REVIEW ARTICLE

Primary Hyperhidrosis: A Review of Epidemiology, Pathophysiology and Management

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Primary hyperhidrosis is termed as excessive sweating exceeding the physiological needs of thermoregulation. This review provides an updated overview focusing on epidemiology, quality of life, pathophysiology, economic impacts, diagnostic approaches and current management strategies. A literature search was conducted in June 2026 across PubMed and the Cochrane Central Register of Controlled Trials. Additional references were identified through manual searches of relevant bibliographies. Reported prevalence of hyperhidrosis varied widely, likely reflecting differences in methodology and disease recognition. Primary hyperhidrosis is associated with autonomic dysregulation involving sympathetic pathways. Emerging evidence suggests that molecular alterations in eccrine glands may represent secondary adaptations to sustained cholinergic stimulation, while genetic variability in receptor expression may contribute to interindividual differences in disease severity. Hyperhidrosis has a strong negative impact on the economy and quality of life, adversely affecting both mental and physical health. Multiple treatment options are available, including topical therapies, systemic agents, device-based interventions, botulinum toxin injections and surgery. Despite increasing recognition of the clinical burden, comprehensive economic evaluations remain limited, with indirect costs and long-term societal impact insufficiently characterized. In conclusion, primary hyperhidrosis imposes a substantial burden on affected individuals, requiring improved recognition, standardized diagnostic frameworks and individualized management strategies supported by high-quality and longitudinal research.

Key words: primary hyperhidrosis; quality of life; cholinergic dysregulation; treatment strategies; economic burden; diagnosis and management.

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SIGNIFICANCE

Primary hyperhidrosis is a common and burdensome condition that remains incompletely understood and insufficiently recognized. Despite growing evidence, substantial gaps remain in understanding disease mechanisms, diagnostic consistency and broader clinical and societal impacts of the disease. Future research should therefore focus on harmonizing diagnostic and outcome measures, clarifying underlying mechanisms and incorporating long-term and economic perspectives to improve patient care, disease recognition and evaluation of interventions.

Hyperhidrosis (HH) is a condition characterized by excessive sweating, more than physiologically necessary for thermoregulation. HH is defined as either a primary idiopathic form (PH), or a secondary form (SH) caused by an underlying medical condition. PH is either focal or multifocal (1), with the latter reported being most common (2). In SH, excessive sweating is more often generalized, affecting large areas of the body, although it can also occasionally be focal (3). This review aims to provide an overview of PH, emphasizing the most clinically relevant aspects regarding epidemiology, clinical manifestations, diagnostic approaches and current management strategies.

MATERIALS AND METHODS

MEDLINE (PubMed), and Cochrane CENTRAL, from January 2005 to June 2026 were searched. In total, 779 studies were screened following the searches, of which 83 were selected for full-text review. Full search strings, limits and detailed steps together with outcomes are provided in Tables SI–SIII.

Synthesis Without Meta-Analysis (SWiM) checklist was performed due to substantial heterogeneity in interventions, outcome measures (HDSS, gravimetry and QoL) and follow-up duration.

Where feasible, standardized responder definitions (≥2-point improvement in Hyperhidrosis Disease Severity Scale, HDSS) were used as the primary outcome measure. For studies reporting gravimetric outcomes, ≥50% reduction in sweat production was considered clinically meaningful. In the absence

of comparable quantitative outcomes, results were synthesized narratively, considering the direction and magnitude of effects, as well as study quality. Heterogeneity was explored based on treatment characteristics (dose, formulation), study design, baseline disease severity, follow-up duration and risk of bias. Risk of bias was assessed using the Cochrane RoB2 tool for randomized trials, and findings were interpreted narratively considering study quality and heterogeneity. Studies were primarily grouped according to treatment modality (Topical treatments, Systemic treatments, Iontophoresis, Minimally invasive treatments, Botulinum toxin injections and Surgical interventions) and further stratified by anatomical site (axillary, palmar/plantar, craniofacial). For non-interventional domains findings were summarized using structured narrative synthesis.

RESULTS

Prevalence of PH

A total of 18 studies were identified, 14 using questionnaire surveys, 3 retrospective or prospective cohorts and one using interviews. Sample size ranged from 253 to 2,513,860 participants, and 6 studies included participants<18 years. A detailed summary of prevalence for HH and PH is provided in Table SIa. Search Strategy for Prevalence of HH and Table SIb. The Prevalence of HH and PH.

The prevalence of HH varied, ranging from 0.7% to 20.3%, whereas the prevalence of PH ranged from 0.9% to 20.6% (4–21) globally. Most studies focused on reporting HH prevalence rather than PH or SH prevalence. Variability in reported prevalence was mainly attributed to factors such as limited disease awareness among participants, geographical and cultural differences, variations in participants' age ranges and differences in research methodologies. Population studies suggested that HH is equally prevalent in both sexes (6, 11, 12), and that PH usually starts in childhood or adolescence, whereas generalised hyperhidrosis, which is often associated with secondary causes, becomes more common with increasing age. The axillae are the most affected sites in PH, followed by the palms and soles (2). Other areas with a high density of eccrine glands, such as the face, scalp, back and groin, could also become affected, although the prevalence of PH in these anatomical regions remains less well established.

Cause and pathophysiology

Unlike most organs innervated by sympathetic adrenergic fibres, the sweat glands are innervated by sympathetic cholinergic fibres. Thus, a mechanism for PH has been attributed to an overactivity in the cholinergic sympathetic nerves (22). However, studies investigating the autonomic nervous system (ANS) with heart rate variability in PH indicate a more complex autonomic dysregulation, involving peripheral overstimulation of the eccrine glands, rather than central sympathetic overactivity originating in the hypothalamus (23). Although no structural abnormalities in eccrine glands (24) or single conclusive genetic traits have been identified as causes for PH (25), a positive family history has been reported for up to 65% of affected individuals (25). Interestingly, recent studies have demonstrated upregulation of acetylcholine and the α7 nicotinic receptor subunit in the sympathetic ganglia and the eccrine glands of PH patients, supporting a peripheral cholinergic mechanism in the pathophysiology of PH (26, 27).

Comorbidities and concurrent diseases

The comorbidities associated with PH are primarily psychological, although various medical and dermatological conditions have also been reported. Psychological disorders in PH include depression, anxiety (notably social anxiety) and heightened stress, which are well-established comorbidities and affect above 10% of individuals with PH (28–30). There are also indications that conditions such as Impostor phenomenon, low self-compassion and perfectionism are highly prevalent in PH (31). In a multicentre study from 17 countries by Schut et al., symptoms of Body Dysmorphia were most common in PH (46.2%) compared to other dermatological conditions, with the highest OR of 27.73 (95% CI 11.04–69.65) relative to healthy controls (32). Concurrent dermatological diseases include atopic dermatitis and hand eczema (30), acne (33) and dyshidrotic eczema (34). Secondary cutaneous complications such as dermatophytosis, onychomycosis and viral warts are coexisting conditions rather than true comorbidities, as the moist microenvironment facilitates the growth and persistence of these pathogens (35). While certain medical conditions, such as migraine (30) may occur concurrently with PH due to a background of autonomic dysfunction, no causal or epidemiological association between the two conditions has been established. In a study by Henning et al. investigating patients with hospital contacts in Denmark between 1994–2018, the most diagnosed morbidity in PH was pain in the abdomen and back, while in general HH, pain in the back and angina pectoris were the most common morbidities (36).

Quality of life (QoL)

A total of 55 studies between the years 2005 and 2025 were identified. The majority (*n*=38/55; 69%) were interventional pre–post studies, followed by retrospective, cross-sectional or epidemiological design

(*n*=14/55; 25%) and qualitative studies (*n*=4/55; 7%). Sample sizes ranged from 10 to 5,000 participants, and most studies used more than one quality-of-life (QoL) assessment tool. The most frequently used instruments were the HDSS (*n*=38; 68%) and the Dermatology Life Quality Index (DLQI) (*n*=26; 47%), followed by the Hyperhidrosis Quality of Life Questionnaire (HQLQ) (*n*=7; 12.5%), Short Form Health Surveys (SF-36/SF-12) (*n*=6; 11%), Children's Dermatology Life Quality Index (CDLQI) (*n*=5; 9%), Visual Analogue Scale (VAS) (*n*=4; 7%), interviews (*n*=4; 7%) and the HidroQoL© (*n*=3; 5%). A detailed summary of the search and the studies are provided in Table SIIa. Search strategy for quality of life in PH & Table SIIb. Quality of life in PH.

Sweating in PH reinforces feelings of emotional distress, social anxiety, embarrassment and stigma in a feedback loop, amplifying the psychological and physical burdens experienced by patients (37–89). These experiences have a negative impact on QoL, affecting the psychological health of individuals, and are equal to or greater than those of other inflammatory dermatological diseases, such as psoriasis and eczema (37). Anxiety, depression and feelings of stress were the most common psychological factors affecting QoL in adolescents and adults with PH (38–46). School activities, hobbies, being in public, meeting people, attending family occasions, shaking hands, developing relationships, participating in sports, having reserve stashes of clothes, leaving sweat marks and spending time on treatments were the most common problems associated with PH and negatively affecting QoL (38–41). The majority of QoL data in studies regarding PH was collected before and after interventions: ETS (endoscopic thoracic sympathectomy) (45, 47–55), Botulinum toxin injections (42, 44, 46, 56–66), thermolysis (67–75), anticholinergics (76–85) and iontophoresis (86), reported to improve the QoL in affected patients. Studies reporting QoL, without interventions, were cross-sectional (7, 8, 12, 16, 43), retrospective (37, 87, 88) or qualitative in design (38–41).

Finally, another important factor affecting QoL in patients with PH is access to healthcare and the availability of effective treatments. Stigma associated with PH, limited awareness of HH and insufficient knowledge and support within healthcare systems discouraged patients from seeking medical care and hindered access to appropriate treatment (39–41) which had negative effects on mental health and QoL.

Economic burdens

Existing evidence indicates that PH imposes significant economic burdens through direct medical costs, nonmedical expenditures and reduced productivity for the individual. However, the true magnitude of HH is underestimated due to limited data on indirect and patient-borne costs. A targeted literature review by Oshima et al. (2023) showed that among studies reporting economic data, hospital-based care and procedural treatments (mainly botulinum toxin) accounted for the largest share of direct medical costs associated with HH (89).

Direct non-medical costs have been described including frequent cloth replacements, laundry and dry-cleaning costs, continuous need of absorbent materials and over-the-counter antiperspirants, rarely captured in administrative healthcare datasets (90). Finally, a study regarding primary palmar hyperhidrosis (PPH) reported an average loss of approximately 7% in work productivity, representing a measurable economic impact for both employers and patients (91).

Recognition and diagnosis

Diagnosis in PH is primarily clinical, with Hornberger's criteria (92) being the most cited and used in clinical practice. The most reported outcome measure tools in clinical settings are the Hyperhidrosis Disease Severity Scale (HDSS) (93) and the Hyperhidrosis Quality of Life Index (HidroQoL©) (94). While HDSS captures the severity of HH in terms of interferences with daily activities, HidroQoL© examines a broader spectrum of HH impacts, including psychosocial and emotional effects. Objective methods, such as the starch–iodine (Minor) test, is both simple and relatively quick for visualizing sweating areas. Whereas gravimetry, which quantifies sweat production, can be time-consuming and difficult to use in clinical practice. No consensus exists on the gravimetric threshold for PH because results vary with collection methods, measurement duration, anatomical site and environmental conditions. Consequently, gravimetry is often used in research or pre-treatment assessment rather than for a diagnosis. In a study by Stefaniak et al. (2013) which evaluated 343 individuals with PH and 220 healthy controls, the thresholds for axillary hyperhidrosis (AH) and PPH were reported as 42 mg/min/m² and 18 mg/min/m², respectively (95). A review by Thorlacius et al. (2015), analysing 27 studies reporting gravimetric data for AH (*n*=1,466), PPH (*n*=173) and a control group (*n*=75), suggested a gravimetric sweat rate>100 mg/5 min (>20 mg/min) as a cut-off for distinguishing AH and PPH from normal physiological sweating (96).

Common treatments for PH

While several treatment options are commonly used for PH, the strength of evidence supporting these approaches varies, and high-quality comparative data are limited. The following sections summarize treatments by category.

Topical treatments. Topical antiperspirants contain mainly aluminium compounds. Aluminium chloride hexahydrate is the most common and effective compound, recommended for mild-to-moderate PH, and a first-line treatment option in AH, PPH and plantar hyperhidrosis (PlH) (1, 93). The treatment is applied nightly to dry skin for 6–8 h and tapered to once weekly as symptoms improve, typically after 1 week. Miliaria and irritant dermatitis are the most common side effects, often dependent on exposure and dosage (97–99). In 3 comparative clinical studies (97–99), topical aluminium chloride (AC) demonstrated high efficacy in the treatment of PH. Aluminium salts consistently improved sweat severity scores and patient-reported outcomes, confirming their role as effective first-line topical therapies. Compared with systemic or topical anticholinergic therapy (98), AC showed inferior efficacy but a more favourable systemic safety profile.

Other topical treatments with anticholinergics (glycopyrrolate, topical oxybutynin, sofpironium bromide and umeclidinium) reduce sweat production by blocking muscarinic receptors on eccrine sweat glands, hindering acetylcholine-mediated stimulation of sweat secretion. Glycopyrronium-based formulations, sofpironium bromide and oxybutynin, demonstrated consistent efficacy and acceptable safety for the treatment of AH. Summary for search and outcomes regarding AC and topical anticholinergics are provided in Table SIIIa–c. The higher certainty of evidence for glycopyrronium-based treatments (77, 82, 84) was supported by the availability of multiple Phase III randomized controlled trials with low risk of bias and consistent efficacy outcomes. In contrast, evidence for sofpironium bromide (100, 101) and topical oxybutynin (102) was derived predominantly from open-label and extension studies, resulting in lower overall certainty due to increased risk of performance and detection bias and limited controlled replication. Risk of bias was assessed using the Cochrane risk of bias (RoB) 2 tool (103) for randomized trials evaluating topical glycopyrronium and sofpironium generally demonstrated low risk of bias, whereas open-label extension studies and observational studies ((e.g.) oxybutynin) were associated with some concerns to high risk of bias, primarily due to lack of blinding and potential deviations from intended interventions. Studies on aluminium salts were judged to have some concerns regarding bias, mainly due to limited reporting of randomization and blinding procedures.

Systemic treatments. Systemic therapy in hyperhidrosis mainly consists of oral anticholinergics used off-label and reserved for patients with therapy-resistant, generalized, or multifocal sweating. Glycopyrrolate and oxybutynin are the most used drugs, though glycopyrrolate is approved for children over 11 years, while oxybutynin is often prescribed off-label. Typical adult doses for glycopyrrolate range from 0.5 to 3 mg once or twice daily, with paediatric dosing titrated by weight (104, 105). Oxybutynin is administered at 2.5–10 mg/day, with doses up to 20 mg in selected adults, and paediatric doses range from 2.5 to 10 mg/day (104, 106, 107). Clinical response and efficacy rates range from 67–79% for glycopyrrolate and approximately 76% for oxybutynin, with improvements in sweat severity and quality-of-life metrics (106, 108).

Adverse effects include dry mouth, xerosis, blurred vision, urinary retention, headache and palpitations (104–106, 109). Both glycopyrrolate and oxybutynin are associated with anticholinergic adverse effects, although glycopyrrolate may result in fewer central nervous system-related adverse effects, though long-term neurological safety remains under investigation (104, 108). Other systemic agents, such as methantheline bromide, have demonstrated efficacy in randomized trials but its use remains limited due to tolerability concerns and a lack of contemporary quality-of-life data (110).

Iontophoresis. Iontophoresis involves placing affected skin, usually palms and soles, in water while a mild electrical current is applied. This method leads primarily to obstruction of sweat ducts and reduced sweating (111, 112). It is usually considered an appropriate treatment for PPH and PlH but can also be used for AH with special electrodes. Treatment is performed 3–4 times weekly for 15–40 min, with improvement occurring after a few weeks and subsequent maintenance therapy once weekly. Home devices improve adherence, and efficacy has been reported in up to 80% of patients (113). Additives such as aluminium chloride or anticholinergics may enhance the effects. Contraindications include pregnancy, metal implants, cardiac disease, epilepsy and implanted electronic devices. Common side effects include discomfort, skin irritation, dryness and paresthesia (114, 115).

Minimally invasive treatments. Microwave thermolysis is a minimally invasive technique that uses electromagnetic energy to generate heat, causing permanent destruction of eccrine sweat glands through dermal fibrosis. The method is approved by the FDA for adults with AH. In a large prospective cohort (n=103), evaluating microwave thermolysis (MiraDry®) over a 1-year follow-up, 88% of individuals with AH achieved a HDSS score ≤2 at 1 year follow-up, alongside significant improvements in QoL, anxiety and depression (67). Other clinical studies report sustained efficacy, with significant reductions in sweating and symptom severity lasting at least 12 months or longer (116, 117). Adverse effects are usually transient and include pain, swelling, erythema and sensory disturbances; rare long-term complications, such as

plexus injury, have been described, particularly in lean individuals (118).

Other procedures include suction curettage, laser-assisted sweat gland ablation and radiofrequency-based techniques. These approaches reduce sweating through mechanical removal or thermal destruction of sweat glands and have primarily been studied in AH (119). Although reported outcomes are generally favourable, current evidence is limited compared with microwave thermolysis, botulinum toxin injections and endoscopic thoracic sympathectomy, and the long-term efficacy data remain sparse.

Botulinum toxin (BTX) injections, particularly type A (BTX-A), are among the most widely used treatments for PH. BTX is a neurotoxic protein produced by the gram-positive bacterium Clostridium botulinum. The toxin temporarily inhibits the release of acetylcholine from presynaptic sympathetic nerve terminals through blockade of vesicular exocytosis, thereby preventing stimulation of eccrine sweat glands and reducing sweat production. While there are numerous reports regarding BTX injections in AH, PPH, PlH and craniofacial hyperhidrosis in adults, the number of high-quality randomized controlled trials remains limited (120). BTX treatment has also been investigated in the paediatric population regarding PH; however, treatment in children remains mostly off label (62, 121). Given the availability of multiple proprietary BTX-A formulations with non-interchangeable unit potencies, direct comparisons between formulations are difficult. In PH, BTX is typically injected at the dermal–subcutaneous junction, approximately 2.5 mm below the skin surface, placed 1–2 cm apart (1). A dose of 50–100 units of onabotulinumtoxinA or 100–200 units of abobotulinumtoxinA per side is recommended for AH (122). While in palmar (PPH) and plantar hyperhidrosis (PlH), a minimum dose of 50–100 units of onabotulinumtoxinA or 100–240 units of abobotulinumtoxinA per side has been described as adequate for effect (123). Larger doses may be needed depending on the size of the palm or sole. Clinical improvement after injections is typically observed within days of treatment and could persist for several months with a high satisfaction rate (124). Compared with BTX-A, BTX-B has a faster onset of action but a shorter duration of effect, a broader adverse-effect profile and greater injection-related discomfort (125). Pain is the most reported adverse effect of BTX treatment, particularly in the palmar and plantar regions. Strategies to reduce pain in conjunction with BTX injections are anaesthesia creams and ointments, icepacks, vibration analgesia, dilution of BTX with lidocaine, sedation, intravenous regional anesthesia and peripheral nerve blocks (126, 127).

Surgical interventions. Surgical treatments for PH include sympathectomy, sympathicolysis and video-assisted thoracoscopic procedures such as endoscopic thoracic sympathectomy (ETS) (1, 121, 127, 128). These techniques involve interruption or removal of the sympathetic chain, typically at the T1–T5 levels via ablation or clipping. The resulting denervation of eccrine glands leads to a sustained reduction in sweat production. The most performed surgical approach is ETS, for PPH and although patient satisfaction is initially high, it may decrease over time (129, 130). Potential complications include pneumothorax, bleeding and neurological injury, as well as Horner syndrome due to unintended stellate ganglion damage (1, 127, 128). Postoperative pain and compensatory sweating are common; the latter often affects the trunk and lower body and represents a major limitation of the procedure. Recurrence of symptoms can also occur. Considering the risks, irreversibility and limited evidence in paediatric populations, surgical intervention should only be considered in carefully selected patients with severe and refractory cases.

DISCUSSION

This review demonstrates that PH is a clinically important yet underrecognized condition with substantial psychosocial, functional and economic impacts. However, the available literature remains heterogeneous regarding definitions, diagnostic criteria and outcome measures, limiting comparability across studies. The wide variation in reported prevalence likely reflects methodological differences as well as under-recognition of the condition. Many affected individuals may not seek care, and PH is still not consistently identified as a medical disorder in clinical practice. Improved awareness in healthcare and in the population is therefore essential to facilitate the recognition of PH and reduce delay in seeking care.

From a mechanistic perspective, PH appears to involve complex autonomic dysregulation rather than a purely increased sympathetic drive. While cholinergic overactivity is a central component, some observed molecular alterations may represent secondary adaptation to prolonged cholinergic stimulation. An important hypothesis from this review is that genetic variation in receptor expression may contribute to increased sweating in certain individuals, even under normal sympathetic stimulation. This could partly explain interindividual variability in disease severity and warrants further investigation.

The burden of PH extends beyond physical symptoms, with psychological morbidity often reported as a key component for distress in those affected. Anxiety, stress and social avoidance appear closely linked to sweating severity, likely through bidirectional feedback mechanisms. However, current evidence does not always distinguish clearly between causation and

association, emphasizing the need for longitudinal studies.

Quality-of-life data confirm that PH has a significant impact on daily functioning, social interaction and emotional well-being. Much of the existing evidence is derived from interventional studies, leaving gaps in our understanding of the natural course of disease and long-term burden, particularly from adolescence to adulthood. Also, the economic impact of PH is increasingly recognized but remains insufficiently characterized. Although both direct and indirect costs appear substantial, comprehensive economic evaluations are scarce. Few studies take a societal perspective, and indirect costs are inconsistently measured. Moreover, economic outcomes are often secondary endpoints in research regarding PH. Thus, standardized cost-of-illness methodologies and longitudinal analyses are needed to better define the long-term economic burden of HH.

The diagnostic challenges in PH remain important. While clinical criteria are widely used, objective measurements lack standardization and are influenced by multiple external factors. Current tools capture different aspects of disease burden, but no single method fully integrates severity, distribution and patient experience. This highlights the need for more unified diagnostic frameworks. Treatment options are diverse and generally effective, but the strength of evidence varies between modalities and anatomical sites. AH is better studied than other forms of PH, and data for paediatric populations remain limited. These differences underscore the importance of individualized treatment strategies based on disease characteristics and patient factors but also the need for the research community to conduct high quality randomized controlled intervention studies in PH.

Overall, important knowledge gaps persist in PH, including lack of methodological standardization, limited data on less common phenotypes and insufficient long-term and comparative studies regarding treatment of the condition.

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Data Availability: The data that support the findings of this study are available from the corresponding author upon reasonable request.

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