Concern has recently emerged regarding the safety of natural health products (NHPs)—therapies that are increasingly recommended by various health providers, including conventional physicians. Recognizing that most individuals in the Western world now consume vitamins and many take herbal agents, this study endeavored to determine levels of toxic element contamination within a range of NHPs.

Methods

Toxic element testing was performed on 121 NHPs (including Ayurvedic, traditional Chinese, and various marine-source products) as well as 49 routinely prescribed pharmaceutical preparations. Testing was also performed on several batches of one prenatal supplement, with multiple samples tested within each batch. Results were compared to existing toxicant regulatory limits.

Results

Toxic element contamination was found in many supplements and pharmaceuticals; levels exceeding established limits were only found in a small percentage of the NHPs tested and none of the drugs tested. Some NHPs demonstrated contamination levels above preferred daily endpoints for mercury, cadmium, lead, arsenic or aluminum. NHPs manufactured in China generally had higher levels of mercury and aluminum.

Conclusions

Exposure to toxic elements is occurring regularly as a result of some contaminated NHPs. Best practices for quality control—developed and implemented by the NHP industry with government oversight—is recommended to guard the safety of unsuspecting consumers.
Introduction

The issue of harm related to healthcare provision has become a persistent problem that has been shrouded in silence. [11, 22] Most people in the Western world believe there is adequate protection when they or their loved ones receive health advice or intervention. [22] Yet, considerable data from varying locales and demographics paints a different story. [13–19] Rather than rare occurrences, adverse events related to provision of health services are common – they frequently cause serious harm and most are entirely preventable. [12, 18] An emerging public health concern relates to hazards posed by exposure to toxicants [23, 24] through contaminated everyday merchandise, [22] including natural health products (NHPs).

The contemporary reality is that most individuals in the Western world now consume some form of NHP [25] and many of these products are increasingly recommended by health providers – a recent survey found about 38% of Canadian physicians now recommend some NHPs to their patients. [26]

Accordingly, this study was designed to determine if toxic element contamination of NHPs is a routine occurrence or a sporadic event. A variety of common pharmaceutical preparations were tested for comparison purposes.

Background

Various items including foods, toys, cosmetics and other personal care products have recently been found to contain toxic compounds [23, 25] including lead, arsenic, mercury, cadmium as well as an array of synthetic agents – raising concern about contamination in common items used by much of the population. NHPs include vitamins, herbal products, probiotics, homeopathic medications and various supplements containing nutrients or other compounds purported to benefit health. The number of assorted dietary supplements has risen to around 55,000 in the United States, [26] with an estimated 60% of Americans now using NHPs. [23] 50% of Europeans on average consume NHPs, [19, 21] and in Canada, approximately 7% of the population uses NHPs, with 38% doing so on a daily basis. [27] Vitamins are the most commonly consumed product – used by 57% of Canadians, followed by 15% using Echinacea and 11% using other herbal, fungal or algal products. [29]

Many health providers now recommend NHPs including prenatal vitamins, iron supplementation, calcium, and vitamin D for a range of recognized indications including deficiency states such as rickets and anemia, as well as illnesses such as multiple sclerosis. [30] Many consumers are also pursuing natural and holistic approaches to medicine (Figure 1) [34] with the result that NHPs have found a ready market in non-allopathic medicine. Over the past two decades, use of alternative medicine has increased. [31, 32] with an annual estimated $700 million spent on all products and therapies in England, [33] $7.84 billion in Canada, [34] and $33.9 billion in the USA with $14.8 billion spent specifically on NHPs. [35]

With increases in globalization, cultural remedies from Chinese, Ayurvedic, and other traditions have become more available to international consumers, offering unfamiliar products with unfamiliar adverse effects. Thus, beyond questions of efficacy and drug interactions, the inherent safety of NHPs has come under increasing scrutiny in the public health community. [15, 33, 36] Consumers are similarly eager for information, with 84% of Canadians believing that “more needs to be done to inform Canadians about the safe use of NHPs”. [32] Although conventional pharmaceuticals are by no means innocuous, [23, 40, 41] international research indicates that NHPs are not always completely safe either. Contamination with toxicants including lead, mercury, arsenic, and other toxic elements has been documented in a variety of NHPs from various parts of the globe, particularly some parts of Asia and the Orient. [44]

Ayurveda

Ayurvedic practices stem from the Vedic culture of southern Asia, and date back over 5000 years. They comprise a purely structural, organ-based approach to health. Ayurveda focuses on the functions of organ systems and the body as a whole. [45] Key to the concept of health is the unique energy patterns of each individual, reflecting a combination of the three energies: vata (metabolism), pitta (structure, stability) and kapha (movement). All clinical symptoms are assessed as an imbalance between these energies; restoration of balance often involves changes in lifestyle and diet, habits of meditation and mindfulness, detoxification, [44] as well as various herbal preparations. [46]
Some Ayurvedic preparations have been found to contain significant amounts of lead, mercury, and arsenic. It is sometimes thought within Ayurvedic tradition that metals and metalloids should be included with minerals to maintain a proper balance for health. Thus, metal content in Ayurvedic supplements may result from intentional additives (that have undergone traditional cleansing procedures), rather than from contamination. Examples of these purifying procedures have been documented, but convincing evidence is lacking to support the efficacy of these procedures in decreasing the toxicity of harmful substances present in the final preparations. Toxins leaching from contaminated soil may also contribute to the toxicant content of the raw materials.

Ayurvedic supplements containing toxic elements are widely available in the United States. Lead exposure has been associated with episodes of neurological damage following Ayurvedic NHP consumption, especially in pediatric populations. Status epilepticus, congenital sensorineural deafness, infant encephalopathy, and developmental delays have all been reported after use of lead-contaminated Ayurvedic NHPs. Acute presentations also include GI symptoms, hepatotoxicity and hematopoietic toxicity. Effects of lead in Ayurvedic preparations may also lead to subacute presentations, with toxic blood levels noted for more than 30 days in some patients after one-time consumption.

Other toxicant related problems have resulted from consumption of Ayurvedic preparations. Mercury from Ayurvedic NHPs has been associated with weight loss, diarrhea, sweating, tremors, paresthesias and peripheral neuropathy, as well as skin lesions in topical preparations. A case of chronic arsenic toxicity secondary to Ayurvedic medications presented with skin lesions (punctate palmoplantar keratoderma and leucomelanoderma) and portal hypertension. In review, toxic element contamination of Ayurvedic NHPs is a well-established concern.

**Traditional Chinese Medicine (TCM)**

Dating back thousands of years, traditional Chinese Medicine (TCM), like Ayurveda, arises from a philosophy of balance as well as pattern-based diagnosis and treatment. Herbs may be classified according to taste (sour, bitter, sweet, pungent, and salty), ‘temperature’ (cold, warm, hot, cool) or direction (ascending, descending, floating, and sinking). Symptoms of illness are categorized, then treated with opposing herbs.

Lead, mercury, arsenic, copper, cadmium, and thallium have been reported in TCM products purchased in the United States and China—intended to treat issues ranging from gingivitis and sore throats to appendicitis and coronary disease. Research from Singapore, where TCM supplements are tightly controlled, showed heavy metal contaminants in 138 of 3320 products screened from 1990–2001. Of the contaminated products, mercury was found in 51.4%, arsenic in 34.8%, lead in 14.5% and copper in 0.7%.

---

**Table 1.** Established Toxicant Limits in Supplements (mcg/day).

https://doi.org/10.1371/journal.pone.0049676.t001

**Table 2.** Overall Results of Toxic Element Contamination

https://doi.org/10.1371/journal.pone.0049676.t002

**Table 3.** Results of Toxic Element Contamination within Subgroups

https://doi.org/10.1371/journal.pone.0049676.t003

**Table 4.** Results of Toxic Element Contamination in a Commonly Consumed
As in Ayurveda, however, heavy metals and metalloids may be intentional components of TCMs. Mercurial compounds by the name of cinnabar (Zhu Sha – a type of rock that contains minerals with various elements including mercury sulphide) and calomel (Qing Fen – containing mercury chloride), may be prescribed as tranquilizers or for external application, respectively. Calomel, for example, has been used for pediatric teething discomfort, resulting in infant poisoning after application to the gums. Lead (litharge and minium, or Mi Tuo Seng and Qian Dan) is believed to grant relief from anxiety, convulsions, phlegm and parasites, while arsenic (realgar, or Xiong Huang), may be used for treatment of malaria, as well as an antidote to venoms. Copper (chalcanthium, Dan Fan) may be used for insomnia.

Various accounts related to TCM contaminated supplement consumption are reported in the literature including arsenic poisoning in a 13 year old girl after ingestion of such supplementation, resulting in pulmonary edema, pericarditis, and eventually renal and liver failure as well as cerebral edema. Chronic lead poisoning has been described in an infant after application of a tongue powder as well as in a woman using a menstrual cramp remedy. Chronic mercury poisoning from TCM preparations has been noted to alter blood pressure and dental health; chronic arsenic exposure has been linked to dermatological lesions and malignancies.

Sources of Contamination

NHPs pass through multiple stages before landing on store shelves, all of which involve possible routes for toxicant contamination. Raw materials for NHPs often come from international sources, including nations with less stringent controls over water, air and soil pollution, and agricultural practices. Plant products may absorb toxic compounds from soil, water and air, while animal products are prone to bioaccumulation in bone and shell materials. Transport of products creates possible routes for toxicant exposure. Open-bed trucks, for example, may permit transfer of exhaust pollutants into NHP ingredients. Raw materials may be processed in substandard factory conditions allowing contamination, and products may be intentionally diluted with contaminated products or fillers when sold by weight. Finally, intentional additives to supplements may be introduced for perceived therapeutic value.

Existing Testing & Regulation

Raw materials and bulk ingredients for NHPs may originate from sources located around the world including Asia, Europe, and the Americas. Raw materials are advertised on the internet or displayed at conventions and trade shows in major jurisdictions where they are evaluated and purchased by manufacturing companies. A small number of raw material suppliers feed the many manufacturing establishments. These companies then assemble and package a proprietary formulation of specific products, which are shipped to distributors and retail suppliers for sale. The location of assembly and packaging varies depending on the company.

No testing for safety or contamination is generally required for the sale and distribution of NHPs in many jurisdictions throughout the world. Testing may take place internally by companies wishing to verify identity, strength, composition, quality, and purity; regulatory requirements for such testing, however, are usually nonexistent. In addition, lack of standardization between origin and processing of raw materials results in variation between NHP batches, complicating analysis of efficacy or safety between batches. The sourcing of raw materials for pharmaceuticals may also take place in nations where labor costs are minimal and quality-control less stringent.

In response to pressure from consumers and health professionals, regulatory measures have been established in a few countries, including Canada’s Natural Health Products Regulations (NHPD), established in 2004 by the Natural Health Product Directorate (NHPD). With this initiative, all NHPs require approval by Health Canada for safety, efficacy and quality, and a product license is required for sale within Canada. Receiving such approval can be a very
In America, ‘Guidelines for Good Manufacturing Practices’ (GMP) have been established to promote a system of processes, procedures, and documentation to ensure that NHPs have the composition, quality, and purity they purport to possess. New regulations from the Department of Health and Human Services have been proposed to enable the American Food and Drug Administration to evaluate whether a NHP is reasonably expected to be safe and accurately represented through all phases of preparation for consumer use including manufacturing, packaging and labeling. Clinical trials to assess NHP efficacy are not standard practice in any country, but many observers are calling for regulated research to ensure accuracy of claims prior to market release. Systems have been established in some jurisdictions for reporting adverse reactions to NHP use.

**Methods**

This study was designed to i) determine if toxic element contamination of NHPs and pharmaceuticals is a routine or rare event, and ii) bring attention to the issue of contamination in NHPs and drugs in order to create credible regulatory processes to ensure public safety.

Testing for toxic elements was carried out on a range of pharmaceuticals and over-the-counter NHPs. To the authors’ knowledge, some preliminary work has been done, but no toxic element contamination studies to date have focused on a broad spectrum of NHP preparations available in Canada. The scientific literature was reviewed to explore relevant information regarding NHP contamination. This was done by assessing available scientific literature from Medline, reviewing books and conference proceedings, consulting several toxicologists, and studying various government publications. Searching techniques included key word searches with terms related to NHPs and toxic element contamination.

In this study, undertaken in 2010–2011, 121 commonly used NHPs (as recommended by retailers) were gathered from 8 health-food stores, industry samples, and 3 herbal dispensaries in Ontario and Alberta, Canada. 49 commonly used pharmaceutical medications were also gathered from physician samples and pharmacies in Edmonton, Alberta. In addition, 5 separate batches of one prenatal supplement manufactured in North America and purchased from 5 independent pharmacies in Alberta (with one sample from the first batch, and 4 samples within each of the remaining 4 batches) were tested. This was done to compare toxicant levels between different batches of the same brand, and within samples of the same batch. An effort was made to include NHPs manufactured in differing areas of the world. The country of manufacture may be listed on NHPs, but labels do not provide the source of raw materials used to manufacture final products. Because of this limitation, we were unable to identify products according to the source countries of their components.

The NHPs (excluding the prenatal supplements) were sent for toxic element testing in three separate groups – each group was analyzed at one of three accredited and specialized toxicology laboratories. (ALS Laboratories, CanAll Laboratories, or Maxxam Analytics). The pharmaceuticals and the prenatal supplements were all tested as one group at ALS laboratories. The full range of element testing was done at ALS laboratories (only toxic element testing was performed at the other labs) but only toxic elements are reported in this study. The results for each group were combined for purposes of analysis. Daily exposure levels were determined for the maximum recommended daily dose for each NHP or drug. When dosing information was factored in, along with the concentration determined by analysis. All laboratories used inductively coupled plasma – mass spectrometry for detection, and the analytical methodology for testing at ALS laboratories (where the majority of products were tested) follows as an example.

Fluid samples were diluted 10-fold with 1.4 M HNO$_3$ (SP grade). For solids, 0.1–0.7 g of sample (depending upon available sample size) were subjected to closed-vessel microwave-assisted digestion (MARS-5 oven, 600W. 1 h holding time) using 5 mL concentrated HNO$_3$ (SP grade), 0.5 mL H$_2$O$_2$ (PA grade) and 0.02 ml HF (SP grade). After digestion, solutions were diluted with 1.4 M HNO$_3$ (SP grade) providing a final dilution factor of approximately 500. A set of digestion blanks and CRMs were prepared together with each digestion batch. All solutions were also spiked with 2 μg/L (internal standard) and analyzed by ICP-SFMS (ELEMENT2, Thermoscientific) using a combination of internal standardization and external calibration. Testing for organic pollutants including biotoxins, various synthetic compounds, and various chemical byproducts was not done.

**Reporting of Values**

Toxic element contamination results from the laboratories were provided for each NHP and pharmaceutical in ng/g (equivalent to parts per billion), mg/kg (parts per million), or mg/g (parts per million). While it has been common in the literature to report NHP contamination concentrations, the actual exposure level to individuals was deemed to be of more importance from a clinical and public health perspective. In order to determine how intake levels compare to established limits, calculation of daily intake rather than simple concentration is required. Accordingly, each laboratory result was multiplied by the weight in grams for each NHP and drug tested to ascertain the total amount of contaminant contained per product. This figure was then multiplied by the maximum daily dose recommended in the product instructions for each specific NHP and pharmaceutical in order to determine a maximum daily intake of each product.

While some individuals may consume lower or higher amounts than is recommended for any given NHP or drug, it was determined through discussion with colleagues, patients, pharmacists, NHP distributors and retailers that most people tend to i) consume the maximal recommended NHP dose in order to achieve what is perceived to be the maximum benefit; and ii) take a pharmaceutical dose within the recommended range provided for the product.
contamination. Many individuals now harbor myriad toxicants associated with multiplicity of toxicant exposures and pre-existing body-burdens of health sequelae of prenatal exposure to toxicants are also documented. Problems is challenging. Causal links between toxic element exposure and illness have, Endeavoring to link specific toxic element exposure levels found in this study directly with health spectrum of potential contaminants in NHPs and drugs. Pharmaceutical contamination as there are many potential synthetic (e.g. parabens, phthalates, pesticides), biological (e.g. mycotoxins), or petrochemical contaminants not assessed in this research. Chinese herbal NHPs or products which originate from marine sources. Several of these products are marine-source NHPs manufactured in North America generally demonstrated the least contamination among samples tested. Although marine-source and Ayurvedic NHPs were most often contaminated, the levels rarely exceed established toxicity guidelines. It is important to note that Tables 2–6 are interpreted together and in context as there were single outliers in some NHPs (such as the mercury level in one Chinese NHP), the inclusion of which skewed means and standard deviations.

Table 1 indicates that most NHPs tested showed detectable contamination with one or more toxic elements; the number of NHPs exceeding the established daily limit of toxicant exposure for any toxic element, however, was less than 10 percent. These figures reflect single exposures and do not depict total accrued levels resulting from repeated exposures. A noteworthy concern given that some compounds such as lead and cadmium have long half-lives. A wide variation in contamination levels was evident for many toxic elements, frequently associated with the NHP source. Almost all pharmaceuticals also had detectable contamination with multiple toxic elements, but the levels were very low. This may be due, in part, to the fact that most drugs are synthetic, while many NHPs are derived from natural sources. None of the pharmaceuticals had levels which exceeded established limits.

Tables 2 & 3 indicate that several NHPs contained noteworthy concentrations of toxic elements—the degree appears to be linked to the country of manufacture, with higher contamination from mercury, arsenic and aluminum primarily found in products imported from China. Marine-source NHPs averaged the highest level of lead contamination overall. Non-marine NHPs manufactured in the United States demonstrated the least contamination among samples tested. The results of this study reveal that there are isolated NHPs available on store shelves that appear to be outliers and demonstrate elevated contamination of toxic elements. Several of these products are Chinese herbal NHPs or products which originate from marine sources.

Results
Our results indicate varying levels of toxic element contamination in the NHPs and pharmaceuticals tested. Proposed limits of acceptable contamination as determined by various agencies can be found in Table 1—the most commonly used grid, published in California under Proposition 65 [85] is provided within our tables as a reference limit. The overall results of NHP contamination in this study can be found in Tables 2–4. Tables 2–4 also provide findings within specific subgroups including Ayurvedic, TCM, and marine-source NHPs. Table 5 displays highest toxicant levels in our study by NHP origin; comparison of NHP toxic element contamination across various published studies is provided in Table 6.

Discussion
Most of the existing literature on toxic element NHP contamination has reported on contaminant concentrations, with no indication of the dose that an individual would receive at the prescribed rate of intake. In this study, however, we endeavored to estimate daily exposure levels of toxic elements for many NHPs and drugs in an effort to determine if some existing NHPs may pose a health hazard to the consuming public. The results of this study demonstrate that toxic element contamination of NHPs and pharmaceuticals is common, but that none of the drugs and only a few NHPs exceeded established daily limits for contamination when taken on their own. Many people, however, consume multiple different NHPs and/or drugs each day; the total level of toxicant exposure will thus be additive.

The results of our testing on one prenatal supplement brand suggest that ascertaining the safety or purity of one NHP batch does not ensure safety of other same-brand batches. While this finding has significance to all NHPs, gestational exposures merit particular attention as ongoing research continues to link assorted prenatal toxicant exposures and pediatric toxicant levels (including toxic elements) with potentially significant health outcomes. [86], [87]. The findings of this study, however, likely underestimate the overall extent of supplement and pharmaceutical contamination as there are many potential synthetic (e.g. parabens, phthalates, pesticides), biological (e.g. mycotoxins), or petrochemical contaminants not assessed in this research. In the scientific literature, there is a paucity of research reported which explores the spectrum of potential contaminants in NHPs and drugs.

Endeavoring to link specific toxic element exposure levels found in this study directly with health problems is challenging. Causal links between toxic element exposure and illness have, however, been established as extensive evidence from observational studies of exposed populations and individuals, from epidemiological studies of the general population, and from animal studies investigating mechanisms of toxicity has confirmed causality. [88]–[91] Long-term health sequelae of prenatal exposure to toxicants are also dose-dependent. [92]–[95] Proving simple linearly from exposure to illness, however, is exceedingly difficult because of confounding associated with multiplicity of toxicant exposures and pre-existing body-burdens of contamination. Many individuals now harbor myriad toxicants [21], [22], [23]—compounds with
effects that may interact independently, additively or synergistically. Furthermore, the Human Genome Project has confirmed the reality of genetic individuality, establishing the basis for differing propensities for inherent detoxification. The response to toxins may thus vary from person to person.

It is also of note that the relevance of specific contamination levels found in this study is uncertain. Assigned tolerance limits for toxic element exposures have declined recently, leading some to conclude that no evidence for a safe exposure threshold to toxic elements exists for some compounds. The United Nations, for example, has recently concluded that lead is toxic at very low exposures — a point which is worth mentioning considering the presence of small amounts of lead found in each prenatal sample tested in this study.

Furthermore, some elements such as lead and cadmium have prolonged half-lives as they sequester in tissues due to enterohepatic re-circulation and ensuing bioaccumulation. Moreover, the usual standards for established limits are based on animal exposure tolerance which may be superior to human tolerance due to differences in detoxification potential. Accordingly, conclusions on health sequelae from specific levels of exposures are difficult to establish. With evidence of NHP contamination juxtaposed with uncertainty about the clinical and public health significance of these findings, how do we move forward?

Widespread and apparently irreconcilable controversy exists regarding the regulation of NHPs. Many within the medical community have expressed concern about the safety and efficacy of NHPs, while the NHP industry has articulated dismay about the possible introduction of additional regulatory legislation. While some suggest that consumers need protection and that NHPs should receive the same scrutiny as pharmaceutical drugs, NHP advocates often contend that oversight similar to pharmaceutical regulation would be ineffective. To support this contention, they cite published outcomes regarding adverse drug sequelae (ADS) confirming that current pharmaceutical oversight is not working: i) estimated pharmaceutical-related annual mortality in America includes 7,000 deaths related to medication mishaps and 106,000 due to non-error drug effects; ii) drug-related morbidity is reflected by 2.3 million emergency room visits attributed to ADS annually. Some propose that NHPs be available only by physician prescription. Others consider this strategy to be ill-advised as most medical doctors have limited toxicological or nutritional training and are often not equipped to evaluate and manage disordered nutritional biochemistry.

A potential solution may involve the NHP industry developing and implementing stringent self-regulatory procedures to ensure safe and reliable NHPs — procedures that are amenable to government oversight by elected officials. ‘Country of Origin’ labeling — including the source country of each component of the product (e.g. ascorbic acid – USA; Vitamin D – New Zealand; folic acid – Japan; etc.) as well as the country where the final product was manufactured, may facilitate full transparency and provide consumers with informed choice. Routine toxicant testing for a wide range of potential contaminants is also required, with full disclosure of toxicant content. The lack of consistency of purity between same-brand batches in this study indicates that ongoing assessment for each batch of every raw material component as well as each batch of manufactured product is needed. This supervised self-regulatory approach is likely more acceptable to industry, and more cost-effective and efficient for governments. Such a process would ensure safety and public confidence.

Conclusions

NHP use has become commonplace in the 21st century with at least half of the North American and European populations ingesting supplements daily. This study demonstrates, however, that while pharmaceuticals appear to have low concentrations of toxic elements, a small percentage of NHPs have noteworthy concentrations, potentially exposing consumers to adverse health sequelae associated with heavy metal and metalloid bioaccumulation. This is particularly evident in certain NHPs from Chinese herbal sources.

With increasing recognition of widespread iatrogenic illness and potential adverse sequelae resulting from assorted therapies, concerted action is required to secure patient safety and public health in all healthcare domains. Although harm from NHP contamination may be less pressing than literature-documented adverse outcomes associated with pharmaceutical use, toxic contamination of NHPs appears to be a not-infrequent occurrence. Mechanisms for regulation and monitoring to confirm purity and authenticity in the manufacture of such heretofore unregulated products are therefore necessary. As NHPs are widely consumed and some appear to be indispensable tools in contemporary evidence-based health care, it is imperative to ensure NHP access, quality and safety for the public. Best practices for quality control, developed and implemented by the NHP industry itself with government oversight, is strongly recommended.

Acknowledgments

The authors would like to express gratitude to Dr. Shelagh K. Genuis, Dr. Meg Sears, Dr. Jon Martin, Dr. Emerson D. Genuis, Ruby Williams, Daniel Eriksson, Patricia Naylor and a peer reviewer who provided invaluable assistance with this research project and/or the preparation of this paper.

Author Contributions

Conceived and designed the experiments: SG GS. Performed the experiments: SG GS IR. Analyzed the data: SG GS. Contributed reagents/materials/analysis tools: SG GS AS. Wrote the paper: SG GS AS IR.

References

1. Landrigan CP, Parry GJ, Bones CB, Hackbarth AD, Goldmann DA, et al. (2010) Temporal trends in rates of patient harm resulting from medical care. The New England journal of medicine 363: 2124–2134.

2. Institute of Medicine (2000) To Err is Human: Building a Safer Health System.
3. Moore TJ, Weiss SR, Kaplan S, Blaisdell CJ (2002) Reported adverse drug events in infants and children under 2 years of age. Pediatrics 110: e53.

4. Starfield B (2000) Is US health really the best in the world? JAMA 284: 483–485.

5. Weingart SN, Iezzoni LI (2003) Looking for medical injuries where the light is bright. JAMA 290: 1917–1919.

6. Zhan C, Miller MR (2003) Excess length of stay, charges, and mortality attributable to medical injuries during hospitalization. JAMA 290: 1868–1874.

7. McGavock H (2004) Prescription-related illness—a scandalous pandemic. J Eval Clin Pract 10: 491–497.

8. Onder G, Pedone C, Landi F, Cesari M, Della Vedova C, et al. (2002) Adverse drug reactions as cause of hospital admissions: results from the Italian Group of Pharmacoepidemiology in the Elderly (GIFA). J Am Geriatr Soc 50: 1962–1968.

9. Juntti-Patinen L, Neuvonen PJ (2002) Drug-related deaths in a university central hospital. Eur J Clin Pharmacol 58: 479–482.

10. Thomas EJ, Brennan TA (2000) Incidence and types of preventable adverse events in elderly patients: population based review of medical records. BMJ 320: 741–744.

11. Green CF, Mottram DR, Rowe PH, Pirmohamed M (2000) Adverse drug reactions as a cause of admission to an acute medical assessment unit: a pilot study. J Clin Pharm Ther 25: 355–361.

12. Brennan TA, Leape LL, Laird NM, Hebert L, Localio AR, et al. (1991) Incidence of adverse events and negligence in hospitalized patients. Results of the Harvard Medical Practice Study I. The New England journal of medicine 324: 370–376.

13. Leape LL, Brennan TA, Laird N, Lawthers AG, Localio AR, et al. (1991) The nature of adverse events in hospitalized patients. Results of the Harvard Medical Practice Study II. The New England journal of medicine 324: 377–384.

14. Lazarou J, Pomeranz BH, Corey PN (1998) Incidence of adverse drug reactions in hospitalized patients: a meta-analysis of prospective studies. JAMA 279: 1200–1205.

15. Leape LL (1994) Error in medicine. JAMA 272: 1851–1857.

16. Classen DC, Pestotnik SL, Evans RS, Lloyd JF, Burke JP (1997) Adverse drug events in hospitalized patients. Excess length of stay, extra costs, and attributable mortality. JAMA 277: 301–306.

17. Steele L, Fawal H (2000) 4th Decennial International Conference on nosocomial and healthcare-associated infections: a challenge for change. Am J Infect Control 28: 207–210.

18. Barbaresi WJ (2003) Use of psychotropic medications in young, preschool children: primum non nocere. Arch Pediatr Adolesc Med 157: 121–123.

19. Ernst E (2010) Deaths after chiropractic: a review of published cases. International journal of clinical practice 64: 1162–1165.

20. Genuis SJ (2006) The chemical erosion of human health: adverse environmental exposure and in-utero pollution - determinants of congenital disorders and chronic disease. J Perinat Med 34: 185–195.

21. Centers for Disease Control, Department of Health and Human Services (2009) Fourth National Report on Human Exposure to Environmental Chemicals. 2009. [Accessed
22. Genuis SJ (2009) Nowhere to hide: Chemical toxicants and the unborn child. Reprod Toxicol 28: 115–116.

23. Gershwin ME, Borchers AT, Keen CL, Hendler S, Hagie F, et al. (2010) Public safety and dietary supplementation. Annals of the New York Academy of Sciences 1190: 104–117.

24. The Canadian Medical Protective Association (2012) Alternative medicine – What are the medico-legal concerns? P1201-1-E © CMPA 2012 1–4.

25. Parks LG, Ostby JS, Lambright CR, Abbott BD, Klinefelter GR, et al. (2000) The plasticizer diethylhexyl phthalate induces malformations by decreasing fetal testosterone synthesis during sexual differentiation in the male rat. Toxicological sciences : an official journal of the Society of Toxicology 58: 339–349.

26. Daughton CG, Ternes TA (1999) Pharmaceuticals and personal care products in the environment: agents of subtle change? Environ Health Perspect 107 Suppl 6907–938.

27. Darbre PD (2005) Aluminium, antiperspirants and breast cancer. J Inorg Biochem 99: 1912–1919.

28. Weidenhamer JD (2009) Lead contamination of inexpensive seasonal and holiday products. Sci Total Environ 407: 2447–2450.

29. Cohen P (2012) Assessing Supplement Safety – The FDA’s Controversial Proposal. January 25, 2012 (10.1056/NEJMp1113325.). N Engl J Med.

30. Ernst E (2000) Prevalence of use of complementary/alternative medicine: a systematic review. Bull World Health Organ 78: 252–257.

31. Thomas KJ, Nicholl JP, Coleman P (2001) Use and expenditure on complementary medicine in England: a population based survey. Complement Ther Med 9: 2–11.

32. (2005) Baseline Natural Health Products Survey Among Consumers. Health Canada. 85 p.

33. Chaudhuri A (2005) Why we should offer routine vitamin D supplementation in pregnancy and childhood to prevent multiple sclerosis. Med Hypotheses 64: 608–618.

34. Eisenberg DM, Davis RB, Ettner SL, Appel S, Wilkey S, et al. (1998) Trends in alternative medicine use in the United States, 1990–1997: results of a follow-up national survey. JAMA : the journal of the American Medical Association 280: 1569–1575.

35. Kam PCA, Liew S (2002) Traditional Chinese herbal medicine and anaesthesia. Anaesthesia: Wiley-Blackwell. 1083–1089.

36. Esmail N Complementary and Alternative Medicine in Canada: Trends in Use and Public Attitudes, 1997–2006. The Fraser Institute.

37. Nahin RL, Barnes P.M., Stussman B.J., Bloom B., (2007) Costs of Complementary and Alternative Medicine (CAM) and Frequency of Visits to CAM Practitioners: United States. National health statistics reports. Hyattsville, MD: National Center for Health Statistics.

38. Chiu J, Yau T, Epstein R (2009) Complications of traditional Chinese/herbal medicines (TCM)–a guide for perplexed oncologists and other cancer caregivers. Supportive Care in Cancer 17: 231–240.

39. Bent S (2008) Herbal Medicine in the United States: Review of Efficacy, Safety, and Regulation. Journal of General Internal Medicine 23: 854–859.

40. Bates DW, Spell N, Cullen DJ, Burdick E, Laird N, et al. (1997) The costs of adverse drug events in hospitalized patients. Adverse Drug Events Prevention Study Group. JAMA 277: 307–311.

41. Phillips DP, Christenfeld N, Glynn LM (1998) Increase in US medication-error deaths.
between 1983 and 1993. Lancet 351: 643–644.

42. Kauffman JF, Westenberger BJ, Robertson JD, Guthrie J, Jacobs A, et al. (2007) Lead in pharmaceutical products and dietary supplements. Regulatory Toxicology & Pharmacology 48: 128–134.

43. Jayasundar R Ayurveda: a distinctive approach to health and disease. Current Science (00113891): Indian Academy of Sciences. 908–914.

44. Herron RE, Fagan JB (2002) Lipophil-mediated reduction of toxicants in humans: an evaluation of an ayurvedic detoxification procedure. Altern Ther Med 8: 40–51.

45. Lad V (2003) Ayurveda, A Brief Introduction and Guide. In: Institute TA, editor. Albuquerque.

46. Saper RB, Phillips RS, Sehgal A, Khouri N, Davis RB, et al. (2008) Lead, Mercury, and Arsenic in US- and Indian-Manufactured Ayurvedic Medicines Sold via the Internet. JAMA: The Journal of the American Medical Association 300: 915–923.

47. Sheerin NS, Monk PN, Aslam M, Thurston H (1994) Simultaneous exposure to lead, arsenic and mercury from Indian ethnic remedies. Br J Clin Pract 48: 332–333.

48. Martena MJ, Van Der Wielen JC, Rietjens IM, Klerx WN, De Groot HN, et al. (2010) Monitoring of mercury, arsenic, and lead in traditional Asian herbal preparations on the Dutch market and estimation of associated risks. Food additives & contaminants Part A, Chemistry, analysis, control, exposure & risk assessment 27: 190–205.

49. Lynch E, Braithwaite R (2005) A review of the clinical and toxicological aspects of 'traditional' (herbal) medicines adulterated with heavy metals. Expert Opin Drug Saf 4: 769–778.

50. Singh SK, Gautam DN, Kumar M, Rai SB (2010) Synthesis, characterization and histopathological study of a lead-based Indian traditional drug: naga bhasma. Indian J Pharm Sci 72: 24–30.

51. Wadekar MP, Rode CV, Bendale YN, Patel KR, Prabhune AA (2005) Preparation and characterization of a copper based Indian traditional drug: tamra bhasma. J Pharm Biomed Anal 39: 951–955.

52. Ernst E (2002) Toxic heavy metals and undeclared drugs in Asian herbal medicines. Trends in Pharmacological Sciences 23: 136–139.

53. (CDC). CfDCaP (2004) Lead poisoning associated with ayurvedic medications–five states, 2000–2003. MMWR Morb Mortal Wkly Rep 53: 582–584.

54. Karri SK, Saper RB, Kales SN (2008) Lead Encephalopathy Due to Traditional Medicines. Curr Drug Saf 3: 54–59.

55. van Vonderen MG K-KE, Craanen ME, Touw DJ, Meuwissen SG, De Smet PA (2000) Severe gastrointestinal symptoms due to lead poisoning from Indian traditional medicine. Am J Gastroenterol 95: 1591–1592.

56. Gair R (2008) Heavy metal poisoning from Ayurvedic medicines. BCMJ 50: 105.

57. Webb A, Hardikar W, Cranswick NE, Somers GR (2005) Probable herbal medication induced fulminant hepatic failure. Journal of Paediatrics and Child Health 41: 530–531.

58. Keen RW, Deacon AC, Delves HT, Moreton JA, Frost PG (1994) Indian herbal remedies for diabetes as a cause of lead poisoning. Postgrad Med J 70: 113–114.

59. Kales SN, Christophi AC, Saper RB (2007) Hematopoietic toxicity from lead-containing Ayurvedic medications. Med Sci Monitor 13: 295–298.

60. Buettner C MK, Gardiner P, Davis RB, Phillips RS, Mittleman MA (2009) Herbal
supplement use and blood lead levels of United States adults. J Gen Intern Med 24: 1175–1182.

Kew J, Morris C, Aihie A, Fysh R, Jones S, Brooks D (1993) Arsenic and mercury intoxication due to Indian ethnic remedies. BMJ 306: 506–507.

Ernst E (2000) Adverse effects of herbal drugs in dermatology. British Journal of Dermatology 143: 923–929.

Khandpur S, Malhotra AK, Bhatia V, Gupta S, Sharma VK, et al. (2008) Chronic arsenic toxicity from Ayurvedic medicines. International Journal of Dermatology 47: 618–621.

Pakade YB KA, Singh S, Sharma R, Tewary DK (2011) Metals in herbal drugs from Himalayan region. Bull Environ Contam Toxicol 86: 133–136.

Tomlinson B, Chan T, Chan J, Critchley J, But P (2000) Toxicity of complementary therapies: an eastern perspective. The Journal of Clinical Pharmacology 40: 451–456.

Garvey GJ, Hahn G, Lee RV, Harbison RD (2001) Heavy metal hazards of Asian traditional remedies. Int J Environ Health Res 11: 63–71.

Ernst E (2002) Heavy metals in traditional Indian remedies. Eur J Clin Pharmacol 57: 891–896.

Ko RJ (1998) Adulterants in Asian Patent Medicines. New England Journal of Medicine 339: 847–847.

Mazzanti G, Battinelli L, Daniele C, Costantini S, Ciaralli L, et al. (2008) Purity control of some Chinese crude herbal drugs marketed in Italy. Food and Chemical Toxicology 46: 3043–3047.

Yee SK, Chu SS, Xu YM, Choo PL (2005) Regulatory control of Chinese Proprietary Medicines in Singapore. Health Policy 71: 133–149.

Woolf AD, Hussain J, McCullough L, Petranovic M, Chomchai C (2008) Infantile lead poisoning from an Asian tongue powder: A case report & subsequent public health inquiry. Clinical Toxicology 46: 841–844.

CDC. (2007) Adult lead poisoning from an Asian remedy for menstrual cramps. MMWR Morb Mortal Wkly Rep 48: 27–29.

Salton S, Namdul T, Dolma S, Dorjee P, Dolma D, et al. (2006) Mercury in traditional Tibetan medicine – panacea or problem? Human & Experimental Toxicology: Sage Publications, Ltd. 405–412.

Wong SS, Tan KC, Goh CL (1998) Cutaneous manifestations of chronic arsenicism: Review of seventeen cases. Journal of the American Academy of Dermatology 38: 179–185.

Cheng S (2003) Heavy metal pollution in China: origin, pattern and control. Environ Sci Pollut Res Int 10: 192–198.

Cheng S (2003) Heavy metals in plants and phytoremediation. Environ Sci Pollut Res Int 10: 335–340.

Fu JZ, Liu J, Liu W, Wang T, Zhang Q, Jiang G (2008) High levels of heavy metals in rice (Oryza sativa L.) from a typical E-waste recycling area in southeast China and its potential risk to human health. Chemosphere 71: 1269–1275.

Cao H CJ, Zhang J, Zhang H, Qiao L, Men Y (2010) Heavy metals in rice and garden
vegetables and their potential health risks to inhabitants in the vicinity of an industrial zone in Jiangsu, China. J Environ Sci (China) 22: 1792–1799.

80. Wong M, Tan P, Wee Y (1993) Heavy metals in some Chinese herbal plants. Biological Trace Element Research 36: 135–142.

81. Chan K (2003) Some aspects of toxic contaminants in herbal medicines. Chemosphere 52: 1361–1371.

82. (2010) About Natural Health Product Regulation in Canada. Health Canada.

83. U. S. Department of Health and Human Services: Food and Drug Administration (2011) Draft Guidance for Industry: Dietary Supplements: New Dietary Ingredient Notifications and Related Issues. Accessed August 15, 2011 at [http://www.fda.gov/Food/GuidanceComplianceRegulatoryInformation/GuidanceDocuments/DietarySupplements/ucm257563.htm].

84. U.S. Department of Health and Human Services: Food and Drug Administration (2010) Guidance for Industry: Current Good Manufacturing Practice in Manufacturing, Packaging, Labeling, or Holding Operations for Dietary Supplements; Small Entity Compliance Guide. Accessed Aug 15,2011 at [http://www.fda.gov/Food/GuidanceComplianceRegulatoryInformation/GuidanceDocuments/SmallBusinessesSmallEntityComplianceGuides/ucm238182.htm].

85. California’s safe drinking water and toxic enforcement act of 1986 (2003) Dietary Supplement Standard 173, Metal Contaminant Acceptance Levels NSF International, August 19,2003 Accessed on Jan 22/2012 at [http://www.nsf.org/business/newsroom/pdf/DS_Metal_Contaminant_Acceptance_Levels.pdf].

86. Ren A, Qiu X, Jin L, Ma J, Li Z, et al. (2011) Association of selected persistent organic pollutants in the placenta with the risk of neural tube defects. Proceedings of the National Academy of Sciences of the United States of America 108: 12770–12775.

87. Campbell M, Petti TA, Green WH, Cohen IL, Genieser NB, et al. (1980) Some physical parameters of young autistic children. Journal of the American Academy of Child Psychiatry 19: 193–212.

88. Bernhoft RA (2012) Mercury toxicity and treatment: a review of the literature. Journal of environmental and public health 2012: 460508.

89. Becaria A, Campbell A, Bondy SC (2002) Aluminum as a toxicant. Toxicol Ind Health 18: 309–320.

90. Bellingter DC (2008) Very low lead exposures and children’s neurodevelopment. Curr Opin Pediatr 20: 172–177.

91. Agency for Toxic Substances Disease Registry (2008) Toxicological profile of Cadmium.

92. Genuis SJ, Birkholz D, Rodushkin I, Beesoon S (2011) Blood, urine, and sweat (BUS) study: monitoring and elimination of bioaccumulated toxic elements. Archives of environmental contamination and toxicology 61: 344–357.

93. Environmental Working Group (2009) Polluton in people: cord blood contaminants in minority newborns. Accessed Sept 6/2011 at [http://www.ewg.org/files/2009-Minority-Cord-Blood-Report.pdf].

94. Centers for Disease Control USDfHaHS, Public Health Service, Agency for Toxic Substances and Disease Registry, Divison of Toxicology. (2001) Agency for Toxic Substances and Disease Registry: Interaction Profiles for Toxic Substances. Accessed Jan 22, 2012 at [http://www.atsdr.cdc.gov/interactionprofiles/index.asp].

95. Stamova B, Green PG, Tian Y, Hertz-Picciotto I, Pessah IN, et al. (2011) Correlations between gene expression and mercury levels in blood of boys with and without autism. Neurotoxicity research 19: 31–48.

96. Tian Y, Green PG, Stamova B, Hertz-Picciotto I, Pessah IN, et al. (2011) Correlations of gene expression with blood lead levels in children with autism compared to typically developing controls. Neurotoxicity research 19: 1–13.

97. United Nations Environment Programme C Lead exposure and human health. Accessed Jan20/2012 at [http://www.chem.unep.ch/pops/pdf/lead/leadexp.pdf].

98. Rat Genome Sequencing Project C (2004) Genome sequence of the Brown Norway rat yields insights into mammalian evolution. Nature 428: 493–521.
99. MacDonald NE, MacLeod S, Stanbrook MB, Hebert PC, Flegel K, et al. (2011) No regulatory double standard for natural health products. CMAJ : Canadian Medical Association journal = journal de l'Association medicale canadienne 183: 2079.

100. National Institutes of Health (2011) InfoFacts: Drug-Related Hospital Emergency Room Visits. Accessed Jan 30,2011 at [http://www.drugabuse.gov/publications/infofacts/drug-related-hospital-emergency-room-visits].

101. Lo C (2000) Integrating nutrition as a theme throughout the medical school curriculum. Am J Clin Nutr 72: 882S–889S.

102. United States Environmental Protection Agency Integrated risk information system. EPA/635/R-05/001. Accessed January 22/2012 at [www.epa.gov/iris].

103. World Health Organization – Europe. European environment and health information system (2009) Exposure of children to chemical hazards in food. Fact sheet 4.4. Accessed on Jan 22/2012 at [http://www.euro.who.int/__data/assets/pdf_file/0004/97042/4.4.-Exposure-of-children-to-chemical-hazards-in-food-EDITED_layouted.pdf].

104. European Food Safety Authority (2008) Safety of aluminium from dietary intake[1] - Scientific Opinion of the Panel on Food Additives, Flavourings, Processing Aids and Food Contact Materials (AFC) Accessed on January 22/2012 at [http://www.efsa.europa.eu/en/efsajournal/pub/754.html].

105. European Food Safety Authority (2004) Opinion of the Scientific Panel on food additives, flavourings, processing aids and materials in contact with food (AFC) on a request from the Commission related to a 2nd list of substances for food contact materials. The EFSA Journal 24: 1–13.

106. Food standards Australia New Zealand (2011) The 23rd Australian Total Diet Study. Accessed on January 22/2012 at [http://www.foodstandards.gov.au/_srcfiles/FSANZ%202010%20ATDS_v5.pdf].

107. European Food Safety Authority (2004) Opinion of the Scientific Panel on contaminants in the food chain [CONTAM] related to mercury and methylmercury in food. Accessed on January 22/2012 at [http://www.efsa.europa.eu/en/efsajournal/pub/34.htm] doi:10.2903/j.efsa.2004.34.

108. European Food Safety Authority (2010) Scientific Opinion on Lead in Food. EFSA Journal 2010; 8(4): 1570 [147 pp.] doi:10.2903/j.efsa.2010.1570.

109. Saper RB, Kales SN, Paquin J, Burns MJ, Eisenberg DM, et al. (2004) Heavy metal content of ayurvedic herbal medicine products. JAMA 292: 2868–2873.

110. Saper RB, Phillips RS, Sehgal A, Khouri N, Davis RB, et al. (2008) Lead, mercury, and arsenic in US- and Indian-manufactured Ayurvedic medicines sold via the Internet. JAMA : the journal of the American Medical Association 300: 915–923.

111. Koh HL, Woo SO (2000) Chinese proprietary medicine in Singapore: regulatory control of toxic heavy metals and undeclared drugs. Drug safety : an international journal of medical toxicology and drug experience 23: 351–362.

112. Pakade YB, Kumari A, Singh S, Sharma R, Tewary DK (2011) Metals in herbal drugs from Himalayan region. Bull Environ Contam Toxicol 86: 133–136.

113. Harris ES, Cao S, Littlefield BA, Craycroft JA, Scholten R, et al. (2011) Heavy metal and pesticide content in commonly prescribed individual raw Chinese Herbal Medicines. Sci Total Environ 409: 4297–4305.

114. Singh R Toxic metal analysis in ayurvedic drug systems. XXXII National Systems Conference, NSC 2008 Dec 17–19, 2008pp 664–666.
Naturally Occurring Contaminants in Food. Contamination during the Food Production, Processing, Storage, and Preparation Phases. Contamination Due to Environmental Influences. Chemical Contaminants in Drinking Water. Contamination during the Food Production, Processing, Storage, and Preparation Phases. Contaminants may be present in the food in their raw stages as a result of environmental sources of contaminants. By-products of pharmaceuticals are also toxic and another identified source of water contamination by chemicals (Shen and Andrews, 2011). Drinking water contaminants include several chemicals such as arsenic, aluminum, lead, fluoride, disinfection by-products, radon, and pesticides (Table 1B). 2019 World Health Organization “Global Vaccine Safety Summit” video has been found and leaked to the world, revealing shocking admissions of the health hazards posed by vaccines and their toxic ingredients. A first-wave compilation of some of the more damning quotes was create. The major health concern which we are seeing are accusations of long term, long term effects. An admission that the W.H.O. is panicking over the fact that many doctors and nurses are finally starting to question the safety and vaccines and are becoming aware of the coordinated cover-up of vaccine injuries: Prof. Heidi Larson, PhD, Director of the Vaccine Confidence Project – We have a very wobbly health professional front line that is starting to question vaccines and the safety of vaccines. Natural toxins are toxic compounds that are naturally produced by living organisms. Other sources of natural toxins are microscopic algae and plankton in oceans or sometimes in lakes that produce chemical compounds that are toxic to humans but not to fish or shellfish that eat these toxin-producing organisms. When people eat fish or shellfish that contain these toxins, illness can rapidly follow. Some of the most commonly found natural toxins that can pose a risk to our health are described below. Aquatic biotoxins. Toxins formed by algae in the ocean and fresh water are called algal toxins.