

# Calcium and Magnesium in Drinking-water

Public health  
significance



World Health  
Organization

# Calcium and Magnesium in Drinking-water

Public health  
significance



World Health  
Organization

## WHO Library Cataloguing-in-Publication Data

Calcium and magnesium in drinking-water : public health significance.

1.Potable water - standards. 2.Water - analysis. 3.Calcium - administration and dosage.  
4.Magnesium deficiency. 5.Calcium metabolism disorders. I.World Health Organization.

ISBN 978 92 4 156355 0

(NLM classification: QV 276)

© World Health Organization 2009

All rights reserved. Publications of the World Health Organization can be obtained from WHO Press, World Health Organization, 20 Avenue Appia, 1211 Geneva 27, Switzerland (tel.: +41 22 791 3264; fax: +41 22 791 4857; e-mail: [bookorders@who.int](mailto:bookorders@who.int)). Requests for permission to reproduce or translate WHO publications – whether for sale or for noncommercial distribution – should be addressed to WHO Press, at the above address (fax: +41 22 791 4806; e-mail: [permissions@who.int](mailto:permissions@who.int)).

The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted lines on maps represent approximate border lines for which there may not yet be full agreement.

The mention of specific companies or of certain manufacturers' products does not imply that they are endorsed or recommended by the World Health Organization in preference to others of a similar nature that are not mentioned. Errors and omissions excepted, the names of proprietary products are distinguished by initial capital letters.

All reasonable precautions have been taken by the World Health Organization to verify the information contained in this publication. However, the published material is being distributed without warranty of any kind, either expressed or implied. The responsibility for the interpretation and use of the material lies with the reader. In no event shall the World Health Organization be liable for damages arising from its use.

Cotruvo J, Bartram J, eds. Calcium and Magnesium in Drinking-water : Public health significance, Geneva, World Health Organization, 2009.

Printed in Spain.

---

# Contents

Preface	v
Acknowledgements	vii
List of acronyms and abbreviations	x
<b>Chapter 1:</b> Expert consensus	1
<i>Meeting of Experts Report</i>	
<b>Chapter 2:</b> Overview of global dietary calcium and magnesium intakes and allowances	16
<i>S.A. Atkinson, R. Costello and J.M. Donohue</i>	
<b>Chapter 3:</b> The mineral composition of water and its contribution to calcium and magnesium intake	36
<i>C.N. Ong, A.C. Grandjean and R.P. Heaney</i>	

<b>Chapter 4:</b> Identifying magnesium deficiency: A diagnostic dilemma <i>R.J. Elin</i>	57
<b>Chapter 5:</b> Magnesium deficiency: Clinical and experimental aspects <i>W.B. Weglicki</i>	60
<b>Chapter 6:</b> Magnesium and hypertension <i>R.M. Touyz and B. Sontia</i>	66
<b>Chapter 7:</b> Atherosclerosis and magnesium <i>B.M. Altura and B.T. Altura</i>	75
<b>Chapter 8:</b> Health significance of calcium and magnesium: Examples from human studies <i>G.F. Combs, Jr and F.H. Nielsen</i>	82
<b>Chapter 9:</b> Calcium and magnesium: Role of drinking-water in relation to bone metabolism <i>C.M. Weaver and J.W. Nieves</i>	94
<b>Chapter 10:</b> Epidemiological studies and the association of cardiovascular disease risks with water hardness <i>R. Calderon and P. Hunter</i>	108
<b>Chapter 11:</b> Alternative hypotheses and knowledge gaps <i>J.K. Fawell</i>	143
<b>Chapter 12:</b> Water production, technical issues and economics <i>P. Regunathan</i>	152
Glossary	165
Index	170

---

# Preface

This document identifies knowledge gaps and recommends research priorities in order to build an evidence base to inform decisions on managing “processed” drinking-water. This is important because of increasing consumption of water arising from advanced treatment processes such as desalination and uncertainty about the resulting health implications.

The World Health Organization (WHO) assembled a diverse group of nutrition, medical, epidemiological and other scientific experts and water technologists at the Pan American Health Organization in Washington, DC, USA, on 27–28 April 2006 to address the possible role of drinking-water containing calcium and/or magnesium as a contribution to the daily intake of those minerals. The overarching issue addressed was whether consumption of drinking-water containing a relatively small contribution to total daily dietary intake of calcium and/or magnesium would provide positive health benefits, especially with respect to cardiovascular disease mortality (the so-called “hard water cardiovascular disease benefits hypothesis”), in the population, particularly in people whose dietary intake was deficient in either of those nutrients. The meeting of experts immediately followed the International Symposium on Health Aspects of Calcium and Magnesium in Drinking Water, which was organized by NSF International and the International Life Sciences Institute in Baltimore, MD, USA.

The impetus for the meeting originated from the process for developing WHO guidance for health and environmental aspects of water desalination, which was initiated by the WHO Regional Office for the Eastern Mediterranean, located in Cairo, Egypt. The meeting was also intended to contribute to the Fourth Edition of the WHO *Guidelines for Drinking-water Quality* (to be published in 2010) in respect to nutrients in drinking-water and water hardness as they influence drinking-water quality and health.

The nutritional essentiality and benefits from sufficient dietary intakes of calcium and magnesium are well established but quantitatively imprecise. Many of the ecological epidemiological studies conducted since the mid-1950s have supported the hypothesis that extra magnesium and/or calcium in drinking-water can contribute to reduced cardiovascular disease and other health benefits in populations. However, most of those studies did not cover total dietary intake and other important factors. Several analytical epidemiological studies that were conducted supported the hypothesis that magnesium correlated best with beneficial effects on cardiovascular mortality rates.

The goal of the meeting of experts was to elucidate the role of drinking-water as a contributor to total daily intake of calcium and magnesium and to determine whether there is a plausible case that drinking-water could be an important health factor, especially for cardiovascular disease mortality, at least for people whose dietary intake is deficient in either of those nutrients. The report of the meeting of experts is the first chapter in this volume.

The remaining chapters provide background information on the scientific, nutritional and technological issues that were discussed by the meeting of experts and the symposium participants and that contributed to the report of the meeting of experts. Among the numerous issues addressed were the concentrations and distributions of minerals in drinking-water worldwide, nutritional requirements, biochemical and biomedical aspects of minerals in the body, technologies such as water softening and desalination that significantly alter the mineral composition of drinking-water, the desirability and feasibility of remineralization for stabilization and potential benefits, and the availability of information on water composition so that the public can make informed judgements with respect to their options for bottled water, softened water and naturally soft water. It is hoped that this publication will advance knowledge and contribute to further discussions on these and related issues in this area.

---

# Acknowledgements

The World Health Organization (WHO) wishes to express its appreciation to all those whose efforts made the production of this book possible, in particular Joseph Cotruvo (Joseph Cotruvo & Associates, Washington, D.C., USA) and Jamie Bartram (Coordinator, Assessing and Managing Environmental Risks to Health, WHO Headquarters), who were the book's editors. The international participants who attended the meeting of experts on 27–28 April 2006 in Washington, DC, USA, and who contributed to the development of individual chapters in this book were as follows:

预览已结束，完整报告链接和二维码如下：

[https://www.yunbaogao.cn/report/index/report?reportId=5\\_29264](https://www.yunbaogao.cn/report/index/report?reportId=5_29264)

