Chapter 35
New Zealand's Experience in Total Diet Studies

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Introduction

Situated in the South Pacific, New Zealand covers some 268,000 km^2 (slightly less than Japan), extending more than 1,600 km from the top of the North Island to the bottom of the South Island. Surrounded by seas and with extensive coastline, it has a temperate climate, which influences its need for use of certain chemicals in agricultural and horticultural food production. Located on the "rim of fire", New Zealand has associated mountain ranges and is geologically active, which contributes to the mineral content of its soils and foods.

New Zealand has a multicultural society, with a population of approximately 4.3 million, of which 67 % are of European descent, 15 % indigenous Maori, 8 % Polynesians and 10 % Asians. Consequently, New Zealand has a predominantly Western diet with additional ethnic influences and variety.

Almost 50 % of New Zealand's gross domestic product earnings come from food production, so it has a very strong emphasis on food safety and quality both domestically and for exports, with a comprehensive regulatory framework to support this. Meat, fish, dairy, cereals, fruit, and vegetables form the basis of the diet. New Zealand prides itself on its "clean and green" image, and also maintains high standards of health and wellbeing for its people. For these reasons, the New Zealand

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total diet study (NZTDS) was established in 1974 as a key part of its food safety program that complements its other food chemical surveillance and monitoring programs and provides a robust scientific basis for food safety risk management decisions.

New Zealand undertakes what the World Health Organization (WHO) considers to be an essential public health function [1] and achieves this in a highly cost-effective manner. Foods are sampled that represent the diet of the general population, or that are important for a particular cohort within the population, and are analyzed for chemicals on an 'as consumed' basis, e.g. meat is cooked, bananas peeled. By assessing foods at the point of consumption, the NZTDS provides the best means of assessing dietary exposures and any potential for risks to the consumer.

Goals and Objectives

The primary focus of the NZTDS, as with other TDSs undertaken by other countries, is to assess the dietary exposure of the population and specific cohorts within it to chemical compounds, such as contaminants and nutrients in food.

The NZTDS[1] enables New Zealand's food regulatory authority to assess the status of certain chemicals in the New Zealand food supply; indicate any potential exposure concerns and initiate any necessary risk management and/or risk communication interventions; demonstrate trends in dietary exposure; and, make comparisons with other countries.

The high quality scientific data that are generated by the NZTDS is fully documented and made available to all interested parties (see Chap. 47 – Involving and Influencing Key Stakeholders and Interest Groups in a Total Diet Study). Data outputs also inform national and international standard setting activities within Food Standards Australia New Zealand (FSANZ) and the Codex Alimentarius Commission (CAC), respectively. By also measuring moisture in the 'as consumed' NZTDS foods, useful nutrient concentration data can be provided to the New Zealand Food Composition Database (NZFCD).

NZTDS data are also fed into risk assessment and risk management by international bodies, such as the Joint Food and Agriculture Organization of the United Nations (FAO)/WHO Expert Committee on Food Additives (JECFA), Joint FAO/WHO Meetings on Pesticide Residues (JMPR), CAC subsidiary bodies and the WHO Global Environmental Monitoring System/Food Contamination Monitoring and Assessment Programme (GEMS/Food).

[1] The NZTDS has in the past been known as the New Zealand Total Diet 'Survey', however internationally the term 'Study' is more usually used, which more accurately reflects the nature of the NZTDS in that the 'survey' component (the sampling and analysis of foods) is only one contributing element to the 'study' which has the primary aim of estimating dietary exposure using both analysis data from food samples and consumption information from the national nutrition surveys.

History

There have been six NZTDSs to date. These have been undertaken approximately every 5 years – the first in the mid 1970s and the most recent completed in 2009. The New Zealand Ministry of Health was responsible for the first five, and the New Zealand Food Safety Authority (NZFSA)[2] for the 2003/04 and 2009 NZTDS. Technical implementation of the NZTDSs was carried out for these agencies by the Institute of Environmental Science and Research Limited (ESR), or prior to 1992, by its predecessor, Department of Scientific and Industrial Research – Chemistry.

In initiating the first NZTDS, New Zealand used the food group composite approach. The 1974/75 NZTDS [2, 3] had a food list of 60 foods combined into eight food groups, i.e. grain and cereals; meat, fish and eggs; dairy products; vegetables; fruits; beverages and confectionery; imported foods; and canned foods, which were each sampled in four regions and at four times of the year. These were based on the diet of an adolescent male, the age-sex cohort with the highest consumption of food on a daily basis. Foods were analyzed for a limited number of pesticide residues, as well as a range of elements.

The 1982 NZTDS [4] also used the *food group composite* approach (83 foods, 33 subgroups, sampled in four cities over two seasons), which consisted of nine food group composites for analysis.

With New Zealand stakeholders increasingly recognizing the importance of the NZTDS based on its success in identifying key exposure risks and informing effective risk management, the 1987/88 NZTDS [5] was able to secure additional funding that allowed the redesign of the NZTDS to use the more flexible and robust *individual foods* approach. The TDS food list was extended to 105 foods, each sampled in four cities over two seasons, resulting in 105 individual food composites for analysis. The change to individual foods enabled the age/gender cohorts to include 1–3-year-old toddlers, 4–6 year children, 19–24 year males (constant throughout all NZTDSs), and 25+ year males and females. Point estimate exposures i.e. deterministic, were calculated by combining food consumption data from simulated 2-week diets for each of the respective age-sex cohorts with concentration data obtained after analysis of the TDS foods prepared 'as consumed'.

For the 1990/91 NZTDS [6, 7], the opportunity was taken to extend the range of analytes to include 11 nutrient elements and one vitamin, and categorize the 107 foods as either *Regional* or *National* foods. The 1990/91 NZTDS and 1997/98 NZTDS [8, 9] followed the *individual foods* approach with the food list extended to 114 foods for the latter, and a total of 460 samples analyzed for pesticide residues and 532 samples for contaminant and nutrients. The 1997/98 NZTDS returned to the more traditional contaminant focus with only selected priority nutrients included. The 2003/04 and 2009 NZTDSs [10, 11] also used the *individual foods* approach.

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[2] NZFSA was established in 2002. From 1 July 2010 NZFSA was amalgamated with the New Zealand Ministry of Agriculture and Forestry (MAF), and on 1 July 2011, the Ministry of Fisheries was also merged into MAF. On the 30 April 2012, the new ministry became the Ministry for Primary Industries (MPI).

Design of the Current NZTDS

Core and Add-on Components

The 2003/04 NZTDS and the 2009 NZTDS have been designed by the Ministry of Primary Industries (MPI) to have two parts, namely a core and add-ons components. This approach is intended to allow for both continuity with past NZTDSs and flexibility to include, on a less regular basis, chemicals of lesser priority. It also allows for the NZTDS to consider emerging or specific issues of interest to stakeholders.

NZTDS Food List

The number of foods sampled and analyzed in NZTDSs had initially increased over time, but now is relatively stable. For example, in the 2003/04 NZTDS, 121 foods spread across 14 food groups were included. Of these, 110 foods, including tap drinking water, were estimated to represent the most commonly consumed foods and amounted to >95 % by weight of the normal diet consumed. Three foods known to be potentially significant sources of certain contaminants were also included, namely, oysters, mussels and liver. The remaining foods were specific favorites with infants and children – baby food, snack bars and flavored drinks. The 2009 NZTDS used essentially the same food list, with only minor changes; adding one new food (an Indian takeaway dish) and separating water into tap and bottled, to give a total of 123 foods.

Population Cohorts

The particular population cohorts for whom dietary exposure estimates are calculated have increased over time. The young males (19–24 years) group was the only estimate made in the original (1974/75) NZTDS and it has been retained as a constant reference point in subsequent NZTDSs. Other age-sex groupings have been added over the years with the 2003/04 and 2009 NZTDSs including eight such cohorts. These are: adult males (25+ years); adult females (25+ years); young males (19–24 years); adolescent boys (11–14 years); adolescent girls (11–14 years); children (5–8 years); toddlers (1–3 years); and infants (6–12 months).

NZTDS Simulated Two-Week Diets

The foods selected for the NZTDS are intended to represent the average and typical diet of New Zealanders from a range of population cohorts. Dietary exposures are estimated using consumption information from simulated 2-week diets. The simulated diets use only the foods on the NZTDS food list to reflect the consumption of the various population cohorts that those foods represent. In the interests of continuity, all foods from the previous NZTDS are usually considered for inclusion and any changes made are based on the most up-to-date available information about what foods are actually being consumed.

Food Consumption Data for Developing NZTDS Food List and Simulated Diets

The information used to develop the NZTDS foods list and the simulated diets is derived from a range of sources. The most important of these are the national nutrition surveys conducted by the Ministry of Health. There are two surveys undertaken at approximately 10 year intervals, one for adults 15 years and older, and one for children 5–14 years (recent surveys being the 1997 National Nutrition Survey [12] and the 2002 Children's Nutrition Survey [13], with another Adult's Nutrition Survey undertaken in 2010). Other sources of information include: retail sales data; specific nutrition surveys for age groups not included in the national nutrition surveys, particularly for those for children under 5 years of age; and advice from industry or academic experts.

Sampling in the NZTDS

There were 63 *National* foods and 58 *Regional* foods in the 2003/04 NZTDS, altered to 62 *National* foods and 61 *Regional* foods for the 2009 NZTDS. *National* foods are those that are expected to be the same no matter where in New Zealand they were purchased – that is they are manufactured or produced by a national or international company and distributed nationwide. Included in this group are imported foods such as bananas, and most beverages, oil, pasta, rice, and many processed foods such as biscuits, cheese etc. *Regional* foods are those foods that could change from region to region. They are grown or manufactured locally, so may be expected to have different agricultural chemical applications or soil contaminant/nutrient contents. This group covers most fresh fruit and vegetables, breads, meats, takeaways, milk products and tap water. The concept of *National* and *Regional* foods was introduced in the 1990/91 NZTDS and has been followed in each NZTDS since then. *Regional* foods have been sampled from four regional sites (two main cities/growing areas in each island – Auckland, Napier, Christchurch and Dunedin), while national foods are sampled from one nationally representative site. This has been Christchurch, the city where sample preparation occurs, thus facilitating transport and sample management (see Fig. 35.1).

Fig. 35.1 Sampling sites of *Regional* and *National* foods in 2009 NZTDS

Foods are sampled over a 12-month period in four sampling rounds. Each of the foods is sampled twice over the entire study. This allows for seasonal variations and also recognizes that some foods, or key ingredients in a food, are imported when not available from domestic production.

For each food, sampling officers are instructed on how much to purchase and, in some cases, brands are suggested. They are also instructed where to purchase the foods, for example from a local supermarket or from a specialist shop (i.e. green grocer, fruit shop, butcher, delicatessen).

Preparation of Samples

In the 2003/04 NZTDS, a total of 4,440 samples were purchased, and these were all prepared 'as consumed' by ESR at their laboratory in Christchurch (see Fig. 35.1).

The 2003/04 NZTDS used the *individual foods* approach. Multiple purchases of each *National* brand or *Regional* food type (i.e. multiple purchases of chocolate biscuits of one brand, or multiple tomato purchases in the Auckland region) were composited before analysis. In compositing the individual foods (e.g. chocolate biscuits, cracker biscuits, white rice, trim milk, etc.), each of the four *National* brands or four *Regional* samples were kept separate in both seasons, resulting in eight analytical samples for each individual food over the course of the 2003/04 NZTDS. This was double the number of analytical samples for each food from the previous NZTDS. Wherever possible, *Regional* and/or seasonal sample information was retained. In total, 990 food samples were analyzed for agricultural compound residues, and 968 samples for specific contaminants and certain nutrient elements. The 2009 NZTDS has also used the *individual foods* approach with the numbers of samples purchased and analyzed increasing slightly to reflect the changes in the food list.

Analyses

To ensure the most cost-effective and robust analytical results would be obtained in the NZTDS, competing laboratories capable of providing an adequate analytical service (range of analytes, limits of detection/quantitation, quality control and assurance, capacity and throughput, timeliness, pricing, etc.) were asked to tender for the analytical services needed in the NZTDS. Use of commercial analytical laboratories is preferred, so that quality is maintained while capturing competitive cost savings (see Chap. 14 – Commercial Analytical Laboratories—Tendering, Selecting, Contracting and Managing Performance).

For agricultural compounds in the NZTDS, there are two specific screens that are currently considered to be core components of the NZTDS. The first is a multi-residue screen. This includes those pesticides on the WHO GEMS/Food priority list for TDSs [14]; compounds that are or have been registered for use in New Zealand; and those registered for use in other countries and may therefore be present on imported foods. The exact number of compounds included in such a screen has increased over time as technical capability as developed, such that for the 2003/04 NZTDS the multi-residue screen, over 200 compounds were included (well over twice that in the previous 1997/98 NZTDS). For the 2009 NZTDS the number increased to 240. The limit at which a residue can be detected has also lowered over that time as advances in technology have been made – these are now typically at the parts per billion or even parts per trillion levels compared to parts per million only about 10 years ago.

The second screen is for dithiocarbamates, which are the most commonly used fungicides in New Zealand and are also on the WHO GEMS/Food priority list for TDSs. In 2003/04 an additional screen for 18 acid herbicides was also included on a limited number of selected foods. In the 2009 NZTDS, the separate acid herbicides screen was not included because the 2003/04 NZTDS did not identify dietary exposure to these compounds in New Zealand as a public health concern.

The nutrient elements, iodine (I) and selenium (Se) are always included in the NZTDS. New Zealand soils are naturally deficient in these and associated intakes are low, so it is extremely important that the NZTDS is used to monitor trends in dietary intake. In the 2003/04 NZTDS the nutrient elements iron (Fe) and sodium

(Na) were also included. For the 2009 NZTDS sodium was again included to allow continued monitoring of New Zealanders intake levels.

Four contaminant elements, arsenic (As), lead (Pb), cadmium (Cd), and mercury (Hg) are currently considered as core for the NZTDS because of New Zealand's level of volcanic activity, historical fertilizer use, and soil make up. All have the potential for adverse health effects and are on the WHO GEMS/Food priority list for TDSs. Thus it is important for New Zealand to check that food concentrations of these elements are do give rise to adverse health effects and that trends are measured over extended time periods. This also requires careful control of the sampling and analytical procedures over time so that valid comparisons can be made. In the 2009 NZTDS, methylmercury (MeHg) was also analyzed in fish and seafood products, given this is the most toxic form of mercury and these foods are by far the dominant contributors to its dietary exposure.

Exposure Assessment and Risk Characterization

Dietary exposures in the NZTDS were estimated by combining the mean concentration data found in each of the individual foods with mean consumption information from simulated 2-week 'typical' diets for eight different age–sex cohorts in the population. Any potential risk to average consumers was characterized by comparing these dietary estimates to international health-based reference values, such as the Acceptable Daily Intake (ADI) for pesticides, Provisional Tolerable Weekly Intake (PTWI) for contaminants, or, in the case of nutrient elements, Estimated Average Requirement (EAR), Recommended Dietary Intake (RDI), or Upper Level of intake (UL).

Reporting

New Zealand places high importance in communicating the results of scientific research, such as the NZTDS (see Chap. 19 – Communicating Results in a Total Diet Study). Communicating results in a timely manner has consequently been one of the key goals for the NZTDS since 1997/98. For this reason, following each quarterly sampling round, a report containing the analytical results for each food/compound combination and for each region or national brand is released on the MPI [15] website. These results are anonymized as regards specific brand names and/or the business from which a food was purchased. This is because only a limited number of product brands are sampled and given the relatively small numbers per product, it is seen as unfair to identify these specifically when their selection may have been somewhat random. The analytical results should not be seen as endorsing a product because it has no residues, or denigrating it because residues (even within legal limits) are present.

The full NZTDS report on the dietary exposures for the various age-sex cohorts and the percentage contribution for each food group to that exposure is released approximately 12–18 months after the sampling and analysis of individual foods is completed. This is a comprehensive scientific report that is internationally peer reviewed before publication and is made available in both printed and electronic form.

Regulatory Action

Total diet studies, including the NZTDS, are not intended as enforcement or compliance tools. However, unusual or unexpected results are notified to the MPI as they are identified, that is, ahead of the presentation of full results. No regulatory action is expected to occur from a single result unless it is suggestive of a possible risk to public health, either alone or as representative of a particular class of product. Examples from the 2003/04 TDS were: very high iodine detected in a soy milk product that was indicative of a systemic product composition problem, and high levels of lead in an infant food which was identified as having been due to one-off contamination of a bulk-container shipment of maize. The latter incident resulted in products being recalled in New Zealand, Australia and Fiji.

Key NZTDS Findings

For pesticides, 97 % of the estimated dietary exposures for the eight age-sex cohorts in the 2009 NZTDS were less than 1 % of the ADIs for various agricultural compound residues, and the remaining 3 % were well below their respective ADIs. This is a key finding as it focuses on the exposures from the total diet. In contrast, if one were to focus on the frequency of residue detections, as some parties are occasionally inclined to do, then the TDS can be misrepresented as implying a health concern. In fact, finding more residues in more recent TDSs is not unexpected given the significant improvements in limits of detection over recent decades. Of the 982 food samples screened for agricultural compound residues in the 2009 NZTDS, 45 % (437 samples) were found to contain detectable residues, and residues of 75 different agricultural compounds were detected. That said, residues were detected in only 910 (0.4 %) of the approximately 237,000 individual analytical agricultural compound residue results. Clearly the focus for effective risk analysis needs to remain on dietary exposures, not maximum concentrations or frequency of detection. It is not so much what is in the food that counts but rather what the dose is from the total diet, i.e. for effective risk assessment. Consequently, the emphasis should not be on the mere presence of the hazard, but on the exposure.

For three contaminant elements (Cd, Hg and MeHg), the estimated dietary exposures were all well within their respective PTWIs (or the Provisional Tolerable Monthly Intake (PTMI) in the case of Cd). The PTWI/PTMI represents the

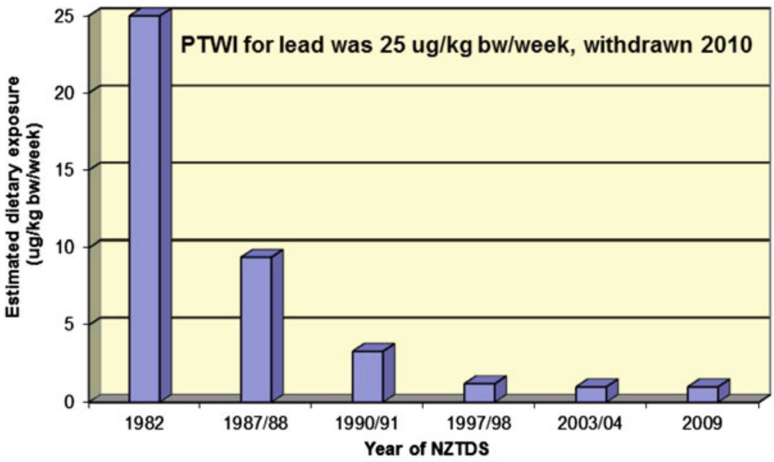

Fig. 35.2 Trends in dietary exposures to lead for 19–24 young males in NZTDSs

permissible human exposure to those contaminants unavoidably associated with consumption of otherwise wholesome and nutritious food i.e. a safe level of intake. Consequently, the contaminant dietary exposures in the 2009 NZTDS were considered to be unlikely to have any adverse health implications for the general New Zealand population. Even with the withdrawal of the international health-based reference values for inorganic arsenic and lead, NZTDS dietary exposures to these contaminants at current levels are unlikely to represent a significant risk to public health. Consequently, the consistency of 2009 NZTDS findings with previous NZTDSs is reassuring. However, it remains important to keep dietary exposures to these contaminants as low as reasonably achievable (ALARA).

Lead as a Case Study

The NZTDS not only has the ability to identify unacceptably high dietary exposures and the associated potential risks to public health, but also successive NZTDSs emphatically demonstrate the effectiveness of risk management strategies. Dietary lead exposure in New Zealand is a very good example. Risk management decisions have included discouraging the use of lead solder in canned foods, and phasing out of lead additives in fuel for vehicles, the benefits of which are clearly evident in the downward trend of estimated lead dietary exposures found over successive NZTDSs (see Fig. 35.2).

It is fair to say that a good proportion of the estimated dietary exposure to lead in 1982 and 1987/88 was associated with uncertainty due to the much higher limit of detection used then (LOD = 0.05 mg/kg) combined with the approach of assigning half of the LOD to 'not detected' results for deriving a mean concentration, and subsequently estimating the dietary exposures. In TDSs in 1997/98, 2003/04 and

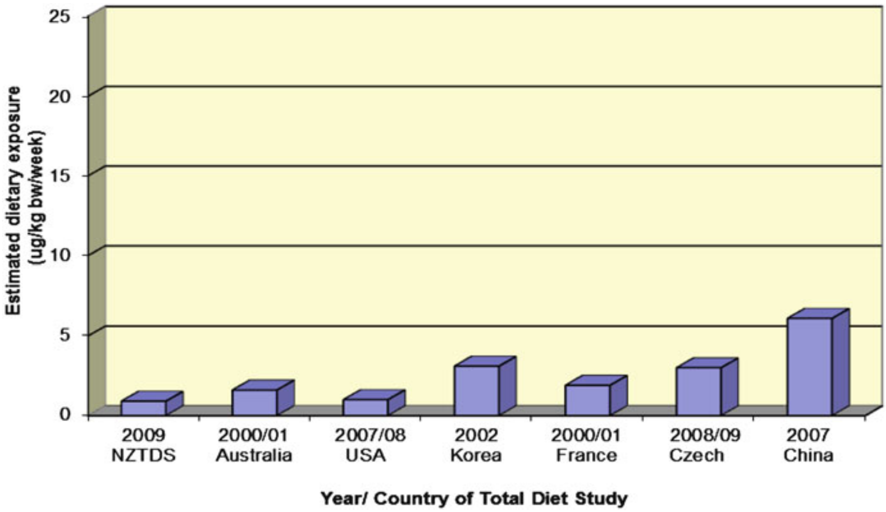

Fig. 35.3 Comparison of estimated weekly dietary exposures (μg/kg bw/week) to lead for 25+ year males in the 2009 NZTSDS with other TDSs

2009, the change of analytical methodology to inductively coupled plasma mass spectrometry (ICPMS) reduced the LOD emphatically to 0.0001 mg/kg in water, 0.001 mg/kg in liquids, 0.002–0.005 mg/kg in high moisture foods like fruit and vegetables, and 0.010 mg/kg in dry or fatty foods. So in 2009, this meant by assigning ND=0, the lower bound dietary exposure for a 19–24 year young male (YM) was 0.8 μg/kg bw/week, the upper bound (ND=LOD) was 1.1 μg/kg bw/week, and by assigning ND=1/2 LOD, the estimated dietary exposure to lead was 1.0 μg/kg bw/week.

From Fig. 35.3, it is clear that New Zealand dietary exposures to lead now compare very favorably with other countries around the world, recognizing that they do have different foods and consumption patterns, and they may have used different calculation methods, such as those for assigning concentrations to 'not-detected' analyses. The 2009 NZTDS lead exposure for an adult male (0.9 μg/kg bw/week) is one of the lowest when compared to Australia (1.6) [16], the USA (0.88) [17], France (1.9) [18], the Czech Republic (2.4) [19], the Republic of Korea (3.1) [20], and China (6.1) [21].

The individual foods contributing to the 2009 NZTDS dietary exposure to lead were spread fairly evenly over the food groups and reflected the ubiquitous environmental presence of residual lead in New Zealand.

While NZTDS dietary lead exposures are now very low, there is no room for complacency. Although not a compliance survey tool, the 2003/04 NZTDS identified a situation of major lead contamination in the New Zealand food supply, initially found in baby food (0.8 mg/kg) but traced back to contaminated corn flour. The level found was 23 mg/kg, which is much higher that the FSANZ Maximum Level in cereals of 0.2 mg/kg. It highlighted the need for prompt risk assessment, risk management and

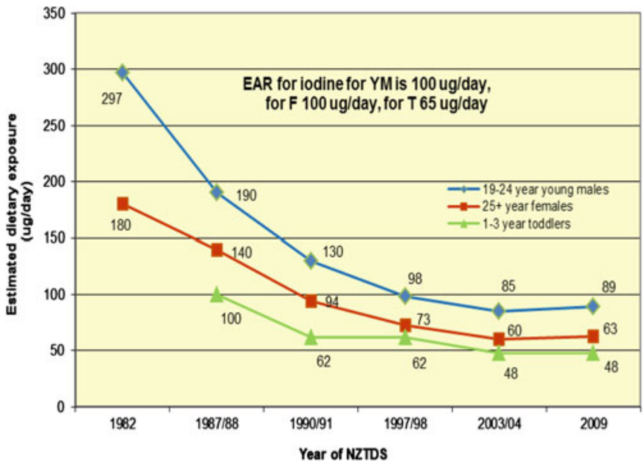

Fig. 35.4 Trends in dietary iodine intakes in NZTDSs

risk communication, as well as ongoing surveillance and monitoring of this and other ubiquitous environmental contaminants. This instance of lead contamination resulted in food recalls in New Zealand, Australia and Fiji [22].

Iodine as a Case Study

From a nutritional perspective, iodine is a key trace nutrient, which is deficient in New Zealand soils and the NZTDS has identified that iodine intakes have been dropping significantly over the last three decades, such that they are now well below Estimated Adequate Requirements (EARs) (see Fig. 35.4). These observations have been confirmed by complementary assessments involving urinary iodine excretion studies and also thyroid volume studies, where indications are that preclinical symptoms of goiter are beginning to re-emerge in New Zealand [23].

Iodine plays an integral part in thyroid and hormone function, and is essential for both mental and physical development, especially in infancy and early childhood. The current low levels of intake have been assessed and the risks of sufficient concern to public health that mandatory fortification of the food supply via iodized salt in breads has been regulated by FSANZ, effective from September 2009.

Sodium as a Case Study

Concentrations of sodium in NZTDS foods ranged from <10 mg/kg up to 35,000 mg/kg (in yeast extract). Higher sodium concentrations are found in processed foods

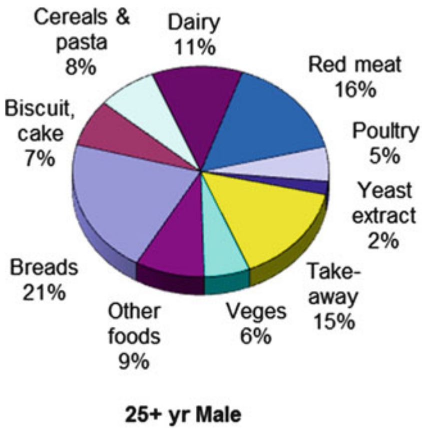

Fig. 35.5 Foods contributing to estimated dietary intake of sodium in 25+ year males in the 2009 NZTDS

(e.g. breads, ham, sausages, etc.) than in unprocessed foods, such that the mean concentration of sodium in bacon was 16,911 mg/kg compared to 909 mg/kg in pork meat. Estimated mean sodium intakes in the 2009 NZTDS exceeded upper limits (ULs) by 116–148 % for all age-sex cohorts except the 25+ year females, whose intakes were below the UL, but still two to four times the adequate intake (AI).

A strength of the NZTDS is being able to identify which foods or food groups contribute most to dietary intakes/exposures (see Fig. 35.5). Processed foods contribute about 65–70 % of dietary sodium, and processed grain products collectively account for 27–48 % of dietary sodium intake. The sodium intake estimates in the 2009 NZTDS do not include the use of discretionary salt added at the time of cooking, or at the table for taste, and it has been estimated that this might add an additional 20 % to total sodium intake [24, 25]. Sodium intakes have not adequately fallen for New Zealand 25+ year males and females, 19–24 year young males and 1–3 year toddlers, decreasing by only 14–28 % for the period 1987–2009 in spite of education programs. It remains important to reduce dietary sodium intake, given it is probably one of the causative factors in New Zealand's high rates of hypertension and cardiovascular disease.

Conclusion

The NZTDS is an important exposure assessment tool for New Zealand's food regulatory authority, and provides essential scientific inputs to regulatory activities that range from risk communication to setting specific food control standards.

While perceived concerns about agricultural compound residues in food do exist among some consumers, the NZTDS has been able to clearly demonstrate such concerns are, in fact, incorrect, and that dietary exposures from agricultural compounds are highly unlikely to pose any adverse health risks for the New Zealand population. Similar conclusions have been found for the contaminant element dietary exposures, including lead. That said, there is no room for complacency, as the lead contamination incident in baby food highlighted. The NZTDS has identified that the low dietary intakes of iodine in New Zealand are a public health concern, helped target appropriate follow-up studies, and contributed to development of regulations for the mandatory fortification of the New Zealand food supply. On the other hand, sodium dietary intakes in the NZTDS continue to exceed upper limits, and reinforce the Ministry of Health guidelines which support a reduction in sodium intake. The ability to also identify which foods are contributing to dietary exposures/intakes is a valuable attribute of the NZTDS. In addition, the NZTDS assesses temporal trends, which enable the effectiveness of risk management and risk communication strategies to be assessed. For all these reasons, future monitoring for agricultural chemicals, chemical contaminants and selected nutrients, such as iodine and sodium, are likely to continue in future NZTDSs.

References

1. WHO (2006) Total diet studies: a recipe for safer food. GEMS/Food Food Safety Department, World Health Organization. http://www.who.int/foodsafety/publications/chem/en/gems_brochure.pdf. Accessed 4 Sept 2013
2. Dick GL, Hughes JT, Mitchell JW, Davidson F (1978) Survey of trace elements and pesticide residues in the New Zealand diet: part 1 – trace element content. New Zealand J Sci 21:57–69
3. Dick GL, Heenan ML, Love JL, Udy PB, Davidson F (1978) Survey of trace elements and pesticide residues in the New Zealand diet: part 2 – organochlorine and organophosphorus pesticide residue content. New Zealand J Sci 21:71–78
4. Pickston L, Brewerton HV, Drysdale JM, Hughes JT, Smith JM, Love JL, Sutcliffe ER, Davidson F (1985) The New Zealand diet: a survey of elements, pesticides, colours, and preservatives. New Zealand J Technol 1:81–89
5. ESR (Institute of Environmental Science and Research Ltd)/MoH (Ministry of Health) (1994) The 1987/88 New Zealand total diet survey. Wellington
6. Vannoort RW, Hannah ML, Pickston L, Fry JM (1995a) 1990/91 New Zealand total diet survey, part 1: pesticide residues. ESR client report FW 95/6. MoH, Wellington
7. Vannoort RW, Hannah ML, Pickston L, Fry JM (1995b) 1990/91 New Zealand total diet survey, part 2: contaminant elements. ESR client report FW 95/7. MoH, Wellington
8. Cressey PJ, Vannoort RW, Silvers K. Thomson BM (2000) The 1997/98 New Zealand total diet survey part 1 – pesticide residues. ESR client report FW99/64. ESR, Christchurch. http://www.moh.govt.nz/notebook/nbbooks.nsf/0/3903b38488ea1a114c2568b1006e43db/$FILE/PesticidesFinal.pdf. Accessed 5 Sept 2013
9. Vannoort RW, Cressey PJ, Silvers K (2000) 1997/98 New Zealand total diet survey part 2: elements. ESR client report FW99/47. MoH, Wellington. http://www.moh.govt.nz/notebook/nbbooks.nsf/0/AC68DD275C26FD3F4C2568B10070F6D2/$file/ElementsFinal.pdf. Accessed 5 Sept 2013
10. Vannoort RW, Thomson BM (2005) 2003/04 New Zealand total diet survey. Agricultural compound residues, selected contaminants and nutrients. NZFSA, Wellington. http://www.foodsafety.govt.nz/elibrary/industry/2003_04-Analyses_Environmental.pdf. Accessed 4 Sept 2013
11. Vannoort RW, Thomson BM (2011) 2009 New Zealand total diet study. Agricultural compound residues, selected contaminants and nutrient elements. MAF, Wellington. http://www.foodsafety.govt.nz/elibrary/industry/total-diet-study.pdf. Accessed 4 Sept 2013

12. Russell DG, Parnell WR, Wilson NC et al (1999) NZ Food: NZ people. Key results of the 1997 national nutrition survey. Ministry of Health, Wellington. http://www.moh.govt.nz/notebook/nbbooks.nsf/0/62C5D9D4C418C4E74C2567D9007186C2/$file/nns.pdf. Accessed 5 Sept 2013
13. Ministry of Health (2003) NZ food NZ children: key results of the 2002 national children's nutrition survey. Ministry of Health, Wellington. http://www.moh.govt.nz/notebook/nbbooks.nsf/0/658D849A2BAC7421CC256DD9006CC7EC/$file/nzfoodnzchildren.pdf. Accessed 5 Sept 2013
14. WHO (2002) GEMS/Food total diet studies: report of the 2nd international workshop on total diet studies Brisbane, Australia 4–15 Feb 2002. Food Safety Programme: Department of Protection of The Human Environment, World Health Organization: Annex V. http://www.who.int/foodsafety/publications/chem/tds_feb2002/en/index.html. Accessed 4 Sept 2013
15. http://www.foodsafety.govt.nz/science-risk/programmes/total-diet-survey.htm. Accessed 4 Sept 2013
16. FSANZ (Food Standards Australia New Zealand) (2003) The 20th Australian total diet study. Canberra. Food Standards Australia New Zealand. http://www.foodstandards.govt.nz/publications/documents/Final_20th_Total_Diet_Survey.pdf. Accessed 5 Sept 2013
17. Egan SK (2011) US FDA total diet study. Dietary intakes of pesticides, selected contaminant and nutrient elements for 2007/08 (personal communication)
18. Leblanc J-C, Guérin T, Noel L, Calamassi-Tran G, Volatier J-L, Verger P (2005) Dietary exposure estimates of 18 elements from the 1st French total diet study. Food Addit Contam 1–18, Food Addit Contam 22(7):624–641
19. Ruprich J (2011) Selected exposure from the 2008/09 total diet study of the Czech Republic. (Personal communication). Department of Food Safety and Nutrition, National Institute of Public Health, Czech Republic
20. Lee H-S, Cho Y-H, Park S-O, Kim B-H, Hahm T-S, Kim M et al (2006) Dietary exposure of the Korean population to arsenic, cadmium, lead and mercury. J Food Compos Anal 19: 531–537
21. Li XW (2011) Selected dietary exposures of the 2007 Chinese TDS. (Personal communication)
22. Lead in cornflour. 26 July 2004. http://www.foodsafety.govt.nz/elibrary/industry/Lead_Cornflour-Zealand_Food.htm. Accessed 4 Sept 2013
23. Mann J, Aitken A (2003) The re-emergence of iodine deficiency in New Zealand? New Zealand Med J 116(1170). 23 Mar 2003. http://journal.nzma.org.nz/journal/116-1170/351/. Accessed 4 Sept 2013
24. Anderson CAM, Appel LJ, Okuda N, Brown IJ, Chan Q, Zhao L, Ueshima H, Kesteloot H, Miura K, Curb JD, Yoshita K, Elliott P, Yamamoto ME, Stamler J (2010) Dietary sources of sodium in China, Japan, the United Kingdom, and the United States, women and men aged 40 to 59 years: the INTERMAP study. J Am Diet Assoc 110(5):736–745
25. Reinivuo H, Valsta LM, Laatikainen T, Tuomilehto J, Pietinen P (2006) Sodium in the Finnish diet: II trends in dietary sodium intake and comparison between intake and 24-h excretion of sodium. Eur J Clin Nutr 60(10):1160–1167