

Epidemiological Studies: Relation Between Water Hardness and Health (Special Reference to Cardiovascular Diseases)

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Abstract

Numerous epidemiologists have conducted many studies to study the relation between the water hardness content and cardiovascular diseases. The amount of hard water a population can intake and the effect of the same on the mortality was studied. Community studies revealed the increase and decrease in the mortality of the population when they are subjected to hard water. The inverse (beneficial) effect of hard water was also studied during the same. Many epidemiological surveys and researches revealed that human exposure to excessive hardness and many hazardous effects of the same are also prevalent in the populations. This paper has summarised and reviewed the literature of many scientific groups and community surveys.

Keywords: Water hardness, cardiovascular disease, calcium, magnesium

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INTRODUCTION

Hardness is the quantity of calcium and magnesium in water; other minute contributors to the same include aluminium, iron and manganese [1]. It is a physicochemical property that is present due to rocks and soil that surround the source of water. These ions are incorporated in water due to the leaching of ions from the rocks and soil; e.g. commonly calcium is introduced by calcium carbonate and calcium sulphate present in the soil (ground) [2].

There are two types of anions that determine the type of hardness—noncarbonate (permanent) and carbonate (temporary). Temporary hardness is removed by boiling the water while permanent is not. Total hardness is the combination of both (carbonate and noncarbonate) caused by calcium and magnesium [3].

Both the extreme ends of the scale, i.e. very soft and very hard water are not recommended for consumption [4].

The relationship between heart diseases and hardness of water was first found out by a Japanese chemist Kobayashi who revealed in his research that the mortality (due to cardio

dysfunction or strokes) of the people consuming hard water as compared to those consuming soft water is less. [5, 6]. Also according to the World Health Organization, no significant evidence of the poor health due to hard water intake is present [7].

The National Research Council came to the conclusion that hard water actually serves as a good source of calcium and magnesium to the body [1].

However, hard water is not fit for industrial settings because it causes scaling of pipelines and boilers which can be both hazardous to health and industrial setup.

This paper summarizes the health effects of hard water, both positive and negative, by reviewing various studies and literature.

REVIEWS

By National Academy of Science

Many workshops were conducted during 1968, 1973, and 1974 in which the diseases that were caused due to trace elements present in the earth's crust were studied. The diseases under scanner were that of gastro, cancer, renal abnormalities and heart dysfunctions including hypertension [8–10].

The NAS–NRC report [11, 12] came to the following conclusions in which the water hardness was related to cardiovascular diseases:

1. When the study sample was of large area it was found that the hard water had a protective effect on cardiovascular diseases and the mortality rate due to same was reduced. However, the same had a reverse effect when the sample size was reduced to small area such as people on altitude, or coastlines.
2. Although most of the studies did not find out the risk factor associated with cardiovascular arrests but some studies mentioned 1.25 (soft: hard risk ratio) as a risk factor for all cardiovascular diseases and 1.2 for stroke, arteriosclerotic and hypertensive diseases as compared to soft water.
3. In the biopsy reports of Canada and U.K., people residing in areas of consumption of soft water were seen to be magnesium deficit. Also the mortality rate due to the same (myocardial infarction) was high.
4. Hard water provides enough magnesium to prevent magnesium deficiency in some patients thereby reducing the risk of cardiovascular arrest.

In 1980, the safe drinking water committee (NAS-NRC) concluded [13] that though some findings have been found but it still cannot be introduced in the National Health Policy and no addition till now are suggested in soft water.

By World Health Organisation

The working group did a thorough study on the effects of calcium and magnesium on health and also on the effects of demineralised and desalinated water (both protective and negative) [14]. But they came to the conclusion that though the data found were not so high in factual evidence that any changes in its health policies must be done.

The group thus concluded that a more fact-based research and study is required to study the relationship between cardiovascular abnormalities and hard water. If the same is proved to be useful then some modification in the drinking water must be done as soon as possible. Water will prove to be the source of these important ions in areas of deficient, also since water is in abundance this source will prove to be vital.

The following conclusions were given based on the report [14] as follows:

1. The use of desalinated and demineralised water must be regulated based on the total mineral intake of the population.
2. The effects of the same on the body must also be regulated.
3. The effect of demineralised water on pipes in industrial settings i.e., corrosion must also be kept in consideration.

EPIDEMIOLOGICAL STUDIES: SUMMARY

More than 50 epidemiological findings were recorded that gave a relation between cardiovascular diseases and hardness of water. It also discussed the findings of mortality rates in relation to the same.

Findings included that of Neri *et al.* [15, 16], Punsar [17], Sharrett [18] and Comstock [19, 20], Sharrett and Feinleib [21].

Study Findings

In mainly 80% of the findings it was revealed that water hardness has a protective effect on the cardiovascular diseases and the mortality rate was low in a lot of study reports. Reports that involved a large population sample revealed that with increasing water hardness the cardiovascular diseases have a lower rate.

The common example is that of a report from Canada where when the entire country was considered as a sample, the inverse relationship was seen but the relationship has a varied effect when the population size was decreased; that is inverse relation is only seen in Quebec and Ontario province [15, 16, 19, 20]. For rest of the provinces, in decreased sample size it was found that the water hardness increase resulted in the increased cardiovascular diseases. The relationship also varied ethnically, i.e. nonwhites in the U.S.A were not found in inverse relationship.

The contradictions to the same were reported in the following studies:

Sharrett [18] reported that because the results of the findings are dependent on the statistical and geographical valuation, the reports of inverse relation are baseless and must not be considered unless specifically analysed.

Comstock [19, 20] stated in its report that the varied result in the same geographical area is due to inadequate analysis and random or systematic errors.

Sharrett [18] studied the composition of hard and soft water to find out the constituents responsible for water hardness these included magnesium, calcium, copper, zinc and lead.

Voors [22] found that cadmium and lead increases the cardiovascular abnormalities while selenium, silicon and zinc protect the body from the same.

Both the findings were reported to be contradictory to each other.

For the USA, hardness of water is said to be dependent upon magnesium and calcium levels. Also the relationship between the two elements are highly dependent therefore attributing the cardiovascular disease to one of them is difficult. In Wales and England the relation of calcium to water hardness is higher than magnesium. Therefore importance of measuring the constituents and their effect individually is more important than the overall hardness dependence [18].

Morris *et al.* [23] found that the mortality rate in 83 county boroughs of England and Wales had a increase of 1.20 where the hardness level was less than 100 mg/l as compared to boroughs where the hardness level was 200 g/l or higher. In 53 county boroughs where calcium was also present in water, mortality rate increased. The water contained calcium less than 10 mg/l as compared to an area with 100 mg/l calcium [24].

Anderson *et al.* [25] stated that 122 increased risk of mortality due to ischemic heart diseases is expected in areas of Ontario which has water hardness of less than 100 mg/l as compared to areas that have hardness of 200 mg/l.

These findings contradicted when the cities with a population of large number were considered and thus the mortality rate with soft water increases.

In Maryland, Comstock, Washington County [19, 20, 26] risks were associated with gender

and ethnicity. It was found that the white men had no increased risk of arteriosclerotic heart disease as compared to white women who have an increased risk by drinking water having less than 150 mg/l of hardness.

Mainly the studies reported an inverse relation between the water and cardiovascular abnormalities such as hypertension and strokes. However results contradict in some cases [27].

Some other health ailments include cancer, congenital malformations, peptic ulcer, cirrhosis, and infant mortality, relation to all these ailments on a general bases was found to be inverse [19, 20].

Crawford *et al.* [28] in U.K studied the effect of hardness and dependence of the same on the cardiovascular diseases. They studied the mortality in towns of soft water (six towns) and harder water (five towns). After the analysis, nine out of 11 towns revealed that the hard water is beneficial for health. The only exception to this finding was the women aged between 65–74 years where the relation was not inverse [29].

Revelation of those compounds in both soft and hard water which are harmful and protective respectively needs to be evaluated. Soft water is corrosive in nature and especially that which is artificially softened may contain high level of sodium which is mainly responsible for cardiovascular abnormalities [30, 31].

The WHO Working Group [14] concluded that lack of calcium might aggravate cardiac arrests because that is responsible for muscle contractions and decreased serum lipid level [13]. Presence of magnesium in water leads to reduced deficiency and causes the reduction of sudden cardiac arrests [14].

CONCLUSION

The main value of these reports was to find out the association between hard water and cardiovascular diseases and the public health benefits of the same. Mainly 80% of the data found that hard water is better for health than soft water based on many geographical findings and details [32].

As per the WHO nutrient report, on an average 25% of excess cardiovascular abnormalities are present in those who live in soft water as compared to those who live in hard water regions [33].

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Cite this Article

Shafiee MN. Epidemiological Studies: Relation between Water Hardness and Health (Special reference to Cardiovascular Diseases). *Research & Reviews: A Journal of Life Sciences*. 2018; 8(2): 6–10p.