

Chlorinated Water and Overall Risk of Cancer: A Systematic Review

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Welcome to Country*

Welcome to Kurna Country
Ninna Marni (A Kurna word for "hello, how are you?")

I would like to Acknowledge that the land we meet on today is the traditional lands for the Kurna people and that we respect their spiritual relationship with their Country. I also acknowledge the Kurna people as the traditional custodians of the Adelaide region and that their cultural and heritage beliefs are still as important to the living Kurna people today.

*Reconciliation South Australia. 2016. Welcome and acknowledgement of country. Available: <http://www.reconciliationsa.org.au/learn/welcome-and-acknowledgement-of-country-> [accessed 11 August 2016].

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Executive summary

Introduction

Chlorine was introduced into large-scale public water supplies early in the 20th century as an inexpensive and expedient solution to render sewage contaminated and infectious water supplies non-infectious. Redraw and recycling of contaminated and infectious water downstream continues to this day around the world e.g. Mississippi River, United States (US) and the Murray-Darling River, Australia. However, today disinfection of redrawn water with chlorine allows consumption of recycled water without causing gastrointestinal epidemics including cholera and typhoid. Trihalomethanes, sourced from chlorinated water drawn from the bottom of the Mississippi River in New Orleans, were first identified in 1974 as the potential carcinogenic agents responsible for the very high rates of cancer occurring there. Since then chlorine disinfection by-products (CDBs) have been a serious public health concern. Exposure to them is widespread and associated with increased cancer risk and adverse reproductive and developmental outcomes. To date increased cancer risk has only been confirmed for bladder and colorectal cancers. The objective of this review is to determine the evidence for an association between chlorinated water and cancer, other than colorectal and bladder.

Method

The Joanna Briggs Institute methodology for systematic reviews was used, with multiple databases date limited to 1974. Data was included according to an *a priori* protocol, and was synthesized through meta-analysis or presented narratively.

Results

Twelve statistically significant point estimates were identified: all reported cancers combined risk index 1.13 (1.07, 1.2) $p = 0.000$, geographical regions of North America and Europe, for males and females as well the following cancer sites breast, female

reproductive, melanoma, non-Hodgkin's and lung. Non-Hodgkin's and lung had significant predictive intervals.

Overall, for all reported cancers a relative increase in risk of 13% was observed. This risk is discussed in terms of the absolute incident and mortality associated with CDBs.

Conclusion

The results from the present work support the association between CDBs and cancer originally made by Rook in 1974 and strengthen the argument for a causal basis.

Recommendations for best practice

The US Environmental Protection Agency (US EPA) since 1974 has been proactive and set the benchmark for regulating CDBs to reduce population risk and exposure. Despite the encouraging action of the US EPA the overwhelming attitude towards disinfection of water supplies with chlorine in public health and within the water industry generally remains one of, "infection control is paramount and in no way should be compromised to lower exposure risk to CDBs". Large urban populations prospered without the need to disinfect water supplies with chlorine for centuries including throughout the 19th century. However, CDBs are now considered a serious public health concern and are recognised in the US as contributing to the burden of chronic non-communicable diseases; including cancer now at epidemic rates. The results of our systematic review help put scale and magnitude to the potential size of the problem. Improved knowledge of biologically safe water, new technology and the hygienic management of sewage to prevent contamination of water supplies will help mitigate the need for disinfection. Ongoing research to determine the most desirable water qualities for health and how to deliver this quality of water to end users will set the gold standard to strive for in the entire water supply chain.

Declaration

I, Gordon David Parbery certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint award of this degree.

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Gordon David Parbery

March 2016

Acknowledgements

Ice crystals shimmered and tinkled. The old Chinese sage had risen, dusted his cloak and pushed back the hood covering his brow. He surveyed the bleak winter landscape. Little birds and animals, drawn by his warmth in the night scattered. Golden light arced into the sky and the sun peeked over the distant sparkling horizon. A new day had begun

Anon.

My journey into academia, beginning this time as it did at the age of 51 has been an interesting one to say the least. Those who know me will understand. I could hold Trish McReynolds responsible, her various, assorted and sundry colleagues and their shenanigans.

I owe much to the ancient ways and friends who have taught me along the path. Glynn Braddy and associates first and foremost, helped to reveal a unique perspective and world view even if old as the world itself. There are others I am extremely grateful to for their incredible support and insight also.

I met Grandpa Charlie Thom, Red Tailed Hawk Walking Backwards into the Future on arrival to California in 1991. Grandpa Charlie cooked me until I was more than done, in the sweat lodge. Then passed me to his son Bobby Lake-Thom (Medicine Grizzly Bear), who continued to teach me high up on the side of Mt. Shasta in Northern California. I was in my thirties and had never met an Aboriginal person from Australia. Bobby guided me back to the land down under and I met Uncle Moogy and Aunty Irene but not before I had travelled to London, Paris and Italy and tasted the waters of the Thames, Seine and in Rome, drank from the Fontana Di Trevi as well as the Tiber.

My father passed over in 1992 at the age of 60 and my mother continued living in Alabama, US. She turned eighty in April 2016 and I was with her to celebrate. There I met her good friend Tom Hendrix, and learnt from him about the Singing River and the Yucchi, first people of Alabama.

I travelled the entire length of the Murray Darling River system with Uncle Moogy. My daughter danced with Aboriginal people all up and down the river. I reported my experiences for continuing education credits as part of my professional learning and development as a clinical dietitian and shortly after was expelled though the adverse finding is contested.

My wife and her towering support drive me. We have been through thick and thin and celebrate 27 years of marriage this year. Our daughter teaches me every day how to be a better dad.

This work could not have been achieved without the enduring patience of my supervisors David Tivey and Alexa McArthur, for that I am grateful. However, there are others including supervisors' integral to the success of the project. Ed Aromatis and Tim Schulz, my original supervisors and without whose input, the nature of the investigation as it became, might never have occurred. The original question posed remains, "Is chlorinated water hydrating?" A clue now, to what the answer may be is clearly exposed. Between the desired urgency of Ed and the measured pace of Dave the thesis evolved. Whenever I need copy editing Alexa McArthur is always ready to insert comma's no matter where I wanted or needed!

Mick Draper, Maria Albanese and all of the library staff also supported the work immensely as did many of the Joanna Briggs Institute administrative staff.

Thank you to all for making it happen.

Gordon David Parbery

2016

There is no truth.

*Anon., Joanna Briggs Institute
May 2013 research school*

Truth is a contentious issue. Nothing is absolutely proven, and the progress of proof is based on repeated revisions, corrections and the rejection of beliefs that were once regarded as 'the truth'.

Glynn Braddy
