Dermatology Practical & Conceptual

Effectiveness of Teledermatology on Clinical, Patient-Reported, and Operational Outcomes: A Systematic Review

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ABSTRACT

Introduction: Teledermatology (TD), the remote diagnosis and management of skin conditions using digital platforms, has rapidly evolved since its initial adoption in 1995. With the onset of the COVID-19 pandemic, the utilization of TD expanded significantly, offering a viable alternative to face-to-face (F2F) consultations, particularly in settings where access to dermatologists are limited.

Objectives: This systematic review aimed to evaluate the effectiveness of TD across three key domains: clinical outcomes, patient satisfaction, and cost-effectiveness.

Methods: A systematic search was conducted across MEDLINE, Embase, and Web of Science for studies published between 2010 and July 2024. Studies comparing TD with in-person consultations in terms of diagnostic accuracy, patient satisfaction, and cost-effectiveness were included. The quality of the included studies were as assessed using the Newcastle-Ottawa Scale (NOS).

Results: From 2,768 articles, 23 studies met the inclusion criteria. Clinical outcomes indicated moderate agreement between TD and F2F consultations, with a mean kappa coefficient of 0.57, reflecting diagnostic concordance. Patient satisfaction varied widely, with 26.57% of patients willing to replace F2F consultations with TD. TD was associated with significant cost savings, averaging US$81.31 per patient, with percentage savings ranging from 6.27% to 45.33%, depending on the healthcare system.

Conclusions: TD provides moderate diagnostic accuracy, substantial cost savings, and varying degrees of patient acceptance. However, successful implementation requires high-quality imaging, clinician training, and robust technical infrastructure. Further research is needed to optimize TD's role in dermatology, particularly in balancing virtual and F2F care.

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Introduction

Teledermatology (TD) refers to the branch of telemedicine concerned with delivering remote dermatological healthcare using telecommunication technology, particularly digital platforms, to diagnose, treat, and manage skin conditions [1]. TD encompasses three main modalities: synchronous (live-interactive) consultations, which resemble in-person consultations but require stable internet connections and may compromise image quality, asynchronous (store-and-forward) methods, which allow efficient scheduling across time zones yet may require follow-up for incomplete histories, and hybrid models, which combine both approaches to optimize image quality and patient interaction [2-4].

The term "teledermatology" was first used in academic publications around 1995, when it was implemented by a study for the delivery of health care to underserved populations in rural Oregon. Since then, the scope and potential of telemedicine have expanded significantly, particularly with the advent of mobile technology. According to the World Bank, as of 2020, there are approximately 108 mobile cellular connections for every 100 people globally. This widespread connectivity has been instrumental in the greater feasibility and accessibility of TD as mobile devices continue to become more affordable, powerful, and user-friendly. A study by Fogel and Teng in 2015 found that as many as 89% of dermatologists in the USA had integrated TD into their practice, further expressing optimism about its continued evolution [5].

The COVID-19 pandemic has further accelerated the adoption of telemedicine worldwide [6]. Government-imposed restrictions, put in place to cut down the virus transmission, generated a surge in demand for telehealth services. Several factors contributed to the rise: SARS-CoV-2 infections are frequently associated with skin disorders, while the excessive use of protective equipment and hand sanitizers exacerbated pre-existing dermatological conditions [6]. In response to this heightened demand, many dermatology practices limited face-to-face (F2F) consultations to urgent cases and surgical procedures, shifting routine consultations to online video, telephone, and email formats. This large-scale transition demonstrated the global potential of TD for the first time by facilitating flexible and high-quality patient care.

The demand also derives from the shortage in the dermatology workforce internationally. A study conducted in Ireland discovered that dermatologists were successful in diagnosing biopsy-proven skin cancers in 87% of the cases, compared to 22% of GPs [7]. This thus necessitates a high referral rate from primary care to dermatological services in secondary care [5]. However, in the USA, a minimum projected deficit of 28% in the number of dermatologists is expected each year through 2036 [8]. Dermatologists, when compared to clinicians of other specialties, also work shorter work weeks and seek retirement earlier [9], further exacerbating the shortage of these specialists, as mentioned above.

While TD is increasingly used in clinical settings, existing literature primarily focuses on its clinical effectiveness, with limited attention to broader impacts. There is a clear need for a comprehensive review that evaluates TD across multiple domains.

Objectives

This review aimed to synthesize current evidence across three key areas: clinical outcomes, patient outcomes, and operational outcomes. By doing so, it will offer a well-rounded understanding of the benefits and limitations of TD in practice, support evidence-based improvements in its implementation, and inform regional and national health policy development.

Methodology

This systematic review was conducted according to the preferred reporting guidelines for Systematic Reviews and Meta-Analysis Protocols (PRISMA-P) checklist (Supplementary Table 1). The protocol was registered on PROSPERO (International Prospective Register of Systematic Reviews). A literature search was performed on 27 December 2024 to identify studies published between 01 January 2010 and 27 December 2024. Three databases (MEDLINE via the PubMed interface, Embase, and Web of Science) were searched.

The search strategy was developed through consulting search terms in current relevant literature. The strategy used a combination of Medical Subject Headings (MeSH) and keywords related to telemedicine, dermatology, and the outcomes assessed. The Newcastle Ottawa Scale (NOS) was used to assess study quality based on selection, comparability, and outcomes, whereby studies scoring below 5 were excluded to ensure methodological rigor.

Table 1. Suggested interpretation of kappa coefficient.

Value of KAPPA	Level of Agreement
0-01.20	*None to slight*
0.21-0.40	*Fair*
0.41-0.60	*Moderate*
0.61-0.80	*Substantial*
0.81-1.00	*Almost perfect agreement*

Study Eligibility

Studies were selected based on the PICO (Population, Intervention, Comparison, Outcomes) framework.

Population

Studies including participants of any age, sex, and dermatological issue who were seeking dermatology services.

Intervention

The intervention being studied in this review was the use of TD to deliver dermatological services.

Comparator

Studies comparing telemedicine with traditional in-person dermatology services

Outcomes

Studies reporting an outcome from at least one of the three following domains:

i. Clinical Outcomes

Clinical outcomes were assessed using the Cohen's Kappa (κ) statistic to evaluate agreement between TD and F2F diagnoses, with F2F as the gold standard. κ, a robust interrater reliability measure, accounts for chance agreement and ranges from -1 to +1, with 0 indicating random agreement [10]. Table 1 shows the suggested interpretation of the κ coefficient [11].

ii. Patient Outcomes

Patient outcomes are measured by percentage of individuals willing to replace F2F consultations with TD. Willingness to replace F2F with TD reflects its integration potential and is influenced by factors like access to care, making it a comprehensive indicator.

iii. Operational Outcomes

Assessed by the cost-effectiveness of the service. Only studies evaluating healthcare provider costs will be included in this review. Therefore, any cost-effectiveness analysis considering societal costs will be excluded.

Data Extraction

All data were extracted into three tables on Microsoft Excel which had been developed and piloted beforehand. One table was generated for each domain of outcomes being assessed in the study. The following were extracted from each article: authors, year of publication, study design, country, number of patients, number of lesions, and the outcome measure for each domain.

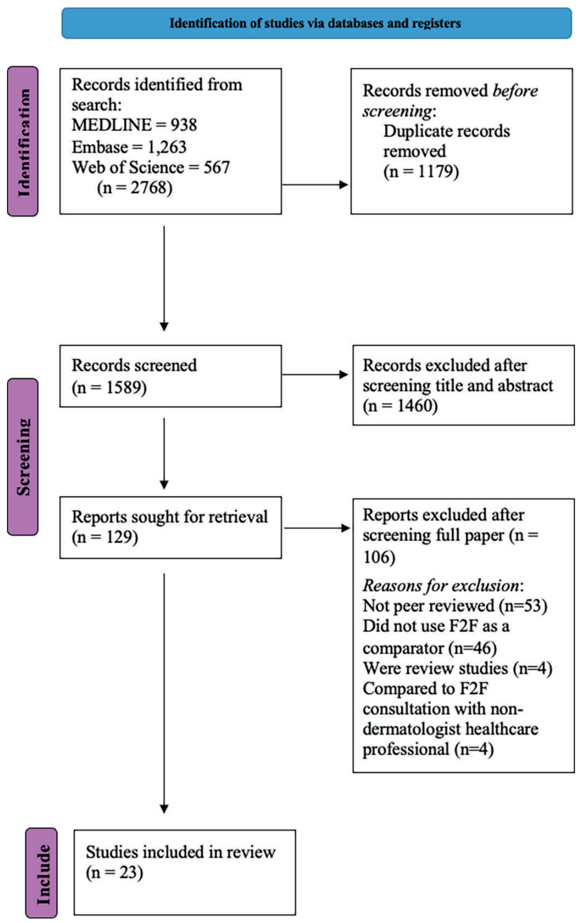

Figure 1. PRISMA flow diagram of included studies.

Results

Study Inclusion

The search generated 2,768 articles from three databases. After removal of duplicates, 1,589 articles remained for review. Following a review of the abstracts, 1,460 articles were removed, leaving 129 articles for full-text review (Figure 1). In total, after assessing full manuscripts, 23 studies remained that met the inclusion and exclusion criteria. Tables 2–4 present the studies included in this review.

Quality Assessment

Twenty-two of the 23 studies (96%) scored 7, while one study (4%) scored 6 on the NOS. None of the 23 studies scored less than our cutoff of 5, meaning that all included studies were deemed of adequate quality to be included in this review. Table 5 below shows all included studies and a breakdown of their NOS score.

Study Characteristics

The studies included a range of countries by geographical location and according to the World Bank income classifications. Thirteen studies (57%) were carried out in the United

Table 2. Table of included studies for clinical outcomes.

Author	Year	Study Design	Country	Method	Patients	Kappa coefficient
Altieri et al.	*2017*	*Prospective Cohort*	*USA*	*Clinical images*	*232*	*0.51-0.57*
Borve et al.	*2012*	*Prospective Cohort*	*Sweden*	*Smartphone images*	*40*	*0.47*
Gabel et al.	*2021*	*Prospective Cohort*	*USA*	*Clinical images taken by digital photography and tablets*	*41*	*0.33*
Keller et al.	*2020*	*Prospective Cohort*	*USA*	*Clinical images*	*100*	*0.45*
Marchell et al.	*2017*	*Quasi RCT*	*USA*	*Digital photography, compressed and uncompressed video*	*216*	*0.43*
Nami et al.	*2015*	*Prospective Cohort*	*Austria*	*Smartphone images stored in MugDerma*	*391*	*0.91*
Ribas et al.	*2010*	*Prospective Cohort*	*Brazil*	*Digital photography*	*174*	*0.80*
Saleh et al.	*2017*	*Prospective Cohort*	*Egypt*	*Clinical images taken by digital photography stored in Dropbox*	*600*	*0.46-0.52*
Clarke et al.	*2021*	*Prospective Cohort*	*USA*	*Clinical images stored in Research Electronic Data Capture*	*206*	*0.60*
Shaijrat et al.	*2024*	*Prospective Cohort*	*Iran*	*Mobile app utilizing the store-and-forward mode*	*89*	*0.87*
Preclaro et al.	*2022*	*Prospective Cohort*	*Phillippines*	*Smartphone images*	*60*	*0.55-0.84*
Patel et al.	*2024*	*Retrospective Cohort*	*UK*	*Store and forward TD*	*891*	*0.64*

Table 3. Table of included studies for patient outcomes.

Author	Year	Study Design	Country	Method	Patients (N)	Willingness to replace F2F with TM
Maul et al.	2023	Cross-sectional pilot study	Switzerland	A questionnaire on demographics, education, telemedicine experience, and willingness to replace in-person consultations with teledermatology was completed by patients, dermatologists, and healthcare workers.	512	8.9%-68.9%
Kaunitz et al.	2022	Prospective cohort	USA	Patient demographics, satisfaction, and visit preferences were assessed in teledermatology and in-person consultations using live-interactive technology.	602	17.25%
Moore et al.	2022	Retrospective cohort	USA	A cross-sectional email survey assessed patient satisfaction with Penn State Hershey Medical Center's live teledermatology service.	171	24.12%
Marchell et al.	2017	Prospective cohort	USA	The study's 210 patients were evaluated thrice; in-person, by high definition live interactive video that was either compressed lower resolution or uncompressed higher resolution, or by store-and-forward methods, with patients and dermatologists rating encounter quality and ranking their preferred method.	210	14%

Table 4. Table of included studies for operational outcomes.

Author	Year	Study Design	Country	Method	Patients	Cost Diff. per Patient	% Cost Change
Zakaria et al.	2022	Retrospective cost-minimization	USA	Decision-tree models for TD vs. conventional care	2,098	$140.12	20.02%
López-Villegas et al.	2020	Multicentre retrospective	Spain	TD vs. CM cost-saving analysis at Hospital de Poniente	7,030	€8.61	31.66%
Yang et al.	2019	Retrospective cohort	USA	TD consult model vs. conventional care	700	$39.79	19.60%
Parsi et al.	2011	RCT - Cost Analysis	USA	Asynchronous TD vs. in-office follow-up	64	$261.10	45.33%
Datta et al.	2015	RCT	USA	Store-and-forward TD vs. conventional referral	391	$30.00	8.88%
Os-Medendorp et al.	2012	RCT - Economic Evaluation	Netherlands	Cost-effectiveness of TD in moderate AD patients	199	€24.00	6.27%
Ahmed et al.	2023	Retrospective cohort	UK	Store-and-forward TD 2WW vs. F2F clinic	360	£9.52	37.07%

Table 5. All included studies and a breakdown of their NOS score.

Author	Year	Selection				Comparability	Exposure			Total score
		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	
Altieri et al.	2017	★	★	N/A	N/A	★	★	★	★	6
Borve et al.	2012	★	★	N/A	N/A	★★	★	★	★	7
Gabel et al.	2021	★	★	N/A	N/A	★★	★	★	★	7
Keller et al.	2020	★	★	N/A	N/A	★★	★	★	★	7
Marchell et al.	2017	★	★	N/A	N/A	★★	★	★	★	7
Nami et al.	2015	★	★	N/A	N/A	★★	★	★	★	7
Ribas et al.	2010	★	★	N/A	N/A	★★	★	★	★	7
Saleh et al.	2017	★	★	N/A	N/A	★★	★	★	★	7
Clarke et al.	2021	★	★	N/A	N/A	★★	★	★	★	7
Shaijrat et al.	2024	★	★	N/A	N/A	★★	★	★	★	7
Preclaro et al.	2022	★	★	N/A	N/A	★★	★	★	★	7
Patel et al.	2024	★	★	N/A	N/A	★★	★	★	★	7
Maul et al.	2023	★	★	N/A	N/A	★★	★	★	★	7
Kaunitz et al.	2022	★	★	N/A	N/A	★★	★	★	★	7
Moore et al.		★	★	N/A	N/A	★★	★	★	★	7
Marchell et al.	2017	★	★	N/A	N/A	★★	★	★	★	7
Zakaria et al.	2020	★	★	N/A	N/A	★★	★	★	★	7
López-Villegas et al.	2022	★	★	N/A	N/A	★★	★	★	★	7
Yang et al.	2019	★	★	N/A	N/A	★★	★	★	★	7
Parsi et al.	2011	★	★	N/A	N/A	★★	★	★	★	7
Datta et al.	2015	★	★	N/A	N/A	★★	★	★	★	7
Os-Medendorp et al.	2012	★	★	N/A	N/A	★★	★	★	★	7
Ahmed et al.	2023	★	★	N/A	N/A	★★	★	★	★	8

States [12-23], two studies (9%) in The UK [24,25], and one study each (4.3%) in Sweden [26], Switzerland [27], Austria [28], The Netherlands [29], and Spain [30], making up high-income countries. Upper-middle-income countries were represented by Brazil [31] and Iran [32], each with a single study (4.3%). Lower-middle-income countries were also represented by Egypt [33] and the Philippines [34], with one study each (4.3%). The allocation of research signifies a large volume of the literature coming from high-income countries, in particular North America. More than half of the studies (N=12; 52%) employed a prospective cohort design [12-14,16,17,19,26-28,31-34], employing a forward-looking approach. Six studies (26%) [18,20,21,24,25,30] utilized a retrospective cohort design, while four studies (17%) implemented a quasi-randomized controlled trial (RCT) [15,22,23,29].

Fourteen (61%) [12–15,17,18,20,21,25-27,30,31,34] of the studies used synchronous models as the TD intervention of choice. These included methods such as live interactive video consultations and real-time video assessments. Asynchronous models were studied in 11 (39%) of the studies and included the use of digital photography, smartphone images stored in various platforms like Tele-Dermis, Dropbox, and MugDerma, and other mobile applications utilizing store-and-forward techniques.

Clinical outcomes were assessed in twelve (52%) of the studies [12-16,24,26,28,31-34], measuring the inter-rater reliability between TD and F2F consultations using the κ coefficient. The total number of patients across these studies was 3,040, with a median of 206 (IQR 41–600). The mean κ coefficient was 0.57, with the median κ coefficient being 0.55. Notable studies include Gabel et al. (2021, USA) [13], which assessed 41 patients and found the lowest κ coefficient at 0.33. In contrast, Nami et al. (2015, Austria) [28] reported the highest κ coefficient of 0.91 in a study of 391 patients. The total number of lesions evaluated across these diagnostic accuracy studies was 3,142, with an average of approximately 262 lesions per study and a median of 206 lesions.

Four studies (17%) [17-19,27] evaluated the willingness to replace F2F consultations with telemedicine. A total of 1,495 patients participated in these investigations. The average number of patients per study was approximately 374, with a median of 361 patients. The mean willingness to replace F2F consultations with TD was 26.57%, ranging from 8.9% to 68.9%. All findings in these studies were statistically significant ($P<0.05$).

Seven studies (30%) [20-23,25,29,30] addressed the operation outcomes by looking at the cost-effectiveness of TD. These studies included a total of 10,842 patients, with substantial variation in sample sizes. On average, the cost difference per patient was $81.31 (USD equivalent), with a median cost difference of US$39.79 per patient. The cost differences ranged from US$8.61 to US$261.10 per patient. As for the average percentage of cost savings, it was 24.69%, while the median was 31.66%, and the savings ranged from 6.27% to 45.33%. It was found important to differentiate between cost saving and % cost savings due to the different natures of healthcare systems involved. For example, Zakaria et al. (2020, USA) [20] found a cost difference of $140.12 per patient and a cost savings of 20.02% in a study involving 2,098 patients. On the contrary, Ahmed et al. [25] found a substantially lower cost difference of £9.52 per patient. However, this accounted for a cost savings of 37.07%.

Discussion

Clinical Outcomes

This review confirms that TD achieved moderate diagnostic accuracy, with a mean κ coefficient of 0.57 across the included studies. High-resolution imaging played a crucial role in enhancing diagnostic outcomes. For instance, studies utilizing advanced digital photography (e.g., Nami et al., who reported a κ of 0.91 [28]) illustrate how image clarity significantly improves a dermatologist's ability to assess lesions accurately. Conversely, lower-resolution images, as reported by Saleh et al. (κ ≈ 0.46) [33], were associated with greater diagnostic discrepancies and often led to repeat consultations.

Differences between TD modalities were also apparent. Asynchronous systems generally yielded higher κ values (averaging ~0.71) compared to synchronous methods (averaging ~0.56) [15,33]. This disparity was likely due to the ability to review high-quality images without the limitations and transmission issues associated with real-time consultations. Diagnostic agreement also varied across economic settings: high-income countries showed a mean κ of 0.55, upper-middle-income countries 0.76, and lower-middle-income countries 0.59. These differences suggest that factors such as case complexity and technological infrastructure influence outcomes. In high-income settings, the presence of more complex dermatological cases may reduce overall concordance, whereas the rapid adoption of TD technologies in upper-middle-income countries may contribute to higher agreement [28,33].

Clinician expertise is another critical factor. Studies showed that dermatologists with formal training in TD tended to achieve higher diagnostic concordance [33,35], highlighting the importance of incorporating structured TD training into dermatology education. This would help standardize image interpretation and reduce variability in diagnostic outcomes.

Patient Outcomes

Patient acceptance and satisfaction are critical to the long-term sustainability of TD services. This review found a wide range in patient willingness to replace F2F consultations with TD, ranging from 8.9% to 68.9%, with a mean of 26.57% [29]. Dissatisfaction was commonly attributed to technical challenges, including poor image quality, connectivity issues, and software glitches. Notably, older patients and those with lower digital literacy were more likely to express reluctance towards using TD [27]. However, previous studies have shown that the availability of real-time technical support can significantly improve patient satisfaction [36].

Despite the convenience of remote consultations, many patients still preferred F2F interactions, particularly for physical examinations. For example, Kaunitz et al. found that 57.9% of patients favored in-person assessments due to the absence of tactile feedback and the inability to fully replicate clinical examination conditions in TD settings [17]. Willingness to adopt TD also varied based on the severity of the condition: 69% of patients preferred remote consultations for minor or non-urgent issues, compared to only 6% for more severe conditions [27]. These findings suggest that while TD is a valuable tool for triage and follow-up care, it may not fully replace in-person evaluations for complex or serious dermatological concerns. Improved patient education on the appropriate uses and limitations of TD may help address hesitations and optimize its integration into clinical practice.

Operational Outcomes

From an operational standpoint, TD shows substantial promise in reducing costs and enhancing workflow efficiency. This review found an average cost saving of $81.31 per patient when using TD compared to traditional F2F consultations. In the United States, where overhead costs for in-office care are high, studies have reported savings of up to $140.12 per patient [20], reflecting the high overhead costs associated with conventional in-office care. In publicly funded systems like that in the UK, more modest absolute savings, such as the £9.52 per patient reported by Ahmed et al., still represent a significant relative reduction of 37.07% in cost, underscoring the value of TD in resource-limited environments [25].

Several factors contribute to these operational savings, including reduced reliance on physical infrastructure, improved appointment scheduling, and lower rates of patient no-shows. Store-and-forward models are particularly efficient, enabling dermatologists to review cases asynchronously and thereby increase patient throughput without compromising care quality [21]. Additionally, the integration of TD platforms with electronic health records (EHRs) helps to minimize redundant investigations and prevent service duplication, supporting more effective resource allocation [31]. However, the extent to which these operational benefits can be fully realized depends on addressing persistent challenges such as inconsistent technological infrastructure, especially in regions where healthcare systems have limited digital investment.

Limitations

Several limitations must be acknowledged. The heterogeneity in study designs, patient populations, and TD modalities poses challenges for direct comparison. Variations in outcome measures, especially the exclusion of neutral patient responses in satisfaction surveys, may have influenced the overall estimates. Moreover, the exclusion of non-peer-reviewed literature could introduce publication bias, potentially limiting the breadth of evidence. Future research should focus on standardizing methodologies and outcome metrics as well as on conducting long-term studies to assess the impact of TD on chronic disease management, healthcare utilization, and longitudinal clinical outcomes.

Conclusion

The evidence suggests that TD is a viable alternative to traditional F2F consultations in many contexts, offering moderate diagnostic accuracy, improved patient satisfaction for selected conditions, and meaningful cost savings. However, its optimal application appears to be within a hybrid care model that combines remote consultations with periodic in-person evaluations. Such an approach leverages the convenience and efficiency of TD while preserving the clinical advantages of direct physical examinations.

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