Online Resource 1: Electronic Supplementary Material

Article: Vitamin D status from infancy to adolescence before Slovenia's first national vitamin D guideline: age, season and sex patterns in 12,028 tested children (2014–2023)

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Definitions and interpretation

The primary cohort comprises the first valid paediatric test per child. Infants are aged 0–<1 year, toddlers 1–<3, preschool children 3–<6, school-age children 6–<12 and adolescents 12–<18. Winter is December–February, spring March–May, summer June–August and autumn September–November. Half-years are December–May and June–November. Concentrations are in nmol/L; percentages describe tested children unless a test-level denominator is stated. Mean CIs use Student's t distribution; percentage CIs use Wilson scores. CI denotes a 95% confidence interval throughout. PR denotes a ratio of proportions among tested children, or among tests in sensitivity analysis (a).

Categories are <30, 30–<50, 50–<75 and ≥75 nmol/L; the open-ended upper category retains high values and does not imply optimal status throughout. High concentrations are >125 nmol/L. The primary cohort retains values >150 nmol/L. Left-censored results (<x) were set to x/2 locally before analysis; 35 paediatric tests were affected. No individual records are reproduced.

Table S1. Age band × meteorological season

First valid paediatric tests; proportions use the age-band/season row denominator.

Age band	Season	N	Mean (95% CI), nmol/L	<50 nmol/L: n; % (95% CI)	<30 nmol/L: n; % (95% CI)
Infants	Winter	248	74.9 (69.5–80.2)	66; 26.6 (21.5–32.4)	32; 12.9 (9.3–17.6)
Infants	Spring	277	69.3 (64.7–73.8)	102; 36.8 (31.4–42.6)	46; 16.6 (12.7–21.4)
Infants	Summer	218	78.1 (72.9–83.2)	56; 25.7 (20.3–31.9)	16; 7.3 (4.6–11.6)

Age band	Season	N	Mean (95% CI), nmol/L	<50 nmol/L: n; % (95% CI)	<30 nmol/L: n; % (95% CI)
Infants	Autumn	260	79.5 (73.9–85.1)	72; 27.7 (22.6–33.4)	25; 9.6 (6.6–13.8)
Toddlers	Winter	254	69.6 (64.7–74.4)	84; 33.1 (27.6–39.1)	31; 12.2 (8.7–16.8)
Toddlers	Spring	286	72.3 (68.0–76.6)	75; 26.2 (21.5–31.6)	17; 5.9 (3.7–9.3)
Toddlers	Summer	240	81.9 (78.3–85.6)	21; 8.8 (5.8–13.0)	1; 0.4 (0.1–2.3)
Toddlers	Autumn	298	81.2 (77.9–84.5)	27; 9.1 (6.3–12.9)	4; 1.3 (0.5–3.4)
Preschool	Winter	463	60.7 (58.1–63.2)	174; 37.6 (33.3–42.1)	29; 6.3 (4.4–8.9)
Preschool	Spring	541	60.9 (58.6–63.3)	188; 34.8 (30.9–38.9)	26; 4.8 (3.3–6.9)
Preschool	Summer	382	78.9 (76.1–81.6)	42; 11.0 (8.2–14.5)	8; 2.1 (1.1–4.1)
Preschool	Autumn	507	75.3 (72.8–77.8)	69; 13.6 (10.9–16.9)	15; 3.0 (1.8–4.8)
School age	Winter	950	57.3 (55.5–59.1)	390; 41.1 (38.0–44.2)	61; 6.4 (5.0–8.2)
School age	Spring	1,054	55.5 (54.2–56.9)	433; 41.1 (38.1–44.1)	78; 7.4 (6.0–9.1)
School age	Summer	768	77.3 (75.3–79.2)	94; 12.2 (10.1–14.7)	6; 0.8 (0.4–1.7)
School age	Autumn	1,157	73.2 (71.8–74.6)	145; 12.5 (10.7–14.6)	19; 1.6 (1.1–2.6)
Adolescents	Winter	1,074	50.2 (48.8–51.7)	581; 54.1 (51.1–57.1)	178; 16.6 (14.5–18.9)
Adolescents	Spring	1,152	48.5 (47.4–49.6)	642; 55.7 (52.8–58.6)	160; 13.9 (12.0–16.0)
Adolescents	Summer	821	70.3 (68.4–72.2)	171; 20.8 (18.2–23.7)	25; 3.0 (2.1–4.5)
Adolescents	Autumn	1,078	67.7 (66.2–69.3)	228; 21.2 (18.8–23.7)	32; 3.0 (2.1–4.2)

Small-cell note: Two cells contain fewer than five children: toddlers sampled in summer with <30 nmol/L (n=1) and in autumn with <30 nmol/L (n=4). Their CIs are imprecise; no individual attributes beyond the table strata are reported.

Table S2. Age band × sex and adjusted female–male contrasts

a. Descriptive first-test results

Age band	Sex	N	Mean (95% CI), nmol/L	<50 nmol/L: n; % (95% CI)	<30 nmol/L: n; % (95% CI)
Infants	Female	437	77.3 (73.4–81.2)	115; 26.3 (22.4–30.6)	47; 10.8 (8.2–14.0)
Infants	Male	566	73.6 (70.1–77.0)	181; 32.0 (28.3–35.9)	72; 12.7 (10.2–15.7)
Toddlers	Female	479	78.0 (75.0–81.0)	89; 18.6 (15.4–22.3)	28; 5.8 (4.1–8.3)
Toddlers	Male	599	74.9 (72.1–77.6)	118; 19.7 (16.7–23.1)	25; 4.2 (2.8–6.1)
Preschool	Female	896	67.6 (65.8–69.5)	219; 24.4 (21.7–27.4)	35; 3.9 (2.8–5.4)
Preschool	Male	997	68.9 (67.1–70.8)	254; 25.5 (22.9–28.3)	43; 4.3 (3.2–5.8)
School age	Female	1,957	64.1 (62.9–65.2)	571; 29.2 (27.2–31.2)	88; 4.5 (3.7–5.5)
School age	Male	1,972	66.7 (65.5–68.0)	491; 24.9 (23.0–26.9)	76; 3.9 (3.1–4.8)
Adolescents	Female	2,372	57.8 (56.8–58.8)	937; 39.5 (37.6–41.5)	229; 9.7 (8.5–10.9)
Adolescents	Male	1,753	59.1 (57.8–60.4)	685; 39.1 (36.8–41.4)	166; 9.5 (8.2–10.9)

b. Model A adjusted female–male concentration differences

Age band	Female–male difference (95% CI), nmol/L	p
Infants	3.7 (−1.6 to 8.9)	0.172
Toddlers	3.2 (−0.8 to 7.2)	0.122
Preschool	−0.6 (−3.1 to 1.9)	0.629
School age	−3.2 (−4.8 to −1.7)	<0.001
Adolescents	−1.8 (−3.3 to −0.3)	0.018

Model A includes age band × harmonic sine/cosine terms, age band × sex, and categorical calendar year. Female–male intervals use HC3 covariance; these are adjusted contrasts.

c. Robust Wald tests of age band × sex

Model/outcome	Wald χ^2	df	p

Model/outcome	Wald χ^2	df	p
Model A: concentration	14.2	4	0.007
Model C: <50 nmol/L	15.4	4	0.004

Model C for sex includes age band × sex, meteorological season and categorical calendar year, with modified Poisson regression and robust HC0 standard errors. Its interaction test is reported; within-band sex PR contrasts were not estimated. Model B estimates the overall female PR for <50 nmol/L as 1.04 (95% CI 0.99–1.09; p=0.163) and for <30 nmol/L as 1.04 (0.91–1.19; p=0.543).

Table S3. Monthly means underlying Fig. 2

Age band	Month	N	Mean (95% CI), nmol/L
Infants	January	98	72.2 (64.2–80.1)
Infants	February	64	75.7 (66.7–84.6)
Infants	March	98	72.4 (64.5–80.3)
Infants	April	68	70.4 (60.4–80.4)
Infants	May	111	65.8 (59.0–72.6)
Infants	June	77	71.9 (64.1–79.6)
Infants	July	78	81.6 (73.2–89.9)
Infants	August	63	81.3 (70.0–92.5)
Infants	September	91	85.6 (74.7–96.4)
Infants	October	78	71.8 (63.7–79.9)
Infants	November	91	80.0 (70.5–89.6)
Infants	December	86	77.4 (66.6–88.2)
Toddlers	January	109	64.0 (58.1–69.9)
Toddlers	February	77	71.3 (60.9–81.7)
Toddlers	March	105	73.9 (65.2–82.5)
Toddlers	April	87	72.4 (65.7–79.1)
Toddlers	May	94	70.6 (64.1–77.0)
Toddlers	June	102	73.3 (67.9–78.8)
Toddlers	July	75	87.6 (81.2–93.9)
Toddlers	August	63	89.1 (82.2–96.0)
Toddlers	September	106	87.0 (81.3–92.8)
Toddlers	October	100	77.7 (73.0–82.4)
Toddlers	November	92	78.2 (71.5–84.9)
Toddlers	December	68	76.6 (66.5–86.6)
Preschool	January	178	61.5 (57.3–65.8)

Age band	Month	N	Mean (95% CI), nmol/L
Preschool	February	155	57.7 (52.6–62.7)
Preschool	March	169	58.1 (54.2–62.0)
Preschool	April	162	59.1 (54.3–63.8)
Preschool	May	210	64.7 (61.1–68.2)
Preschool	June	176	70.6 (67.0–74.1)
Preschool	July	121	79.2 (75.1–83.2)
Preschool	August	85	95.7 (88.8–102.6)
Preschool	September	155	86.1 (81.2–91.0)
Preschool	October	167	72.9 (69.0–76.9)
Preschool	November	185	68.3 (64.4–72.2)
Preschool	December	130	63.1 (59.6–66.7)
School age	January	338	54.8 (52.3–57.3)
School age	February	272	55.2 (51.7–58.8)
School age	March	347	56.1 (53.5–58.6)
School age	April	314	53.4 (51.0–55.8)
School age	May	393	56.8 (54.9–58.7)
School age	June	331	64.5 (62.2–66.8)
School age	July	206	80.8 (77.3–84.2)
School age	August	231	92.4 (88.6–96.2)
School age	September	349	85.5 (82.6–88.4)
School age	October	407	71.0 (68.8–73.2)
School age	November	401	64.7 (62.9–66.6)
School age	December	340	61.4 (58.1–64.6)
Adolescents	January	377	48.4 (46.0–50.8)
Adolescents	February	325	49.8 (46.5–53.1)
Adolescents	March	416	47.1 (45.1–49.0)
Adolescents	April	328	47.4 (45.3–49.5)
Adolescents	May	408	50.9 (49.1–52.7)
Adolescents	June	318	57.1 (55.0–59.1)
Adolescents	July	239	72.0 (68.9–75.1)
Adolescents	August	264	84.7 (80.7–88.7)
Adolescents	September	326	77.1 (74.1–80.0)
Adolescents	October	366	66.6 (64.3–69.0)
Adolescents	November	386	60.9 (58.4–63.4)

Age band	Month	N	Mean (95% CI), nmol/L
Adolescents	December	372	52.5 (50.6–54.4)

These are unadjusted monthly means, not fitted values from the harmonic model.

Table S4. Sensitivity analyses

(a) All 25,484 valid paediatric tests, retaining repeats, analysed using exchangeable GEE clustered by child. (b) First tests of 7,782 children with only a single valid paediatric test in the export. (c) First tests after excluding >150 nmol/L: 11,847 children; 181 first-test observations were excluded. Exclusion was applied after first-test selection, without substituting a later test.

The primary cohort contains 12,028 children. Sensitivity analyses repeat Model A for concentrations and Model B for <50 nmol/L; <30 nmol/L models and Model C interactions were not repeated. Amplitudes below are point estimates; bootstrap CIs were computed for the primary analysis only.

Estimate	Primary	(a)	(b)	(c)
PR <50 nmol/L: Infants	1.07 (0.96–1.20)	1.06 (0.95–1.18)	0.93 (0.78–1.10)	1.10 (0.99–1.23)
PR <50 nmol/L: Toddlers	0.71 (0.63–0.81)	0.72 (0.64–0.80)	0.69 (0.58–0.82)	0.73 (0.64–0.83)
PR <50 nmol/L: Preschool	0.91 (0.83–1.00)	0.93 (0.86–0.99)	0.90 (0.80–1.01)	0.91 (0.83–1.00)
PR <50 nmol/L: Adolescents	1.42 (1.34–1.51)	1.41 (1.34–1.48)	1.53 (1.42–1.66)	1.41 (1.33–1.50)
PR <50 nmol/L: female vs male	1.04 (0.99–1.09)	1.05 (1.00–1.10)	1.02 (0.96–1.09)	1.04 (0.98–1.09)
PR <50 nmol/L: winter vs summer	2.69 (2.43–2.97)	2.70 (2.52–2.91)	2.90 (2.55–3.30)	2.67 (2.42–2.95)
PR <50 nmol/L: School age (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Seasonal amplitude, nmol/L: Infants	5.6	8.1	6.9	2.4
Proportion <50 nmol/L, %: Infants	29.5	26.5	23.3	30.9
Seasonal amplitude,	8.3	7.7	8.7	9.8

Estimate	Primary	(a)	(b)	(c)
nmol/L: Toddlers				
Proportion <50 nmol/L, %: Toddlers	19.2	16.3	16.5	19.8
Seasonal amplitude, nmol/L: Preschool	13.9	12.8	14.3	13.8
Proportion <50 nmol/L, %: Preschool	25.0	21.3	22.4	25.3
Seasonal amplitude, nmol/L: School age	15.6	15.3	16.2	15.5
Proportion <50 nmol/L, %: School age	27.0	22.9	24.7	27.3
Seasonal amplitude, nmol/L: Adolescents	15.5	13.9	16.5	15.1
Proportion <50 nmol/L, %: Adolescents	39.3	33.8	38.5	39.6

PR intervals are 95% CIs. References are school age, male sex, summer and calendar year 2014. Models include the covariates and interaction terms described in the manuscript. In (a), the percentages describe tests and children with repeated testing contribute more than once; they are not child-level proportions.

Table S5. Test-level summary of all paediatric measurements

All 25,484 valid paediatric measurements, with no first-test deduplication or upper concentration exclusion. Age band, sex and sampling time refer to each test. A child may contribute multiple tests and may contribute to more than one age band. These summaries support comparison with the parent database report [1].

Age band	Tests, N	Female, %	November–April, %	Mean (SD), nmol/L	Median (Q1–Q3), nmol/L	<50 nmol/L, %	<30 nmol/L, %

Age band	Tests, N	Female, %	November–April, %	Mean (SD), nmol/L	Median (Q1–Q3), nmol/L	<50 nmol/L, %	<30 nmol/L, %
Infants	1,663	43.2	49.7	80.6 (43.9)	76.0 (48.0–105.5)	26.5	10.5
Toddlers	1,949	46.5	48.4	79.9 (33.9)	76.0 (58.0–99.0)	16.3	4.2
Preschool	3,524	47.6	50.3	72.3 (31.2)	68.0 (52.0–87.0)	21.3	3.9
School age	8,664	49.1	50.1	69.5 (29.7)	65.0 (51.0–82.0)	22.9	3.6
Adolescents	9,684	53.8	51.1	61.4 (26.0)	58.0 (44.0–75.0)	33.8	7.6
All tests	25,484	50.1	50.3	68.3 (30.8)	64.0 (48.0–83.0)	26.6	5.7

November–April sampling is retained only for comparability with the earlier test-level summaries; it differs from the December–May contrast used in the present models. The parent report summarised children as one pooled 0–18-year row; differences in the unit of analysis and age-band definition limit direct numerical comparison with that row.

Full Model B coefficient tables

All Model B coefficients are shown on the exponentiated scale. The intercept is the fitted baseline proportion for school-age boys tested in summer in 2014; it is not a PR. All other coefficients are adjusted PRs. The standard error is on the log scale. Models use robust HC0 covariance; categorical calendar year is included.

Outcome: <50 nmol/L

Term	Exponentiated coefficient (95% CI)	SE (log scale)	p
Intercept (baseline proportion)	0.14 (0.12–0.16)	0.07	<0.001
Infants vs school age	1.07 (0.96–1.20)	0.06	0.221
Toddlers vs school age	0.71 (0.63–0.81)	0.06	<0.001
Preschool vs school age	0.91 (0.83–1.00)	0.05	0.039

Term	Exponentiated coefficient (95% CI)	SE (log scale)	p
Adolescents vs school age	1.42 (1.34–1.51)	0.03	<0.001
Female vs male	1.04 (0.99–1.09)	0.03	0.163
Winter vs summer	2.69 (2.43–2.97)	0.05	<0.001
Spring vs summer	2.67 (2.42–2.95)	0.05	<0.001
Autumn vs summer	1.03 (0.91–1.16)	0.06	0.641
2015 vs 2014	1.20 (1.06–1.37)	0.07	0.004
2016 vs 2014	1.21 (1.06–1.37)	0.07	0.004
2017 vs 2014	1.21 (1.07–1.36)	0.06	0.002
2018 vs 2014	1.10 (0.98–1.24)	0.06	0.122
2019 vs 2014	1.22 (1.09–1.36)	0.06	<0.001
2020 vs 2014	0.89 (0.78–1.01)	0.06	0.069
2021 vs 2014	0.91 (0.81–1.02)	0.06	0.115
2022 vs 2014	0.92 (0.82–1.03)	0.06	0.147
2023 vs 2014	0.98 (0.88–1.10)	0.06	0.785

Outcome: <30 nmol/L

Term	Exponentiated coefficient (95% CI)	SE (log scale)	p
Intercept (baseline proportion)	0.02 (0.01–0.02)	0.18	<0.001
Infants vs school age	2.74 (2.18–3.43)	0.12	<0.001
Toddlers vs school age	1.16 (0.86–1.56)	0.15	0.329
Preschool vs school age	0.96 (0.74–1.25)	0.13	0.785
Adolescents vs school age	2.18 (1.83–2.60)	0.09	<0.001
Female vs male	1.04 (0.91–1.19)	0.07	0.543
Winter vs summer	4.75 (3.60–6.26)	0.14	<0.001
Spring vs summer	4.20 (3.18–5.55)	0.14	<0.001
Autumn vs summer	1.27 (0.92–1.76)	0.17	0.148
2015 vs 2014	1.19 (0.87–1.63)	0.16	0.270
2016 vs 2014	1.35 (1.00–1.82)	0.15	0.050
2017 vs 2014	0.99 (0.73–1.35)	0.16	0.939
2018 vs 2014	1.05 (0.79–1.41)	0.15	0.728
2019 vs 2014	0.92 (0.69–1.22)	0.15	0.555
2020 vs 2014	0.79 (0.58–1.08)	0.16	0.136

Term	Exponentiated coefficient (95% CI)	SE (log scale)	p
2021 vs 2014	0.80 (0.60–1.07)	0.15	0.139
2022 vs 2014	0.71 (0.53–0.95)	0.15	0.021
2023 vs 2014	1.01 (0.77–1.32)	0.14	0.961

Model A peak timing and bootstrap details

Age band	Peak date	Peak day of year	Circular 95% CI, day of year	Peak-to-trough variation (95% CI), nmol/L
Infants	28 Sep	271.0	232.3–313.7	11.2 (4.7–19.5)
Toddlers	27 Aug	238.6	218.5–258.7	16.5 (10.8–22.3)
Preschool	25 Aug	237.5	231.1–244.1	27.8 (23.9–31.6)
School age	29 Aug	241.2	237.5–244.9	31.3 (28.8–33.6)
Adolescents	01 Sep	243.5	240.0–246.9	31.1 (28.9–33.4)

Peak dates and circular day-of-year interval endpoints are reported as estimated. Percentile intervals use 2,000 successful child-level bootstrap replicates, seed 20261030; no bootstrap replicates were skipped. G-computation used the resampled empirical covariate mix within each replicate. Dates summarise fitted peaks, not the month with the largest observed sample mean.

Aggregate counts underlying Fig. 3

Each panel uses its own age-band/half-year denominator. Categories are mutually exclusive; displayed percentages may not sum exactly because of rounding.

Half-year	Age band	N	<30 nmol/L, n (%)	30–<50 nmol/L, n (%)	50–<75 nmol/L, n (%)	≥75 nmol/L, n (%)
Dec–May	Infants	525	78 (14.9%)	90 (17.1%)	122 (23.2%)	235 (44.8%)
Dec–May	Toddlers	540	48 (8.9%)	111 (20.6%)	177 (32.8%)	204 (37.8%)
Dec–May	Preschool	1,004	55 (5.5%)	307 (30.6%)	401 (39.9%)	241 (24.0%)
Dec–May	School age	2,004	139 (6.9%)	684 (34.1%)	905 (45.2%)	276 (13.8%)
Dec–May	Adolescents	2,226	338 (15.2%)	885 (39.8%)	777 (34.9%)	226 (10.2%)
Jun–Nov	Infants	478	41 (8.6%)	87 (18.2%)	119	231

Half-year	Age band	N	<30 nmol/L, n (%)	30–<50 nmol/L, n (%)	50–<75 nmol/L, n (%)	≥75 nmol/L, n (%)
					(24.9%)	(48.3%)
Jun–Nov	Toddlers	538	5 (0.9%)	43 (8.0%)	190 (35.3%)	300 (55.8%)
Jun–Nov	Preschool	889	23 (2.6%)	88 (9.9%)	353 (39.7%)	425 (47.8%)
Jun–Nov	School age	1,925	25 (1.3%)	214 (11.1%)	858 (44.6%)	828 (43.0%)
Jun–Nov	Adolescents	1,899	57 (3.0%)	342 (18.0%)	868 (45.7%)	632 (33.3%)

References

1. Osredkar J, Siuka D, Jerin A, Štabuc B, Godnov U (2026) Ten-Year Trends in Serum 25-Hydroxyvitamin D in Slovenia (2014-2023): Laboratory-Based Data from Tested Individuals and COVID-19-Period Changes. Nutrients 18:1168. https://doi.org/10.3390/nu18071168