

Sea water desalination and removal of iodine: effect on thyroid function

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ABSTRACT

In Israel, about 55% of drinking water is derived from desalination (DSW) which removes all iodine. A recent study from Israel demonstrated high rates of iodine deficiency among school-aged children and pregnant women. There are concerns that low iodine may lead to impaired thyroid function. However, to date, the impact of consuming DSW on body iodine status has not been studied. The objective was to assess whether the increased use of DSW is associated with increased rates of hypothyroidism. Using data from a large health fund in Israel, we compared proportions of patients with higher than normal thyroid stimulating hormone (TSH), and lower than normal T3 and T4 levels before and after a massive desalination project became operational in August 2013 in areas with high vs. low use of DSW. Over 400,000 cases were compared in 2010–2013 vs. 2014–2016. Overall, there was no increase in the proportion of individuals with higher than normal TSH levels, or lower than normal T3 and T4 levels. In conclusion, in this population-based study, following the introduction of DSW, there was no evidence of increased incidence of low thyroid function tests, and the trends were similar in both areas highly consuming, or not consuming, DSW.

Key words | desalinated water, desalination, iodine, thyroid stimulating hormone, thyroxine, triiodothyronine

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INTRODUCTION

Iodine deficiency during fetal life and among young children adversely affects brain development with detrimental life-long effects through a decrease in thyroid functions (Bath *et al.* 2013). To circumvent such risk, the WHO promotes universal salt iodination as the method of choice to ensure adequate intake of iodine (van der Haar *et al.* 2011). Worldwide, fresh water needs increasingly exceed the available supply, leading to implementation of technologies for desalinating sea and brackish water. It has been estimated that as of 2015, about 300 million people worldwide used desalinated sea water (DSW) (Desalination Association 2015). Israel is among the leading countries in the production of DSW, using reverse osmosis technologies, and it has been estimated that by 2020 it will account for 60–70% of the

country's drinking water consumption (Israel Ministry of Health 2017). Hence the potential health effects of DSW on iodine need to be carefully monitored.

Fresh water from the Israeli National Water Carrier (NWC) contains varying concentrations of iodine (between 2 and 150 mcg/L) depending on the water source (Israel Ministry of Health 2017). In contrast, DSW contains virtually no iodine due to its removal during the desalination process (Yermiyahu *et al.* 2007). However, to date, no analysis exists in which the potential impact of the massive introduction of DSW was measured directly on the incidence of thyroid disease. Some main sources of dietary iodine are seaweed (16–2,984 mcg per serving), cod (99 mcg per serving), dairy products (56 mcg), grain products (45 mcg), and eggs

(24 mcg). Dairy products, especially milk, and grain products are major contributors of iodine in western diets (NIH 2017).

Regular ('hard') water in Israel contains between 2 and 250 mcg/L of iodine, and hence it may account from negligible and up to 20% of the daily requirements of iodine (Israel Ministry of Health 2017; NIH 2017). In Israel, there is negligible use of iodized salts (Israel Ministry of Health 2017), and hence it may be argued that iodine in water may be more important than in countries that have implemented use of iodized salts, the rest coming from nutritional sources. In light of recent findings of high rates of iodine deficiency among Israeli school aged children and pregnant women, as measured by urinary iodine concentrations (Ovadia *et al.* 2017), it is critical to examine whether the massive introduction of water desalination has contributed to a clinically relevant decrease in body burden of iodine, potentially putting people at increased risk of hypothyroidism.

The objective of the current study was to quantify potential changes in the incidence of hypothyroidism in a large population-based study, comparing levels before and after the introduction of DSW.

SUBJECTS AND METHODS

For this retrospective cohort study, we used data from the computerized files of Maccabi Healthcare Services (MHS), a two million health maintenance organization in Israel. According to the National Health Act in Israel (1994), MHS may not bar applicants for any reason, thus all Israeli population sectors are represented in MHS.

For the purpose of the present analysis, we identified 15 communities where DSW was introduced as a source of drinking water in 2013, when the Sorek desalination facility was introduced in central Israel, and 24 communities where no such change took place, and hence they continued to consume mainly regular 'hard' drinking water.

The study periods compared the years 2010–August 2013 vs. 2014–May 2016.

The information regarding distribution of DSW was cross-checked by measuring magnesium, which, like iodine, is also totally removed during desalination, in 53 samples of tap water from both areas of DSW and non-DSW use. The mean magnesium levels in the DSW

communities were 5.4 mg/L (range 0–9.42), compared to 25.1 mg/L (11–37.5) in tap water from naturally occurring 'hard' water.

For the years studied, we extracted from the MHS database all measurements of thyroid stimulating hormone (TSH), thyroxine (T4) and triiodothyronine (T3) performed on MHS members residing in the selected communities. When more than one measurement was available, only the first one was included. All laboratory tests were performed by one central laboratory of MHS (MegaLab, Rehovot Israel), adjusting the normal range by age, sex, and trimester of pregnancy.

Two different types of analyses were conducted:

1. Comparison of thyroid functions between 2010–2013 and 2014–2016 in the whole cohort, reflecting a 25% increase in the total supply of DSW in Israel between these two periods.
2. A similar comparison was repeated, broken to communities close to desalination plants in central and southern Israel, where most of the drinking water supply consisted of DSW vs. communities in Northern Israel receiving mostly non-DSW.

Using chi-square test, we compared the percentage of TSH levels above the norm, and of T3 and T4 below the norm for the period 2010–2013 to 2014–2016.

RESULTS

A total of 345,573 subjects had TSH levels during 2010–2013, and 321,593 during 2014–2016. For T3 there were 30,837 subjects in 2010–2013 and 22,570 in 2014–2016. For T4 the numbers were 71,444 in 2010–2013 and 49,880 in 2014–2016).

Studying all communities during 2010–2013, 9.12% of TSH levels were above the normal range. This proportion did not increase in 2014–2016 (7.23%). For T4, 8.73% of levels were below normal in 2010–2013 and this proportion did not increase in 2014–2016 (6.24%). For T3 the proportion of lower than normal levels was 8.33% in 2010–2013 and virtually did not change in 2014–2016 (7.67%).

In the desalinated regions, the percentage of higher than normal TSH was 9.05% in 2010–2013 and virtually did not

increase (7.3%) in 2014–2016. Similarly, in the non-desalinated regions, the percentage of higher than normal TSH was 9.14% in 2010–2013 and 7.21% in 2014–2016.

In the desalinated regions, the percentage of lower than normal T4 was 8.74% in 2010–2013 and 6.3% in 2014–2016. In the non-desalinated regions, the percentage of lower than normal T4 was 8.67% in 2010–2013 and 5.7% in 2014–2016.

Similar trends were recorded for T3. In desalinated regions, the percentage of lower than normal results was 8.39% in 2010–2014 and 7.61% in 2014–2016; in non-desalinated regions, it was 8.08 and 7.95%, respectively.

DISCUSSION

A recent study documented that 62% of Israeli school children and 85% of pregnant women had inadequately low urine iodine concentrations in 2016 (Ovadia *et al.* 2017). The authors surmised that this may be explained, at least in part, by increasing consumption of water totally depleted of iodine, as they also found in a small cohort study that the majority of individuals with thyroid dysfunction in a southern Mediterranean city had iodine intake below the daily estimated average requirement of 95 mcg (Ovadia *et al.* 2016). As about 55% of tap water in Israel comes from DSW, it is theoretically possible that this contributes to the national moderate levels of iodine insufficiency, although a major identified cause stems from Israel not complying with WHO recommendations to use iodized salts (Israel Ministry of Health 2017).

Our population-based cohort suggests that the massive increase in usage of DSW was not associated with increasing proportions of individuals exhibiting laboratory findings consistent with hypothyroidism, as a result of lack of iodine intake. These results are consistent with the recent Israeli study showing that Israeli school children and pregnant women had low urinary iodine independent of region of living in northern or southern parts of the country. Of note, iodine content in natural water sources in Israel is lower in the north and gradually increases in central and southern Israel (Israel Ministry of Health 2017).

The higher proportions of DSW depleted of iodine in central and southern Israel may counterbalance the differences in iodine content in drinking water between the

north and the south. Thus, it is possible that iodine concentration in drinking water in all parts of Israel could be low.

In countries which have adopted the WHO recommendation to use this strategy, the source contribution of iodine from drinking water to the total daily iodine content is relatively low, compared to dietary sources and salt iodization.

A closer examination of the sources of dietary iodine intake may explain these results: An individual consuming daily one cup of yogurt (75 mcg iodine), one cup of milk (56 mcg), one serving of fish (54 mcg) and two slices of bread (45 mcg), has an intake of 230 mcg of iodine, which exceeds by far the RDI in all age groups (NIH 2017). Hence, even if one consumes 1 L per day of DSW with zero iodine levels, s/he are not likely to be iodine depleted.

CONCLUSIONS

Our study suggests that the introduction of DSW has not had an obvious impact on rates of laboratory markers of hypothyroidism. The more obvious cause for the moderate level of iodine insufficiency in Israel is the fact that Israel does not have an iodine deficiency disorder prevention program, urinary iodine monitoring program, nor a universal salt iodization (Ovadia *et al.* 2017). It is very likely that, similar to other countries, establishment of universal salt iodization will change the grim reality of moderate iodine insufficiency.

CONFLICT OF INTEREST

The authors state that no conflict of interest exists regarding this paper.

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