International Journal of Innovative Technologies in Social Science

e-ISSN: 2544-9435

Operating Publisher
SciFormat Publishing Inc.
ISNI: 0000 0005 1449 8214

2734 17 Avenue SW,
Calgary, Alberta, T3E0A7,
Canada
+15878858911
editorial-office@sciformat.ca

ARTICLE TITLE	HONEY AND PROPOLIS IN PUBLIC HEALTH: EVIDENCE, REGULATION, AND TECHNOLOGY-ENABLED QUALITY ASSURANCE
DOI	https://doi.org/10.31435/ijitss.1(49).2026.5288
RECEIVED	11 January 2026
ACCEPTED	23 March 2026
PUBLISHED	27 March 2026
LICENSE	The article is licensed under a **Creative Commons Attribution 4.0 International License.**

HONEY AND PROPOLIS IN PUBLIC HEALTH: EVIDENCE, REGULATION, AND TECHNOLOGY-ENABLED QUALITY ASSURANCE

Daria Danielczyk *(Corresponding Author, Email: daria.danielczyk@gmail.com)*
Wojewódzki Szpital Zespolony w Kielcach, Kielce, Poland
ORCID ID: 0009-0002-4955-4883

Michał Babicz
Jan Kochanowski University, Kielce, Poland
ORCID ID: 0009-0007-7611-4695

Kamil Chudzicki
Wojewódzki Szpital Zespolony w Kielcach, Kielce, Poland
ORCID ID: 0009-0001-2734-7720

Wiktor Czyżewski
Independent Public Health Care Institution of the Ministry of the Interior and Administration in Kielce named after St. John Paul II, Kielce, Poland
ORCID ID: 0009-0003-0277-8203

Katarzyna Rosa
Uniwersyteckie Centrum Kliniczne, Gdańsk, Poland
ORCID ID: 0009-0005-9307-4774

Agata Słoma
Uniwersyteckie Centrum Kliniczne, Gdańsk, Poland
ORCID ID: 0009-0004-6807-7706

Anna Szot
Jan Kochanowski University, Kielce, Poland
ORCID ID: 0009-0003-2613-1068

Dominik Szydełko
Wojewódzki Szpital Zespolony w Kielcach, Kielce, Poland
ORCID ID: 0009-0002-9907-858X

Martyna Szymczyk
Jan Kochanowski University, Kielce, Poland
ORCID ID: 0009-0005-0772-7119

Paweł Żurek
Medical University of Warsaw, Warsaw, Poland
ORCID ID: 0009-0006-3023-5128

ABSTRACT

Bee-derived products such as honey and propolis are increasingly used as foods, supplements, and components of traditional and complementary medicine. At the same time, public health systems face antibiotic overuse, a rising burden of chronic diseases, and an expanding market of natural products whose quality, safety, and claims are variable. This review synthesizes recent peer-reviewed evidence on honey- and propolis-based products with an emphasis on (i) clinically and socially relevant application areas, (ii) public health determinants of safe use (knowledge, regulation, and information pathways), and (iii) modern technologies that can improve standardization, authentication, and consumer protection. A targeted narrative review was conducted using PubMed, PMC, and Google Scholar, prioritizing recent reviews, clinical and preclinical studies, and analytical quality-control research. The literature suggests the strongest and most mature evidence base for symptom relief in selected pediatric respiratory infections, alongside emerging but heterogeneous findings in chronic disease contexts (e.g., metabolic and kidney-disease populations). Across indications, major translation barriers include variability in botanical origin and composition, inconsistent preparations and dosing, contamination and adulteration risks, and uneven professional guidance. Survey data indicate important knowledge gaps among healthcare professionals and highlight social media as a dominant information source, raising concerns about misinformation-driven use. Advances in chemical analytics (spectroscopy, chromatography-mass spectrometry), DNA-based botanical verification, and non-thermal decontamination approaches can strengthen quality assurance. Integrating these technologies with clearer governance and health-professional education may help translate honey and propolis into responsible, evidence-aligned public health practices.

KEYWORDS

Honey, Propolis, Apitherapy, Public Health, Quality Assurance, Digital Traceability

CITATION

Daria Danielczyk, Michał Babicz, Kamil Chudzicki, Wiktor Czyżewski, Katarzyna Rosa, Agata Słoma, Anna Szot, Dominik Szydełko, Martyna Szymczyk, Paweł Żurek. (2026) Honey and Propolis in Public Health: Evidence, Regulation, and Technology-Enabled Quality Assurance. *International Journal of Innovative Technologies in Social Science*. 1(49). doi: 10.31435/ijitss.1(49).2026.5288

Introduction

Honey and propolis occupy a hybrid position between food, traditional remedies, and regulated health products. In many contexts they are culturally trusted, widely accessible, and perceived as "natural" options for symptom relief. However, the public health implications of increasing apitherapy use extend beyond pharmacology: products circulate through complex supply chains, quality varies by geography and processing, and health claims are shaped by digital information environments as much as by clinical evidence.

Three converging trends make honey and propolis particularly relevant to the International Journal of Innovative Technologies in Social Science. First, health systems face persistent demand for low-risk self-care interventions for mostly self-limiting conditions, especially respiratory infections. Pediatric infections are a high-frequency driver of healthcare consultations and of antibiotic requests, even when antibiotics are not indicated. A recent scoping review of phytotherapeutic, homeopathic, and bee-product interventions for pediatric infections identifies a relatively mature evidence base for honey in cough-related outcomes, while also documenting substantial heterogeneity in interventions and measures (Bertoni et al., 2025). From a social science perspective, this sets up an implementation question: can symptom-relief options reduce inappropriate antibiotic demand without introducing new safety and misinformation risks?

Second, chronic non-communicable diseases motivate interest in complementary approaches. Reviews in diabetes and metabolic disease describe plausible anti-inflammatory, antioxidant, and microbiome-related mechanisms for bee products, yet also emphasize variability in products and study designs (Jagua-Gualdrón et al., 2025). In this context, public health relevance depends on clarifying who benefits, at what dose, and under what conditions, while avoiding overgeneralized claims that can displace evidence-based care.

Third, enabling technologies are rapidly changing what "natural products" can be in practice. Analytical tools such as Fourier-transform infrared spectroscopy (including FTIR-ATR), nuclear magnetic resonance (NMR), and chromatographic mass spectrometry, combined with chemometric modeling, can support botanical origin discrimination, adulteration detection, and batch-level quality grading (Anjos & Miguel, 2025). DNA-based methods can complement classical pollen analysis, and non-thermal decontamination approaches may reduce microbial risks in products such as bee pollen (Rezazadeh et al., 2025). Importantly, these laboratory capabilities have governance implications: they can underpin standards, certification, enforcement, and consumer protection.

At the same time, social systems determine whether such capabilities translate into safer real-world use. A national survey of healthcare professionals in Türkiye reports that only 55.9% were aware of the term "apitherapy," while 60.8% were unaware that apitherapy is regulated nationally; social media was the most common information source (Gökkaya et al., 2025). These findings highlight an information and training gap that can amplify misinformation and reduce the quality of counseling offered to patients.

Against this background, this review adopts a socio-technical framing. Honey and propolis are treated not only as bioactive substances but also as health-adjacent products embedded in markets, regulations, and information ecosystems. The paper addresses three aims: (1) summarize current evidence on health-related applications of honey and propolis that are most relevant to public health; (2) identify safety, regulation, and professional-knowledge constraints that shape implementation; and (3) map modern technologies that can support quality assurance, traceability, and responsible communication.

Methodology

Design and lens. This study is a targeted narrative review that synthesizes biomedical evidence and social-science implementation considerations relevant to honey and propolis products. The guiding lens is socio-technical: translation depends on interactions between evidence, product standardization, regulation, professional knowledge, and the information environment.

Data sources and search approach. Searches were conducted in PubMed, the PubMed Central (PMC) open-access archive, and Google Scholar. Search terms were combined iteratively and included: honey, propolis, apitherapy, bee products, pediatric infection, cough, diabetes, hemodialysis, Parkinson's disease, bee venom, melittin, quality control, adulteration, authenticity, spectroscopy, chemometrics, DNA metabarcoding, and microbial load. The review was seeded by a set of recent open-access articles supplied by the study team and was supplemented by backward citation tracking and targeted searches for high-relevance clinical trials and quality-control studies.

Eligibility and scope. Eligible publications were English-language peer-reviewed research articles, reviews, and editorials that contributed to at least one of the following domains: (a) clinical or preclinical evidence for honey- or propolis-related health outcomes; (b) professional knowledge, attitudes, or regulatory

context relevant to apitherapy; (c) analytical, manufacturing, or processing technologies relevant to product authentication and safety; or (d) public health implications (risk communication, stewardship, equity, consumer protection). The focus was on publications from approximately 2020 to early 2026, while allowing inclusion of key background where needed for coherence.

Charting and synthesis. Included sources were charted by product type (honey, propolis, mixed preparations, other bee products where relevant to mechanisms), study design (review, clinical trial, preclinical), population/setting, and key findings. Evidence was synthesized thematically into a pathway model that links technological enablers (analytics, standardization, decontamination, traceability) to governance functions (standards, labeling, professional guidance, and monitoring).

Ethical considerations. This review used publicly available literature only and did not involve human participants or identifiable private data. Therefore, ethical approval was not required.

Limitations of the approach. The review was not designed as a PRISMA-based systematic review and did not perform quantitative meta-analysis. Instead, it emphasizes interpretive synthesis across evidence types and highlights where heterogeneity and standardization gaps limit translation.

Results

Table 1 summarizes key sources informing the socio-technical synthesis presented in this review.

Table 1. Selected sources included in the review and their contribution to socio-technical understanding

Source	Design/context	Key contribution for this review
Bertoni et al., 2025 (Nutrients)	Scoping review of pediatric infections and non-conventional interventions	Identifies where evidence for bee products (especially honey) is most developed for pediatric symptom relief; documents heterogeneity and need for cautious translation.
Gökkaya et al., 2025 (J Pharmacopuncture)	National online survey of healthcare professionals in Türkiye	Quantifies awareness and regulatory knowledge gaps; highlights social media as a dominant information source and an implementation risk factor.
Jagua-Gualdrón et al., 2025 (J Complement Integr Med)	Narrative review of apitherapy products in diabetes mellitus	Summarizes proposed mechanisms and heterogeneous clinical implications; supports the need to align claims with evidence and with comorbidity-sensitive guidance.
Kemp et al., 2025 (Toxins)	Randomized double-blind placebo-controlled trial in hemodialysis patients	Demonstrates trial-ready standardized preparations (royal jelly + green propolis EPP-AF) and measurable changes in inflammatory and lipid markers.
Karagözoğlu et al., 2025 (ACS Omega)	Preclinical rat model of insulin resistance with apilarnil	Illustrates emerging products and mechanisms; emphasizes that preclinical signals are insufficient for population recommendations without clinical confirmation.
Rezazadeh et al., 2025 (PLOS ONE)	Quality evaluation of bee pollen (botanical origin, phenolics, microbial load)	Shows variability and microbial considerations; recommends DNA metabarcoding and discusses non-thermal decontamination approaches (including cold plasma).

Source	Design/context	Key contribution for this review
Anjos & Miguel, 2025 (Foods)	Editorial overview of chemistry, bioactivity, and authenticity approaches	Details analytical pathways for origin classification, highlights chemometrics, and notes ISO standardization efforts relevant to governance.
Sanlier et al., 2026 (Food Sci Nutr)	Comprehensive review of multiple bee products	Synthesizes broad health-effect claims while emphasizing lack of standardization as a key barrier; discusses safety considerations and dosing ranges.
Matias et al., 2025 (Molecules)	Review of propolis for non-motor manifestations of Parkinson's disease	Represents an emerging clinical-interest area linking antioxidant, anti-inflammatory, and gut-brain mechanisms; highlights evidence gaps.
Solanki et al., 2025 (Int J Gen Med)	Review of bee venom and anti-leukemic potential	Summarizes mechanisms and delivery challenges; highlights nanotechnology approaches to mitigate toxicity and improve targeting.
Li et al., 2025 (Front Neurosci)	Preclinical study of melittin for chemotherapy-induced neuropathic pain	Demonstrates mechanistic evaluation and the importance of safety and delivery considerations for venom-derived therapeutics.

3.1. Public health-relevant evidence in pediatric respiratory infections and antibiotic stewardship

The strongest and most socially relevant clinical evidence base for honey relates to pediatric upper respiratory tract infection (URTI) symptoms, especially cough. Pediatric cough is a frequent driver of parental concern and healthcare consultation, and it is also a context in which antibiotics may be requested despite limited clinical indication for many viral URTIs. From a public health standpoint, interventions that safely reduce symptom burden could support antibiotic stewardship by lowering demand for unnecessary prescriptions.

A 2025 scoping review covering phytotherapeutic, homeopathic, and bee-product interventions for pediatric infections identifies multiple studies evaluating honey and bee-product formulations in URTI contexts (Bertoni et al., 2025). The review reports that several randomized studies observed improvements in cough-related outcomes and sleep quality for children and caregivers. However, the evidence base is not uniform: interventions differ in botanical origin, formulation, dosing, comparator, and outcome measurement. This heterogeneity limits comparability and complicates direct translation into standardized recommendations.

For implementation, the critical issue is not only whether honey can reduce cough severity in controlled trials, but also how honey is used in real communities. Use is shaped by household practices, cultural norms, and online information. This can create "benefit-risk drift," where a moderate evidence signal for a narrow outcome (e.g., cough symptom relief) becomes generalized into broad claims (e.g., treating infections or replacing antibiotics). Such drift is a known challenge in translating complementary interventions: imprecise claims can produce inappropriate substitution for evidence-based care, while dismissive communication can push users toward unregulated markets.

The pediatric evidence therefore has two implications for technology and governance. First, a public-facing recommendation must be coupled with clear contraindications and age thresholds. Although honey is widely discussed as a cough remedy, it is not appropriate for infants under one year of age due to the risk of infant botulism from Clostridium botulinum spores (Sanlier et al., 2026). Second, product quality matters even for household use. Honey's composition and contamination risk can vary by origin and handling, and regulators and producers must account for contaminants such as microorganisms, pesticide residues, and antibiotics (Anjos & Miguel, 2025). These risks are inherent to the biology of bees and the environments they forage.

In summary, pediatric URTI symptom relief is the most plausible entry point for evidence-aligned integration of honey into public health practice. However, translation requires a socio-technical package: evidence boundaries, age-specific guidance, quality-assured products, and communication strategies that reduce misinformation and support stewardship rather than uncritical substitution.

3.2. Chronic metabolic disease: diabetes, insulin resistance, and the limits of generalization

Beyond acute respiratory symptoms, chronic metabolic disease is a major driver of interest in honey and propolis. Diabetes mellitus is both prevalent and socially salient, and it often motivates experimentation with supplements perceived as "natural." In this context, public health concerns include exaggerated claims, possible delays in evidence-based treatment, and product use patterns that may not align with metabolic risk profiles.

A 2025 review focusing on apitherapy products and diabetes mellitus summarizes proposed mechanisms through which bee products could influence metabolic health, including modulation of oxidative stress, chronic inflammation, gut dysbiosis, and tissue remodeling (Jagua-Gualdrón et al., 2025). These mechanistic arguments are biologically plausible, but they do not resolve the social question of appropriate use. For example, honey is a carbohydrate-rich food; even if it contains bioactive compounds, any metabolic benefit is contingent on dose, substitution patterns, and overall dietary context. Without clear guidance, "honey for diabetes" can become an information hazard: a message that is easily shared but easily misapplied.

Preclinical research illustrates both promise and uncertainty. A 2025 animal study evaluated apilarnil (a drone brood-derived apitherapy product) in a rat model of type 2 diabetes-induced insulin resistance, testing multiple doses and mechanistic markers across oxidative stress and insulin signaling pathways (Karagözoğlu et al., 2025). The authors report that apilarnil balanced some findings relative to the diabetes group but did not demonstrate a fully anti-diabetic effect. From a translation standpoint, this is important: early signals may guide hypothesis generation and product development, but they cannot justify population-level recommendations.

In chronic disease domains, the most policy-relevant research pathway involves standardized preparations and clinically meaningful endpoints. Standardization is critical because propolis composition varies markedly with geography and plant sources (Anjos & Miguel, 2025; Sanlier et al., 2026). Without consistent markers and dosing, different studies can effectively test different interventions under the same name, producing inconsistent results and undermining trust.

For social systems, a key question is how to integrate nuanced evidence into consumer decision-making. Digital platforms can amplify simplified narratives and commercial claims. Therefore, if honey and propolis are to be positioned as complementary supports in metabolic disease, they must be embedded within credible counseling channels (primary care, dietetics, pharmacy), supported by labeling that communicates dose and evidence boundaries, and monitored for misinformation trends. Technology-enabled traceability and batch-level certificates of analysis can help shift the market toward products that are consistent enough to evaluate and regulate.

3.3. Chronic kidney disease and cardiovascular risk: standardized extracts in a randomized trial

A clear example of translational progress is the use of standardized preparations in randomized controlled trials. In a 2025 double-blind placebo-controlled trial, hemodialysis patients were allocated to receive royal jelly plus green propolis EPP-AF (100 mg royal jelly + 500 mg green propolis) or placebo daily for two months (Kemp et al., 2025). The study measured biochemical parameters, inflammatory cytokines, and uremic toxins before and after supplementation.

Among the 38 patients who completed the intervention, the treatment group showed a statistically significant reduction in interleukin-6 (IL-6) and total cholesterol, while the placebo group showed no comparable changes (Kemp et al., 2025). Uremic toxins did not change. These findings do not establish clinical outcome benefits, but they demonstrate two implementation-relevant points. First, standardized extracts (in this case, a named and commercially produced propolis preparation) make trials more interpretable and can support regulatory discussion. Second, selection of measurable biomarkers can create a bridge between mechanistic hypotheses and pragmatic outcome research.

The trial also illustrates governance considerations. The authors disclose employment of one contributor by the propolis producer during the conduct of the study, while other authors report no conflicts (Kemp et al., 2025). This does not invalidate results, but it highlights the need for transparency and for independent replication, especially in markets where commercial incentives are strong.

From a public health perspective, the hemodialysis trial suggests that apitherapy products can be studied with modern clinical trial rigor and standardized dosing, supporting a pathway toward evidence-aligned integration. Future work would need to confirm durability, clinical relevance, safety over longer periods, and effects across diverse patient populations and medication regimens.

3.4. Neurological, pain, and oncological applications: high-interest areas with higher translation risk

Some of the most visible narratives around bee products relate to serious chronic diseases such as neurodegeneration and cancer. These areas attract public attention and commercial marketing, but they also carry higher risks of misinformation-driven substitution for effective therapies. The evidence base in such domains is primarily preclinical and mechanistic, and therefore requires careful communication.

In Parkinson's disease, a 2025 review explores the potential of propolis to alleviate non-motor manifestations, linking propolis-derived compounds to antioxidant and anti-inflammatory mechanisms and to potential modulation of the gut-brain axis (Matias et al., 2025). The review frames propolis as a candidate adjunct that could target pathways relevant to neuroinflammation and oxidative stress, but it also underscores that clinical confirmation is limited. For public health, the key issue is to differentiate "biologically plausible adjunct" from "proven treatment," and to prevent the migration of speculative claims into patient decision-making.

Research on bee venom-derived molecules shows a similar pattern: strong mechanistic interest with non-trivial safety and delivery constraints. A 2025 review on the anti-leukemic potential of bee venom describes bioactive components such as melittin and phospholipase A2 and discusses their cytotoxic and immunomodulatory properties (Solanki et al., 2025). Because systemic toxicity is a major barrier, the review emphasizes delivery strategies, including nanoparticle-based approaches, to improve targeting and reduce off-target effects (Solanki et al., 2025). This is an example of how "modern technology" (nanotechnology in this case) becomes a prerequisite for translation rather than an optional enhancement.

A 2025 preclinical study further illustrates the depth of mechanistic work underway. In a rat model of paclitaxel-induced peripheral neuropathic pain, melittin administered at an acupoint (ST36) reduced cold and mechanical hypersensitivity and attenuated spinal neuronal hyperexcitability; neuropharmacological analysis suggested mediation via the endogenous noradrenergic system (Li et al., 2025). These methods integrate behavioral testing, in vivo electrophysiology, and mechanistic modulation. Yet the translational leap from controlled animal models to safe human application remains substantial, especially given the allergic and toxicity risks associated with venom components.

Overall, neurological and oncological applications showcase how apitherapy research intersects with modern technologies (advanced analytics, targeted delivery, mechanistic neuroscience). They also demonstrate why public-facing guidance must be conservative: high-interest conditions create fertile ground for misinformation and overclaiming. Responsible translation requires clear distinction between preclinical signals and clinical evidence, strong safety protocols, and regulatory oversight of products that move beyond food-grade use.

3.5. Safety, contraindications, and population-level risk management

Safety considerations determine whether honey and propolis can be responsibly recommended, especially at scale. Two categories of safety risk are particularly important for public health: (1) intrinsic risks tied to biological content (allergies, age-related vulnerability), and (2) extrinsic risks tied to production environments and markets (contamination, adulteration, and misleading claims).

Age-related contraindications are an essential starting point. Honey can contain spores of Clostridium botulinum, and infants under one year of age are particularly vulnerable to colonization and infant botulism (Sanlier et al., 2026). This hazard must be visible in public communication, labeling, and professional counseling. The problem is not merely clinical; it is informational. When honey is promoted online as a general remedy, age thresholds may be omitted, and caregivers may be exposed to dangerous advice.

Allergic reactions are another intrinsic risk that becomes more salient as products diversify. Propolis is a resinous product with variable phytochemical composition, and it has been associated with allergic reactions in sensitive individuals (Sanlier et al., 2026). Risk increases when consumers use concentrated extracts, multiple products, or topical formulations without guidance. Even when adverse events are uncommon, public health practice demands that they are anticipated and communicated.

Extrinsic risks arise from contamination and from supply chain complexity. Honey's microbial content can originate from the bee gut, environmental sources, the hive, and post-harvest handling and storage (Anjos & Miguel, 2025). Beyond microorganisms, honey and other bee products can contain pesticide residues and antibiotics due to environmental exposure and beekeeping practices, and can accumulate metals in industrial regions (Anjos & Miguel, 2025). These hazards motivate a shift toward quality assurance systems that are standardized, transparent, and auditable.

A related issue is the integrity of chemical composition during storage and processing. Hydroxymethylfurfural (HMF) content is used as a quality indicator for honey, and standards commonly set a maximum limit (Sanlier et al., 2026). Such indicators are governance tools: they allow regulators to enforce quality and allow buyers to differentiate products.

From a socio-technical perspective, safety management requires more than "consumer education." It requires systemic supports: (a) standardized labeling that includes contraindications and evidence boundaries; (b) testing frameworks for contamination and adulteration; (c) traceability that links products to verifiable certificates of analysis; and (d) accessible channels for reporting adverse events. These elements align with contemporary public health governance approaches in other domains of supplements and food-derived products.

3.6. Professional awareness, regulation, and information pathways as implementation bottlenecks

Healthcare professionals serve as key intermediaries between consumer markets and evidence-based practice. When patients ask about honey or propolis, clinicians, pharmacists, and nurses are expected to provide guidance on safety and effectiveness. If professional knowledge is limited, counseling can default to either uncritical endorsement ("natural equals safe") or blanket dismissal, neither of which supports rational public health outcomes.

Survey evidence from Türkiye provides a useful window into this implementation challenge. In a national online survey, 55.9% of participating healthcare professionals reported being aware of the term "apitherapy," while 60.8% were unaware that apitherapy is subject to specific regulation in Türkiye (Gökkaya et al., 2025). Nearly half (49.9%) were unaware that apitherapy is practiced by a certified physician, even though 87.5% believed it should be applied by a physician (Gökkaya et al., 2025). Social media and television were the most common information sources, whereas undergraduate coursework was selected far less frequently (Gökkaya et al., 2025). These findings suggest a mismatch: professionals recognize that apitherapy should be governed clinically, yet many do not know the governance structures or possess structured education.

This mismatch matters because misinformation travels efficiently through digital platforms. When social media is a dominant knowledge channel for professionals, it is likely to be even more dominant for the public. The result can be a feedback loop: consumer demand shaped by online claims leads to more questions in clinical settings, but clinicians may lack tools to respond confidently, increasing reliance on the same online sources.

Implementation therefore requires intentional education pathways. The survey authors propose incorporating apitherapy content into health-professional curricula (Gökkaya et al., 2025). From a technology perspective, education can be strengthened through digital learning modules, evidence dashboards, and decision-support tools that integrate contraindications (e.g., infants under one year) and evidence boundaries (e.g., symptom relief vs cure claims). Standardized product information (batch composition, contaminants testing, dosing) can further improve counseling and reduce uncertainty.

Finally, the Türkiye survey highlights the role of regulation as a social technology. Regulation defines scope of practice, quality requirements, and accountability. However, regulation only protects public health when it is understood and operationalized by professionals and when it is visible to consumers through labeling and enforcement. Bridging this "regulation-awareness gap" is a core socio-technical challenge for honey and propolis products.

3.7. Technology-enabled quality assurance: authenticity, decontamination, and traceability

Variability is the central barrier to translating honey and propolis into reproducible health-adjacent products. Botanical origin, geography, seasonality, and processing conditions can substantially alter chemical profiles and biological activity (Anjos & Miguel, 2025; Sanlier et al., 2026). Consequently, quality assurance depends on both analytical technologies and governance mechanisms that incentivize standardization.

Authenticity and origin verification. Classical identification of honey's botanical source relies on pollen analysis (melissopalynology). While informative, this method is time-consuming, requires specialized expertise, and may be impractical for routine high-throughput verification (Anjos & Miguel, 2025). The Foods editorial by Anjos and Miguel describes how honey classification can be supported by alternative approaches based on phytochemical profiles (carbohydrates, volatiles, phenolics, organic acids), biomacromolecules (proteins, DNA), and modern analytical instrumentation such as FT-NIR, FTIR-ATR, emission spectroscopy, and NMR, often paired with chemometric processing to create reference profiles (Anjos & Miguel, 2025). Importantly, the authors note that ISO/TC 34/SC 19 (Bee Products) is working toward an ISO standard for

honey origin identification (Anjos & Miguel, 2025). This is a concrete example of technology enabling governance: standards translate analytical capacity into enforceable market rules.

Contamination control and microbial safety. Bee products can contain microorganisms from primary sources (bee gut, environmental contact, hive) and secondary sources (extraction, handling, equipment, storage) (Anjos & Miguel, 2025). Quality assurance therefore requires hygienic processing and, in some cases, decontamination methods that preserve bioactivity. Bee pollen is a useful case study because it is consumed as a supplement and may have higher microbial risk. In a 2025 PLOS ONE study, Rezazadeh and colleagues characterized botanical origin, total phenolic content, and microbial load across bee-pollen samples, reporting wide variability and recommending DNA metabarcoding as a complementary method for botanical verification (Rezazadeh et al., 2025). The study also discusses a combined decontamination approach incorporating drying, ethanol exposure, and atmospheric cold plasma as a potentially non-destructive method for microbial reduction (Rezazadeh et al., 2025). If scalable, such approaches could reduce reliance on harsher treatments and support safer products.

From laboratory control to consumer-facing trust. Analytical capacity alone does not guarantee safer public use; results must be legible and actionable. One practical pathway is to connect batch-level testing to consumer and clinician access via digital traceability. For example, a QR code on packaging can link to a certificate of analysis (botanical origin, key marker compounds, contaminants screening, expiration conditions) and to evidence summaries and contraindications. This can reduce information asymmetry between producers, regulators, and consumers and can strengthen accountability when adverse events occur.

Traceability also has equity implications. High-quality analytics can be expensive, potentially advantaging large producers and marginalizing small-scale beekeepers. Implementation research should therefore consider tiered models: basic safety compliance (microbial limits, contaminants screening) as a baseline, with additional "premium" authentication layers (NMR profiles, DNA verification) where feasible. Public or cooperative laboratories, standardized sampling, and subsidized testing may help democratize access to quality assurance.

Finally, quality assurance must be paired with claims governance. When products are marketed for disease treatment, the threshold for evidence and standardization should be higher than for food-grade use. Technology-enabled labeling and traceability can help align claims with product quality and with the strength of evidence. Table 2 summarizes how modern technologies can be mapped to public health and implementation functions.

Table 2. Mapping of enabling technologies to public health and implementation functions for honey and propolis products

Technology domain	Examples	Public health / implementation function	Key considerations
Botanical origin verification	Melissopalynology; DNA metabarcoding	Supports authenticity claims; enables origin standards and reduces fraud	Requires reference databases; sampling protocols; trained personnel
Chemical profiling and adulteration detection	FTIR-ATR; FT-NIR; NMR; GC-MS; LC-MS; chemometrics	Identifies marker compounds; detects adulteration; supports batch consistency	Cost and equipment access; standard methods; inter-lab comparability
Microbial safety and decontamination	Drying protocols; ethanol exposure; atmospheric cold plasma	Reduces microbial load; improves safety for supplement-type products	Need to preserve bioactivity; validate scalability and residues
Standardized extracts and formulations	Marker-based standardization (e.g., green propolis EPP-AF); GMP manufacturing	Enables interpretable clinical trials and clearer dosing	Transparency about composition; independent verification; conflict-of-interest management

Technology domain	Examples	Public health / implementation function	Key considerations
Digital traceability and labeling	QR codes; batch IDs; certificates of analysis; (optional) blockchain/RFID	Reduces information asymmetry; supports inspection, recalls, and informed choice	Data governance; usability for consumers and clinicians; privacy and interoperability
Professional education and decision support	E-learning modules; guideline summaries; clinical checklists	Improves counseling quality; reduces misinformation-driven use	Needs institutional adoption; update cadence; evaluation of learning outcomes
Post-market monitoring	Adverse event portals; pharmacovigilance linkage; social media signal monitoring	Detects safety signals; supports responsive regulation	Reporting incentives; false positives; integration with health systems

3.8. Implementation scenarios, equity, and evaluation metrics for technology-enabled apitherapy governance

Evidence and laboratory capability are necessary but insufficient conditions for public health impact. Implementation depends on how honey and propolis are embedded into real-world care pathways and consumer practices. For honey and propolis, three common implementation scenarios can be distinguished, each with different governance and technology requirements.

Scenario 1: Household self-care and retail purchase. In many settings, honey and propolis are purchased as foods or over-the-counter supplements and used without professional contact. This scenario offers reach and autonomy but also maximizes information risk. Governance priorities include clear labeling (age contraindications, allergens, storage, intended use), minimum safety standards, and rapid recall capacity when contamination or fraud is detected. Technology can support these priorities through batch identification, QR-linked certificates of analysis, and consumer-facing summaries of evidence boundaries. In this scenario, public health outcomes depend heavily on health literacy and on the ability of trusted institutions to compete with social media claims.

Scenario 2: Clinician-guided adjunct use. Here, honey and propolis are used as complements to standard care, for example as symptom support for cough or as carefully monitored supplements in chronic disease contexts. This scenario reduces misinformation risk because counseling is available, but it depends on professional capacity. The Türkiye survey shows that such capacity cannot be assumed; knowledge gaps and reliance on social media can undermine counseling quality (Gökkaya et al., 2025). Technology-enabled education (short evidence modules; contraindication checklists; continuing professional development) can help, but it requires institutional adoption. Importantly, clinician-guided use also requires more reliable products than household use: standardized extracts, transparent composition, and verified contaminant testing, as exemplified by trial-ready preparations in hemodialysis research (Kemp et al., 2025).

Scenario 3: Regulated traditional and complementary medicine (TCM) services. In contexts where apitherapy is regulated as a clinical service (as described in Türkiye), governance includes scope of practice, certification, and clinical oversight (Gökkaya et al., 2025). This scenario can reduce risk by professionalizing practice, but it also creates accountability demands: services must document indications, dosing, and adverse events and must avoid overclaiming beyond evidence. Digital tools can support documentation, consent, and monitoring, especially if integrated with broader health information systems.

Equity and access considerations cut across all scenarios. Advanced analytics and traceability systems can raise product quality, but they can also raise costs. If quality assurance becomes a premium feature, affluent consumers may access safer products while others are exposed to lower-quality markets. Public health strategies should therefore consider minimum universal safety requirements, pooled testing infrastructure, and transparent labeling norms that protect all consumers. Supporting small-scale producers to meet baseline standards can also sustain rural livelihoods while improving public protection.

Evaluation metrics are essential to determine whether socio-technical interventions deliver value. For stewardship-related use-cases (e.g., cough symptom relief), evaluation could include changes in antibiotic prescribing requests, healthcare utilization (visits for uncomplicated URTIs), and caregiver-reported symptom

management. For quality assurance interventions, metrics could include rates of product non-compliance detected through routine sampling, prevalence of adulteration, and time-to-recall when issues are identified. For education interventions, outcomes could include knowledge gains among clinicians, changes in counseling behavior, and reporting of adverse events. Finally, equity metrics should track who benefits from improved quality assurance (price changes, geographic access, and distribution of certified products).

Taken together, these scenarios show that "innovative technologies" should be evaluated not only for technical performance but also for governance fit: how well they reduce risk, support informed choice, and maintain equitable access in real markets. This implementation orientation is necessary if honey and propolis are to move from promising evidence and laboratory capability to measurable public health benefit.

Discussion

The reviewed literature points to a central translation dilemma. Honey and propolis are widely accessible and culturally trusted, yet their safe integration into health-adjacent practices requires levels of standardization and information quality that are not uniformly present. This dilemma is not unique to bee products; it is characteristic of many natural products that move from traditional use into global markets. What makes honey and propolis distinctive is that modern technologies now make reproducible quality assurance technically feasible, while social systems determine whether this feasibility becomes routine practice.

Public health implications and stewardship. The pediatric infection literature suggests that honey-based interventions may provide symptom relief in cough-related contexts (Bertoni et al., 2025). If communicated responsibly, such interventions could support stewardship goals by reducing demand for inappropriate antibiotics. However, stewardship benefits are not automatic. Overstated claims can increase inappropriate substitution for evidence-based care, and under-communicated contraindications can create avoidable harms (e.g., infant botulism risk). Therefore, public health messaging should emphasize narrow indications, age thresholds, and the difference between symptom relief and antimicrobial therapy.

Chronic disease and risk of overclaiming. In metabolic and neurodegenerative contexts, the evidence base is more heterogeneous and often mechanistic (Jagua-Gualdrón et al., 2025; Matias et al., 2025). These areas are high-risk for misinformation because patients may be vulnerable and motivated to try alternatives. The solution is not to reject apitherapy categorically, but to strengthen the infrastructure that distinguishes exploratory evidence from clinically actionable guidance. This includes improved professional education, standardized products, and transparent claims governance.

Technology as governance infrastructure. Analytical and processing technologies can be understood not only as laboratory tools but also as components of governance. When authenticity and contamination risks can be detected reliably, regulators can enforce standards more effectively and producers can differentiate high-quality products in a transparent way (Anjos & Miguel, 2025; Rezazadeh et al., 2025). Yet the equity challenge is that advanced testing can be costly. Public health approaches should therefore consider shared infrastructure (public laboratories, cooperative testing), tiered standards, and support for small producers to avoid consolidating markets in ways that reduce rural livelihoods.

Information ecosystems and professional capacity. The survey from Türkiye demonstrates that healthcare professionals may rely heavily on social media for apitherapy information and may lack awareness of regulatory frameworks (Gökkaya et al., 2025). This is a system-level vulnerability: without credible education pathways, misinformation can become an unintentional driver of demand. Digital learning modules and evidence dashboards could be deployed at scale, but they must be supported institutionally (curricula, continuing education requirements) and evaluated for impact on counseling and patient outcomes.

A proposed socio-technical pathway. Based on the synthesized evidence, a practical pathway for responsible integration includes five steps. (1) Define evidence boundaries and target use-cases (e.g., pediatric cough symptom relief in children older than one year). (2) Standardize products and dosing through marker-based specifications and reproducible manufacturing. (3) Implement quality assurance using validated analytics and safe processing, with clear contaminant limits. (4) Make information actionable through labeling, digital traceability, and professional education. (5) Monitor real-world use through adverse event reporting and market surveillance, enabling rapid response when safety or fraud issues emerge.

Research agenda. Future studies should prioritize standardized preparations and pragmatic trials with outcomes that matter to patients and systems (symptom burden, healthcare utilization, antibiotic prescribing patterns, quality of life). Comparative policy research could examine how different regulatory models affect market quality and misinformation prevalence. Technology-focused research should evaluate cost-effective analytics for routine monitoring and test digital traceability approaches that are usable for both consumers and

clinicians. Finally, social-science research is needed on trust, risk perception, and equity to ensure that innovations protect vulnerable populations rather than amplifying disparities.

Limitations. Because this is a targeted narrative review, it does not provide exhaustive coverage or pooled effect estimates. Nevertheless, the socio-technical framing highlights a coherent implementation logic: in domains where evidence and safety are strongest, honey and propolis can be integrated cautiously; in domains where evidence is preliminary, governance and communication must be especially conservative.

Digital public health methods can also be leveraged to manage the "information hazard" dimension of honey and propolis. Because social media is a key knowledge source even for healthcare professionals (Gökkaya et al., 2025), monitoring and rapid-response communication become practical components of governance. Health authorities and professional bodies can use social listening to identify recurring misinformation themes (for example, claims that honey or propolis can replace antibiotics or cure chronic diseases) and then publish timely, plain-language corrections that link to evidence summaries and safety warnings. This approach is especially relevant for high-interest conditions such as cancer or neurodegenerative diseases, where preclinical findings are easily misinterpreted as clinical proof. When combined with traceability tools, digital communication can point consumers to verified products and discourage purchases from unverified sources. Importantly, these interventions should be evaluated like other public health programs: not only by reach (views or clicks) but by outcomes such as changes in consultation behavior, reductions in unsafe practices, and improved alignment between consumer choices and the strength of evidence.

Conclusions

Honey and propolis are increasingly positioned as modern health products, yet their public health value depends on evidence boundaries, safety governance, and technology-enabled quality assurance. Current literature suggests the most actionable evidence for honey lies in symptom relief for selected pediatric respiratory infections, while chronic disease applications remain promising but heterogeneous and often mechanistic. Across use-cases, variability in botanical origin and composition, contamination and adulteration risks, and uneven professional knowledge create barriers to responsible translation.

Modern technologies can address several of these barriers. Advanced chemical analytics (spectroscopy, chromatography-mass spectrometry), DNA-based botanical verification, and non-thermal decontamination approaches can strengthen authentication and microbial safety, enabling more reproducible products and more interpretable research. Digital traceability and accessible certificates of analysis can reduce information asymmetry and support consumer protection, while education and decision-support tools can reduce misinformation-driven use.

For policy and practice, the key is integration: technical capabilities must be linked to standards, labeling, professional training, and monitoring systems. A socio-technical pathway that connects evidence, standardization, quality assurance, communication, and surveillance offers a practical route to align bee products with public health goals. With these safeguards, honey and propolis may serve as responsible, evidence-aligned complements in selected contexts, while ongoing research clarifies their role in broader clinical and social applications.

Conflicts of Interest: The authors declare no conflicts of interest.

Author's contribution:

Research concept and design: Daria Danielczyk, Katarzyna Rosa, Michał Babicz
Data collection: Kamil Chudzicki, Wiktor Czyżewski, Anna Szot, Dominik Szydełko
Data analysis and compilation: Agata Słoma, Martyna Szymczyk, Paweł Żurek
Writing: Daria Danielczyk, Michał Babicz, Paweł Żurek, Katarzyna Rosa
Supervision, project administration: Daria Danielczyk

All authors have read and approved the final version of the manuscript.

REFERENCES

1. Anjos, O., & Miguel, M. G. (2025). Unveiling the chemistry and bioactivity of bee products and their derivatives. *Foods, 14*(17), 3058. https://doi.org/10.3390/foods14173058
2. Bertoni, C., Alberti, I., Parri, N., Agostoni, C. V., Bettocchi, S., Zampogna, S., & Milani, G. P. (2025). Phytotherapeutic, homeopathic interventions and bee products for pediatric infections: A scoping review. *Nutrients, 17*(19), 3137. https://doi.org/10.3390/nu17193137
3. Gökkaya, İ., Renda, G., Ayhan, F., & Yazici, N. (2025). Awareness of apitherapy: A study of healthcare professionals in Türkiye. *Journal of Pharmacopuncture, 28*(1), 35–46. https://doi.org/10.3831/KPI.2025.28.1.35
4. Jagua-Gualdrón, A., García-Reyes, N. A., & Fernández-Bernal, R. E. (2025). Apitherapy for diabetes mellitus: Mechanisms and clinical implications. *Journal of Complementary and Integrative Medicine, 22*(2), 228–236. https://doi.org/10.1515/jcim-2024-0367
5. Karagözoğlu, F., Şahin, E., Melek, Ş., Şahin, S. B., Koca, R. H., Yüksel, H., & Güngören, A. (2025). Effects of apilarnil on type 2 diabetes-induced IRS-1/PI3K/Akt mediated insulin resistance in male rats. *ACS Omega, 10*(23), 25027–25038. https://doi.org/10.1021/acsomega.5c02662
6. Kemp, J. A., Mendonça, M., Chrispim, P., Ribeiro, M., Britto, I., Coutinho-Wolino, K. S., Ribeiro-Alves, M., Nakao, L. S., Kussi, F., Coelho, E. B., Berretta, A. A., Mafra, D., & Cardozo, L. (2025). Apitherapy with royal jelly and green propolis EPP-AF improves cardiovascular risk markers in patients undergoing hemodialysis: A randomized double-blind placebo-controlled trial. *Toxins, 17*(8), 369. https://doi.org/10.3390/toxins17080369
7. Li, D., Wu, Y., Chang, L., Song, Y., Du, X., Xue, F., Liu, Y., Wu, J., & Wang, T. (2025). Therapeutic effects of melittin on paclitaxel-induced peripheral neuropathic pain and spinal neuronal hyperactivity in male rats. *Frontiers in Neuroscience, 19*, 1622553. https://doi.org/10.3389/fnins.2025.1622553
8. Matias, K. V., Gonçalves, V. de C., & Scorza, F. A. (2025). Nature's remedies: Exploring the potential of propolis to alleviate non-motor manifestations of Parkinson's disease. *Molecules, 30*(8), 1672. https://doi.org/10.3390/molecules30081672
9. Rezazadeh, A., Mehrabian, A. R., Maleki, H., Shakoori, Z., Zarei Golbaghi, N., Sharifi, T., Yazdi, H., & Zarqami Amirsalari, M. (2025). Evaluation of bee pollen by characterizing its botanical origin, total phenolic content, and microbial load for the formulation of apitherapy products. *PLOS ONE, 20*(9), e0327480. https://doi.org/10.1371/journal.pone.0327480
10. Sanlier, N., Yildiz Kaya, E., & Yucel, I. I. (2026). Health effects of bee products: A comprehensive review. *Food Science & Nutrition, 14*(2), e71165. https://doi.org/10.1002/fsn3.71165
11. Solanki, P., Rana, M., Choudhary, K. S., Ahuja, V., Kumar, V., & Tyagi, A. (2025). The anti-leukemic potential of bee venom. *International Journal of General Medicine, 18*, 7395–7408. https://doi.org/10.2147/IJGM.S560153