



Review

5 Advances in Artificial Intelligence in Cosmetic Dermatology

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ABSTRACT

Artificial intelligence (AI) has evolved from science fiction into a key tool in everyday life. In cosmetic dermatology, it has revolutionized skin assessment and the development of personalized treatments. Advanced algorithms enable the diagnosis of conditions, predict responses to laser therapies, and optimize dermocosmetic formulations. Mobile applications such as Skiana® and PROVEN Beauty® analyze the skin and recommend products, while clinical devices like VISIA® facilitate diagnosis. Machine learning and deep learning models enhance accuracy in detecting dermatological issues but still face challenges such as data biases and clinical validation. As AI advances, it promises to transform cosmetic dermatology with more efficient and personalized approaches.

12 Introduction

13 **Q2** Since the 20th century, the hypothesis has been proposed that
 14 machines could simulate human behaviour, not only in terms of intelligence but even in emotional processes.¹ This concept has evolved
 15 rapidly over time and has been reflected in popular culture. Films from
 16 the early 2000s, such as *A.I., Bicentennial Man*, and *I, Robot*, portrayed
 17 a distant and almost esoteric future. However, within a span of 10–20
 18 years, productions such as *Ex Machina* and *Her* began to depict a much
 19 closer future, increasingly similar to our present reality. Nevertheless,
 20 the portrayal of artificial intelligence (AI) in cinema does not always
 21 reflect contemporary reality.^{2,3}

22 Currently, AI is already part of daily life. According to data from
 23 the United Nations Development Programme, in countries such as
 24 Colombia, AI is applied across multiple sectors (Fig. 1). Its implementation
 25 has enabled the automation of processes that previously required
 26 manual parameterisation, optimising tasks as diverse as traffic management
 27 and the synchronisation of traffic lights.⁴

28 During the 1950s and the two following decades, AI was limited to
 29 executing single commands. However, since the turn of the millennium,
 30 its complexity has increased substantially, enabling it to interpret and,
 31 eventually, learn from the data it processes.¹

32 The use of AI spans multiple scientific fields, including medicine,
 33 where it promises revolutionary advances in areas such as novel drug
 34 development, diagnostic image interpretation, and even the performance
 35 of high-precision surgical procedures.^{5,6} In dermatology, AI has
 36 applications in dermoscopy and in the clinical assessment of immune-
 37 mediated diseases such as psoriasis and atopic dermatitis. Tools have
 38 even been developed to improve clinical dermatological diagnosis, such
 39 as *bellePRO*. Within cosmetic dermatology, AI facilitates patient follow-
 40 up, provides educational tools, and contributes to the optimisation of
 41 multiple therapeutic strategies.^{7,8}

42 This article presents a review of the application of emerging AI technologies
 43 in the field of cosmetic dermatology.

45 Methodology

46 The study was conducted by a primary reviewer and, in cases of
 47 uncertainty, validated by a second reviewer.

48 Search strategy

49 A narrative review was conducted across three English-language
 50 databases (EMBASE, PubMed, and IEEE Xplore) and one Spanish-
 51 language database (LILACS) from January 2023 through June 2024,
 52 with the aim of identifying articles related to artificial intelligence and
 53 cosmetic dermatology. Search terms included combinations of: "artificial
 54 intelligence", "AI", "AI algorithm", "deep learning", "convolutional

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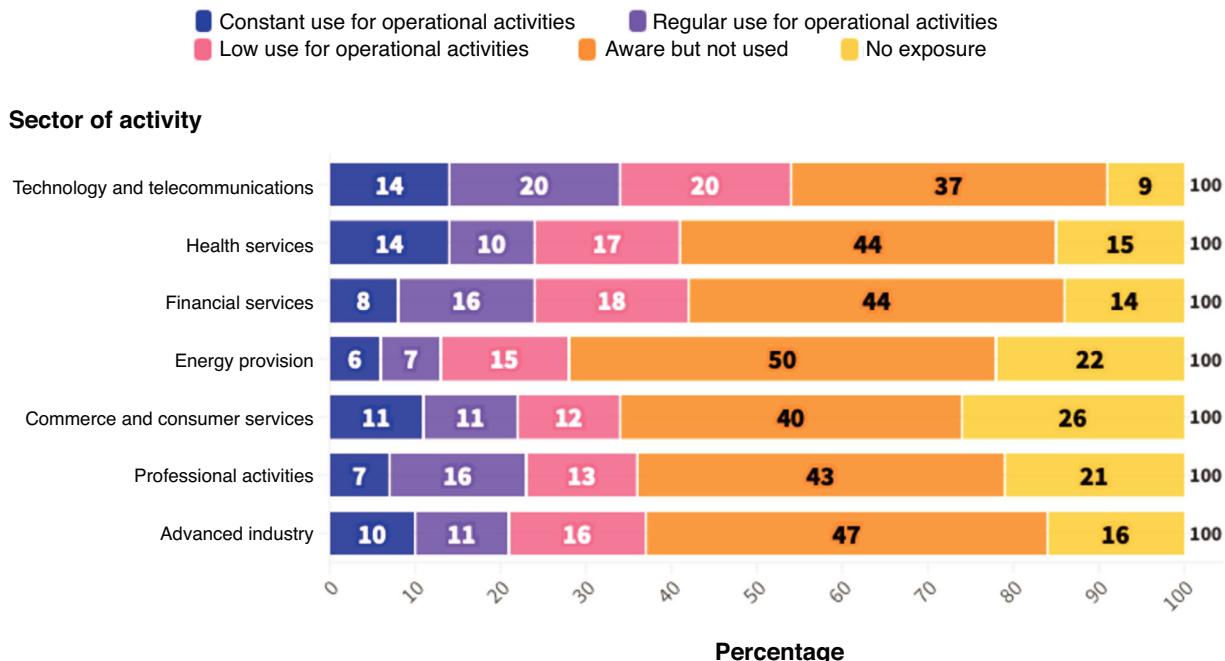
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Percentage of Generative Artificial Intelligence Use by Sector of Activity

Developing Countries 2023



Source: UNDP based on McKinsey Global AI Survey 2023

Figure 1. Percentage of generative artificial intelligence use by sector of activity.

Adapted from UNDP: *Implications of Generative Artificial Intelligence in the Colombian labour market*.

55 *neural network*", "inteligencia artificial", "IA", and "redes neuronales".
 56 In addition, specific cosmetic dermatology terms were used: "cosmetic
 57 dermatology", "cosmetic", "dermatology", "dermatología cosmética", and
 58 "dermatología". Articles published in English and Spanish were included.
 59 A manual search was also performed to identify additional relevant arti-
 60 cles, which were incorporated into the references.

Big Data

79 Big Data refers to data sets that are too large or complex to be pro-
 80 cessed and analysed using conventional technologies. In this context, AI
 81 plays a crucial role by automating data processing and generating more
 82 efficient predictive models.¹⁰
 83

Machine learning

84 Machine learning is a method of developing AI in which the machine
 85 generates its own programming to perform a specific task. This requires
 86 "training" through data input and is classified into three modalities:
 87 supervised, unsupervised, and hybrid.
 88

- 89 **Supervised:** Each data input is assigned a corresponding output.
 90 Through trial and error, the system learns to predict the correct
 91 response.
- 92 **Unsupervised:** Data are analysed without predefined outputs, which is
 93 useful for identifying patterns in large datasets.
- 94 **Hybrid:** Combines both approaches, providing some labelled data and
 95 others unlabelled, thereby reducing the need for manual classifica-
 96 tion.⁹

97 In dermatology, the use of labelled data predominates, as most AI
 98 programmes rely on the analysis of medical images.¹⁰

Deep learning

99 Deep learning is a form of machine learning that employs multi-
 100 ple processing layers. In dermatology, the most widely used technique
 101 is artificial neural networks (ANNs). In these systems, each layer pro-
 102 gressively receives and processes information, enabling the model to be
 103 trained to predict outcomes with increasing accuracy (Fig. 2).⁹

61 Study selection

62 The retrieved results were screened, and only studies evaluating the
 63 relationship between cosmetic dermatology and artificial intelligence
 64 were included. Publications addressing clinical or surgical dermatology
 65 in relation to AI were excluded. Review articles, letters to the editor, and
 66 clinical trials were selected, resulting in a total of 37 articles included
 67 in this review.

68 Results

69 Basic concepts of artificial intelligence

70 Broadly speaking, AI can be classified into two main types: strong
 71 or "general" AI and weak AI. Strong AI refers to machines capable
 72 of performing multiple tasks, possessing ethical awareness, and even
 73 achieving a degree of consciousness, that is, a level of intelligence "sim-
 74 ilar" to that of humans. Although some applications of this type exist,
 75 it remains largely a concept associated with science fiction. By contrast,
 76 weak AI is trained to accomplish a specific objective, and therefore its
 77 programs are designed for concrete tasks. This is the type of AI most
 78 widely used today.^{9,10}

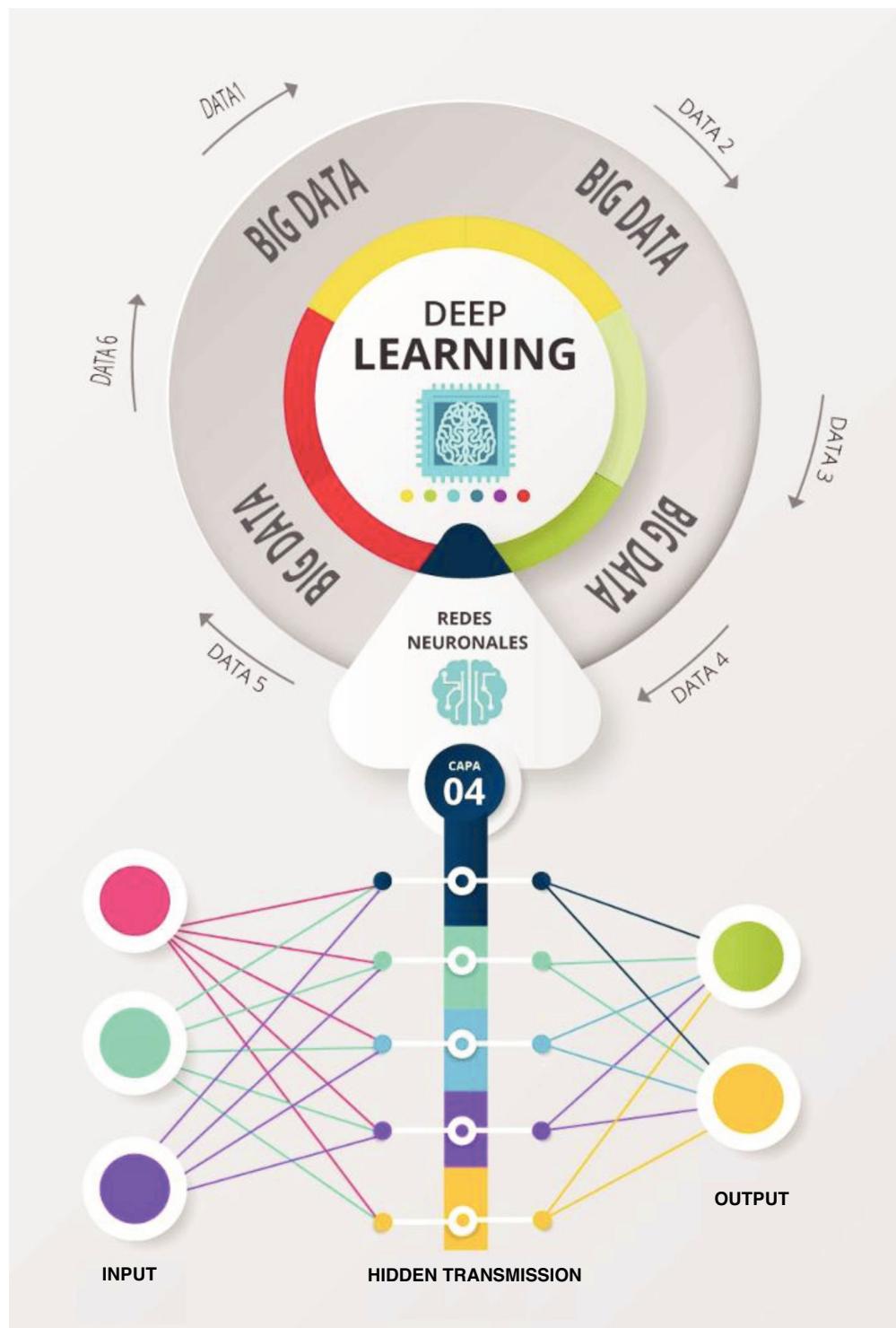


Figure 2. Schematic functioning of neural networks.

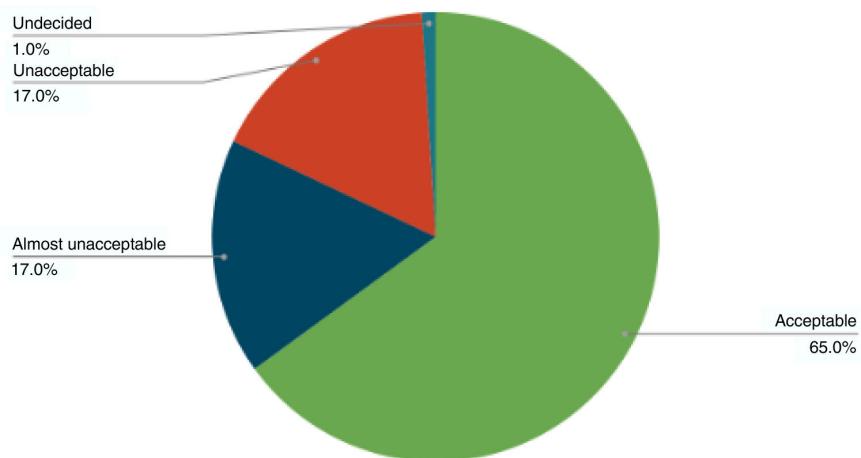
105 Overall, when the volume of data is small, machine learning provides
 106 better predictive performance. However, when data volumes become
 107 very large, deep learning surpasses machine learning in both accuracy
 108 and overall performance.¹¹ Given that dermatology relies heavily on
 109 image analysis, the use of artificial neural networks represents the pre-
 110 dominant methodology in this field.⁹

Artificial intelligence and cosmetic dermatology

111
 112 Applications of AI have experienced remarkable growth
 113 in cosmetic dermatology, encompassing multiple areas
 114 of practice and optimising key clinical and industrial
 115 processes.

A

Public opinion on animal experimentation in medical research



B

Public opinion on animal experimentation for dermocosmetic development

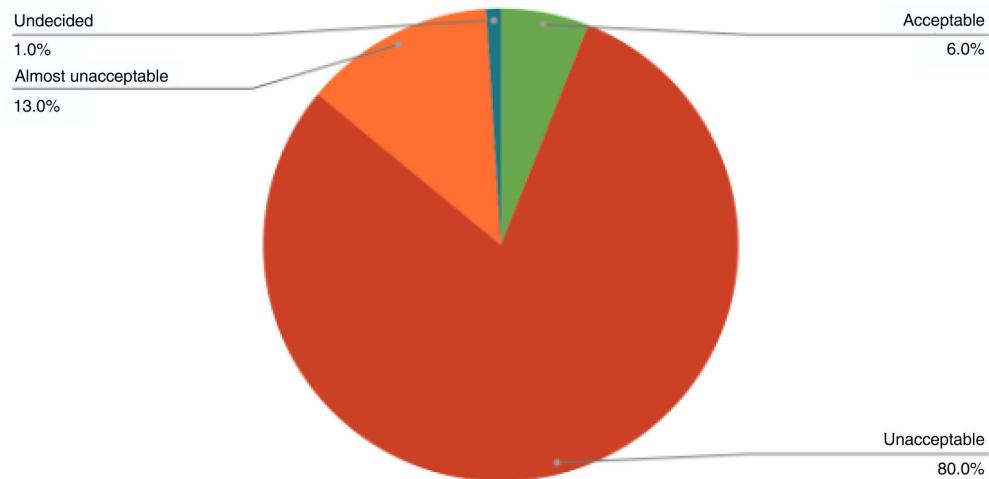


Figure 3. (A and B) Public opinion in the United Kingdom regarding animal experimentation.

Adapted from Kabene et al.

116 **AI in dermocosmetic development**

117 Traditionally, the assessment of the sensitising potential of dermo-
 118 cosmetic substances has been conducted using animal studies, in which
 119 excipients and active ingredients are applied topically or intradermally
 120 to evaluate sensitivity reactions. However, these methods have been
 121 ethically challenged and show low public acceptance, which has led to
 122 increasing regulatory restrictions on their use (Fig. 3A and B).¹²

123 Alternatively, in vitro methods employing tissues or cells to assess
 124 antigenic stimulation have been developed. Although their equivalence
 125 to animal and human studies remains under debate, these tools require
 126 considerable resources. In this context, Kalicinska et al. developed
 127 an AI-based programme using historical epidemiological data, achiev-
 128 ing sensitisation potential predictions comparable to in vitro studies,
 129 although limited by data bias.¹³

130 Over the past decade, multiple machine learning models have also
 131 been developed to predict whether a product exhibits sensitising or

132 comedogenic potential.^{14–18} Given this trend, it is likely that future
 133 dermocosmetic evaluation will increasingly rely on *in silico* simulations
 134 rather than *in vitro* or *in vivo* testing.¹⁹

135 In addition, Yeh et al. designed AI systems capable of identifying
 136 drug combinations that may mitigate cutaneous ageing. Using genetic
 137 and molecular pathway mapping, three networks were constructed: one
 138 encompassing genetic and epigenetic mechanisms, a second analysing
 139 protein interactions, and a third compiling gene regulators. Based on
 140 these datasets, a neural network evaluated medications affecting key
 141 targets, identifying patient-specific combinations according to age. The
 142 predictive accuracy of the model reached 93%.²⁰

143 **AI in mobile and office-based applications for skin care**

144 Several mobile applications have incorporated AI into cosmetic
 145 dermatology. One example is Neutrogena® Skin360™, which uses
 146 smartphone cameras to evaluate hyperpigmentation, periorbital dark



Figure 4. PROVEN Beauty® 3-step routine (cleanser, day cream, night cream).

Source: official website.

circles, rhytides, and skin texture, subsequently providing a score and 147
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193 **AI in cosmetic procedures**

194 AI models have been trained to predict patient response to excimer
 195 laser therapy in vitiligo, suggesting that similar models could forecast
 196 the effectiveness of laser treatments for acne scars, dyschromia, and vas-
 197 cular disorders.²¹ Indeed, models capable of predicting laser treatment
 198 response in patients with ephelides have already been implemented.²⁸
 199 Three-dimensional modelling has further enabled prediction of cosmetic
 200 procedure outcomes, particularly for dermal fillers, allowing patients to
 201 visualise potential results prior to treatment.²⁹ Shah et al. demonstrated
 202 the generation of post-rejuvenation 3D facial images using multilayer
 203 neural networks. These models created three-dimensional facial scans
 204 to identify optimal filler injection landmarks and predict precise filler
 205 volumes, achieving 62.5% accuracy – surpassing previously available
 206 techniques.³⁰

207 Predictive modelling also facilitates automation of device para-
 208 meters in procedures such as radiofrequency and microneedling, allowing
 209 real-time adjustment based on pigmentation, texture, curvature, and
 210 other skin characteristics, thereby reducing manual configuration
 211 time.²¹

212 **AI in patient education and follow-up**

213 Moreover, AI has been implemented as an educational tool. Shi et al.
 214 developed an AI-based application, "Skincare Mirror", which predicts
 215 post-treatment skin appearance following product use, providing per-
 216 sonalised visualisation of expected outcomes. This system significantly
 217 improved user engagement and satisfaction, particularly among male
 218 participants.³¹

219 **Risks of artificial intelligence use in cosmetic dermatology**

220 The risks associated with the use of AI in cosmetic dermatology
 221 require careful consideration. One of the most concerning issues is the
 222 potential loss of clinical judgement, as increasing automation of diagno-
 223 sis and treatment could discourage continuous medical education and
 224 critical thinking among professionals. This may compromise the qual-
 225 ity of care and reduce clinicians' ability to manage atypical cases or
 226 complex decision-making. Furthermore, inappropriate or unsupervised
 227 use of AI systems may jeopardise patient safety, particularly in sensi-
 228 tive medical decisions. Another major risk lies in the subjectivity of
 229 aesthetic concepts such as beauty and skin quality, which may lead to
 230 inappropriate, unethical, or culturally biased recommendations.³²

231 **Limitations of artificial intelligence in cosmetic dermatology**

232 The principal limitations of AI in cosmetic dermatology relate to the
 233 quality and representativeness of training datasets. Many algorithms are
 234 developed using datasets that are small, low quality, or insufficiently
 235 diverse, limiting their generalisability in clinical practice.³³ Moreover,
 236 current AI models lack continuous learning mechanisms comparable
 237 to the cumulative experience of human clinicians. AI also struggles
 238 with image interpretation in anatomically complex areas such as the
 239 scalp, mucosal surfaces, and regions affected by tattoos or makeup,
 240 thereby restricting its applicability in real-world scenarios.³⁴ Finally,
 241 the absence of standardised criteria for measuring aesthetic attributes
 242 hinders the development of accurate and personalised algorithms.^{35,36}

243 **Regulatory and implementation barriers in cosmetic dermatology**

244 From a regulatory perspective, the application of AI in dermatol-
 245 ogy faces a notable absence of specific legal and ethical frameworks.
 246 Medical liability in cases of algorithmic error remains unresolved, with
 247 uncertainty regarding whether responsibility should fall on the clinician,
 248 the developer, the institution, or the software provider when AI fails
 249 in diagnosis or treatment. In addition, robust international standards

250 for the evaluation, validation, and integration of AI systems into med-
 251 ical practice are lacking. Technical challenges include limited platform
 252 interoperability, difficulties integrating AI into electronic health record
 253 systems, and the requirement for advanced hardware. The growing
 254 threat of cyberattacks further compromises data privacy and integrity.
 255 Substantial investment in infrastructure, training, and institutional sup-
 256 port is therefore essential to ensure safe and effective adoption.^{32,37}

257 **Existing gaps in AI implementation in cosmetic dermatology**

258 A significant gap exists between AI research conducted in controlled
 259 environments and its applicability in daily clinical practice. Most AI
 260 developments rely on retrospective studies involving limited or biased
 261 populations, without proper validation in real-world clinical settings.
 262 This creates a disconnect between the theoretical potential of AI and
 263 its practical utility for healthcare professionals. Furthermore, social
 264 health inequalities may be exacerbated if AI systems are trained on
 265 non-representative datasets. The exclusion of vulnerable populations,
 266 ethnic minorities, and diverse skin phototypes can lead to less accurate
 267 diagnoses and suboptimal treatment recommendations for these groups.
 268 Inclusive and representative model design and validation are therefore
 269 critical. Additionally, many clinicians either lack sufficient training in
 270 AI usage or remain sceptical of its reliability, further widening the gap
 271 between innovation and implementation.³⁷

272 **Discussion**

273 AI has emerged as a transformative tool in cosmetic dermatol-
 274 ogy, driving advances in image analysis, dermocosmetic development,
 275 and personalised treatment planning. Its application has enhanced dia-
 276 gnostic accuracy and optimised the identification of skin conditions and
 277 therapeutic strategies.

278 The development of ANN-based algorithms has proven particularly
 279 valuable in medical image evaluation, surpassing traditional methods
 280 in efficiency and objectivity. Models applied to high-frequency ultra-
 281 sound analysis and laser treatment response prediction have opened new
 282 avenues for individualized medicine.

283 Within the cosmetic industry, AI has revolutionised product develop-
 284 ment and personalisation. Systems such as PROVEN Beauty® integrate
 285 genetic and environmental data to formulate customised skincare rou-
 286 tines. Similarly, both clinical and home-based devices, including VISIA®
 287 and Opté®, have improved skin assessment and treatment monitoring,
 288 allowing for more precise product recommendations.

289 Nevertheless, challenges persist, including data bias, the need for
 290 rigorous clinical validation, and unequal access to these technologies
 291 across regions. As AI continues to evolve, its integration into cosmetic
 292 dermatology holds substantial promise for improving diagnosis, preven-
 293 tion, and treatment of skin disorders, ultimately transforming clinical
 294 practice through a more precise and evidence-based approach.

295 **Conclusions**

296 The concept of balance is fundamental: AI is not intended to replace
 297 human expertise, but rather to complement it. In cosmetic dermatology
 298 – where professional judgement is essential – AI functions as a support-
 299 ive tool, enhancing efficiency without replacing the specialist's role. Its
 300 integration can transform consultations, improve treatment planning,
 301 facilitate progress monitoring, and strengthen patient education. Ulti-
 302 mately, this synergy is expected to drive significant advances in the field
 303 of cosmetic dermatology.

304 **Conflict of interest**

305 The authors declare no conflict of interest.

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