Decoding increasing prevalence of noncommunicable diseases

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ABSTRACT

Background: In recent times, noncommunicable diseases (NCDs) have attained epidemic status in India and several other countries. Globally, each year, NCDs cause premature deaths of nearly 40 million people younger than 60 years accounting for 70% of all deaths; 80% of these premature deaths are reportedly in the low- and middle-income countries. Many studies have reported increasing prevalence of NCDs such as type 2 diabetes, coronary and pulmonary diseases, and cancer. Incidentally, all these studies besides discussing environmental pollution have grossly ignored dietary profiling of affected populace despite the fact that several studies have established a direct correlation between food quality and good health.

Objective: Besides pollutants, an attempt is made to analyze mathematically effects of dietary changes over the last four decades on constantly increasing prevalence of NCDs at cellular level. A relationship seems to exist between increasing prevalence of NCD and large-scale consumption of synthetic salt.

Conclusions: Elimination of essential trace elements and micro- and macro-minerals in regular diet through synthetic salt fortified with iodine alone appears to cause more harm than benefits associated with iodization of salt than pollutants. Regular intake of essential trace elements is necessary for normal functioning of many fundamental functions of the body such as Na-K pump, electron–proton transport, biochemistry, and thermodynamics. An attempt has been made to study effects of salt constituents used in food at the most fundamental cellular level by means of disturbances in body electrolyte through heat and ion transport mechanism that is fundamental to various underlying processes in human body. Interestingly, almost all the families who switched over to unprocessed rock salt from synthetic iodized salt reported improvement in general health and reported reduction in medical visits.

Keywords: Himalayan salt, iodine deficiency disorder, iodine-induced hyperthyroidism, iodized salt, ion transport mechanism, Na/K pump, noncommunicable disease, proton pump, sea salt

Introduction

From time immortal, human beings are dependent upon natural sources of water such as springs, lakes, and rivers rich in micro- and macro-nutrients as well as natural salt obtained from lakes, sea, or rocks containing large number of essential trace elements and micro- and macro-minerals. This natural dependence has played decisive role in the biological evolution of the human body. In the last 6–7 decades, there have been large-scale changes in dietary pattern, and large section of global population has moved from natural water to processed water and natural salt to iodized salt for various reasons. This dietary move has deprived the population from daily regular intake of trace elements and micro- and macro-nutrients.

Greater understanding of human physiology and advances in medicine appears to be of little help in controlling growing and spreading various noncommunicable diseases (NCDs) such as type 2 diabetes, hypertension, hyperacidity, coronary deceases such as cardiovascular, angina pectoris, aortic stenosis, heart valve malfunction,
atrial fibrillation, gallstone pancreatitis, or renal deceases such as calculi, hypercalcemia, IgA nephropathy, eye disorders and cancer that were earlier attacking middle age onwards have started attacking at pediatric stage at an alarming rate. Every year, NCDs are responsible for premature deaths of 40 million people younger than 60 years accounting for 70% of all deaths globally; 80% of these premature deaths are in the low- and middle-income countries.

As per the American Cancer Society, childhood cancer incidence rates have slowly increased by 0.6% per year since 1975 and estimated 10,380 new cases in 2016 with 1,250 deaths. However, advances in treatment brought down death rate to almost 66% from 1969. Similarly, about 1,685,210 Americans were expected to be diagnosed with new cancer cases in 2016 with about 595,690 deaths that translate to about 1,630 deaths per day. Cancer is the second most common cause of death in the US, exceeded only by heart diseases, and accounts for nearly 1 of every 4 deaths. Congenital anomalies and reproductive system disorders such as endometriosis, sperm disorders, and birth defects are also slowly but surely reaching epidemic stage. Besides several external factors such as tobacco, alcohol, infectious organism, and inherited genetic mutations responsible for increasing prevalence in NCDs, “unhealthy diet” appears to be more prominent.[1]

Among NCDs, we have chosen type 2 diabetes for the sake of study and discussion; the same discussion goes very well for other NCDs as well because it is based on fundamental processes of human body.

Type 2 diabetes is one of the most debated ailments across the world with global prevalence estimate of 108 million in 1980 to projection of 422 million in 2014 a whopping growth rate of 390% over a period of just 34 years.[2] Viner et al.[3] and McGavock[4] have associated diabetes in adolescents with poverty. Poverty is an important factor but not the sole cause for the prevalence of the disease. There are other factors too which are seriously responsible for diabetes and NCD in the developing countries such as India. In 2017, the World Health Organization (WHO) has related 61% of deaths to NCDs in India; globally, it is 70%.[3]

Observations and data
Several studies have been made on the prevalence of type 2 diabetes in India and other countries. The most recent study named ICMR-INDIAB by the government’s Indian Council of Medical Research (ICMR) covering 15 states widely geographically distributed in India and published in the Lancet Journal of Diabetes and Endocrinology in August 2017; Table 1 shows the prevalence verses per capita gross domestic product (GDP).[6]

As evident in Table 1 of the ICMR study, Indian states with higher GDP have been found to have a higher prevalence of type 2 diabetes.

In rural area of all participant states, type 2 diabetes is more prevalent in individuals of higher socioeconomic status (SES). The populace with lower SES are still dependent upon raw sea salt on account of fraction of price compared to iodized salt and are incidentally free from type 2 diabetes. Although there is an official ban on sale of cheaper raw sea salt for human consumption, it is available for animals and thus used by poor rural populace on account of economic considerations.

On the other hand, urban areas of some affluent states such as Chandigarh, Maharashtra, and Tamil Nadu show a higher prevalence of type 2 diabetes in people with even lower SES populace; it means that economically disadvantaged strata of society are found to be more vulnerable to type 2 diabetes and other NCDs. This is due to nonavailability of cheaper raw sea salt, on account of official ban on raw sea salt for human consumption, leading to forced dependence on iodized salt, thus making poor populace starve of essential trace elements and micro- and macro-minerals available in raw sea salt who are already devoid of balanced diet.

This is very valuable statistical data,[4] and a deeper insight reveals the cause of prevalence as well but has been missed by the authors inadvertently.[6] The study has totally missed

| Indian States | GDP per capita (US$) | Prevalence of diabetes |
|---------------|-----------------------|------------------------|
| Bihar         | 682                   | 4.3                    |
| Manipur       | 909                   | 5.1                    |
| Assam         | 968                   | 5.5                    |
| Jharkhand     | 1009                  | 5.3                    |
| Meghalaya     | 1346                  | 4.5                    |
| Tripura       | 1525                  | 9.4                    |
| Mizoram       | 1665                  | 5.8                    |
| Andhra Pradesh| 1780                  | 8.4                    |
| Arunachal Pradesh | 1870   | 5.1                    |
| Karnataka     | 1959                  | 7.5                    |
| Punjab        | 2020                  | 10                    |
| Gujarat       | 2337                  | 7.1                    |
| Tamil Nadu    | 2464                  | 10.4                   |
| Maharashtra   | 2561                  | 8.4                    |
| Chandigarh    | 3433                  | 13.6                   |

GDP: Gross domestic product
to correlate important changes in dietary intake with diabetes prevalence.

Broad dietary pattern of Indian rural and urban populace can be tabulated in Table 2.

We would like to supplement reasons for type 2 diabetes increasing prevalence. Before the early 1970s, only handful of urban families had a history of type 2 diabetes, this was the period when everyone was dependent upon raw sea salt crystals in regular cooking, and Himalayan salt was only used, being expensive, during Hindu fasting days. Both salts contained >80 micro- and macro-minerals and trace elements.[3] There was no iodized salt in the market during that time frame.

Let us go back a little historically. The populace in some geographical areas were suffering with goiter. To counter iodine deficiency and thyroid disorders, the Government of India undertook salt iodization program in the 1950s. Encouraged with the positive results on goiter control, the Government of India launched the National Goiter Control Programme in 1962 assisted by the WHO and UNICEF with total annual installed capacity of 0.385 million tons. One of the objectives of the program was to supply iodized salt in place of common salt (sea salt) to all the identified and notified goiter endemic areas in the country. Early iodized salt production could not meet the requirement of all endemic areas till 1983 when private sector was also roped in to promote production of iodized salt. Although the iodized salt was meant to be for goiter endemic area, subsequently in 1998, it was made mandatory across the board through a ban on human consumption of natural sea salt. The ban was lifted for some time in 2000 after widespread protests and re-imposed in 2005[8] without any authentic study on the impact of widespread iodized salt consumption even in nonendemic area. The last 50 years of state-sponsored program on forced consumption of iodized salt could not eliminate occasional limited prevalence of thyroid disorder and rather it has attained epidemic status along with other NCDs. Today, it is hard to find a family where thyroid patients are not available; in fact, the populace have embraced it as a lifestyle disorder and do not mind a popping up a little thyroxin tablet every morning.

The prevalence of type 2 diabetes in urban Indians has steadily increased from 2.1% in the 1970s to 8.2% in the 1980s, later climbing to 12%–16%. India now leads the world with 40.9 million people in type 2 diabetes in 2007. Moreover, it is projected that, by the year 2025, 80.9 million Indians will have type 2 diabetes. The phenomenon of high prevalence of type 2 diabetes spreads to urban India and is rapidly moving to rural areas as well.[9] Interestingly, this is the period when thyroid disorders have also shown almost the same growth pattern despite forcing the public to adopt iodized salt through a government ban on raw sea salt. A Sri Lankan study has found a close relationship between consumption of iodized salt and the serum thyroid-stimulating hormone (TSH) levels.[10,11]

In India, agriculture is one of the traditional activities in rural areas, and still, in the digital age and rapid mechanization, it remains labor intensive where majority of farmers plough their fields with bullocks. Surprisingly, despite no genetic history of type 2 diabetes, these remote rural folks are slowly but steadily falling prey to type 2 diabetes despite their lifestyle is far from sedentary that is attributed for its prevalence as compared to urban folks. Interestingly, type 2 diabetes, obesity, and thyroid disorders in urban folks are almost catching up with white collar and blue collar, rich and hard working poor with the same vigor. Even fisherman both sweet water and coastal whose staple diet is fish and seafood, rich in iodine, are untouched from diabetes. Similarly, vegetarian and nonvegetarians populace are suffering alike in this matter.

**Discussion**

The above widespread observations compel one to reason out why such vast spectrum society has started suffering from thyroid and type 2 diabetes disorders despite the fact that upper strata of society being rich and health conscious manage balanced diets and health supplements. It means there is something very seriously wrong in daily food intake that is very common among rural as well as

| Populace         | Vegetables intake       | Fruit and dairy intake | Iodized salt intake | Sea salt intake | Diabetes cases       |
|------------------|-------------------------|------------------------|---------------------|-----------------|----------------------|
| Deep rural (A)   | Occasional              | Rare                   | Never               | Always          | None reported*       |
| Deep rural (B)   | Occasional              | Rare                   | 2%-5% populace      | Rest            | Low                  |
| Urban poor       | Occasional/daily        | Occasional             | 90%-95%             | 10%-5%          | Higher               |
| Urban rich       | Daily                   | Daily                  | 100%                | 0%              | Very high            |

*This may be due to poor health facilities and awareness available in deep rural areas. A: Indian villages far from city and devoid of modern amenities and iodized salt, B: Indian villages nearer to city, some homes with modern amenities.
urban folks, rich and poor, and has been changed in recent times. Further, this “change” is part of staple diet of urban and rural populace alike despite a huge variation in food habits and food preparations which is known to vary every 20 km or so and neighborhood to neighborhood. In Indian scenario, type 2 diabetes first caught the urban-rich populace and then reaching to urban poor. Now, the rural populace also follow the qualitative consumption pattern of iodized salt and its adoption from urban to rural.

Manufacturing of iodized salt removes micro- and macro-minerals and trace elements from sea salt and rock salt that contribute about 14% by weight. These micro- and macro-minerals and trace elements are removed from the regular diet and substituted with pure sodium chloride.

This large substitution of essential minerals and trace metals by NaCl causes major changes in electrolyte composition leading to impairment of various fundamental processes in the human body such as functioning of Na-K pump, calcium pump, and various thermodynamic and biological functions of the body system that are largely dependent on the concentration of various components.

Functional impairment of various body systems has been attempted on the basis of principles of physics. For example, heat and mass transfer across the cell changes drastically with changes in electrolyte composition causing impairment of neuron conduction in nerve cells. Heat movement in human cell can be illustrated by the following differential heat conduction equation:\[12\]

\[
\frac{\partial}{\partial x} \left[ K(x,t) \frac{\partial \theta(x,t)}{\partial x} \right] = \rho(x,t)C(x,t) \frac{\partial \theta(x,t)}{\partial t} \tag{1}
\]

where \( K(x,t) \) is space- and time-dependent thermal conductivity of cell internal fluid.

\( \rho(x,t) \) is space- and time-dependent density of cell internal fluid.

\( C(x,t) \) is space- and time-dependent specific heat of cell internal fluid.

\( \theta(x,t) \) is temperature of cell internal fluid at any instant \( t \) and position \( x \).

It is evident from the above mathematical formulation that thermodynamics of whole body changes with change in concentration of cell internal fluid \( \rho(x,t) \) and composition of body electrolytes leading to changes in specific heat \( C(x,t) \) and thermal conductivity \( K(x,t) \). These physical changes are responsible for malfunctioning of various fundamental body processes such as Na\(^+\)/K\(^+\) pump, thereby causing malfunction of glands and body organs with manifestation of many diseases such as type 2 diabetes and other NCDs.

Similarly, transport mechanism of main electrolyte ions Na\(^+\) and K\(^+\) within nerve cell can be formulated as below:\[13\]

\[
\frac{J_{Na^+}}{q} = D_{Na^+} \nabla Na^+ + Na^+ \mu_{Na^+} E \tag{2}
\]

\[
\frac{\partial Na^+}{\partial t} = - \nabla \cdot \frac{J_{Na^+}}{q} \tag{3}
\]

\[
\frac{J_{K^+}}{q} = D_{K^+} \nabla K^+ + K^+ \mu_{K^+} E \tag{4}
\]

\[
\frac{\partial K^+}{\partial t} = - \nabla \cdot \frac{J_{K^+}}{q} \tag{5}
\]

Where

Na\(^+\) and K\(^+\) are concentration of sodium and potassium ions in the nerve cell, respectively.

\( q \) is elementary charge on the sodium and potassium ions, respectively.

\( J_{Na^+} \) and \( J_{K^+} \) are electric currents due to sodium and potassium ions in the nerve cell, respectively.

\( E \) is the electric vector.

\( \mu_{Na^+}, \mu_{K^+} \) are mobility of Na and K ions, respectively.

\( \nabla Na^+ \) and \( \nabla K^+ \) are concentration gradients of Na\(^+\) and K\(^+\) ions within nerve cell, respectively. \( \nabla \) represents divergence and \( t \) is the time at any instant.

Equations (1) through (5) clearly show effects of changes in electrolyte composition on performance of Na\(^+\)/K\(^+\) pump. Performance degradation of Na\(^+\)/K\(^+\) pump disturbs transmission of brain neuron signals which produce an electrical spike called action potential (AP). After an AP, the Na\(^+\)/K\(^+\) pump resets the arrangement of Na\(^+\) and K\(^+\) ions back to their original positions so that the neuron is then ready to relay another AP when it is called upon to do so. Hence, the Na\(^+\)/K\(^+\) pump has a “housekeeping” role rather than a direct role in brain signaling; this is the long-held, entrenched viewpoint.\[14,15\] However, novel research upon cerebellar Purkinje neurons suggests that the Na\(^+\)/K\(^+\) pump may have a direct role in brain coding and computation.\[16\]
Similarly, functioning of other transport pumps such as calcium pump and proton pump gets impaired due to imbalances in body electrolytes.

Precisely controlled movements of ions into and out of cells and organelles are essential for all life. For example, in cells, ion flows mediate processes as disparate as signaling, pH balance, volume regulation, and the cell cycle, and in higher organisms, they underlie fertilization, immune responses, secretion, muscle contraction, and all electrical signals in nerves, muscles, and synapses.\[16]\]

Recently, Sodha and Agarwal\[17]\ have studied ambipolar diffusion in gaseous plasmas consisting of electrons and ions of multiple varieties that have perfect application to human cells more specifically Na\(^+\)/K\(^+\) exchange pump where we encounter four types of positive and negative ions and neutral particle, namely Na\(^+\), K\(^+\), Cl\(^-\), and P. Similarly, proton pump and calcium (Ca\(^{++}\)) pump also present brilliant example of ambipolar diffusion. Interestingly, human body needs more than 80 trace elements and micro- and macro-nutrients for perfect functioning, thus making physical processes undergoing within the body at various levels becomes extremely complex and sensitive to even minute disturbances.

Results and Conclusions

It is increasingly evident that pH, electrolyte composition, micro- and macro-nutrients, and trace elements play a vital role for maintenance of a healthy body. The body maintains a typical electrolyte balance for various organs such as the brain, heart, digestive systems, reproductive systems, kidney, skin, and hairs through blood, bile, and several other types of fluids. Processed table salt which is a major intake everyday deprives the body of most essential micro- and macro-nutrients together with trace elements that kick off many disturbances. Any chemical imbalance leads to cascading disturbances such as in sodium–potassium pump or electron–proton transport or cell membrane potential or RNA and DNA, all at the cellular level as well as electrode reactions of redox enzymes. Lack of essential trace elements and micro- and macro-minerals is causing more harm than benefits associated with iodized salt because of impairment of many fundamental functions of the body such as Na\(^+\)/K\(^+\) pump, electron–proton transport, biochemistry, and thermodynamics.

This could be more plausible reason for growing NCD epidemics such as obesity, diabetes, cancer, cardiac, pulmonary, infertility, and renal ailments despite improved understanding of body processes and tools developed over three-quarter of the century.

Impact of iodized salt was not visible immediately and thus misunderstood at a larger scale. It is very strongly felt that instead of countering iodine deficiency syndrome, iodized salt is causing more harm on wider scale through impairment of various functions of the human body leading to increased prevalence of NCDs. Interestingly, countries where consumption of iodized salt has been made mandatory through state legislature such as India lead in thyroid disorders and type 2 diabetes along with other NCDs. A limited study indicates a significant drop in TSH levels in chronic patients after switching to natural (Himalayan) salts within a period of 6 months resulting in reduced intake of thyroxin sodium tablet from 50 mcg to 25 mcg. In one particular clinical case levels of T3, T4, and TSH dropped to normal functioning of thyroid gland in 1-year time.

These disturbances manifest into one or more diseases internally and make body susceptible to external biological or chemical attacks. Based on this premise, 78 families consisting of 314 members of both genders in varying age groups ranging from children to adults of 88 years were advised to switch from branded iodized salts to unprocessed rock salt over a period of 2–3 years. Interestingly, almost all the families reported improvement in general health and reported reduced visit to hospitals and medical practitioners. Consumption of unprocessed rock salt in India is not unusual; indeed, Himalayan rock salt is considered as religiously pure and consumed on the occasion of religious fasting and rituals by Hindus.

Recommendations

A new policy to handle iodine deficiency disorder needs to be evolved rather than feeding each and every one with extra iodine resulting in iodine-induced hyperthyroidism along with other host of diseases getting precipitated on account of stripping off of trace elements and micro- and macro-minerals. Development of an improved technology for extra fortification of iodine without stripping off trace elements and micro- and macro-minerals from natural salt is the need of hour. It is extremely necessary to formulate a national policy for consumption of iodized salt.

Limitations of study

Due to the paucity of funds, the study could not be extended over larger geographical areas outside India. The study has no financial support from the Government of India or any other institution or industry.
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Conflicts of interest
There are no conflicts of interest.

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