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Pleurostylia capensis Turcz (Loes): A review of its phytochemistry, pharmacology and toxicology and its ethnomedicinal uses

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Background: *Pleurostylia capensis* Turcz (Loes) is a tree species found in Africa that has been used in traditional medicine for various ailments.

Aim: This review aims to investigate the phytochemistry, pharmacology and toxicity of *P. capensis* Turcz (Loes) and its ethnomedicinal uses.

Method: A comprehensive search was conducted using electronic databases, including PubMed, Scopus and Web of Science. The keywords used were '*Pleurostylia capensis*', 'phytochemistry', 'pharmacology', 'toxicology' and 'ethnomedicine'. Studies were included if they reported on the phytochemical composition, pharmacological activities, toxicological evaluations and/or ethnomedicinal uses of *Pleurostylia capensis*.

Results: A phytochemical analysis revealed the presence of various bioactive compounds including alkaloids, flavonoids, terpenoids and phenolic compounds. Pharmacological studies have reported the plant's potential as an anti-inflammatory, antioxidant, antimicrobial and a potential agent for bone and articular cartilage regeneration. Toxicological evaluations have shown that the plant is safe for human consumption at recommended doses.

Conclusion: The review highlights the potential of *Pleurostylia capensis* as a source of bioactive compounds with pharmacological activities. Toxicological evaluations have also shown that the plant is safe for human consumption. The review provides useful information for further research on the development of new drugs from natural products.

Contribution: This review provides a comprehensive summary of the phytochemistry, pharmacology, toxicology of *Pleurostylia capensis* and its ethnomedicinal uses. The review highlights the potential of the plant as a source of bioactive compounds and provides a basis for further research on the development of new drugs from natural products.

Keywords: *Pleurostylia capensis*; phytochemistry; pharmacology; toxicology; ethnomedicine.

Introduction

The use of medicinal plants for the treatment of human diseases has a long history in many cultures and remains an important source of healthcare worldwide. Among the diverse array of plants used for medicinal purposes, *Pleurostylia capensis* Turcz (Loes) (*P. capensis*) has received attention in recent years because of its beneficial pharmacological properties and potential therapeutic applications. *Pleurostylia capensis* Turcz (Loes) is a species of flowering plant native to South Africa. It belongs to the family Celastraceae (Darbyshire et al. 2016); and is commonly known as the Cape satinwood. It is a tree or shrub that can grow up to 20 m tall and is often found growing in coastal forests, dune scrub and rocky hillsides (Pote et al. 2006). A researcher named Turczaninow, first reported on *P. capensis* Turcz (Loes) in the early 1800s, described the plant as *Euonymus capensis* and later, in 1852, as a new species, *P. capensis* (Turczaninow 1829). This article aims to provide a comprehensive overview of the taxonomic classification, geographical distribution, common names, morphological characteristics, traditional medicinal uses, cultural practices use, commercialisation, non-medicinal uses, toxicology and pharmacological properties of *P. capensis*. The article presents a detailed analysis of the available literature on *P. capensis*, with a focus on its ethnobotanical and pharmacological significance. The information presented in this study may be useful for researchers and practitioners interested in exploring the potential applications of *P. capensis* in the fields of medicine and pharmacology.

Methods

A systematic review of the literature was conducted to identify, evaluate and synthesise peer-reviewed journal articles and relevant data on *P. capensis*. A comprehensive search of electronic databases including PubMed, Scopus and Web of Science was conducted using the keywords '*Pleurostylia capensis*', 'phytochemistry', 'pharmacology', 'toxicology' and 'ethnomedicine'. Inclusion criteria were studies reporting on the plant's phytochemical composition, pharmacological activities, toxicological evaluations and/or ethnomedicinal uses. Additional information deemed noteworthy by the investigator was also included. A total of 35 relevant journal articles, documents and data were included in the study. The main objective was to compile information on the plant, including harvest patterns based on traders' commercialisation and conservation status.

Review findings

Classification

P. capensis is a species of flowering plant that belongs to the eudicot clade within the plant kingdom. It is classified under the order Malpighiales, which is a diverse group of flowering plants, consisting of 36 families. *P. capensis* belongs to the Phyllanthaceae family, which includes tropical and subtropical plants like trees, shrubs and herbs. The *Pleurostylia* genus, to which *P. capensis* belongs, is native to Africa and Madagascar (Darbyshire et al. 2016).

Geographical distribution

P. capensis is native to Southern Africa and its distribution range includes several countries in the region. The plant is specifically found in South Africa, Lesotho, Eswatini, Mozambique, Zimbabwe and Botswana. Within these countries, it is found in diverse types of woodland and forest habitats, including the Fynbos biome in South Africa, the Zambezian and Mopane woodlands in Mozambique and Zimbabwe. Additionally, the *P. capensis* plant species has been introduced to other regions such as Australia and Madagascar (Darbyshire et al. 2016; Hyde et al. 2023; Loffer & Loffer 2005; eds. Manning & Goldblatt 2012; Van Wyk, Oudtshoorn & Gericke 1997).

Vernacular names

P. capensis is known by different names depending on the region or country. The general English language refers to *P. capensis* as mountain hard pear, coffee pear and saffron wood. The South African Afrikaans speaking citizens have termed it *koffiehardepeerhout, koffiepeer and berghardepeerhout.* The AmaXhosa clan who originate from the Eastern Cape, South Africa call it *umthunywalele*, *umbovane ontsaka* and *umngqangqa* (Johnson 1990). The people who speak IsiZulu have termed it *umngqangqa*, *umthunyelelwa*, *umthelela* and *thunyulelelwa* (Grace et al. 2003). The Tonga people who live in Zimbabwe refer to it as Mulyamandebele (Tshisikhawe, Van Rooyen & Bhat 2012).

Physical description

This plant grows up to a height of 20 m. It is a spindly shrub that has glistering dark green to fresh green leaves as depicted in Figure 1. *P. capensis* grows in coastal and mountainous forests, along the banks of rivers, canyons and streams (Razwinani, Tshikalange & Motaung 2014).

The bark is the most harvested part of the plant. The use of the bark for medicinal purposes is reported for approximately 30% of the woody species (Tshisikhawe et al. 2012). The appearance of the outer bark varies depending on the age of the plant. Young stems are relatively smooth and have a rectangular scale, while mature trunks have a rough bark with irregular flakes as depicted in Figure 1.

The inner part of the bark of the plant has a smooth texture with vertical ridges and is stratified by yellow and pink layers when cut longitudinally. The bark powder has a pinkish-grey colour and a sawdust smell. These descriptions are based on the trader' reports and observation of the plant, and the descriptions of the bark physical characteristics as reported by Khumalo (2018).

Traditional practices of *P. capensis*

In addition to its medicinal use, *P. capensis* is also employed in traditional practices. Reports about the plant were said to be believed to have strong sorcery properties among the Venda people in South Africa, as cited by Mabongo (2012). Traditional practitioners grind the plant into a powdery form, which is then mixed with other anti-parasitic medicinal plants and animal or plant materials to create a magical mixture. This mixture is then blown towards a specific individual and is believed to have an effect even if the individual is distant from the source (Razwinani et al. 2014). Other reported uses of *P. capensis* include its utilisation for traditional and religious purposes; wherein the patient undergoes a ritualistic body wash to purge against witchcraft (Razwinani et al. 2014).

Commercialisation of *P. capensis*

Historical studies have classified *P. capensis* as a vulnerable and a rapidly declining plant species in KwaZulu-Natal, South Africa (Grace et al. 2003). *P. capensis* is readily available for commercial uses and pharmaceutical companies. The proliferation of medicinal plant trade appears to be prevalent in the Venda, Gauteng and Mpumalanga region, of South Africa. Ethnobotanical studies previously revealed that the expanding market for indigenous medicinal plants in South Africa poses a significant risk to the conservation and preservation of many plant species (Tshisikhawe et al. 2012).

However, in the recent study, *P. capensis* was assessed for its conservation status by the South African National Biodiversity Institute (SANBI). The most recent assessment

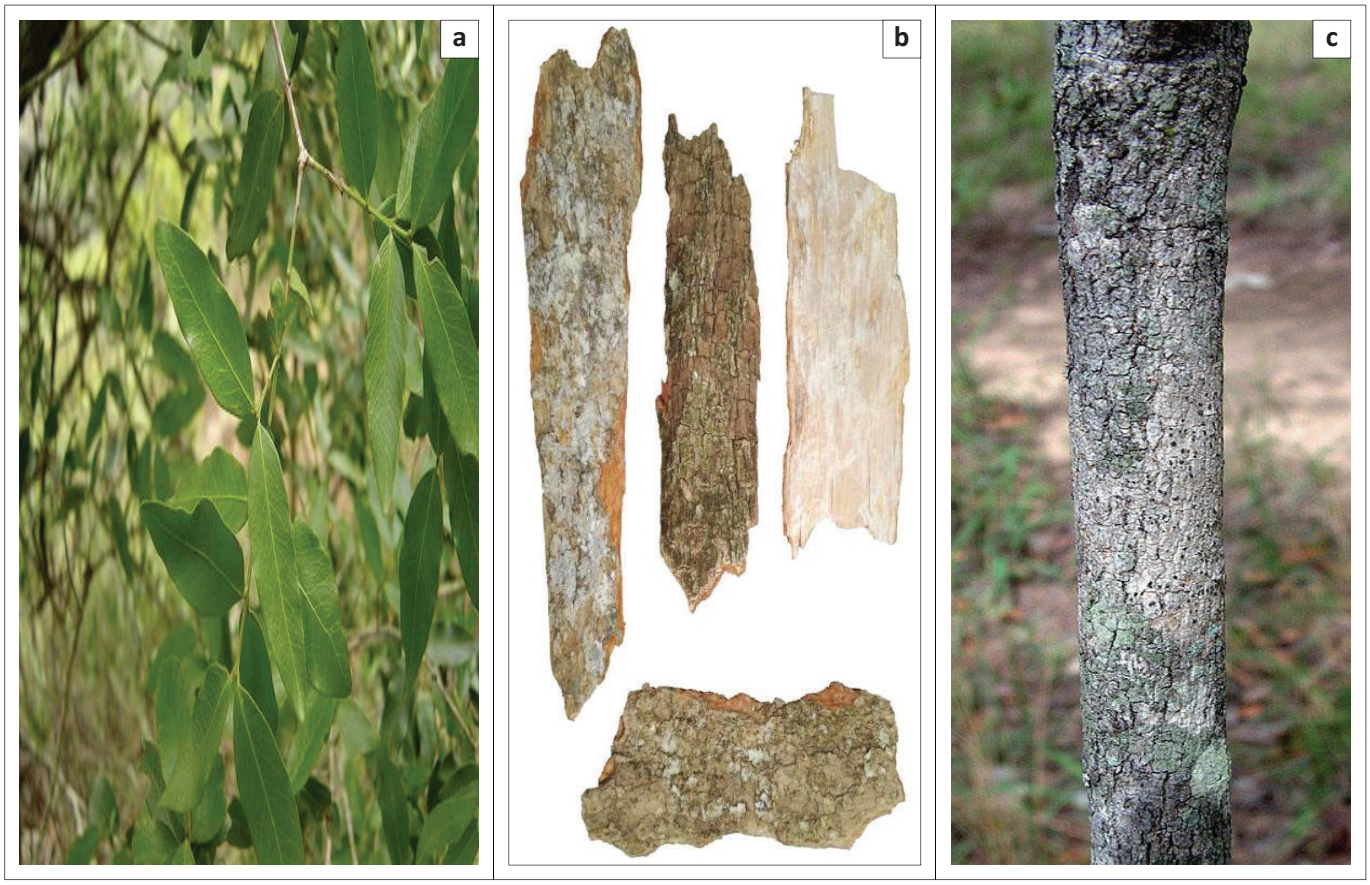

FIGURE 1: (a) The leaves (Loffer 2022); (b) bark (Khumalo 2018) and (c) stem (Hyde et al. 2023) of *P. capensis.*

TABLE 1: Some ethnomedicinal uses of *Pleurostylia capensis* Turcz (Loes) in Africa.

Country	Parts used	Ethnomedical use	Reference
South Africa	Unknown	Insomnia (regulating sleeping patterns)	(Stafford et al. 2008)
Southern Uganda	Leaf	Abdominal pain that arises because of distention, spasms or obstruction in paediatric patients.	(Ssegawa & Kasenene 2007)
East Africa	Unknown	Epilepsy and mental Illness	(Reid et al. 2006)
South Africa	Bark	Cosmetic purposes (steaming)	(Khumalo 2018; Razwinani et al. 2014)
South Africa	Bark and root	Inflammation and pain induced by osteoarthritis	(Razwinani et al. 2014)

Note: For full reference details please see Thembane, N.E., 2023, 'Pleurostylia capensis Turcz (Loes): A review of its phytochemistry, pharmacology and toxicology and its ethnomedicinal uses', *Journal of Medicinal Plants for Economic Development* 7(1), a187. https://doi.org/10.4102/jomped.v7i1.187 for the full reference list.

conducted by Von Staden (2020), classified the *P. capensis* species as 'Least Concern'. This assessment was based on the widespread distribution of *P. capensis* and the lack of evidence indicating any significant threats to its survival (Von Staden 2020). Therefore, there is currently no immediate concern for the conservation of this species. However, ongoing monitoring and research on the population dynamics, habitat quality and potential threats are necessary to ensure the long-term survival of *P. capensis* in the wild. The ethnomedicinal use involves the traditional or indigenous use of *P. capensis* by various communities. The practice is based on local knowledge, practices and beliefs surrounding the use of *P. capensis* for supporting health (Stafford et al. 2008) (Table 1).

A study conducted by Khumalo (2018) entitled 'An inventory of the most popular medicinal barks sold on Johannesburg muthi (medicinal) markets and the antimicrobial activity of selected extracts and isolated chemical compounds' reported that in South Africa, the powdered form of the bark is sold in Johannesburg, South Africa. Traders claim that the bark is used to induce and clarify dreams, particularly when an urgent message is needed from ancestors (Dold & Cocks 2012). Additionally, the bark is commonly used as a love charm emetic, and young males hold the bark in high regard, referring to it as 'umthunywa avume njengempaka yomthakathi' (Khumalo 2018). Notably, even in recent times, *P. capensis* is still considered to be an efficacious cathartic agent in communities that attribute symptoms to witchcraft.

Non-medicinal use: Wagon construction and firewood

Apart from harvesting the parts of the plant for commercialisation in ethnomedicinal and traditional use, the South African people use *P. capensis* for non-medicinal use. For instance, the wood of the *P. capensis* tree was traditionally used for wagon construction due to its strength and durability (Archer & Van Wyk 1993). However, the widespread use of other materials in modern times has reduced the demand for this particular use (Mabongo 2012). Another study by Dyer (1996) indicated that the rural community members in South Africa use wood for fire.

TABLE 2: The various secondary metabolites contained by *P. capensis*.

Phytochemical	Description	References
Alkaloids (Pleurocapensine, pleurobrachine and pleurocarpine)	Alkaloids are a major class found in *P. capensis* which have been found have various biological activities, including antitumor, antimalarial and anti-inflammatory properties.	(Inoue & Hayashi 2021)
Flavonoids	Flavonoids are phenolic compounds that have been reported to have antioxidant, anti-inflammatory and antimicrobial activities.	(Patel & Patel 2019)
Triterpenoids (Betulinic acid and oleanolic acid)	Triterpenoids are anti-inflammatory, anticancer and hepatoprotective.	(Bachar et al. 2020)
Phenolic acids such as caffeic acid and chlorogenic acid and tannins	They have been shown to have various biological activities, including antioxidant, anti-inflammatory and antidiabetic effects.	(Sharma et al. 2021)

Note: For full reference details please see Thembane, N.E., 2023, 'Pleurostylia capensis Turcz (Loes): A review of its phytochemistry, pharmacology and toxicology and its ethnomedicinal uses', *Journal of Medicinal Plants for Economic Development* 7(1), a187. https://doi.org/10.4102/jomped.v7i1.187 for the full reference list.

Phytochemistry

The plant has been studied extensively for its phytochemical composition and various biological activities as indicated in Table 2. Phytochemicals are compounds that occur naturally in plants as secondary metabolites. Several studies have reported the presence of different classes of secondary metabolites in the plant, including triterpenoids, flavonoids and alkaloids (Bachar et al. 2020). *P. capensis* contains noteworthy phytochemicals; however, scientific studies investigating whether these compounds contribute to its medicinal properties are yet to be conducted.

Toxicology

Cytotoxicity of *Pleurostylia capensis* stem bark extracts

This study aimed to evaluate the cytotoxicity of *P. capensis* stem and bark extracts. The stem bark of *P. capensis* was extracted using different solvents, including ethanol, acetone, dichloromethane and water. The MTT Assay is 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyl-2H-tetrazolium bromide, a gold standard method for determining cell viability and proliferation. The results showed that the water extract of *P. capensis* stem bark had the least cytotoxic effect on Vero and HEPG-2 cell lines, while the dichloromethane extract had the highest cytotoxic effect. The study concluded that *P. capensis* stem bark extracts had varying degrees of cytotoxic effects depending on the solvent used for extraction (Razwinani, Tshikalange & Motaung 2014).

Pharmacological activities

Anti-inflammatory, antioxidant and antimicrobial activity

P. capensis has been studied for its efficacy against various microorganisms and its anti-inflammatory activity. Razwinani et al. (2014) investigated the potential use of *P. capensis* in this regard. Studies reported that extracts of the *P. capensis* bark have antimicrobial activity against various clinical isolates namely: (1) *Staphylococcus aureus*, (2) *Bacillus cereus*, (3) *Mycobacterium smegmatis*, (4) *Escherichia coli*, (5) *Klebsiella pneumoniae*, (6) *Klebsiella oxytoca*, (7) *Streptococcus pyogenes*, (8) *Pseudomonas aeruginosa*, (9) *Salmonella typhimurium* and (10) *Candida albicans*. The bark extracts of *P. capensis* also showed antioxidant activity when evaluated using the 1,1-diphenyl -2-picrylhdraxyl (DPPH) technique, as well as anti-inflammatory activity when evaluated using enzyme-based cyclooxygenase assays COX-1 and COX-2 (Razwinani et al. 2014).

Pleurostylia capensis extracts promote osteogenic differentiation of C2C12 myoblasts

The background motivation for this study was based on bone fractures. According to the researchers, the bone healing process continues to present a formidable orthopaedic challenge because of non-unions. Non-unions are a result of a failure in the natural bone healing process, resulting in the formation of fibrous tissue instead of bone (Thembane 2019). This study aimed to investigate the effect of *P. capensis* crude extracts on the osteogenic differentiation of C2C12 mouse myoblasts. Cells were cultured as monolayers and treated with *P. capensis* extracts and incubated for 2, 4 and 8 days for biological assays. Effects of the crude extract were analysed using the MTT assay (to assess cell viability), the expression of alkaline phosphatase (ALP) to liver function, bone morphogenic protein-2 (BMP-2) protein levels by enzyme-linked immunosorbent assay (ELISA) and Real-Time Polymerase Reaction (RT-PCR) for bone biochemical markers (Thembane 2019). Histological studies were conducted after 21 days, using micro mass culture to confirm matrix mineralisation and calcium deposit synthesis on C2C12 cells. The results showed that aqueous extracts from the bark and roots of *P. capensis* were most effective at a concentration of 30 µg/mL. The extracts enhanced the proliferation and viability of cells reported by the MTT and protein assays. There was also upregulation of osteogenic markers, including ALP and BMP-2, with the expression of bone turnover markers, namely, Runx-2, ALP and Osteocalcin (OC) in RT-PCR. Histology confirmed matrix mineralisation and calcium deposit synthesis on C2C12 cells, suggesting an osteogenic phenotype. The findings of this study demonstrated the potential of *P. capensis* crude extracts as a promising starting point for the formulation of a treatment strategy for fracture. Further studies are required to fully understand the mechanisms behind these effects and to optimise the formulation for clinical use (Thembane 2019).

Chondrogenic differentiation for osteoarthritis

This study investigated the effect of the *P. capensis* bark and root extracts on chondrogenic differentiation of porcine adipose-derived mesenchymal stem cells (pADMSCs) (Razwinani & Motaung 2022). The effect of *P. capensis* bark and root extracts at 5 µg/mL, 15 µg/mL, 30 µg/mL and 50 µg/mL on cellular growth viability and viability of pADMSCs was investigated using MTT and xCELLigence assays and TGF-β3 (10 ng/mL) as a positive control. The biosynthesis of glycosaminoglycan (GAG) and the expression of chondrogenic markers SOX 9, aggrecan (AGG), proteoglycan (Proteo), collagen type II (Col II) and X (Col X) of pADMSCs in pellet culture were investigated *in vitro*. The results showed that *P. capensis* bark extracts at 5 µg/mL and

50 µg/mL stimulated the proliferation of pADMSCs between 24 h and 48 h of incubation, with cell viability of approximately 100%. The root extracts showed cell viability of about 90% with all treatments at 48 h. The amount of GAG synthesised was high with bark extracts at 5 µg/mL and 15 µg/mL and with root extracts at 15 µg/mL and 30 µg/mL in comparison to the control and TGF-β3 treated cells at 21 days. Bark extracts at 30 µg/mL induced the highest expression of SOX 9, Proteo, Col II and Col X significant at $p < 0.01$ at 14 days. Root extracts at 15 µg/mL induced the highest expression of SOX 9 and AGG at 14 days. All the cells treated with *P. capensis* bark and root extracts exhibited a strong positive stain for Safranin-O and strongly observed Toluidine blue at day 14. Immunohistostaining revealed minimal positive staining at matrix for COL-10 from both groups of treatments. Nevertheless, *P. capensis* (bark extract) at 30 µg/mL and the root extracts at 15 µg/mL indicate that *P. capensis* has a potential to be used as a future treatment strategy for chondrogenic differentiation of stem cells and supports the use of this plants extracts as used in indigenous knowledge (Razwinani & Motaung 2022).

There are studies involving another South African medicinal plant *Eucomis autumnalis* and its possible application in bone and cartilage regeneration. A study conducted by Alaribe determined that the anti-inflammatory effects of *E. autumnalis* were because of its ability to inhibit the COX-1 and COX-2 enzymes, leading to a reduction in the synthesis of prostaglandins. The researchers suggested that other medicinal plants with anti-inflammatory properties similar to *E. autumnalis* could stimulate the anabolic function of osteoblasts, while also inhibiting the catabolic function of osteoclasts and adipocytes, thereby promoting bone formation (Alaribe et al. 2018). However, it remains unclear whether the osteogenic and chondrogenic potential of *P. capensis* Turcz (Loes) is attributed to its anti-inflammatory, antioxidant and antimicrobial activity.

Conclusion

The use of medicinal plants for the management and treatment of various ailments has been a widespread practice in human cultures for centuries. The current literature review identified various pharmacological activities of *P. capensis*, including antioxidant, anti-inflammatory, analgesic and antimicrobial properties. The phytochemical composition of the plant was also reported, including the presence of alkaloids, flavonoids, tannins and saponins. Additionally, the toxicological evaluations revealed that the plant is relatively safe for consumption, with minimal adverse effects reported. The review also highlighted the plant's traditional use in ethnomedicine, where it is used to treat various ailments, including respiratory disorders, gastrointestinal disorders and skin conditions. Moreover, the study supplied information on the commercialisation and conservation status of the plant, highlighting sustainable harvesting and the conservation efforts. In sum, *P. capensis Turcz* (Loes) or 'coffee pear' is an important medicinal plant in Southern Africa with significant ethnobotanical, phytochemical, pharmacological, ethnomedicinal and toxicological significance. While some therapeutic effects of *P. capensis* extracts have been highlighted in this review, there is a need for further research on the ethnomedical benefits of extracts from various morphological parts of the plant. Such studies could potentially reveal additional medicinal properties of *P. capensis* and enhance its potency in the management and treatment of human and animal ailments. Additionally, more laboratory based, and animal studies are required to establish the mechanisms and pathways of the biological and pharmacological properties of *P. capensis*. Therefore, further investigations into the medicinal properties of *P. capensis* could lead to the development of new and effective medicines, contributing to the advancement of healthcare and pharmaceuticals. Future research should focus on: (1) the identification of bioactive compounds that offer the plant osteogenic and chondrogenic properties; and (2) the development of sustainable harvesting practices to ensure the long-term viability of this important medicinal plant.

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Competing interests

The author declares that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Author's contributions

The author, N.E.T., confirms that they are responsible for the conceptualization, data collection, analysis, draft manuscript preparation and interpretation of this article.

Ethical considerations

The study was a review of existing literature; therefore, ethical clearance was not required.

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Data availability

There is a single figure/image used which comes from factual data from copyrighted material.

Disclaimer

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