

Therapeutic promise of *Prunus laurocerasus* compounds for cardiovascular disease and type 2 diabetes

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Abstract

Background Cardiovascular disease (CVD) and type 2 diabetes (T2D) remain leading drivers of global mortality and share a common pathological network of oxidative stress, chronic inflammation, and insulin resistance. *Prunus laurocerasus* L. (cherry laurel), an evergreen shrub indigenous to the Black Sea region, has emerged as a promising multi-target candidate by virtue of its phenolic acids, anthocyanins, and flavonoids.

Methods Phenolic acids, catechins, and anthocyanins were quantified in juice, dried fruit (35 °C drying), and processing residues of Georgian autochthonous cherry laurel using validated spectrophotometric methods. Antioxidant activity was assessed by the DPPH radical-scavenging assay and expressed as the IC₅₀ (mg of sample required for 50 % inhibition).

Results Dried fruit contained the highest concentrations of total anthocyanins, catechins, and phenolic acids and showed the strongest antioxidant activity (IC₅₀ = 1.98 ± 0.02 mg). Processing residues outperformed juice on antioxidant potency (IC₅₀ = 3.23 ± 0.05 mg vs 5.05 ± 0.07 mg), indicating that a substantial fraction of the most active antioxidant compounds remains bound to skins and pulp residues after pressing.

Conclusion Georgian cherry laurel — and particularly its dried fruit and processing residues — represents a concentrated and effective substrate for the development of standardised antioxidant, antidiabetic, and cardioprotective preparations. The retention of significant bioactivity in waste fractions supports a circular-economy approach to nutraceutical development. Translation from bench to bedside will require standardised extracts and rigorous human clinical trials.

Keywords *Prunus laurocerasus*; cherry laurel; antioxidant activity; polyphenols; anthocyanins; catechins; type 2 diabetes; cardiovascular disease; metabolic syndrome; waste valorisation

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1. Introduction

1.1 Polyphenols and the burden of cardiometabolic disease

Plant-derived phenolic compounds are secondary metabolites characterised by one or more hydroxyl groups attached to aromatic rings. They include phenolic acids, flavonoids, stilbenes, and lignans, and form a major subset of the broader bioactive compounds, which also encompass carotenoids, alkaloids, and terpenoids. These molecules exert physiological effects beyond basic nutrition, functioning as antioxidants, enzyme modulators, and signalling regulators [1,9].

Global interest in polyphenol-rich foods and nutraceuticals has expanded rapidly in light of their reported roles in neutralising free radicals, modulating inflammatory pathways including NF- κ B [2,7], improving insulin sensitivity, influencing gut microbiota, and producing antimicrobial, neuroprotective, anticancer, and cardioprotective effects. Concurrently, the worldwide burden of non-communicable diseases — particularly cardiovascular disease (CVD) and type 2 diabetes (T2D) — continues to rise despite advances in pharmacotherapy [3,5,10,35].

CVD remains the leading cause of global mortality, accounting for approximately one-third of deaths annually, while T2D substantially increases the risk of cardiovascular complications and contributes to premature mortality, nephropathy, neuropathy, retinopathy, and reduced life expectancy [4]. CVD deaths have risen substantially over the past two decades, with projections suggesting continued growth driven by ageing populations and lifestyle factors [3,10]. T2D prevalence has similarly increased worldwide, with hundreds of millions of affected individuals and projections indicating further expansion in the coming decades [5].

These diseases are closely interconnected. T2D approximately doubles the risk of cardiovascular events, and chronic hyperglycaemia contributes to endothelial dysfunction, oxidative stress, and accelerated atherosclerosis [4,8]. Both conditions share a common pathological network: oxidative stress, chronic low-grade inflammation, insulin resistance, dyslipidaemia, endothelial dysfunction, and mitochondrial and endoplasmic reticulum (ER) stress. Given this shared mechanistic core, therapeutic strategies capable of modulating oxidative stress, inflammation, insulin signalling, and lipid metabolism simultaneously are of particular interest. Natural phytochemicals, especially polyphenol-rich plant extracts, represent promising multi-target agents in this context [2,9].

Within this context, *Prunus laurocerasus* L., commonly known as cherry laurel, has emerged as a candidate of

particular interest because of its rich phytochemical profile and demonstrated biological activities [2,6].

1.2 Botanical background and phytochemical composition

Prunus laurocerasus L., belonging to the Rosaceae family, is an evergreen shrub or small tree indigenous to southeastern Europe and southwestern Asia, particularly western Georgia and northeastern Turkey [36,37]. Traditionally consumed fresh or processed into juices and preserves, cherry laurel fruits have also been used in regional folk medicine.

Modern phytochemical analyses using advanced chromatographic techniques reveal that cherry laurel fruits contain diverse bioactive compounds. The dominant classes include phenolic acids (predominantly chlorogenic acid), anthocyanins, and flavonoids [2,23,30]. Phenolic acids such as chlorogenic, caffeic, and protocatechuic acid exhibit strong radical-scavenging activity and modulate carbohydrate metabolism enzymes [19,27]. Anthocyanins, particularly cyanidin-3-glucoside and delphinidin derivatives, contribute to the deep purple pigmentation and demonstrate potent antioxidant and endothelial-protective effects [15,32]. Flavonoids including quercetin, rutin, and epicatechin influence insulin signalling and lipid metabolism [9,21].

Phytochemical composition varies significantly with genotype, environmental conditions, and ripening stage. Methanolic and ethanolic extracts typically yield higher total phenolic content than aqueous preparations [6]. Standardisation therefore remains essential for reproducible therapeutic development.

1.3 Antioxidant properties and molecular mechanisms

Oxidative stress plays a central role in the progression of both T2D and CVD. Pancreatic β -cells are particularly vulnerable owing to their relatively low intrinsic antioxidant expression [15]. Cherry laurel fruit extracts demonstrate strong antioxidant capacity in DPPH, ABTS, and FRAP assays [6,7,37]. Beyond direct radical scavenging, one of the most significant mechanisms involves modulation of the Keap1/Nrf2 pathway [11,12,37].

Experimental data indicate that cherry laurel extracts decrease Keap1 expression while enhancing Nrf2 activation, resulting in upregulation of superoxide dismutase, catalase, and glutathione peroxidase [11,12,34]. In vivo studies demonstrate reductions in lipid peroxidation markers such as malondialdehyde and decreases in oxidative DNA damage indicators [11,37]. Increased consumption of anthocyanins is

associated with reduced markers of oxidative stress and improved cardiometabolic profiles [15,32].

1.4 Anti-inflammatory and cytoprotective effects

Chronic low-grade inflammation contributes significantly to insulin resistance and atherosclerotic progression [8]. Activation of NF- κ B leads to increased expression of pro-inflammatory cytokines such as TNF- α , IL-6, and IL-1 β , as well as enzymes including COX-2 and inducible nitric oxide synthase [1,2]. Polyphenols present in cherry laurel extracts appear to suppress NF- κ B activation and improve insulin sensitivity [8,17].

At the cellular level, these extracts also influence apoptotic signalling pathways. Increased expression of anti-apoptotic Bcl-2 and reduced levels of pro-apoptotic Bax and Caspase-3 have been observed [14,20]. Such effects protect pancreatic β -cells and cardiomyocytes from oxidative-stress-induced apoptosis [11,21].

1.5 Antidiabetic mechanisms

Cherry laurel fruit extracts exhibit significant inhibition of the digestive enzymes α -glucosidase and α -amylase [30,31]. In streptozotocin-induced diabetic rat models, administration of cherry laurel extract significantly lowers fasting blood glucose levels and improves glucose tolerance [21,33]. At the molecular level, cherry laurel components modulate insulin signalling pathways, enhancing phosphorylation of insulin receptor substrate (IRS-1) and increasing GLUT4 translocation [8,15].

Higher dietary intake of chlorogenic acid and catechins improves postprandial glucose levels and insulin sensitivity in patients with T2D [5,15]. Anthocyanins similarly reduce insulin resistance in diabetic animal models while protecting pancreatic cells from necrosis [12,18].

1.6 Cardioprotective effects

Experimental models of doxorubicin-induced cardiotoxicity demonstrate that cherry laurel extracts reduce myocardial oxidative stress and decrease ER stress markers [11,12]. In metabolic models, extract administration improves lipid profiles by decreasing total cholesterol and triglycerides while increasing HDL cholesterol [31,33]. Anthocyanins and flavonoids may enhance endothelial nitric oxide bioavailability, improving vascular function; evidence also indicates that anthocyanins improve dyslipidaemia and inflammatory status in subjects with metabolic disorders [8,32].

1.7 Regulation of apoptosis, autophagy, and ER stress

Recent evidence suggests that cherry laurel fruit extracts can restore cellular homeostasis under stress conditions through interaction with autophagy-related proteins such as LC3 and Beclin-1 [24,34]. This is particularly relevant in preventing liver and cardiac tissue damage caused by oxidative triggers [12,34]. The identification of specific secondary metabolites in Georgian processing residues provides a foundation for developing these activities into sustainable therapeutics [23].

1.8 Safety considerations and current limitations

Although fruit pulp appears safe, seeds contain cyanogenic glycosides that require careful removal during extract preparation [25,36]. Standardisation of extracts remains a major challenge owing to variability in phenolic content across cultivars [6,30,37]. Current knowledge is derived primarily from in vitro and animal studies; human clinical trials are largely absent and study durations are often short [2]. Differences in extraction methods and dosing regimens further limit comparability across studies. Rigorous randomised controlled trials in individuals with T2D or high cardiovascular risk are required to determine clinical efficacy [5,21].

2. Aim and objectives

The principal aim of this study was to quantify phenolic acids, anthocyanins, and catechins in the juice, dried fruit, and processing residues of wild and cultivated Georgian cherry laurel (*Prunus laurocerasus*) and to evaluate their potential therapeutic value for patients with type 2 diabetes and cardiovascular disease. Georgian cherry laurel has not previously been characterised using contemporary analytical methods, and information on its bioactive compound profile remains limited.

The specific objectives were:

- (i) quantitative analysis of phenolic compounds in Georgian autochthonous cherry laurel, with attention to compounds with established antioxidant, antidiabetic, and cardioprotective effects; (ii) assessment of waste valorisation potential and the prospect of obtaining pharmaceutical preparations from production residues; (iii) appraisal of the current clinical and pre-clinical literature describing the biological activity of these compounds and their possible role in the management of T2D and CVD; and (iv) assessment of the potential therapeutic value of

these compounds against the international pharmacological and biochemical evidence base.

3. Methods

3.1 Materials and sample preparation

Georgian autochthonous cherry laurel juice, dried fruit, and processing waste (skins and pulp residues) were used as study materials. Fresh fruits were dried at 35 °C to obtain the dried samples; juice extraction yielded both juice and a residual waste fraction. All three materials — dried fruit, juice, and waste — were subjected to maceration with 75 % ethanol prior to analysis.

3.2 Quantitative determination of phenolic acids

Total phenolic acid content was determined by spectrophotometry [27]. A 250 µL aliquot of extract was mixed with 250 µL of 0.1 % HCl in ethanol and 4.55 mL of 2 % HCl. After vigorous mixing the mixture was incubated for 15 min and absorbance was read at 320 nm. Concentrations were calculated against a caffeic acid calibration curve ($y = 4.1338x + 0.0393$; $R^2 = 0.9986$) and expressed as caffeic acid equivalents (mg/g of sample).

3.3 Quantification of catechins

Total catechin content was determined by the vanillin method [29]. Three millilitres of vanillin reagent was added to 1 mL of the extract; after 3 min the optical density of the resulting red solution was read at 500 nm. The control tube contained 1 mL of the corresponding extractant and 3 mL of vanillin reagent. Results were calculated using a (+)-catechin calibration curve ($y = 33.62x - 0.036$; $R^2 = 0.995$) and expressed as catechin equivalents (mg catechin equivalents per gram of sample).

3.4 Quantification of total anthocyanins

Total anthocyanin content was determined by direct UV-Vis spectrophotometry at 520 nm [16,22]. Samples were extracted with 70 % ethanol containing 0.1 % HCl. Absorbance of the analytical extract was measured at 520 nm (A_{520}) and 700 nm (A_{700}); corrected absorbance was calculated as $A_{corr} = A_{520} - A_{700}$, using 70 % EtOH + 0.1 % HCl as a blank. Anthocyanin concentrations were calculated from the Beer–Lambert law:

$$c \text{ (mol/L)} = A_{corr} / (\epsilon \times b), \quad C_{mg/L} = (A_{corr} \times MW) / (\epsilon \times b) \times 1000,$$

with $\epsilon = 26\,900 \text{ L} \cdot \text{mol}^{-1} \cdot \text{cm}^{-1}$, $b = 1 \text{ cm}$, and MW (malvidin-3-O-glucoside chloride) = 528.9 g/mol. Results were expressed as malvidin-3-O-glucoside equivalents (mg/g).

3.5 Determination of antioxidant activity

Antioxidant activity was assessed using the DPPH (2,2-diphenyl-1-picrylhydrazyl) radical-scavenging assay [7]. A 1.0 mL aliquot of each extract was mixed with 3.0 mL of 0.1 mM DPPH methanolic solution and incubated in the dark at room temperature for 15 min. Absorbance was read at 517 nm using a UV-Vis spectrophotometer. The radical-scavenging capacity of the sample was expressed as the percentage inhibition of DPPH (In %), calculated as:

$$\text{In\%} = \frac{A_c - A_s}{A_c} \times 100$$

where In % represents the inhibition of 0.1 mM DPPH, A_c is the absorbance of the 0.1 mM DPPH ethanolic solution, and A_s is the absorbance of the reaction mixture containing the DPPH solution and the sample extract.

The extract concentration required to achieve 50 % inhibition of the 0.1 mM DPPH radical (IC_{50}) was calculated as $IC_{50} = (m \times V \times F \times 100) / \text{In \% } 50$, where m is the mass of the tested sample (mg), V is the volume of sample extract (mL), F is the dilution factor, and In % 50 represents the inhibition percentage within the 45–55 % range used to interpolate the IC_{50} value. A lower numerical IC_{50} indicates higher antioxidant potency.

4. Results

Quantitative analysis of the three sample types (dried fruit, processing residues, juice) revealed a consistent hierarchy across all three classes of secondary metabolites measured: anthocyanins, catechins, and phenolic acids. Dried fruit also showed the strongest antioxidant activity, requiring only $1.98 \pm 0.02 \text{ mg}$ of sample to reach the 50 % DPPH inhibition threshold, while processing residues outperformed juice on antioxidant activity ($3.23 \pm 0.05 \text{ mg}$ vs $5.05 \pm 0.07 \text{ mg}$).

4.1 Total anthocyanin content

Total anthocyanin content (Chart 1) was highest in dried fruit (0.2829 mg/kg malvidin-3-O-glucoside equivalents), approximately 3.6-fold greater than in processing residues (0.0787 mg/kg) and 8.1-fold greater than in juice (0.0348 mg/kg). The marked enrichment of anthocyanins in the dried fraction is consistent with concentration of pigment compounds during low-temperature drying, while the residual fraction retains a substantial proportion of the original anthocyanin content bound to skins and pulp.

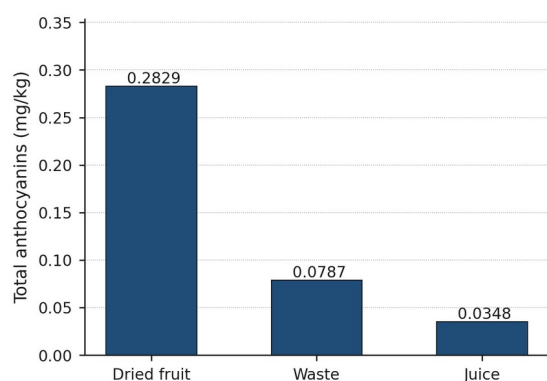


Chart 1. Total anthocyanin content (mg/kg, malvidin-3-O-glucoside equivalents) in dried fruit, processing residues (waste), and juice obtained from Georgian cherry laurel.

4.2 Total catechin content

Catechin content followed the same hierarchy (Chart 2). Dried fruit yielded 1.5662 mg/g (catechin equivalents, fresh-weight basis), substantially exceeding the residue fraction (0.4431 mg/g) and the juice (0.1615 mg/g). The dried-fruit-to-juice ratio of approximately 9.7 : 1 indicates that a large proportion of total catechins remains in the solid matrix and is not transferred to the liquid phase during pressing.

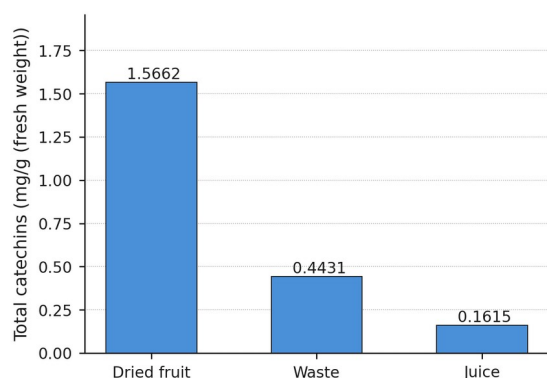


Chart 2. Total catechin content (mg/g, fresh weight, catechin equivalents) in dried fruit, processing residues (waste), and juice obtained from Georgian cherry laurel.

4.3 Total phenolic acid content

Phenolic acid concentrations were more uniformly distributed across the three sample types (Chart 3): dried fruit 0.0250 mg/g, juice 0.0240 mg/g, and processing residues 0.0180 mg/g (caffeic acid equivalents). Unlike anthocyanins and catechins, a substantial fraction of phenolic acids partitions into the aqueous juice phase during pressing, accounting for the relatively close juice and dried-fruit values.

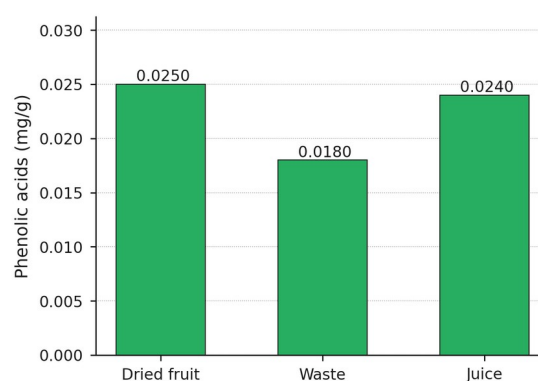


Chart 3. Total phenolic acid content (mg/g, caffeic acid equivalents) in dried fruit, processing residues (waste), and juice obtained from Georgian cherry laurel.

4.4 DPPH antioxidant activity

DPPH IC₅₀ values mirrored the bioactive-compound hierarchy. Dried fruit demonstrated the strongest radical-scavenging activity (1.98 ± 0.02 mg), followed by processing residues (3.23 ± 0.05 mg) and juice (5.05 ± 0.07 mg). The finding that residues outperform juice — despite juice retaining a comparable share of phenolic acids — confirms that significant bioactive content (notably catechins and anthocyanins) is retained in the skins and pulp residues after juice extraction. Processing residues therefore represent a potentially rich raw material for the development of preparations containing biologically active substances — an additional benefit in terms of valorisation of production by-products.

5. Discussion

Because cherry laurel is a seasonal fruit cultivated in open-field conditions, one of the principal motivations of this study was to characterise processed forms — juice, dried fruit, and residual by-products — that could ensure year-round availability of its bioactive compounds. By examining not only fresh fruit but also juice, dried fruit, and processing residues, this study highlights the added value of processing waste as a potential source of bioactive compounds, supporting sustainable valorisation strategies.

Our quantitative analysis revealed a consistent hierarchy in antioxidant potency. The dried fruit exhibited the strongest radical-scavenging activity, requiring only 1.98 mg to achieve 50 % inhibition of the DPPH radical. This superior activity correlates with the finding that dried samples contain the highest concentrations of bioactive secondary metabolites, including chlorogenic acid, catechins, and anthocyanins. The drying process at 35 °C effectively concentrates phenolic compounds by removing water without the thermal degradation typical of higher-temperature processing.

A particularly noteworthy finding was that processing residues (waste) demonstrated higher antioxidant potency (IC₅₀ = 3.23 mg) than the extracted juice (IC₅₀ = 5.05 mg). This pattern indicates that a substantial portion of the most active antioxidant compounds remains bound to the skins and fibrous pulp rather than transferring into the liquid phase during pressing. While juice remains a valuable dietary source, the dried fruit and industrial waste therefore represent the most concentrated and effective substrates for developing standardised cardiovascular and antidiabetic extracts. These findings extend earlier UPLC-PDA-MS observations on Georgian endemic plant residues [23] and align with the broader phytochemical literature on *Prunus laurocerasus* [6,30,37].

Mechanistically, the inverse relationship between bioactive content and DPPH IC₅₀ is consistent with multi-target activity reported for cherry laurel extracts, including modulation of the Keap1/Nrf2 axis, suppression of NF-κB-driven inflammation, inhibition of α-glucosidase and α-amylase, and improvement of insulin signalling [11,12,15,21,30]. Combined with their antioxidant capacity, these effects support the rationale for further investigation of cherry laurel-derived preparations as adjuncts in cardiometabolic disease management.

Several limitations of the present study should be acknowledged. The analyses were conducted on a defined set of Georgian samples and do not capture the full inter-cultivar and inter-seasonal variability documented elsewhere [6,19,37]. Antioxidant capacity was assessed by a single in vitro assay (DPPH); confirmation in cellular and animal models is needed before clinical inferences can be drawn. Finally, while the residue fraction shows promising bioactivity, scaling waste valorisation to a standardised pharmaceutical-grade extract will require further work on extraction efficiency, stability, and toxicological characterisation [25,27].

6. Conclusion

Prunus laurocerasus L. (cherry laurel) fruit extracts contain a complex profile of phenolic acids, anthocyanins, and flavonoids with antioxidant, anti-inflammatory, antidiabetic, and cardioprotective activity. The present study underscores the multi-target therapeutic potential of these compounds through modulation of Nrf2-mediated antioxidant defences, NF-κB-driven inflammatory signalling, and pathways governing insulin and lipid metabolism.

Quantitative analysis of Georgian autochthonous cherry laurel demonstrated a clear hierarchy of

antioxidant potency: dried fruit displayed the highest radical-scavenging activity, followed by processing residues and juice. The retention of substantial bioactive content within processing waste — exceeding the antioxidant potency of the juice itself by mass — supports the development of cherry laurel residues as a sustainable raw material for high-value nutraceuticals and aligns with circular-economy principles.

While these pre-clinical and phytochemical results are promising, translation from bench to bedside will require standardised extract preparations and rigorous, long-term randomised controlled trials in humans to establish efficacy and safety. With continued systematic investigation, Georgian cherry laurel may serve as a useful adjunctive strategy in the prevention and management of cardiovascular and metabolic disease.

Abbreviations

Bcl-2 — B-cell lymphoma 2

Bax — Bcl-2-associated X protein

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COX-2 — cyclooxygenase-2

CVD — cardiovascular disease

DOI — Digital Object Identifier

DPPH — 2,2-diphenyl-1-picrylhydrazyl

ER — endoplasmic reticulum

FRAP — ferric reducing antioxidant power

GLUT4 — glucose transporter type 4

HDL — high-density lipoprotein

IC₅₀ — half-maximal inhibitory concentration

IL-1β — interleukin-1 beta

IL-6 — interleukin-6

IRS-1 — insulin receptor substrate 1

Keap1 — Kelch-like ECH-associated protein 1

LC-MS/MS — liquid chromatography–tandem mass spectrometry

NF-κB — nuclear factor kappa B

Nrf2 — nuclear factor erythroid 2-related factor 2

PHIG — Public Health Institute of Georgia

T2D — type 2 diabetes

TNF-α — tumour necrosis factor alpha

UPLC-PDA-MS — ultra-performance liquid chromatography with photodiode array and mass-spectrometric detection

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Authors' contributions

EM: Conceptualisation; methodology; investigation; formal analysis; visualisation; writing — original draft; writing — review and editing; final approval.

MV: Methodology; investigation; supervision; resources; writing — review and editing; final approval.

AK: Methodology; supervision; resources; writing — review and editing; final approval.

IJ: Investigation; data curation; final approval.

LJ: Investigation; resources; final approval.

IA: Investigation; resources; final approval.

All authors read and approved the final manuscript.

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Declarations

Ethics approval and consent to participate Not applicable. The study used plant material only and did not involve human participants, identifiable personal data, or animal experiments. Ethical approval was therefore not required.

Consent for publication Not applicable. The article does not contain any individual-level or identifying personal information.

Conflict of interest disclosures The authors declare no competing interests, financial or non-financial, related to the subject matter of this article.

Data sharing All quantitative data underlying this analysis are presented in full within the article (text and Charts 1–3). No additional individual-level datasets were generated. The article is archived under its DOI and deposited via the journal's preservation infrastructure.

AI use disclosure Generative AI tools (Gemini for reference sorting and language editing; Perplexity for literature search; Claude (Anthropic) for editorial structuring and typesetting in the Georgian Medical Journal house style) were used as assistive aids. AI is

not an author. All factual claims, experimental results, statistical analyses, and analytical judgements were reviewed and approved by the authors, who take full responsibility for the content of this article.

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