

Age-Specific Dravyaguna in Children: A Developmental Pharmacology Approach to Ayurvedic Drug Selection and Dosing - A Narrative Review

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Abstract

Background: Kaumarabhritya, the pediatric branch of Ayurveda, has advocated age-graded drug selection and dosing (Vaya-anusara Matra-nirdharana) for over two millennia, grounded in classics such as the Kashyapa Samhita, Charaka Samhita, and Sharangdhara Samhita. Modern developmental pharmacology has independently shown that drug absorption, distribution, metabolism, and excretion (ADME) ontogeny requires maturation-specific dosing rather than simple linear extrapolation from adult regimens. This review asks whether classical Dravyaguna principles of pediatric dosing correspond to, and can be reframed through, this modern ontogeny-based paradigm.

Methods: A structured narrative-review synthesis was undertaken of classical Ayurvedic compendia (Kashyapa, Charaka, Sushruta, Ashtanga Hridaya and Sharangdhara Samhitas) together with peer-reviewed literature identified through PubMed, Scopus, Google Scholar and AYUSH research repositories using combinations of the terms “Dravyaguna,” “Kaumarabhritya,” “pediatric dose,” “developmental pharmacology,” “ontogeny,” and “Ayurveda safety.” Because CONSORT reporting standards apply specifically to randomised controlled trials rather than narrative reviews, this abstract has been organised in IMRAD format as requested, while the review itself follows a PRISMA-informed narrative-synthesis approach; any interventional trials cited are individually assessed for CONSORT-consistent reporting.

Results: Classical texts stratify children into defined life-stages (Garbha, Bala, Ksheerannada, Kumara) and prescribe doses that escalate with age using organic-object equivalents (e.g., jujube-seed and amalaki-fruit units), later systematised by Sharangdhara into fractional rules that parallel, though were derived independently of, modern age- or weight-based formulae and body-surface-area dosing. Sixteen classical determinants of dose (Dosha, Dushya, Bala, Kala, Agni, Prakriti, Vaya, Vyadhi, Dravya, Koshta, Satva, Satmya and related factors) conceptually map onto recognised modern drivers of pharmacokinetic variability, including hepatic cytochrome P450 and renal glomerular-filtration maturation, gastric pH, and body-composition change. Evidence for specific pediatric interventions such as Suvarnaprashana and Balachaturbhadra Churna remains dominated by small, heterogeneous studies, while heavy-metal contamination of Rasashastra (herbo-mineral) preparations is a recurrently documented pediatric safety concern.

Conclusion: Ayurvedic pediatric dosing frameworks show meaningful conceptual convergence with the developmental-pharmacology paradigm of ontogeny-based dosing, but require rigorous pharmacokinetic validation, standardised and CONSORT-compliant trial reporting, and strengthened pharmacovigilance before age-specific Dravyaguna can be safely integrated into evidence-based pediatric care.

Keywords: Dravyaguna; Kaumarabhritya; Ayurveda; pediatric dosing; developmental pharmacology; ontogeny; drug safety; Kashyapa Samhita

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Introduction

Selecting the right drug at the right dose for a child is not a scaled-down version of adult prescribing; it is a distinct clinical problem. Contemporary pediatric clinical pharmacology recognises that children — and especially neonates and young infants — differ from adults in body composition, organ maturity, and enzyme expression in ways that materially change how a drug is absorbed, distributed, metabolised, and excreted [1,2]. Centuries before these mechanisms were characterised biochemically, Ayurveda had already organised a dedicated clinical speciality, Kaumarabhritya, around the empirical observation that children require drugs, forms, and doses distinct from those used in adults [3,6]. The classical treatise most closely identified with this speciality, the Kashyapa Samhita, devotes extensive sections to age-wise dose escalation, feeding practices, and drug forms suited to the infant gut and temperament [1,3].

Dravyaguna — the Ayurvedic science of substance, quality, taste, potency, post-digestive effect and unique action (Dravya, Guna, Rasa, Virya, Vipaka, Prabhava) — provides the theoretical scaffold on which Kaumarabhritya practitioners select drugs for children. Yet Dravyaguna teaching has historically been organised around the substance and the disease rather than around the developing physiology of the recipient. This review brings these two literatures into dialogue: it asks how classical age-specific dosing principles in Ayurvedic paediatrics correspond to the modern discipline of developmental pharmacology, where the convergences are genuine and clinically useful, and where the gaps in evidence and safety oversight remain.

The objective of this review is threefold: (i) to consolidate the classical Ayurvedic framework for age-specific drug selection and dosing in children; (ii) to juxtapose this framework against current understanding of ontogenic changes in drug disposition; and (iii) to identify the evidence, safety, and regulatory gaps that must be addressed before age-specific Dravyaguna can be responsibly incorporated into contemporary integrative pediatric practice.

2. Methods

This is a narrative review rather than a systematic review or clinical trial report; CONSORT criteria, which govern the reporting of randomised controlled trials, were therefore applied only to the individual interventional studies discussed within the review, and a PRISMA-informed approach (transparent search terms, explicit inclusion rationale, qualitative source appraisal) was used to structure the overall synthesis. Primary classical sources consulted were the Kashyapa Samhita, Charaka Samhita, Sushruta

Samhita, Ashtanga Hridaya, and Sharangdhara Samhita, read in standard published Sanskrit-Hindi/English commented editions [1-5]. Secondary and contemporary literature was identified through PubMed, Scopus, Google Scholar, ResearchGate, and AYUSH-affiliated repositories, using combinations of the search terms “Dravyaguna,” “Kaumarabhritya,” “Ayurveda pediatric dose,” “posology,” “Suvarnaprashana,” “Rasashastra safety,” “developmental pharmacology,” “pediatric pharmacokinetics,” and “drug ontogeny.” Articles were prioritised for inclusion if they were peer-reviewed reviews, clinical trials, pharmacovigilance communications, or regulatory advisories; blog content and non-peer-reviewed material were excluded except where used to illustrate classical dose tables already attributed to named Samhitas. No formal risk-of-bias scoring was performed, consistent with the narrative (non-systematic) design of this review; this limitation is discussed in Section 8.

3. Conceptual Framework: Dravyaguna and Kaumarabhritya

3.1 Dravyaguna Shastra as pharmacological grammar

Dravyaguna Shastra analyses a medicinal substance (Dravya) along five interlinked axes: Rasa (taste, the first-perceived pharmacological signal), Guna (physical/qualitative attributes such as heaviness, unctuousness or mobility), Virya (potency, broadly heating or cooling), Vipaka (the post-digestive transformed effect), and Prabhava (an idiosyncratic action not explained by the preceding four). This five-fold analysis functions, in effect, as a qualitative structure-activity framework used to predict a drug's action, and it underlies drug selection across every age group. What Dravyaguna teaching does not by itself specify is how a fixed pharmacological profile should be re-weighted for an immature physiology — that recalibration is the specific contribution of Kaumarabhritya.

3.2 Kaumarabhritya and the Kashyapa Samhita

Kaumarabhritya is formally one of the eight classical clinical branches (Ashtanga Ayurveda) and is dedicated to child health, from conception through adolescence [3,6]. The Kashyapa Samhita (attributed to the sage Kashyapa/Vridhdhajivaka) is regarded as the foundational pediatric compendium and is unusual among the classics for explicitly tabulating drug quantity by age from the immediate neonatal period onward [1,7]. Portions of Kaumarabhritya knowledge are also distributed across the Charaka Samhita, Sushruta Samhita, Ashtanga Hridaya/Sangraha, and later compilations such as the Sharangdhara Samhita, which is credited with formalising many of the

fractional pediatric dose rules used by later commentators [2-5,9].

3.3 Ayurvedic life-stage classification of childhood

Ayurvedic texts do not treat “childhood” as a single undifferentiated category. Distinct life-stages are named, each with characteristic feeding patterns, physiological expectations, and therapeutic latitude (Table 1). These stage boundaries were not arbitrary: they tracked observable maturational milestones — dependence on milk, eruption of teeth, onset of solid feeding, and pubertal change — that correspond loosely to neonatal, infant, toddler, and adolescent epochs recognised in modern paediatrics.

Life stage (Sanskrit term)	Approximate age span	Classical source	Nearest modern developmental epoch
Garbha	Conception to birth	Charaka Samhita, Sharirasthan	Prenatal/fetal period
Bala (Ksheerapa)	Birth – 1 year (exclusively/predominantly milk-fed)	Kashyapa Samhita, Sutrasthana	Neonatal & infant period
Ksheeranna	~1 – 2 years (milk plus supplementary feeds)	Kashyapa Samhita	Transitional/weaning infant
Kumara / Kaumara	1 – 16 years (Sushruta) / up to 16 years (Kashyapa)	Sushruta Samhita, Sutrasthana; Kashyapa Khilasthana	Toddler through adolescence

Yauvana onset	~16 years onward	Ashtanga Hridaya, Uttara-sthana	Adolescence / young adulthood
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4. Classical Principles of Age-Specific Dosing (Vaya-Matra Correlation)

4.1 The determinants of dose

Ayurvedic pharmacology does not treat dose as a single number attached to a drug; dose is explicitly described as contingent on a cluster of patient- and context-specific variables, prominently including Dosha, Dushya, Bala, Kala, Agni, Prakriti, Vaya, Vyadhi, Dravya, Koshtha, Satva, Satmya, and Desha [1,32,34]. Kashyapa is quoted to the effect that the ideal drug is one that eliminates disease without depleting the patient's strength, and that drug selection must follow assessment of Dosha, Agni, Bala, Vaya, Vyadhi, Koshtha, Prakriti, Satmya, Desha and Kala together [31]. The Ashtanga Hridaya likewise states that dose in children must be kept lower than the adult dose and further adjusted to the child's strength (“alpam balature karyam, bale chottamamalpakam”) [37]. Table 3 maps these sixteen classical variables against their nearest correlates in modern pharmacokinetic theory.

4.2 Kashyapa's neonatal-infant dose escalation

The most granular classical dosing schedule is Kashyapa's description of drug-quantity escalation across the first year of life, expressed not in weight-based units (which were unavailable) but in familiar organic-object equivalents — beginning with a dose the size of a single jujube (Badari) seed immediately after birth and escalating stepwise, through half- and whole-jujube-fruit equivalents, to amalaki-fruit equivalents by four to six months (Table 2) [1,35]. This schedule encodes two principles that remain axiomatic in modern neonatal dosing: (i) the youngest and smallest patients receive the smallest fraction of any given preparation, and (ii) dose is escalated gradually rather than in large steps as the infant matures — an empirical anticipation of the low, rapidly changing drug-clearance capacity of the neonatal and early-infant period that is now explained mechanistically by hepatic and renal immaturity [10-14].

4.3 Sharangdhara's fractional rules and dosage-form selection

The Sharangdhara Samhita is credited with introducing more systematic fractional apportioning of the adult dose (Pramana Matra) for children by age band, a structure that later Ayurvedic pharmacology

texts and CCRAS-affiliated teaching compare directly to Young's, Clark's and Fried's age/weight-based pediatric dosing rules used in conventional pharmacy [34]. Dosage-form selection was itself age-sensitive: soft, palatable, small-volume forms — Avaleha/Lehya (linctus), Ghrita (medicated ghee), and fine Churna (powder) — were preferred for infants and young children, while more concentrated or higher-volume forms such as Kashaya (decoction) and Vati (tablet) were reserved for older children, with maximum decoction volumes explicitly capped and only reached near sixteen years of age [7,31]. This graded escalation of both dose and dosage form mirrors the modern pediatric formulation principle that palatability, swallowability, and excipient burden — not efficacy data alone — often determine what can safely be given to a young child.

5. Developmental Pharmacology: The Modern Correlate

5.1 Ontogeny of drug disposition

Developmental pharmacology describes systematic, age-dependent changes in each ADME component. Gastric pH is relatively higher (less acidic) in neonates and gastric emptying is slower and more variable, altering oral drug absorption; total body water and extracellular fluid volume are proportionally larger in neonates and infants, increasing the volume of distribution for hydrophilic drugs; plasma protein binding is reduced in the newborn, increasing free drug fraction; hepatic phase I (cytochrome P450) and phase II (glucuronidation, sulfation) enzyme systems mature along distinct, enzyme-specific trajectories over the first months to years of life; and glomerular filtration rate rises steeply over the first weeks after birth before approaching adult-normalized values later in infancy [10-14]. These ontogenetic trajectories are non-linear and enzyme-specific: some pathways (e.g., sulfation) are relatively mature at birth, while others (e.g., CYP3A4, CYP1A2, and glucuronidation via UGT enzymes) increase gradually over months to years [11,12].

5.2 Clinical consequences of ignoring ontogeny

The clinical cost of dosing children as “small adults” is well documented. The historical grey-baby syndrome — cardiovascular collapse following chloramphenicol dosed on an adult-derived, weight-adjusted basis — is a textbook illustration of what happens when immature hepatic glucuronidation and renal clearance are not accounted for [14]. Similarly, characterisation of cytochrome P450 3A4 ontogeny using cisapride disposition in neonates and infants demonstrated marked, age-dependent variability in clearance that a fixed mg/kg dose cannot capture [11]. Contemporary reviews emphasise that dose individualisation in paediatrics increasingly requires integration of age, weight, organ function and known

enzyme-ontogeny profiles, particularly for narrow-therapeutic-index drugs such as aminoglycosides and vancomycin, and that physiologically based pharmacokinetic (PBPK) modelling is emerging as a tool to formalise this integration [13]. A scoping review of drug metabolism in prematurely born children further underscores how heterogeneous and incompletely reported gestational-age-specific pharmacokinetic data remain even in modern clinical pharmacology, leaving preterm neonates especially vulnerable to off-label, empirically extrapolated dosing [10].

5.3 Where the classical and modern models converge and diverge

The conceptual convergence is genuine: both systems reject linear, weight-only extrapolation from adult dosing; both stratify the pediatric population into physiologically meaningful sub-stages rather than treating “child” as one category; and both identify digestive/metabolic capacity (Agni in Ayurveda; hepatic and gastrointestinal ontogeny in modern pharmacology) as a central, age-dependent moderator of drug effect. The divergence is equally important: classical dose schedules were derived from clinical observation and object-equivalent approximation rather than measured pharmacokinetic parameters, are drug-form-specific rather than active-moiety-specific, and were not validated against the compound-specific enzyme trajectories now known to vary substantially between individual drugs and even between formula-fed and breastfed infants for the same enzyme pathway [11]. Reframing Dravyaguna's age categories using ontogeny data therefore does not validate classical dose numbers as pharmacokinetically precise; it clarifies which of the classical cautions (very small, gradually escalated doses in the first months of life; preference for gentler, more dilute forms) are mechanistically well-founded, and which require fresh pharmacokinetic study before they can be extended to specific modern formulations.

6. Age-Specific Dravyaguna Selection: Illustrative Categories

6.1 Neonatal/infant supplementation — Suvarnaprashana and Lehana

Suvarnaprashana (administration of purified gold, typically as Swarna Bhasma levigated with honey and ghee) is among the most widely practised Kaumarabhritya interventions, described in the Kashyapa Samhita as promoting Medha (intellect), Agni (digestive/metabolic capacity), and Bala (immunity/strength), and traditionally administered from birth through adolescence, often timed to the Pushya lunar asterism [22,25,28]. A single-blind randomised controlled trial in 102 healthy infants comparing gold-honey-ghee against honey-ghee alone reported favourable parental-perceived outcomes on

growth and general health over a four-week intervention with eight-week follow-up, though the trial itself notes substantial response-failure and relies heavily on subjective/parental outcome measures [22,26]. Subsequent systematic reviews of Suvarnaprashana trials describe consistently reported immunomodulatory and nootropic claims but caution that the evidence base remains small, methodologically heterogeneous, and largely uncontrolled for confounding secular trends in childhood illness [23,24]. Because Kashyapa does not specify a fixed Suvarnaprashana dose, practitioners are instructed to extrapolate from his general age-wise dosing schedule (Table 2), illustrating how age-specific Dravyaguna principles are applied even to formulations not individually dosed in the classical text [32].

6.2 Balachaturbhadra Churna and other classical pediatric compounds

Balachaturbhadra Churna — a four-drug combination of Musta (*Cyperus rotundus*), Pippali (*Piper longum*), Ativisha (*Aconitum heterophyllum*) and Karkatashringi (*Pistacia integerrima*), first described in the Chakradatta — remains one of the most frequently prescribed Kaumarabhritya formulations for infantile digestive and respiratory complaints [8]. A systematic review of published work on this formulation reports that toxicity studies used doses several-fold higher than clinical doses without significant adverse findings at therapeutic levels, but also flags that recent concern about Aconitum-derived ingredients has prompted renewed scrutiny of its safety margin, and that very few rigorous clinical studies have been published to date [8]. This combination of long clinical tradition, a botanically active (and potentially toxic in overdose) ingredient, and a thin modern evidence base is emblematic of the evaluative task facing age-specific Dravyaguna: favourable classical reputation is not, by itself, sufficient reassurance for a pediatric population with reduced metabolic reserve.

6.3 Rasayana and Medhya (nootropic) drugs across childhood

Rasayana (rejuvenative) and Medhya Rasayana (nootropic) drugs — including Vacha (*Acorus calamus*), Yashtimadhu (*Glycyrrhiza glabra*), Mandukaparni (*Centella asiatica*), and Brahmi (*Bacopa monnieri*) — are traditionally graded across childhood, with gentler forms and smaller quantities used in infancy and progressively fuller Rasayana regimens reserved for the Kumara stage once Agni and Koshtha are judged more stable. This graded introduction again parallels the developmental-pharmacology observation that hepatic and renal clearance capacity, and hence tolerance for cumulative or repeated dosing, increases through infancy and

early childhood rather than being fixed from birth [12,13].

6.4 Drugs and forms cautioned or avoided in children

Classical Kaumarabhritya explicitly restricts certain therapeutic categories in children: strong Vamana (emetic) and Virechana (purgative) Kashayas are capped at markedly lower volumes than adult Deepaniya/Sanshamaniya decoctions and are generally deferred to later childhood [7,31]; potent single metallic/mineral (Rasa) preparations are used, when at all, in minute, closely supervised doses; and Virudhahara (incompatible food-drug combinations) is emphasised as a distinct pediatric hazard given children's narrower physiological buffer. These cautions anticipate, in qualitative form, the modern principle that narrow-therapeutic-index and highly bioactive agents carry disproportionate risk in patients with immature clearance mechanisms [13,14].

7. Safety, Pharmacovigilance, and the Regulatory Landscape

The clearest and best-documented pediatric safety signal in Ayurvedic pharmacotherapy concerns heavy-metal content in Rasashastra (herbo-mineral) preparations. A widely cited investigation of Ayurvedic herbal products sold in the Boston area found detectable lead, mercury, or arsenic in roughly one in five products tested [16,19]. Subsequent public-health cluster investigations of lead poisoning have repeatedly traced elevated pediatric blood-lead or blood-mercury levels to Ayurvedic preparations, and regulatory bodies including the US FDA have issued specific consumer warnings after laboratory testing confirmed high lead and mercury content — in one case alongside undisclosed strychnine and brucine — in a marketed Ayurvedic product [17,20,21]. Because heavy metals are disproportionately harmful to the still-developing brain and organs of young children, these findings carry particular weight for Kaumarabhritya practice specifically [17].

It should be noted that classical Rasashastra explicitly requires an elaborate purification (Shodhana) and incineration (Marana) process intended to render metals biologically inert or beneficial rather than toxic, and that structured toxicological evaluation of individual classical formulations — for example, ninety-day rodent studies of Mahayograj Guggulu — has in some cases found no significant toxicity at therapeutically advocated doses despite measurable trace heavy-metal content [20,36]. The safety literature is therefore not uniformly alarming, but it is consistent on one point: safety cannot be assumed from classical pedigree alone and must be established, formulation by formulation and dose by dose, through modern analytical and toxicological testing — a standard that is especially non-negotiable in children

[15,16]. India's National Pharmacovigilance Programme for Ayurveda, Siddha and Unani (ASU) drugs, established in 2008, and the broader AYUSH regulatory apparatus provide an institutional mechanism for this ongoing surveillance, but published pediatric-specific adverse-event data through this programme remain sparse relative to the scale of pediatric Ayurvedic use [15,35].

8. Towards an Integrative, Ontogeny-Informed Model of Age-Specific Dravyaguna

Bringing Sections 4 through 7 together suggests a practical, testable framework rather than a wholesale endorsement or rejection of classical pediatric dosing. First, the Ayurvedic life-stage boundaries (Table 1) can be explicitly cross-referenced against known ontogenic windows — for example, treating the Bala/Ksheerapa stage as coextensive with the period of most rapid hepatic and renal maturational change, during which the classical instinct toward minimal, gradually escalated dosing (Table 2) is mechanistically best supported. Second, the sixteen classical dose-determining variables (Table 3) can be used as a structured clinical checklist that a modern-trained Ayurvedic pediatric practitioner applies alongside, rather than instead of, weight- and, where feasible, body-surface-area-based calculation. Third, individual widely used pediatric Dravyas and compound formulations (Suvarnaprashana, Balachaturbhadra Churna, and comparable Rasayana preparations) require formulation-specific pharmacokinetic and dose-ranging studies in children — not extrapolation from adult or animal data alone — before precise, age-banded dosing recommendations can be considered evidence-based. Fourth, any future pediatric Ayurveda trial should be designed and reported to CONSORT standards (or the CONSORT extension for herbal interventions where applicable) to allow the resulting evidence to be appraised on equal footing with conventional pediatric pharmacology literature [27]. Fifth, heavy-metal and contaminant testing should be a mandatory, batch-level quality checkpoint for any Rasashastra-containing pediatric formulation, given the documented risk and the absence of physiological safety margin in this population [16,17,21].

9. Limitations of This Review

This review is narrative rather than systematic: formal risk-of-bias assessment, meta-analytic pooling, and pre-registration were not performed, and publication bias in the predominantly Indian Ayurveda literature cannot be excluded. Classical Sanskrit dose descriptions were interpreted through published, commented translations rather than independent primary-source Sanskrit analysis, and the organic-object dose units used by Kashyapa (jujube-seed, amalaki-fruit equivalents) cannot be converted into precise modern metric or mg/kg equivalents with

certainty, limiting direct quantitative comparison with modern pediatric dosing rules. Much of the cited clinical evidence for specific Kaumarabhritya interventions derives from small, single-centre, and in some cases unblinded or survey-based studies, restricting the strength of conclusions that can be drawn about efficacy, even where classical dosing logic appears mechanistically plausible.

10. Conclusion

Ayurvedic Kaumarabhritya independently arrived, through centuries of clinical observation, at several principles that modern developmental pharmacology now explains mechanistically: children are not small adults, the youngest infants require disproportionately smaller and more gradually escalated doses than simple weight-scaling would suggest, and drug form and digestive/metabolic capacity are as important as drug identity in determining safety. This conceptual convergence is a legitimate basis for renewed clinical and research interest, not for uncritical adoption of classical dose tables as precise modern prescribing guidance. Realising the potential of an age-specific, ontogeny-informed Dravyaguna will require formulation-specific pharmacokinetic study in children, contaminant-tested manufacturing, and CONSORT-compliant clinical trial reporting — an integrative research agenda that respects the empirical insight of Kaumarabhritya while holding it to the evidentiary standards that pediatric patients, as one of medicine's most vulnerable populations, deserve.

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