Vitamin D testing in children and adolescents in Victoria, Australia: are testing practices in line with global recommendations?

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ABSTRACT

Objective To describe changing primary care ordering of serum 25-hydroxyvitamin D (25OHD) tests in Australian children.

Design Longitudinal, population-based descriptive study of 25OHD testing using a large administrative dataset of pathology orders and results, 2003–2018.

Setting and participants Three primary health networks in Victoria, Australia. Patients aged ≤18 years with a serum 25OHD test ordered by the general practitioner (GP).

Main outcome measures Trends over 15 years in the number of 25OHD tests ordered, proportion indicating low levels or vitamin D deficiency and details of repeat testing.

Results Of 970 816 laboratory tests, 61 809 (6.4%) included an order for a 25OHD test. The 61 809 tests were performed in 46 960 children or adolescents. The odds of ordering a 25OHD test in 2018 was 30.4 times higher compared with 2003 (95%CI 22.6 to 40.8, p<0.001). The odds of detecting a low 25OHD (<50 nmol/L) compared with the baseline in 2003 remained steady (adjusted OR<1.5) over time. Repeat tests (14 849) were undertaken in 9626 patients (median intertest interval 357 days, IQR 172–669 days). A total of 4603 test results indicated vitamin D deficiency (<30 nmol/L), but in only 180 (3.9%) of these was a repeat test performed within 3 months as recommended.

Conclusion Testing volumes increased 30-fold, but the odds of detecting low 25OHD remained steady. Current Australian policy and the Global Consensus Recommendations for the prevention and management of nutritional rickets do not support routine 25OHD testing. Education and electronic pathology ordering tools may assist GPs to better align practice with current recommendations.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Rates of serum 25-hydroxyvitamin D (25OHD) testing continue to increase despite policy to drive down this low-value practice.
⇒ Rates of testing and detection of low vitamin D in children and adolescents ≤18 years are unknown.

WHAT THIS STUDY ADDS

⇒ The odds of a child having a 25OHD test increased 30-fold (2003–2018), but the odds of detecting a low 25OHD level remained stable.
⇒ When the initial test showed vitamin D deficiency (<30nmol/L), only 3.9% were repeated.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Practical codesigned interventions to increase adoption of current Global Consensus Recommendations are needed.

BACKGROUND

Vitamin D (25-hydroxyvitamin D (25OHD)) deficiency and nutritional rickets are re-emerging in high-income countries.[1] In Australia, the incidence of nutritional rickets is estimated at 4.9 per 100 000 children. Similar estimates have been reported in the UK and in North America.[2–4] Nutritional rickets affects the health, growth and development of infants, children and adolescents and may have health implications in adulthood.[5 6] Serious complications of vitamin D deficiency are more common when accompanied by dietary calcium deficiency and include rickets, hypocalcaemic seizures, limb pain and fractures.[5 6] These can be prevented by ensuring adequate vitamin D and calcium supplies.[5] In Australia, the primary source of vitamin D is through direct skin exposure to UVB radiation from sunlight, with only a small proportion obtained through dietary intake.[7] Increased risk of vitamin D deficiency is associated with dark skin colour, extensive skin covering (eg, for cultural reasons, extensive application of sun protection), restricted exposure to sunlight, prolonged exclusive breast feeding (>6 months), seasonal variation at high latitudes, restricted dietary intake, and gut malabsorption syndromes or chronic liver disease.[8]

The Global Consensus Recommendations (GCRs) on the prevention and management of nutritional rickets do not recommend routine screening for serum 25OHD levels.[5] To prevent complications of vitamin D deficiency, supplementation of all infants (<12 months) with 400 IU/day of vitamin D (cholecalciferol) and all pregnant women with 600 IU/day is recommended.[5] Children aged over 12 months require 600 IU/day (dietary and/or supplementation), and those at risk of vitamin D deficiency should continue to be supplemented with 600 IU/day, for life.[5 6]

To prevent vitamin D deficiency and its consequences at the population level, mandatory fortification of staple foods such as dairy products

has decreased rates of vitamin D deficiency.[9] In Australia, only margarine products are subject to mandatory fortification.[10] In the absence of mandatory food fortification, vitamin D supplementation according to the GCRs provides a safe, cost-effective and easily accessible solution for children at risk of vitamin D deficiency and nutritional rickets.[5]

Little is known about serum 25OHD test ordering practices for children in primary care settings. Data on reimbursement payments from the Medical Benefits Schedule (MBS) showed sharply increasing rates of 25OHD tests across all age groups, an increase by 3587% from 2003/2004 to 2012/2013.[11] This was identified as low-value testing and led to new and more restrictive MBS reimbursement criteria in 2014.[11 12] Although these changes initially drove down the number of 25OHD tests performed, testing rates increased by 34% between 2015 and 2019, with MBS costs reaching over $104 million in 2019.[13] The MBS data, however, do not provide information about retesting in the same person, nor the test results to detect rates of low vitamin D levels or deficiency.[14]

Using a unique population-based dataset, we aimed to describe the patterns of 25OHD test ordering between 2003 and 2018 by Australian general practitioners (GPs) for children and adolescents aged up to 18 years, including test numbers, repeat testing and detection of vitamin D deficiency.

METHODS

Study population and variables

We used non-identifiable electronic health record data, from the state of Victoria, Australia, 2003–2018. General practice data from three primary health networks were included: Eastern Melbourne, South Eastern Melbourne and Gippsland. Data were extracted by the Population-Level Analysis and Reporting tool and provided by the data custodian, Outcome Health.[15] The number of practices increased over time, with newer practices added over the study period; a total of 236 GP practices provided data.

We identified all pathology test results for patients aged up to 18 years. Extracted information included non-identifiable patient identifier number (ID unique within a practice), test name/Systematized Nomenclature of medicine (SNOMED)[16] code of pathology test, test result, abnormality of test result as indicated by pathology provider (low, normal or high), and test request and result dates. Vitamin D test results were identified through SNOMED codes and test result names. Patient IDs were used to link these pathology results with the patient's year of birth (used to calculate age as year of pathology request−year of birth) and postcode (from which socioeconomic status was determined using the Australian Indexes of Relative Socioeconomic Advantage and Disadvantage).[17] Seasonal variation was determined based on the date of the pathology test request. Test results were defined as low if the 25OHD level was <50 nmol/L or denoted by the pathology provider as low, sufficient if denoted by the pathology provider as normal or the result was from ≥50 nmol/L to ≤250 nmol/L, and high if denoted by the pathology provider as such, or if the result was >250 nmol/L. A 25OHD result of <50 nmol/L was considered low, and<30 nmol/L was considered to indicate vitamin D deficiency.

Statistical analysis

Descriptive statistics are presented as prevalence, proportion and medians. Proportion of 25OHD tests were calculated each year, as a ratio of all tests in any given year (eg, 25OHD tests in 2003 divided by all tests in year 2003) and then converted to a percentage. Adjusted ORs (AORs) were calculated for (1) a 25OHD test request and (2) a test returning an abnormally low result, using generalised

Table 1 Pathology tests (any test and 25OHD test) undertaken by age, season, year and socioeconomic status

		% of 25OHD tests among all tests	25OHD tests	All tests
Age (year)	<1	1.06	441	41 619
	1	1.93	1213	62 904
	2	2.55	1292	50 745
	3	3.02	1539	50 933
	4	3.36	1728	51 445
	5	3.88	1848	47 651
	6	4.08	1816	44 528
	7	4.85	2052	42 340
	8	5.52	2181	39 489
	9	5.54	2056	37 107
	10	6.44	2333	36 245
	11	6.92	2459	35 530
	12	7.97	2748	34 492
	13	9.16	3524	38 485
	14	10.15	4608	45 405
	15	10.03	5707	56 927
	16	10.04	7101	70 703
	17	9.67	8194	84 747
	18	9.01	8969	99 521
Season	Spring	6.57	17 143	260 975
	Summer	6.14	12 552	204 594
	Autumn	6.34	14 987	236 314
	Winter	6.37	17 127	268 933
Year of test	2003	0.31	45	14 509
	2004	0.54	97	18 017
	2005	0.77	156	20 333
	2006	1.06	291	27 489
	2007	1.54	475	30 876
	2008	3.12	1088	34 863
	2009	5.05	2294	45 429
	2010	6.76	3839	56 806
	2011	7.06	4761	67 445
	2012	8.65	6327	73 151
	2013	9.37	7431	79 347
	2014	8.59	7454	86 791
	2015	6.03	5638	93 427
	2016	6.08	6148	101 101
	2017	6.62	7387	111 516
	2018	7.64	8378	109 716
Socioeconomic status (IRSAD decile)	1 (lowest)	8.20	7158	87 271
	2	8.28	4211	50 876
	3	8.65	2885	33 354
	4	4.83	3737	77 375
	5	8.49	5643	66 472
	6	4.74	3542	74 679
	7	5.67	4833	85 302
	8	6.34	10 264	161 781
	9	6.67	9939	149 070
	10 (highest)	5.20	9377	180 306
	No record	5.08	220	4330

*IRSAD, where 1 is most disadvantaged and 10 is most advantaged.
IRSAD, Index of Relative Socioeconomic Advantage and Disadvantage; 25OHD, 25-hydroxyvitamin D.

Table 2 Adjusted ORs of a 25OHD test being requested by year, age group and socioeconomic status

	OR	P value	Lower 95% CI	Upper 95% CI
Year				
2003	Reference			
2004	1.78	0.001	1.25	2.53
2005	2.43	<0.001	1.74	3.40
2006	3.26	<0.001	2.37	4.48
2007	4.78	<0.001	3.51	6.51
2008	9.72	<0.001	7.19	13.14
2009	16.76	<0.001	12.45	22.58
2010	24.63	<0.001	18.31	33.12
2011	26.84	<0.001	19.96	36.08
2012	33.65	<0.001	25.04	45.23
2013	37.49	<0.001	27.90	50.37
2014	34.81	<0.001	25.90	46.77
2015	24.08	<0.001	17.92	32.36
2016	24.33	<0.001	18.10	32.69
2017	26.75	<0.001	19.91	35.95
2018	30.37	<0.001	22.60	40.80
Age group (years)				
0–1	Reference			
2–4	1.86	<0.001	1.76	1.96
5–12	3.51	<0.001	3.34	3.69
13–18	6.62	<0.001	6.30	6.96
Socioeconomic status				
Low	Reference			
Middle	0.65	<0.001	0.63	0.67
High	0.66	<0.001	0.65	0.68
Season				
Summer	Reference			
Spring	1.09	<0.001	1.06	1.11
Autumn	1.03	0.02	1.00	1.05
Winter	1.05	<0.001	1.03	1.08

25OHD, 25-hydroxyvitamin D.

estimating equations, with data clustered by practice and patient, and estimates based on binomial distribution function with exchangeable within-group correlation, logit link function and robust variance. Covariates included in the equations were age group (categorised as 0–1, 2–4, 5–12 and 13–18), year test ordered, season and socioeconomic status category.

All statistical analyses were conducted using Stata/MP V.16.0.

RESULTS

Vitamin D (25OHD) testing in general practice

A total of 970 816 laboratory tests were performed in 356 514 children aged up to 18 years; 61 809 (6.4%) test orders included a 25OHD test in 46 960 children. Breakdown of the tests by age, season, year and socioeconomic status is presented in table 1. Slightly more tests were ordered in winter and spring (AOR 1.1, 95% CI 1.3 to 1.8 in winter, and AOR 1.09, 95% CI 1.6 to 1.1 in spring) compared with summer. The proportion of 25OHD tests ordered increased with age, peaking among adolescents aged 14–18 years (AOR 6.6, 95% CI 6.30 to 7.0) compared with infants aged 0–1 year. The odds of having a vitamin D test in 2018 were 30 times higher compared with 2003 (AOR 30.4, 95% CI: 22.6 to 40.8) (table 2). During late 2014/early 2015, vitamin D testing decreased, although the increasing trend continued thereafter (figure 1).

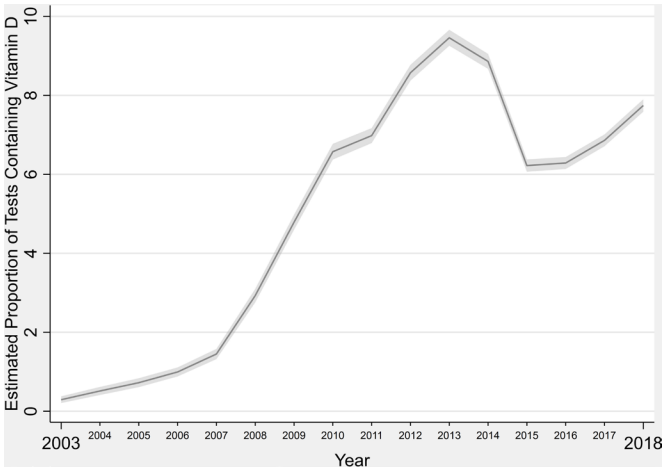

Figure 1 Estimated proportion (%) of pathology test requests containing a vitamin D test order (per year (%) and 95% CI for each year). Estimates were based on a multivariate generalised linear model containing age, sex and socioeconomic status as covariates.

25OHD test results

Based on the pathology provider's assessment, 22 391 (36.2%) of 25OHD test results were marked as low, 24 467 (39.6%) as normal and 63 (0.1%) as high; however, 14 888 (24.1%) were not marked.

The odds of a 25OHD test returning an abnormally low result, as indicated by the pathology provider, were higher during winter (AOR 2.4, 95% CI 2.3 to 2.6) and lower among those of middle (AOR 0.59, 95% CI 0.5 to 0.6) or high (AOR 0.5, 95% CI 0.4 to 0.5) socioeconomic status (table 2). Toddlers (age 0–1 year) were less likely to have a low result compared with children and adolescents 2–4 years old (AOR 1.5, 95% CI 1.3 to 1.7), 5–12 years old (AOR 1.3, 95% CI 1.1 to 1.5) and 13–18 years old (AOR 1.3, 95% CI 1.1 to 1.5). No other age group differences were observed. No significant differences in the likelihood of returning an abnormally low 25OHD result were observed over time (table 3).

Repeat 25OHD testing

Of the 46 960 patients who had a 25OHD test, 9626 (20.5%) had a repeat test (14 849 (24.1%)). The median time between initial and repeat testings was 357 days (IQR 172–669 days). The proportion of repeated tests was 26.7% when the initial result was low compared with 19.2% when the initial test was normal (table 4). In addition, 4603 initial test results were indicative of vitamin D deficiency (<30 nmol/L); of these, only 180 (3.9%) had a repeat test within the next 3 months, and of the 180 repeat tests, 98 (54.4%) returned a low result at 3 months.

Other pathology tests accompanying 25OHD test orders

The 61 809 25OHD tests were accompanied by the following tests: alkaline phosphatase (ALP), 35 488 (57.4%); calcium, 13 609 (22.0%); phosphate, 6815 (11.0%); parathyroid hormone, 1262 (2.0%); ferritin, 25 872 (41.7%); haemoglobin, 43 345 (70.1%); and coeliac serology (transglutaminase and/or gliadin peptide), 4298 (6.9%).

Of the 35 488 ALP tests accompanying 25OHD tests, 557 (1.6%) showed an elevated level,[18] and in 249 (0.7%), there was also a low 25OHD level detected.

DISCUSSION

For the first time, our population-based study has shown that, although 25OHD test ordering in children <18 years increased over

Table 3 Adjusted ORs of a 25OHD test returning a low result

	OR	P value	Lower 95% CI	Upper 95% CI
Year				
2003	Reference			
2004	1.06	0.91	0.39	2.86
2005	2.73	0.04	1.07	6.96
2006	1.38	0.45	0.60	3.18
2007	1.38	0.43	0.62	3.08
2008	1.46	0.35	0.67	3.18
2009	1.27	0.54	0.59	2.75
2010	1.19	0.65	0.55	2.58
2011	1.08	0.85	0.50	2.32
2012	1.05	0.91	0.49	2.25
2013	1.87	0.11	0.87	4.03
2014	1.20	0.65	0.56	2.58
2015	0.76	0.49	0.35	1.65
2016	0.62	0.23	0.29	1.34
2017	0.75	0.45	0.35	1.61
2018	0.61	0.21	0.28	1.32
Age (years)				
0–1	Reference			
2–4	1.49	<0.001	1.29	1.72
5–12	1.30	<0.001	1.15	1.48
13–18	1.31	<0.001	1.15	1.48
Socioeconomic status				
Low	Reference			
Middle	0.59	<0.001	0.56	0.62
High	0.49	<0.001	0.46	0.51
Season				
Summer	Reference			
Spring	2.01	<0.001	1.90	2.12
Autumn	1.24	<0.001	1.17	1.31
Winter	2.46	<0.001	2.33	2.60

25OHD, 25-hydroxyvitamin D.

15 years to 2018, there was no accompanying increase in vitamin D deficiency. In other words, increased testing does not lead to greater detection of vitamin D deficiency among children and adolescents. Our findings align with the longitudinal patterns observed in Australian data for all age groups[14] and with testing volumes according to season,[1 19] suggesting overuse of vitamin D testing and that the practice described in this paper is unlikely to be unique to the study site. The current GCRs state that there is no place for routine screening for vitamin D deficiency in the absence of symptoms or a risk profile.[5] There are no paediatric Choosing Wisely recommendations; however, the European Academy of Paediatrics and the UK's National Osteoporosis Society do not recommend routine vitamin D testing in children.[20 21]

While vitamin D deficiency is a risk factor for osteomalacia and rickets, the majority of children with low vitamin D levels have neither of these conditions.[5] A recent publication suggested that ALP levels provide a more accurate method of screening for nutritional rickets or osteomalacia than 25OHD alone. ALP screening is also cheaper, faster and more accessible.[3 22] In our study, over 40% of 25OHD tests were not accompanied by an ALP test, potentially limiting their clinical utility. However, where ALP and 25OHD were measured in the same patient, only a tiny proportion of results (0.7%) were consistent with nutritional rickets (elevated ALP and low 25OHD).

Treatment guidelines for nutritional rickets recommend repeated biochemistry at 3 months.[5] Among children and adolescents in our study who initially had vitamin D deficiency, a repeat test was undertaken in only 3.9% within 3 months. On the other hand, repeat testing was undertaken in 19.2% of children or adolescents with normal initial vitamin D levels. The reasons for these seemingly counterintuitive follow-up practices are unclear and do not align with current recommendations.[5] Low rates of retesting, after detection of deficiency, may be related to onward referral for specialist care; however, the dataset contained no information about referrals. Higher rates of repeat testing among those with a normal initial result and a median retesting interval of 350 days suggest that ordering a 25OHD may simply be 'routine'. This routine testing appears to have little advantage to patients, potentially creating disruption for children and families and unnecessary discomfort for children from venepuncture. To understand the drivers for this variation in practice, mixed-method studies are needed to explore factors and circumstances that contribute to GPs' decision making. Factors that drive test ordering practice, such as the use of standard pathology order sets and prompts in electronic ordering software, should also be evaluated.

Despite nutritional rickets having peak incidence in the first 2 years of life, this age group was the least likely to have a 25OHD test. Children aged under 4 years were proportionately more likely to have a low result compared with their older counterparts. However, in our study, older children and especially adolescents (14–16 years) were more likely to be tested. This implies a higher index of suspicion among GPs of vitamin D deficiency among these older age groups. However, population-level evidence to support this is lacking.

Our data suggest that vitamin D deficiency among children and adolescents is uncommon in Australia. To comply with the GCRs, unless there are specific indications for vitamin D testing, it should not be done. Higher rates of deficiency detected among preschoolers despite lower rates of testing for that age group suggest that GPs may be more selective when deciding to test younger children, targeting those with known risk factors. A targeted approach, in line with the GCRs, should be adopted regardless of age.[23] GPs have an important role in the prevention of nutritional rickets and in supporting good bone health in children and adolescents by recognising risk profiles and early signs and symptoms of potential vitamin D deficiency. There is a need for greater implementation of the GCRs in primary care using codesigned interventions that align with the nuances and complexities of primary care practice. Educational programmes could be strengthened by highlighting the unintended consequences of routine testing for 25OHD for children and families, health system costs and the environment in the form of increased plastic

Table 4 25OHD tests with a recorded result note (low, normal and high) by the pathology provider

Noted result	Repeated tests N (%)	Repeated within 90 days (N)	Repeated within 1 year (N)	Median time to repeat (IQR)
Low (<50 nmol/L)	5983 (26.72)	793	1704	344 (159–673)
Normal (≥50 to ≤250 nmol/L)	4702 (19.22)	461	1058	375 (199–672)
High (>250 nmol/L)	19 (30.16)	3	7	306 (114–515)

25OHD, 25-hydroxyvitamin D.

waste and carbon emissions.[24] A recent 'Practice Change' article in the British Medical Journal simply asks, 'Do not routinely test for vitamin D'.[25] A similar, concise and widely implemented guide on vitamin D testing in children is needed for primary care clinicians and families.

Targeted screening and supplementation are currently recommended for children and adolescents with risk factors for vitamin D deficiency.[5 26] Supplementation is cheap, approximately AU$24 per year compared with the cost of one pathology test (~$A30.05) in Australia.[27] Vitamin D supplementation in pregnant women and in young children in the UK showed cost-effectiveness.[28] However, universal supplementation, including through fortification of common foods (eg, dairy products), has wide reach and may be the most effective and cheapest option to prevent vitamin D deficiency and associated consequences, including nutritional rickets.[9 29] Fortification of milk, for example, has had benefits in European countries, the USA and Canada.[9]

Strengths and limitations

The size of this unique dataset of 25OHD pathology test orders and results, which covers ordering practice over 15 years, is a considerable strength, especially in the absence of similar datasets for Australian children and internationally. Our analysis was limited because specific reasons for ordering 25OHD tests were not systematically recorded in the dataset. Additionally, the dataset did not contain information about children's symptoms, or their risk factors for vitamin D deficiency or nutritional rickets, for example, medical conditions, skin colour and ethnicity. The current dataset was not detailed enough to explore what drives decision making when ordering 25OHD in children, and further mixed-method studies are needed to understand these drivers. The findings in this study reflect vitamin D test ordering practices in a specific region of Australia and may not be generalisable, although the patterns of test ordering align with national population-based testing data from the MBS.

CONCLUSION

High volume of testing, low rates of detected deficiency, low rates of retesting when initial results showed vitamin D deficiency and relatively high rates of retesting when initial results were normal suggest decision making that is somewhat counterintuitive. The first course of action for patients with potential vitamin D deficiency is supplementation as it is safe, widely available and cost-effective for patients, families and health systems. Further research is needed to develop a deeper understanding of decision-making drivers associated with 25OHD test ordering to support codesigned fit-for-purpose interventions to reduce this low-value practice. A national unified, pathology data resource is needed to support future research on a larger scale.

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Contributors YZ and AG conceived the study and GS undertook the data analysis. CFM provided clinical expertise to guide the research questions and data interpretation. YZ wrote the initial draft with substantial input from GS and CFM. AG and CI critically reviewed the manuscript. AG is guarantor.

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Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by the Macquarie University Human Research Ethics Committee (5201700872). Ethics approval to collect general practice health record data has been obtained by the data provider, Outcome Health, from the RACGP National Research and Evaluation Ethics Committee (NREEC 17–008).The study is based on a deidentified population-based dataset or primary care pathology requests and results.

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Data availability statement Data may be obtained from a third party and are not publicly available. Data are available on request from Outcome Health.

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