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SIGNIFICANCE OF ACQUIRED COLOR VISION DEFECTS IN THE DIAGNOSIS OF VASCULAR DISEASES

Color vision testing can be used to detect subtle disturbances in retinal function, which can often occur before clinical symptoms and, for the ophthalmologist, before visible changes in the fundus of the eye in general vascular diseases. This makes it possible to carry out rapid and inexpensive early diagnosis by detecting acquired color vision disorders, which can prevent further damage by optimizing therapy. Here it is particularly important to work closely with general practitioners and internists. Such aspects should be given greater consideration in occupational medicine. In many areas of industry, high demands are placed on color vision. In areas such as the textile industry, the chemical paint industry, the food industry, the automotive industry (paints) and in painting companies, normal color perception is of fundamental importance. Color vision testing is an inexpensive and easy-to-perform examination method that can provide an early indication of acquired color vision deficiency under standardized conditions. In addition to the detection of a generalized microcirculatory disorder, this determination is also useful in occupational medicine in order to better determine suitability for certain occupational groups.

Key words: color vision, vascular diseases, diabetes, arterial hypertension, migraine.

Introduction

The eye is supplied by the ophthalmic artery as a branch of the internal carotid artery. The central artery is responsible for supplying the inner retinal layers and is subject to autoregulation [1], which ensures a constant blood flow as long as the average arterial blood pressure does not vary by more than 40% [2].

Material and Methods

This study is an evaluation review. The literature was searched in the databases PubMed, Scopus, Web of Science, Springer. Duplicate publications have been checked and deleted.Initially , 83 articles were identified . After removing duplicates, 57 publications remained (26 excluded) as a result of searching in electronic databases and viewing links to articles. The application of inclusion/exclusion criteria and a thorough study of the abstracts led to the exclusion of 21 studies. Of the remaining 36 articles, 5 were excluded for the following reasons: 4 – there is no complete text, 1 – questionable methods of statistical analysis. The rest of the studies were suitable for qualitative synthesis.

Results and Discussion

The choroid is mainly fed by the short posterior ciliary arteries, and supplies per diffusionem the outer retinal layers with the photoreceptors (cones, rods) up to the retinal pigment epithelium as well as the anterior part of the optic nerve via ciliary (choroidal) arteries. The major portion of the blood from the ophthalmic artery, contributes to uveal circulation (85%) and only 2-5% goes to the retinal vasculature [3]. Due to the pronounced capillary network, the choroid has the largest blood volume in proportion to the perfunded tissue weight in the entire body with a blood flow volume of 18 ml/min/g tissue [4]). It also appears to have autoregulation [5], although this is far less effective than retinal autoregulation.

Due to the size of the retinal and choroidal vessels below 300 μm, ocular perfusion is part of the microcirculation. If systemic diseases lead to a disturbance of the microcirculation, microvascular dysfunction is considered a systemic disease [6], as it then generally affects all organ systems, including ocular perfusion. As this can affect the retinal photoreceptors, color vision is also a sensitive marker for microcirculatory disorders.

Color vision is one of the most highly developed human senses. It is made possible by the 3 photoreceptors (green, red and blue cones) in the retina and by cerebral processing [7,8].

Rhodopsin serves as a light sensor for incident light. It occurs as a photopigment in both the rods and the cones. Rhodopsin differs in the individual photoreceptor groups by slightly altered amino acid sequences in the opsin part, which causes the different wavelength sensitivity: rod rhodopsin has an absorption maximum around 500 nm (maximum sensitivity for green light), the cone rhodopsins have absorption maxima at 445 nm (blue cones), 545 nm (green cones) and 565 nm (red cones). They form the basis of color vision [9].

The three types of cones occur with different frequencies, the green cones are the most common with 55%, followed by the red cones with 33% and the blue cones with 12%. The blue cones only make up 2-3% of the color receptors in the fovea [10]. They are the youngest cones in evolutionary terms and react particularly sensitively to external factors [11].

As a result, the onset of acquired color vision disorders often begins with blue-yellow disorders with a typical color axis (Figure 1).
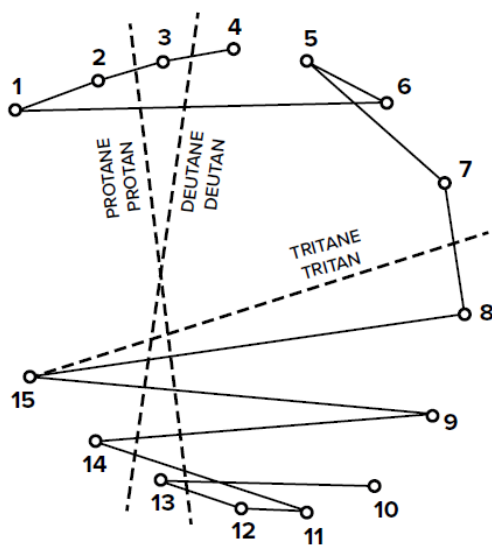
Figure 1 – Blue-yellow disorder in panel D 15 desaturated [31]

Findings without a reliable color axis
Acquired color vision deficits can, however, also be conspicuous by a "finding without a reliable axis" [12]. This is a dyschromatopsia without a preferred axis disorder. If there is also a low error sum, this indicates an incipient color vision disorder, which can later develop into a definite color vision disorder.

If there is a "finding without a reliable axis" with a very high error sum, this is an indication of a far advanced color vision disorder, in the course of which a generalized disorder of all photoreceptors has occurred.

Acquired color vision deficits can occur in the context of all general vascular diseases and indicate a microcirculatory disorder at an early stage [13]. This gives color vision testing a new dimension and significance in everyday clinical practice in the field of non-invasive early detection of vascular diseases, which can also be implemented easily and inexpensively.

Difference between acquired and congenital color vision disorders
Acquired color vision disorders generally differ from congenital color vision disorders in that they are highly variable, often begin unilaterally, are usually accompanied by conspicuous eye findings and are highly dependent on the examination conditions [14]. This shows that the examination conditions must be as standardized as possible in order to obtain reliable information, especially during the course of the disease [14]. A learning defect and the patient's level of experience in handling colors must be taken into account [15]. It is also important to note that reliable qualitative and quantitative information can only be obtained with color pigment sample tests (e.g. Panel D 15 desaturated, Farnsworth 100-hue test) or with an anomaloscope with Rayleigh and Moreland equation. In addition, the anomaloscope should also have a 4° eyepiece instead of the usual 2° eyepiece in order to be able to better diagnose the low foveal blue cone density.

Benefits of detecting acquired color vision defects
In an earlier study, it was shown that ventilation with 10% oxygen results in a blue-yellow disorder and a "finding without a reliable axis" compared to normal breathing with 21% oxygen [16]. This is explained by an oxygen deficiency of the retinal ganglion cells. This basic experiment proved that, in principle, any type of circulatory disorder in the ocular microcirculation can lead to color vision defects. It is therefore quite possible to use the color sense test to make an indirect statement about the state of the microcirculation in the eye and as a representative of the general microcirculation.

Acquired color vision deficits in vascular diseases
Acquired color vision deficits have been demonstrated in patients with functional vascular disorders, such as in the free interval in sudden hearing loss [17] and migraine [18], as well as in vascular

diseases with structural remodeling processes in the vessels, such as arterial hypertension [19], diabetes mellitus [20,21] or coronary heart disease [22].

In diabetes mellitus, for example, a color vision disorder was detected before changes occurred in the fundus of the eye [23]. Typically, a blue-yellow disorder [24] or a "finding without a definite axis" occurs [25]. These findings are of general relevance. In the Early Treatment Diabetic Retinopathy Study, approximately 50% of patients with diabetic retinopathy had abnormal hue discrimination compared to published data on normal subjects. The severity of macular edema, age and the presence of new vessels were the factors most strongly associated with impaired color discrimination [26].

However, acquired color vision deficits also occur in hematologic diseases, such as pernicious anemia and acute myeloid leukemia, both of which can lead to vascular dysfunction [27,28,29]. In addition, acquired color vision defects also occur with elevated serum LDL cholesterol levels and are more pronounced the higher the LDL cholesterol levels are [30].

Consequences of color vision deficits in the workplace

In many areas of industry, high demands are placed on color vision. In areas such as the textile industry, the chemical paint industry, the food industry, the automotive industry (paints) and in painting companies, normal color perception is of fundamental importance. However, if workers have general vascular diseases, their color perception can be significantly impaired. Although it has been shown that employees can compensate for part of their acquired color perception disorder through their color experience [15], this is no longer possible in the case of more severe general illnesses. Further studies are needed to better assess the effects of these color vision impairments in occupational medicine using standardized color vision tests [14].

Conclusion

Color vision testing is an inexpensive and easy-to-perform examination method that can provide an early indication of acquired color vision deficiency under standardized conditions. In addition to the detection of a generalized microcirculatory disorder, this determination is also useful in occupational medicine in order to better determine suitability for certain occupational groups.

Acknowledgments

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Significance-of-acquired-color-vision-defects-in-the-diagnosis-of-vascular-diseases

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HYGIENIC ASSESSMENT OF FLUORIDE CONTENT IN ENVIRONMENTAL OBJECTS AND ITS IMPACT ON CHILDREN'S HEALTH IN THE REPUBLIC OF TAJIKISTAN

The importance of fluoride for human health, particularly in dental caries prevention and bone growth, is well-recognized, yet its optimal balance is crucial to avoid adverse effects like dental and skeletal fluorosis. In Tajikistan, misconceptions exist about high fluoride levels in drinking water; however, recent studies reveal a widespread deficiency, except near industrial areas like the Tajik Aluminum Plant in Tursunzade city, where fluoride exposure risks are heightened. This research aims to assess fluoride's environmental impact and its effects on children's health across Tajikistan, focusing on the Bohtar region and Tursunzade city, to inform public health policy and interventions.

The study aims to assess the impact of environmental fluoride exposure on children's health in Tajikistan by analyzing fluoride levels in water, air, and food, and their relation to dental health outcomes. For our study on fluoride's impact on children's health in Tajikistan, we employed a multifaceted research methodology. The investigation included collecting and analyzing samples from various environmental sources–water, air, and food–in different regions, with a focus on the Bohtar region and the city of Tursunzade. Water samples were tested for fluoride content using ion-selective electrode analysis, while air and food samples were analyzed for fluoride concentration through spectrophotometric methods. Health assessments, including dental examinations of children aged 6-12 years, were conducted to identify dental caries and fluorosis, correlating these findings with fluoride exposure levels. The study also reviewed the sanitary and hygienic state of water supply systems. Data analysis incorporated both quantitative and qualitative methodologies, including statistical analysis to determine the correlation between fluoride exposure and health outcomes, ensuring a comprehensive understanding of fluoride's effects on children's health within the studied areas.

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This study highlights the necessity of balancing fluoride levels in drinking water to protect child dental health in Tajikistan. It calls for targeted fluoride management strategies tailored to regional needs, emphasizing the importance of public health interventions, system improvements, and awareness campaigns to prevent dental issues and enhance children's health.

Key words: Fluoride, dental health, public health, environmental exposure, fluorosis, child health, Tajikistan.

Introduction

The importance of fluoride for human health is a subject of significant academic and public health interest. Fluoride, a critical microelement, is essential for the normal development and maintenance of human health, particularly in preventing dental caries and ensuring bone growth. However, the dual nature of fluoride–beneficial in optimal quantities but harmful when excessive–presents a complex challenge for environmental health and public health policy, especially concerning children's health. This challenge is pronounced in the Republic of Tajikistan, where the fluoride content in environmental objects such as drinking water, atmospheric air, and food varies significantly across different regions.

Recent studies highlight a paradox in the scientific community's perception of fluoride levels in Tajikistan, with some mistakenly classifying the country as having high fluoride concentrations in its drinking water. Contrary to these claims, domestic research over the last five years indicates a prevalent fluoride deficiency in most of the Republic's regions, except in areas influenced by industrial activities, such as near the Tajik Aluminum Plant in Tursunzade city, where fluoride exposure risks, including dental and skeletal fluorosis, are elevated.

This study aims to provide a comprehensive evaluation of the water supply system and investigate the fluoride content in the external environment and its impact on children's health across Tajikistan, with a specific focus on the Bohtar region and Tursunzade city. Our research tasks encompass examining the sanitary and hygienic state of water supply and provisioning systems; determining fluoride levels in the air, water, and food; establishing causal links between fluoride exposure and dental health outcomes in children; and developing hygienic recommendations to optimize access to clean drinking water and prevent fluoride-associated health issues among the pediatric population.

This research represents a pioneering effort in Tajikistan to apply an internationally recognized health risk assessment methodology to study fluoride's effects on children. Our findings offer new insights into the natural sources of drinking water, provide a sanitary assessment of water supply systems, and establish a link between fluoride exposure and the prevalence of dental caries and fluorosis among children. Based on these outcomes, we propose scientifically grounded recommendations for public health interventions to mitigate these risks.

Given the existing gap in comprehensive studies on water quality's impact on health in Tajikistan, particularly concerning fluoride, this work is of paramount importance. It contributes to the development of public health systems, enriches the academic discourse on environmental hygiene, and underscores the critical need for targeted preventive measures to safeguard children's health against the backdrop of varying environmental fluoride exposure.

Materials and methods

Analysis of Fluoride Content in Food Products

The determination of fluoride ions in food was conducted using an electrochemical method with fluoride-selective electrodes, utilizing a potentiometer PI-1 Mi and the "Expert-001" liquid analyzer. This approach allowed for the precise measurement of fluoride ions in various food samples, accounting for a 15% methodological error margin at a 95% confidence interval. To minimize measurement errors, three samples were taken from each food item, and three parallel measurements were conducted for each sample. The methodology ensured that the error in determining fluoride concentrations was significantly reduced, making the data highly reliable for assessing dietary fluoride exposure.

Establishing Cause-and-Effect Relationships

This stage of the research evaluated the dose-effect relationship (cause-and-effect links) between fluoride content in drinking water and the prevalence of dental caries and fluorosis among children in selected areas. Given the significant cost and complexity of this research phase, the study focused on Tursunzade and Bohtar cities. These areas were selected based on their proximity to fluoride emission sources and varying water fluoride concentrations. The target population for this stage consisted of 12-year-old schoolchildren, identified as particularly susceptible to environmental factors.

Risk Assessment and Characterization of Dental Caries and Fluorosis

Following the establishment of cause-and-effect relationships, this research phase assessed the risk of dental caries and fluorosis among the target population. This analysis exclusively considered the fluoride content in drinking water as a variable, with risk expressed as an odds ratio (OR) of disease occurrence.

Statistical Analysis

The collected data were processed using SPSS Statistics 21.0 and Statistica 10 software. The analysis employed descriptive statistics to summarize the data and analytical statistics to explore the relationships between independent variables. The research utilized various statistical tests, including ANOVA, the Kruskal-Wallis test, and the Mann-Whitney U-test, to compare the fluoride content across different environmental mediums and its impact on health outcomes. A binary logistic regression model was applied to adjust for the influence of variables, while factor analysis with linear correlation was used to examine the effect of waterborne fluoride on the incidence of dental caries and fluorosis.

Results

Fluoride in Atmospheric Air

The investigation into the fluoride content in the atmospheric air revealed significant findings, especially in areas proximate to the aluminum plant located in Tursunzade. The primary emissions from the plant, gaseous hydrogen fluoride, and solid fluoride compounds were detected, demonstrating the industrial impact on air quality.

The results, particularly concerning the fluoride levels in the air during different seasons and directions of the wind, are summarized in Tables 3.3 and 3.4. The maximum concentration of hydrogen fluoride in the experimental zone (Dzh.Navobod) was observed during the autumn period, exceeding the maximum allowable concentration (MAC) up to 0.08 mg/m³ for hydrogen fluoride. Meanwhile, the concentration of fluoride salts varied, remaining below the MAC standards, with the highest levels recorded in the autumn.

In contrast, the control zone (Dzh. Dzh.Rahmonov), aside from lower levels of hydrogen fluoride which did not exceed the MAC, did not show detectable levels of other fluoride compounds, highlighting the localized impact of industrial emissions based on wind direction and geographical location.

Fluoride concentrations were affected significantly by the wind's direction, with the highest levels recorded during autumn when the wind blew from the west. The spring sampling showed a decrease in fluoride levels, yet certain areas still recorded measurements slightly above the MAC. This seasonal fluctuation underscores the varying impact of industrial activities and environmental factors on air quality concerning fluoride contamination.

The data presented in Table 3.5 further illustrate the annual average fluoride content, taking into account the wind direction. It was observed that fluoride levels were generally lower or just slightly above the MAC, with the exception of certain areas during the autumn when wind conditions favored the dispersion of pollutants from the aluminum plant.

Regional Comparisons in the Bohtar Region

Table 3.6 offers a comprehensive overview of the fluoride content in the atmospheric air across 15 administrative cities and districts within the Bohtar region. Notably, the investigation revealed an absence of fluoride salts in all sampled locations, with only trace amounts of hydrogen fluoride detected in certain areas. These findings indicate a low fluoride impact in regions without fluoride-emitting industrial activities, aligning with Tajikistan's broader characterization as a region with fluoride deficiency.

The observed atmospheric fluoride concentrations, particularly in proximity to industrial sources like the aluminum plant in Tursunzade, necessitate ongoing monitoring and potentially targeted public health interventions to mitigate exposure risks. While the broader Bohtar region shows minimal fluoride presence in the air, highlighting the localized nature of industrial impact, it's critical to balance industrial activities with environmental health considerations to ensure community well-being.

Fluoride in Drinking and Utility Water

This section discusses the fluoride content in drinking and utility water, a crucial factor for both environmental and public health perspectives in Tursunze, highlighting regional comparisons, methodological approaches, and statistical analyses.

Contrary to some reports which mistakenly classify Tajikistan alongside areas with elevated fluoride levels like Estonia, Moldova, and certain regions of the Russian Federation, our studies confirm that many regions in Tajikistan actually fall into the category of endemic areas with fluoride deficiency. This is except for areas near the aluminum plant, which experiences anthropogenic pollution from fluoride compounds such as hydrogen fluoride and solid fluorides.

The chemical makeup of surface waters in Tajikistan, reflective of Central Asia at large, is defined by natural factors and exhibits regional specifics. It is characterized by either an excess or a deficit of macro- and micro-elements, including notably low levels of iodine and fluoride. This has been linked to prevalent iodine deficiency disorders and dental caries among the population.

Water for drinking and utility purposes in many regions of Tajikistan, particularly in the Khatlon region and other areas, is marked by insufficient fluoride content. For instance, average annual fluoride concentrations in the Bohtar region's water supply network ranged around 0.13±0.09 mg/L, indicating a widespread fluoride deficiency across different water sources, including centralized and non-centralized water supply systems.

The study reveals significant seasonal and regional variations in fluoride content. For example, the highest fluoride concentration observed in the Bohtar region during the autumn was 0.14 mg/L, which did not exceed the Maximum Allowable Concentration (MAC). Similarly, fluoride concentrations in various water samples, whether from centralized or non-

centralized sources, generally stayed below the MAC, showcasing a consistent deficiency across the board.

The statistical treatment of collected data employed the Kolmogorov-Smirnov and Shapiro-Wilk tests to assess the normality of fluoride distribution across different water sources. It was found that fluoride distribution did not follow a normal distribution, indicating the need for non-parametric statistical methods for further analysis. The study also highlighted statistically significant correlations between fluoride content and water sources, underscoring the heterogeneous distribution of fluoride across the region.

The study underscores a critical public health issue – the widespread fluoride deficiency in drinking and utility water across Tajikistan. This condition is particularly acute in regions away from industrial pollution sources like aluminum plants. Considering the climatic variability and regional dietary habits, this deficiency poses a considerable risk for dental health, necessitating interventions to ensure adequate fluoride intake for the population.

Study on the Impact of Fluoride on Children's Health

The analysis of the population's exposure to different fluoride levels was conducted by correlating data obtained from fieldwork, which determined fluoride content in drinking water, with information about each water source and the corresponding population using water from that specific source.

Our study covers a significant part of the population of Khatlon region and Tursunzade city, where 30% and 59.9%, respectively, have access to centralized water supply systems. The rest of the sample consisted of sources from a distributed system. Half of Tursunzade residents receive drinking water from surface water with low fluoride content (0.47 mg/l), while the other half consume groundwater with optimal fluoride content. The second largest settlement, Seshanbe, in the city of Tursunzade, received water with an optimal fluoride content, mainly from underground sources. Residents of the control zone received groundwater with a low fluoride content.

A significant portion (76.1%) of Tursunzade's residents (44,124 individuals) was exposed to optimal fluoride levels (0.5–1.5 mg/L) in their water supply. A smaller population segment (21.9%, 12,690 individuals) consumed water with low fluoride levels (<0.5 mg/L), and water with high fluoride content (>1.5 mg/L) was consumed by 1,177 individuals, representing 2.0% of the population.

The study on the prevalence of dental caries and dental fluorosis was conducted among 12-year-old schoolchildren born and living in Tursunzade and Bohtar, where the fluoride concentration in drinking water varied significantly from one locality to another.

The oral examination and sociological study results showed that out of 224 surveyed 12-year-olds in Tursunzade (161) and Bohtar (63), 19 children in Tursunzade were found to have mild degrees of dental fluorosis. It is essential to note that no cases of moderate or severe fluorosis were identified in the target cities. Notably, fluorosis was not detected in Bohtar during the fieldwork.

The research highlighted a significant dependency between the level of fluoride in drinking water and the number of children with dental fluorosis. The prevalence of fluorosis tended to increase with the concentration of fluoride in the drinking water (r = 0.87). The Navobod community, with the highest average water fluoride concentration, saw a more than fivefold increase in fluorosis prevalence among children compared to the Pakhtaobod community, where the water fluoride concentration was the lowest.

The risk assessment utilized baseline data from the study, specifically the correlation between dental fluorosis and caries and the fluoride content in drinking water. Among all surveyed children in Bohtar (63), 48 had light dental caries, accounting for a 76.2% prevalence rate.

In Tursunzade (161), 19 children had light dental fluorosis, accounting for an 11.8% prevalence rate, and 21 children had light dental caries, marking a 13% prevalence of this pathology.

No fluorosis was observed in areas with low fluoride (<0.5 mg/L). Fluorosis prevalence in Tursunzade was noted with its increase in drinking water containing optimal fluoride levels (1.0–1.5 mg/L), suggesting a direct correlation: as fluoride levels in drinking water rise, so does the prevalence of dental fluorosis.

A strong positive correlation (r=0.87) was found between the fluoride content in drinking water and the prevalence of dental fluorosis.

High fluoride content in drinking water represents excessive exposure that can be avoided. This study stage focused on the population risk. Risk indicators for acquiring the disease were compared with the exposure group's risk, exposed to drinking water fluoride levels of 0.50–1.5 mg/L. The risk (expressed as odds ratio) of dental fluorosis was calculated according to 3 exposure categories based on the World Health Organization's recommendation. The

probability of developing dental fluorosis in the exposure category of 0.51 to 1.50 mg/L was 2.1 times higher than when the exposure was below the limit of 0.50 mg/L.

Discussion

In the context of technological progress and increased stress for humans, the impact of unfavorable socio-economic factors, observed in almost all countries, including the Republic of Tajikistan, plays an important role in maintaining the health of the population. Children are especially sensitive to the negative impact of environmental factors. It has been established that eliminating or minimizing environmental pollution factors, considering a number of tasks to optimize the water supply and sanitation system, organizing optimal and nutritious nutrition help to increase the body's resistance to the harmful effects of the environment.

Fluoride, one of the chemical elements most often found in contaminated areas, poses a serious threat to human health. Fluorine is an important trace element necessary for maintaining the structure and functioning of dental bones, and its physiologically required amount is very close to the dose that has a toxic effect. The main source of fluoride in the human body is drinking water and food. Many studies conducted in the 20th century have shown that insufficient consumption of fluoride leads to the development of caries, and an overdose leads to fluorosis. Currently, the problem of the impact of excess amounts of fluoride on human health is not underestimated and remains relevant. The problem of complex consumption of fluoride, along with other chemicals, is of scientific interest.

According to numerous studies conducted in the second half of the 20th century, insufficient levels of fluoride in drinking water were found in many areas of Tajikistan, with the exception of the area of the city of Tursunzade, where the Tajik aluminum plant is located, whose residents had a high incidence of fluorosis. In this context, the study of sanitary The hygienic condition of water and gas supply systems plays an important role, since this area has not yet been studied and makes it difficult to carry out sanitary assessments of water chemistry. This has increased the need for broader research to study the condition of water supply and sewerage systems, the lack or excess of fluoride in the environment, and the cause-and-effect relationship between caries and the frequency of flu orosis, and a number of preventive measures have been developed.

Currently, 67.3% of the republic's population is provided with centralized drinking water, and 95.3% of the urban population is provided with centralized drinking water. At the same time, only 42.1% of the remote rural population has access to a centralized and safe water supply, and 51.9% uses water from unprotected sources. The population of the Bokhtar district is 2,126,494 people, of which only 30% are provided with tap drinking water, and the rest (70%) use water from open sources (rivers, canals, irrigation ditches, etc.). Previous similar studies assessing water supply in GBAO show that 18.7% of the population of GBAO is provided with drinking water, which is compared with the results of our research. According to our research, in the municipal water tap of the centralized drinking water supply system there are poor sanitary conditions and there is no water meter. However, many rural water supply systems do not purify or disinfect the water, and there is no laboratory control of water quality. This is shown in the picture. But in some rural areas, such as Vakhsh, Qubadieni Vakhdat, the population independently maintains and even expands existing water use systems. Of the 125 operating water systems in the Bokhtar district, 63% do not meet sanitary and hygienic requirements, and 69 water supply systems do not work due to wear and tear of the distribution network. The lack of high-quality drinking water in most rural settlements of the Bokhtar district is due to both a lack of water and the unsatisfactory condition of the infrastructure. A relatively good situation with the functioning of the water supply system was revealed during a similar study, in which 16 out of 10 water supply systems of the GBA were in working order.

In the most remote areas of the Bokhtar region, such as Jami, Panj, fresh groundwater is absent or partially absent. Almost 97% of the population in the Jaikhun and Vakhsh regions use surface water (rivers, canals, ditches) as a source of water supply. Fountain N. It is used as a source of water supply for 30.0% and 11.4% of the population of the Khusravi-Nurek districts. In the Dustian region, where About half of the population (48.0%) uses imported water for food, and stricter conditions regarding water supply will be observed in the near future. 3 out of 1(27.2%) population of Khorasan region use well water as a source of fresh water and 25.9% use rainwater. The population of Qubadiensky (66.9%), Shakritsa (42.6%), Kushoninsky (35.5%) and Panjsky (31.6%) districts use groundwater using hand pumps (tube wells). It should be noted that about 40% of the population of the Bokhtar district uses water from irrigation canals flowing in its territories as the main source of drinking water. The results of our research

are consistent with the results of similar studies conducted by Tajik scientists in the Republic of Tajikistan.

Currently, in the Republic of Tajikistan there are no production enterprises that pollute the atmosphere of populated areas with various fluoride compounds, with the exception of the giant non-ferrous metallurgy – an aluminum plant located in the densely populated region of the Gissar Valley in the city of Tursunzade.

Some authors mistakenly classify the Republic of Tajikistan, along with some countries, as zones with high fluoride content in drinking water. However, it has been proven that many areas of Tajikistan belong to endemic areas with limited fluorine content, with the exception of areas with aluminum smelters, where anthropogenic pollution of the environment with fluorine compounds is observed. The maximum amount of fluoride in the UK in the spring experimental zone (jamoatnavobod) exceeded the maximum permissible concentration in the western direction. The direction ranged from 0.01 to 1.0 mg/m3 and did not exceed the MPC value. In the control zone (jamoat Jura Rakhmonov) there were no necessary external substances, with the exception of hydrogen fluoride, which in the fall did not exceed the MPC.

When the wind direction from the side of the aluminum smelter changed from west to north and northeast, as well as the average content of hydrogen fluoride and hydrofluoric acids, both in spring and autumn, was from 0.001 to 0.06 mg/m3 and from 0.01 to 1.2 mg /m3. 0001 to 0. It was decided from 08 mg/m3 to 0.01-0.2 mg/m3. In atmospheric studies from the selected control zone in the city of Tursunzaden, no fluorine compounds were detected. The results of atmospheric studies in 15 cities and districts of the Bokhtar region showed a complete absence of hydrofluoric acid in all visible atmospheric samples. Minor traces of fluorine compounds, amounts from 0.0001 to 0.002 mg/m3, were found in Kubodien K, ushonien, Yavane, N. They were found in the areas of Khusrawa and the city of Levakant.

The overall negative effects of fluoride can vary significantly by region. In turn, this depends on the fluoride content in drinking water, food products and other environmental objects. The results of research by scientists such as Buzalaf M.A.R. and Levy S.M. The fact is that the leading producer of fluoride is drinking water. In our studies, the fluoride content in water concentration, the fluoride concentration in all studied water samples of Bokhtarsky was below the MPC and fluctuated over a wide range: 0.01–0.45 mg/l with an average value of 0.13 mg/l. In 1148 (92.2%) samples the fluoride content was below

0.3 mg/l. A relatively deeper situation with fluoride content in water was found in the Khorasan region, where its maximum content in water was 0.09 mg/l. Correlation analysis on a scale with seasons revealed a difference in the fluorine content in water in autumn with statistical significance (p<0.001). The population of the Yavan and Pyanj regions, consuming water from centralized municipal and departmental water supply systems, respectively consume water close to the normal fluoride content in drinking water of 0.41 mg/l – 0.43 mg/l, respectively. The most significant situation with low fluoride content in the water of centralized systems with departmental water supply was noted in the Dusti and Khorasan regions, where the maximum fluoride content in the water was 0.02 mg/l, respectively. The concentration of fluoride in water samples detected from open water sources does not exceed 0.19 mg/l at an average temperature throughout the Bokhtar region of 0.11 mg/l. The population of the Pyanj and Kushoniyon regions consume water from closed water sources with a high concentration of 0.44 and 0.45 mg/l, respectively, which is a relatively low figure for the entire region. The results of the analysis confirmed that fluoride levels were lowest in NCSOI compared with CSCW (p<0.001), CSCWW (p<0.001) and NCSZI (p<0.001). The highest level of fluoride content was observed in NCSZI (0.18 [0.10, 0.27]), however, when analyzing the CSCW and CSCWW indicators, no statistically significant signs were found (p>0.05).

The average annual fluorine content in water samples from the village of Tursunzade ranged from 0.43 to 1.50 mg/l, with an average value of 1.04 mg/l, and the highest concentration of fluorine (1.52 mg/l) was found in the fall in jamoat Navobod (village Shodien). However, the concentration of fluoride in water samples taken from closed springs (wells) on the territory of the aluminum smelter was slightly higher than in other sources. This indicates that fluorine compounds deposited on the soil surface move along its profile, polluting groundwater. The population of Navobod jamoat (experimental zone) consumes water with a maximum concentration of 1.50 mg/l, while the minimum concentration of fluoride in water was found in Pakhtaobod jamoat (experimental zone). In the control zone located east of the plant (jamoat J.In, water samples were taken from the Rakhmonov spring), at different times of the year fluorine was detected in amounts ranging from 0.39 to 0.60 mg/l, not exceeding the maximum permissible concentration.

Our study showed that in growing aquatic products selected as a sample for research in the village of Tursunzade, the fluorine content ranged from 0.39

to 1.99 mg/kg. 0.19 mg/kg. Jamoat Nasvoboda was recognized as the most relatively polluted zonal settlement in Tursunzoda, with a low content of fluorine in food products. It was found that fluorine-containing samples collected in the control direction of the eastern wind were the poorest. Considering that fluorine was found in the external environment of several settlements in the experimental city of Tour at Sunset Yes, we can say with confidence that the actual level of environmental pollution with fluorine represents the current risk to the health of the population of these places. Region. When studying the target cities and districts of the Bokhtar region, the fluorine content in products of plant and chicken origin remained practically unchanged and remained below the MPC.

A statistically significant difference in the level of fluoride content in food products between zones was established. It should be noted that dynamic observation in the zone of harmful effects of aluminum smelters on fluorine content over a certain period of time in various environmental objects (selected experimental zone of the city of Tursunzade) revealed a slight dynamic accumulation of this element in them, but its content was higher than in other regions. However, in this regard, it is necessary to establish a quantitative relationship between the degree of environmental pollution and the health status of the population living in these areas by conducting targeted studies to establish daily fluoride intake by studying actual nutrition.

A study conducted in Iran showed that the influence of drinking water on total fluoride exposure can vary from 70 to 90% depending on the level of fluoride in drinking water. Analysis of the impact of different levels of fluoride in water in the population showed that the total fluoride exposure of residents of Tursunzaden was at the optimal level (0.5-1.5 mg/l) fluoride content was 76 .1% (44,124 people). Residents have a low fluoride content in water (<0.5 mg/l) was consumed by a minority of the population (21.9%, 12,690 inhabitants), and water with a high fluoride content (>1.5 mg/l) -1177 people, which is 2.0%. The vast majority of the population of Bokhtar consumes water with a very low fluorine content (less than 0.50 mg/l) in the input. Consequently, as research results show, poisoning of the human body with fluorine compounds in the artificially exposed area of the aluminum smelter in the city of Tursunzade occurs due to water and food. Our data are relatively consistent with the results of research by many Tajik scientists.

The results of studies of the prevalence of dental diseases among various segments of the population conducted in Tajikistan in the 1980s revealed that the prevalence of caries in temporary and permanent teeth among children aged 7-17 years in the city of Dushanbe ranged from 76 to 90%. The highest rates were recorded in children aged 7-9 years: from 87 to 90%, and in children aged 15-17 years: from 81 to 85%. In the process of work, an analysis of the incidence of fluorosis and caries among schoolchildren in the cities of Bokhtar and Tursunzade was carried out, which revealed a strong correlation between the level of fluoride in drinking water and the incidence of disease. The prevalence of mild fluorosis among schoolchildren in the city of Tursunzade was 11.8%, of which 6.2% were boys, 5.6% were girls, with a significant portion (43%) living in areas with optimal fluoride content. The prevalence of various stages of dental caries among children was 13% in the city of Tursunzade and 76.3% of children in the city of Bokhtar. The results of our research are consistent with other studies, however, Tajik scientists state a very high prevalence of caries among 7-year-old schoolchildren in the city of Tursunzade. The intensity of caries according to DMFT data among children aged 7-15 years in the city of Tursunzade was 1.12. A high prevalence among children was also revealed by Mirzoev M.Kh., where the prevalence of caries among children aged 15 years reached absolutely high levels (96.3%) due to the lack of preventive measures at the proper level. In Navobod jamoat, where the average fluoride concentration in water was the highest, the prevalence of fluorosis among children was more than five times higher than in Pakhtaobod jamoat, where fluoride concentration in water was lowest.

Factor analysis revealed an insignificant correlation between the level of fluoride in drinking water and the number of children with caries and fluorosis. It should be noted that the prevalence of fluorosis tended to increase with increasing fluoride concentrations in drinking water, and the prevalence of dental caries tended to increase with decreasing fluoride concentrations in drinking water. There was a strong positive correlation (r=0.87) between fluoride levels in drinking water and the prevalence of fluorosis. The results of our study are consistent with the results of similar studies conducted by Tajik scientists in the Republic of Tajikistan among children aged 7 years, which revealed a cause-and-effect relationship between dental caries and fluoride content in drinking water depending on the climatic and geographical zone. Thus, in the city of Tursunzade, which was supplied with drinking water with a fluorine content of up to 2 mg/l, the prevalence of varying degrees of fluorosis among

children aged 6 years was up to 25%, and among children aged 15 years up to 30%. It should be noted that the DMFT index in older children did not differ from children living in the Rudaki region and the city of Dushanbe, where there was a lack of fluoride. In the cities of Tursunzade and Dushanbe, an increase in the DMFT index among children aged 6-15 years was noted: in Tursunzade up to 2, in the capital – 3, respectively. Among schoolchildren in the city of Bokhtar, with insufficient fluoride content, dental caries is mainly diagnosed, and in the city of Tursunzade, with a relatively high fluoride content, fluorosis is diagnosed. The likelihood of developing fluorosis in the 0.51 to 1.50 mg/L exposure category is 2.1 times higher than for exposures below the 0.50 mg/L limit. Similar studies conducted by Tajik scientists in the city of Bokhtar revealed an increase in the prevalence of caries among the population aged 40-49 years from 74 to 80%, and the DMPT index from 4 to 8. Issues of reducing the prevalence and prevention of caries dental caries is recorded in national programs, in In connection with this, Tajik scientists have conducted a number of studies, in particular, they have considered the implementation of treatment and preventive programs involving the use of fluoride-containing drugs before and after the eruption of both temporary and permanent teeth, differentiated sanitation of the oral cavity and active sanitary educational work, which were carried out at the end of the twentieth century. century in the city of Khujand, led to a decrease in the prevalence of caries among children from 97 to 95%.

Conclusion

The health of the population, particularly children, in the Republic of Tajikistan is significantly impacted by unfavorable socio-economic factors and environmental pollution, especially concerning fluoride contamination. Fluoride, while essential in small amounts for dental health, poses a significant health risk when present in excessive amounts.

In Tajikistan, various studies have revealed both insufficient and excessive levels of fluoride in drinking water across different regions, leading to dental caries and fluorosis, respectively.

Centralized water supply is inadequate, especially in rural areas, resulting in a reliance on unprotected and potentially contaminated water sources. In regions like Bokhtar and Tursunzade, studies show a prevalence of dental diseases correlating with fluoride levels in water. Tursunzade, impacted by emissions from an aluminum plant, exhibits higher fluoride levels and corresponding higher rates of fluorosis among children. Conversely, areas with low fluoride levels, such as Bokhtar, have high rates of dental caries.

Addressing these issues requires improved water purification systems, consistent monitoring of fluoride levels, and preventive healthcare measures. This includes public health initiatives focused on optimizing water supply and sanitation, providing nutritious diets, and implementing fluoride management programs to mitigate the dual burdens of dental caries and fluorosis. Through these efforts, the overall health and resistance of the population to environmental hazards can be significantly enhanced.

Competing interests

The authors declare that they have no competing interests.

Acknowledgments

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A STUDY TO COMPARE INTRAVENOUS NITROGLYCERINE AND MAGNESIUM SULPHATE FOR ATTENUATING THE HAEMODYNAMIC STRESS RESPONSE TO LARYNGOSCOPY AND ENDOTRACHEAL INTUBATION

The article is devoted to monitoring the condition of the respiratory tract during general anesthesia, which is the most important duty of an anesthesiologist. Despite advances in airway monitoring devices, rigid laryngoscopy and intubation remain preferred methods. Airway treatment during intubation causes a hemodynamic reaction due to stimulation of the upper respiratory tract, which leads to an increase in catecholamine levels, which leads to hypertension, tachycardia and rhythm disturbances. This reaction reaches its maximum immediately after intubation and usually lasts 5-10 minutes. Despite the successful use of both nitroglycerin for intravenous administration and magnesium sulfate for this purpose, there is currently no direct comparison of these two drugs in the literature with respect to attenuation of hemodynamic changes during laryngoscopy and intubation. Therefore, our research is aimed at conducting such a comparative study. The study was a double-blind, prospective, randomized study involving sixty patients aged 18 to 60 years who were scheduled for surgery requiring general anesthesia and endotracheal intubation, with the status of asa I and II.Both intravenous administration of MgSO4 (30 mg/kg) and NTG (1 mcg/kg) were effective in attenuating the pressor reaction caused by laryngoscopy and endotracheal intubation. However, MgSO4 was significantly superior to NTG in reducing heart rate.

Key words: Airway management, general anaesthesia, nitroglycerine, magnesium sulphate, haemodynamic stress.

Introduction

Airway management during general anaesthesia is a crucial responsibility of an anaesthesiologist. Despite advancements in airway devices, rigid laryngoscopy and intubation remain the preferred technique [1,2]. Airway handling during intubation causes hemodynamic response due to upper airway stimulation, leading to increased catecholamine levels which results in hypertension, tachycardia, and rhythm disturbances. This response peaks immediately after intubation and typically lasts 5-10 minutes [3,4]. While healthy individuals generally tolerate this response, hypertensive patients or those with ischemic heart disease are at higher risk of complications like myocardial ischemia, intracranial pressure changes, hemorrhage, and cardiac failure [5]. Pharmacological strategies to mitigate this pressor response include topical or intravenous lignocaine, opioids (e.g. fentanyl, alfentanil, remifentanil), alpha- and beta-adrenergic blockers (e.g. esmolol), calcium channel blockers (e.g. diltiazem and verapamil), vasodilators (e.g. nitroglycerine), and alpha-2 agonists (e.g. clonidine, dexmedetomidine). Magnesium sulphate, traditionally used in eclampsia, has emerged as another option to reduce the pressor response of intubation by inhibiting catecholamine release. This mechanism reduces serum epinephrine levels, decreasing atrial contraction, bradycardia, and vasodilation [6, 7]. Nitroglycerine, acting on vascular smooth muscle, induces dilatation of veins and arterioles. Due to its rapid metabolism and non-toxic nature, it has been effectively utilized to mitigate the pressor response triggered by airway handling during intubation at doses of 1 mcg/kg and 2 mcg/kg [8]. Despite the successful use of both intravenous nitroglycerine and magnesium sulphate for this purpose, there is currently a lack of direct comparison in the literature between these two agents in blunting the hemodynamic changes during laryngoscopy and intubation. Therefore, our study aims to conduct such a comparative investigation.

Methods

We conducted a double-blind, prospective randomized trial and enrolled sixty patients who were planned for any surgery requiring general anaesthesia administration and endotracheal intubation in ASA status I and II in the age group of 18 to 60. The Institutional Ethics Committee approval was obtained, and patients' enrolment was started after that. Exclusion criteria encompassed declining to participate, those with anticipated difficult airways, seizure disorders, BMI > 30 kg/meter square, drug allergies, and individuals with poor cardiopulmonary reserves. Additionally, patients taking antidepressants, antipsychotics, beta-blockers, or antihypertensive medications, as well as pregnant patients, were excluded from the study.

The purpose of the study and protocol were thoroughly explained to all the patients and informed written consent for participation in the trial was taken. Fasting instructions were given to patients as per the latest institutional policy which is six hours for solid food and two hours for clear fluid before the scheduled surgery. The night before the surgery, they were premedicated with an orally administered tablet of alprazolam (0. 25 mg) and pantoprazole (40 mg). Baseline readings of vital parameters were recorded upon arrival of the patient in the operating room {B1}. Patients were randomized using computer-based randomization into two groups of 30 patients each. Group 1 received intravenous magnesium sulphate (MgSO4) at a dose of 30 mg/kg in 10 ml of saline over 5 minutes before induction. Group 2 patients received intravenous nitroglycerine (NTG) at a dose of 1 mcg/kg in 10 ml of saline over the same duration before induction. Throughout the drug infusion, all patients underwent pre-oxygenation for 3 minutes. Following the completion of the infusions, standard anaesthesia techniques were employed for induction in both groups, involving the administration of fentanyl, thiopentone sodium, and vecuronium. Subsequently, direct laryngoscopy was performed using Macintosh blade, and endotracheal intubation was performed by an experienced anaesthesiologist, followed by connection to the ventilator. Study parameters were recorded at baseline, post-drug administration, pre-laryngoscopy, and at 1 minute (T1), 3 minutes (T3), and 5 minutes (T5) after intubation. Anaesthesia maintenance was achieved using a combination of nitrous oxide in oxygen (50:50) and sevoflurane titrated to 1 MAC. Upon completion of the surgical procedure, residual neuromuscular blockade was reversed with neostigmine and glycopyrrolate, followed by extubation.

Data was entered into a Microsoft Excel spreadsheet and statistical analysis was performed using IBM SPSS Version 25. Descriptive statistics, including percentages, means, and standard deviations, were computed. Kolmogorov-Smirnov test was used to assess Normality of data. The unpaired t-test was utilized for quantitative data comparison between two independent observations, while the chi-square test was employed for qualitative data comparison of all clinical indicators. $P \leq 0.05$ was considered significant.

Results

The baseline status of the enrolled patients in the two groups is depicted in Table 1. There was no significant difference observed between the two groups in terms of age, sex, body mass index (BMI), or difficulty of intubation assessed preoperatively by mallampati grading (MPG).

Table 1 – Baseline status of enrolled patients

	Magnesium group	NTG group	P value
Age (Mean ± SD)	32.7 ± 12.7	35.4 ± 13.2	0.42
Males (%age)	46.7 %	40 %	0.6
Females (%age)	53.3 %	60 %	
BMI (mean ± SD)	23.7 ± 2.3	25.1 ± 6.7	0.29
ASA status (n)			
Status I	19	12	0.07
Status II	11	18	
MPG grade (n)			
Grade I	11	8	0.21
Grade II	17	22	
Grade III	2	0	

The heart rate in both groups was similar at baseline, after administering the study drug, and before laryngoscopy. However, there was a statistically significant decrease in heart rate in Group 1 (Magnesium sulphate group) when compared to Group 2 at 1, 3, and 5 minutes after intubation (Graph 1). Similarly, we found that there was lower systolic, diastolic and mean blood pressure after intubation at 1, 3 and 5 minutes in Magnesium sulphate group (Group 1) when compared to the nitroglycerine group (group 2) which was statistically significant. Also, in both the groups the blood pressure values were similar statistically at baseline, after giving the drug, and before laryngoscopy. (Graph 2,3, and 4)
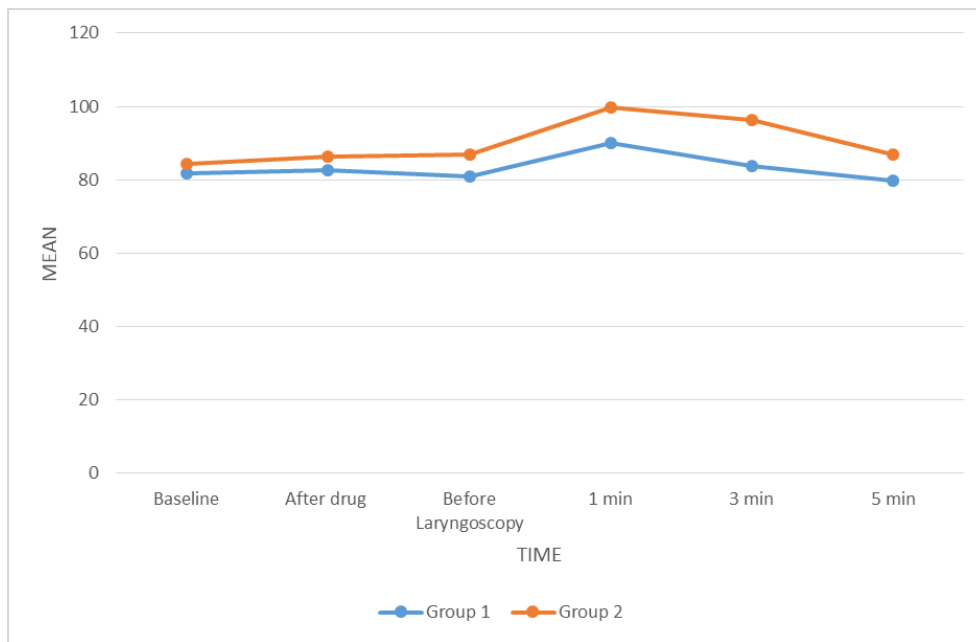
Graph 1 – Statistically significant decrease in heart rate
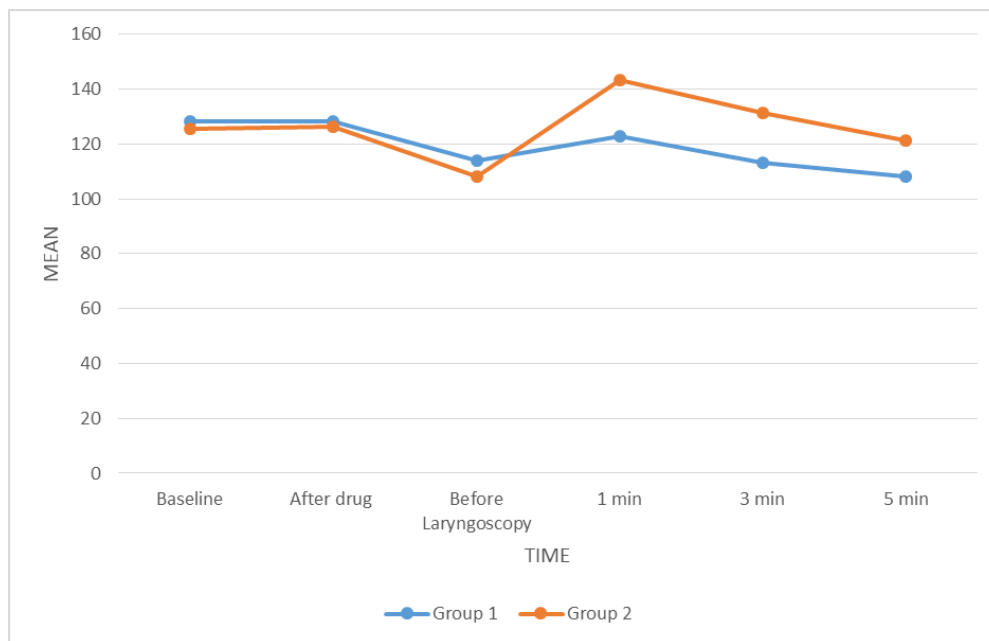
Graph 2 – The blood pressure values the group that took nitroglycerin
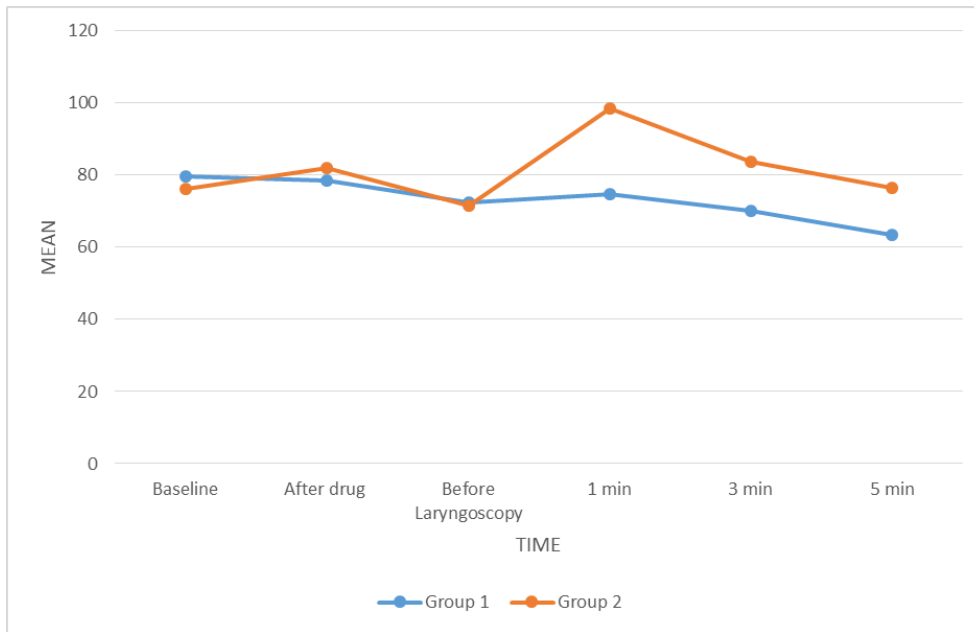
Graph 3 – The blood pressure values after giving the drug
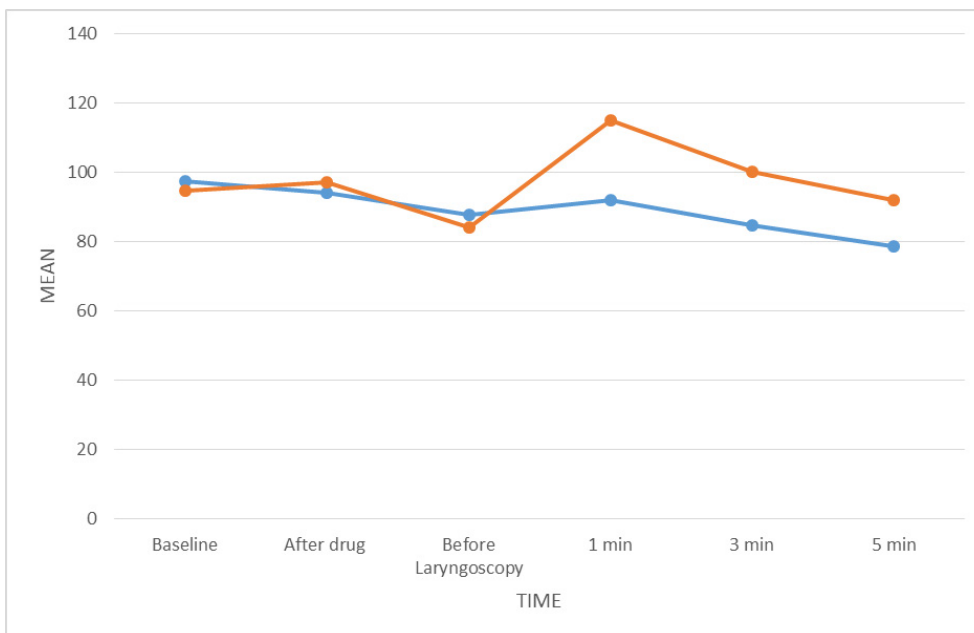
Graph 4 – The blood pressure values before laryngoscopy

Discussion

Laryngoscopy and intubation often trigger a sympathetic pressor response, resulting in approximately a 20% increase in heart rate and a 40-50% rise in blood pressure. Healthy patients typically tolerate this response well however, hypertensive individuals may suffer from such hypertensive effects which may cause episodes of MI, arrhythmia, or intracranial events. Therefore, it is highly desirable to attenuate this pressor response to airway manipulation in such high-risk patients. [10] Intravenous magnesium sulphate (30-50 mg/kg) has been extensively studied and effectively utilized to mitigate the hemodynamic stress response to laryngoscopy and intubation. Similarly, intravenous nitroglycerine (1-2 mcg/kg) has

also been shown in numerous studies to blunt the hemodynamic stress response.

Despite their effectiveness, there has been no direct comparison between intravenous nitroglycerine and magnesium sulphate on the pressor response associated with laryngoscopy and endotracheal intubation. Thus, we conducted this study to compare magnesium sulphate and nitroglycerine in this context.

Our findings reveal that intravenous MGSO4 is superior to NTG for blunting the pressor response associated with laryngoscopy and endotracheal intubation as we found in this trial that patients who received MGSO4 experienced greater attenuation of stress response as compared to those who received NTG.

Our findings align with the results of a study done by Nandal S et al., where MGSO4 was demonstrated to effectively blunt the pressor response due to airway manipulation caused by laryngoscopy. They administered MGSO4 in a dose of 30mg/kg and 40mg/kg prior to anaesthesia induction. They observed that compared to baseline values, the increase in HR and BP associated with the laryngoscopy and intubation was not significant in all the groups. So, they concluded in their trial that magnesium sulphate in the dose of 30mg/kg effectively controls the hemodynamic stress response during intubation [9].

Kasar et al., compared intravenous MGSO4 and lignocaine for the blunting of haemodynamic response to laryngoscopy. Statistically significant reduction in HR was observed at an interval of 1, 3, and 5 minutes after intubation in the MGSO4 group [10]. Similarly, Jain P et al. found that MGSO4 significantly attenuates the stress response associated with laryngoscopy and nasotracheal intubation [11]. Kiran KN showed that MGSO4 significantly blunts the stress response following the laryngoscopy and endotracheal intubation. MGSO4 was given in a dose of 50 mg/kg intravenously 60 seconds prior to intubation. Mild transient tachycardia was there in study group which settled back to near preinduction values. Similarly, in our study HR settled back to baseline values in the magnesium group [12]. The findings of our study align with results demonstrated by Kesar et al, and Kiran et al. Our findings are also in coherence with Azim H et al, who studied the effect of different doses of intravenous MGSO4 on laryngoscopy-associated haemodynamic response. Variations in HR were not significantly reported amongst groups in the study. However, changes in SBP, DBP and MAP were found to be significantly lower at 1, 3 and 5 minute intervals in the group who received magnesium sulphate compared to the control group.[7]

Our findings are in contrast with those of Kotwani DM et al., who compared intravenous MGSO4 and NTG spray via sublingual route for blunting the hemodynamic stress response during laryngoscopy. They found that heart rate and BP in both groups increased during laryngoscopy however the difference was statistically not significant at any time points. Thus, author concluded that intravenous magnesium sulphate and sublingual nitroglycerine spray are equally effective for blunting of pressor response to laryngoscopy. [6]

The action of MGSO4 involves several mechanisms:[10]

1. Inhibits neurotransmitter release at the presynaptic level in a dose-dependent manner.

2. Physiological and pharmacological NMDA blocker action in neuronal tissue.

3. Smooth muscle relaxation, peripheral vasodilation, and decreased vascular resistance, thus promoting hemodynamic stability.

4. Decreases catecholamine release from adrenergic nerve terminals.

5. Antiarrhythmic properties.

In our study, we did not observe any adverse event in any of the patients in either group. However, our study had several limitations; first of all, we did not included high risk ASA status III and IV patients in our trial. We also did not included anticipated difficult airway patients, including MPG IV; and also did not measured the laryngoscopy duration in our study. There is a propensity for increased duration of laryngoscopy including multiple attempts at intubation in difficult airway cases which would have an exaggerated impact on the haemodynamic stimulation. In the wake of above limitations, the results of our study are not generalisable to all groups of patients. We also did not use any anaesthesia depth monitor before attempting laryngoscopy. Patients at different depths of anaesthesia would have different levels of haemodynamic stimulation with a lighter depth of anaesthesia patients having higher stimulation.

Conclusion

Both intravenous MgSO4 (30 mg/kg) and NTG (1mcg/kg) were effective for attenuation of pressor response caused by laryngoscopy and endotracheal intubation. However, MgSO4 was significantly superior to NTG in attenuating heart rate, systolic BP, diastolic BP, and mean arterial pressure variations associated with the laryngoscopy.

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COOPERATION OF NURSING STAFF AND THEIR SATISFACTION WITH WORK IN THE HOSPITAL OF A MEDICAL ORGANIZATION

A "team" in healthcare is traditionally referred to as an interdisciplinary team. Studying this particular professional group is important to understand how teamwork exists among those who provide most of the patient care. Communication skills contribute to the development of interpersonal relationships. Improving the quality of communication between participants in the healthcare system is a global priority and can contribute to better diagnosis and treatment.

The purpose of the study: to study the relationship of interpersonal communication with the degree of job satisfaction of a nurse among nurses.

Meterials and methods. Design is an observational cross–sectional study using analytical statistics methods. Data collection was carried out using a survey (using the on-line Google Form server), in one of the State Clinical Hospitals in Almaty, in 2023. 281 nurses participated in the study. The questionnaire developed by us is an assessment of the strategy of behavior of nurses in the event of a conflict situation) It was carried out using Pearson's chi-square criterion and/or Fisher's exact test, with the calculation of relative risk (RR), as well as binary logistic regression. In addition to these basic methods, the following tests were used for analysis: single-sample binomial criterion and single-sample chi-square criterion. The null hypothesis was rejected in the case of $p < 0.05$.

Results and discussion. In general, the proportion of nurses who were satisfied and dissatisfied with their work was 39.86% (n=112) and 60.14% (n= 169), respectively. The asymptotic significance of a single sample binomial criterion was p=0.001, which indicates the reliability of differences in proportions. Among the nurses dissatisfied with their work (n=169), the following prevailed: older sisters ($\chi2 = 40.645$, $p \leq 0.001$), sisters with less work experience ($\chi2 = 90.941$, $p \leq 0.001$) and sisters engaged in practical activities ($\chi2 = 83.568$, $p \leq 0.001$). The results obtained indicate the presence of a statistically significant association of the level of satisfaction of nurses with work activities with such characteristics as "team cohesion" (RR=8,050, $p \leq 0.001$), "the level of trust in the team" (RR=3,470, $p \leq 0.001$), "friendly and business criticism in the team" (RR=3.393, p=0.004), "free expression of opinion in the team" (RR=12.285, $p \leq 0.001$), "the emotional attitude with which you usually come to work" (RR=4.442, p=0.003) and "the moral and psychological climate in the team" (RR=7.068, $p \leq 0.001$).

Key words: collaboration, job satisfaction, nurse.

Introduction

The "team" in healthcare is traditionally perceived as an interdisciplinary team, and nursing teams are rarely considered in the literature. Studying this particular professional group is important to understand how teamwork exists among those who provide most of the patient care [1]. To date, there are few known studies that could provide a comprehensive analysis of teamwork typical of nurses [2]. There is information that teamwork increases the productivity of nursing, improves the satisfaction of nurses and significantly contributes to

the optimal quality of patient care [3]. Collaboration in the teamwork of nurses will be no exception, as it is known that the nurse and nursing work in the general medical work of the hospital is an important part of the clinical service [4]. It is cooperation that combines issues such as the exchange of experience, negotiation and understanding, trust, equality and respect. A fundamental component of collaboration is collegiality, in which communication and teamwork skills are considered key levers of successful team work. And the success of cooperation largely depends on mutual understanding, dedication to a common cause, interpersonal communication skills and

trust. Communication is considered one of the most important and effective tools, simple and accessible to use, which is based on mutual understanding, the ability to effectively negotiate, capable of improving the quality of teamwork and the quality of medical care [5].

Communication skills are of particular importance in human-centered professions and nursing practice will be no exception. Effective communication has a number of positive aspects such as high-quality diagnostics, creation of an optimal working environment, time savings, a positive impact on work efficiency, effective workload management and reduction of errors committed by nursing staff, a positive effect on mood, satisfaction of both nurses and patients [6, 7].

And not enough high-quality communication skills of nurses in general teamwork can lead to confusion and a decrease and loss of trust among team members, along with stress, job dissatisfaction and emotional satisfaction [8]. Today, experts agree that effective teamwork ensures safe and effective care at various levels of the healthcare system [9].

The philosophy of nursing teaches that the basic principle of a mid-level medical professional is respect and dedication to their work. Nursing is unthinkable without the responsible formation of caring relationships between nurses. Cooperation issues, as an important component of teamwork, should be important for nursing and adhere to the principle of working harmoniously together with others. This issue is insufficiently covered in the available literature [10]. Several nursing associations, including the International Council of Nurses, consider the possibility of intra-professional cooperation as an important factor in a healthy work environment. Some studies have focused on the organizational characteristics of the nurses' work environment, which had a significant impact on their relationships and job satisfaction. And today, the work environment also plays an important role that promotes open, friendly teamwork and a positive perception of the well-being of nurses, as well as encourages nurses to work together to achieve high-quality and cost-effective care [11].

Thus, communication is one of the many mechanisms that creates a healthy work environment that can provide fertile ground for effective communication and can contribute to increased job satisfaction for nurses [12].

Most of the existing literature on the impact of workspace on teamwork is related to the office environment, although several studies have examined environmental factors in medical institutions. Given the crucial role of teamwork and communication in the provision of medical care, knowledge about the interaction between teamwork and communication among nurses can provide valuable information for healthcare [13].

It is known from research that the quality of medical care is represented by an environment of practical activity, known as a climate, which can be hostile and in practice threaten the quality of nursing care provided by nurses. A favorable working climate is associated with less burnout and exhaustion of nurses, higher job satisfaction, fewer unwanted mistakes, and a higher level of quality of medical care provided by secondary medical personnel [14]. In turn, job satisfaction, workplace support, increased teamwork, as well as an improved spirit of cooperation can reduce staff turnover, which, today, is a significant problem for healthcare [15]. It should also be remembered that the relationship between the positive characteristics of the working environment of nurses with a high level of personal abilities creates a better working environment and contributes to favorable results regarding the health of patients [16].

No studies have been found in Kazakhstan that present results on the impact of various communicative competencies on job satisfaction among nurses, which indicates the relevance of our research aimed at studying the level of communication skills, working conditions of nurses in Kazakhstan, and their readiness to work in a team. The obtained results of this study will help in developing recommendations for improving the work of nurses in a team environment, which will contribute to improving the quality of medical services, organizing convenient conditions for high-quality, productive work of a nurse.

The purpose of this study was to study the relationship between various communication skills (interpersonal interaction) in a nursing team, the moral and psychological climate in the workplace and job satisfaction. And also to provide justification for the development of programs to improve communication skills, increase job satisfaction for better awareness of the peculiarities of interpersonal relations in the staff of nursing staff for the development of a high-quality nursing community and improve the quality of their services.

Materials and Methods

Design is an observational cross–sectional study using analytical statistics methods. Data

collection was carried out using a survey (using the on-line Google Form server), in one of the State Clinical Hospitals in Almaty, in 2023. 281 nurses participated in the study. The calculated minimum required sample size in this study was 248 people, with a population size of 695 people (with a 95% confidence probability). Thus, the sample we are analyzing is representative. The survey model was characterized by the following features: voluntary and anonymous questioning, regional level, sample population, use of "closed-ended questions". Having chosen the theoretical scheme of the study, we received a practical guideline for the selection of questionnaire questions. The questionnaire consisted of two parts: standard "passport" data (questions on clarifying the age of nurses, their type of activity and work experience) and direct questions on the study of communicative characteristics and the indicator of satisfaction with the work of nurses. The questionnaire developed by us was approved by the Ethics Commission of the Al-Farabi Kazakh National University (No. IRB-A637 dated June 22, 2023), and also registered with the patent office (Certificate of entry of information into the state. register of rights to objects protected by copyright No. 36334 dated 05/29/2023). An informed consent was attached to the questionnaire, which outlined all the ethical characteristics of the study. The results were processed using statistical methods in the IBM SPSS Statistics program. The assessment of the associative relationship of the level of satisfaction of nurses with some of the studied characteristics (team cohesion, level of trust in the team, etc., was carried out using Pearson's chi-square criterion and/or Fisher's exact test, with the calculation of relative risk (RR), as well as binary logistic regression. In addition to these basic methods, the following tests were used for analysis: single-sample binomial criterion and single-sample chi-square criterion. The null hypothesis was rejected in the case of $p < 0.05$.

Results and Discussion

The total number of nurses participating in the survey aged "under 30" was 64 people (or 22.78%), 143 people aged "30 to 50" (or 50.89%) and 74 people aged "over 50" (or 26.33%). Among all respondents, 15 people (or 5.34%) have professional experience in the healthcare system up to 1 year, 115 people (or 40.93%) – from 1 year to 10 years, 122 people (or

43.42%) – from 10 years to 30 years and 29 people (or 10.32%) – from 30 years and more. More than 2/3 (234 people or 83.27%) of the surveyed nurses indicated that they were engaged in practical medical activities, 10 nurses (or 3.56%) were administrators (chief nurses) and 37 of the surveyed nurses (or 13.17%) reported other functional activities in the questionnaire.

In general, the share of nurses satisfied and dissatisfied with their work was 39.86% (112 people) and 60.14% (or 169 people), respectively. The asymptotic significance of the single-sample binomial criterion was p=0.001, which indicates the reliability of differences in proportions. Among the nurses dissatisfied with their work (n=169), the following prevailed: older sisters ($\chi2$=40.645, p≤0.001), sisters with less work experience ($\chi2$=90.941, p≤0.001) and sisters engaged in practical activities ($\chi2$=83.568, p≤0.001). Table 1 presents the results of an analysis to assess the associative relationship between the level of satisfaction of nurses and some of the studied characteristics. The results obtained indicate the presence of a statistically significant association of the level of satisfaction of nurses with work activities with such characteristics as "team cohesion" (RR=8,050, p≤0.001), "the level of trust in the team" (RR=3,470, p≤0.001), "friendly and business criticism in the team" (RR=3.393, p=0.004), "free expression of opinion in the team" (RR=12.285, p≤0.001), "the emotional attitude with which you usually come to work" (RR=4.442, p=0.003) and "the moral and psychological climate in the team" (RR=7.068, p≤0.001).

Teamwork in healthcare is considered a difficult task. It is based on the premise that professionals with their own interests are willing to work together. Teamwork brings tremendous benefits to team members, patient care, and healthcare systems. Thus, cooperation occupies a prominent place in many aspects of health care in both low- and high-income countries[17].

Communication in the hospital environment is complex and dynamic due to the huge flow of information, various teams of professionals and numerous complex relationships [18]. The role of nurses is important in the development of teamwork in the healthcare system, capable of influencing both teamwork and interpersonal interaction to improve treatment outcomes in relation to patient health [19].

Table 1 – Communication skills of nurses in teamwork, taking into account their level of job satisfaction

Evaluation of characteristics from 1 to 5 points		Nurses' satisfaction with their work		p-value
		Completely satisfied	Not satisfied and/or partially satisfied	
Team cohesion	score 4-5 points	111	151	p≤0,001
	score 1-3 points	1	18	
The level of trust in the team	score 4-5 points	108	141	p≤0,001
	score 1-3 points	4	28	
Friendly ils business criticism in the team	score 4-5 points	109	148	p=0,004
	score 1-3 points	3	21	
Free expression of opinion in the team	score 4-5 points	111	142	p≤0,001
	score 1-3 points	1	27	
Adequacy of the management style of senior employees	score 4-5 points	65	91	p=0,489
	score 1-3 points	47	76	
Mutual assistance among employees	score 4-5 points	63	89	p=0,555
	score 1-3 points	49	80	
Adequate acceptance of the responsibility of colleagues for the actions performed	score 4-5 points	65	93	p=0,619
	score 1-3 points	47	76	
The emotional attitude with which you usually come to work	score 4-5 points	110	150	p=0,003
	score 1-3 points	2	19	
Professional qualities of the majority of the team members	score 4-5 points	71	107	p=0,989
	score 1-3 points	41	62	
Personal qualities of the majority of the team members	score 4-5 points	70	102	p=0,718
	score 1-3 points	42	67	
The moral and psychological climate in the team	score 4-5 points	110	139	p≤0,001
	score 1-3 points	2	30	

Communicative interaction in the form of high-quality cooperation related to the exchange of information, where mutual respect, the desire to help another plays a primary role, capable of influencing patient safety, professional and personal characteristics of nurses, since they are considered one of the international goals in the field of patient safety established by the World Health Organization [20].

Studies by other researchers have studied the peculiarities of interaction skills between nurses and doctors in various departments, as well as between nurses and patients, relatives of patients. Nevertheless, information that can clarify the structural links between them from all sides and how they affect the satisfaction of nurses remains insufficiently studied [21].

It is known that hospitals do not have any systematic tools or programs to evaluate and improve professional communication and communication values of staff. Accordingly, the present study aims to identify the relationships between the main attributes of interpersonal interaction that correlate with job satisfaction in the nursing team [22]. Thus, this study provides the data needed to develop programs to improve nursing activities or nursing interaction. And we hope that a better understanding of this issue will allow us to develop strategies for the leadership of healthcare organizations, teachers of medical universities and colleges to create conditions for effective teamwork that promotes joint treatment of patients.

Our study showed that more than 60.14% (or 169 people) were dissatisfied with the work of nurses than 39.86% (112 people) were satisfied.

Among the nurses who were dissatisfied with their work (n=169), older sisters, sisters with less work experience and sisters engaged in practical

activities prevailed. Most likely, this is due in older nurses to (the perception of) a higher workload over many years of work, which is associated with fatigue due to prolonged psychological and physical exertion, stressful working conditions, and in nurses with less work experience, emotional stress and higher workload pressure also causes a stressful state, but to which they have not yet got used to the latter- nurses engaged in practical activities experience greater stress in terms of strength associated with assigning multiple work responsibilities to one person and high workload, as well as high demands on the activities of nurses and significant responsibility, which can negatively affect job satisfaction and lead to emotional burnout, as well as not effective enough interactions between medical staff in this cohort.

Job satisfaction has a great impact on most healthcare organizations, as well as on nurses [23]. Job satisfaction can be defined as a person's general attitude towards their work, this applies not only to activities or tasks, but also to aspects such as the work environment, which is often very stressful and emotionally manifested in attitude and commitment to work [24]. The work environment affects several factors, such as the quality of care and patient safety, absenteeism, and an increased intention to leave work. In addition, dissatisfaction with the work of nurses is a serious problem due to the negative effects of nurse turnover and the fact that the number of nurses worldwide is declining [25]. There is evidence that nurse retention is an ongoing problem related to job satisfaction [26]. Research shows that job satisfaction has decreased in developing countries and therefore it is important to better understand the factors associated with job satisfaction [27]. Since our country is also among the developing countries.

Low satisfaction with the work of nurses is due to many factors, including interaction with colleagues. And it should be noted that only a few studies have studied how communication skills affect job satisfaction [28]. Communication is one of the many mechanisms that can determine how a positive work environment for nurses can contribute to nurses' job satisfaction and their intention to stay. Improving communication between nurses is a potential strategy to increase job satisfaction and the intention to stay in it [29].

In a study by Harris & Blackhall et al 2016; Sheehan et al, 2017, the collaboration of nurses when interacting with each other was positively correlated with job satisfaction.When collaboration was insufficient, job satisfaction decreased.

It should be noted that only a limited number of studies on nurse collaboration can be found in the literature. Moreover, when researchers Durmuş SÇ et al, Ekici D et al, 2018 studied the literature on healthcare in Turkey, several studies were conducted regarding the cooperation of nurses and doctors; In studies aimed only at collaboration between nurses, there was not much done.2 In a study conducted by Durmush et al., Ekici D et al., 2018, it was noted that job satisfaction is more and primarily related to reciprocity, but separately such attributes of cooperation as trust, goodwill, cohesion could not be considered in their study. They proposed to continue the study with the inclusion of these attributes included in interpersonal interaction.But our study differs in that we examined the impact of the components of interpersonal interaction/cooperation on job satisfaction separately. What was not carried out in the study of these authors.

According to the results of the study, the nurse pointed out that the higher the cohesion in the team, the trusting and friendly relationships in which they can freely express their opinions without fear of condemnation or being misunderstood, as well as a positive emotional attitude create a favorable working environment, which is characterized by a healthy moral and psychological climate that affects high satisfaction hard work. Among the satisfied there are not enough or not at all satisfied nurses, the number of which may grow every year if appropriate measures are not taken to improve communication skills among the middle level of medical staff and not increase the number of nurses satisfied with their work, which may lead to a continued outflow of this group by a health worker and exacerbate the current shortage of nurses even more. Similar results were obtained in a study by DiMeglio, K., et al. (2018), where group cohesion contributes to increased nurse satisfaction.

In a study by Apker et al. 2006; Karamanoglu et al. 2009, it was confirmed that teamwork, cohesion in the nursing team increased job satisfaction and even prevented confrontations. And it was also determined that effective communication in a team is a vital aspect of a positive nursing practice environment, and identified four sets of communication skills that nursing professionals demonstrate: cooperation, trust, compassion and coordination.

In our study, benevolence showed a high statistical association with job satisfaction. Employees with a significant level of this trait in their character are able to feel the need for a positive solution to any conflict situation at the interpersonal level. It should be noted

that everyone has their own opinion and individual differences are related only to strengthening it, which can lead to awareness of the need to improve their communication skills.As for the aspect of mutual trust, which is more often associated with competencies such as respect, politeness, the results of this study show that nurses consider this aspect important, which also affects job satisfaction, and this conclusion is consistent with the Esmailpur-Bandboni study el.at . 2017. Moreover, the American Nurses Association has identified criteria that are necessary for a healthy working environment: relationship, trusting interaction, cohesion, a good and friendly emotional attitude in the department of the organization and interaction, in our study demonstrated a high correlation with job satisfaction, which can create a friendly working environment for nurses [30]

Nurses who work in conditions considered friendly to the profession, with high convenience and mutual respect, show good results of their activities and good and effective patient care. And there is also evidence that cohesion, friendly professional relationships between nurses, and trust are fundamental attributes of communication skills that can in turn improve professional practice, guarantee greater job satisfaction, and contribute to a better quality of care provided to patients in inpatient settings [31].

Nevertheless, there are no studies in Kazakhstan evaluating these favorable conditions, the peculiarities of the professional practice of nurses, which justifies the development of this study. Thus, interpersonal communication plays an important role in fulfilling this mission. In work situations in which nurses are constantly subjected to physical and psychological stress, environmental factors are perceived with discontent and without effective coping mechanisms, which may indicate burnout. Which subsequently requires the development of measures to improve communication, mutual assistance and friendly relationships.

Conclusion

Teaching such communication skills of relationships is the most effective method of eliminating emotional burnout of nurses, as well as increasing satisfaction with their work.But insufficient communication between nurses can lead to job dissatisfaction and emotional burnout, as well as a decrease in trust between team members

[32]. It is also known that nurses in most cases are concerned about both their own problems and the problems of patients, which contributes to the creation of an increased socio-psychological burden. Statistics show that their nervous system and overall health are weaker than those of workers in other professions, which is most likely due to high emotional, mental and physical overloads. And we see that there is a need to take measures to reduce stress in nurses. It is also important to develop and implement measures in a timely manner that are aimed at preventing the occurrence of conflict situations, increasing the availability of medical care for people and its quality. An analysis of the results of our research has shown us that the problem of interpersonal interaction and collaboration in a team is very pressing and requires a speedy solution. The results of the study show the importance and necessity of active development of communication skills among nursing staff, contributing to cohesion, strengthening and strengthening the spirit of teamwork in the team.

The first conclusion is that nursing staff should be open to interpersonal interaction characterized by honesty, through an adequate interpretation of the thoughts, feelings and relationships of another person.

The analysis of the results of the survey made it possible to draw the following conclusions:

1. Our research has shown that low indicators of emotional mood, goodwill, trust, cohesion, and business criticism before work deserve special attention, since they prevail in most cases among the dissatisfied.

2. Older nurses, sisters with less work experience, as well as sisters engaged in practical activities (tend to give a lower assessment of job satisfaction) made up the majority of those dissatisfied with work.

Based on the above, it can be concluded that the department needs to carry out active and purposeful work in order to develop and strengthen the communication skills of nurses. To do this, we have developed the following recommendations for medical:

1. It is necessary to organize the training of nurses in the basics of communicative interaction, which will help to increase cohesion and improve the socio-psychological climate in the team.

2. It is necessary to develop and implement programs for training nurses in communication styles and the development of personal competencies related to communication skills. These competencies

should improve the accuracy of communication and, consequently, improve the climate of personal and professional relationships in the workplace. It is necessary to develop and implement training programs for the development of personal competencies related to communication skills.

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NAVIGATING THE GLOBAL CHALLENGE OF DIABETES MELLITUS: INSIGHTS FROM KAZAKHSTAN'S HEALTHCARE LANDSCAPE AND STRATEGIES FOR IMPROVED MANAGEMENT

The global prevalence of diabetes mellitus presents a significant challenge to public health, with projections indicating a substantial rise in cases, particularly in low- and middle-income countries. This study acknowledges the critical lack of comprehensive research and under-reporting of diabetes cases, emphasizing the need for improved screening strategies and healthcare access. Theoretical and practical significance is evident in the complexity of estimating prevalence, regional variations in Central Asia, and global initiatives recognizing diabetes as a major health concern. While successful management programs exist, challenges persist, including under-reporting, discrepancies in estimations, and delayed diagnoses, impacting patient quality of life and healthcare costs. Multidisciplinary approaches are essential due to the presence of multiple comorbidities among patients, emphasizing the need for coordinated efforts. Robust data sources and proactive healthcare policies are crucial in understanding prevalence trends and addressing this burgeoning health crisis on a global scale. This study aims to utilize administrative healthcare data from Kazakhstan to comprehensively explore diabetes epidemiology, including demographic factors, mortality, and comorbidities. Findings seek to inform targeted interventions and advance diabetes management strategies within the country's healthcare landscape. The uneven distribution of type 2 diabetes prevalence, particularly among women, underscores the economic and societal significance of the issue, necessitating specialized medical care and focused research efforts. Identifying the true prevalence of diabetes is crucial for planning health improvement, treatment, and preventive measures. Collaboration among specialists is imperative to improve the health outcomes of type 2 diabetes patients, emphasizing the importance of screening and managing chronic non-communicable diseases to mitigate the medical and social impact of this global problem.

Key words: global health, diabetes mellitus, prevalence, management, epidemiology, healthcare access, comorbidities, statistics.

Introduction

Investigating the frequency and treatment of diabetes mellitus is inherently imperative due to its substantial impact on global public health. The escalating prevalence of diabetes poses a formidable challenge, with the International Diabetes Federation reporting an estimated 387 million cases in 2014, projected to surge to a staggering 592 million by 2035, most of which are expected in countries with lower and middle incomes [1]. This choice of theme stems from acknowledging the critical absence of comprehensive research and under-registration of diabetes cases, signifying the potential health implications of undetected cases and the urgent need for improved screening strategies and healthcare access [2].

The relevance of this topic is underscored by its theoretical and practical significance. Theoretical significance is evident in the divergence of estimates and projections on diabetes prevalence, accentuating the complexity of forecasting this health issue [3,4]. Practical relevance is highlighted by the variation in diabetes prevalence across Central Asian countries, as exemplified by the data from the Diabetes Education Foundation of the Republic of Kazakhstan [5]. Furthermore, international acknowledgments such as those discussed at the United Nations General Assembly and initiatives such as the Global Plan for Diabetes Prevention underscore the global recognition of diabetes as a significant health issue, demanding united efforts [6, 8].

The criticality of diabetes management programs is evidenced by their tangible outcomes, as seen in

Kazakhstan's national program resulting in reduced mortality and disability rates among individuals affected by diabetes [9]. Nevertheless, challenges persist, including under-reporting, discrepancies in prevalence estimations, and delayed diagnoses, contributing to a decreased quality of life for patients and increased healthcare costs [10, 12, 13]. The need for interdisciplinary approaches is underscored by the prevalence of multiple comorbidities among patients with type 2 diabetes, necessitating coordinated efforts from a range of specialists [33].

IDF's analysis underscores the crucial role of reliable data sources in comprehending trends in diabetes prevalence and designing effective interventions [19, 20]. Moreover, projecting diabetes to become the seventh leading cause of death by 2030 underscores the imperative for proactive healthcare policies and interventions to tackle this escalating global health crisis [21].

Type 2 diabetes stands as a significant medical-social and interdisciplinary issue, demanding widespread awareness campaigns, lifestyle modifications, and early detection strategies to combat its escalating burden [27, 29, 30]. The societal impact of diabetes in Kazakhstan is profound, reflecting the regional disparities in prevalence rates and the necessity for enhanced research efforts and reliable data collection methodologies [1, 5].

Ultimately, this study aims to utilize healthcare data collected administratively from Kazakhstan's Unified National Electronic Health System (UNEHS) to comprehensively explore the epidemiology of both type 1 and type 2 diabetes, including demographic factors, all-cause mortality, and associated comorbidities. Such an exploration seeks to contribute valuable insights into crafting targeted interventions and advancing diabetes management strategies within Kazakhstan's healthcare landscape.

Therefore, the prevalence of type 2 diabetes varies unevenly across different regions of the country. A higher prevalence rate is found among women. Considering the current situation and associated costs, the economic impact of diabetes is underscored by significant labor losses due to its high prevalence. The growing prevalence and extended lifespan of individuals with diabetes result in an increase in the number of patients needing specialized medical care, including those with chronic complications from the disease.

The current disparity between national and global statistics on diabetes prevalence calls for focused research to reveal an accurate and detailed picture of the disease's spread. Such findings would lay a scientific foundation for planning health improvement, treatment, and prevention strategies. Given the extensive impact of type 2 diabetes and its complications on society, it is essential to further examine how to organize the collaboration of various specialists (endocrinologists, ophthalmologists, neurologists, cardiologists, etc.) who work together to enhance the health of type 2 diabetes patients. Successfully implementing a diabetes screening program and a chronic non-communicable disease management program in the country will decrease the medical and social burden of this issue and identify optimal solutions for tackling these challenges.

Materials and Methods

The approach to searching was initiated by conducting a thorough examination of primary databases. To identify relevant studies spanning from January 2010 to November 2023, we meticulously surveyed several principal databases, namely Medical Literature Analysis and Retrieval System Online (MEDLINE), Scopus, Web of Science (WOS), and the Cochrane library. Utilizing Medical Subject Headings (MeSH), we identified synonyms and pertinent keywords related to this article. For Scopus and Web of Sciences, searches involved combinations of keywords pertaining to cost, effectiveness, diabetes, and screening. To enhance our search scope, we extended our exploration to include "Google Scholar," the Center for Reviews and Dissemination, and the CEA Registry. Additionally, we conducted a manual inspection of the reference lists of all publications, comprising original studies and reviews. This process aimed to identify studies that might not have been captured through our systematic search.

1. Exploring the Prevalence and Management of Diabetes Mellitus

The frequency and management of diabetes are crucial healthcare issues, covering its prevalence in populations and effective strategies for controlling, treating, and preventing complications. Diabetes mellitus presents a major challenge in global public health. As per the International Diabetes Federation, the figures are striking: in 2014, 387 million individuals worldwide were diagnosed with diabetes, amounting to 8.3% of the global populace. Disturbing forecasts anticipate a surge to 592 million cases by 2035, with 77% occurring in low- and middle-income nations. This underscores the critical need

for targeted interventions and resources to effectively tackle this escalating global health crisis. [1].

Certainly, the under-registration of diabetes cases is a significant concern highlighted by several researchers. Their argument emphasizes the substantial gap between diagnosed and undiagnosed diabetes cases within the adult population, estimated to reach a staggering 174.8 million worldwide. This discrepancy underscores the potential magnitude of undetected diabetes cases, signifying challenges in early detection and healthcare access. This unaccounted population remains at risk of experiencing undetected complications, thereby emphasizing the imperative need for improved screening strategies, heightened awareness campaigns, and enhanced healthcare infrastructure to address this under-recognized segment and mitigate the potential long-term health implications [2].

Divergent estimates and projections on diabetes prevalence underscore the complexity of forecasting this health issue. According to statistics from the World Health Organization, diabetes prevalence is on a troubling trajectory, projected to increase significantly by 2030, potentially surpassing 360 million among adults aged 18 and older. This sharp rise, compared to a global prevalence of 2.8% in 2000, expected to reach 4.4% by 2030, highlights the critical need for proactive healthcare policies and interventions to address this alarming trend and its accompanying healthcare challenges [3, 4].

The statistics presented by the Diabetes Education Foundation of the Republic of Kazakhstan highlight varying levels of diabetes prevalence across Central Asian countries, with 155,000 cases in Uzbekistan, 46,917 in the Kyrgyz Republic, and 30,000 in Tajikistan, indicating the complex nature of the issue in this region [5]. Global recognition of diabetes as a significant health concern, particularly the absence of comprehensive national strategies for its prevention and treatment highlighted during the 61st Session of the United Nations General Assembly, underscores the global scale of the challenge and the need for collective action [6]. The long-term goals of the St. Vincent Declaration, established in 1989, emphasize proactive measures and scientific advancements in mitigating severe diabetes complications, emphasizing the importance of prevention and ongoing research to reduce the disease's impact on public health. This alignment of data and global recognition underscores the urgency of coordinated efforts at both national and international levels to effectively address the multifaceted challenges posed by diabetes [7]. To prevent the diabetes epidemic,

the International Diabetes Federation has developed and presented the Global Plan for the Prevention of Diabetes for 2011-2021. Key provisions of the plan include improving the health status of people with diabetes through education on self-care principles, preventing the development of type 2 diabetes, and eradicating discrimination against people with diabetes [8].

The documented link between diabetes prevalence and the implementation of a focused state program underscores the significant impact of strategic healthcare initiatives. Notable successes in this regard are apparent over a five-year span, during which the program's execution led to a remarkable four-fold decrease in mortality rates and a 25% reduction in disability rates among diabetes patients [9]. These achievements are particularly vital considering the direct association between rising diabetes prevalence and its adverse effects, such as increased hospital admissions, higher healthcare costs, and elevated disability rates among affected communities [10]. The significance of these outcomes not only underscores the effectiveness of a targeted state program but also emphasizes the vital role of such interventions in mitigating the health and economic burdens associated with diabetes. These findings highlight the imperative nature of sustained efforts in implementing comprehensive programs aimed at diabetes management and prevention to alleviate the societal impact and healthcare burden posed by this chronic condition.

The World Health Organization (WHO) emphasizes the importance of establishing a diabetes registry. This is motivated by both a notable rise in patient numbers and the crucial need for accurate data on new case registrations, existing complications, laboratory test results, and effective monitoring and management of patients' health statuses [11].

As of early 2014, data from the National Registry in Kazakhstan indicated a substantial diabetic population, comprising 244,892 individuals affected by the condition. This included a breakdown showing 12,816 adults diagnosed with type 1 diabetes and a larger cohort of 229,712 adults were diagnosed with type 2 diabetes. Furthermore, there were 493 adolescents diagnosed with type 1 diabetes and 31 with type 2 diabetes, as well as 1,441 children diagnosed with type 1 diabetes and 48 with type 2 diabetes. By 2015, these figures surged, reaching a total of 261,453 registered cases, marking a notable increase of 6.77%. Among these cases, 13,250 were classified as type 1 diabetes cases, while an overwhelming 245,655 cases were attributed to type

2 diabetes within the adult population. Adolescents had 536 cases of type 1 diabetes and 30 cases of type 2 diabetes, while children had 1,576 cases of type 1 diabetes and 58 cases of type 2 diabetes. These escalating numbers over a mere year underscore the concerning trend of diabetes prevalence across different age groups and call for heightened efforts in both prevention and management strategies to tackle this growing health challenge in Kazakhstan. The current diabetes registry in the country includes information solely on patients who are already aware of their condition [12]. However, it's important to note that a substantial number of patients receive care in private medical facilities and may not be included in the registry. These aspects warrant further investigation and clarification.

Government-reported statistics from Kazakhstan suggest that around 1.34% of the total population has been diagnosed with type 2 diabetes, representing a relatively lower prevalence compared to the estimations proposed by the IDF. The IDF's data indicates a significantly higher prevalence of approximately 7.5% in the population, suggesting there may be around 500,000 undiagnosed cases in the country [13]. However, this estimate has sparked debate and lacks unanimous agreement. Some researchers [14] challenge the IDF's calculations, arguing that they exaggerate the prevalence of diabetes in Kazakhstan. This discrepancy in estimates highlights the complexity of accurately assessing diabetes prevalence and underscores the need for further comprehensive studies and refined methodologies to better understand the true extent of this health issue among the Kazakhstani population. Typically, diabetes diagnoses often occur late, after complications have already developed, leading to a diminished quality of life for patients. It is also crucial to consider the broad range of associated conditions and the importance of providing outpatient care [15].

In certain regions of Kazakhstan, a three-tiered diabetes management program has been integrated into primary healthcare services to mitigate complications among newly diagnosed diabetic patients. The first tier encompasses 70-80% of the affected population, where patients can independently manage their condition and actively participate in their treatment (self-management). The second tier (15-25%) includes patients at higher risk levels who receive care from a multidisciplinary team following clinical guidelines based on evidence-based medicine and supported by a healthcare information system. The third tier (5%) addresses the most complex cases. Key challenges in diabetes management include issues like poor self-management, inadequate screening, low patient awareness, and insufficient access to self-monitoring devices [16].

Researchers assert that the success of diabetes management programs [17] hinges on improving medical care quality, reducing complication and disability rates, optimizing bed usage efficiency, cutting healthcare expenditures, and other metrics.

Various factors affect diabetes prevalence in the population, notably age, gender distribution, lifestyle choices, and the implementation of screening programs, which lead to an increase in reported cases. Early detection initiatives for diabetes are conducted based on epidemiological, healthcare, demographic, and economic considerations [18].

In recent years, there has been a notable rise in both national and international literature focusing on diabetes epidemiology, assessments of mortality and disability, studies on diabetes literacy among patients, and evaluations of their perceptions of care quality. The influence of various international and European organizations, including the IDF, EASD, EURADIA, and others, in conducting diabetes research and providing statistical data, is increasing.

The IDF conducted a thorough analysis to measure the global prevalence of diabetes among adults aged 20-79 years. This comprehensive assessment included evaluating demographic, ethnic, and economic factors across various regions to understand trends in disease prevalence [19]. The study highlighted that the accuracy of estimating diabetes prevalence relies heavily on the quality and reliability of the data sources used for analysis [20]. Recognizing the importance of robust and dependable data sources is crucial for accurately assessing diabetes prevalence worldwide, underscoring the necessity for consistent and comprehensive data collection methods to improve the precision of estimates.

Diabetes represents a pressing global societal issue, projected by the WHO to become the seventh leading cause of death by 2030 [21]. The scale of this challenge is starkly evident in global statistics from 2015, which estimated that 415 million individuals aged 20-79 were living with diabetes worldwide. Among them, 215.2 million were men, a figure expected to rise to 328.4 million by 2040. Similarly, 199.5 million women were affected in 2015, with projections indicating an increase to 313.3 million by 2040. The forecasts are alarming; the International Diabetes Federation predicts a dramatic escalation, projecting the diabetic population to reach 642 million by 2040. Regional disparities are also notable, as highlighted by the IDF Diabetes Atlas, with the

Western Pacific region hosting a significant diabetic population of 153.2 million in 2015, expected to grow to a daunting 215.8 million by 2040. Southeast Asia closely follows with 78.3 million affected individuals, expected to rise significantly to 140.2 million by 2040. Europe, while relatively lower in prevalence with 59.8 million cases in 2015, is still poised to witness a substantial increase, projected to reach 71.1 million by 2040 [22]. These staggering figures underscore the pressing need for global health initiatives to address the burgeoning diabetes crisis, urging for concerted efforts in prevention, management, and intervention strategies to mitigate the impending health burden on a global scale.

The Russian Federation is experiencing a significant rise in diabetes prevalence, driven primarily by increasing rates of type 2 diabetes among its adult population, alongside declining mortality rates among those affected by both type 1 and type 2 diabetes [23]. Of particular concern is the growing number of individuals affected by type 2 diabetes, particularly prevalent among those aged 65-69, highlighting the severity of the health issue [24]. The trajectory of this health crisis is underscored by an average annual growth rate of 6.23% [25], emphasizing the urgent need for comprehensive interventions and health policies to address its escalating impact.

Additionally, prior research [26] has highlighted shortcomings in the current diabetes patient registration system in Almaty, Kazakhstan. These studies indicate an inherent inability to accurately delineate the structural dynamics and various prevalence characteristics of the disease. Such inadequacies in data collection impede the formulation of effective and tailored organizational and managerial strategies. Addressing these systemic gaps is crucial to not only enhance the accuracy of disease surveillance but also to craft targeted interventions that are responsive to the diverse facets of diabetes prevalence within the region, thereby facilitating more effective management and prevention measures.

2. Type 2 Diabetes as a Medical-Social and Interdisciplinary Issue

Diabetes mellitus poses a significant global health challenge, evidenced by a substantial global prevalence of 8.8% in 2015 [27]. Accurate assessments of diabetes burdens are crucial for effective resource allocation and comprehensive evaluation. According to the IDF Diabetes Atlas (7th edition, 2015), an alarming 415 million individuals were living with diabetes worldwide in 2015, a number projected to rise to approximately 642 million by 2040. Notably, China reported the highest prevalence of diabetes among adults aged 20-79, with an estimated 109.6 million cases (99.6-133.4), followed by India with 69.2 million (56.2-84.8), and the USA with 29.3 million (27.6-30.9).

The rise in global type 2 diabetes cases can be attributed to several factors, including population growth, aging populations, rising obesity rates due to unhealthy diets, and sedentary lifestyles [28]. It is concerning that over 90% of diabetes cases are classified as type 2, and nearly half of these cases remain undiagnosed [29]. Numerous studies have consistently emphasized the critical importance of regular screenings in significantly reducing or delaying the onset of complications linked to type 2 diabetes [30,31].

These findings highlight the pressing need for extensive awareness campaigns, proactive health interventions, and accessible healthcare services to tackle the growing diabetes crisis. With global prevalence on the rise, there is an increasing urgency to prioritize preventive measures, lifestyle changes, and early detection strategies to alleviate the growing burden of type 2 diabetes and its associated complications worldwide. The presence of multiple comorbidities among type 2 diabetes patients necessitates the involvement of various specialists. A survey of 204 patients indicated that 40.7% regularly visit a cardiologist, 45.1% see an ophthalmologist, while only 5.4% and 8.8% consult a neurologist and nephrologist, respectively, as recommended by endocrinologists. Delays in doctor visits were primarily attributed to lengthy appointment wait times (53.4%), insufficient awareness about the necessity of specialist consultations (51.5%), and visiting an endocrinologist solely for prescription renewals (71.5%).

A comprehensive retrospective analysis involving a large cohort of 1,389,016 participants, where 53% were women with an average age of 65 years, revealed striking statistics concerning type 2 diabetes patients and their associated health conditions. Remarkably, 97.5% of these individuals were found to have at least one comorbidity, with a significant 88.5% experiencing two or more concurrent health issues. Among the prevalent comorbidities, hypertension emerged as the most widespread, affecting 82.1% of type 2 diabetes cases, followed closely by overweight or obesity at 78.2%, hyperlipidemia at 77.2%, chronic kidney disease at 24.1%, and cardiovascular disease at 21.6% [33]. In another study [34], concerning

findings emerged regarding a notably elevated standardized mortality rate among individuals aged 15-30 years, with a rate of 3.4 [95% CI 2.7–4.2]. Additionally, results from the extensive UKPDS study, spanning over two decades and involving more than 5000 type 2 diabetes patients, demonstrated a significant outcome. It was shown that even a modest 1% reduction in glycated hemoglobin (HbA1c) levels could lead to substantial prevention: preventing 35% of microvascular complications, 18% of myocardial infarctions, 15% of strokes, and notably, 25% of deaths linked to diabetes-related complications [33].

These compelling findings highlight the critical necessity for embracing comprehensive and multidisciplinary healthcare strategies to effectively combat the challenges posed by type 2 diabetes. Robust and well-coordinated management approaches, underscored by vigilant monitoring and proactive interventions, play a pivotal role in not only addressing the diverse spectrum of associated comorbidities but also in mitigating the pronounced mortality rates, especially prevalent among younger demographics. Implementing a multidisciplinary, team-based approach proves highly effective in managing type 2 diabetes, fostering a collaborative relationship between healthcare providers and patients. This approach prioritizes patient education, empowering them to autonomously manage their health, and promotes active participation in their treatment plan [33,34]. Furthermore, type 2 diabetes stands among the trio of conditions encompassed within disease management programs, signaling a significant shift from traditional preventive medicine towards a proactive paradigm centered around self-health management [33]. This transformation in healthcare paradigms emphasizes the pivotal role of patient engagement and self-management, not only in the context of type 2 diabetes but also in shaping a more patient-centered approach within the broader landscape of healthcare delivery.

3. Type 2 diabetes as a social problem of Kazakhstan

In recent decades, there has been a significant and concerning rise in the global prevalence of diabetes, making it a critical public health issue worldwide. As of 2019, an estimated 463 million people were affected, representing a prevalence rate of 9.3%. Projections suggest a troubling increase to 10.2% (578 million) by 2030 and a staggering 10.9% (700 million) by 2045 [1]. Urban

areas notably show a higher prevalence at 10.8% compared to 7.2% in rural regions, highlighting the influence of lifestyle and environmental factors [1]. Additionally, a stark disparity exists between high-income and low-income countries, with prevalence rates reaching 10.4% in high-income nations versus a significantly lower 4.0% in low-income countries [1]. These statistics underscore the urgent need for coordinated global efforts to address the multifaceted challenges posed by diabetes. These efforts should encompass lifestyle interventions, socio-economic considerations, and healthcare system strengthening to mitigate the increasing burden on individuals and healthcare systems alike.

However, despite ample data on diabetes from high-income nations, there is a notable lack of published information on the epidemiology of both type 1 and type 2 diabetes in low- and middle-income countries in Central Asia, including Kazakhstan. Several small-scale observational studies have attempted to explore diabetes epidemiology in Kazakhstan [2,3,4,5]. For example, a cross-sectional study conducted across four geographically distant regions of Kazakhstan, involving 4,753 participants using the WHO STEP survey, reported a survey-weighted prevalence of impaired fasting glycemia (IFG) at 1.9% and type 2 diabetes mellitus (T2DM) at 8.0% [4]. However, there remains a gap in research investigating diabetes epidemiology using national health registry data in Kazakhstan.

Kazakhstan boasts a well-developed electronic healthcare system, notably the Unified National Electronic Health System (UNEHS), initiated in 2003 and fully established by 2014. This system aggregates medical claims from diverse electronic data sources across healthcare facilities nationwide. Integration and analysis of this comprehensive electronic healthcare data could offer profound insights into the nuanced epidemiology of diabetes across Kazakhstan [6, 7].

Therefore, our study aims to investigate the descriptive epidemiology of both type 1 and type 2 diabetes, as well as to analyze demographic factors associated with all-cause mortality among individuals affected by these conditions. Additionally, we aim to identify comorbidities linked to all-cause mortality among patients with type 1 and type 2 diabetes in Kazakhstan, utilizing extensive administrative healthcare data from the Unified National Electronic Health System (UNEHS) spanning from 2014 to 2023.

4. Tackling the Rising Tide of Type 2 Diabetes in Kazakhstan

Type 2 diabetes represents a substantial global health challenge due to its multifaceted impact on various populations, and the Republic of Kazakhstan is no exception to this concerning trend. As of 2023, the incidence and prevalence rates of type 2 diabetes within Kazakhstan have become a subject of intense scrutiny and analysis within the realm of public health. Detailed reports and surveys conducted across diverse regions of the country have consistently highlighted the persistent and worrisome burden that type 2 diabetes poses on the health of its citizens [30].

The data collected from these various regions unequivocally underscores the widespread nature of this health issue, affecting a considerable segment of the Kazakh population. This concerning trend is indicative of the complex interplay between lifestyle factors, genetic predispositions, dietary habits, and socio-economic conditions contributing to the increasing prevalence of type 2 diabetes. Medical professionals, policymakers, and health experts have been increasingly focused on devising comprehensive strategies to address this escalating health concern. The need for robust public health interventions, including awareness campaigns, lifestyle modifications, improved access to healthcare, and enhanced diabetes management programs, has become imperative. The impact of type 2 diabetes extends beyond individual health, exerting substantial economic burdens on the healthcare system and the country's overall productivity. Addressing this issue demands collaborative efforts between government initiatives, healthcare providers, community organizations, and educational institutions to implement sustainable solutions.

Understanding the regional disparities and factors influencing the prevalence of type 2 diabetes within Kazakhstan is crucial for tailoring targeted interventions. Efforts to promote healthier lifestyles, encourage physical activity, and improve nutritional education are pivotal in curbing the progression of this chronic condition. Moreover, fostering a culture of early detection through regular screenings and diagnostic measures is pivotal in mitigating the adverse effects and complications associated with untreated or poorly managed type 2 diabetes. By emphasizing prevention and proactive management, it is possible to alleviate the societal burden caused by this disease. The table labeled as Table 1 presents the occurrence of type 2 diabetes within the populace of the Republic of Kazakhstan for the year 2022 [30].

Table 1 – The incidence of type 2 diabetes in the population of the Republic of Kazakhstan in 2022

The name of the region	The number of adults	The number of children (aged 0 – 17 years)	Total
Akmola Region	903	198	1101
Aktobe Region	683	156	839
Almaty Region	2100	417	2517
Almaty City	2529	595	3124
Atyrau Region	721	145	866
East Kazakhstan Region	2040	339	2379
Nur-Sultan City	2010	365	2375
Zhambyl Region	763	228	991
West Kazakhstan Region	898	120	1018
Karaganda Region	2071	439	2510
Kostanay Region	1318	178	1496
Kyzylorda Region	605	169	774
Mangystau Region	696	164	860
Pavlodar Region	1025	169	1194
North Kazakhstan Region	1005	145	1150
Turkistan Region	1155	319	1474
Shymkent City	1104	230	1334
Total	2126	4376	26002

The data collected provides insights into the distribution of type 2 diabetes among adults and children (aged 0-17 years) in different regions of Kazakhstan. This information not only reveals the magnitude of the issue but also underscores the necessity for targeted health interventions and strategies to combat this chronic condition effectively [27].

Looking at the breakdown by region, it is evident that some areas experience a higher prevalence of type 2 diabetes than others. Almaty City and Almaty Region show substantial numbers, with 3124 and 2517 cases respectively, demonstrating a considerable burden of this metabolic disorder. These regions, being densely populated urban centers, might be susceptible to lifestyle factors contributing to diabetes, such as sedentary lifestyles and unhealthy dietary habits.

Other regions like Karaganda, East Kazakhstan, and Nur-Sultan City also demonstrate notable numbers of reported cases, signaling the widespread nature of this health issue across diverse geographical areas within the country [18].

Analyzing the data further by age groups, it is concerning to note that children are also affected by type 2 diabetes. The statistics reveal significant numbers of children diagnosed with this condition across several regions, with a total of 4376 cases reported in 2023. The presence of type 2 diabetes in children is particularly alarming as it may result from a combination of genetic predisposition and lifestyle factors, indicating the need for early prevention and intervention strategies targeting both adults and children [34].

With a reported total of 26,002 cases, there is a clear need for a comprehensive public health strategy to manage and prevent type 2 diabetes. This strategy should include initiatives such as promoting healthy lifestyles through education, ensuring access to quality healthcare services, encouraging physical activity, and enhancing nutritional awareness among the population.

Efforts to tackle this health challenge should be customized to meet the unique needs and contexts of each region. For example, urban areas may benefit from interventions aimed at promoting healthier diets and enhancing physical activity, while rural regions may benefit from enhanced access to healthcare facilities and educational campaigns to raise awareness about diabetes prevention.

Collaborative initiatives involving healthcare professionals, policymakers, community leaders, and individuals themselves are crucial to combatting type 2 diabetes effectively. By implementing proactive measures and promoting a culture of health and wellness, Kazakhstan can work towards reducing the incidence and impact of type 2 diabetes on its population [33].

Overall, the data on type 2 diabetes incidence in the Republic of Kazakhstan in 2023 serves as a clarion call for concerted efforts to address this pressing public health issue. Through targeted interventions, education, and community engagement, Kazakhstan can strive towards a healthier future with reduced instances of type 2 diabetes and improved well-being for its citizens.

Conclusion

The distribution of type 2 diabetes varies across regions within the country, showing a disparity, particularly with a higher prevalence among women. This gender discrepancy in prevalence underscores the necessity for targeted interventions aimed at specific demographic groups. Moreover, the economic impact of diabetes highlights significant labor losses due to its prevalence, underscoring the urgent need for effective interventions. The rising prevalence and longer lifespan of individuals with diabetes contribute to an increasing number of patients requiring specialized medical care, especially those managing chronic complications of the disease.

The disparity in diabetes prevalence indicators within the country, in contrast to global statistics, necessitates focused research to accurately determine the true extent of this condition. These detailed insights would serve as a scientific basis for developing customized strategies for health enhancement, treatment, and prevention. Considering the scale of the problem and its societal impact, there is an urgent requirement for coordinated collaboration among diverse specialists including endocrinologists, ophthalmologists, neuropathologists, and cardiologists. This collective effort aims to improve health outcomes for individuals with type 2 diabetes.

To effectively address this multifaceted challenge, the implementation of a robust diabetes screening program alongside a comprehensive strategy for managing chronic non-communicable diseases at a national level is imperative. Such programs not only aim to reduce the medical and social burden associated with diabetes but also seek to identify optimal solutions for mitigating the impact of these health issues on the population. This collective focus on proactive healthcare management can greatly reduce the negative impact of type 2 diabetes and its related complications on society as a whole.

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RHINOLARYNGOLOGICAL AND SYSTEMIC CAUSES OF HALITOSIS: A MINI-REVIEW

Halitosis, commonly known as bad breath, is a common condition that affects a significant portion of the population. Volatile molecules resulting from pathological and non-pathological causes from oral or extra-oral sources are known to be responsible for halitosis. While poor oral hygiene is often the primary cause of halitosis, several other factors can contribute to this condition, and most of these causes are ignored. such as problems in the nose and throat and the presence of systemic diseases that affect different parts of the body. These problems can lead to the production of foul-smelling gases that are released through the mouth, resulting in bad breath. Some examples Halitosis producing conditions include sinusitis, tonsillitis, and systemic diseases. In addition to these conditions, certain medications and lifestyle habits, such as smoking and alcohol consumption, can also contribute to halitosis. Halitosis negatively impacts a person's everyday life; the majority of those who complain about it seek treatment at a clinic, however, some halitosis sufferers have no detectable halitosis. Halitosis can be determined using a variety of techniques. Understanding the various causes of halitosis is essential for effective treatment and management of this condition.

Key words: ENT, etiology, extra-oral, halitosis, pseudohalitosis, systemic.

Introduction

Human breath is made up of highly complex chemicals with numerous and varied smells that can cause unpleasant conditions such as halitosis. Halitosis is a Latin term derived from the words halitus "breathed air" and osis "pathologic changes" [1]. It can also refer to any unpleasant odor originating from the mouth, air, or breath. Other names used to define and characterize halitosis include foetor oris, oral malodor, mouth odor, bad breath, and awful mouth odor [2]. The Listerine Company first used the term "halitosis" in 1921 to describe bad breath independent of its source [3]. Few researchers have studied the prevalence of oral malodor in the general population [2]. According to several articles, the prevalence ranges from 2.4% to 78% [4–6]. According to the American Dental Association, approximately 50% of American adults have a bad breath at some point in their lives. Half of this population may have persistent, intermittent, or chronic breath odor problems [7, 8]. Additionally, while waking up in the morning, almost half of the adults and elderly people have socially undesirable breath that is caused by physiological factors [2].

This broad range in prevalence is due to the halitosis evaluation methodologies, whether the results are based on self-reporting or objective measures of oral malodor, geographic area, and year of study. Furthermore, neither objective nor subjective standard criteria for identifying patients with halitosis have been widely accepted [2]. Owing to its high prevalence, research into its origin and patient-reported outcomes is on the rise. Halitosis has an adverse impact on patient's quality of life. Patients who feel humiliated by their behavior, especially in interpersonal interactions, are more likely to seek professional assistance [9, 10]. It is a common problem that can have an impact on personal relationships because it interferes with communication between individuals [11]. According to Al-Ansari et al findings, some factors were significantly linked to self-perceived halitosis: current or past smoking, female gender, age 30 or older, having only completed high school, history of chronic sinusitis or gastrointestinal disorders, never using Miswak (a natural toothbrush made from

the twigs of the Salvadora persica tree), and never using dental floss [12]. To compare epidemiological data, halitosis study need a standardized evaluation process. Therefore, the gold standard for studies on bad breath should be a mechanical detection method [13]. Understanding its origin is essential for healthcare professionals, particularly general practitioners and, dentists [14].

Aim: The objectives of this review were to explore Nose, Throat and systemic causes of halitosis as well as to provide a snapshot of the impact of halitosis on social life.

Causes of Halitosis

Volatile sulfur compounds (VSCs), which are odoriferous substances present in the exhaled air as a result of the action of anaerobic oral Gram-negative bacteria (*Bacteroides loescheii, Centipedaperiodontii, Eikenellacorrodens, Treponema denticola, Prevotella intermedia, Porphyromonas gingivalis, Fusobacterium nucleatum, Selenomona*) [6]. 90% of the VSCs in bad breath are hydrogen sulfide, methyl mercaptan, and, to a lesser amount, dimethyl sulfide [9]. A temporary change in breath odor can be brought on by eating foods like garlic or some spicy dishes, drinking alcohol, or using tobacco products [15].

1 extra-oral causes

Halitosis is thought to have extra-oral origins in 10–20% of cases [16, 17]. The extra-oral conditions that can cause halitosis include chronic sinusitis, post-nasal drip, nasal foreign bodies, respiratory tract infections and cancer, gastrointestinal illness, inflammatory bowel disease, endocrine, hematologic system abnormalities, and helicobacter pylori infection [16, 18]. Dimethyl sulphoxide is the primary VSC linked to extra-oral halitosis, whereas methyl mercaptan and hydrogen sulfide are the primary VSCs contributing to intra-oral halitosis [16, 17].

1.1 ENT region
Up to 10% of cases of oral malodor come from the ENT (ears, nose, and throat) area, with the tonsils contributing to 3% of those cases [19].

1.1.1 Paranasal Sinuses causes
Nasal bad breath may be mostly brought on by chronic sinusitis [20]. 50% to 70% of people who have chronic sinusitis complain of bad breath. Ten percent of sinusitis may be linked to problems of one or more teeth. Upper respiratory tract infections, persistent mucosal diseases, and abnormal intranasal structures are some of the potential causes of chronic sinusitis. Streptococcus pneumonia and Haemophilus influenza are the two main bacteria involved in the development of bacterial sinusitis[21]. These bacteria have a clear link with halitosis since they can produce VSCs. The most typical signs include postnasal drip, coughing, coated tongues, and hawking [22]. It is believed that the purulent material, which already contains microbiota, falls on the base of the tongue, predisposing to the production of VSC [23, 24]. Antibiotics are frequently used to treat acute sinusitis, which lowers the incidence of anaerobic microorganisms and malodor problems A characteristic odor comes about when purulent mucus becomes apparent[21]. Referrals to an ear, nose, and throat specialist for causative treatment of patients with halitosis and chronic nasal/paranasal sinus conditions are recommended [23].

1.1.2 Atrophic rhinitis
Atrophic rhinitis is a long-term condition that affects the nasal mucosa. Dryness, crusting, atrophy, halitosis, and a paradoxical perception of nasal congestion are the disease's primary symptoms, and it is characterized by excessively broad nasal cavities[25]. The primary atrophic Rhinitis cause is unknown [26]. Primary atrophic rhinitis typically affects both nostrils and is six times as prevalent in women. The main symptom of the condition is that the nose gives off an unpleasant odor as a result of crusting and secondary infections. keeping friends and family away, this factor alone causes social issues for the sufferer [27]. The patient is frequently anosmic for the following reasons: there is an inadequate and non-uniform air blast that may not reach the olfactory areas; there may be a genuine obstruction with large crusts blocking the air flow to the olfactory area in the roof of the nose; and there may be an atrophic process involving the olfactory epithelium and the bipolar nerve cells and nerve fibers. Nasal obstruction is a common primary complaint that can be caused by a variety of things, including congestion of the nasal mucosa (the "blunting effect"), large crusts that obstruct airflow, and disruptions to the normal laminar and eddy current pattern of the inspiratory and expiratory air flows. Patients may also express headache complaints. Anaerobic bacteria frequently cause thick, purulent discharge with an unpleasant odor. Periodically, crusts with dark greenish color with a bad smell are expelled from the nostrils. Rarely, crusts may dislodge into the pharynx and induce choking and the feeling of a foreign body.

With the dislodging of crusts, minor nosebleeds may be seen. Occasionally, patients may experience pharyngitis sicca, which causes the nose and throat to become dry [26–28].

1.1.3 Foreign Bodies and cleft palate

Foreign objects in the nasal cavity can also produce a bad odor. Additionally, a cleft palate might cause poor breath [29].

1.1.4 Chronic Tonsillitis and Tonsilloliths

Chronic caseous tonsillitis (CCT) is frequently correlated to halitosis and is also a common disease [30]. Chronic caseous or follicular tonsillitis is caused by recurrent infections of the tonsils [31]. The tonsils contain deep crypts that, as a result of their anatomy, favor the collection of food, saliva, and necrotic debris. When exfoliated epithelial cells, keratin debris, and foreign objects are retained in the crypts of the palatine tonsils, a tonsillolith develops [32]. Tonsilloliths form if these materials are not naturally removed, and they raise the probability of abnormal VSC levels by ten times[30]. The palatine tonsils are the best locations in the upper airway system for anaerobic bacterial activity [30]. Upon observation, the tonsils are normally not hyperemic and may or may not be hypertrophied. The bacteria most usually involved are streptococci, while viral infections (such as infectious mononucleosis) are a further possibility. Tonsilloliths have been shown to include several anaerobic bacterial species, including those from the genera Eubacterium, Fusobacterium, Porphyromonas, Prevotella, Selenomonas, and Tanerella [33]. The typical CCT symptoms include retention of a tonsillolith, throat irritation, feeling of foreign substances, and halitosis, all of which can be extremely debilitating for the patient. In over 77% of CCT patients, halitosis is present. CCT can happen to men or women at any age. When medical treatment with oral antibiotics and topical antiseptics fails to provide relief, tonsil removal surgery is advised[34]. Tonsillary cryptolysis using a CO_2 laser has recently been presented as a less invasive treatment option. Utilizing CO_2 laser ablation can minimize tonsillolith retention and crypt depth, maintaining the tonsils' immunological activity. This procedure can be carried out in an office work setting while the patient is under local anesthesia, is basically painless, and is able to return normal activities as soon as possible[35]. As a result, the tonsils' size, shape, coating, hyperaemia, and presence of tonsilloliths should be the first thing examined during a clinical investigation[36].

1.1.5 larynx

The larynx is rarely involved [36].

1.2 Systemic
1.2.1 Respiratory disorders

Differentiating the expired air is necessary to determine whether the malodor is nasal or oral in origin. The patient is instructed to close the lips and exhale through the nostrils. If the examiner detects an unpleasant odor originating from the nose, he/she will note it. The patients are next directed to squeeze their noses and exhale through their mouths [16]. By doing so, we can estimate whether the nasopharynx, paranasal sinuses or nasal cavity are the source of the halitosis [16].

Even if symptoms result in significant quantities of sputum such as, pneumonia and bronchitis caused by aerobes, mycoplasma, or viruses rarely end in halitosis. Halitosis is mentioned as a relevant symptom in a variety of clinical respiratory conditions. Included in those are anaerobic lung abscesses, debris lodged in the respiratory system, necrotizing pneumonia, emphysema, lung cancer, bronchiectasis, and tuberculosis[37]. The lungs serve as a source for smells produced by metabolism. Alcohol, high-fat diets, ketosis (also known as diabetic ketoacidosis or DKA), nitrates, chloral hydrate, and iodine-containing medications are some examples of substances that enter the bloodstream and exit the lungs through expired air [8].

1.2.2 Gastrointestinal disorders

Although the majority of halitosis cases are thought to originate from the gastrointestinal system, only 0.5% of cases are, contrary to what the medical profession and many patients believe. Esophageal reflux, achalasia, pyloric stenosis, and hiatal hernia are a few gastrointestinal disorders that can result in bad breath. These disorders result in weakened or inhibited esophageal closure, insufficient emptying into the stomach, and retention of food, drink, and saliva, which results in malodor [38]. On the other hand, gastroesophageal reflux, an extremely common condition, infrequently results in halitosis. Heartburn is the most common symptom, and the related odor is similar to a simple belch and smells like the most recent meal [8]. Halitosis has been linked to bezoars, malabsorption syndromes, stomach carcinomas, and a few enteric diseases[39]. Whittle et al., describe metabolic disorders in the intestines as a cause of halitosis[13]. Regardless of dental or otolaryngological findings, gastrointestinal pathology is quite common in individuals with

halitosis, and the majority of patients got better after therapy [40]. Feller and Blignaut described pancreatic insufficiency as a cause of extra-oral halitosis as well [41]. Fetor hepticus, an unpleasant, excremental smell (the breath of death), is caused when liver function becomes impaired as waste products are released through the lungs[42]. Failure of the liver prevents the body's ability to detoxify itself, leading to the unpleasant odors known as Fetor hepticus [43].

1.2.3 Endocrine disorders

Patients who have type 2 diabetes (T2DM) typically smell sweet and fruity. Different extra-oral causes of halitosis, such as DM, can be diagnosed using gas chromatography-mass spectrometry[8]. Diabetic ketoacidosis leads to a typical breath odor [13]. Additionally, a few congenital diseases might affect breathing; the most known example is tyrosinemia, which causes a strong cabbage odor. In addition to the hormone cycle, several other intestinal disorders also appear to have an impact on mouth odor [44, 45]. 4.6% of women reported having halitosis throughout their menstrual cycle, indicating a connection between the hormones and halitosis. According to Alzoman et al., findings, women's self-perceived halitosis and the frequency of oral health symptoms can be affected by the regularity of the menstrual cycle and hormonal changes [46].

1.2.4 Kidney disorders

Phenylketonuria, trimethylaminuria are known to be causes of oral mal odor [8]. Patients with chronic renal failure have high blood urea nitrogen levels and reduced salivary flow. The odor is typically uremic associated with dry mouth[41].

1.2.5 Drugs

The use of bisphosphonates has recently been associated with oral malodor in addition to medications that cause a dry mouth and indirectly contribute to halitosis, such as anticholinergics, antihistaminics, antipsychotics, anxiolytics, antidepressants, antihypertensives, diuretics, and opioids. Malignant bone tumors and their metastases are treated with bisphosphonates, which are powerful medicines that block bone resorption[47]. In a recent systematic review, medications that can cause extra-oral halitosis were identified as follows: Aminothiols, antacids, Anticholinergics, steroids, Anti-spasmodics, Chemotherapeutic agents, dietary supplements (fish oil, vitamin E), and Diclofenac. To identify the involvement of different drugs in leading to extra-oral halitosis, more research is required [48].

1.3 Miscellaneous
1.3.1 Fish Odor Syndrome

Trimethylaminuria's breath odor, often known as "fish odor syndrome," can induce severe halitosis[49]. The inability of the organism to metabolize trimethylamine is the hallmark of the hereditary illness called trimethylaminuria. This volatile chemical builds up in the body and is eventually excreted in the urine, but it is also present in sweating and breath, giving it a fishy smell. The authors claim that this hereditary condition is the main reason for undetected body odor and that its social impacts can include frustration and social isolation. [50]. By adjusting dietary changes to avoid precursors, particularly trimethylamine N-oxide, which is present in high concentrations in marine fish, the symptoms of trimethylaminuria can be alleviated. Antibiotic therapy to manage gut flora or activated charcoal therapy to sequester trimethylamine may both be helpful [51].

2.1 Oral causes

Poor oral hygiene, periodontal disease, a coated tongue, food impaction in the interdental spaces, unhygienic dentures, and unsuitable prostheses are the main causes of bad breath in the oral cavity [52]. In 85–90% of patients with halitosis, the oral cavity is the main cause of bad breath [8].

Classifications

Halitosis can often be divided into three categories: Genuine (true) halitosis, pseudo-halitosis (false halitosis), and halitophobia. Genuine halitosis can be further categorized as physiologic or pathologic. About 27% of patients who complain of halitosis are found to have non-genuine halitosis [11]. Pseudo-halitosis can be defined as a condition in which the patient is the only one to notice an obvious odor problem, Halitosis is not perceived by others. Halitophobia is a condition in which a patient complains about halitosis after receiving therapy for either real or fake halitosis (generally after the adequate treatment of genuine or pseudohalitosis), even though no obvious signs may be found during a physical examination. Halitophobic patients may need to undergo neurological and mental testing[19].

Impact of Halitosis on Social Life

Odor is a tool that society employs to engage and characterize the outside environment. The olfactory, or smelling, experience is personal, very emotional, and it links us to the outside world. This means that a person's breath odor might either make them

feel more connected to their social environment or less connected to their close relationships. When someone believes they have a persistent bad breath problem, they may employ defense mechanisms and even avoid social interactions. This has an impact on a person's health [53]. Teenagers and young adults with poor breath reported feeling anxious and depressed [54]. Smell perception is subjective and influenced by emotional and cognitive factors, just like other human senses. Those who are unaware of their bad breath may experience unfair romantic, social, and professional rejection. Few people are willing to confront those who have a problem due to the sensitive nature of bad breath and other internal odors. The apparent inability to tell whether or how much one has bad breath is a very intriguing issue with it [55].

Investigations for Underlying Causes

Despite the subjective character of halitosis, various objective tests have been applied in clinical evaluation. It's critical to evaluate the patient's perception of oral malodor as their primary social problem. It is not, however, very reliable[56]. A plastic tube is put into the patient's mouth to prevent the mouth from getting diluted with room air when undergoing an organoleptic assessment of oral malodor by trained and calibrated professionals. In most cases, a screen with a straw or tube hole separates the patient and examiner. Despite being fairly simple to use, this approach is very subjective and prone to nutritional influences on patients. It's also fairly simple to use the "spoon test," an organoleptic assessment technique. On the tongue's dorsum, a spoon or similar object is used, and the scraped material is smell [57]. The objective evaluation of oral malodor makes use of additional objective techniques like VSC measurements with electrochemical reactions like halimeters, gas chromatography, or salivary study for bacterial load and other chemicals. Due to its simplicity of use, the Halimeter portable VSC detector is in high demand. However, additional substances that may also contribute to oral malodor include volatile short-chain fatty acids, polyamines, alcohols, phenyl compounds, alkanes, ketones, and substances containing nitrogen, this test only identifies VSC products[56, 58]. To perform a salivary incubation test, saliva is collected in a glass and placed in an aerobic chamber at 37 °C. The examiner can measure odor after some time has passed. In contrast to other diagnostic procedures, the salivary incubation test is associated with other tests and far less affected by patients' dietary habits.

By washing the mouth with urea solution for at least 30 seconds and then closing it for around five minutes, an ammonia test could be carried out. The amount of ammonia produced by bacteria can be measured from a scale using a detector. Ammonia levels typically correspond with VSC levels [59]. To find low-molecular-weight amines in breath, the ninhydrin method is used. This quick and simple test has a good test-to-test correlation[20]. The TaqMan system's real-time polymerase chain reaction (PCR) can also be used to find microorganisms that produce VSC. Oral bacterial DNA may be quickly detected and identified using this amplification technique [60].

Management of the causative factors

Treating the identified causes should be the first line of therapy[61]. The effects of toothpaste can vary, but they are often minimal. Mouthwash is also frequently recommended. It is normally advised to use it twice or three times every day for at least 30 seconds on each occasion. In addition to vitamin A and vitamin B12, zinc, and copper are essential minerals for the olfactory and gustatory systems. Their inefficiency may exacerbate or contribute to symptoms of halitosis. The treatment also includes the use of zinc and copper ions. Along with other positive properties including antibacterial action, they immediately neutralize VSCs. VSCs can also be reduced by mouthwashes and toothpastes, particularly those containing zinc ions. Mouthwashes that contain alcohol, phenol, and chlorhexidine may also cover up the odor of the breath [62]. Frequently used antibiotics may reduce the bacterial load and minimize mouth odor. However, using antibiotics additionally kills all bacteria that are part of the normal flora [63]. Probiotics are thus useful and appropriate therapy options for a variety of microorganisms that contribute to the development of halitosis. Before that connects non-genuine halitosis to a psychiatric issue, organic causes must be ruled out. A patient's level of depression and psychogenic diseases needs to be assessed, particularly in cases of non-genuine halitosis [64]. The primary causes of the disease must be treated for long-term effects. The patient must receive a thorough explanation of the causes and treatment options for halitosis. Always keep systemic issues in mind, and if there are any suspicions, further testing should be done to rule out any of these possible causes. It is important to avoid bad habits like smoking and eating foods like onion, garlic, and others. It is also necessary to advise the patient to eat regular meals and to end each meal with some fruit or vegetables, such as carrots or pineapples [23].

Conclusion

In conclusion, halitosis or bad breath can be caused by various factors such as poor oral hygiene, infections in the nose and throat, and systemic diseases. In cases where halitosis is caused by infections in the nose and throat, seeking medical attention and treating the underlying condition can help alleviate bad breath. Additionally, managing systemic diseases can also help reduce halitosis. Overall, understanding the causes of halitosis and taking appropriate measures to address them can help individuals maintain fresh breath and improve their overall oral health. Even Though oral pathologies are the primary culprits, nose, throat and systemic causes can also be the source and need to be properly addressed. Halitosis may be a sign of significant health issues like cancer, thus this must be considered. Planned observations by ENT doctors, dentists, or internal medicine specialties are required to find other causal factors. Patients exhibiting depressive symptoms in either group—true halitosis or non-true halitosis—are typically referred for a psychiatric assessment. halitosis is a common condition that can be caused by a variety of factors. While it can be a source of embarrassment, by addressing these underlying issues, individuals can improve their overall oral health and quality of life.

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