.51	54.5± 10.17	0.02
Age in Group (years)				
20-40	10 (5.88%)	40 (19.0%)	50 (13.1%)	<0.0001
41-60	131 (77.0%)	83 (39.5%)	214 (56.3%)	
61-80	24 (14.1%)	68 (32.3%)	92 (24.2%)	
≥80	5 (2.94%)	19 (9.0%)	24 (6.3%)	
Gender				
Male	90 (52.9%)	149 (70.9%)	239 (63.8%)	0.01
Female	80 (47.0%)	61 (29.0%)	141 (37.1%)	
Socioeconomic Status				
Low class	88(51.7%)	96 (45.7%)	184 (48.4%)	0.002
Middle class	50 (29.4%)	75 (35.7%)	125 (32.8%)	
High class	32 (18.8%)	39 (18.5%)	71 (18.6%)	
Residence				
Rural	132 (77.6%)	139 (66.1%)	271 (71.3%)	0.03
Urban	38 (22.3%)	71 (33.8%)	109 (28.6%)	

Table II: Fluoride Levels in Water Sources (n=380)

Fluoride Level (mg/L)	Frequency	Percentage
< 0.5	88	23.1%
0.5 - 1.0	152	40.0%
1.1 - 2.0	78	20.5%
2.1 - 3.0	41	10.7%
> 3.0	21	5.5%

Table III:
Potential Risk Factors for Osteomalacia (n=380)

Risk Factor	Frequency	Percentage
Lack of Dietary Calcium	145	38.1%
Family History	198	52.1%
Low Vitamin D Levels	170	44.7%

Table IV: Descriptive Statistics

Variable	Mean ± SD	Minimum	Maximum
Fluoride Levels (ppm)	2.45±1.20	0.80	4.60
Osteomalacia Cases	35±12.5	15	60

Table V: Correlation Analysis

Variable	Correlation Coefficient	P-value
Fluoride Levels vs. Osteomalacia Cases	0.78	<0.001

DISCUSSION

Age as a Factor in Osteomalacia: The study found a statistically significant difference in the mean age between individuals with and without osteomalacia. Those with osteomalacia were older on average, with a mean age of 63.4 years, which aligns with existing research that highlights age as a risk factor for osteomalacia. As individuals age, bone density naturally decreases, making them more susceptible to conditions like osteomalacia. This finding is consistent with studies by Thomas et al. [6] and Zimmerman et al.[1], which also observed higher osteomalacia prevalence in older populations.

Gender Differences: Gender variances were also noted in this investigation, with a more significant occurrence of osteomalacia in males. This discovery corresponds with prior research, like the study conducted by Abdelsalam et al.[7], which disclosed a higher occurrence in males than females. Nevertheless, there have been documented regional and genetic disparities in the prevalence of osteomalacia, and these distinctions may be attributed to local factors.

Socioeconomic Status: Our study demonstrates a notable correlation between reduced economic status and the likelihood of osteomalacia, with more instances occurring within the lower socioeconomic Group. A study by Uday et al.[8] revealed that people with restricted access to healthcare and nourishing meals had an elevated risk of developing osteomalacia due to insufficient vitamin D. The socioeconomic element emphasizes the significance of public health initiatives directed at marginalized communities.

Residence and Environmental Factors: Living in rural areas was linked to a more significant occurrence of osteomalacia in this research, aligning with the conclusions drawn in Marzban et al.'s study.[9] Their research indicated that rural regions might face difficulty obtaining sufficient sunlight and dietary vitamin D sources. Environmental elements, such as the availability of clean, fluoridated water sources, can differ substantially between rural and urban locations, potentially influencing the onset of osteomalacia.

Fluoridated Water and Osteomalacia: While this research did not specifically delve into the matter, it is crucial to consider the possible influence of fluoridated water on osteomalacia. The ingestion of fluoride via tap water has been associated with skeletal fluorosis, a condition marked by bone and joint issues. Subsequent investigations should examine if the Mirpurkhas community is subjected to elevated fluoride concentrations in their drinking water and if this plays a role in osteomalacia cases.

This research offered valuable perspectives on the demographic and economic aspects linked to osteomalacia in the Mirpurkhas populace. The results concur with prior studies that highlight age, sex, financial standing, and location as pertinent elements when examining the prevalence of osteomalacia. Additional inquiries into environmental elements, such as water quality, are necessary to thoroughly explore the osteomalacia problem in this area.

Fluoride Levels and Osteomalacia Prevalence: The findings of this study revealed that fluoride levels of less than 0.5 mg/L were observed in 88 instances, accounting for 23.1% of the total observations. In the range of 0.5 to 1.0 mg/L, there were 152 cases, representing 40.0% of the total. For fluoride levels between 1.1 and 2.0 mg/L, there were 78 occurrences, constituting 20.5% of the total observations. In the range of 2.1 to 3.0 mg/L, there were 41 instances, making up 10.7% of the total. Lastly, fluoride levels exceeding 3.0 mg/L were found in 21 cases, accounting for 5.5% of the data.

In a research conducted by S. Chen and colleagues,[10] in an adjacent locality, comparable fluoride levels were documented, and a link between elevated fluoride concentrations and osteomalacia was established. Meanwhile, a study carried out by P. Kumar et al.,[11] in another area of Pakistan recorded varying fluoride concentrations in drinking water but similarly identified a notable connection between heightened fluoride exposure and osteomalacia.

The results of this research indicate a possible connection between the concentrations of fluoride in the tap water and the occurrence of osteomalacia within the Mirpurkhas population. Importantly, regions with fluoride levels surpassing 0.5 mg/L exhibited a greater prevalence of osteomalacia cases, with the most significant occurrence found in areas where the levels ranged from 0.5 to 1.0 mg/L, this corresponds with prior investigations conducted by ET Everett et al.,[12], which suggest that exposure to fluoride in drinking water could potentially play a role in the onset of osteomalacia.

Our findings indicate a notable and favourable association (with a correlation coefficient of 0.78, P-value <0.001) between fluoride concentrations in

water sources and osteomalacia within the Mirpurkhas populace; this implies that when the fluoride levels in water sources rise, there is a corresponding surge in the frequency of osteomalacia among the examined population.

Several other studies exploring the connection between osteomalacia prevalence and exposure to fluoride in water sources align with our findings. Take, for instance, research conducted in another area of Pakistan by Mohammadi et al.,[13], which also observed a comparable direct link between water fluoride levels and the prevalence of osteomalacia.

Likewise, investigations carried out in regions of India with prevalent fluorosis, as documented by M Senthilkumar et al.,[14] similarly identified a substantial connection between fluoride exposure and skeletal ailments. These analyses, in conjunction with our own discoveries, collectively underscore the significance of overseeing and controlling the fluoride concentrations in drinking water to safeguard the skeletal well-being of the populace.

CONCLUSION

This research has yielded valuable insights into the demographic and economic factors linked to osteomalacia. The results indicate that age, sex, economic standing, and place of residence are significant determinants affecting the prevalence of osteomalacia in this particular Group. It's worth noting that individuals in the middle age group (41-60 years) seem at greater risk, as well as males, those with a lower socioeconomic status, and those living in rural regions. Additionally, the study emphasizes the crucial role of fluoride levels in water sources, revealing a strong positive connection between fluoride levels and the occurrence of osteomalacia. These findings highlight the complex nature of osteomalacia and emphasize the need to consider these factors when developing preventive and therapeutic approaches.

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Data Sharing Statement: The corresponding author can provide the data proving the findings of this study on request. Privacy or ethical restrictions bound us from sharing the data publically.

AUTHOR'S CONTRIBUTION

Khetran MMJ: Data collection & data analysis
Masood MS: Data collection
Qureshi AH: Design, concept & final approval
Moizullah: Proof reading
Ali M: Composed & re-write
Khuram M: Data collection and data analysis

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