THE NEW ZEALAND MEDICAL JOURNAL
Journal of the New Zealand Medical Association

Vitamin D insufficiency and deficiency: New Zealand general practitioners' perceptions of risk factors and clinical management

Anthony I Reeder, Janet A Jopson, Andrew R Gray

Abstract

Aims To report perceptions regarding vitamin D sources; risk factors, prevention and management of vitamin D deficiency and insufficiency; supplement prescribing practices; patients' enquiries.

Methods A NSW survey instrument was adapted and pre-tested for NZ conditions. Royal NZ College of General Practitioners online weekly newsletter recipients were provided an electronic survey link. The Medical Council emailed an invitation and online survey link to non-respondents. Hard copy questionnaires were posted to remaining non-respondents.

Results 1089 GPs responded (32% participation). Several sources of information on vitamin D were identified. Sun exposure was considered the main vitamin D source in summer (85%), but in winter (47%) supplements (13%) and food sources were more commonly mentioned. Daily sunlight exposure at low UV times (79%) was identified as the main factor preventing deficiency, followed by high-dose supplements and fortified foods (54% each), winter sun-protection relaxation (48%), daily low-dose supplements (47%), daily sunlight exposure at peak UV times (35%) and relaxation of sun protection, year-round.

Patient characteristics prompting alertness to vitamin D status included being housebound or institutionalised (96%), wearing concealing clothing (88%), past history of bone fractures (87%), age over 65 years (84%), poor nutrition (71%) and current bone disease (69%). Insufficiency and deficiency were managed primarily through high-dose supplementation and advice to receive more sunlight. Almost half (47%) had received patient requests for vitamin D testing, and 40% requests for prescribed vitamin D.

Conclusions study results should help inform possible educational and other interventions to optimise vitamin D and sun-exposure advice.

An increased risk of bone disease (rickets, osteomalacia and osteoporosis) is attributable to vitamin D deficiency, and serum 25(OH)D levels tend to be negatively associated with an increased risk of other diseases, although convincing evidence of causality is lacking.[1]

The main vitamin D source in humans is usually endogenous synthesis from exposure of the skin to solar ultraviolet-B (UV-B),[2] although diet plays a role, depending on the food types eaten, as well as fortification and supplementation practices.[3]

Endogenous vitamin D production is related to personal characteristics. Darker colour skin types require longer UVR exposure for a given amount of vitamin D to be

produced, whereas lighter colour skin types require shorter times and are also more susceptible to erythema.

The efficiency of endogenous vitamin D production, as well as absorption from nutritional intake, tends to decline with age and supplementation is commonly recommended for the elderly and prescribed for the institutionalised or housebound. Endogenous vitamin D production is related to the pattern of sun exposure, being most efficient during peak summer UVR around solar noon. However, that is also the time when erythema occurs most quickly.

In high latitudes, such as southern NZ, very little vitamin D may be produced from incidental UVR exposure in winter months. Vitamin D production is also influenced by behavioural factors, such as the amount of time spent outdoors and the area of skin exposed - which is related to cultural body coverage practices, including the wearing of veils and other concealing clothing.

Assuming conditions of minimal sun exposure, the US Institute of Medicine recently proposed a target of 50 nmol/L,[4] whereas the Endocrine Society Clinical Practice Guideline recommended levels above 75nmol/L.[3] There is also debate about the amount of UV radiation exposure required to achieve particular levels of serum 25(OH)D.[5,6]

In response to these issues, a Consensus Statement on Vitamin D and Sun Exposure in NZ was recently released.[7] The NZ Ministry of Health recommends an annual mean serum vitamin D level of 50 nmol/L, and reports that in the 2008 NZ Adult Nutrition Survey of those 15 years and over, 27% were below this level, though not deficient (defined as <25 nmol/L), with 4.9% showing mild to moderate deficiency (12.5-24.9 nmol/L) and 0.2% severe deficiency (<12.5 nmol/L).[8]

In NZ, as elsewhere, there is evidence that vitamin testing has increased (although this is not a recommended routine practice for the NZ general population); there are concerns about the need for, accuracy and cost of, serum testing for vitamin D, and also some indication that more patients may be requesting such testing.[9]

Given the situation where an increased risk of bone disease is attributable to vitamin D insufficiency or deficiency and there are associations with other health outcomes, it is important to know about the perceptions and practices of health professionals with respect to vitamin D.

GPs are a widely respected source of health information for the general NZ population, yet lack confidence about their vitamin D knowledge and would appreciate clinical guidelines,[10] confirming Australian conclusions about a need for greater clarity in the advice that GPs provide.[11] The findings reported here are part of a broader study about sun exposure and vitamin D.

The aim of this paper is to describe current perceptions, practice and advice provided by GPs with respect to vitamin D sufficiency/deficiency. In particular, perceptions of factors which may prevent vitamin D deficiency and prompt alertness to vitamin D status; ways to manage vitamin D insufficiency and deficiency; the ordering of serum vitamin D tests; the prescribing the 50,000 IU vitamin D supplement; and perceived common vitamin D related patient enquiries.

The overall goal being to document current practice and identify any information and resource needs of GPs around vitamin D sufficiency/deficiency. Our findings also provide baseline levels for possible follow-up study following the release of the Consensus Statement.

Methods

Instrument—A study-specific survey instrument, which drew on Australian precedent,[11] was developed and pre-tested for NZ conditions. The measures obtained included demographics (sex, ethnicity), training (when, where and which qualifications were received) and practicing issues (years of practise, skin cancer clinic work, usual number of sessions in General Practice per week).

Ethnicity was categorised following recommended Level 1 (five category) coding procedures.[12] In addition, there were items about awareness of vitamin D and its relation to sun exposure, sun protective practices, the accessing of key information sources and perceived information needs.[10]

The present paper focuses on those questionnaire items concerned with patient contact and vitamin D status. As some questionnaire items involved making selections from lists of items, providing the potential for response bias due to list order, those items were listed in random order for online presentation and four (colour coded) versions of the instrument were randomly distributed in hard copy mailings.

Questionnaire data were supplemented with information about whether or not the GP was based in a metropolitan area with a medical school—a potential marker of ease of access to seminars and other educational opportunities. In addition, five latitude bands were created reflecting levels of ambient UVR, with each including at least one major population cluster.

Population—All NZ medical practitioners are required to register annually with the Medical Council of NZ (MCNZ) and hold a current practicing certificate. Permission to access the MCNZ register was obtained and it was accessed on 1 Sept 2010. It was not possible to determine precisely how many on the register were currently practicing GPs, so those with 'General Practice' as a vocational scope or any GP college noted in their qualifications were selected, cross checking with the Royal NZ College of General Practitioners (RNZCGP) 2010 membership list. The resulting 'master file' contained a total of 3,450 potentially eligible practitioners.

Procedures—Study procedures, described in full elsewhere,[10] are summarised here. The practicalities of administration using LimeSurvey version 1.87, an open source online survey application.[13] were tested by an IT contractor.

Once a secure survey site was activated, all recipients of the online RNZCGP electronic weekly newsletter *ePulse* were notified that they could click a link and begin the survey by entering their Medical Council registration number. This link was provided for two successive weeks, from Tuesday 12 October to Monday 25 October 2010. The first survey question asked potential participants how many sessions of general practice they worked each week and only those reporting at least one session were defined as currently practicing GPs and invited to complete the survey.

Two weeks after the second *ePulse* mailing, a list of all those remaining on the 'master file' who had not yet responded was provided to the Medical Council which then made direct email contact (2nd November 2010) with an invitation and an online link to the survey. This email was repeated on 16th November 2010.

For those who did not respond to any of these electronic opportunities, a hard copy questionnaire was posted in the first week of December 2010, with a reply paid, addressed envelope enclosed.

When completing the questionnaire, participants were asked to refer to a Survey Information Sheet which provided contemporary definitions of vitamin D status used in NZ.[14] Vitamin D deficiency was defined as 'below 25 nmol/L', insufficiency as 'between 25 and 50 nmol/L' and 'adequate vitamin D as '50 nmol/L or above.' Otherwise, respondents were invited to 'answer according to your current understanding and beliefs.'

Analysis—Appropriate descriptive statistics were used to summarise demographic, training and practising measures. Where data were available, comparisons were made with the NZ medical workforce.[15]

The number of work sessions per week was coded as 1-3, 4-7, and 8+ per week, with 8+ sessions assumed to be equivalent of 'full time', allowing 1 day for administration and training. This variable was taken to indicate the 'intensity' of general practice work. Stata statistical software, version 12.0 was used for all analyses. [16]

Results

Demographic, training and practicing data were obtained from 1089 GPs (Table 1), producing an estimated 32% participation rate, with 686 (63%) returning a hard copy questionnaire.

Table 1. Characteristics of the 1089 study participants

Variables	*n*	%
Sex		
Male	533	49.0
Female	555	51.0
Missing data	*1*	
Ethnicity ***(multiple identification possible)***		
Māori	22	2.0
Pacific	2	0.2
Asian	134	12.4
NZ European/European	933	86.4
Other	15	1.4
Missing data	*9*	
Location		
Metropolitan centres with a medical school	547	50.2
All other	542	49.8
Missing data	*0*	
Latitude bands for location of practice		
Upper N: 34 to 36.59	344	31.8
Mid-N: 37 to 39.59	282	26.0
Lower N/upper S: 40 to 41.59	199	18.4
Mid-S: 42 to 44.59	171	15.8
Lower S: 45 to 47	87	8.0
GP practice (years)		

Variables	*n*	%
< 5	94	8.7
5 to 10	159	14.7
11 to 20	324	29.9
> 20	505	46.7
Missing data	*7*	
Practice sessions per week		
1 to 3	117	11.1
4 to 7	388	36.7
≥ 8	553	52.3
Missing data	*31*	
Place of medical graduation		
NZ	767	70.4
US/UK/other European	191	17.6
SE Asian	30	2.8
S Africa	39	3.6
All other	31	2.9
Australia	28	2.6
Missing data	*3*	
Highest medical qualification		
Medical degree	173	15.9
Graduate certificate/diploma	76	7.0
Master's degree	21	1.9
College fellowship	799	73.4
Research doctorate	16	1.5
Other	3	0.3
Missing data	*1*	
Year received highest medical qualification		
Before 1980	88	8.2
1980–1999	478	44.7
2000 and after	504	47.1
Missing data	*19*	
Skin cancer course completion		
Yes	190	17.4
No	899	82.6

Comparison with available Medical Council of New Zealand data on medical practitioners indicates that participants were somewhat under representative of GPs who trained overseas (30% vs 42%) and over representative of women who account for 44% of GPs. [15]

Despite questionnaire item wording, when asked: 'How have you **mostly** obtained information about vitamin D deficiency?' many (47%) of the 686 GPs who completed the hard copy questionnaire indicated that there had been more than a single source, an option not available to online respondents.

Among all of the remaining respondents who identified a single main source (including hard copy and electronic responses), professional guidelines (20%), journals (19%), courses/training programmes (19%), colleagues (14%), medical training (10%), non-professional internet sources (7%), industry literature and promotions (4%), mass media (3%) and patients (<1%). Three per cent reported never having obtained information about vitamin D.

When asked: 'Which is the main source of vitamin D in NZ' during summer months, 10% of hard copy respondents again selected multiple sources. Among all other respondents, most (91%) identified 'exposure to sunlight outdoors' as the single main source, followed by those who were 'not sure' (4%), fortified milk products (2%) 'fish with a high fat content' and supplements (1%). No other fixed response source category (fortified cereals, exercise and exposure to artificial UVR) reached the 1% endorsement level.

For winter, 13% of hard-copy respondents selected multiple sources, but 'exposure to sunlight outdoors' remained the most frequently reported source among all of the other respondents, although with a much reduced frequency (51%), followed by 'supplements' (14%), 'not sure' (12%), fortified milk products and margarine (10%), 'fish with a high fat content' (8%) and 'fortified cereals' (3%), with the remainder ('exposure to artificial UV light' and 'exercise') each failing to reach the 1% level.

When provided with a list and asked 'Which of the following do you believe may prevent vitamin D deficiency in the general population?' GPs responded as ranked by the frequency of reporting presented in

Table 2. Factors which may *prevent* vitamin D deficiency in the general population, ranked by frequency of reporting

Rank	Factor	*n*	%
1	Daily exposure to sunlight outdoors at low UV times of day	853	79
2	A course of high-dose (50,000 IU) vitamin D tablets	590	54
3	Adequate intake of vitamin D fortified foods	582	54
4	Relaxation of sun protection during winter	515	48
5	Daily low dose (2,000 IU or less) vitamin D supplements	514	47
6	Daily exposure to sunlight outdoors at peak UV times of day	379	35
7	Relaxation of sun protection throughout the year	283	26
8	Adequate physical activity	146	13
9	Daily exposure to artificial UV light	101	9
10	Daily calcium supplements	30	3
11	There is no effective way to prevent vitamin D deficiency	7	<1
12	No response selected	5	

When provided with a list of 17 possibilities, responses to the question 'Which of the following patient features would prompt you to be alert to vitamin D status?' are reported in rank order in Table 3.

Table 3. Which of the following patient features would prompt you to be alert to vitamin D status?

Rank	Factor	*n*	%
1	People who are housebound or institutionalised	1,006	96
2	People who wear concealing clothing for cultural or religious reasons	922	88
3	Past history of bone fractures	917	87
4	Aged over 65 years	878	84
5	Poor nutrition	750	71
6	Current bone disease	727	69

7	Dark skin (Fitzpatrick skin types V-VI)	580	55
8	Muscle aches and weakness	487	46
9	Pregnant or breastfeeding women	351	33
10	Women in general	330	31
11	Depression	326	31
12	Fatigue	318	30
13	Very fair skin (Fitzpatrick skin types I-II)	233	22
14	Obesity	148	14
15	Current skin disease	143	14
16	Children (aged under 16 years)	113	11
17	Not sure	19	2

(In addition, 38 did not select a response option).

Asked about 'In which ways do you manage vitamin D *insufficiency?*' and similarly with respect to deficiency, the percentages reporting specific fixed responses for summer and winter, respectively, were as presented in Table 4.

Table 4. Reported ways of managing vitamin D insufficiency and deficiency by season, ranked by percentages of GPs reporting

Ways of management	Season and vitamin D status			
	Summer		Winter	
	Insufficiency	Deficiency	Insufficiency	Deficiency
	%	%	%	%
Monthly high-dose vitamin D supplements	72	85	81	87
Advice to receive more natural sunlight	59	55	71	62
Nutrition advice	48	42	48	42
Daily low dose vitamin D supplements	16	18	17	18
Calcium supplements	11	14	12	15
Advice to receive more artificial UV light	3	3	5	4

Management strategies were ranked in the same order for both seasons and statuses, with higher percentages advising monthly high dose supplements and receipt of more natural sunlight in winter for insufficiency, but either the same or similar percentages for other options and seasons.

When asked to 'Please estimate the number of patients for whom you have made a laboratory investigation of serum vitamin D in the last 12 months', many GPs reported having done this (80%) and a few (n=19) specifically noted that this was either 'not recommended', 'not current practice', 'too expensive' or 'the laboratory won't do it.'

GPs reported a wide range of estimates (0-100%, mean of 21% from 802 GPs) for the percentage of their serum vitamin D orders in the last 12 months that were requested by patients. Of all those patients for whom a serum vitamin D test was ordered, some GPs indicated that they either did not know, were not sure or were unable to estimate how many of the proportion producing results indicated either insufficiency (n=24, 3% of those requesting tests) or deficiency (n=7, <1% of those requesting tests).

When asked to estimate 'for how many patients have you prescribed high dose vitamin D supplements in the past 12 months', the median for the 1005 providing this

information was 30 (25th percentile 10, 75th percentile 80), but some (n=24, 2%) indicated that they either did not know, were not sure or could not estimate that number.

Finally, participants were invited to indicate 'Which are the more common vitamin D related patient enquiries you receive?' (Table 5).

Table 5. The more common vitamin D-related patient enquiries received, ranked by frequency of reporting

Rank	Factor	*n*	%
1	Requests for vitamin D level tests	504	47
2	Requests for prescribed vitamin D	437	40
3	Information about sources of vitamin D	343	32
4	Advice regarding how much time they should spend out in the sun	270	25
5	Advice regarding the use of sun protection and effects on vitamin D	264	24
6	Did not receive any or received very few patient enquiries regarding vitamin D	274	24
7	Information about vitamin D following media reports	262	24
8	Requests for complementary and alternative therapies	120	11
	Missing	8	

Discussion

Prevention of vitamin D deficiency in the general population—It was encouraging to find that less than 1% of NZ GPs considered that there was no effective way to prevent vitamin D deficiency in the general population.

There was widespread agreement that daily exposure to sunlight, at times of day when there are low levels of UVR, may prevent deficiency.

However, this may not be a sufficient or practical strategy in winter for those who spend relatively little time outdoors in southern regions of the South Island where lower temperatures may discourage exposure of more than the face and hands, and winter levels of UVR may generate little endogenous vitamin D production.

The possible benefit of supplementation to this population, at least May-August, has been acknowledged in the recent Consensus Statement.[7]

Of possible concern was the quite high endorsement of daily exposure during peak UV (35%), given that these responses may not have referred to winter, alone. There was also quite frequent endorsement of the relaxation of sun protection throughout the year (26%). Such relaxation could increase skin cancer risk from summer exposure and, during winter may have minimal impact, particularly in the south of the South Island.

It is reassuring that there was low (9%) endorsement of artificial UV exposure, although even that level of support is a concern, given the increased risk of melanoma, particularly for those <35 years,[17,18] in contrast to the efficacy, relative economy, ready availability and greater safety of supplements.

There was more than 50% endorsement of 50,000 IU vitamin D supplements as a preventive strategy, equivalent endorsement of vitamin D fortified foods and similar levels of endorsement of low dose (≤2,000 IU) supplements (47%).

Taken overall, these responses demonstrate the potential importance of the recently developed Consensus Statement which aims at achieving a balance between vitamin D requirements and protection against skin cancer risk, taking into account differences in personal characteristics, such as skin type, and latitude.

There was agreement between NZ and Australian GPs regarding the efficacy of daily exposure to sunlight outdoors at low UV times of day (79:78%) and similarly low levels of endorsement of exposure to artificial UV (9:10%), but substantial differences in the percentages reporting intake of fortified foods (54:76%), daily vitamin D supplements (47:80%), relaxation of winter sun protection (47:28%) and differences in peak UV sun exposure (35:53), relaxation of sun protection throughout the year (26:18) and physical activity (13:27).[11]

The option of a course of high-dose vitamin D supplements, selected by 54% in NZ, was not available to NSW GP's as these tablets had not been approved for prescription there, whereas in NZ they are the recommended treatment option for the general population at risk. Furthermore, there is a move in NZ to make this supplement more readily available through pharmacies, rather than just on prescription. The lack of this option in Australia is likely to have resulted in increased NSW endorsement of the fortified foods and daily supplementation options.

Risk factors/groups for vitamin D status—Most GPs identified being housebound or institutionalised as a patient characteristic which would prompt alertness to vitamin D status. The prescribing of vitamin D supplementation for these groups is encouraged by the Accident Compensation Corporation and subsidised in NZ. There were also high levels of awareness regarding those who wear concealing clothing, have a history of bone fractures or current bone disease and are over 65 years of age.

There was relatively less acknowledgment of the potential needs of pregnant and breastfeeding women and even less for children under 16 years. The vitamin D needs of these groups have recently been reviewed for a Consensus Statement, similar to that already available with respect to adults.

In response to similar questions about risk factors/groups for vitamin D status, broadly similar percentages of GPs in NZ and NSW[11] identified those in institutional care (96% each), those who wear concealing clothing (88:95%), those over 65 years of age (83:91%), those with current bone disease (69:61%), pregnant or breastfeeding women (33:41%), women in general (31:41%), the obese (14:24%)) and children (11:13%) as groups at increased risk.

The NSW study did not report about a past history of bone fractures, skin type differences, depression, muscle aches and weakness or fatigue, so the inclusion of those items among the NZ response options may have influenced response patterns. However, where comparable information was available, percentages differed by no more than 10%, indicating broad agreement in perceived risk factors across both countries.

Ways of managing vitamin D insufficiency and deficiency—Management strategies most commonly reported by NZ GPs were the same as those reported for NSW,[11] namely, the prescription of supplements, followed by advice to receive more natural sunlight, then nutrition advice. However, there were major differences in reported practices which reflect health policy.

Unless clinically indicated otherwise, a monthly 50,000 IU supplement is the standard management strategy in NZ, but it is not a registered medicine approved for use in Australia, where lower dose daily supplements are prescribed and were reported by 97% of surveyed NSW GPs, whereas only 18% reported this in NZ. In NSW, most

GPs (58%) had referred >21 patients for testing in the past year, 14% having referred more than 100, with most tests (82%) initiated by the physician.[11]

Vitamin D testing is not encouraged in NZ because the cost of testing greatly exceeds the cost of treatment, and few GPs reported ordering laboratory tests. However, internationally, there is evidence of significantly increased test frequency in recent years, prompting expression of concerns about test reliability, cost and need.[19]

In most cases in NZ, testing is considered unnecessary, as the 'vast majority of tests performed currently do not reveal vitamin D deficiency' so that 'a move away from routine vitamin D measurements seems sensible, though they are still indicated when investigating suspected metabolic bone disease or hypocalcaemia'.[9]

A portion of the observed increase in testing may be attributable to a recent increase in vitamin D research, although some of that testing is done, in-house, within research institutions.

Another difference is that Australia and many other Western countries have broader fortification policies and practices than New Zealand.

In Australia it is mandatory for food manufacturers to fortify edible oil table spreads, which are estimated to contribute almost 50% of daily total vitamin D intake, excluding supplements.[20] Nevertheless, serum 25(OH)D levels in the NZ European population are, broadly, comparable to Australia and the UK. However, 25(OH)D levels tend to be higher in North America, most likely due to wider fortification practices together with higher levels of supplementation and, at least in parts of the United States, lower latitude.[21]

The most common vitamin D related patient enquiries received—Requests for vitamin D level tests were the most commonly reported patient enquiries received in both NZ (47%) and NSW (36%), followed, in NZ, by requests for prescribed vitamin D (40%)— a response option not provided in the NSW study. However, about one quarter of NZ and one-third of NSW GPs reported not receiving any vitamin D related patient enquiries.

Similar proportions reported requests for advice about how much time should be spent in the sun, the use of sun protection and its impact on vitamin D, and information about vitamin D following media reports. Given the low levels of confidence in their knowledge about these issues reported by GPs in both studies, the recent Consensus Statement on Vitamin D and Sun Exposure in NZ, should help to meet GP needs in responding to patient enquiries. However, as acknowledged in that Statement, given existing uncertainties and the level of current research, it is likely that the advice provided will need to be reviewed and updated as new evidence emerges.

Conclusions

Study findings should help inform possible educational and other interventions to optimise vitamin D and sun-exposure advice.

Broad similarities were observed in the patterns of responses from NZ and NSW GPs, but there were also some notable differences, largely attributable to policies and guidelines around vitamin D testing—which is discouraged in NZ, and supplement

prescribing practices—with routine use of a high dose monthly supplement in NZ, but not NSW.

These differences illustrate how public health policy can impact on GP practices and, potentially, health outcomes. The reported low NZ levels of confidence in vitamin D knowledge reinforce the importance of developing educational guidelines.

It would be informative for a second survey to be conducted once sufficient time has been allowed for the 2012 Consensus Statement to exert a potential influence.

Competing interests: AIR participated in the Consensus Statement Workshop process which provided advice for the drafting of the Ministry of Health and Cancer Society of New Zealand: Consensus Statement on Vitamin D and Sun Exposure in New Zealand.[7]

Author information: Anthony I Reeder, Associate Professor and Director, Cancer Society Social and Behavioural Research Unit; Janet A Jopson, Assistant Research Fellow; Andrew R Gray, Biostatisician; Preventive & Social Medicine, Dunedin School of Medicine, University of Otago, Dunedin

Acknowledgements: This study was conducted with support from the Cancer Society of New Zealand Inc and the University of Otago.

We thank Dr Billie Bonevski (University of Newcastle, Australia) for permission to modify her survey instrument for New Zealand conditions. We also thank the IT consultants Standby Consulting and DataSynergy for the development of the electronic questionnaire and secure website, respectively, and the New Zealand College of General Practitioners for providing access to their national database. Lastly we extend our gratitude to survey participants.

Correspondence: Assoc Prof Anthony Reeder, Preventive & Social Medicine, Dunedin School of Medicine, PO Box 913, Dunedin, New Zealand. Email: tony.reeder@otago.ac.nz

References:

1. Ross AC, Manson JE, Abrams SA, et al. The 2011 report on dietary reference intakes for calcium and vitamin D from the Institute of Medicine: What clinicians need to know. J Clin Endinocrinol Metab. 2011;96:53-58.
2. Heaney RP, Davies KM, Chen TC, Holick MF, Barger-Lux MJ. Human serum 25-hydroxycholecalciferol response to extended oral dosing with cholecalciferol. Am J Clin Nutr. 2003;77:204-210.
3. Holick MF, Binkley NC, Bischoff-Ferrari HA, et al. Evaluation, treatment, and prevention of vitamin D deficiency: an Endocrine Society clinical practice guideline. J Clin Endocrinol Metab. 2011;96:1911-1930.
4. Institute of Medicine of the National Academies. Dietary reference intakes for calcium and vitamin D. Washington DC: The National Academies Press; 2011.
5. de Gruijl FR. Sufficient vitamin D from casual sun exposure? Photochem Photobiol. 2011;87:598-601.
6. Diffey BL. Is casual exposure to summer sunlight effective at maintaining adequate vitamin D status? Photodermatol Photo. 2010;26:172-176.
7. Ministry of Health, Cancer Society of New Zealand. Consensus Statement on Vitamin D and Sun Exposure in New Zealand. Wellington; 2012.
8. Ministry of Health. Vitamin D status of New Zealand adults: Findings from the 2008/09 New Zealand Adult Nutrition Survey. Wellington; 2012.

9. Bolland MJ, Grey AB, Davidson JS, Cundy T, Reid IR. Should measurement of vitamin D and treatment of vitamin D insufficiency be routine in New Zealand? N Z Med J. 2012;125:5045.
10. Reeder AI, Jopson, J.A, Gray A.R. "Prescribing sunshine": a national, cross-sectional survey of 1,089 New Zealand general practitioners regarding their sun exposure and vitamin D perceptions, and advice provided to patients. BMC Fam Pract. 2012;13:85. http://www.biomedcentral.com/1471-2296/13/85
11. Bonevski B, Girgis A, Magin P, Horton G, Brozek I, Armstrong B. Prescribing sunshine: a cross-sectional survey of 500 Australian general practitioners' practices and attitudes about vitamin D. Int J Cancer. 2012;130:2138–2145.
12. Ministry of Health. Ethnicity data protocols for the health and disability sector. Wellington: Ministry of Health; 2004.
13. LimeSurvey [computer program]. Version LimeSurvey Copyright © 2003, version 1.87. Hamburg, Germany; 2003.
14. Australian and New Zealand Bone and Mineral Society, Osteoporosis Australia, Australasian College of Dermatologists, Australia CC. Risks and benefits of sun exposure. Position statement 2005. Canberra, Australia.
15. Medical Council of New Zealand. The New Zealand medical workforce in 2009. Wellington: MCNZ; 2009.
16. Stata statistical software: Release 12, [computer program]. Version Release 12.0. College Station, Texas: Stata Corporation; 2011.
17. International Agency for Research on Cancer Working Group on artificial ultraviolet (UV) light and skin cancer. The association of use of sunbeds with cutaneous malignant melanoma and other skin cancers: a systematic review. Int J Cancer. 2006;120:1116-1122.
18. Cust AE, Armstrong BK, Goumas C, et al. Sunbed use during adolescence and early adulthood is associated with increased risk of earlyonset melanoma. Int J Cancer. 2011;128:2425-2435.
19. Sattar N, Welsh P, Panarelli M, Forouhi NG. Increasing requests for vitamin D measurement: costly, confusing, and without credibility. Lancet. 2012;379:95-96.
20. Nowson CA, Margerison C. Vitamin D intake and vitamin D status of Australians. Med J Aust. 2002;177:149-152.
21. Lips P. Worldwide status of vitamin D nutrition. J Steroid Biochem. 2010;121:297-300.