ISSN: 2347-6567

International Journal of Allied Medical Sciences and Clinical Research (IJAMSCR)

IJAMSCR |Vol. 14 | Issue 3| Jul - Sep 2026

www.ijamscr.com

DOI : https://doi.org/10.61096/ijamscr.v14.iss3.2026.1554.1569

Vitamins, Electrolytes, and Trace Elements in Human Physiology: A Narrative Review Based on Leroy's Cocktail Formulation

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Published on:

19.09.2026

Published by:

Futuristic Publications

Abstract:

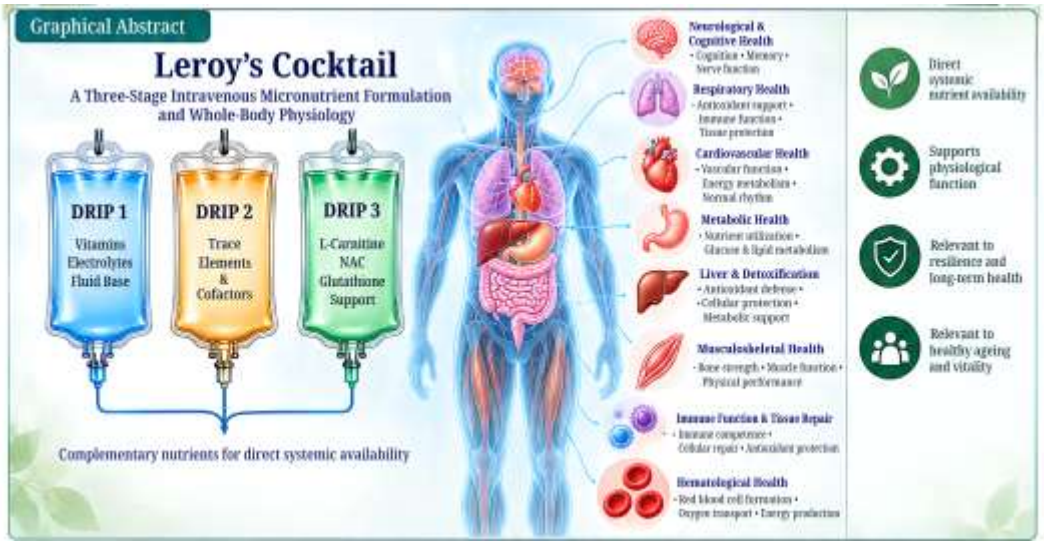
Background: Vitamins, electrolytes, and trace elements are required for normal neurological, hematological, cardiovascular, musculoskeletal, immune, metabolic, and tissue-maintenance functions throughout adult life, and adequacy may be challenged by ageing, dietary restriction, multimorbidity, polypharmacy, and impaired gastrointestinal absorption. Leroy's Cocktail is a three-stage sequential intravenous formulation that combines water-soluble vitamins, electrolytes, trace elements, and the metabolic and redox-support compounds L-carnitine, N-acetylcysteine, and glutathione.

Methods: This focused narrative review prioritized recent systematic reviews, meta-analyses, large cohort studies, randomized trials, and clinical-nutrition guidelines on micronutrient sufficiency, adult nutrition, healthy ageing, multimorbidity, frailty, cardiometabolic health, cognition, musculoskeletal and immune function, respiratory disease, and trace-element nutrition. Evidence was organized by organ-system domain.

Results: Each constituent has established physiological roles across multiple organ systems. Micronutrient status is linked with frailty, functional capacity, cardiometabolic health, cognition, skeletal integrity, and immune competence, although supplementation trials in frailty, fracture prevention, heart failure, and chronic obstructive pulmonary disease have often shown small or null effects. Intravenous delivery bypasses gastrointestinal absorption, which is relevant when oral provision is inadequate or absorption is impaired. A five-stage physiological-sufficiency continuum is proposed as a conceptual model. Chronic kidney disease, diabetes, and frailty require individualized nutritional and safety assessment. No clinical data are available for the complete formulation.

Conclusion: Leroy's Cocktail offers a multinutrient framework grounded in the established physiological roles of its constituents. Its safety, tolerability, and effects on nutritional biomarkers, functional capacity, and healthspan-relevant outcomes should be evaluated in adults with demonstrable micronutrient vulnerability arising from ageing, chronic disease, polypharmacy, or impaired absorption.

Keywords: Micronutrients; intravenous micronutrients; physiological resilience; healthy ageing; Leroy's Cocktail



Graphical Abstract: Conceptual overview of Leroy's Cocktail as a three-stage intravenous micronutrient formulation considered in relation to systemic nutrient availability, multi-system physiological support, resilience, and healthy ageing. Organ-system domains reflect established roles of individual constituents rather than demonstrated effects of the complete formulation.

Abbreviations

Abbreviation	Meaning
BMD	bone mineral density
CKD	chronic kidney disease
COPD	chronic obstructive pulmonary disease
CoA	coenzyme A
FAD	flavin adenine dinucleotide
FMN	flavin mononucleotide
G6PD	glucose-6-phosphate dehydrogenase
GSH	reduced glutathione
IV	intravenous
NAC	N-acetylcysteine
NAD	nicotinamide adenine dinucleotide
NADP	nicotinamide adenine dinucleotide phosphate
PLP	pyridoxal-5′-phosphate
TPP	thiamine pyrophosphate

1. Introduction: Micronutrients as Physiological Infrastructure

Human health depends on a continuous supply of essential micronutrients. Although required in small quantities relative to macronutrients, vitamins and minerals participate in functions that are indispensable to normal life, including blood-cell production, nerve and muscle activity, skeletal maintenance, immune competence, tissue repair, fluid-electrolyte balance, and the maintenance of normal metabolism. Contemporary nutrition research therefore increasingly considers micronutrient adequacy as part of the physiological infrastructure required to preserve function rather than only as a means of preventing classical deficiency syndromes[1-4].

The scale of inadequate intake remains substantial. A global modeling analysis published in 2024 identified widespread inadequacy for multiple micronutrients across populations[1], while recent reviews emphasize that clinically meaningful insufficiency may occur in modern settings despite adequate caloric

intake[2,3]. The distinction is important: energy sufficiency does not necessarily ensure vitamin and mineral sufficiency, and the determinants of nutritional status change throughout adult life.

Ageing provides a particularly relevant context. Older adults may experience lower dietary diversity, appetite changes, gastrointestinal disorders, medication exposure, multimorbidity, mobility limitations, and reduced capacity to acquire or prepare nutrient-dense foods. Recent reviews link these circumstances to inadequate micronutrient status and to outcomes such as frailty, anemia, falls, and loss of cognitive and physical function[5,6]. Healthy ageing is therefore increasingly discussed in terms of healthspan—the maintenance of function and independence during added years of life—rather than longevity alone[4,7].

This review uses the nutrient composition of Leroy's Cocktail as a framework for examining how essential micronutrients contribute to overall human physiological health. The emphasis is clinical and focused on adult physiology: the forms in which these constituents are utilized in humans, the organ systems that depend on them, the ways disease and ageing may influence nutritional adequacy, and the rationale for prospective evaluation of a broad multinutrient intravenous formulation in physiological-sufficiency research.

2. Review Approach

This article is a focused narrative review of literature relevant to micronutrient sufficiency, adult nutrition, healthy ageing, multimorbidity, polypharmacy, frailty, cardiovascular and metabolic health, cognition, musculoskeletal integrity, immune function, respiratory disease, and clinical trace-element nutrition. Priority was given to recent systematic reviews, meta-analyses, large prospective studies, randomized trials, and contemporary clinical-nutrition reviews published predominantly from 2022 onward.

The synthesis is organized around physiological sufficiency and organ-system health. Ingredient-level evidence is used to establish the normal human relevance of individual nutrients and to identify populations in whom nutritional assessment may be important. Evidence concerning an individual vitamin, mineral, or compound is not treated as a substitute for direct study of the complete formulation.

3. Micronutrient Sufficiency Across Adult Life

Micronutrient requirements in adults are dynamic. Adult life introduces occupational and lifestyle demands, dietary restriction, obesity, metabolic disease, and medication exposure, and later adulthood increasingly combines physiological ageing with chronic disease and functional limitations (Figure 1). The causes of inadequacy therefore differ between individuals and change over time.

Zinc illustrates this principle. Lowe et al. described zinc deficiency as relevant to immunity, glucose regulation, and cardiometabolic health throughout adult life[8]. Similar reasoning applies to B-group vitamins, calcium, magnesium, selenium, and other micronutrients whose biological importance persists throughout adult life even though the causes and consequences of inadequacy change with age[3,4].

In older adults, micronutrient status becomes especially sensitive to the interaction between intake, absorption, disease, and medication exposure[5,6]. Multimorbidity and polypharmacy are common in ageing populations, although reported prevalence varies widely between studies[9], while polypharmacy itself can coexist with malnutrition through effects on appetite, gastrointestinal tolerance, nutrient handling, and dietary behavior[10,11]. This creates a clinically relevant setting in which micronutrient sufficiency must be considered alongside overall nutritional status rather than inferred from body weight or caloric intake alone.

The resulting spectrum can be viewed as a continuum from adequate status to reduced nutritional reserve, marginal insufficiency, functional vulnerability, and eventually overt deficiency. This continuum is a conceptual tool rather than a new diagnostic classification; its value lies in emphasizing that nutritional assessment is most useful before severe deficiency manifestations appear.

4. Intravenous Delivery as a Route of Systemic Nutrient Availability

Oral nutrition remains the normal and preferred foundation for meeting micronutrient requirements in most healthy individuals. Orally consumed nutrients must, however, pass through gastrointestinal dissolution, intestinal transport, and absorptive processes before entering the systemic circulation; for vitamin C, for example, intravenous administration produces substantially higher peak plasma concentrations than the same dose taken orally[12]. The intravenous route differs fundamentally at the delivery step because the administered constituent is placed directly into the vascular compartment, making systemic availability independent of gastrointestinal absorption at that moment (Figure 2).

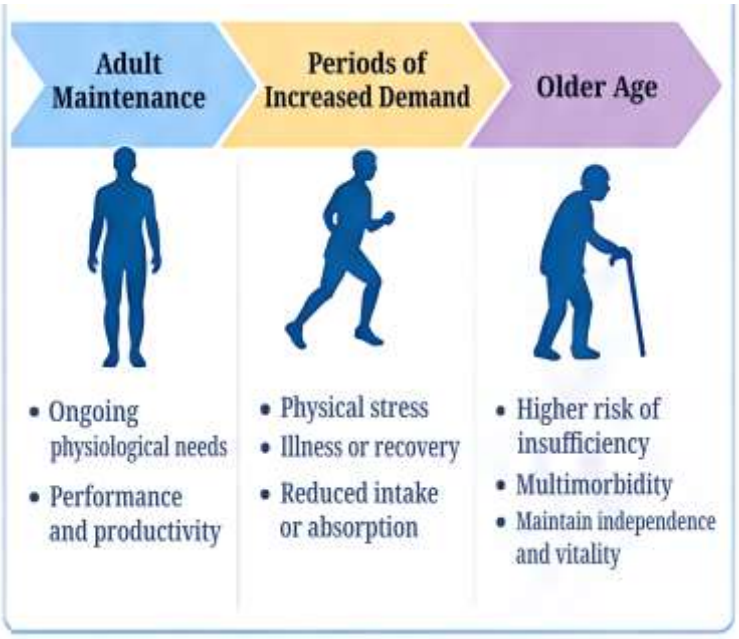


Fig 1: Adult perspective on micronutrient sufficiency. Nutritional requirements and vulnerability vary across adult maintenance, periods of increased physiological demand, and older age.

This distinction is clinically relevant in nutrition practice when oral or enteral provision is inadequate, unsuitable, or complicated by absorption problems. Clinical-nutrition guidance treats trace elements as an essential part of nutrition support: standard enteral feeds usually supply them, whereas parenteral nutrition requires their separate prescription and periodic monitoring[13]. The scientific interest of an IV multinutrient formulation therefore lies not simply in ingredient number but in the controlled systemic delivery of multiple physiologically relevant constituents within one clinical sequence.

Direct vascular delivery should nevertheless be understood as a route characteristic rather than a universal claim of greater clinical benefit. Tissue uptake, baseline nutrient status, renal and hepatic handling, disease state, and physiological demand still influence the biological response after a nutrient reaches the circulation. For research purposes, this makes IV delivery particularly suitable for studying defined systemic exposure while retaining the need for clinical selection and monitoring. A randomized, placebo-controlled pilot trial of a multinutrient intravenous infusion (the "Myers' cocktail") in adults with fibromyalgia found no statistically significant between-group differences[14], underscoring that the effects of intravenous micronutrient formulations must be tested directly rather than assumed.

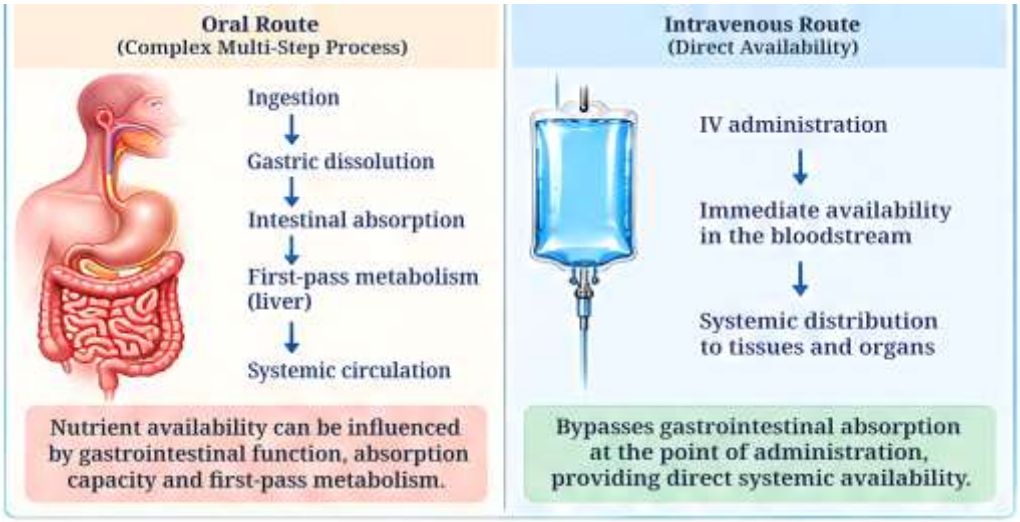


Fig 2: Conceptual distinction between oral and intravenous delivery. Intravenous administration enters the systemic circulation without requiring gastrointestinal absorption at the point of administration, followed by distribution to tissues and organs.

5. Leroy's Cocktail: Ingredients, Physiological Forms, and Human Roles

For this review, the three stages are described qualitatively without dose quantities. Several constituents, notably vitamin C, L-carnitine, N-acetylcysteine, and glutathione, are provided in amounts that exceed usual dietary intakes. Tables 1–3 emphasize the form that is physiologically active, utilized, or incorporated in humans and the major health domain supported by each constituent. This format provides a concise clinical-physiology overview of how the individual components relate to normal human function.

5.1 DRIP 1: Vitamins, Electrolytes, and Fluid Components

Table 1. DRIP 1 constituents, their physiologically active or utilized forms, and principal roles in human physiology

Ingredient	Physiologically active / utilized form	Principal role in human physiology
Normal saline	Na^+ and Cl^- in extracellular fluid	Provides an isotonic fluid vehicle and contributes to extracellular fluid and electrolyte balance.
Vitamin C	Ascorbate	Required for collagen formation and tissue integrity; supports normal immune function and iron handling; contributes to antioxidant nutrient status[15].
Magnesium chloride	Mg^{2+}	Essential for neuromuscular function, normal cardiac physiology, bone health, and numerous enzyme-dependent processes; relevant to healthy-ageing research[16-18].
Potassium chloride	K^+	Principal intracellular cation required for membrane potential, nerve conduction, and muscle contraction; higher intake lowers blood pressure, most markedly in hypertension[19].
Calcium gluconate	Ca^{2+}	Required for bone mineralization, neuromuscular function, cell signaling, and muscle contraction; supplementation shows little or no effect on fractures or falls[20].
Thiamine (vitamin B1)	Thiamine pyrophosphate (TPP)	Supports normal nervous-system function and energy-yielding metabolism; clinically important when thiamine status is inadequate[21,22].
Riboflavin (vitamin B2)	FMN and FAD	Provides flavin coenzymes required for normal cellular metabolism and redox-related enzyme function[21].
Niacinamide (vitamin B3)	NAD^+ and $NADP^+$ pools	Contributes to normal cellular energy and redox metabolism and maintenance of cellular function[21].
D-panthenol / vitamin B5 source	Pantothenate → CoA	Supports coenzyme A formation and normal intermediary metabolism[21].
Pyridoxine (vitamin B6)	PLP	Required for amino-acid metabolism, neurotransmitter-

		related reactions, hemoglobin physiology, and multiple aspects of normal nervous-system function[21].
Methylcobalamin (vitamin B12)	Methylcobalamin; cobalamin also functions as adenosylcobalamin	Essential for normal neurological function and red-blood-cell formation; status is particularly relevant in ageing, malabsorption, and metformin use[21,23-25].

5.2 DRIP 2: Trace-Element Components

Table 2. DRIP 2 trace-element constituents, their physiologically active or utilized forms, and principal roles in human physiology.

Ingredient	Physiologically active / utilized form	Principal role in human physiology
Manganese	Mn^{2+} incorporated in metalloenzymes	Supports normal enzyme systems involved in metabolism, connective-tissue biology, and antioxidant defense; both adequacy and exposure level are important[26].
Zinc	Zn^{2+} in zinc-dependent proteins and enzymes	Supports immune competence, wound healing, and protein- and DNA-related functions; low status is linked with malnutrition and frailty in older adults[8,27].
Selenium	Selenium is incorporated as selenocysteine in selenoproteins	Supports selenoprotein functions relevant to redox control, thyroid physiology, immune health, muscle function, and ageing; adequacy is concentration-dependent[28].
Chromium	Predominantly trivalent chromium (Cr^{3+})	Has been investigated in relation to glucose and insulin-associated metabolic health; human supplementation effects vary across studies[29,30].
Copper	Cu^{+}/Cu^{2+} incorporated in copper-dependent proteins	Supports iron handling, connective-tissue formation, neurological function, and multiple essential metalloenzymes[13].

5.3 DRIP 3: Metabolic and Redox-Support Components

Table 3. DRIP 3 constituents, their physiologically active or utilized forms, and principal roles in human physiology.

Ingredient	Physiologically active / utilized form	Principal role in human physiology
L-carnitine	Free carnitine and acylcarnitine pools	Supports normal fatty-acid handling and cellular energy metabolism; particularly relevant in tissues with high energy demand[31].

N-acetylcysteine (NAC)	Cysteine precursor	Provides a bioavailable cysteine source and supports endogenous glutathione availability and thiol homeostasis[32].
Glutathione	Reduced glutathione (GSH) / glutathione redox system	Major endogenous cellular antioxidant and redox-buffering compound that supports cellular protection against oxidative burden[33].

The three stages therefore span complementary physiological domains: water-soluble vitamin sufficiency, major electrolyte balance, trace-element-dependent protein function, and physiologically relevant compounds associated with cellular energy and redox support. This breadth is the principal reason the formulation is suitable for evaluation as a whole-body micronutrient-support framework rather than as a single-disease preparation. L-carnitine, N-acetylcysteine, and glutathione are not essential micronutrients: carnitine and glutathione are synthesized endogenously, and N-acetylcysteine acts as a cysteine donor[31-33]. Figure 3 presents the three sequential drips as an integrated visual overview of constituent grouping and delivery rationale.

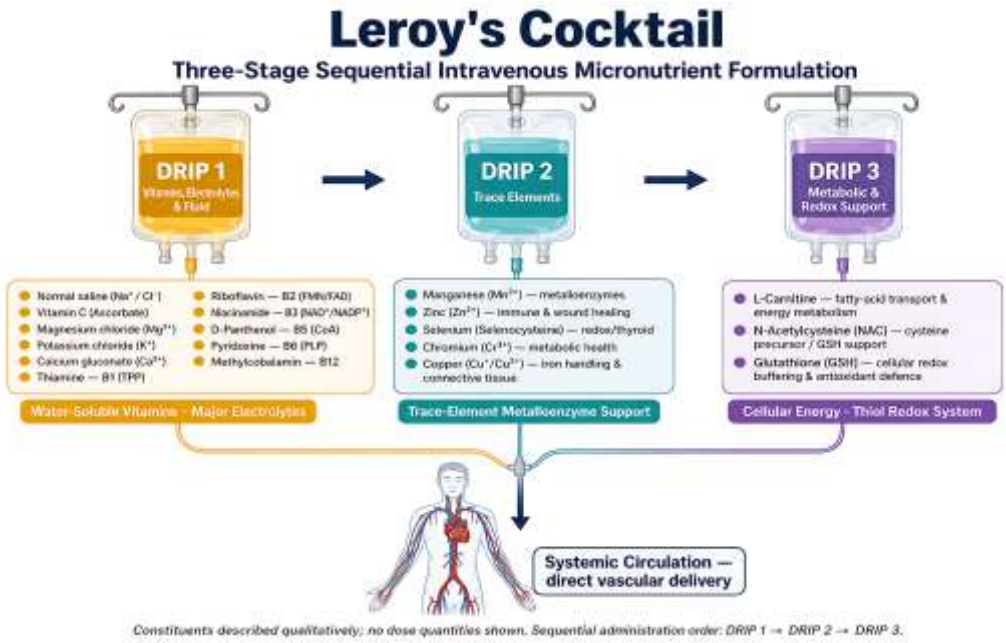


Fig 3: Three-stage Leroy's Cocktail intravenous protocol. Drip 1 contains water-soluble vitamins (vitamin C, thiamine, riboflavin, niacinamide, D-panthenol, pyridoxine, and methylcobalamin) and electrolytes (potassium, magnesium, and calcium) in normal saline. Drip 2 contains the trace elements manganese, zinc, selenium, chromium, and copper. Drip 3 contains L-carnitine, N-acetylcysteine, and glutathione. The drips are administered sequentially (Drip 1 → Drip 2 → Drip 3), and all constituents enter the systemic circulation directly. Constituents are shown qualitatively, without dose quantities.

6. Micronutrients Across Major Domains of Human Health

6.1 Neurological, Cognitive, and Hematological Health

The nervous system is particularly sensitive to inadequate status of selected B vitamins. Thiamine, pyridoxine, and cobalamin contribute to normal neurological function, while vitamin B12 is also indispensable for normal hematopoiesis. A contemporary review of B vitamins in healthy ageing emphasizes their continued relevance to neurological and systemic health across later life[21].

Vitamin B12 deserves particular attention because ageing, gastrointestinal disorders, and medication exposure can alter its status. Metformin is a clinically important example of treatment-related vulnerability: in a 2024 mini-systematic review, most included studies linked metformin use with lower B12 concentrations, and the risk of deficiency rose with dose and duration of therapy[24].

Cognition is a healthspan outcome of major interest. A 2025 meta-analysis of randomized trials in adults aged 60 years or older found high-certainty evidence of only a very small effect of vitamin B6, folate, or vitamin B12 supplementation on global cognition[25], and the COcoa Supplement and

Multivitamin Outcomes Study (COSMOS) reported that daily multivitamin-mineral supplementation modestly benefited global cognition and episodic memory[34]. These findings support further investigation of micronutrient sufficiency in cognitive ageing without requiring the assumption that any one formulation functions as a treatment for neurodegenerative disease.

6.2 Cardiovascular and Vascular Health

Cardiovascular physiology depends on appropriate electrolyte and micronutrient status. Potassium contributes to membrane and vascular physiology, magnesium to neuromuscular and cardiovascular function, calcium to contraction and signaling, and thiamine to normal energy-yielding metabolism. Their clinical relevance is especially evident in hypertension, heart failure, diuretic therapy, and polypharmacy in older adults.

Recent randomized evidence supports a clinically measurable relationship between mineral intake and blood pressure. Pooled trial data published in 2025 showed that magnesium supplementation lowers blood pressure modestly, with the clearest reductions in people with hypertension[17], and a separate dose-response meta-analysis found that increasing potassium intake produced greater blood-pressure reductions in people with hypertension than in normotensive participants[19]. These data reinforce the physiological importance of adequate mineral status while also highlighting the need for individualized administration in people with renal or cardiovascular disease.

Thiamine status has been investigated in chronic heart failure. An updated meta-analysis of seven randomized trials found that thiamine supplementation corrected thiamine deficiency but had no significant effect on left-ventricular ejection fraction, six-minute walk distance, natriuretic peptide levels, or functional class[22]. The finding is useful for a sufficiency-oriented model: correcting an identified nutrient deficit and treating the underlying cardiovascular disease are related but distinct clinical objectives.

6.3 Metabolic Health and Diabetes

Type 2 diabetes illustrates how nutritional status can intersect with chronic disease, medication use, and long-term functional health. A network meta-analysis of 170 randomized trials assessed multiple vitamin and mineral interventions in type 2 diabetes and reported improvements in selected glycemic or lipid outcomes for some nutrients, although certainty varied across interventions[29].

Magnesium is frequently considered in metabolic-health research because of its broad physiological importance, while chromium has historically been investigated in relation to insulin-associated metabolism. A 2024 systematic review found heterogeneous findings for chromium supplementation in type 2 diabetes[30]. Rather than supporting universal supplementation, these data strengthen the case for studying baseline nutritional status, specific deficiencies, and patient phenotype when evaluating multinutrient strategies.

In diabetes care, periodic vitamin B12 assessment during long-term metformin therapy shows how treatment decisions can change micronutrient needs and bring nutritional monitoring into routine follow-up[24].

6.4 Musculoskeletal Health, Frailty, and Functional Independence

Healthy ageing requires preservation of mobility, skeletal integrity, muscle performance, and independence. Calcium and magnesium are central mineral components of skeletal health, while vitamin C contributes to collagen-containing tissues and zinc supports tissue repair and protein-dependent functions. Pooling observational studies of adults aged 60 years or older, a systematic review and meta-analysis found that higher magnesium intake was linked with greater hip and femoral-neck bone mineral density (BMD), whereas the limited data showed no relationship with BMD elsewhere or with fractures[18].

Frailty provides a broader framework than bone health alone. Contemporary reviews show that evidence from supplementation trials in frailty and sarcopenia remains limited, with no significant effect of vitamin D on mortality (moderate certainty) and only very-low-certainty evidence for multicomponent supplementation[35], and too few mineral-supplementation studies to allow pooling[36], while lower zinc status has been associated with malnutrition and frailty-related phenotypes[27]. Links between vitamin B12 status and muscle strength, muscle quality, and physical function in older people have also been examined[23]. These findings support the inclusion of micronutrient assessment within multidimensional approaches to functional ageing.

Calcium remains physiologically essential, but supplementation outcomes depend on the population and endpoint. Pooling 69 randomized trials, a 2026 meta-analysis showed that calcium and

vitamin D, given alone or together, offered little or no reduction in fractures or falls, and most of this evidence was rated moderate or high certainty[20]. The appropriate interpretation is that physiological necessity, nutritional adequacy, and disease-prevention efficacy are separate questions that should be studied at the correct evidence level.

6.5 Immune Competence, Tissue Integrity, and Respiratory Health

Immune function depends on adequate nutritional support rather than on a single nutrient. Vitamin C, zinc, selenium, and B vitamins contribute to normal immune physiology through different roles, while protein-energy status and overall diet remain equally important. A 2026 meta-analysis of nine randomized trials in older adults reported a small overall improvement in immune measures, with the largest effects seen for vitamins D and E, neither of which is a constituent of Leroy's Cocktail[37].

Vitamin C is particularly relevant to tissue integrity and healthy-ageing research because it is required for collagen formation and contributes to normal immune function. A 2024 review discussed lower vitamin C status in some older and chronically ill populations and highlighted its relevance to ageing physiology[15]. Zinc adequacy is likewise considered important for resistance to infection throughout adulthood[8].

Chronic respiratory disease can coexist with nutritional vulnerability, reduced intake, and loss of functional capacity. A 2024 meta-analysis of 20 randomized trials in COPD found benefits of macronutrient supplementation for body mass index, fat-free mass, exercise capacity, and quality of life, but no measurable benefit when micronutrients were given on their own[38]; micronutrient provision in respiratory disease should therefore be considered alongside, rather than instead of, protein-energy support.

6.6 Trace Elements and Whole-Body Micronutrient Sufficiency

Trace elements illustrate why micronutrient nutrition is both essential and concentration-dependent. Zinc, copper, selenium, and manganese are incorporated into proteins or enzyme systems required for normal physiology. Current clinical-nutrition literature emphasizes that trace-element provision in parenteral settings should be purposeful and accompanied by appropriate assessment because isolated deficiencies, altered requirements, inflammation, and organ dysfunction can influence measured status[13].

Manganese is required in small amounts for several metalloenzymes, while excessive exposure is also biologically relevant; a 2024 review summarizes its roles across human physiology[26]. Selenium similarly has a biologically important but relatively narrow adequacy range. A 2026 review discusses selenium and selenoproteins in immune, metabolic, muscular, cognitive, and ageing biology[28]. This concentration-dependent behavior reinforces a central principle for trace elements: physiological sufficiency, rather than indiscriminate escalation, is the appropriate objective of their provision. Figure 4 summarizes the major physiological domains discussed in this section, and Figure 5 maps the constituents of each drip stage onto the organ systems they principally support.

Fig 4: Major physiological domains associated with micronutrient sufficiency. The nutrient groups discussed in this review contribute to neurological, cardiovascular, musculoskeletal, immune, metabolic, hematological, and other normal physiological functions.

7. Physiological Resilience: From Nutrient Availability to Functional Capacity

Physiological resilience refers broadly to the capacity to maintain or recover function when the body encounters stress. In gerontology, resilience is increasingly discussed together with intrinsic capacity, which encompasses mobility, cognition, psychological function, sensory capacity, and vitality[39]. Nutritional status is one modifiable contributor to this wider reserve.

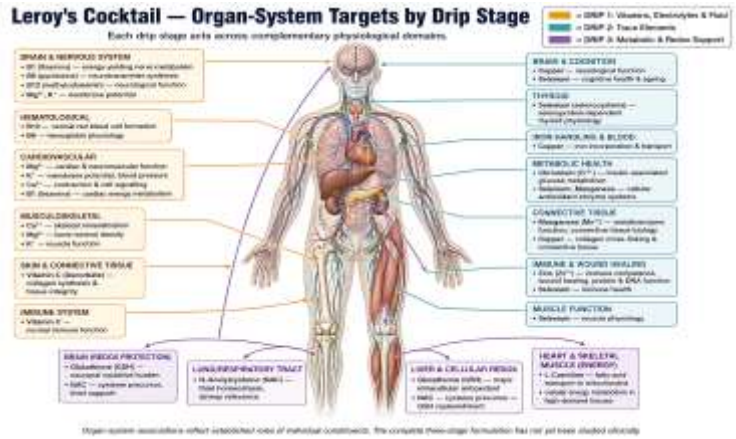


Fig 5: Organ-system associations of Leroy's Cocktail constituents by drip stage. Drip 1 constituents (amber) are linked with brain and nervous-system, hematological, cardiovascular, musculoskeletal, skin and connective-tissue, and immune functions. Drip 2 trace elements (teal) are linked with brain and cognitive function, thyroid physiology, iron handling, metabolic health, connective tissue, immune function and wound healing, and muscle function. Drip 3 compounds (violet) are linked with redox protection in the brain, the respiratory tract, liver and cellular redox systems, and energy metabolism in the heart and skeletal muscle. Associations reflect established roles of individual constituents; the complete formulation has not been studied clinically.

The concept of micronutrient reserve can therefore be reframed positively as a state of physiological preparedness. When vitamin and mineral availability is adequate, nutrient-dependent functions can proceed without nutritional limitation. During periods of poor intake, malabsorption, illness, medication exposure, or increased physiological demand, reserve may narrow and previously marginal status can become more clinically relevant. In later adulthood, multimorbidity, polypharmacy, and drug–nutrient interactions are frequent reasons for this narrowing of reserve, as outlined in Section 3[9-11].

Evidence from frailty research supports this integrated view while also showing that micronutrients function within a larger system. Systematic reviews of micronutrient and mineral supplementation in frailty have not established benefit for any single nutrient[35,36]. Instead, the literature favors a multidimensional model in which adequate micronutrients complement protein-energy nutrition, physical activity, disease management, sleep, rehabilitation, and social determinants of health.

7.1 Proposed Physiological-Sufficiency Continuum

Figure 6 summarizes the proposed pathway from adequate micronutrient availability to healthy ageing, and Figure 7 presents the sufficiency continuum as a five-stage model with reserve-narrowing factors and the multidimensional support framework described above.

Fig 6: Proposed pathway from micronutrient sufficiency to healthy ageing. Adequate micronutrient availability supports normal physiological function and contributes to resilience, functional health, and healthy ageing within the broader context of diet, lifestyle, and clinical care.

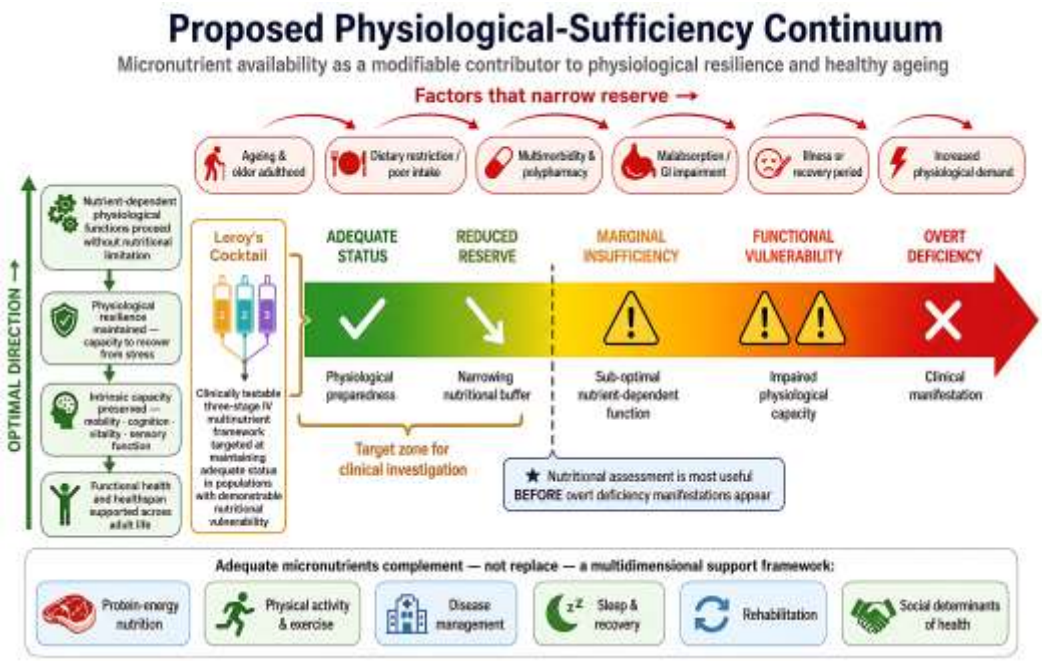


Fig 7: Proposed physiological-sufficiency continuum. Micronutrient status is shown as five stages: adequate status (physiological preparedness), reduced reserve (narrowing nutritional buffer), marginal insufficiency (sub-optimal nutrient-dependent function), functional vulnerability (impaired physiological capacity), and overt deficiency (clinical manifestation). Ageing, dietary restriction, multimorbidity and polypharmacy, malabsorption or gastrointestinal impairment, illness or recovery, and increased physiological demand narrow reserve and shift status toward deficiency. The left panel summarizes the functional benefits of maintained sufficiency; the bracket marks the range of status the formulation is intended to maintain in nutritionally vulnerable adults and therefore the proposed target zone for clinical investigation; the lower panel indicates that adequate micronutrients complement, rather than replace, protein-energy nutrition, physical activity, disease management, sleep, rehabilitation, and social determinants of health. The continuum is a conceptual tool, not a diagnostic classification.

8. Healthy Ageing and Healthspan: Maintaining Function Rather Than Simply Adding Years

Healthy ageing is increasingly defined by the quality and functionality of added years. Maintaining cognition, mobility, bone strength, cardiovascular stability, immune competence, and the capacity to recover from illness is therefore central to healthspan. Recent reviews explicitly connect micronutrient sufficiency with physiological homeostasis and the broader goal of optimizing healthspan[4,7].

Magnesium and vitamin C have each been examined within ageing research[15,16], while B vitamins remain relevant to neurological and systemic function in later life[21]. Selenium has also re-emerged as an ageing-related micronutrient because both inadequate and excessive status may influence health[28]. Taken together, these studies support an integrative view in which long-term health depends on maintaining adequate—not simply maximal—micronutrient availability.

Large human studies also help define realistic endpoints. Across three large prospective US cohorts, adults who took multivitamins daily did not have lower all-cause mortality than non-users[40], whereas COSMOS reported modest benefits for selected cognitive outcomes[34]. The distinction is scientifically informative: mortality, disease incidence, cognition, function, and recovery are different endpoints. For a multinutrient IV formulation, future studies should therefore prioritize measurable healthspan outcomes rather than assuming that one outcome predicts all others.

9. Disease-Associated Nutritional Contexts Requiring Individualization

Micronutrient sufficiency becomes clinically more complex in chronic disease. CKD may alter vitamin handling, mineral balance, and the safety profile of electrolyte administration; a 2023 review summarizes ongoing questions around vitamin supplementation in CKD[41]. Cardiovascular disease, diabetes, and respiratory disease similarly interact with diet, medications, inflammation, and functional status[17,19,22,24,29,38].

These conditions do not weaken the rationale for micronutrient assessment; they strengthen the need for individualization. Renal function, medication profile, baseline laboratory values, nutritional intake, age, and comorbidity determine whether a given nutrient requires correction, maintenance, restriction, or monitoring. This principle is especially important for potassium, magnesium, calcium, selenium, and other constituents for which both deficiency and excess may have clinical consequences.

Accordingly, a multinutrient formulation is most appropriately evaluated not for universal use, but in defined populations with a plausible nutritional need. This approach aligns with contemporary clinical-nutrition guidance on trace elements and micronutrient monitoring[13].

Intravenous administration also carries specific safety requirements. Impaired renal function limits potassium elimination and predisposes to hyperkalemia[42], and clinically severe hypermagnesemia is largely confined to patients with advanced loss of kidney function who are exposed to magnesium-containing products[43]. Recognized complications of high-dose intravenous vitamin C occur chiefly in patients with renal impairment or glucose-6-phosphate dehydrogenase (G6PD) deficiency[44]. In a Canadian cohort of 6455 intravenous N-acetylcysteine courses given for acetaminophen poisoning, 8.2% were complicated by anaphylactoid reactions, most of them cutaneous[45], and no study has assessed the safety of long-term intravenous glutathione use[46]. Assessment of renal function, electrolyte status, and G6PD status, together with medical supervision, is therefore required before administration.

10. Research Directions for Leroy's Cocktail

Leroy's Cocktail brings together several classes of physiologically important constituents within a single intravenous sequence: water-soluble vitamins, major electrolytes, trace elements, and metabolic/redox-support compounds. The scientific rationale for studying this combination lies in its breadth across human physiological systems and in the direct systemic route of administration. No clinical, pharmacokinetic, or safety data for the complete formulation have yet been published.

A research program should therefore ask whether the formulation can reproducibly improve nutritional status or functional outcomes in people selected for nutritional vulnerability. Candidate populations could include adults with poor dietary intake, individuals with clinically documented micronutrient insufficiency, patients with malabsorptive conditions, or carefully characterized recovery populations. Appropriate selection would require baseline laboratory assessment and exclusion of conditions in which specific electrolytes or trace elements are unsuitable.

Outcomes should extend beyond serum nutrient concentrations. Relevant endpoints include validated fatigue scales, handgrip strength, gait speed, frailty indices, cognitive measures, physical-performance testing, quality of life, and recovery trajectories. Biomarker assessment may include vitamins and trace elements relevant to the administered formulation, interpreted in the context of inflammation, renal function, and clinical status[4,13,39].

This design would allow the formulation to be evaluated as a micronutrient-support strategy while remaining grounded in measurable human physiology. It would also distinguish three clinically different aims: maintaining adequacy, correcting documented insufficiency, and evaluating whether functional benefit follows restoration of nutrient status.

11. Evidence Interpretation, Limitations, and Future Direction

The evidence base summarized in this review is strongest for the physiological importance of the individual micronutrients and for the clinical relevance of maintaining adequate status. Disease-specific supplementation effects vary according to baseline status, dose, route, population, and outcome, as illustrated by recent evidence in hypertension, diabetes, frailty, cognition, fracture prevention, and heart failure[17,19,20,22,25,29,30,34,35].

The complete three-stage formulation should therefore be treated as a prospective research entity. Its broad nutrient coverage and IV delivery provide a coherent basis for clinical investigation, particularly in populations with demonstrable nutritional vulnerability. Formulation-level studies can add the missing evidence by defining patient selection, systemic exposure, tolerability, biomarker response, and functional outcomes under standardized clinical conditions.

This review has limitations. It is a narrative, non-systematic synthesis. Most intervention evidence cited evaluated oral, often long-term supplementation and cannot be directly extrapolated to intermittent intravenous administration of a combined formulation. Several nutrients commonly inadequate in the cited epidemiological literature, including vitamin D, iodine, iron, folate, and vitamin E, are not constituents of the formulation[1,6]. All authors are employed by the company associated with the formulation.

12. Conclusion

Micronutrients are not peripheral additions to human physiology; they are essential components of the nutritional infrastructure required for normal neurological, cardiovascular, hematological, musculoskeletal, immune, metabolic, and tissue-maintenance functions. Their importance persists throughout adult life, while the determinants of adequacy change with diet, ageing, chronic disease, medication exposure, gastrointestinal function, and recovery from illness.

Leroy's Cocktail combines a broad spectrum of vitamins, electrolytes, trace elements, and physiologically relevant compounds in an intravenous sequence that places administered constituents directly into the systemic circulation. Viewed from an adult whole-body health perspective, the formulation provides a practical multinutrient framework for examining physiological sufficiency, organ-system function, resilience, and healthy ageing.

The most productive research direction is therefore to identify populations in whom micronutrient reserve is genuinely challenged and test whether standardized administration improves nutritional biomarkers, functional capacity, resilience, recovery, or other healthspan-relevant outcomes. Such work would provide a direct clinical bridge between the established importance of essential micronutrients and the integrated formulation represented by Leroy's Cocktail.

Declarations

Author Contributions

All authors contributed to the conception and development of the review, interpretation of the literature, critical revision of the manuscript, and approval of the final version. All authors agree to be accountable for the accuracy and integrity of the work.

Funding

No external funding was received for the preparation of this review.

Competing Interests

All authors are employees of Biotex Life Solutions Pvt. Ltd. This review discusses Leroy's Cocktail, a formulation associated with Biotex Life Solutions Pvt. Ltd.; we disclose this relationship as a potential competing interest. The authors declare no other competing interests.

Ethics Approval and Consent to Participate

Not applicable. This article is a narrative review of published literature and does not report original research involving human participants or animals.

Consent for Publication

Not applicable.

Data Availability Statement

No new datasets were generated or analyzed for this review. All evidence discussed is derived from published literature cited in the reference list.

Declaration of Generative AI and AI-Assisted Technologies

During the preparation of this manuscript, the authors used AI-assisted tools to support drafting and language editing. The authors reviewed and edited all content, verified the references, and take full responsibility for the publication's content.

Acknowledgements

None.

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