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Risk factors fueling Meghalaya's cancer incidence

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Abstract

Nestled in the heart of Northeast India, Meghalaya, meaning "Abode of the Clouds," is a state renowned for its lush landscapes and unique cultural heritage. Despite the state's natural beauty and cultural richness, Meghalaya faces a range of healthcare challenges, particularly in the realm of cancer. Many factors have been shown to contribute to the limited access to quality cancer care in the region. The state faces a high prevalence of preventable risk factors, including tobacco and alcohol use, poor diet habits like unhealthy consumption of areca nuts and smoked meats coupled with dietary deficiencies arising from malnutrition and limited access to diverse, nutrient-rich foods. This review paper delves into the multifaceted factors contributing to the high cancer rates in Meghalaya, examining the interplay of lifestyle choices, socio-economic disparities, limited healthcare access and low awareness levels.

Keywords: Betel nut, cancer, Meghalaya, smoke meat, tobacco.

Introduction

Cancer remains one of the leading causes of morbidity and mortality worldwide, with its prevalence continuing to soar as the global population ages. As per the Global Cancer Observatory (GLOBOCAN) estimates, 2020 saw a total of 19.3 million new cancer cases globally (Sung *et al*. 2021). India is the third country with the most cancer cases in the world, after China and the United States. It is expected that the number of cancer cases in India will increase by 57.5% between 2020 and 2040, reaching 2.08 million cases (Sathishkumar *et al*. 2023). The northeast region of India bears the highest cancer burden in the country due to a lack of awareness, socio-economic disparities and limited access to diagnosis and treatment facilities, highlighting a geographic disparity compared to more urbanized areas (Mohan *et al*. 2018).In the last few years, the Northeast part of India, especially Meghalaya, has seen a troubling rise in cancer rates, which is causing a big public health crisis. This increase is due to a mix of environmental, lifestyle and socio-economic factors that make people more at risk

for different types of cancer.Meghalaya has an alarmingly high incidence of certain cancers compared to other regions in India. Tobacco consumption remains a significant contributor to cancer incidence in Meghalaya (Vaiphei and Sisodia 2020). Additionally, old customs like betel nut chewing and diets high in preserved foods are connected to higher cancer risks (Shanker *et al*. 2021).There is also a very low level of awareness about cancer prevention and screening, with only a few women getting the screenings they need, highlighting a strong need for focused education efforts (Oswal *et al*. 2020).

Meghalaya is a state in Northeastern India known for its breathtaking natural beauty and diverse tribal culture. The state has lush green landscapes, stunning waterfalls, and unique living root bridges. It is also home to the vibrant Khasi, Garo and Jaintia tribes, each with its own distinct traditions and languages(Roy and Tomar 2001). Limited access to healthcare facilities, particularly cancer screening and treatment centers, poses a significant obstacle for the population. The rising global cancer burden puts a tremendous strain on healthcare systems around the world, requiring significant investment in infrastructure and resources. Despite limited data and research specifically on cancer incidence in Meghalaya, this review aims to highlight the key risk factors contributing to the growth of cancer cases within the state.

Overview of cancer incidence in Meghalaya and its significance

In recent times, cancer data from Meghalaya has shown alarming trends that highlight the area's public health issues. In Meghalaya, esophageal cancer is the most common type of cancer for both men and women. Among men, hypopharynx and stomach cancer are the second and third most common, while for women, cervix-uteri and mouth cancer are the second and third most common. A large majority of cancers in both men (67%) and women (43%) are related to tobacco use, with esophageal cancer being the leading tobacco-related cancer for both genders (ICMR-NCDIR 2021). In addition, the very low screening rates, just 0.2% for women and even less for menshow a lack of early diagnosis efforts that could greatly enhance survival rates (Shanker *et al*. 2021). Moreover, complex socio-economic issues, like poor access to health care and high tobacco use, worsen the cancer situation in the area (Vaiphei and Sisodia 2020). Therefore, grasping these factors is essential not only for individual health but also for developing effective public health strategies to address this escalating crisis in Meghalaya.

Cancer facilities in Meghalaya

Currently, cancer care and services in Meghalaya are primarily provided by Shillong Civil Hospital, NEIGRIHMS (North Eastern Indira Gandhi Regional Institute of Health and Medical Sciences), and Tura Civil Hospital. According to a study on the development of cancer care in Northeast India (Harris *et al*. 2022) the first cancer treatments in the state were offered at Shillong Civil Hospital in 1995. Subsequently, NEIGRIHMS has offered chemotherapy services since 2006. Notably, to this day only NEIGRIHMS is the sole government-operated hospital providing radiation therapy to cancer patients within Meghalaya. The state's limited healthcare infrastructure and relatively small population often result in inadequate facilities and specialized expertise. Consequently, many patients seeking advanced treatment or specialized care are compelled to travel outside the state, particularly to neighboring Assam, where larger hospitals and cancer centers offer a wider range of services.While Meghalaya has some hospitals providing cancer care, the number of specialized cancer centers remains limited. A significant increase in financial resources is crucial to improve infrastructure. While the state has a network of Primary Health Centers (PHCs) and Community Health Centers (CHCs), there is a significant shortage of medical professionals, including specialists and radiographers. This shortage, coupled with the state's difficult terrain, poses a barrier to accessing appropriate healthcare. PHCs are the first point of contact for many people in Meghalaya, especially in rural areas. Strengthening PHCs by improving infrastructure, ensuring adequate staffing, and providing essential resources can significantly enhance healthcare access. Establishing more dedicated cancer hospitals or comprehensive cancer care units within existing hospitals can improve access to specialized treatment and diagnostics.Existing cancer care facilities like NEIGRIHMS and Civil Hospital can be further strengthened by increasing bed capacity, upgrading equipment, and ensuring the availability of essential medicines and supplies.The government should also prioritize investment in crucial medical equipment, such as diagnostic tools and advanced treatment technologies.By implementing these strategies, Meghalaya can significantly improve its healthcare infrastructure and ensure accessible and quality healthcare services for all its citizens.

Current cancer statistics and trends in Meghalaya

Current data on cancer shows a concerning situation in Meghalaya, with high rates of occurrence and significant death figures. The state has some of the highest cancer rates in India, with cancers like esophageal, stomach, and cervical cancer being especially common

among the people (Shanker *et al*. 2021). East Khasi Hills district in Meghalaya has the highest rates of various cancers, particularly those related to the mouth, throat and esophagus, especially among men**.** This region also has the highest incidence of Human papillomavirus(HPV)-related oropharyngeal cancers in India. Key factors causing this increase seem to be linked to lifestyle habits, including high tobacco use, which is common among both men and increasingly among women (Vaiphei and Sisodia 2020). Unfortunately, many people in Meghalaya face late cancer diagnosis, which significantly reduces their chances of survival. This is largely due to the weak healthcare system and lack of screening programs. A shockingly low 0.2% of women had cancer screenings during that period (ICMR-NCDIR 2021).

Despite the Meghalaya government's efforts to implement public health interventions to combat cancer, the effectiveness of these programs has been limited due to various challenges.One major public health intervention is the National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases and Stroke (NPCDCS), implemented nationwide in 2010 (Muksor and Parmar 2022). This program focuses on strengthening infrastructure, human resource development, health promotion, early diagnosis, management, and referral for non-communicable diseases, including cancer. It has led to the establishment of NCD clinics, but data on its impact on cancer screening and incidence reduction is limited due to challenges like vacant health staff positions and low community awareness.Another significant initiative is Ayushman Bharat – Health and Wellness Centres (HWCs) incorporate screening for oral, breast, and cervical cancers as a key service. Despite the establishment of over 173,000 HWCs across India, data on their impact on cancer screening in Meghalaya needs further evaluation (Ministry of Health & Family Welfare 2024). While studies suggest HWCs have increased NCD detection and encouraged public healthcare facility use, their specific impact on cancer screening in Meghalaya requires further assessment. Public health interventions in Meghalaya also face challenges due to sociocultural barriers, such as traditional beliefs and stigma associated with cancer, which hinder prevention and early detection. These beliefs can lead to delays in seeking medical attention and a preference for traditional remedies over conventional treatment (Dkhar *et al*. 2024). Furthermore, deeply ingrained cultural practices like betel nut chewing and tobacco use contribute significantly to cancer risk, and these habits are often concealed, making it difficult to address them effectively through public health campaigns. Cancer treatment can be expensive and many people in Meghalaya face financial barriers to accessing quality care. While health insurance schemes exist, their coverage and effectiveness in addressing the

financial burden of cancer treatment needs improvement. Limited healthcare access, lack of awareness about cancer risk factors and prevention strategies, and financial constraints further compound the challenges in effectively countering cancer in Meghalaya.

Lifestyle and environmental risk factors

The mix of how people live and what they are exposed to in the environment plays a big role in the increasing number of cancer cases in Meghalaya, which is shown by local eating habits and substance use.Like other Northeastern states in India, Meghalaya experiences high rates of tobacco and alcohol use, consumption of fermented and smoked meat and chewing of smokeless tobacco. The region also tends to have a lower intake of fruits and vegetables (Shanker *et al*. 2021). Also, many people eat preserved and smoked foods, which can lead to a higher risk of different cancers because of harmful chemicals used in making these foods(Govindasamy *et al*. 2018). Moreover, tobacco use is still very common, especially among young people, where society often accepts it, allowing continued use even though many know about the health risks (Harris *et al*. 2022). With nearly 70% of cancer cases in India linked to avoidable risk factors, these insights highlight the critical need for public health programs focused on education and changing behaviors (Lyngdoh *et al*. 2024). Dealing with these lifestyle and environmental risks through specific actions will be essential to reducing the growing cancer problem in Meghalaya.

Tobacco and betel nut use as major contributors to cancer

Research indicates a significantly higher prevalence of tobacco use among adults in Meghalaya, with 47.0% of adults using tobacco products, surpassing the national average of 28.6%. This breakdown includes smokers (26.7% in Meghalaya vs. 7.2% nationally), smokeless tobacco users (15.4% in Meghalaya vs. 17.9% nationally) and dual users (4.9% in Meghalaya vs. 3.4% nationally) (Biswas *et al*. 2021). Tobacco use has been identified as a significant factor in about two-thirds (67%) of cancer cases in males and 43% in females in Meghalaya. The most common cancer sites related to tobacco use were the esophagus, with 31.0% in males and 22.3% in females, and other prominent sites included the hypopharynx and stomach in males, and cervix-uteri and mouth in females (Shanker *et al*. 2021). The long-standing popularity of tobacco use within the community reflects a complex mix of tradition and modernity. Practices like betel nut chewing and smokeless tobacco are often seen as normal in social situations, especially among young people. With a high rate of tobacco use among both adults (47%) and young people (33.6%), these habits are deeply

ingrained in community identity and family traditions. This is especially clear when you see how much parents' tobacco use influences young people starting to use tobacco themselves (Ladusingh *et al*. 2017). Research indicates that the state has the highest rates of esophageal cancer in the country, with a substantial fraction of these cases linked to tobacco usage. Moreover, tobacco-related deaths in Meghalaya exceed 8,000 annually, underscoring the pressing public health crisis (Government of Meghalaya 2023). Among the over 7,000 chemicals present in tobacco smoke, approximately 70 are classified as carcinogens, including polycyclic aromatic hydrocarbons, nitrosamines, and formaldehyde. These compounds directly contribute to genetic mutations within human cells, leading to the development of malignancies. Notably, tobacco smoke is a well-established cause of lung cancer, accounting for approximately 85% of cases, but its impact extends beyond the lungs. Cancers of the mouth, throat, esophagus, pancreas, bladder, kidney, and cervix are also linked to tobacco use, with the synergistic effects of other risk factors, such as alcohol consumption, exacerbating these risks (Hecht 1999). Failure to implement comprehensive tobacco control measures will perpetuate the cycle of health deterioration associated with tobacco use, necessitating urgent action to protect the future generations of Meghalaya.

Betel nut chewing has been a part of Southeast Asian cultures for centuries. It is more than just a habit; it is a tradition that brings people together. In India, especially in Meghalaya, betel nuts have a long history,it's often used in rituals and symbolizes friendship and welcome (Shanker *et al*. 2021). In Meghalaya, high prevalence rates of betel nut use correlate with a troubling rise in oral and esophageal cancers. Many young people start chewing betel nuts because their friends and family do it. They often think it helps with digestion and makes them feel good. Betel nuts are easy to find and are often accepted. In fact, 72.1% of young people chew betel nuts without tobacco. Moreover, an alarming number of users are either unaware of the associated health risks, including its strong correlation with oral cancers, or mistakenly believe such risks are negligible or restricted to tobacco users (Snigdha *et al*. 2021). The consumption of areca nut, a primary component of betel quid, has been linked to a spectrum of health issues, notably oral squamous cell carcinoma (OSCC). The International Agency for Research on Cancer (IARC) has classified betel nut as a Group 1 carcinogen, signifying sufficient evidence for its cancer-causing properties in humans (Warnakulasuriya and Chen 2022). Research indicates that chronic exposure to areca nut compounds leads to significant alterations in chromosomal regions associated with cancer progression, particularly the 9p21 locus, which harbors critical tumor suppressor genes such as CDKN2A. Additionally, its mind-altering effects can lead to addiction, making it difficult

to quit and encouraging continued use among young people (Rai *et al*. 2012). The complicated chemical makeup of betel nut includes a variety of bioactive compounds, most notably arecoline, which has been linked to its cancer-causing properties. Arecoline is a powerful alkaloid that can affect different metabolic processes and potentially cause DNA damage, a precursor to cancer development, and contributes to the development of oral premalignant lesions. These lesions, such as leukoplakia and oral submucous fibrosis, can progress to oral cancer if betel nut use persists (Pankaj 2011). Understanding the carcinogenic properties of betel nut, which is classified as a Group 1 human carcinogen by theWorld Health Organization (WHO), can provide crucial insights into its association with the increasing rates of oral cavity and pharyngeal cancers in places like Meghalaya, where an estimated 75% of the population engages in betel nut chewing(Senevirathna *et al*. 2023). The alarming statistics indicating that areca nut chewing contributes to roughly 9.4% of all oral cancers in India reveal an urgent need for focused research to address the health risks associated with its consumption(Garg *et al*. 2014). Despite the ongoing efforts, betel nut use remains widespread in Meghalaya. Studies indicate a high prevalence of betel nut chewing among both adults and youth, with a higher female-to-male ratio. This highlights the deeply rooted nature of the habit and the need for sustained interventions. Alarmingly, children in Meghalaya are becoming familiarized with betel nuts at a young age (10-12 years), emphasizing the need for early intervention and prevention programs (Snigdha *et al*. 2021). Betel nut chewing stands as the primary cause of oral cancer in Meghalaya. The scientific evidence unequivocally links betel nut consumption to an increased risk of this devastating disease. While cultural factors contribute to the widespread prevalence of this habit, public health interventions are crucial to mitigate the oral cancer burden.

Dietary habits and their impact on cancer risk

Over 85% of Meghalaya's population consumes meat (Tripathi *et al*. 2019). A study on dietary habits in Meghalaya reveals that the average monthly meat consumption per consumer unit is significantly higher than the national average. Specifically, rural areas report consuming 0.856 kg, urban areas consume 0.892 kg, while the national average sits at a much lower 0.468 kg (Govindasamy *et al*. 2018). Meghalaya's rugged terrain, dense jungles, and limited access to modern preservation techniques have shaped traditional food practices. The challenging landscape makes frequent food gathering difficult, leading communities to rely on smoking as a means of preserving meat. This age-old method allows them to extend the shelf life of their limited food resources, ensuring sustenance amidst the challenging

geographical conditions. However, these culinary practices raise substantial health concerns due to the presence of carcinogenic compounds, notably polycyclic aromatic hydrocarbons (PAHs) and heterocyclic amines (HCAs), which are formed during the smoking process (Lu *et al*. 2017). The interaction of heat with organic matter during smoking processes is pivotal to the formation of PAHs, a group of hazardous substances known for their mutagenic potential. During smoking, the incomplete combustion of wood and the pyrolysis of fat contribute significantly to PAH production, as volatile compounds from the burning materials interact with the meat. Studies have highlighted that various factors including temperature, smoking duration, and the type of wood used affect PAH concentrations in smoked products, presenting considerable health risks when these compounds are ingested (Roshandel *et al*. 2012). Nitrosamines, which are well-known cancer-causing compounds, are thought to play a significant role in the cancer risk associated with red and processed meats (Xie *et al*. 2023). Nitrosamines, such as N-nitroso dimethylamine (NDMA), arise through reactions between nitrites commonly used as preservatives in cured meats and amines during the smoking process (Iko *et al*. 2021). Nitrosamines, found in these products, are not only carcinogenic but are also recognized as one of the three most potent cancer-causing agents globally. Their danger lies in their genotoxic nature, meaning they can damage DNA, cause mutations, and ultimately lead to an increase in the risk of colorectal cancer (Diallo *et al*. 2018). According to one study on colorectal cancers in India, the incidence rate of colon cancer in Meghalaya peaked among individuals aged 60-65, with a negligible rate in younger females. The lifetime risk of developing colon cancer was highest in the Northeast region for both sexes, reaching 1 in 167. Dietary factors such as beef consumption, pungent spices, and red meat may have contributed to this higher incidence (Asthana *et al*. 2021). Consuming smoked meat and living in a poorly ventilated smoky environment was also shown to increase the risk of nasopharyngeal carcinoma (NPC), which has been shown to be the highest in the Northeastern regions (Kataki *et al*. 2011). These findings underline the necessity of strict monitoring and informed dietary practices, as excessive intake of smoked meats laden with toxic substances could significantly contribute to the global burden of cancer.

Alcohol use and other risk factors

In recent years, patterns of alcohol consumption in Meghalaya have garnered attention due to their alarming implications for public health, particularly regarding cancer risk. The prevalence of alcohol use in this state is notably higher than the national average, where

approximately 60% of men engage in drinking, significantly exceeding the national average of 38% in India (Yadav *et al*. 2017). This trend is concerning, as studies have established a robust link between alcohol intake and various cancers, including those of the oral cavity, pharynx, and liver cancers that are already widespread in Meghalaya due to regional tobacco use (Bhattacharjee *et al*. 2020). In Meghalaya, nearly 12% of the population reportedly consumes alcohol, positioning it along with tribal practices that may contribute further to this trend (Swargiary 2023). Alcohol consumption poses significant health risks, particularly with various cancers. Among these, liver cancer stands out, with heavy alcohol intake leading to cirrhosis—an established precursor to hepatocellular carcinoma. In India, alcohol accounts for 6.5% of male cancer cases and about 0.8% in females, underscoring the pervasive nature of this issue, especially in resource-limited regions like Meghalaya (Mehrotra *et al*. 2022). Furthermore, studies indicate that breast cancer risk rises with alcohol use, driven by ethanol's role in increasing estrogen levels and its potential to promote tumorigenesis(Blot 1992).The risk of esophageal cancer, notably high in heavy drinkers, increases significantly with combined alcohol and tobacco use. This is especially relevant in Meghalaya, which has the highest rates of tobacco consumption (Simila *et al*. 2023). Given these correlations, the alarming increase in alcohol consumption in Northeast India, coupled with the socio-cultural acceptance of drinking, raises concerns about the rising incidence of these cancers, highlighting the need for targeted interventions and public health strategies to mitigate these risks.

Other contributing factors to the high prevalence of cancer cases in the state are the low consumption of fruits and green vegetables and more towards a meat-based diet that has been commonly seen within the Northeastern states. Although Meghalaya has been blessed with a lush green forest harboring a wide variety of fruits and vegetables it has been found that there has been a large gap in their intake across each district in the state(Kumar *et al*. 2024). Consumption of many different fruits and vegetables has been shown to reduce the incidence of cancer, and so significant emphasis has been directed in recent years to dietary implications for cancer prevention (Reddy *et al*. 2003). Malnutrition is also another significant concern contributing to the increased risk of cancer in the region.In Meghalaya, high rates of undernutrition, particularly among rural indigenous hill communities, exacerbate the public health crisis (Bhagat 2021). The nutritional landscape in the state presents a significant public health concern, characterized by alarmingly high rates of malnutrition among various demographics. Studies indicate that approximately 31% of children in the region are classified as underweight, with stunting and wasting affecting 57% and 10% of the

child population, respectively. Severe anemia also impacts a staggering 68% of children and 83% of women, highlighting pervasive deficiencies in essential micronutrients. Furthermore, the reliance on staples such as rice, combined with inadequate consumption of fruits and vegetables only representing 10.7% of consumer expenditure exacerbates dietary deficiencies and elevates the risk of nutrition-related diseases, including cancer (Nongbri *et al*. 2020). Malnutrition significantly exacerbates cancer risks, establishing a complex interplay between inadequate nutrition and cancer progression. The alarming rates of malnutrition, particularly among vulnerable populations, have critical implications for cancer patients, as noted by research illustrating that 30% to 85% of these individuals face nutritional deficiencies, particularly in settings like Meghalaya where dietary choices are limited (Lyngdoh *et al.* 2024). This nutritional inadequacy is compounded by specific cancer types that induce cachexia, a syndrome characterized by severe weight loss and muscle wasting, which further compromises the immune system and overall health (Argiles 2005). Lastly, in Meghalaya, many people still deeply trust traditional healers for their healthcare. While these healers are important figures in the community, this trust sometimes means people delay or interrupt conventional cancer diagnosis and treatment. Sadly, this often leads to people seeking help when their cancer is more advanced, which makes treatment less effective and lowers the chances of survival (Lyngdoh 2022).

Socio-economic and educational influences

Socio-economic factors play a big role in the increase in cancer rates in Meghalaya. Research shows a clear link between low income and poor access to healthcare resources. Being financially unstable often leads to late diagnoses and insufficient treatment options, making cancer outcomes worse. A local study found that only certain groups understood cancer risk factors, with those who had more money and education being more aware (Oswal *et al*. 2020). This gap in education makes health communication less effective, leaving many at-risk groups not knowing about the importance of prevention and early detection. Moreover, traditional eating habits, shaped by economic conditions, have been connected to higher cancer rates, especially due to the common use of tobacco and preserved foods (Ladusingh *et al*. 2017). Therefore, tackling these socio-economic and educational challenges is important to improving cancer awareness, lowering risk factors, and boosting health outcomes in Meghalaya.

Awareness and knowledge gaps regarding cancer and its risk factors

Even with high cancer rates in Meghalaya, many people still lack awareness and knowledge about its risk factors and ways to prevent it. A cross-sectional study was conducted in the Northeast Region of India, involving 1,400 participants from Assam, Meghalaya and Nagaland. Results revealed limited awareness of cancer types, especially cervical cancer. Understanding of risk factors, symptoms, and signs was also low. While 34% were aware of cancer screening, only a small fraction had undergone any screening. Media was the primary source of cancer information (Oswal *et al*. 2020). This lack of awareness is worrying, especially since preventable risk factors like tobacco and alcohol use are common in the area. Additionally, even though most people understand the importance of early detection and screening, actual participation in these measures is very low (Sathishkumar*et al*. 2021). Limited access to information, along with social and cultural issues, continues to widen these gaps, often resulting in late-stage cancer diagnoses when treatment options are limited (Dutta *et al*. 2022).

Impact of socio-economic status on cancer prevalence, early detection, and treatment access

Socio-economic factors play a big role in cancer rates and treatment access, especially in places like Meghalaya. People from lower income levels often find out they have cancer at more advanced stages because they cannot get the cancer screenings and healthcare they need. For example, the alarming statistic that only 0.2% of women have had screenings for cervical and breast cancer shows how serious these socio-economic gaps in health services are(ICMR-NCDIR 2021). These gaps are made worse by a lack of awareness and education; many people do not know about cancer risk factors and how to prevent them.The rates of certain cancers, like those related to tobacco such as oral and lung cancers, are much higher in poorer communities because these individuals are more likely to take part in risky behaviors without the help to quit (Shanker *et al*. 2021). Therefore, tackling the socio-economic factors affecting health is crucial to improving early detection, treatment access, and overall cancer results in Meghalaya.

Government policies and initiatives play a vital role in cancer control. These include implementing tobacco control measures, promoting healthy diets and ensuring affordable access to cancer treatment.Early cancer detection is critical for successful treatment and improved survival rates, and Meghalaya has implemented various programs to facilitate early screening. Several cancer screening programs operate in Meghalaya, including the "Megh

CAN Care" program, which focuses on community engagement and early detection of prevalent cancers, having screened over 32,000 beneficiaries as of December 2023 (World Economic Forum 2024). Additionally, the nationwide NPCDCS and "Ayushman Bharat – Health and Wellness Centres" include cancer screening as part of their services. Still, data on the number of people screened in Meghalaya is not readily available. Despite these programs, cancer screening in Meghalaya faces challenges such as limited data on long-term impact, hindering proper evaluation and improvement. Sociocultural barriers, including traditional beliefs and stigma, can also hinder screening uptake. Additionally, limited infrastructure and workforce shortages, particularly in rural areas, pose challenges to accessing screening services.

To enhance the effectiveness of cancer screening programs in Meghalaya, it is crucial to strengthen data collection and monitoring, address sociocultural barriers through culturally sensitive awareness campaigns, improve healthcare access, especially in rural areas, and ensure financial support for screening to reduce financial barriers.

Role of education in promoting cancer prevention and early detection

Education is essential for improving cancer prevention and early detection, especially in places like Meghalaya, where awareness is very low. A cross-sectional study on senior school and college-going girls in Shillong revealed that despite a high awareness of breast cancer, a significant portion of respondents were unsure or believed that early detection did not guarantee a favorable prognosis. Breast self-examination (BSE) was less familiar, with only a small percentage of respondents having performed it. While most girls expressed interest in learning BSE, fewer were willing to advocate for its practice in the community showing a lack of serious knowledge of Breast Cancer among senior and college-going girls in Meghalaya (Biswas *et al*. 2020). A significant proportion of women in Meghalaya are diagnosed with breast and cervical cancer at advanced stages (III and IV). This late detection is compounded by the sociocultural context in the tribal community, where open discussions about sexual and reproductive health, including issues related to sexual organs, are often limited in both private and public spheres (Dkhar*et al*. 2024). Better educational programs can give people information about cancer risk factors—like tobacco use, which is closely related to high cancer rates, and promote good health habits, such as regular check-ups (Shanker *et al*. 2021). Additionally, including cancer education in school programs can help teach healthy behaviors from an early age, encouraging changes in how

think about cancer prevention. Successful examples, like those in cities with better education levels, show the need for focused outreach programs(Brawley 2017). In the end, using education to create informed communities is crucial for improving early detection, which may help decrease the overall cancer burden in Meghalaya.

Conclusion

The rising cancer cases in Meghalaya discussed in this review show a serious public health issue that needs prompt and thorough action.The cancer situation in Meghalaya shows a worrying pattern where certain types of cancer are more common due to local lifestyles and environmental influences. Data shows that oral cancer makes up many cases, mainly caused by the high use of tobacco and areca nut, worsened by poor oral hygiene(Chaturvedi 2012).Breast cancer rates are increasing among urban women. Still, knowledge about risk factors and screening is very low, with only a small part of the population practicing preventive methods like BSE. Also, the data shows a worrying trend of late-stage cancer diagnoses, increasing death rates, especially for cervical cancer, where screening is very low at just 0.2% in the region. The combination of lifestyle habits, especially tobacco and betel nut use, is an important point in looking at cancer rates in Meghalaya, India. These products are deeply tied to local culture but also play a major role in the high rates of oral and esophageal cancers in the area. Research shows that tobacco accounts for about 67% of cancer cases in men and 43% in women, underscoring its widespread nature as a cancer-causing agent.Even though many people are aware of health issues, there are still gaps in knowledge about how these habits relate to cancer, with only 63% aware of key symptoms for diseases like cervical cancer. Important awareness campaigns should focus on encouraging healthier, nutrient-rich foods rich in fruits and vegetables which have been shown to have a wide range of anti-cancer properties (Kapinova *et al*. 2017). Consequently, targeted educational initiatives that consider socio-economic factors could be instrumental in curbing tobacco use and enhancing overall public health. Integrating awareness campaigns in schools, particularly for younger populations, serves as an essential strategy to boost knowledge and ultimately reduce tobacco-related health risks. The high incidence of tobacco-related diseases highlights the necessity for stringent enforcement of existing regulations such as the Cigarettes and Other Tobacco Products Act (COTPA) to restrict access to tobacco among minors. Some European countries have successfully implemented strict tobacco control laws, resulting in decreased smoking rates and lower incidences of lung

cancer (Gredner *et al*. 2021). These strategies include high tobacco taxes, plain packaging, graphic health warnings, and smoke-free public places, demonstrating the potential for similar policies to reduce tobacco-related cancers in Meghalaya effectively. Implement stricter regulations on the sale, advertising and consumption of tobacco products, similar to those for betel nuts, with increased taxation and penalties for violations. Engaging local tribal leaders and influencers in anti-tobacco and anti-betel nut initiatives can be highly effective in promoting behavior change within communities. By actively engaging in health promotion campaigns, they can disseminate crucial information about cancer risk factors, prevention strategies, and the importance of early detection. Their involvement can help overcome sociocultural barriers and encourage community members to adopt healthier lifestyles, participate in screening programs, and seek timely medical attention.By understanding the risk factors contributing to cancer incidence and implementing comprehensive cancer control strategies, the state can strive to reduce its cancer burden and improve the health and well-being of its population. Ultimately, a collaborative framework involving local government, healthcare providers, and educational institutions is crucial for fostering a cancer-free environment in Meghalaya.

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