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RESEARCH ARTICLE

Evaluation of vitamin D level in children at rural tertiary healthcare center.

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Abstract: ***Background:*** Despite abundant sunlight, Indian children frequently exhibit suboptimal vitamin D status. Evidence from rural tertiary pediatric settings remains limited. ***Methods:*** A hospital-based observational study was conducted among 110 inpatients (aged 1 month–<18 years) in Gujarat, India. Serum 25(OH)D was measured using chemiluminescent immunoassay and classified as deficient (<12 ng/mL), insufficient (12–20 ng/mL), or sufficient (>20 ng/mL). Associations of sufficiency with dietary pattern, recent supplementation, sun exposure, sun protection, skin type, and antiepileptic drug (AED) use were evaluated using chi-square or t-tests. ***Results:*** Vitamin D sufficiency was observed in 62.7% of children. Sufficiency was significantly lower in older children (p=0.003) but did not differ by sex (p=0.109). Dietary pattern (vegetarian/eggetarian vs non-vegetarian, p=0.007) and recent supplementation (p=0.027) were significantly associated with sufficiency, while sun-exposure hours, sun protection, skin type, and AED use were not (all p>0.05). Mean alkaline phosphatase levels did not differ between groups (p=0.302). ***Conclusions:*** Two-thirds of hospitalized children were vitamin D sufficient using a >20 ng/mL cut-off. Dietary factors and recent supplementation were major determinants of sufficiency, whereas sun-exposure proxies and ALP were not. These findings support continued emphasis on guideline-concordant supplementation and dietary fortification strategies in pediatric care.

Keywords: Vitamin D, Children, Supplementation, 25-hydroxyvitamin D, Rural hospital.

INTRODUCTION

Vitamin D is essential for calcium homeostasis and skeletal growth in childhood and adolescence, supporting bone mineralization, muscle function, and the prevention of rickets [1,2]. Beyond musculoskeletal effects, vitamin D modulates innate and adaptive immunity, influences neurodevelopment, and participates in cellular growth and differentiation [3,4].

Despite abundant sunshine, India reports a high burden of suboptimal serum 25-hydroxyvitamin D [25(OH)D] across age groups, including children in rural areas [5,6]. Contributing factors include darker skin pigmentation, limited outdoor exposure, clothing practices, air pollution, and low dietary vitamin D intake (diet typically contributes <10% of total vitamin D) [7,8]. Although rural children are often presumed to obtain adequate sunlight (cutaneous synthesis accounts for ~90% of vitamin D), undernutrition, poor maternal health, low socioeconomic status, and limited awareness about sun exposure and diet contribute to hypovitaminosis D even in these settings [9,10].

Multiple organizations have proposed differing diagnostic thresholds, and an India-specific consensus has been evolving. Notably, the Indian Academy of Paediatrics (IAP) issued practice guidance to harmonize assessment and supplementation strategies, and many centres now implement supplementation protocols for infants and children based on the IAP's 2021 guidance [11]. Against this background, careful identification of contextual risk factors remains essential to inform efficient, targeted management.

We conducted a study in hospitalized children at a rural tertiary centre to estimate the prevalence of vitamin D sufficiency/insufficiency and to examine associated factors relevant to this setting.

AIMS & OBJECTIVES

AIM

This study aimed to assess and analyze of vitamin D levels in children at rural tertiary healthcare center.

OBJECTIVES OF THE STUDY

To know the prevalence of vitamin D deficiency and insufficiency.

To identify the risk factors associated with vitamin D deficiency and insufficiency.

MATERIAL AND METHODS

Study design and setting

We conducted a hospital-based, observational study in the Pediatric Ward and Pediatric Intensive Care Unit of a rural tertiary-care teaching hospital (Parul Sevashram Hospital, Vadodara, Gujarat, India) over 12 months (March 2024–February 2025).

Participants

Consecutive inpatients aged 1 month to <18 years were eligible. We excluded children with chronic systemic conditions known to affect vitamin D status (e.g., chronic kidney disease, chronic liver disease, fat-malabsorption syndromes) and those with incomplete key data. Written informed consent was obtained from parents/guardians; assent was obtained from older children as appropriate.

Variables and data collection

A structured case-record form captured:

- Demographics and clinical details.
- Anthropometry (weight, length/height, BMI in children ≥5 years) measured by trained staff following WHO/IAP recommendations. Nutritional status was classified as: for <5 y, MAM/SAM per WHO; for 5–18 y, thinness/overweight/obesity using age- and sex-specific BMI references; short stature per standard height-for-age criteria.
- Sun-exposure (caregiver/patient-reported average hours/day) and sun-protection practices (e.g., sunscreen, clothing barriers).
- Dietary pattern (vegetarian, non-vegetarian, eggetarian).
- Recent vitamin D supplementation (any preparation within the preceding ≤2 months, yes/no).
- Prolonged antiepileptic drug use (yes/no).
- Fitzpatrick skin phototypes (Types 2–5).
- Laboratory: serum 25-hydroxyvitamin D [25(OH)D], alkaline phosphatase (ALP), and routine indices as available.

Laboratory methods

Serum 25(OH)D was measured using a chemiluminescent immunoassay (CLIA) according to the manufacturer's protocol. ALP was measured on the hospital analyser (routine biochemistry platform). Internal quality controls were run per laboratory policy.

Definitions and outcomes

Vitamin D status was categorized a priori as:

- Deficient: <12 ng/mL
- Insufficient: 12–20 ng/mL
- Sufficient: >20–100 ng/mL
- Toxic: >100 ng/mL

The primary outcome was the prevalence of vitamin D sufficiency/insufficiency. Secondary analyses evaluated associations between vitamin D sufficiency and prespecified exposures (dietary pattern, recent supplementation, sun-protection, skin phototype, antiepileptic drug use, and sun-exposure hours) and compared ALP across vitamin D groups.

Statistical analysis

Descriptive statistics are reported as n/N (%) for categorical variables and as mean±SD for continuous variables. Group comparisons used:

- Chi-square tests for categorical associations (e.g., sufficiency across dietary pattern, supplementation, sun-protection, skin type, AED use).
- Independent t-test to compare sun-exposure hours/day between sufficient vs insufficient/deficient groups.
- Welch's t-test for comparing ALP (U/L) between vitamin D groups.

Two-sided α=0.05 defined statistical significance. Analyses were performed on complete cases consistent with the above definitions.

Ethics

The study protocol was approved by the Institutional Ethics Committee of the teaching hospital. Written informed consent and age-appropriate assent were obtained for all participants.

RESULTS AND OBSERVATIONS:

1. Participant characteristics

We enrolled 110 children. Summary distributions for age bands and sex, nutritional status by age strata, skin phenotype, sun-protection, diet, recent vitamin D supplementation, antiepileptic drug use, and descriptive laboratory/exposure measures appear in Table 1. Percentages are shown using the appropriate subgroup denominators.

Vitamin D status (primary outcome)

Overall, 69/110 (62.7%) children were vitamin D sufficient (25[OH]D >20 ng/mL). Sufficiency differed across age bands (χ^2=11.343, df=2, p=0.003), with lower proportions in the 5–18-year group; there was no significant difference by sex (χ^2=2.568, df=1, p=0.109). Subgroup counts and proportions are shown in Table 2, and age-wise sufficiency percentages are visualized in Figure 1.

Associations with prespecified risk factors

Dietary pattern and recent vitamin D supplementation showed significant associations with sufficiency; sun-protection use, skin type, antiepileptic drug use, and overall sun-exposure hours did not (Table 3). Figure 2 visualizes sufficiency proportions across exposure categories.

Table 1. Baseline demographic, anthropometric, and clinical characteristics (n=110)

Variable group	Category/metric	n	Denominator	%
Age band	<1 year	11	110	10.0
Age band	1–5 years	40	110	36.4
Age band	5–18 years	59	110	53.6
Sex	Male	70	110	63.6
Sex	Female	40	110	36.4
Nutritional status (<5 y)	Normal	30	51	58.8
Nutritional status (<5 y)	MAM	7	51	13.7
Nutritional status (<5 y)	SAM	14	51	27.5
Nutritional status (<5 y)	Short stature	9	51	17.6
Nutritional status (5–18 y)	Normal	43	59	72.9
Nutritional status (5–18 y)	Thinness	14	59	23.7
Nutritional status (5–18 y)	Overweight/Obesity	2	59	3.4
Nutritional status (5–18 y)	Short stature	3	59	5.1
Skin type (Fitzpatrick)	Type 2	4	110	3.6
Skin type (Fitzpatrick)	Type 3	30	110	27.3
Skin type (Fitzpatrick)	Type 4	49	110	44.5
Skin type (Fitzpatrick)	Type 5	27	110	24.5
Sun-protection use	Yes	23	110	20.9
Sun-protection use	No	87	110	79.1
Dietary pattern	Vegetarian	46	110	41.8
Dietary pattern	Non-vegetarian	23	110	20.9
Dietary pattern	Eggetarian	41	110	37.3
Recent vitamin D supplementation (≤2 months)	Yes	23	110	20.9
Recent vitamin D supplementation (≤2 months)	No	87	110	79.1
Prolonged antiepileptic drug use	Yes	9	110	8.2
Prolonged antiepileptic drug use	No	101	110	91.8
Laboratory	ALP (U/L), mean±SD	134.0 ± 39.4		

Notes: Percentages use the subgroup denominator shown in the fourth column. ALP indicates alkaline phosphatase.

Secondary laboratory comparison

Mean ALP values were similar between vitamin D–sufficient and insufficient/deficient groups, with overlapping ranges and no meaningful difference (Table 4).

Table 2. Vitamin D status overall and by subgroup (n=110)

Stratum	Group	Outcome	n/N	%	Statistic
Overall	All participants	Sufficient	69/110	62.7	
Overall	All participants	Insufficient/Deficient	41/110	37.3	
By age band	<1 year	Sufficient	7/11	63.6	
By age band	1–5 years	Sufficient	33/40	82.5	χ^2=11.343, df=2, p=0.003
By age band	5–18 years	Sufficient	29/59	49.2	
By sex	Male	Sufficient	40/70	57.1	χ^2=2.568, df=1, p=0.109
By sex	Female	Sufficient	29/40	72.5	

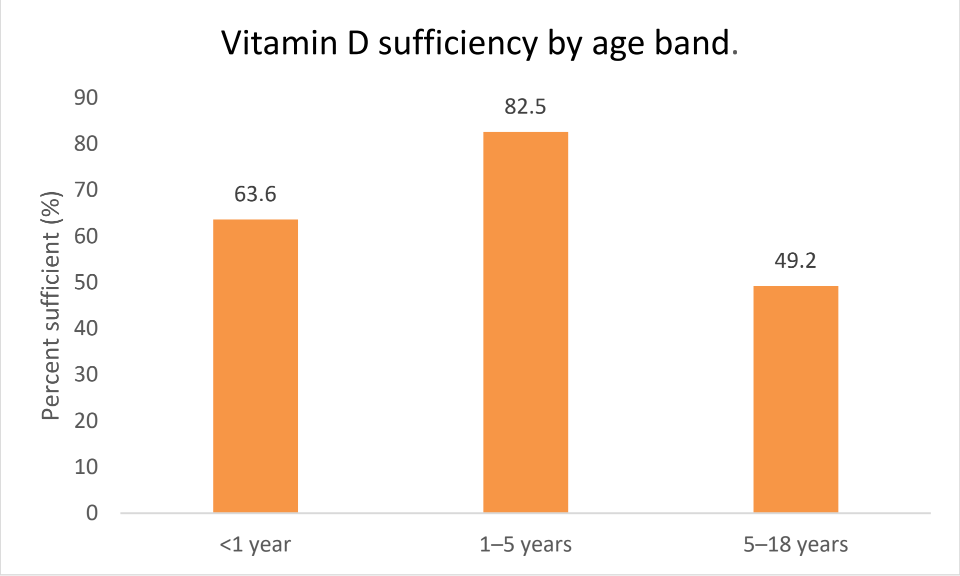

Figure 1. Vitamin D sufficiency by age band. Bars show the percentage of children with serum 25(OH)D >20 ng/mL; data labels indicate n/N for each age group.

Table 3. Association between vitamin D sufficiency and prespecified exposures (unadjusted)

Exposure	Category	Sufficient n/N (%)	Insufficient/Deficient n/N (%)	Denominator	Comparison
Dietary pattern	Vegetarian	33/46 (71.7%)	13/46 (28.3%)	46	χ^2=9.823, df=2, p=0.007
Dietary pattern	Eggetarian	28/41 (68.3%)	13/41 (31.7%)	41	
Dietary pattern	Non-vegetarian	8/23 (34.8%)	15/23 (65.2%)	23	
Vitamin D supplementation (≤2 months)	Yes	19/23 (82.6%)	4/23 (17.4%)	23	χ^2=4.916, df=1, p=0.027
Vitamin D supplementation (≤2 months)	No	50/87 (57.5%)	37/87 (42.5%)	87	
Sun-protection use	Yes	14/23 (60.9%)	9/23 (39.1%)	23	χ^2=0.043, df=1, p=0.836
Sun-protection use	No	55/87 (63.2%)	32/87 (36.8%)	87	
Skin type (Fitzpatrick)	Type 2	1/4 (25.0%)	3/4 (75.0%)	4	χ^2=7.697, df=3, p=0.053
Skin type (Fitzpatrick)	Type 3	17/30 (56.7%)	13/30 (43.3%)	30	
Skin type (Fitzpatrick)	Type 4	37/49 (75.5%)	12/49 (24.5%)	49	

Skin type (Fitzpatrick)	Type 5	14/27 (51.9%)	13/27 (48.1%)	27	
Prolonged AED use	Yes	6/9 (66.7%)	3/9 (33.3%)	9	χ^2=0.065, df=1, p=0.799
Prolonged AED use	No	63/101 (62.4%)	38/101 (37.6%)	101	
Sun exposure (hours/day)	Sufficient vs Insufficient/Deficient	—	—	—	t=-0.089, p=0.933

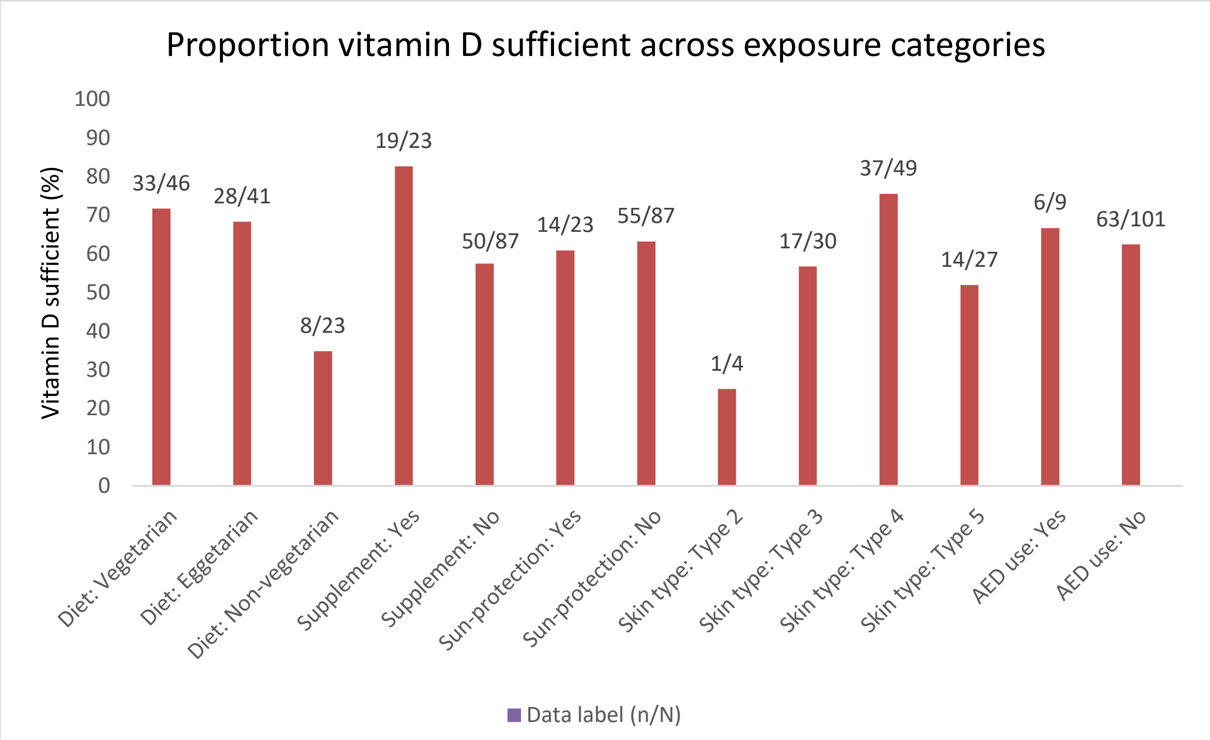

Figure 2. ***Proportion vitamin D sufficient across exposure categories.*** *Bars show the percentage of children with serum 25(OH)D >20 ng/mL in each category; labels indicate n/N. Comparisons are unadjusted (see Table 3 for χ^2 and p-values).*

Table 4. Alkaline phosphatase (ALP) by vitamin D status

Vitamin D group	n	ALP mean (U/L)	ALP SD (U/L	ALP range (U/L)
Sufficient (>20 ng/mL)	69	131.0	39.5	100–258
Insufficient/Deficient (≤20 ng/mL)	41	139.0	38.8	101–256

Welch's t-test: t=-1.039, df=85.5, p=0.302

DISCUSSION

Summary Of Key Findings

Sufficiency was observed in 62.7% (69/110) of hospitalized children. Dietary pattern (χ^2=9.83, p=0.007) and recent vitamin D supplementation (≤2 months) (χ^2=4.91, p=0.027) were significantly associated with sufficiency, whereas sun-protection use (p=0.836), skin type (p=0.053), antiepileptic drug use (p=0.799), overall sun-exposure hours (t=−0.089, p=0.933), and ALP (p=0.302; no difference) were not.

Our prevalence of vitamin D sufficiency was 62.7% (69/110) among hospitalized children at a rural tertiary centre, with the remainder insufficient/deficient, and a clear age gradient (lowest sufficiency in 5–18 years). In an eastern-India pediatric hospital, Basu et al. (2015) reported markedly lower 25(OH)D concentrations in inpatients, with deficiency often exceeding half of admissions; their ward-based prevalence aligns with our finding that hospital-attending cohorts can carry a substantial burden of suboptimal vitamin D despite abundant sunlight [12]. Among critically ill South Indian children, Ebenezer et al. (2016) observed low 25(OH)D to be common at PICU admission and explored associations with outcomes; although their severity spectrum differs from our general pediatric inpatients, both datasets emphasize that hospitalized

Indian children frequently have suboptimal vitamin D status [13].

Diet and recent supplementation were the two exposures that tracked most strongly with sufficiency in our cohort. The diet pattern signal (vegetarian/eggetarian > non-vegetarian for sufficiency) may reflect higher intake of fortified dairy or egg consumption in the former groups locally, rather than meat per se. Babu and Calvo (2010) argued over a decade ago for national food fortification because habitual Indian diets contribute <10% of vitamin D needs; they estimated that without fortification, daily intakes often fall below 200 IU, making cutaneous synthesis or supplementation indispensable [15]. Our supplementation association (≈25–30 percentage-point higher sufficiency in those supplemented within ≤2 months) is directionally consistent with programmatic guidance. The recent Indian expert consensus led by Kalra et al. (2025) recommends age-appropriate prophylaxis and therapeutic dosing and has catalyzed wider implementation of supplementation in Indian centres—our data reinforce the practical yield of such protocols in real-world inpatients [14].

In contrast, sun-exposure hours did not differ between sufficient and insufficient/deficient groups ($t=-0.089$, $p=0.933$), and reported sun-protection use showed no association. Several factors could blunt the expected relationship. Harinarayan et al. (2013) showed that required exposure times in India vary by latitude, season, and time-of-day; at certain UV indices, even 15–30 min/day may be insufficient for darker phototypes to maintain >20 ng/mL, especially if exposures are not at peak UVB or much of the skin is covered [17]. Tugrul et al. (2023) found modest seasonal drops in children and mixed effects of sunscreen/covering behaviours on 25(OH)D, noting that real-world application patterns, clothing, and time-of-day often confound any singular "sunscreen effect" [16]. Our Fitzpatrick skin-type trend ($p=0.053$) is biologically plausible—Bonilla et al. (2014) reported lower 25(OH)D with darker pigmentation in a large UK birth cohort—yet our ward sample may have been underpowered to detect small-to-moderate differences once behaviour and timing of exposure are considered [18]. Together, these data suggest that in clinical Indian cohorts, diet/supplementation signals can dominate over self-reported sun-exposure proxies.

We observed no association between prolonged antiepileptic drug (AED) use and vitamin D status. Vestergaard (2015) reviewed AED–bone interactions and noted enzyme-inducing AEDs can increase vitamin D catabolism and reduce BMD over time, but effects vary by molecule and dose, and prophylactic supplementation mitigates risk [19]. In our setting, relatively small numbers on AEDs (n=9) and contemporary supplementation practices may have attenuated detectable differences. Clinically, this argues for proactive monitoring/supplementation rather than expecting large cross-sectional gaps in 25(OH)D at admission.

Biochemically, ALP did not differ meaningfully across vitamin D groups in our cohort, which is consistent with a ward population in which overt rickets/osteomalacia are uncommon. Pettifor (2008) emphasized that rickets in infants and young children arises from combined vitamin D and calcium deficits; ALP elevations are most pronounced in active rickets, whereas many children with modest hypovitaminosis D may show ALP in the broad normal range [20]. Our data align with that clinical reality—suboptimal 25(OH)D without frank mineralization disorder.

Interpretation must consider definitional context. We used >20 ng/mL to define sufficiency—thresholds endorsed in several pediatric statements for population monitoring—while higher targets (e.g., ≥30 ng/mL) are advocated by others. Vieth and Holick (2018) summarized the IOM vs Endocrine Society debate, noting that choice of cut-point can shift "deficient/insufficient" prevalence by 10–30 percentage points in the same dataset [21]. Applying stricter thresholds would inflate our insufficiency figures, but would not change the observed direction of associations (benefit of supplementation and diet signal).

Regionally, our results fit within an Indian pattern of high hypovitaminosis D burden alongside sunlight abundance. Basu et al. (2015) highlighted the paradox in an eastern hospital context [12], Harinarayan et al. (2013) detailed latitude/UV realities across India [17], and Babu & Calvo (2010) pointed to the structural solution—food fortification—complemented by targeted supplementation [15]. The IAP-aligned consensus (Kalra et al., 2025) provides a standardized framework for dosing and prevention, which our findings empirically support in a rural tertiary inpatient population [14].

Contrasting findings in the literature—such as studies that report stronger correlations between reported sun time and 25(OH)D—often arise in ambulatory, community samples with wider exposure gradients and standardized exposure diaries, rather than hospitalized children with variable routines and clothing/shade constraints [16–18]. Methodological differences (season of sampling, assay platform, cut-points) and regional factors (air pollution, altitude, cultural clothing) further explain heterogeneity in effect sizes and prevalence estimates across studies [15,17,20,21].

In sum, in rural tertiary inpatients we found approximately two-thirds sufficiency using a >20 ng/mL cut-point, with dietary pattern and recent supplementation as actionable correlates, and sun-exposure proxies, sun-protection, skin type (borderline), AED use, and ALP showing no significant associations.

These data support continued emphasis on supplementation per Indian guidance and argue for pragmatic public-health strategies—dietary fortification and targeted counselling on effective sun practices—while acknowledging regional and methodological variation that shapes measured prevalence and effect sizes in India [12–21].

Limitations

This single-centre, cross-sectional study of hospitalized children limits generalizability and precludes causal inference. The modest sample size reduces power for subgroup effects (e.g., skin phototype, AED use). Sun exposure was self-reported without standardization for season, time-of-day, clothing, or body-surface area, and all assays were performed on one platform (CLIA) using a single sufficiency cut-off (>20 ng/mL), so different cut-points or assays could shift prevalence. Analyses were unadjusted, and residual confounding cannot be excluded.

CONCLUSION

Among hospitalized children in a rural Indian tertiary centre, 62.7% were vitamin D sufficient (25[OH]D >20 ng/mL). Dietary pattern and recent vitamin D supplementation were significantly associated with sufficiency, whereas sun-protection use, reported sun-exposure hours, skin phototype, AED use, and ALP were not. These results support continued emphasis on guideline-concordant supplementation and practical nutrition strategies in inpatient paediatrics, alongside public-health measures such as food fortification and targeted counselling on effective sun practices. Future multicentre, season-aware studies with multivariable modelling and clinically relevant outcomes can refine risk stratification and inform policy.

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