

REVIEW ARTICLE

Medicinal value of *Azadirachta indica*: A review

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Abstract

Nature has been a great source of therapeutic compounds. The use of plants and plant-derived products as medicine has been a popular tradition as the beginning of human civilization. Plants are considered as the richest source of traditional and modern medications as well as food supplements, pharmaceutical intermediates and chemical entities for synthetic drugs. Among them, *Azadirachta indica* is one of the most versatile, multitudinous tree having immense potentials. Since Vedic times, it has been known as the multi-directional therapeutic uses in India. It is economically cheaper and safe and its different parts such as leaves, flowers, bark, fruits, gum, seeds, oil possesses great medicinal properties. The aim of this review is to assemble all the information regarding the distribution, botanical description, commercial and medicinal values of *Azadirachta indica*. This paper is fully based on secondary data. Information was gathered from about 28 published articles from various online portals and these gathered information is analyzed and presented well here in this paper. *Azadirachta indica* is commonly known as 'Neem' which is regarded beneficial to humans and animals. Different parts of neem has been used for treating various diseases such as cancer, Dental diseases, stress, ulcers, heart diseases, malaria, skin diseases, viral diseases, AIDS, oral diseases, sexually transmitted diseases, etc. Chemically diverse and structurally complex phytochemical constituents such as azadirachtin, nimbinin, nimbidin, gedunin, nimbidol, Quercetin, gallic acid, glycoside, amino-acid, ascorbic acid, salannin and many others are found in *Azadirachta indica* which show anti-diabetic, anti-viral, anti-oxidant, anti-microbial, anti-parasitic, anti-malarial, anti-cancer, anti-ulcer, hepatoprotective and gastro-protective activities. Thus, more attention must be given for the production of this plant.

Keywords: *Azadirachta indica*, neem, distribution, propagation, medicinal property, phytochemistry.

Introduction

Nepal is a small country having diversified plant species with a great source of medicinal values. Thousands of species having medicinal properties are distributed in different parts of the country. Out of 7000 species of plants having medicinal value found all over the world, more than 900 kinds of valuable medicinal plants are found in Nepal. Since ancient times, these medicinal plants have been used to heal a variety of ailments. Different active constituents are extracted from various parts of the plants which are used to make herbal medicines. These herbal medicines are still the centerpiece of about 75%-80% of the total population in the traditional therapy (Joshi et al., 2010). Among different medicinal plants, *Azadirachta indica* is the most important and valuable medicinal plant.

Azadirachta indica is commonly called as 'Neem' that belongs to family Meliaceae (Dubey and Kashyap 2014).

(Kharwar et al. 2020 ; Pandey et al. 2014) reported that the neem is a fast growing evergreen tree originated from the Indian Sub-continent. Neeb in Arabic, Margosa tree in English, Nimba in Ayurvedic, Neem in Nepali, Arishta in Sanskrit and Azadarachte in Hindi are some of the vernacular names for this plant (Ahmad et al. 2014). In Sanskrit, Neem means 'Arishtha' that symbolizes complete, perfect and imperishable. Also, Arishtha means 'Reliever of sickness' (Pandey et al. 2014). According to Hindu Mythology, the Aryans considered that there was a divine origin of the neem tree. It was said that when Amrita was transported to heaven by Garuda, and a few drips of Amrita dropped on the neem tree. Also in another story, when Indira sprayed the Amrita on Earth, then the neem tree became arise. It was also regarded as the gift of god and was related to Dhanvantri (the Aryan god of medicine) (Puri 2005).

(Yadhav et al. 2016) reported that neem is considered as a holy tree which grows upto 15 m-20 m in height and lives more than 150-300 years. It has been well suited in different topographic ranges, climatic conditions and edaphic factors (Ogbuewu et al. 2011). In the 21st century, it is the most valuable and researched tree in the global context and naturally grows well at the altitude upto 1500 m. It prefers the wide range of temperature 0-49 degree Celsius and rainfall the range of 450 mm to 1200 mm. It grows well in stony shallow soil, dry soil, less water-logged areas and well-drained soils with the pH range of 4 to 10 (Ogbuewu et al. 2011). It is mostly cultivated for ornamental purpose and often for shade than for the production of timber (Visvanathan et al. 1995).

Different parts such as flowers, leaves, fruits, roots, seeds and bark of the neem have medicinal property. Since the time immemorial, the neem has been employed in Ayurveda, Siddha, Unani, Polyherbal preparation called 'Panchang' in Ayurveda and Homoeopathic medicine and now it has been used in preparation of modern medicine, different cosmetics, pharmaceuticals and toiletries (Bhowmik et al. 2010 ; Puri 2005). Different chemical constituents are extracted from various portions of the neem plants including azadirachtin, alkaloids, phenolic compounds, triterpenoids, ketones, flavonoides, volatile oils, carotenoids and salannin which shows different pharmacological actions such as anti-malarial, anti-inflammatory, antipyretic, anti-cancer, anti-filarial, anti-ulcer, anti-microbial, hepatoprotective and analgesic (Kharwar et al. 2020 ; Hashmat et al. 2012). (Bhowmik et al. 2010 ; Biswas et al. 2002) reported that various parts of neem have been utilized to manufacture different Ayurvedic as well as modern medicine to cure various diseases such as skin diseases like psoriasis, acne, eczema, leprosy, dandruff, wrinkles rashes, viral diseases like chicken-pox, wart and smallpox, healing of wounds and

cuts, sprains, headaches, fevers, intestinal helminthiasis, constipation, respiratory disorders. It is also effectively works as a mosquito repellent.

Literature Review

The entire paper is fully based on secondary data. The required information for this paper was extracted from about 28 published articles. Various online portals like Research gate and Google Scholar were used to search and download published articles. The keywords such as *Azadirachta indica*, Neem, Distribution, Propagation, Medicinal Property, Phytochemistry were used to search articles. Various researched articles about the pharmacological, ethnomedicinal, phytochemical extraction, biological activity and medicinal properties of *Azadirachta indica* were found. In this review article, information on the taxonomy, distribution, botanical description, phytochemical analysis, medicinal properties and commercial values of the species were gathered, examined, analyzed, assembled, structured and presented scientifically. This methodology is illustrated in detail with the help of Prisma flowchart in Fig. 1.

Results and Discussion

Table 1. Taxonomy of *Azadirachta indica* (Uzzaman, 2019).

Kingdom	Plantae
Sub-kingdom	<i>Tracheobionta</i>
Division	<i>Magnoliophyta</i>
Class	<i>Eudicot</i>
Subclass	<i>Rosidae</i>
Order	<i>Sapindales</i>
Family	<i>Meliaceae</i>
Genus	<i>Azadirachta</i>
Species	<i>A. indica</i>

Distribution of *Azadirachta indica*

Azadirachta indica is originated from East Indian

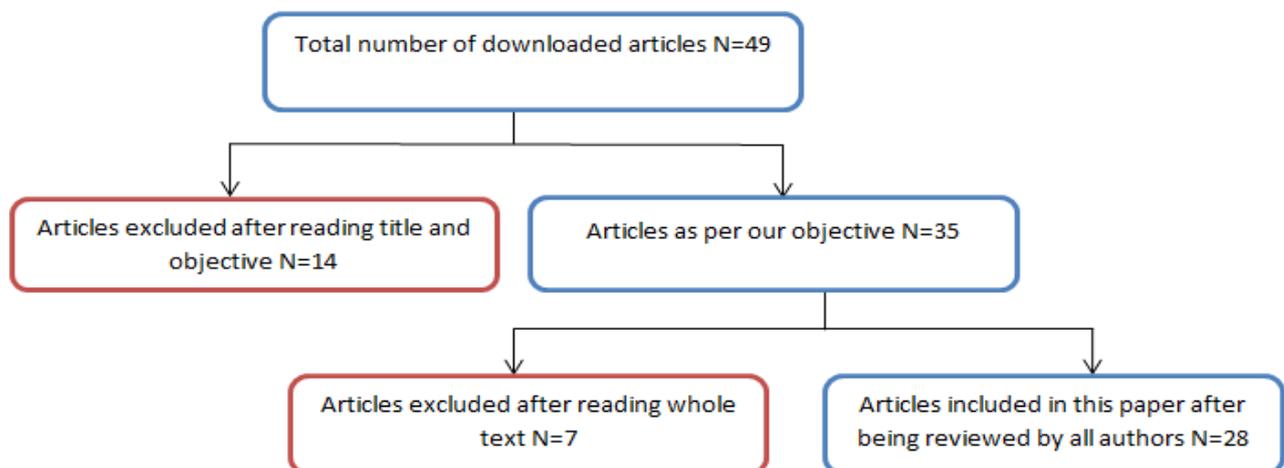


Figure 1. Prisma Flowchart for the study of Medicinal Values of *Azadirachta indica*.

Sub-Continent and Burma (Hashmat et al. 2012) (Fig. 1). Nowadays, it is widely distributed in different Asian, African, Australian and American countries (Tinghui et al. 2001). Neem is widely planted in different Asian countries such as India, Nepal, Thailand, Cambodia, Indonesia, Srilanka, Burma, Pakistan, Bangladesh and Vietnam (Tinghui et al. 2001). In Nepal, it is planted in a vineyard and in the wild of different regions of Terai and Inner terai at an altitude of 900 m. It is extensively cultivated in the dry western part of terai than in the wet eastern area (Karki and Karki 1993). In India, it is widely distributed in the dry forest of Andra Pradesh, Karnataka, Siwalik Hills and Tamil Nadu upto an elevation of 700 m (Hashmat et al. 2012). Commonly, it is planted in the roadside for shading in India. More than 60% of the total population of neem is cultivated in different parts of India (Tinghui et al. 2001). In continental Africa and Mauritius and American countries, people from India raised neem tree. The abundant amount of neem is planted in African countries such as Senegal, Guinea, Ghana, Mali, Mauritania, Nigeria, Ethiopia, Kenya, Sudan, Tanzania, Somalia and Mozambique. Also, it is widespread in Central and South America and countries named as Guyana, Tobago, Jamaica, Suriname, Dominican, Mexico, Bolivia, Brazil, St. Lucia (Tinghui et al. 2001). A large amount of neem trees are planted in Malaysia and Philippines too (Sultana et al. 2011). (Djibril et al. 2015) reported that the population of 18 to 30 million of neem trees in Senegal.

Neem is a wide adaptability plant found in tropical and subtropical region of the world (Tab. 1). It is grown in the plains at an elevation of 1850 m (Bhowmik et al. 2010). It grows well in well-drained, shallow, dry, lateritic crusts, stony, sandy, clayey, highly leached soils at the annual mean temperature of 21-32 degree Celsius. It prefers areas having sub-humid to sub-arid conditions at the annual rainfall between 400 m to 1200 m (Bhowmik et al. 2010).



Figure 2. Tree of *Azadirachta indica*.

Botanical Description of *Azadirachta indica*

Azadirachta indica is one of the multifunctional fast growing evergreen tree, but often it becomes deciduous due to extreme weather conditions (Chaguthi et al. 2018; Sultana et al. 2011). It grows upto 12 m-18 m in diameter and the girth of the stem is 1.8 m-2.4 m (Quraishi et al. 2018 ; Sultana et al. 2011). Hard and woody bark of the neem plant which is composed of secondary phloem and dark grey and reddish brown in colour having several longitudinal and oblique furrows and scattered tubercles (Chaguthi et al. 2018 ; Tewari 1993). Leaves are imparipinnate, compound, alternate and opposite having leaflets 8 cm-19cm long (Quraishi et al. 2018; Hashmat et al. 2012; Subapriya and Nagini 2005). The leaflets are acuminate apex, lanceolate and serrate margin (Sultana et al. 2011)(Fig. 2). Flowers of the neem are numerous, fragrant and beautiful (Nicoletti and Murugan 2013) and aromatic (Chaguthi et al. 2018), bisexual in nature and pale yellow and white in colour (Quraishi et al. 2018). The time of flowering season is spring (Rahmani et al. 2018) between March and April (Hashmat et al. 2012). Fruits are green in colour in unripen phase and becomes yellow to brown colour having bitter taste when becomes mature (Chaguthi et al. 2018) and smooth, small and oblong fruits called Niboli (Quraishi et al. 2018). The ripening of fruits occurs between June to August (Nicoletti and Murugan 2013). A large number of ovoid-shaped oil seeds having diameter of 1 cm-2 cm are found in neem (Chaguthi et al. 2018). (Quraishi et al. 2018; Sultana et al. 2011) reported that the axillary inflorescence, imbricate calyx, polypetalous, short cylindrical stigma, elongated style occurs in the neem plant.



Figure 3. Leaves of *Azadirachta indica*.

Phytochemical Analysis of *Azadirachta indica*

Various research papers revealed that neem is the most versatile and valuable plant that is made up of different kinds of phytochemicals which are very useful to make different medicines for treating various diseases (Fig. 3). Different portions of neem such as leaves,

bark and seeds are used to extract over 140 compounds (Bhowmik et al. 2010). Leaves of neem plant consists of different chemical constituents such as cyclic trisulphide, nimbin, nimbandiol, nimbanene, cyclic tetrasulphide, ascorbic acid, 6-desacetyl nimbinene, sulfur compounds, polyphenolics such as flavonoids, tannins and different amino acids (Uzzaman 2019; Rahmani et al. 2018). Chemical compounds such as Polysaccharides GIa, GIb, Gallic acid, catechin, NB-II peptidoglycan, polysaccharides GIIa, GIIa, epicatechin and margolone are isolated from the bark of neem plant. Similarly, neem seed consists of oil and chemical constituents such as nimbin, Gedunin, Nimbidin, Nimbolide, Mahmoodin (Uzzaman 2019). Hexane, ethanol, petroleum ether, alcohol, acetone are also extracted from the seeds of neem (Lloyd et al. 2005). (Djibril et al. 2015) reported that seeds of neem contains dry matter, lignins, cellulose, lipids, hemicellulose, proteins, hydrosoluble components, minerals, Azadirachtin. Also, study suggested that seed of neem contains 43.28% of parietal constituents, 29.27% of lipids and 12.10% of proteins. Fatty acids such as (8%-16%) of linoleic acid, (13%-15%) of palmitic acid, (50%-60%) of oleic acid, (14%-19%) of stearic acid, dodecanoic acid, eicosanoic acid and tetradecanoic acid are found in neem seed (Shrirangasami et al. 2020; Djibril et al. 2015; Nicoletti and Murugan 2013). (Shrirangasami et al. 2020) reported that the heartwood of neem consists of potassium, iron salts and calcium and 30% of Charcoal and 38.4% of pyroligneous acid are obtained from the heartwood through the destructive distillation process.

Natural Regeneration

The abundant amount of seeds are produced in the neem tree. In neem tree, natural regeneration occurs through dispersal of seeds by rodents, birds and humans (Chinnamani 1993). Apart from by seeds, it also naturally regenerates through root suckers and coppice. Fruits of neem are ripening during the rainy season and it falls up from the tree on the ground and germination lots of seedlings. Seeds are dropped out rapidly after 2 weeks because of its less durability. Natural regeneration of neem can be done in such areas which is degraded, in forest and farmers' field (Chinnamani 1993). Once the seedlings are germinated on the ground, it becomes hard to remove (Tewari 1993).

Artificial Regeneration

Artificial regeneration is the most reliable method to reduce the variability and also to increase the production capacity of neem. It is mostly done through vegetative propagation technique, including grafting, stem cutting, root cutting and stump cutting (Gehlot et al. 2014). Among these vegetative propagation method, the most

key method to reproduce a plant is stem cutting. In vegetative propagation, plants are taken from the natural population to increase the elite trees with high genetic similarity. The growth rate and development of cutting rely on age variation, season, diameter of stem, moisture level, temperature, the growing media and nutrient status. Mostly, healthy, well-matured, robust and young shoots with feasible buds are taken for the cuttings (Gehlot et al. 2014). (Tiwari 1993) reported that direct sowing and polypot seedlings are also used to establish the neem plant, in addition to vegetative propagation. Root-shoot cutting and polypot seedlings are more applicable for silvi-pastures, agroforestry and roadside avenue plantations.

Traditional Medicinal Value

India is the native country of neem. It is used commercially from over 4000 years BC. Since Vedic period, it has been used in India because of its anti-viral, anti-fungal, anti-diabetic, anti-bacterial, contraceptive, anthelmintic and sedative properties (Chaguthi et al. 2018; Nicoletti and Murugan 2013). Various chemical constituents are found in different parts of neem such as leaves, bark, seeds, roots, fruits have been utilized in the Indian Unani, Siddha and Ayurvedic of medicines (Bhowmik et al. 2010; Joshi et al. 2010) (Fig. 4). In Hindu culture, the use of medicinal plants was started in between 4500-1600 BC in 'Rigveda' (Joshi et al. 2010). In Indian rural communities, it is used for many diseases so called as 'Village Pharmacy' (Nicoletti and Murugan 2013). In Nepal, mainly in remote areas like Humla, Doti, Jumla and Dadeldhura utilized various parts of neem for curing different diseases such as asthma, dental disorder, inflammation and indigestion due to scarcity of doctors, medicines and high expenses (Joshi et al. 2010). Neem twigs consist of anti-septic property which is used as toothbrushes for dental care and prevents from tooth decay, infection and sore gums (Bhowmik et al. 2010). (Sultana et al. 2011) reported that the indigenous people from village Pethi (Punjab) used the neem plants for 2-3 weeks regularly at the roots of hair to clean hair and kill lice by mixing of an equal amount of 10 g fruits powder and 10 ml seed oil. Also, dried part of the leaf in powder form mixed with 2-5 drops of rose extract by the local woman from salt range (Punjab) to remove freckles on the face. Dried leaves are soaked in water for a night in an earthen pot and daily consumption helps to cure hepatitis and to reduce Alanine Aminotransferase (ALT) with no side effects. In a similar way, Punjabi people also used branches as a toothbrush, leaves used to heal wounds and for facial mask to raise the beauty of girls and women. In Sindh, leaves are taken to make fresh juice for reducing blood sugar level and for purifying the blood

(Sultana et al. 2011). (Brahmachari 2004) reported that leaves, flower, twig, bark, fruits, gum, seed pulp, oil and root are used to extract as folk medicine in the treatment of such diseases like eye problems, skin ulcers, leprosy, anorexia, removal of intestinal worms, bile suppression, asthma, urinary disorder, hemorrhoids, diabetes, cough, wounds, ringworm, etc.



Figure 4. Bark of *Azadirachta indica*.

Medicinal Value of *Azadirachta indica*

Several researched papers revealed that *Azadirachta indica* has a great medicinal property in treating various diseases from ancient time. Almost all parts of neem plant are advantageous in the life of mankind (Dubey and Kashyap 2014). Plant parts such as leaves, flowers, fruits, barks, seed pulp, twigs, seed oil, gums have different chemical compounds such as alkaloids, saponins, phenolic compounds, glycosides, tannins, steroids and flavonoids which shows medicinal properties for curing different diseases (Pandey et al. 2014; Biswas et al. 2002). It shows the activities such as anti-bacterial, anti-inflammatory, anti-fungal, anti-arthritic, anti-neoplastic, anti-pyretic, anti-filarial, anti-tumor, anti-malarial, anti-cancer, anti-oxidant, anti-hypertensive, anti-viral, anti-bovine, anti-diabetic, anti-typanosomal, anthelmintic (Singh 2019; Dubey and Kashyap 2014). Neem leaves have many health benefits. Diseases such as leprosy, intestinal worms, eye problem, skin diseases such as skin ulcers, acne etc, biliousness, epistaxis, anorexia etc has been treated with the extraction of neem leaves (Singh 2019; Biswas et al. 2002). In addition to, it is very effective against certain fungi such as *Microsporum*, *Trichophyton*, *Trichosporon*, *Candida*, *Epidermophyton* and *Geotricum* (Subapriya and Nagini 2005). Leaves also used as anti-bacterial and anti-microbial agent against both gram negative and gram positive organisms and other human and animal diseases causing bacteria such as *E. coli*, *Salmonella*, *Streptococcus* (Dubey and Kashyap 2014). Leaves help in increasing the immune system and

also in the protection of liver from damage (Singh 2019; Dubey and Kashyap 2014). (Dubey and Kashyap 2014) reported that in the early morning, taking off 8-10 leaves of neem for about 24 days helps the body protecting from diseases such as hypertension and diabetics. Bark of neem is bitter, cool, astringent, refrigerant and acrid in nature (Bhowmik et al. 2010). It is beneficial for treating diseases such as malaria, cough, fever, intestinal ulcers, pain, worm infestation, skin diseases and diabetes (Singh 2019; Bhowmik et al. 2010). (Singh 2019; Biswas et al. 2002) reported that flower of the neem plant has been used to treat anorexia, removal of intestinal worms, bile suppression, nausea, phlegm and bleaching. Fruits of neem are also bitter and purgative in nature and acts as anti-hemorrhoids and anthelmintic and helps to treat diseases such as urinary disorder, phlegm, intestinal worms, eye problems, wounds, epistaxis and leprosy (Bhowmik et al. 2010; Biswas et al. 2002). Twigs of neem is used as natural toothbrushes, which helps to fight against germs and in saliva it helps to maintain the alkaline level, treat swollen gum and make the teeth whitish in colour (Bhowmik et al. 2010). Similarly, seeds of neem is used to treat diseases such as the leprosy, powder form in reducing sugar level, killing intestinal worms, for birth control and oil is used as a facial oil which treats acne, pimples and other skin diseases and chemical constituents such as palmitic, oleic and linoleic acid in oil helps to the glowing and healthy skin (Singh 2019). (Subapriya and Nagini 2005) reported that the oil from the leaves also shows anti-bacterial property and used against gram positive and gram negative microorganisms such as *M. tuberculosis* and *Streptomycin*. (Ahmad et al. 2014; Sultana et al. 2011) reported that the extraction of neem plant parts has been used to treat diseases such as amenorrhoea, conjunctivitis, fatigue, jaundice, leucoderma, paralysis, snake bite, toothache, atonic dyspepsia, hemiplegia, scorpion sting, leucorrhoea, rheumatism, hepatitis, etc.

Commercial Value

Neem plants parts such as leaves, flowers, roots, branches, seeds and trunks have various applications (Bhowmik et al. 2010). Several industries such as pharmaceuticals, disinfectants, biopesticides, cosmetics, textiles and rubber industries have set up to use neem different parts for manufacturing different products (Kumar and Bhat 2008). NeemAura is the first company to create ecologically certified neem leaf goods like toothpaste, hand and body lotion, cream, neem herbal spray and soap (Yadhav et al. 2016). India itself produces a wide range of neem products including agricultural products, soap and veterinary goods which are utilized in India as well as other Asian and African countries (Yadhav et al. 2016). The wood of neem is used to manufacture

furniture and is quite durable. Because heartwood is robust and long lasting, it is used to construct buildings, cart wheels, agricultural implements, boats and other items (Singh 2019; Kumar and Bhat 2008). Leaves and bark of neem is used to manufacture different cosmetics, insecticides, fertilizers, pesticides, health care products, medicines, dental care products like toothpaste (Singh 2019; Bhowmik et al. 2010; Kumar and Bhat 2008). Neem leaves can also be used to keep insects away from woolen and silk garments that are being preserved (Bhowmik et al. 2010). Bark of neem contains gums and tannins which are employed in tanning and coloring processes (Bhowmik et al. 2010). Neem oil is used to manufacture different insecticides, fungicides, veterinary medicines, cosmetic products, propellants, soaps, hair oils, shampoos, toothpaste and other health care goods (Singh 2019). Neem cake is used as natural insecticide, soil fertilizer, soil neutralizer, soil moisturizer and cattle feed (Ogbuewu et al. 2011; Kumar and Bhat 2008). In India and Europe, neem-based toothpaste is commonly used (Ogbuewu et al. 2011). In the fermentation industry and for methane gas production, neem seed pulp is employed as high-carbohydrate sources (Kumar and Bhat 2008). (Singh 2019) reported that toothbrushes made from the twigs of the neem are also used for dental hygiene.

Conclusions

Azadirachta indica, commonly known as 'Neem' is the most versatile and multifunctional tree used in various industries such as pharmaceuticals, disinfectants, biopesticides, cosmetics, textile and rubber industries. Different chemical compounds are extracted from its parts are used to treat diseases such as leprosy, intestinal worms, eye problems, skin diseases, paralysis, jaundice, dental diseases, viral diseases, etc. It is recognized as uncountable and more valuable gift to living forms in the ecosystem. Various researches have been carried out till now about its traditional uses, distribution, therapeutic uses, propagation and commercial importance. But so little research has been done on the biological activity and potential medical application of chemical constituents. In the 21st century, the global landscape shifts towards the use of non-toxic plant products having therapeutic uses, also the development of modern neem medications for the treatments of a variety of ailments should be prioritized. So, further research work should be undertaken on neem and its products for their better economic and therapeutic utilization.

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