

**Digitale Gesundheitsinterventionen bei Hauterkrankungen:
Eine Analyse von Bedarfen, Barrieren und fördernden Faktoren aus
der Perspektive von Patienten und Fachpersonal im
Gesundheitswesen**

Dissertation

zur Erlangung des akademischen Grades eines
Doktor der Philosophie (Dr. phil.)
an der
Medizinischen Fakultät der Universität Hamburg.

vorgelegt von:

Patrick Reinders

aus

Langenfeld (Rheinland)

2025

Betreuer:in / Gutachter:in der Dissertation: Prof. Dr. Matthias Augustin

Gutachter:in der Dissertation: PD Dr. Jan Zeidler

Vorsitz der Prüfungskommission: Prof. Dr. Matthias Augustin

Mitglied der Prüfungskommission: Prof. Dr. Stefan Schneider

Mitglied der Prüfungskommission: PD Dr. Jan Zeidler

Datum der mündlichen Prüfung: 21.01.2026

Inhaltsverzeichnis

1. Darstellung der Publikation.....	7
1.1. Hintergrund.....	7
1.1.1. Status der Dermatologischen Versorgung Heute und Morgen.....	7
1.1.2. Digital Health als Ansatz zur Lösung.....	9
1.1.2.1. Definition von Digital Health.....	9
1.1.2.2. Positive Effekte von Digital Health auf die Gesundheitsversorgung.....	10
1.1.2.3. Risiken und Herausforderung von Digital Health.....	14
1.1.3. Gesetzeslage.....	17
1.1.4. Status der allgemeinen digitalen Versorgung in Deutschland.....	20
1.1.5. Status der digitalen dermatologischen Versorgung in Deutschland.....	21
1.1.6. Hinleitung zu den Forschungsfragen.....	23
1.1.7. Zielstellung.....	24
1.2. Überblick der verwendeten Methoden.....	26
1.2.1. Publikation 1: Systematische Übersichtsarbeit.....	26
1.2.2. Publikation 2: Fokusgruppen und qualitative Inhaltsanalyse.....	27
1.2.3. Publikation 3 und 4: Cluster-Analysen.....	28
1.2.4. Publikation 5: Umfrage Dermatologenschaft.....	29
1.2.5. Publikation 6: Repräsentative Umfrage zur Anwendung von Digital Health- Anwendungen in der Bevölkerung.....	30
1.2.6. Publikation 7: Discrete Choice Experiment zur Teledermatologie.....	31
1.3. Ergebnisse.....	36
1.3.1. Übersicht der verfügbaren Digital Health-Anwendungen.....	36

1.3.2.	Ergebnisse der Fokusgruppen	38
1.3.3.	Akzeptanzprofile der Dermatologen	38
1.3.4.	Akzeptanzprofile von dermatologischen Patienten	41
1.3.5.	Nutzung und Akzeptanz von Digital Health-Anwendungen bei Dermatologen	43
1.3.6.	Nutzung und Akzeptanz von Digital Health-Anwendungen bei Patienten	45
1.3.7.	Präferenz von Patienten mit einer Psoriasis zur teledermatologischen Versorgung	49
1.4.	Diskussion	53
1.4.1.	Evidenz und Verfügbarkeit von Digital Health-Anwendungen in der Dermatologie	53
1.4.2.	Wichtige Barrieren von Digital Health aus Perspektive der Dermatologenschaft	54
1.4.3.	Verbreitung von Digital Health-Anwendungen in der Bevölkerung.....	55
1.4.4.	Fehlende Akzeptanz und Kompetenz - Arzt oder Patient?.....	55
1.4.5.	Digital Divide durch die Digitale Dermatologie	57
1.4.6.	Datenschutz und Datensicherheit.....	58
1.4.7.	Päferenzen für Digital Health-Anwendungen	59
1.4.8.	Stärken und Limitationen der Arbeiten.....	59
1.4.9.	Implikationen für die Praxis	62
1.5.	Fazit.....	63
2.	Artikel oder Manuskript mit Letter of Acceptance.....	64
2.1.	Publikation 1	64
2.2.	Publikation 2	65
2.3.	Publikation 3	66
2.4.	Manuskript 4 (Nicht akzeptiert; Stand 10.05.2025).....	67
2.5.	Publikation 5	68

2.6. Publikation 6	69
2.7. Publikation 7	70
3. Zusammenfassung.....	71
3.1. Zusammenfassung Deutsch	71
3.2. Summary Englisch.....	73
4. Literaturverzeichnis	75
5. Abkürzungsverzeichnis.....	95
6. Abbildungsverzeichnis.....	97
7. Tabellenverzeichnis.....	98
8. Erklärung des Eigenanteils an den Publikationen	99
9. Eidesstattliche Versicherung	100
10. Danksagung	101

Zur besseren Lesbarkeit wird in dieser Dissertationsschrift das generische Maskulinum verwendet. Die in dieser Arbeit verwendeten Personenbezeichnungen beziehen sich – sofern nicht anders kenntlich gemacht – auf alle Geschlechter.

1. Darstellung der Publikation

Die vorliegende Dissertation analysiert den Status quo der Digitalisierung in der dermatologischen Versorgung in Deutschland. Begonnen bei den tatsächlichen Nutzungsraten von digitalen Angeboten, über die Verfügbarkeit, die Akzeptanz, Barrieren und fördernde Faktoren, bis hin zu Präferenzen für digitale Versorgungsprogramme, umfasst die Arbeit das Thema aus verschiedenen Perspektiven.

1.1. Hintergrund

In diesem Kapitel soll zunächst ein Überblick über die derzeitige und potenziell zukünftige dermatologische Versorgung gegeben werden. Anschließend folgt eine Einführung in *Digital Health*-Anwendungen und welche Auswirkungen die Einführung dieser auf die Versorgung hat und zukünftig haben kann. Im Weiteren folgt eine Übersicht über die derzeitige Gesetzeslage der Bundesrepublik Deutschland und die Entwicklung im nationalen Gesundheitswesen zu diesem Themenkomplex. Zwar werden in einigen Themenfeldern internationale Vergleiche gezogen, jedoch beschränkt sich die Analyse der Entwicklung der Digitalisierung weitestgehend auf den Standort Deutschland. Daran anschließend erfolgt die Hinleitung zur Zielstellung, um die weitere Relevanz der Fragestellungen darzulegen.

1.1.1. Status der Dermatologischen Versorgung Heute und Morgen

In diesem Kapitel soll der derzeitige und zukünftige Status der Dermatologie dargestellt werden. Dabei werden zunächst Kennzahlen der Versorgung dargelegt: Angefangen mit der Versorgungsstruktur (Anzahl an Dermatologen, Anzahl an Arztkontakten) gefolgt von den häufigsten Diagnosen und der Versorgungszufriedenheit der Patienten. Abschließend werden die größten Herausforderungen der Dermatologie, deren Auswirkungen auf die Versorgung und potenzielle Lösungsansätze analysiert.

Stand heute sind rund 6.000 Dermatologen (Facharztbezeichnung: Haut- und Geschlechtskrankheiten) im deutschen Gesundheitswesen tätig. Davon sind 4.900 im ambulanten Sektor und 1.100 im stationären Sektor in Hautkliniken tätig [1]. Im ambulanten Sektor sind 3.400 Dermatologen selbstständig niedergelassen, und 1.500 arbeiten in einem Angestelltenverhältnis [1]. In der gesamten Dermatologenschaft sind 27 % der Ärzte über 60 Jahre alt, und weitere 31 % sind über 50 Jahre alt [1]. Im ambulanten Sektor versorgt jeder Arzt jährlich durchschnittlich 5.200 – 5.600 Fälle [2]. Ein deutlich kleinerer Anteil an Leistungen mit häufig höherem Schweregrad wird dagegen in den 115 Hautkliniken erbracht [3]. Im Schnitt

werden jährlich in einer Hautklinik 2.300 Fälle stationär und 13.100 Fälle ambulant versorgt [4].

Pro Jahr haben ca. 30 % der Erwachsenenbevölkerung mindestens eine Konsultation bei einem Dermatologen in Deutschland [5]. Die Hauterkrankungen mit der höchsten Prävalenz umfassen dabei Pilzinfektionen (8,9 %), atopische Dermatitis (5,5 %) und die Akne (5,4 %) [6]. Chronische Erkrankungen, wie die atopische Dermatitis (Prävalenz: 5,5 %) oder Psoriasis (Prävalenz: 3,9 %) haben einen vergleichsweise hohen Anteil an der Versorgung [6–10].

Die dermatologische Versorgung in Deutschland zeichnet sich durch hohe Zufriedenheitsraten mit der Behandlung aus [5]. Allerdings ist die Dermatologie bereits heute von langen Wartezeiten auf einen Termin geprägt. Die Akuität der Erkrankung und regionalen Unterschiede sind wesentliche Einflussfaktoren für die Wartezeit [11]. Bei Personen mit einer Psoriasis hat sich zuletzt gezeigt, dass Personen ohne Inanspruchnahme eines Versorgungsangebotes die lange Wartezeit auf einen Termin und die geringe Zeit mit dem behandelnden Dermatologen als Gründe für die Nicht-Inanspruchnahme angeben [12].

Die Dermatologie steht, ebenso wie die gesundheitliche Versorgung insgesamt, vor großen Herausforderungen. Hierbei ist der demografische Wandel als Hauptgrund zu nennen. Aufgrund der Binnenmigration jüngerer Personen von Land zu Stadt sind die Auswirkungen in ländlichen Regionen stärker zu verzeichnen [13]. Der demografische Wandel wirkt sich sowohl auf das Angebot als auch die Nachfrage der Versorgung aus. Da etwa zwei Drittel der Dermatologenschaft über 50 Jahre alt sind, werden diese in den nächsten Jahrzehnten aus der Versorgung ausscheiden [1]. Gleichzeitig nimmt aufgrund des zunehmenden Alters der Gesamtbevölkerung die Wahrscheinlichkeit für verschiedene Hauterkrankungen, wie Hautkrebs und dermatologische Infektionen zu [14]. Des Weiteren ist künftig mit einer steigenden Zahl multimorbider und pflegebedürftiger Patienten sowie einer parallelen Zunahme der Polypharmazie zu rechnen [15]. Auf Grundlage der beschriebenen Verschiebung von Angebot und Nachfrage ergab eine Szenario-Analyse, dass bis zum Jahr 2035 in 11 % bis 23 % der regionalen Planungsbereiche des Gemeinsamen Bundesausschusses (G-BA) eine Unterversorgung in der Dermatologie vorliegen wird [16]. Des Weiteren können 6 – 13 % der Regionen gar nicht dermatologisch versorgt werden [16]. Zusätzliche Daten weisen darauf hin, dass bereits heute bis zu 25 Millionen Menschen aus ca. 11 Millionen Haushalten von einer vulnerablen Versorgungslage betroffen sind. Diese umfasst nicht nur eine Unterversorgung im Sinne des Verhältnisses von Ärzten zu Einwohnern, sondern auch den erschwerten räumlichen Zugang zu Praxen sowie eine erhöhte Arbeitsbelastung der Ärzte [17].

Empfehlungen zur Milderung der beschriebenen Effekte umfassen die Delegation von Leistungen an weitere medizinische Fachkräfte (z. B. Krankenpflege, medizinische Fachangestellte) [18], die Schaffung von Anreizstrukturen – sowohl finanzieller Natur als auch in Form familienfreundlicherer Arbeitsbedingungen, sowie eine verbesserte Koordination der Leistungserbringer [19].

Des Weiteren wird der Digitalisierung des Gesundheitswesens ebenfalls eine wichtige Rolle für die Sicherstellung einer qualitativ hochwertigen Versorgung, bei zeitgleicher Entlastung des Gesundheitspersonals, zugeschrieben [17,20–22]. Die Anwendungsmöglichkeiten der Digitalisierung und die potenziellen Effekte auf die Versorgung werden im nächsten Kapitel beschrieben.

1.1.2. Digital Health als Ansatz zur Lösung

In diesem Kapitel soll ein Überblick in den Themenkomplex *Digital Health* geschaffen werden. Dazu zählen die wichtigsten Definitionen, die möglichen positiven Effekte auf die Versorgung und die Risiken und Herausforderungen von *Digital Health* in der allgemeinen Versorgung.

1.1.2.1. Definition von Digital Health

Aufgrund des dynamischen Feldes der Digitalisierung existieren verschiedene Definitionen unterschiedlicher Institutionen. Das World Health Assembly hat im Jahr 2005 eine erste Definition des Begriffes *eHealth* veröffentlicht:

„eHealth is the cost-effective and secure use of information and communications technologies in support of health-related fields, including health-care services, health surveillance, and health education, knowledge and research” [23].

Mit der Verbreitung mobiler Endgeräte – insbesondere von Smartphones – und des mobilen Internets prägte die World Health Organization (WHO) im Jahr 2011 den Begriff mobile Health (mHealth) als Teil von eHealth und definierte ihn wie folgt:

„mHealth or mobile health as medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices..” [24]

Um dem Auftreten von *Big Data*, künstlicher Intelligenz und der vermehrten Verfügbarkeit von sogenannten Genomanalysen Rechnung zu tragen, wurden diese Aspekte neu im Begriff *Digital Health* vom Executive Board der WHO zusammengefasst:

Digital Health is „... a broad umbrella term encompassing eHealth (which includes mHealth), as well as emerging areas, such as the use of advanced computing sciences in ‘big data’, genomics and artificial intelligence” [25]

Alle drei Definitionen beziehen sich vor allem auf die technischen Möglichkeiten und deren Anwendungsgebiete und verweisen nicht auf die sozio-kulturellen Aspekte von *eHealth* bzw. *Digital Health* hin. Dies wird in der viel zitierten Definition von Eysenbach 2001 deutlicher herausgearbeitet:

„e-health is an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies. In a broader sense, the term characterizes not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve health care locally, regionally, and worldwide by using information and communication technology” [26]

Somit ist nicht nur die Technologie, sondern auch deren Anwender und dessen Einstellungen entscheidend für eine erfolgreiche Implementierung von E-Health-Anwendungen.

Im weiteren Verlauf dieser Arbeit wird der Begriff *Digital Health* im Sinne der WHO-Definition verwendet und bezieht sich dabei ebenfalls auf die eingebrachten sozio-kulturellen Aspekte von Eysenbach 2001 [26].

1.1.2.2. Positive Effekte von Digital Health auf die Gesundheitsversorgung

Im Anschluss an die Definitionen stellt der folgende Abschnitt dar, wie Anwendungen aus dem Bereich *Digital Health* (*Digital Health*-Anwendungen; DHAs) die Versorgung positiv ergänzen können. Dabei wird Bezug auf das Konzeptionsmodell *eHealth*, entwickelt von Shaw et al. 2017 (siehe Abbildung 1), verwendet und mit Beispielen aus der dermatologischen Versorgung erläutert [27].

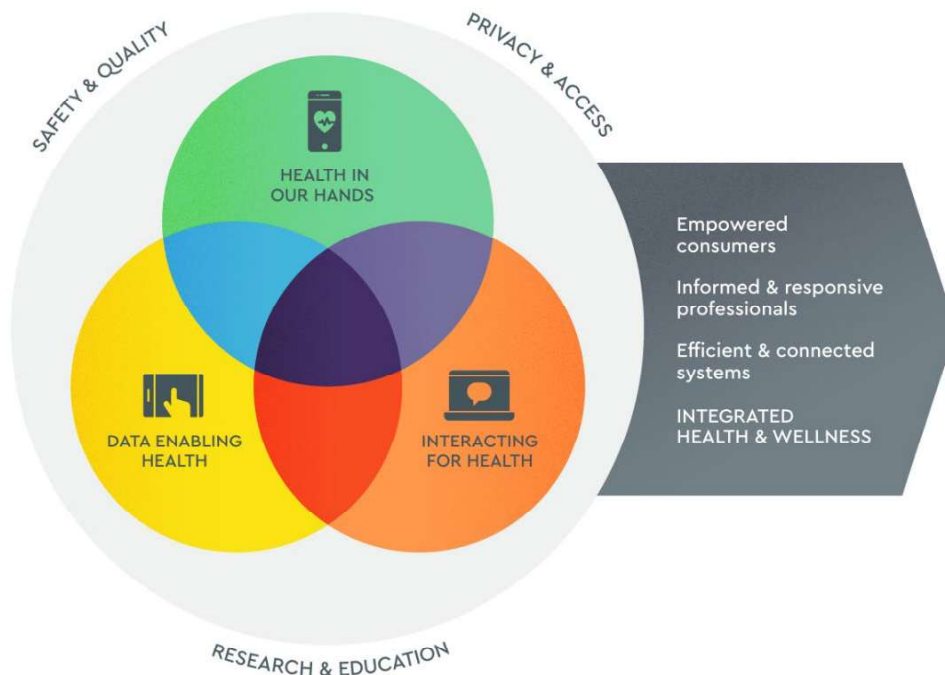


Abbildung 1 “A conceptual model for eHealth“ von Shaw et al. 2017 [27] lizenziert unter [CC BY 4.0](#)

Die erste Domäne *Health in Our Hands* umfasst hierbei den zeitlich und örtlich unbegrenzten Zugang zu persönlichen Gesundheitsdaten (z.B. Arztbriefe, Laborwerte) und Gesundheitsinformationen (z.B. Patientenportale). Der Zugang zu diesen Informationen findet beispielsweise über Informationswebseiten (z.B. Gesundheitsinformation.de) oder die elektronische Patientenakte statt [27]. Daneben können digitale Patientenselbsthilfeprogramme dabei unterstützen, psychische Begleiterkrankungen von dermatologischen Erkrankungen zu behandeln [28]. Potenzielle Vorteile in dieser Domäne sind die Stärkung der Patientenzentrierung und die aktivere Mitarbeit und Mitentscheidung durch Patienten (*Patient Empowerment*) [27].

Die zweite Domäne (*Interacting for Health*) umfasst alle Formen der Kommunikation zwischen den an der Versorgung beteiligten Gruppen, einschließlich der Patienten. Zum einen sind hierunter telemedizinische Angebote gemeint, die entweder synchron (z.B. via Videosprechstunde oder Telefon) und asynchron (z.B. via Instant Messenger, E-Mail; sog. *Store-And-Forward* Teledermatologie; S&F Teledermatologie) oder als eine Kombination aus beiden (Hybrid) ablaufen können. Zum anderen gehören auch der Austausch in sozialen Medien und Foren, die Erinnerung über Apps (z. B. zur Verbesserung der Adhärenz) durch

Push-Up-Nachrichten sowie neue Therapieformen in virtuellen Räumen zu diesen Entwicklungen [27]. Aufgrund des visuellen Charakters der Dermatologie gibt es eine Vielzahl an Beispielen aus dem Bereich der Teledermatologie. Dies kann zum einen die Diagnosestellung [29], das Telekonsil zwischen Haus- und Hautarzt [30], sowie die regelmäßige Verlaufskontrolle zwischen Arzt und Patient darstellen [31]. Die Vorteile der digitalen Kommunikation sind der orts- und zeitunabhängige (nur bei asynchroner) Charakter der Kommunikation, welche eine effiziente Versorgung für Patienten und Ärzte ermöglichen kann. In den bereits beschriebenen unterversorgten Regionen (siehe Kapitel 2.1) kann die Telemedizin helfen, den Zugang zur dermatologischen Versorgung sicherzustellen bzw. zu verbessern [17,32]. Es gibt erste Hinweise, dass die telemedizinische und teledermatologische Versorgung im Speziellen den Zugang zur Versorgung verbessert, zu einem effizienteren Ressourceneinsatz beiträgt (z.B. weniger Krankenhauseinweisungen) und die Qualität der Versorgung nicht negativ beeinflusst. [31,33–37].

Die dritte Domäne (*Data Enabling Health*) umfasst jegliche Datenverarbeitung inklusive der Erhebung, Speicherung, Auswertung und Kommunikation von Gesundheitsdaten des Patienten [27]. Hierbei spielen die elektronische Patientenakte, als auch weitere Patientenportale eine wesentliche Rolle. In der Dermatologie gibt es vereinzelt Bestrebungen mit Hilfe von Webportalen systematisch objektive klinische Endpunkte (z.B. Laborwerte) und *Patient Reported Outcomes* (z.B. die Lebensqualität) zu erheben, die Veränderung über die Zeit zu analysieren und allen Beteiligten zur Verfügung zu stellen [38]. Mit Hilfe eines standardisierten Datensatzes könnte zudem sichergestellt werden, dass alle für die medizinische Entscheidung relevanten Daten vorliegen [39]. Neben der besseren Verlaufskontrolle von Patienten kann die Datenerhebung auch mögliche Behandlungsfehler (Kontraindikation von Arzneien) anzeigen. Die erhobenen Daten könnten der Forschung zugänglich gemacht werden, um die Behandlung von Patientengruppen zu optimieren [27]. Ein weiterer wichtiger Aspekt dieser Domäne ist die Anwendung künstlicher Intelligenz (KI), die in der Dermatologie zur Diagnosestellung und Verlaufskontrolle durch Bilddaten bereits eingesetzt wird [40,41]. Des Weiteren können KI-Modelle auf Basis des *Natural Language Processing* Ärzte dabei unterstützen, Diagnose- und/oder Therapieentscheidungen zu treffen, automatische Dokumentationen vorzunehmen und Arztbriefe zu verfassen [42].

Die drei aufgezeigten Domänen bestehen dabei nicht losgelöst voneinander, sondern sorgen bei Interaktion für weitere mögliche positive Effekte für Ärzte, Patienten sowie das Gesamtgesundheitswesen. Verschiedene Versorgungsmodelle sind demnach denkbar. So könnte z. B. die Festlegung eines kritischen Wertes für einen *Patient Reported Outcome* - etwa im Rahmen von *Data Enabling Health* - eine Empfehlung zum rechtzeitigen Arztbesuch aussprechen (*Health in Our Hands*). Die anschließende Kommunikation *Interacting for Health*

könnte digital über Telemedizin erfolgen, wobei die erhobenen Daten (*Data Enabling Health*) in die Entscheidungsgrundlage für eine mögliche Therapie einfließen.

Darüber hinaus bieten DHAs ein breites Spektrum an Einsatzmöglichkeiten in der Dermatologie, insbesondere in Situationen, in denen die herkömmliche medizinische Versorgung eingeschränkt ist (siehe Abbildung 2). Ein Vorteil liegt in der Überwindung von Sprachbarrieren durch die Mehrsprachigkeit vieler Apps, was die Kommunikation zwischen Patienten und Ärzten erheblich erleichtert. Zudem können DHAs in geografisch isolierten oder schwer zugänglichen Gebieten, wie auf Schiffen oder in abgelegenen Regionen, eine wertvolle Ergänzung zur medizinischen Versorgung darstellen [43]. Auch für Menschen mit häufig wechselndem Wohnsitz, etwa Schausteller oder anderen häufigen (beruflichen) Reisetätigkeiten bieten diese Anwendungen eine kontinuierliche Betreuung unabhängig vom Aufenthaltsort. Auf globaler Ebene eröffnet die Telemedizin durch den Einsatz von DHAs das Potenzial, die dermatologische Versorgung in Entwicklungsländern zu verbessern und so einen Beitrag zur Reduktion gesundheitlicher Ungleichheiten zu leisten [44].

Mehrsprachigkeit von Anwendungen zur Überwindung von Sprachbarrieren	Sicherstellung der kontinuierlichen Behandlung für Personen mit Reisetätigkeit oder wechselndem Wohnsitz
Verbesserung der medizinischen Versorgung in geografisch isolierten Gebieten (z. B. auf Schiffen)	Förderung des Zugangs zu medizinischer Expertise in ländlichen oder unterversorgten Regionen

Abbildung 2 Weitere Einsatzmöglichkeiten und Vorteile von DHAs in der Dermatologie (Eigene Abbildung)

Zusammenfassend lässt sich festhalten, dass DHAs durch eine stärkere Einbindung von Patienten, einen flächendeckenden und schnellen Zugang sowie eine verbesserte Datengrundlage für Entscheidungen ein hohes Potenzial haben, die Versorgung effizienter und patientenzentrierter zu gestalten. Die aufgezeigten Effekte des demografischen Wandels (siehe Kapitel 2.1) könnten durch die Einbindung solcher Anwendungen abgemildert werden.

Neben den aufgezeigten Vorteilen für die Versorgung ist es ebenso erforderlich, die möglichen Risiken und Herausforderungen von DHAs zu betrachten.

1.1.2.3. Risiken und Herausforderung von Digital Health

In diesem Kapitel werden die bereits bekannten Risiken und Herausforderungen der Digitalisierung dargestellt, dabei widmen sich die Unterkapitel speziell den Themen des *Digital Divides*, der Verwendung von nicht-evidenzgestützten Anwendungen und des Datenschutzes.

Digital Divide

Der *Digital Divide* bezeichnet die unterschiedliche Nutzungshäufigkeit von Informations- und Kommunikationstechnologien zwischen verschiedenen Bevölkerungsgruppen [45]. Es wird dabei zwischen dem *Digital Divide* erster und zweiter Ordnung unterschieden [46]. Während ein *Digital Divide* erster Ordnung, lediglich den Zugang zu Informations- und Kommunikationstechnik (IKT) bezeichnet und Aspekte wie Hardware (Computer und Smartphone) und Internetgeschwindigkeit umfasst, zielt der *Digital Divide* zweiter Ordnung auf Kompetenzen im Umgang, Akzeptanz und Art der Nutzung gegenüber IKT ab. Der Zugang zu IKTs (*Digital Divide* erster Ordnung) scheint in den letzten Jahren eine verminderte Relevanz darzustellen – so besaßen im Jahr 2022 annähernd 90 % der deutschen Bevölkerung ein Smartphone und nahezu 95 % nutzten mindestens einmal im Jahr das Internet [47]. Beinahe alle Haushalte in Deutschland, unabhängig von der Region, hatten mindestens einen Breitbandanschluss (96,5% aller privaten Haushalte mit ≥ 50 Mbits) sowie Zugang zur Mobilfunktechnologie Long Term Evolution (LTE; auch als 4G bezeichnet; 99,9% aller privaten Haushalte) [48,49]. Eine Mindestgeschwindigkeit von 50 Mbit/s wird als technologische Grundvoraussetzung für die Durchführung einer Videosprechstunde angesehen, wodurch eine flächendeckende Implementierung grundsätzlich realisierbar ist [50]. Dagegen ist der *Digital Divide* zweiter Ordnung wesentlich ausgeprägter. Der *Digital Skills Indicator 2.0*, welcher von *Eurostat* entwickelt wurde, zeigt deutliche Unterschiede in Bezug auf Alter, Bildung und Region (Stadt/Land) auf [51]. Während 60 % der Bevölkerung im Alter von 16 bis 29 Jahren mindestens befriedigende Kompetenzen aufweisen, trifft dies nur auf etwa 30 % der Kohorte im Alter von 65 bis 74 Jahren zu. Bei in städtischen Regionen lebenden Personen liegt der Anteil bei 60 %, während er in ländlichen Regionen nur 45 % beträgt. Zwischen hochgebildeten (72 %) und niedrig gebildeten Personen (31 %) sind besonders hohe Unterschiede festzustellen [51]. Neben allgemeinen digitalen Kompetenzen finden sich diese Diskrepanzen ebenfalls bei der Erhebung der digitalen Gesundheitskompetenz und der Nutzung von Gesundheits-Informationsangeboten wieder [52]. Wobei die digitale

Gesundheitskompetenz die „*selbsteingeschätzten Schwierigkeiten beim Finden, Verstehen, Beurteilen und Anwenden von digitalen Gesundheitsinformationen*“ erfasst [52].

Der Zugang zum digitalen Raum wird dabei immer häufiger als eine wichtige soziale Determinante der Gesundheit verstanden [53]. Wichtige Aspekte des Alltags, welche alle direkt oder indirekt eine Auswirkung auf die individuelle Gesundheit haben, benötigen vermehrt digitale Kompetenzen. Dazu zählt die soziale Teilhabe, die Suche nach Jobs oder Wohnungen, Wahrnehmung von Bildungsangeboten oder die Information und Inanspruchnahme von behördlichen Leistungen [53]. In Bezug auf die direkte Inanspruchnahme von Versorgungsleistungen konnten erste Auswertungen aus den USA während verhängter Ausgangssperren im Zuge der Covid-19-Pandemie zeigen, dass bereits benachteiligte Gruppen seltener digitale Versorgungsangebote in Anspruch genommen haben [54,55]. Eine verstärkte Integration von *Digital Health* in den Versorgungsalltag könnte daher neben den aufgezeigten Vorteilen (siehe Kapitel 2.2.2) auch bereits bestehende Disparitäten in der Versorgung verstärken. Angesichts dessen werden in der Forschung vermehrt Rahmenkonzepte entwickelt, die den Zugang zu *Digital Health*-Anwendungen als wichtigen Bestandteil einer gerechten Gesundheitsversorgung identifizieren [56].

Fehlende Validierung und Evidenz von Digital Health

Das Technologieunternehmen Meta (Mutterkonzern von Facebook) hatte lange Zeit das Unternehmensmotto „*Move Fast and Break Things*“ und spielte damit auf die disruptiven Geschäftsmodelle des Unternehmens an [57]. Auch die Idee des „*Minimum Viable Products*“, also der Entwicklung von Produkten, die zunächst eine geringe Auswahl an Funktionen haben und über die Zeit kontinuierlich an die Kundenbedürfnisse angepasst und weiterentwickelt werden, haben ebenfalls ihren Ursprung bei Technologiekonzernen [58]. Beides widerspricht, zumindest in großen Anteilen, den Vorgehensweisen im Gesundheitswesen. Hier gelten, zum Schutze des Patienten, hohe rechtliche Hürden, wie das Arzneimittel- und Medizinproduktrecht. Dies trägt zu den langen Zeiträumen von der Produktidee bis zur Marktreife eines neuen Arzneimittels oder Medizinprodukts bei [59]. Auch der Nachweis des Nutzens durch klinische Evidenz ist bei Arzneimitteln und teilweise bei Medizinprodukten Teil des Zulassungsprozesses und in den meisten europäischen Ländern Voraussetzung für den Markteintritt [60–62].

Die schnelle Entwicklung von DHAs kann zunehmend in den beiden App-Stores (*Google Play und Apple AppStore*) beobachtet werden. Hier umfasst die Anzahl der *Digital Health-Apps* aktuell mehr als 350.000, wobei täglich etwa 250 Anwendungen hinzukommen [63]. Demgegenüber steht lediglich eine geringe Anzahl von ca. 2.000 Publikationen, welche die

Validität, Wirksamkeit, Sicherheit und Effektivität von Anwendungen untersucht haben [63]. Der fehlende Nachweis der Validität und des Nutzens kann dabei zu vielfältigem Risiko für Anwender führen, wie zum Beispiel der fehlerhaften Dokumentation des Blutdruckes via *DHAs* [64]. Ebenfalls im Bereich der Dermatologie fehlen häufig Validierungen und klinische Effektivitätsdaten. Von insgesamt 41 dermatologischen KI-Apps lagen nur bei fünf mindestens eine *peer-reviewed* Publikation zur klinischen Validität vor. Zudem waren lediglich zwei dieser Anwendungen als Medizinprodukt zugelassen [65]. Fehlinformationen und falsche Empfehlungen können Patienten verunsichern und im schlimmsten Fall sogar negative Auswirkungen auf den Gesundheitszustand haben [65,66]. Der fehlende Nachweis lässt sich zum einen Teil durch geringe regulatorische Anforderungen und zum anderen Teil durch die hohen Kosten von klinischen Studien erklären, welche sich die häufig in der Gründungsphase befindlichen Unternehmen nicht leisten können [67,68].

Eine zusätzliche Besonderheit von *DHAs* besteht darin, dass diese häufig von Patienten eigenständig im Internet recherchiert und genutzt werden. Dabei verfügen viele Patienten nicht über die notwendige Kompetenz (siehe Kapitel 2.2.3.1), um die Qualität der Anwendung angemessen beurteilen zu können [52,69]. Von den bereits beschriebenen 41 dermatologischen KI-Apps richteten sich 32 spezifisch an den Patienten [65].

Die hohe Anzahl der Anwendungen sorgt ebenfalls dafür, dass es Ärzten zunehmend schwerfällt, die Qualität und Wirksamkeit der Anwendungen korrekt einzuschätzen [70]. Die bis dato in vielen Fällen fehlende Evidenz sorgt auch für Herausforderungen aufseiten der Krankenversicherungen bzw. des Kostenträgers, welche zunehmend evidenzgestützte Entscheidungen bezüglich der Kosteneffektivität von Maßnahmen treffen müssen [71].

Aufgrund der speziellen Herausforderung von *DHAs* sind in den letzten Jahren zahlreiche nationale und internationale Evaluationsrahmen entwickelt worden [69,70,72,73]. Der Evaluationsrahmen des *National Institute for Health and Care Excellence* (NICE) enthält zum Beispiel verschiedene Klassen, für die unterschiedliche Anforderungen an die Evidenz bestehen [72]. Besonders hervorzuheben ist hier ebenfalls das DIGA-Fast-Track-Verfahren des Bundesinstituts für Arzneimittel und Medizinprodukte (BfArM), welches digitale Gesundheitsanwendungen (DiGAs) im Sinne der Digitalen-Gesundheitsanwendungen-Verordnung (DiGAV) evaluiert und somit die Erstattungsfähigkeit durch die gesetzlichen Krankenversicherungen festlegt. Ein wichtiger Baustein des Verfahrens stellt hierbei die Sicherstellung der Anforderungen an den Datenschutz und -sicherheit dar, welche im anschließenden Kapitel behandelt werden [73].

Datenschutz und Datensicherheit

Gesundheitsdaten gelten als sensibel und sind gemäß Artikel 9 Abs. 1 der Datenschutzgrundverordnung (DSGVO) im besonderen Maße schützenswert. Dieser Schutz hat das Ziel, den Einzelnen vor Beeinträchtigungen seiner Persönlichkeitsrechte und seiner persönlichen Entwicklung zu bewahren, welche durch den Umgang mit den erhobenen personenbezogenen Daten entstehen können [74]. Der Datenschutz hat das Ziel, die verantwortungsvolle Verarbeitung personenbezogener Gesundheitsdaten zu gewährleisten. Dabei spielt die Datensicherheit eine entscheidende Rolle. Bei dieser wird durch technische Maßnahmen wie Firewalls und Verschlüsselung sowie organisatorische Maßnahmen wie den räumlichen Zugangsschutz sichergestellt, dass die Daten vor unbefugtem Zugriff, Manipulation oder Zerstörung geschützt sind und somit sicher gespeichert und verarbeitet werden können. [75].

Mit der aufgezeigten Zunahme von vorliegenden Gesundheitsdaten aufgrund einer zunehmenden Digitalisierung im Gesundheitswesen nehmen die Schwere und Häufigkeiten von Missbräuchen dieser erhobenen Daten zu [75]. Die Auswirkungen von Verletzungen des Datenschutzes bzw. der Datensicherheit für den Einzelnen sind vielfältig und umfassend: Identitätsdiebstahl, Diskriminierung (z.B. am Arbeitsplatz oder durch Versicherungen), Erpressung, das Gefühl von Überwachung, Vertrauensverluste in Institutionen des Gesundheitswesens oder sogar negative medizinische Auswirkungen aufgrund von Datenmanipulation [76–78].

Aufgrund der dargelegten Auswirkungen bestehen bei Patienten Datenschutzbedenken, die einen signifikant negativen Einfluss auf die Akzeptanz von DHAs haben [79].

Auf Seite der Gesundheitsdienstleister hat die Umsetzung der DSGVO zu erheblichen Zusatzkosten geführt, Arbeitsprozesse verändert und zu zeitlichem Mehraufwand geführt [80]. Angesichts dessen gibt es deutliche Anzeichen, dass Ärzte kritisch gegenüber der Einführung der DSGVO stehen [81].

Die DSGVO wird in Deutschland strenger ausgelegt, was in der Geschichte Deutschlands im 20. Jh. begründet liegt [82]. Die strengere Auslegung wird von Experten als wichtige Hürde bei der Digitalisierung im Gesundheitswesen gesehen [83].

1.1.3. Gesetzeslage

Nachdem in dem vorausgegangenen Kapitel ein Überblick über die Definition von DHAs, ihren potenziellen Vorteilen, Risiken und Herausforderungen ausführlich dargebracht wurde, befasst

sich dieses Kapitel mit der Gesetzeslage. Der Fokus liegt dabei auf den wichtigsten auf Bundesebene verabschiedeten Gesetzen, die explizit zum Ziel haben oder hatten, die Gesundheitsversorgung mit Hilfe von digitalen Lösungen zu verbessern. Die Darstellung der Gesetzeslage ist unabdingbar, um die Forschungsergebnisse dieser Arbeit in den Kontext der Gesamtversorgung einzuordnen.

Das erste Gesetz, das den Grundstein für die digitale Versorgung in Deutschland legen sollte, war das „Gesetz zur Modernisierung der gesetzlichen Krankenversicherung“, welches zum 01.01.2004 in Kraft getreten ist. Neben zahlreichen Maßnahmen außerhalb von Digitalisierungsaspekten, wurden bereits eine stärkere elektronische Kommunikation zwischen Leistungserbringern und dem Patienten gefordert (§ 67 Absatz 1 Sozialgesetzbuch (SGB V)), die Finanzierung von elektronischen Gesundheitsakten ermöglicht (§ 69 SGB V), die Einführung der elektronischen Gesundheitskarte (§ 291a Absatz 1 SGB V) und deren Anwendungen (§ 291a Absatz 3) festgelegt. Letztere umfassen die Eignung der Gesundheitskarte für einen Notfalldatensatz oder die Arzneimitteldokumentation (§ 291a Absatz 3 SGB V) [84]. Ein Jahr später wurde mit dem Gesetz zur Organisationsstruktur der Telematik im Gesundheitswesen die Gesellschaft für Telematik (GEMATIK) gegründet, welche zur Aufgabe hatte ein Konzept und Vorgaben für die Entwicklung einer digitalen Telematikinfrastruktur zu schaffen (§ 291b Absatz 1 SGB V) [85].

Aufgrund des unzureichenden Fortschrittes und unklaren Zuständigkeiten innerhalb der Selbstverwaltung des Gesundheitswesens, wurde im Jahr 2015 das „Gesetz für sichere digitale Kommunikation und Anwendungen im Gesundheitswesen“ (auch bekannt als E-Health-Gesetz) vom Deutschen Bundestag verabschiedet und trat noch im selben Jahr in Kraft [86,87]. Ziel des Gesetzes war, die Telematikinfrastruktur weiter auszubauen, sodass bis zum 31.12.2018 alle Leistungserbringer (Arztpraxen und Krankenhäuser) an diese angeschlossen werden (§ 291a und § 291e SGB V). Darüber hinaus sollte der Weg für telemedizinische Behandlungen geebnet werden (§ 291 g SGB V), eine größtmögliche Interoperabilität sichergestellt werden (§ 291e SGB V), eine elektronische Patientenakte (§ 291a Absatz 5c SGB V) eingeführt sowie weitere Anwendungen der elektronischen Gesundheitskarte, wie den Medikationsplan (§ 31 SGB V), konzipiert und in der Versorgung etabliert werden. Für die Umsetzung der technischen Aspekte war die GEMATIK beauftragt (§ 291 Absatz 2b SGB V). Die vollständige Umsetzung des Gesetzes scheiterte allerdings erneut, da zum Ende 2018 lediglich ca. 30 % der Leistungserbringer an die Telematikinfrastruktur angeschlossen waren [88]. Ein wesentlicher Grund hierfür ist die begrenzte Verfügbarkeit von Konnektoren, die einen sicheren Zugang zur Telematikinfrastruktur gewährleisten sollen. Der erste Konnektor wurde von der GEMATIK erst Ende 2017 offiziell zugelassen [89].

Im Zuge der Festlegung des § 291 g SGB V (Etablierung von telemedizinischen Leistungen) und weiterer Rahmenbedingungen für die telemedizinische Versorgung galt die Neufassung des ausschließlichen Fernbehandlungsverbotes (§ 7 Abs. 4 (Muster-)Berufsordnung für die in Deutschland tätigen Ärztinnen und Ärzte; MBO-Ä) in den Berufsordnungen der Landesärztekammern als unabdingbar [90]. Diese Neufassung wurde beim 121. Deutschen Ärztetag im Jahr 2019 in Erfurt beschlossen und erlaubt eine „ausschließliche Beratung oder Behandlung über Kommunikationsmedien im Einzelfall“. Ferner können Ärzte „Kommunikationsmedien unterstützend einsetzen“ [91]. Die vollständige Einführung der Neufassung in die Berufsordnungen aller Landesärztekammern wurde erst 2024 mit der Änderung durch die Landesärztekammer Brandenburg abgeschlossen [92]. Ebenfalls im Jahr 2019 wurde das Gesetz für mehr Sicherheit in der Arzneimittelversorgung verabschiedet, welches die Abgabe von verschreibungspflichtigen Medikamenten nach einer Fernbehandlung ermöglicht (§ 48 AMG Abs. 1) und Regelungen zum elektronischen Rezept von der Selbstverwaltung eingefordert hat (§ 86 SGB V) [93,94].

Die erneute Verpflichtung zum Anschluss an die Telematikinfrastuktur, diesmal zusätzlich mit Kürzungen der Vergütung hinterlegt, aller Leistungserbringer wurde im Digitale-Versorgungsgesetz festgelegt, welches zum 19.12.2019 in Kraft getreten ist. Als wichtiger Meilenstein des Gesetzes gilt die Verordnungsmöglichkeit von DiGAs [95]. Darunter sind digitale Medizinprodukte mit niedriger Risikoklasse zu verstehen, welche vor allem zur „Erkennung, Überwachung, Behandlung oder Linderung von Krankheiten“ bestimmt sind und nach Prüfung durch das BfArM von einem Arzt oder Psychotherapeut verordnet werden können (§ 33a Absatz 1 SGB V) [96]. Des Weiteren wurde die elektronische Verordnung (eRezept) (§ 86 SGB V) festgelegt und den gesetzlichen Krankenkassen Fördermittel für digitale Innovationen zur Verfügung gestellt (§ 68a SGB V) [96].

Im Terminservice- und Versorgungsgesetz, welches am 11.05.2019 in Kraft getreten ist, wurde erstmals die elektronische Übermittlung der Arbeitsunfähigkeitsbescheinigung mit Hilfe der Telematikinfrastuktur festgelegt und gesetzliche Krankenkassen (GKV) verpflichtet, ihren Patienten eine elektronische Patientenakte zur Verfügung zu stellen, welche ohne den Einsatz der elektronischen Gesundheitskarte erfolgen kann (§ 291a SGB V) [97].

Im Gesetz zur digitalen Modernisierung von Versorgung und Pflege, welches am 09.09.2021 verabschiedet wurde, wurden digitalen Pflegeanwendungen (DiPA) als Pendant zur DiGA eingeführt (§ 40a SGB V), die Interoperabilität zwischen Daten aus DiGAs mit der elektronischen Patientenakte gesetzlich sichergestellt und der G-BA mit der Beauftragung einer Richtlinie zur telemedizinischen Arbeitsunfähigkeitsbescheinigung beauftragt (§ 88 SGB V) [98].

Am 22. März 2024 verabschiedete der Bundestag das Gesetz zur Beschleunigung der Digitalisierung des Gesundheitswesens. Im Kern sieht es vor, für alle gesetzlich Versicherten eine elektronische Patientenakte (ePA) einzuführen, wobei die Versicherten der Nutzung widersprechen können (sogenannte Opt-out-Lösung, gemäß § 337 Absatz 3 und § 342 Absatz 1 SGB V). Die Einführung der ePA erfolgte zum 15. Januar 2024 [99].

Darüber hinaus wurden weitere bedeutsame Entscheidungen getroffen, darunter die erweiterte Integration des digitalen Medikationsplans, des eRezepts, der DiGA — mit Ausweitung auf Medizinprodukte der Risikoklasse IIb — sowie die Lockerung von Beschränkungen in der Telemedizin (insbesondere die Aufhebung bestehender Mengenbegrenzungen) [99].

Am 26.03.2024 wurde das Gesetz zur verbesserten Nutzung von Gesundheitsdaten verabschiedet worden, welches vor allem Grundsätze zur Verknüpfung von Gesundheitsdaten aus verschiedenen Datenquellen zu Forschungszwecken schafft – so sollte ein Forschungsdatenzentrum gegründet werden (§ 303d SGB V). Auch wurde die Opt-out-Lösung zur Datenfreigabe von Daten aus der ePA eingeführt (§ 363 SGB V Absatz 1, 2 und 5) [100].

1.1.4. Status der allgemeinen digitalen Versorgung in Deutschland

Trotz der aufgezeigten zahlreichen Gesetzesinitiativen, welche ihren Startpunkt bereits im Jahr 2004 hatten, belegte Deutschland in einer Studie der Bertelsmann-Stiftung aus dem 2019 zur digitalen Gesundheitsversorgung im Vergleich zu 17 Industrienationen lediglich Platz 16 [101]. Die Gründe dafür lagen in der unzureichenden Marktreife digitaler Anwendungen, wie dem eRezept oder der ePA, dem Fehlen einheitlicher technischer Standards sowie der begrenzten tatsächlichen Nutzung der verfügbaren digitalen Angebote [101]. Estland galt im Zuge der Studie als Vorreiter der digitalen Gesundheitsversorgung, aufgrund der hohen Nutzungsrate der nationalen ePA und der umfassenden Integration von erhobenen Gesundheitsdaten in den Versorgungsprozess [101].

Auf Seiten der Leistungserbringer hat es seit dem Jahr 2019 in Deutschland zwar einen deutlich positiven Trend gegeben, nicht zuletzt aufgrund der COVID-19-Pandemie, dennoch ist der Einsatz von digitalen Anwendungen weiterhin gering. So kommunizierten (stand 2023) lediglich 41 % der ambulanten Ärzteschaft mit ihren Kollegen und nur 7 % mit Krankenhäusern, mehrheitlich in digitaler Form. Des Weiteren boten nur 37 % der Praxen ihren Patienten die Möglichkeit zur Videosprechstunde, lediglich jede vierte Praxis (26 %) verordnet eine digitale Gesundheitsanwendung (DiGA), und nur 20 % nutzten die ePA [102]. Einem Großteil der Bevölkerung sind mittlerweile die vielen digitalen Anwendungen bekannt,

wie dem eRezept (97 %), der elektronischen Arbeitsunfähigkeitsbescheinigung (eAU) (93 %), der Videosprechstunde (85 %) und der ePA (95 %). Allerdings wurde Letztere im Jahr 2023 nur von einem Prozent der Personen verwendet [103].

Die Telemedizin hat in den letzten Jahren an Relevanz in der Versorgung gewonnen, insbesondere aufgrund der durch mehrere Lockdowns in den Hochzeiten der COVID-19-Pandemie reduzierten persönlichen Arzt-Patienten-Kontakte. So bot eine zunehmende Anzahl an Leistungserbringern (ca. 25 % im Jahr 2021 vs. 4 % im Jahr 2017) die Videosprechstunde an [104]. Dabei gilt es jedoch zu bedenken, dass trotzdem lediglich ca. 2 % der Versicherten eine solche Leistung bis zum Jahr 2022 in Anspruch genommen haben und diese weitestgehend der psychotherapeutischen Versorgung zugeordnet werden können [104]. Die langfristigen Auswirkungen der Pandemie auf das Versorgungsgeschehen bleiben jedoch abzuwarten, so sind die Anzahl der Videosprechstunden von ca. 3,5 Millionen im Jahr 2021 auf 2,2 Millionen im Jahr 2023 gesunken [105]. Bei knapp 800 Millionen Arzt-Patienten-Kontakten pro Jahr in Deutschland ist dieser Anteil nach wie vor als gering einzuschätzen [106].

Hürden beziehungsweise Gründe für die unzureichende Digitalisierung werden in der Literatur zahlreich benannt. Die Autoren der bereits zitierten Bertelsmann-Studie deuten auf die strikte Auslegung des Datenschutzes, die fehlende Strategie auf Bundesebene und fehlende finanzielle Anreize für Leistungserbringer hin [101]. Eine qualitative Expertenbefragung aus dem Jahr 2018 hat die Interessenkonflikte innerhalb der Selbstverwaltung, fehlende finanzielle Anreize und Mehrwerte für Leistungserbringer sowie die fehlende Interoperabilität von Software-Systemen als Hürde aufgezeigt [83]. Aus Perspektive der Leistungserbringer wurde der Anpassungsbedarf (Zustimmung 71 %), ein ungünstiges Kosten-Nutzen-Verhältnis der digitalen Angebote (Zustimmung 72 %) oder die fehlende Nutzerfreundlichkeit (Zustimmung 62 %) als Hemmnisse identifiziert [102]. Auch die sogenannte Präsenzpflcht in der vertragsärztlichen Versorgung und das damit verbundene Angebot von 25 Sprechstunden pro Woche für GKV-Patienten am Vertragsarztsitz (§17 Abs. 1 und 1a Bundesmantelverträge – Ärzte) stellen Hindernisse für die Einführung der Telemedizin, als Videosprechstunde sowie für die zeitversetzte sog. S&F-Telemedizin dar [22,107], da sie den flexiblen Einsatz der Technologie und Integration in den Praxisalltag erschwert und somit die Möglichkeit der überregionalen Versorgung behindert.

1.1.5. Status der digitalen dermatologischen Versorgung in Deutschland

Die digitale dermatologische Versorgung in Deutschland ist von der allgemeinen digitalen Gesundheitsversorgung abhängig. Dennoch ist die spezifische Analyse des Status quo der

Digitalisierung in der Dermatologie aufgrund der beschriebenen besonderen Rahmenbedingungen (hohe Fallzahlen, viele chronische Erkrankungen und Auswirkungen des demografischen Wandels) besonders hervorzuheben. Darüber hinaus eignen sich bestimmte Anwendungen, wie Telemedizin oder KI-basierte Bildanalysen, besonders gut für die Dermatologie, da diese Fachrichtung stark auf visuelle Diagnostik angewiesen ist.

Als eine der ersten Facharztgruppen besitzt die Dermatologie in Deutschland einen Leitfadens zum Einsatz von telemedizinischen Anwendungen in der Routineversorgung, welcher zusätzlich in einer S2k (konsensbasierten) Leitlinie mündete [108,109]. Innerhalb des Leitfadens werden die Grundlagen, Anwendungsbereiche, Indikationen und Kontraindikationen sowie rechtliche Rahmenbedingungen aufgezeigt [108], während in der Leitlinie Empfehlungen zur konkreten Anwendung der Telemedizin gegeben werden [109]. Als ein Beispiel wird innerhalb der Leitlinie die Erstdiagnostik bei Verdacht auf Psoriasis nicht empfohlen, aber die Verlaufsdagnostik per Videosprechstunde oder per zeitversetzter sog. Store-And-Forward-Teledermatologie (S&F-Teledermatologie) [109]. Analog dazu wurde ein Fortbildungsangebot zur Teledermatologie seitens der Deutschen Dermatologischen Akademie geschaffen [110].

Trotz bestehender Leitlinie, Leitfadens und Fortbildungsangeboten ist der derzeitige Einsatz der Telemedizin am Anteil der Gesamtversorgung gering. Zwar boten im Jahr 2020 bereits ca. 40 % der Dermatologen eine Form der teledermatologischen Versorgung (Videosprechstunde ca. 28 % und Store-And-Forward Teledermatologie ca. 22 %) an. Dennoch wurden im Jahr 2023 lediglich ca. 16.000 Videosprechstunden von Dermatologen abgehalten [105,111]. Da die Versorgung mit der S&F-Teledermatologie von privatwirtschaftlichen Unternehmen, wie OnlineDoctor [112], Derma2Go [113], AppDoc [114] oder Dermanostic [115] organisiert wird, kann der Anteil an der Versorgung lediglich geschätzt werden. Dermanostic gibt selbst an, von 2019 bis 2023 mehr als 300.000 Patienten versorgt zu haben [115], während OnlineDoctor seit Gründung im Jahr 2016 mehr als 200.000 Patienten versorgt hat [112]. Im Verhältnis zu ca. 5 Millionen Behandlungsfällen im Quartal ist der Anteil an der Versorgung beider Arten der Telemedizin gering und nach wie vor im niedrigen einstelligen Bereich einzuordnen [116].

Eine Hürde bei der Versorgung mit Hilfe der S&F-Teledermatologie ist, dass diese bis dato nicht als Regelleistung im einheitlichen Bewertungsmaßstab (EBM) vorgesehen ist [117] und daher von den Nutzern selbst gezahlt werden muss. In Einzelfällen bestehen gesonderte Verträge mit einzelnen GKVn zur Kostenübernahme [118].

Zum Einsatz weiterer DHAs in der Dermatologie fehlt bis dato eine systematische Übersicht. Eine Analyse des IQVIA Institutes kam zu dem Ergebnis, dass ca. 2 % aller

erkrankungsspezifischen Smartphone-Apps speziell für Hauterkrankungen in den App-Stores zur Verfügung stehen [63]. Bis dato (Stand: 30.03.2025) ist keine der 68 im DiGA-Verzeichnis gelisteten Anwendungen für eine dermatologische Indikation entwickelt worden [119]. Ähnlich zu den S&F-Telemedizin-Plattformen gibt es auch hier vereinzelt Anbieter, wie zum Beispiel die Nia Health App zur Anwendung bei Atopischer Dermatitis, die Verträge zur Kostenübernahme mit einzelnen GKVern geschlossen haben [120].

Ein weiterer Anwendungsbereich von *Digital Health*, der eine zunehmende Relevanz aufweist, ist die KI. Dermatologen stehen dem Einsatz positiv gegenüber und es stehen zahlreiche Anwendungen zur Verfügung [40,41,121,122]. Jedoch fehlen aktuelle Zahlen, welche den derzeitigen Einsatz innerhalb der Regelversorgung, zum Beispiel beim Einsatz des Hautkrebsscreenings, untersuchen. Stand heute gibt es keine gesonderten Abrechnungsziffer für dermatologische KI-Leistungen im EBM [117].

1.1.6. Hinleitung zu den Forschungsfragen

In den vorangegangenen Kapiteln wurde der Kontext, die Vorteile und Risiken sowie die bis dato bekannten Hürden der Digitalisierung in der Gesundheitsversorgung im Allgemeinen und in der Dermatologie im Speziellen erläutert. Im Folgenden wird die Hinleitung zu den untersuchten Forschungsfragen dargestellt.

Wie bereits aufgezeigt, eignen sich bestimmte Anwendungen, wie die Teledermatologie, eher für das Feld der Dermatologie als andere. Es herrscht derzeit jedoch Unklarheit darüber, welche Anwendungen bereits Gegenstand von Untersuchungen in der wissenschaftlichen Literatur waren, für welche Indikationen und welche Anwendergruppen. Eine systematische Übersichtsarbeit ermöglicht, Forschungslücken zu identifizieren und weitere systematische Reviews zu den ermittelten Anwendungsfeldern anzustoßen.

Des Weiteren sind spezifische Barrieren und fördernde Faktoren in der digitalen Dermatologie bisher nicht systematisch untersucht und veröffentlicht. Die publizierte Forschung zu unterschiedlichen Fachbereichen bzw. zur Gesamtversorgung [83,123] umfasst die spezifischen Anforderungen der Dermatologie (z.B. chronische Erkrankungen und visuelle Diagnostik) nur unzureichend. Diese Aspekte zunächst qualitativ und anschließend quantitativ zu untersuchen, ermöglicht diese Lücke zu schließen. Eine qualitative Befragung mittels Fokusgruppen stellt dabei sicher, dass relevante Aspekte der Zielgruppen (Ärzte, Pflegekräfte und Patienten) identifiziert werden und in die Fragebogenentwicklung und Dateninterpretation einfließen [124,125].

Aktuell gibt es eine unzureichende Datenlage bezüglich der Nutzung von digitalen Anwendungen in der täglichen Versorgung von dermatologischen Patienten. Aufgrund der fehlenden Forschung besteht eine unzureichende Datengrundlage für politische und versorgungstechnische Entscheidungen. Bis dato wurde lediglich eine Befragung veröffentlicht, welche den Einsatz von teledermatologischen Anwendungen bei Dermatologen untersucht [111]. Weitere Befragungen unter verschiedenen Anwendergruppen (Patienten und Ärzte), welche mit Hilfe von Regressionsanalysen und Cluster-Analysen ausgewertet werden, können Rückschlüsse auf einzelne Bevölkerungsgruppen und deren Aspekte darlegen.

Ein wichtiger Aspekt bei der Implementation von neuen Angeboten, analog sowie digital, in der Versorgung ist die Erhebung von Präferenzen gegenüber Angebotseigenschaften [126]. Diese werden in der vorliegenden Arbeit anhand der Teledermatologie für die Verlaufskontrollen von Patienten mit Psoriasis mit Hilfe von *Discrete Choice Experimenten* untersucht. Zwar gibt es bereits eine Vielzahl von Präferenzforschungen zur Telemedizin oder Teledermatologie, allerdings ist diese häufig international und nicht auf die Versorgung von chronischen Patienten in der Dermatologie in Deutschland zugeschnitten [127–130]. Für die Teledermatologie gibt es bereits ausreichend Forschung zur Effektivität in der Versorgung [31,131]. Die vorliegende Evidenz legt jedoch nahe, dass sich die Mehrzahl der Teledermatologie-Anbieter gegenwärtig auf die Erstdiagnose fokussiert, während die Bedeutung der Verlaufskontrolle bislang vernachlässigt wird [112–115].

1.1.7. Zielstellung

Die vorliegende Dissertation hat zum Ziel, den Status quo der digitalen Dermatologie in Deutschland zu beschreiben und eine Wissensgrundlage für Politik, Forschung, Entwickler, aber auch Anwendergruppen (z.B. Fachpersonal im Gesundheitswesen und Patienten) zu schaffen. Dies umfasst eine Übersicht der verfügbaren und in der Literatur beschriebenen DHAs, der Identifikation von fördernden Faktoren und Barrieren aus Perspektive drei verschiedener Stakeholdergruppen (Patienten, Pflegekräfte, Ärzte), der Einstellung dieser Stakeholdergruppen zur Digitalisierung, der Verbreitung von einzelnen DHAs, sowie der Präferenz von Patienten zu spezifischen Charakteristika von teledermatologischen Versorgungsangeboten. Dies führt zu sieben konkreten Fragestellungen, welche mit sieben Publikationen beantwortet werden.

Publikation 1: Systematische Übersichtsarbeit

- (1) (a) Welche *Digital Health*-Anwendungen wurden für welche Anwendergruppen, mit welchen Studien und Endpunkten in *peer-reviewed* Publikationen veröffentlicht und (b) welche Trends und Forschungslücken lassen sich daraus ableiten?

Publikation 2: Qualitative Inhaltsanalyse von Fokusgruppen

- (2) (a) Welche fördernden Faktoren und Barrieren lassen sich in Bezug auf die Verwendung von *Digital Health*-Anwendungen aus der Perspektive von drei relevanten Stakeholdergruppen (Dermatologen, Pflegekräften in dermatologischen Praxen und dermatologische Patienten) identifizieren und (b) welche Unterschiede lassen sich zwischen den Gruppen beschreiben?

Publikation 3 und 4: Clusteranalysen von Umfrageergebnissen von Ärzten und Patienten zur Einstellung gegenüber *Digital Health*-Anwendungen

- (3) (a) Welche Einstellungen haben Dermatologen und dermatologische Patienten zu *Digital Health*-Anwendungen und (b) Gibt es einen Zusammenhang zwischen der Einstellung gegenüber *Digital Health*-Anwendungen und dem realen Nutzungsverhalten?

Publikation 5 und 6: Verbreitung von *Digital Health*-Anwendungen in der Bevölkerung und in der Versorgung

- (4) (a) Wie verbreitet die *Digital Health*-Anwendungen bei Dermatologen und bei dermatologischen Patienten und (b) welche Zusammenhänge lassen sich zwischen der Verwendung von *Digital Health*-Anwendungen und soziodemografischen Determinanten feststellen?

Publikation 7: Präferenzen von Patienten gegenüber der teledermatologischen Versorgung

- (5) (a) Welche Präferenzen haben Patienten mit einer Psoriasis gegenüber teledermatologischen Anwendungen und (b) Welche Interaktionseffekte zu weiteren Determinanten können festgestellt werden?

1.2. Überblick der verwendeten Methoden

1.2.1. Publikation 1: Systematische Übersichtsarbeit

Es wurde eine systematische Literaturrecherche in MEDLINE via Pubmed und Referenzartikeln durchgeführt. Die identifizierten Publikationen wurden im Anschluss anhand definierter Aspekte, wie Art der DHA oder der Anwendergruppe (Arzt, Patient, sonstige), kategorisiert und die Häufigkeiten der Kategorien ausgezählt. Die Übersichtsarbeit wurde im *Journal of the European Academy of Dermatology & Venereology* (JEADV) unter dem Titel: *“Digital health interventions in dermatology - Mapping technology and study parameters of systematically identified publications”* [132] veröffentlicht. Eingeschlossen wurden zunächst alle Publikationen, welche eine DHA in der Dermatologie untersucht haben. Bei Studien zu Anwendungen, die auf Methoden der KI beruhen, wurden nur solche eingeschlossen, die entweder einen Algorithmus zur Standardversorgung verglichen, den Algorithmus in einer prospektiven Studie untersucht oder eine marktverfügbare Anwendung analysiert haben. Dies wurde vorgenommen, um Arbeiten auszuschließen, die sich auf die theoretische mathematische Entwicklung von KI-Anwendungen in der Dermatologie konzentrieren [133]. Des Weiteren wurden lediglich Publikationen mit quantitativen Methoden, Originalarbeiten, Arbeiten in Deutsch oder Englisch sowie Publikationen, welche zwischen 2010 und 2022 veröffentlicht wurden, eingeschlossen. Das Titel- und Abstract- sowie Volltextscreening wurde mit mindestens zwei Forschern durchgeführt. Bei Nichtübereinstimmung wurde die jeweilige Publikation diskutiert und zusammen über Ein- bzw. Ausschluss diskutiert. Für die standardisierte Datenextraktion wurde auf eine Extraktionstabelle aus einem vorherigen systematischen Review zum Thema Teledermatologie zurückgegriffen und diese für die vorliegende Arbeit angepasst [34]. Neben typischen Studienparametern (inkl. Studiendesign, Anzahl Patienten/Fälle, Jahr der Publikation) wurde die Art der DHA weitestgehend mit der von der WHO entwickelten *classification of digital health interventions* [134] kodiert. Diese wurde nach einer ersten Inspektion der eingeschlossenen Publikationen angepasst, um die Studien spezifischer kategorisieren zu können. So wurde zum Beispiel der Bereich KI unterschieden in KI zur Analyse von Bildern und KI zur Datenanalyse zur individuellen Risikoeinschätzung aufgrund anderer Datenquellen. Zusätzlich wurde das Ziel der Anwendung (inkl. Diagnosestellung, Verlaufskontrolle, Prävention, Therapieunterstützung oder Edukation), die betrachtete Hauterkrankung, die Zielgruppe und die Ziele der Publikation (inkl. Wirksamkeit/Effektivität, Effizienz, diagnostische Leistung usw.) extrahiert. Eine Übersicht aller eingeschlossenen Studien kann dem Anhang der Publikation entnommen werden [132]. Die extrahierten Daten wurden deskriptiv ausgewertet und es wurden Kreuztabellen gebildet, zum

Beispiel zwischen der Art der DHA und dem Studiendesign. Diese wurden grafisch mit Hilfe von Blasendiagrammen dargestellt.

1.2.2. Publikation 2: Fokusgruppen und qualitative Inhaltsanalyse

Um die Einstellungen, Barrieren und fördernden Faktoren gegenüber DHAs in der Dermatologie bei verschiedenen Anwendergruppen zu erkunden, wurden Fokusgruppen mit Dermatologen, dermatologischen Patienten und Pflegekräften (medizinische Fachangestellte sowie Gesundheits- und Krankenpfleger) durchgeführt und ausgewertet. Das Ergebnis wurde mit dem Titel „*Exploring Acceptability, Barriers, and Facilitators for Digital Health in Dermatology: Qualitative Focus Groups with Dermatologists, Nurses, and Patients*“ im *Journal of Medical Internet Research Dermatology (JMIR Dermatology)* veröffentlicht [135]. Fokusgruppen sind eine Forschungsmethode der qualitativen Forschung, welche moderierte Diskussionen in Kleingruppen umfasst und aufgrund der Interaktion zwischen Teilnehmern eine tiefgründige Erforschung von Perspektiven und Meinungen sowie geteilten Erfahrungen zu einem Thema ermöglicht [124]. Für die strukturierte Durchführung der Fokusgruppen wurde ein semistrukturierter Interviewleitfaden entwickelt. Dieser gliederte sich in drei Teile: 1) Fragen zum aktuellen Status der dermatologischen Versorgung und zu Problemen damit; 2) Vorstellung und Diskussion von fünf DHAs, die überwiegend auf den in der systematischen Literaturübersicht identifizierten DHAs basierten. Die Teilnehmer wurden gebeten, zu erläutern, ob sie sich vorstellen könnten, diese Anwendungen zu nutzen, und was sie möglicherweise davon abhalten würde; 3) Zudem wurden die Teilnehmer spezifisch zu den Themen Datensicherheit und -schutz, Evidenz zu Anwendungen und dem Einfluss auf die Patienten-Arzt-Beziehung befragt. Der Leitfaden wurde an die drei Anwendergruppen angepasst, behielt jedoch in jedem Fall die angegebene Grundstruktur bei.

Bei allen drei Anwendergruppen wurde ein *purposeful sampling* anhand demografischer Aspekte durchgeführt, sodass Stichproben mit hoher Varianz an Personen eingeschlossen wurden. Bei Dermatologen und Pflegekräften wurde eine Variation anhand von Altersklassen (< 39 Jahre, 40–49 Jahre, 50 Jahre und älter), Geschlecht (männlich/weiblich) sowie Geografie (Ost, West, Nord, Süd und Stadt/Land) als Auswahlkriterium berücksichtigt. Bei Patienten wurde zusätzlich darauf geachtet, dass unterschiedliche Erkrankungen eingeschlossen wurden. Insgesamt wurden 30 Dermatologen, 30 Pflegekräften, sowie 34 dermatologische Patienten in insgesamt 18 Fokusgruppen (sechs Gruppen je Anwendergruppe) befragt.

Die Fokusgruppen wurden aufgrund der COVID-19-Pandemie und der unterschiedlichen regionalen Herkunft der Personen online durchgeführt. Um dabei einen inhaltsreichen

Austausch sicherzustellen, wurde den STEER Empfehlungen (*Stability of Group Number, Technology, Environment, Evaluation und Recruitment*) gefolgt [136].

Die Transkripte der Fokusgruppen wurden qualitativ inhaltlich nach Elo und Kyngäs (2008) ausgewertet [125]. Die Analyse erfolgte induktiv-deduktiv – dabei wurden die Hauptkonstrukte des *Unified Theory of Acceptance and Use of Technology* (UTAUT) deduktiv als übergreifende Konstrukte verwendet [137]. Das UTAUT-Modell zielt darauf ab, die Akzeptanz und Verwendung von neuen Technologien zu erklären und besitzt vier Hauptkonstrukte: *Performance Expectancy, Effort Expectancy, Facilitating Conditions and Social Influence*. Das Modell wird häufig in der quantitativen Erhebung der Akzeptanz von *Digital Health*-Anwendungen angewendet [138]. Zudem wird das Modell vermehrt in der qualitativen Forschung als deduktives Konstrukt angewendet [139]. Die Haupt- und Unterkategorien wurden induktiv zunächst auf Ebene der fünf DHAs und Themengebiete (z.B. Evidenz, Datenschutz) gesammelt, in einem weiteren Schritt wurden übergeordnete Haupt- und Subkategorien abstrahiert und im Anschluss den UTAUT-Konstrukten zugeordnet. Anschließend wurden die Kategorien je Anwendergruppe abgeglichen und gegenübergestellt. Die Erstellung der Haupt- und Subkategorien, sowie die Zuordnung dieser wurde von Patrick Reinders durchgeführt und in mehreren Treffen mit den Koautoren (Marina Otten und Anastasia Fleyder) offen diskutiert.

1.2.3. Publikation 3 und 4: Cluster-Analysen

Eine Umfrage unter Patienten und Ärzten wurde durchgeführt, um die Einstellungen von Dermatologen und dermatologischen Patienten zu *Digital Health*-Anwendungen festzustellen sowie ob es einen Zusammenhang zwischen der Einstellung und deren tatsächlicher Anwendung gibt.

Die Fragebögen für beide Zielgruppen, Patienten und Ärzte, basieren auf den Ergebnissen der Fokusgruppen und wurden mit Literaturquellen zum Thema abgeglichen [140–142]. Es wurde zum Beispiel der eHeals-Fragebogen (*eHealth Literacy Scale*), der die Kompetenzen von Patienten im Bereich eHealth erhebt, für die Fragebogenentwicklung für Patienten hinzugezogen [141]. Insgesamt wurden 27 Items für Patienten und 31 Items für die teilnehmenden Dermatologen entwickelt bzw. aus der Literatur übernommen. Jedes Item war ein Statement zum Themenbereich der Akzeptanz – beispielsweise „Ich könnte mir vorstellen vermehrt digitale Anwendungen für die Versorgung zu nutzen.“- Die Zustimmung zu jedem Item wurde jeweils auf einer Likert Skala von 1 (Stimme gar nicht zu) bis 5 (Stimme voll und ganz zu) von den Teilnehmenden vorgenommen.

Neben den Items zur Akzeptanz wurden Fragen zur derzeitigen und zukünftigen Nutzung von DHAs verwendet. Die derzeitige Nutzung wurde abgefragt mit „Ja“, „Nein“ oder „Weiß nicht“. Items zur zukünftigen Nutzung basierten ebenfalls auf Statements, die mit derselben Likert-Skala zugestimmt oder abgelehnt wurden. Die Auswahl der Anwendungen basierte auf der bereits vorgestellten systematischen Übersichtsarbeit [132]. Um die Länge des Fragebogens für Ärzte zu reduzieren und somit die Teilnehmerquote zu erhöhen, wurden weniger Anwendungen abgefragt. Zusätzlich wurden dagegen vier selbst entwickelte Items zur nationalen eHealth-Strategie eingefügt, die ebenfalls mit einer Likert-Skala zu beantworten waren.

Um die zugrundeliegende Struktur der 27 bzw. 31 Items zur Akzeptanz festzustellen und diese Faktoren zu nutzen, um die Akzeptanz der Patienten näher zu beschreiben, wurde eine explorative Faktorenanalyse (EFA) für beide Gruppen, Patienten und Ärzte, durchgeführt. Hierbei wird generell empfohlen, mindestens 150 Teilnehmer einzuschließen [143]. Um diese Fallzahl zu erreichen, wurde eine zufällige Auswahl von 1.000 Dermatologen aktiv über die Deutsche Dermatologische Akademie angeschrieben, da bei vorherigen Projekten eine geringe Rücklaufquote (10 – 20 %) beobachtet wurde [142,144]. Patienten mit verschiedenen chronischen dermatologischen Erkrankungen wurden über verschiedene Patientenverbände, wie dem Deutschen Psoriasisbund (DPB e.V.) oder dem Deutschen Allergie- und Asthmabund (DAAB) rekrutiert, um eine diverse Stichprobe zu erreichen.

Im Anschluss an die EFA wurden die identifizierten Faktoren in beiden Fällen genutzt, um eine zweistufige Cluster-Analyse (*Hierarchical and k-means Cluster*) durchzuführen, mit dem Ziel, Subgruppen, die sich aufgrund ihrer Akzeptanz unterscheiden, zu identifizieren [145]. Des Weiteren wurden die identifizierten Cluster auf Grundlage ihrer Demografie, Geografie (z.B. Stadt/Land) und bei Patienten zusätzlich auf Grundlage ihrer Krankheitsgeschichte näher beschrieben und Unterschiede zwischen den Clustern identifiziert. Zudem wurde geprüft, ob die Zuordnung zu einem Cluster eine Aussagekraft gegenüber der derzeitigen und potenziell zukünftigen Nutzung von *Digital Health*-Anwendungen hat.

1.2.4. Publikation 5: Umfrage Dermatologenschaft

Mithilfe einer Umfrage unter Dermatologen wurde die Nutzungshäufigkeit von DHAs und die Veränderung bezüglich des Interesses und der Erwartungen dazu in den Jahren 2019 und 2021 ermittelt. Die Umfrage wurde unter dem Titel: *Attitudes Toward and Use of eHealth Technologies Among German Dermatologists: Repeated Cross-Sectional Survey in 2019 and 2021* im *Journal of Medical Internet Research* veröffentlicht [142]. Der Unterschied dieser Umfrage im Vergleich zur zuvor beschriebenen Umfrage liegt vor allem in der Teilnehmerzahl,

die eine höhere Generalisierbarkeit und bessere Möglichkeiten der statistischen Auswertung zulässt. In beiden Erhebungszeitpunkten wurde daher lediglich ein einseitiger Fragebogen mit insgesamt 23 Items (im Jahr 2019) bzw. 29 Items (im Jahr 2021), einschließlich der demografischen Daten, verwendet. Alle Dermatologen, die der Deutschen Dermatologischen Akademie angehören (ca. 3.500), wurden angeschrieben.

Die statistische Auswertung verfolgte zwei übergeordnete Ziele: 1) Die Veränderungen in der Nutzung von DHAs, das Interesse an diesen sowie die Erwartungen an diese zwischen den beiden Erhebungszeitpunkten zu analysieren, und 2) Unterschiede zwischen Subgruppen zu identifizieren, die sich durch demografische Merkmale unterscheiden (Alter [≥ 50 / < 50 Jahre], Geschlecht [männlich/weiblich], Geografie [Stadt/Land]). Die Berechnung logistischer Regressionen ermöglichte eine Adjustierung basierend auf demografischen Unterschieden.

1.2.5. Publikation 6: Repräsentative Umfrage zur Anwendung von Digital Health-Anwendungen in der Bevölkerung

Mithilfe einer repräsentativen Umfrage wurde die Einsatzhäufigkeit von DHAs sowie die Akzeptanz gegenüber DHAs untersucht. Darüber hinaus wurde analysiert, welche Faktoren – wie etwa das Vorhandensein einer Hauterkrankung und/oder soziodemografische Merkmale – einen Einfluss auf die Nutzung und Akzeptanz haben. Die Umfrage wurde im *Journal der Deutschen Dermatologischen Gesellschaft (JDDG)* unter dem Titel: „*General and dermatological population's use and acceptance of digital health in Germany – a representative survey*“ veröffentlicht. Der Fragebogen bestand neben der Erhebung der Soziodemografie aus vier Bereichen:

- (1) Kompetenz und Einstellung zur Digitalisierung via ausgewählten Items des deutschen eHEALS-Fragebogens (**eHealth Literacy Scale**) [141], Items zu Datenschutz/-sicherheit [146] und dem *Digital Confidence Score* [147].
- (2) Leistungserwartung (engl.: *Performance Expectancy*) und Akzeptanz gegenüber *Digital Health*-Anwendungen via Items aus Fragebögen zum UTAUT-Modell [137,140].
- (3) Nutzung von *Digital Health*-Anwendungen basierend auf selbst entwickelten Items, die Anwendungen umfassen, welche in der systematischen Übersichtsarbeit identifiziert wurden [132].
- (4) Die Erhebung umfasste das Vorliegen einer Hauterkrankung in den letzten 12 Monaten (Ja/Nein) und die Inanspruchnahme des Gesundheitssystems mittels eines selbst entwickelten Items.

Die Umfrage wurde vom FORSA Institut (Forsa Gesellschaft für Sozialforschung und statistische Analysen mbH) im Auftrag der Arbeitsgruppe „Digital Health“ des Instituts für Versorgungsforschung in der Dermatologie (IVDP) auf der Grundlage von anerkannten Methoden des Arbeitskreises Deutscher Markt- und Sozialforschung e.V. durchgeführt. Die Umfrage wurde zunächst deskriptiv ausgewertet und in einem weiteren Schritt wurden Unterschiede zwischen Personen ohne und mit Hauterkrankungen festgestellt. Daraufhin wurden logistische Regressionen berechnet, um den Einfluss von verschiedenen Parametern auf die Akzeptanz und die Nutzung von *Digital Health*-Anwendungen festzustellen. Die Parameter umfassten dabei die Soziodemographie und Items der Kompetenz und Einstellung zu digitalen Angeboten.

1.2.6. Publikation 7: Discrete Choice Experiment zur Teledermatologie

Während sich alle bisherigen Umfragen dieser Dissertation auf die Akzeptanz und den aktuellen Einsatz von DHA konzentrierten, soll diese Publikation explizit die Präferenz für eine spezifische DHA (Teledermatologie) untersuchen. Die Erhebung der Akzeptanz ermöglicht grundsätzlich, die Bereitschaft der Nutzung gegenüber Gesundheitsangeboten festzustellen. Dies bedeutet allerdings nicht, dass Patienten diese gegenüber klassischen Versorgungsangeboten bevorzugen. Patienten können eine hohe Akzeptanz gegenüber der Nutzung telemedizinischer Versorgungsangebote aufweisen, präferieren jedoch die Inanspruchnahme dermatologischer Leistungen in der örtlichen Praxis, da sie die persönliche Interaktion schätzen. Die Präferenz gegenüber Anwendungen/Versorgungsangeboten ist dabei stets eine Abwägung verschiedener Attribute, um eine finale Entscheidung zwischen mehreren Angeboten zu treffen und den Nutzen zu maximieren [148]. Zur Erhebung der Präferenz werden sogenannte *Discrete Choice Experimente (DCE)* verwendet. Dabei werden den Teilnehmern mehrfach mehrere hypothetische Versorgungsangebote gegenübergestellt, die innerhalb von vorausgewählten Attributen, zum Beispiel Zeitaufwand oder Nutzen, voneinander abweichen. Aus der Gesamtzahl der Entscheidungen kann die relative Wichtigkeit der einzelnen Attribute zueinander festgestellt werden [126]. Die Ergebnisse können dann wiederum genutzt werden, um Versorgungsangebote zu entwickeln, welche besser mit dem Bedarf der Patienten übereinstimmen.

In der vorliegenden Arbeit wurde das DCE zur teledermatologischen Versorgung von Patientinnen und Patienten mit Psoriasis durchgeführt, weil die S2k-Leitlinie Teledermatologie ausdrücklich Empfehlungen für den Einsatz dieser Versorgungsform bei dieser Patientengruppe ausspricht [109]. Die Entwicklung des DCEs erfolgte dabei in mehreren Schritten und schloss die Erkenntnisse der Vorarbeiten mit ein, im Speziellen die in der systematischen Übersichtsarbeit identifizierten Anwendungsfälle und der Fokusgruppen

[132,135]. Zusätzlich wurden Interviews mit Patienten mit einer Psoriasis, Dermatologen und zwei *Digital Health*-Unternehmern durchgeführt. Die Entwicklung erfolgte in mehreren Schritten:

(1) **Auswahl der Anwendungsszenarien:** Das DCE wurde für zwei Anwendungsszenarien durchgeführt, zum einen für die teledermatologische Verlaufskontrolle und zum anderen für die Nutzung bei einem akuten Schub der Psoriasis. Für den ersten Fall liegt bereits umfangreiche Evidenz vor, und diese wird in der S2k-Leitlinie explizit genannt [31,109]. Das zweite Szenario wurde von den befragten Patienten und der Literatur beschrieben [29]. Dagegen wurden folgende Szenarien ausgeschlossen: Erstkonsultation (nicht empfohlen in der S2k-Leitlinie), Zweitmeinung (als irrelevant in den Fokusgruppen identifiziert). Beide Szenarien wurden auch ausgewählt, da sie relevant und als realistisch von den Patienten und Ärzten in den Interviews eingestuft wurden.

(2) **Auswahl der Attribute und Ausprägungen dieser:** In diesem Schritt wurde mit Hilfe der Transkripte der Fokusgruppen und relevanter Literatur eine Liste relevanter Attribute mit unterschiedlichen Ausprägungen erarbeitet. Diese wurde den interviewten Personen (Patienten, Unternehmer, Dermatologen) vorgestellt und diese wurden gebeten, jeweils eine Auswahl von fünf Attributen aus der Gesamtliste mit einer Begründung auszuwählen. Auf Grundlage aller Informationen wurde eine Entscheidung für zunächst vier Attribute getroffen (siehe Attribute und Ausprägungen der Choice SetsTabelle 2). Das Anwendungsszenario bei einem akuten Fall wurde um ein weiteres Attribut (Wartezeit auf einen Termin) ergänzt, da dieses nur bei diesem Szenario eine Relevanz hat.

(3) **Entwicklung der Choice-Sets:** Basierend auf den Anwendungsszenarien, den Attributen und deren Ausprägungen wurden für beide Anwendungsszenarien (Akut, Verlaufskontrolle) 16 Choice Sets mithilfe eines *fractional factorial Designs* entwickelt. [149]. Neben der Auswahl zwischen zwei teledermatologischen Optionen hatten die Patienten die Möglichkeit, die Vor-Ort-Versorgung auszuwählen (siehe *Abbildung 3*).

Tabelle 1 Attribute und Ausprägungen der Choice Sets zum Discrete Choice Experimente zur Teledermatologie

Attribute	Ausprägung
Art der Versorgung	<ul style="list-style-type: none"> - Videosprechstunde - Zeitversetzte Online-Behandlung
Behandelnder Arzt	<ul style="list-style-type: none"> - bekannter Arzt, der meine Psoriasis derzeit behandelt - fremder Dermatologe mit Zugriff auf meine bisherigen medizinischen Daten - fremder Dermatologe ohne Zugriff auf meine bisherigen medizinischen Daten
Rückfragen	<ul style="list-style-type: none"> - keine Fragen möglich - begrenzte Anzahl an Fragen möglich - Wie Vor-Ort-Sprechstunde
Wie gut der Arzt auf meine Anliegen eingeht?	<ul style="list-style-type: none"> - befriedigend - gut - sehr gut
Wartezeit	<ul style="list-style-type: none"> - 4 bis 7 Tage - 2 bis 3 Tage - bis zu 24 Stunden

Bitte treffen Sie eine Entscheidung für <u>eine der drei</u> Behandlungsoptionen bei einem akuten Schub.			
	Option A	Option B	Option C
Art der Versorgung	Videosprechstunde mit eRezept	Videosprechstunde mit eRezept	übliche Sprechstunde vor Ort bei meinem Arzt mit eRezept und der Möglichkeit es auszudrucken
Behandelnder Arzt	bekannter die Psoriasis behandelnder Arzt	fremder Dermatologe mit <u>Zugriff</u> auf meine medizinischen Daten	
Rückfragen an den Arzt	begrenzte Anzahl an Fragen möglich	wie vor-Ort Sprechstunde	
Wie gut der Arzt auf meine Anliegen eingeht	befriedigend	befriedigend	
Wartezeit	bis zu 24h	4 bis 7 Tage	
Ihre Entscheidung	<input type="checkbox"/>	<input type="checkbox"/>	

Abbildung 3 Beispiel eines von 16 sogenannten Choice Sets, das Teilnehmern im Anwendungsszenario ‚Akut‘ vorgelegt wurde.

Der Fragebogen des DCEs umfasste neben der 16 *Choice Sets* auch Fragen zur Soziodemografie, zur Erkrankung (z.B.: Dauer, Schweregrad [150]), zur Versorgungssituation (z.B. behandelnder Arzt, Häufigkeit der Behandlung, Medikation) und Einstellung zur Technologie (z.B. Generelle Akzeptanz und Datenschutz [146,151]).

Patienten wurden mit Unterstützung des DPB rekrutiert und zu Beginn der Erhebung einem Anwendungsszenario (Verlaufskontrolle oder Akut) zufällig zugeordnet.

Die Erhebung des DCEs wurde mittels *Conditional Logit Model* ausgewertet, wie von der *International Society of Pharmacoeconomics* (ISPOR) empfohlen [126]. Dabei wurde je ein Haupteffekt Model berechnet, welches den Einfluss eines Attributes auf die Präferenz der Patienten darstellt und je ein Interaktionseffekt Model, welches den Einfluss von soziodemografischen sowie krankheits- bzw. versorgungsspezifischen Charakteristika auf die Entscheidung erhebt.

Tabelle 2 Übersicht über alle Publikationen

Publikation	Datengrundlage	Auswertungsmethode
Publikation 1 [132]	Artikel zu <i>Digital Health</i> -Anwendungen in der Dermatologie identifiziert in der MEDLINE Datenbank und via Referenzartikel	Systematische Kategorisierung der Artikel anhand von Art der <i>Digital Health</i> -Anwendungen, Art des Studiendesigns, Zielgruppen und weiteren Aspekten
Publikation 2 [135]	Transkripte von Fokusgruppen (Patienten / Dermatologen / Pflegekräfte)	Qualitative Inhaltsanalyse – induktiv - deduktiv Rahmenkonzept des UTAUT [137]
Publikation 3 (Stand 10.05.2025; Angenommen aber bisher nicht veröffentlicht)	Onlineumfrage; Aussendung an 1.000 Dermatologen via der Deutschen Dermatologischen Akademie	Clusteranalysen auf Grundlage der Einstellung zu <i>Digital Health</i> -Anwendungen
Manuskript 4f (Stand 10.05.2025 – Eingereicht – aber bisher nicht veröffentlicht)	Onlineumfrage; Aussendung via Selbsthilfegruppen zu dermatologischen Erkrankungen (Psoriasis, Atopische Dermatitis, Alopecia Areata, Akne Inversa)	Clusteranalysen auf Grundlage der Einstellung zu <i>Digital Health</i> -Anwendungen
Publikation 5 [142]	Online- und Offline-Umfrage; Aussendung an ca. 3.500 Dermatologen via der Deutschen Dermatologischen Akademie in den Jahren 2019 und 2021	Vergleich zwischen 2019 / 2021; multivariate logistische Regressionen zur Feststellung der Einwirkung von soziodemografischen Parametern auf die Verwendung und Einstellungen zu <i>Digital Health</i> -Anwendungen.
Publikation 6 [152]	Forsa-Umfrage (Repräsentative Umfrage)	Deskriptive Auswertung, Regressionsanalysen, Subgruppenanalysen
Publikation 7 [153]	Discrete Choice Fragebogen	Berechnung der Präferenz via „conditional logit model“

1.3. Ergebnisse

Im Folgenden wird eine Auswahl der Ergebnisse der Publikationen dargestellt. Alle Ergebnisse können den dazugehörigen Publikationen bzw. eingereichten Manuskripten entnommen werden.

1.3.1. Übersicht der verfügbaren Digital Health-Anwendungen

In der systematischen Übersichtsarbeit wurden 404 Publikationen zu DHAs identifiziert (siehe Abbildung 4). Von diesen haben 262 Publikationen DHAs für Gesundheitsberufe (inkl. Ärzte, Pflegekräfte; engl. Health Care Provider; HCP) evaluiert, 66 Publikationen adressierten Patienten und 76 Publikationen adressierten DHAs für Patienten und Gesundheitsberufe (HCP) (z.B. Telemedizin-Anwendung, die Arzt und Patient verbindet). Hautkrebs war die am häufigsten vertretene Indikation: Ungefähr ein Drittel der Publikationen (n = 148) untersuchte DHAs für diese Indikation, gefolgt von Wunden (n = 29) und Psoriasis (n = 29). In etwa einem Drittel der Publikationen (n = 135) wurde eine DHA bei verschiedenen Erkrankungen bzw. keiner spezifischen Erkrankung angewendet. Mehr als jede zweite Publikation (n = 254) zielte auf die Diagnosestellung ab, gefolgt von der Triage (n = 107) und der Verlaufskontrolle (n = 79). Die diagnostische Performanz wurde bei 166 Publikationen, die Akzeptanz bei 92 und die Effektivität der DHA bei 92 Publikationen untersucht. Die am häufigsten vertretene DHA war die Store-And-Forward Konsultation zwischen Ärzten (n = 144), der KI-Bildanalyse (n = 55) und der Store-And-Forward Konsultation zwischen Gesundheitsberufen (HCP) und Patienten (n = 45).

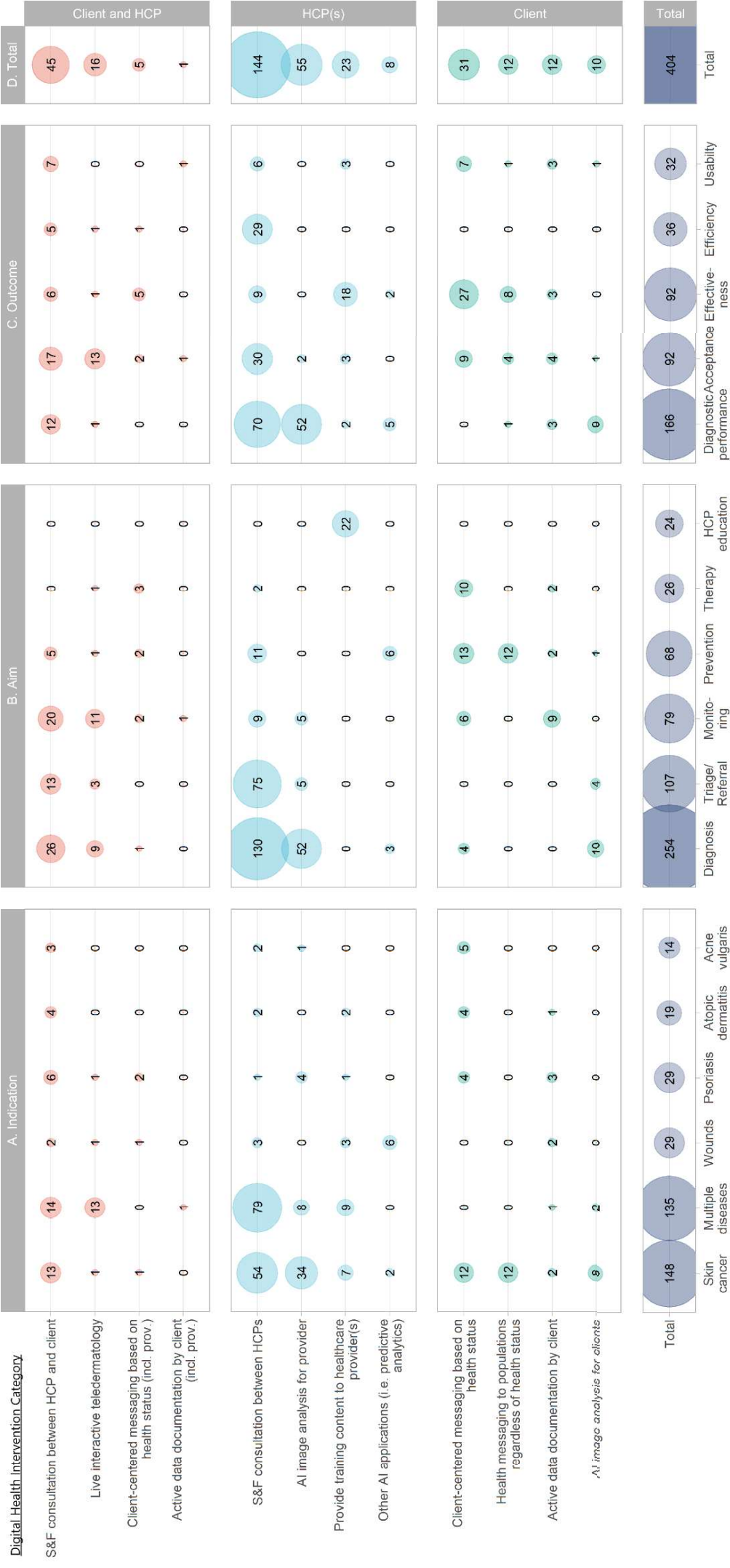


Abbildung 4 Übersicht der identifizierten Digital-Health-Anwendungen nach Kategorien (n = 404) aus Reinders et al. 2023 [132] lizenziert unter CC-BY (Lizenznummer: 5937721328143)

Anmerkung: Die Größe der Kreise entspricht der Anzahl der identifizierten Anwendungen innerhalb der jeweiligen Kategorie

1.3.2. Ergebnisse der Fokusgruppen

Die Analyse der Fokusgruppen ergab, dass innerhalb der Patientengruppen viele Vorteile (engl. *Performance Expectancy*) von Anwendungen beschrieben wurden, darunter eine reduzierte Wartezeit und eine allgemeinere Verbesserung der Verlaufskontrolle ihrer Erkrankung. Zudem wiesen Patienten auf die potenzielle unpersönlichere Arzt-Patienten-Beziehung hin. Dermatologen benannten positive Effekte, wie die Standardisierung der Versorgung. Jedoch äußerten sie zudem negative Auswirkungen, wie die Zunahme des Arbeitspensums – durch eine höhere Fallzahl bzw. vermehrte Anfragen der Patienten sowie durch eine schlechte Integration der DHAs in den Arbeitsalltag. Zusätzlich beschrieben Dermatologen die Sorge vor einer, keinen Zusatznutzen bringenden, Informationsflut. Pflegekräfte und Dermatologen wünschten sich Anwendungen, die einfach in den Arbeitsalltag zu integrieren sind. In Bezug auf die Aufwandserwartung (*Effort Expectancy*), also die Einfachheit der Nutzung für Anwendergruppen, benannten alle drei Gruppen potenzielle Schwierigkeiten bei der Anwendung durch ältere Patientengruppen. Die Dermatologen wiesen auf einen möglichen Ausschluss einzelner Gruppen von digitalen Versorgungsangeboten hin. Ein hohes Vertrauen in die Empfehlung des Arztes sahen sowohl Patienten als auch Pflegekräfte als zentrales Element bei der Einführung von DHAs an (Konstrukt: *Social Influence*). Beide Gruppen gaben außerdem an, dass die endgültige Verwendung einer DHA entscheidend von der Akzeptanz des Arztes gegenüber dieser abhängt. Ärzte wiederum beschrieben ihr hohes Vertrauen gegenüber Empfehlungen von Verbänden und direkten Kollegen. Als fördernde Faktoren benannten Ärzte eine ausreichende Vergütung für den Einsatz von DHAs. Potenzielle Barrieren sind Aspekte wie ein hoher Aufwand der IT-Infrastruktur, eben auch aufgrund der hohen Anforderungen an den Datenschutz, und der Schwierigkeit, die DHAs in die bestehenden Alltagsroutinen zu integrieren. Neben den Dermatologen nannten auch Patienten den Datenschutz als eine Barriere, welche die Funktionalität von DHAs reduziert.

1.3.3. Akzeptanzprofile der Dermatologen

An der Umfrage zur Akzeptanz gegenüber DHAs nahmen 170 Dermatologen teil, wobei von diesen 155 mit vollständigen Datensätzen mit Hilfe der Clusteranalyse drei Clustern zugeordnet werden konnten. Für die drei Cluster wurde jeweils die Summenscores der mittels EFA gebildeten vier Faktoren verwendet (siehe Abbildung 5). Basierend auf den durchschnittlichen Summenscores jedes Clusters wurden beschreibende Clusternamen festgelegt: (1) *Rejectors* mit n = 26; (2) *Indecisives* mit n = 69; (3) *Adopters* mit n = 60. Die

Rejectors hatten eine geringe positive Erwartung an DHAs (Faktor 1), schätzten ihre digitalen Kompetenzen (Faktor 2) als gering ein und erwarteten den Eintritt negativer Folgen der Digitalisierung (Faktor 3). Demgegenüber stehen die *Adopters*, die eine hohe Erwartung zeigen (Faktor 1), hohe Kompetenzen aufweisen (Faktor 2) und niedrige negative Effekte erwarten (Faktor 3). Die *Indecisives* liegen bei ihren Einstellungen zwischen den *Rejectors* und den *Adopters*. Bezüglich der Notwendigkeit einer ausreichenden Vergütung stimmen alle drei Cluster überein (Item 16). Zudem zeigten alle drei Cluster Bedenken hinsichtlich der möglichen Zunahme des Arbeitsaufwandes (Item 17) und einer fehlenden Kompetenz aufseiten der Patienten (Item 21).

Die drei Cluster unterschieden sich signifikant in Bezug auf das Alter, wobei die *Adopters* deutlich jünger als *Rejectors* und *Indecisives* und *Indecisives* jünger als *Rejectors* waren. Zusätzlich wurden Assoziationen bezüglich der regionalen Verteilung festgestellt, wobei *Adopters* seltener aus städtischen Regionen kamen, im Vergleich zu *Rejectors*.

Die nationale eHealth-Strategie wurde von den drei Clustern unterschiedlich bewertet. Alle *Rejectors* bewerteten die Strategie als unzureichend – so widersprachen 100 % dieses Clusters der Aussage, dass die eHealth-Strategie Mehrwerte für die Dermatologen erbracht hatte. Auch ein großer Anteil (71 %) der *Indecisives* widersprach dieser Aussage, während zumindest ein Drittel der *Adopters* (36 %) einen Mehrwert durch die Strategie wahrgenommen hat.

Es konnte ebenfalls ein Zusammenhang zwischen der Cluster-Zuordnung und der Nutzung von DHAs aufgezeigt werden. *Adopters* nutzten die E-Mail-Kommunikation mit ihren Kollegen (95 %) deutlich häufiger als *Indecisives* (61 %) und *Rejectors* (44 %) ($p < 0.001$). Ein signifikanter Zusammenhang konnte bei 7 von 10 der vorgestellten DHAs festgestellt werden.

Auch bei der potenziell zukünftigen Nutzung von DHAs konnte ein ähnlicher Zusammenhang aufgezeigt werden. *Adopters* konnten sich deutlich häufiger vorstellen (82 %) ihren Patienten ein digitales Krankheitstagebuch zu empfehlen, im Vergleich zu *Indecisives* (55 %) und *Rejectors* (19 %) ($p = 0.01$). Dieser signifikante Zusammenhang konnte bei jedem der vorgestellten DHAs festgestellt werden.

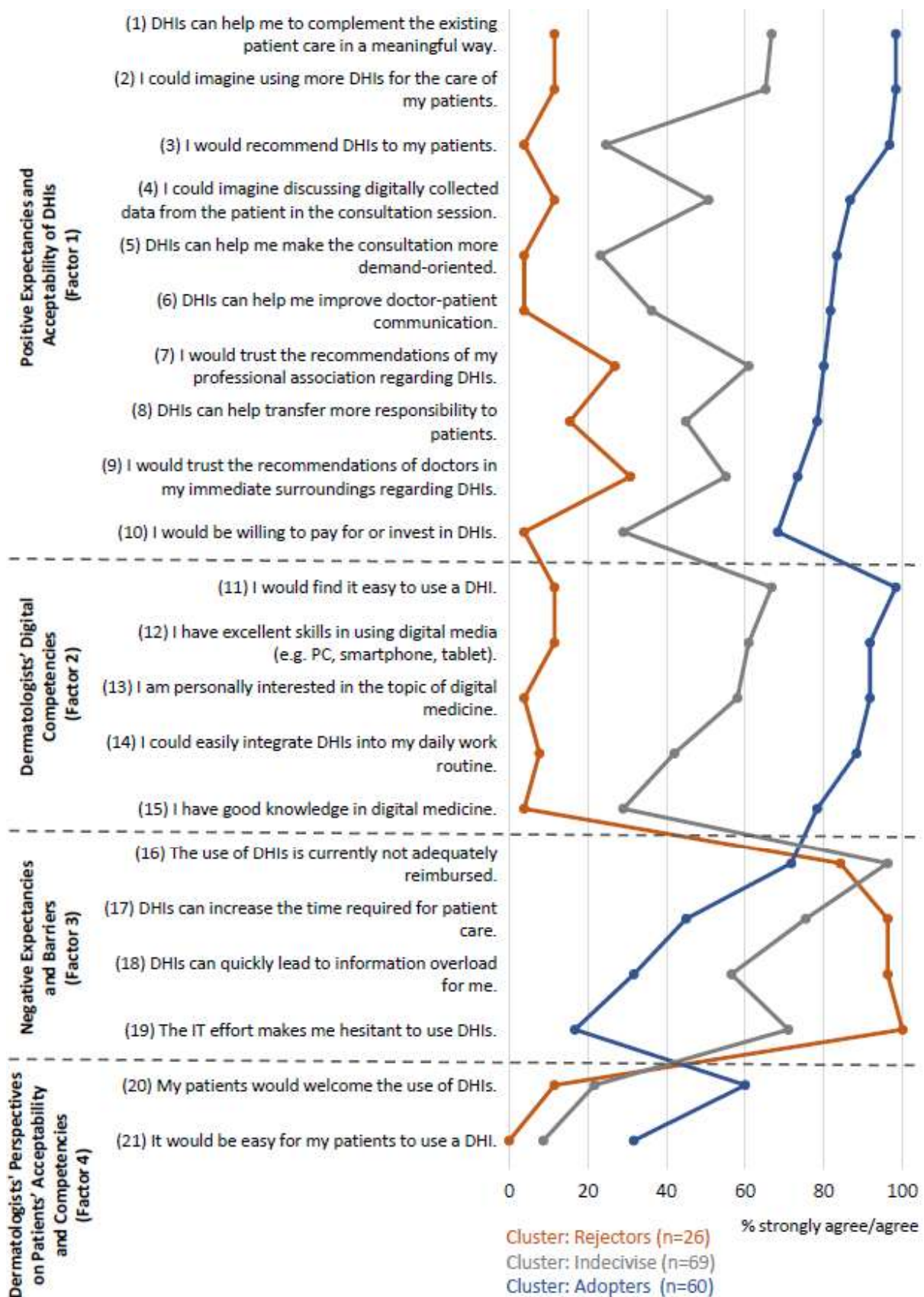


Abbildung 5 Clusterbezogene Akzeptanzprofile der befragten Dermatologen (n = 155) zu Digital Health-Anwendungen auf Item-Ebene

Anmerkung: Jeder Punkt im Liniendiagramm gibt den Anteil der Dermatologen im jeweiligen Cluster an, die dem jeweiligen Item zugestimmt ("Stimme voll zu" / "Stimme zu") haben.

1.3.4. Akzeptanzprofile von dermatologischen Patienten

Mit derselben Methodik wurden vier Faktoren durch die EFA innerhalb der Umfrage unter Patienten identifiziert (siehe Abbildung 6). Mit den Mittelwerten dieser vier Faktoren wurden insgesamt 315 (Patienten mit vollständigen Datensätzen) der insgesamt 344 Patienten vier unterschiedliche Patientenclustern in Bezug auf ihre Einstellungen zu DHAs zugeordnet: (1) *Digital Sceptics* ($n = 49$); (2) *Cautious Adopters* ($n = 106$); (3) *Digital Enthusiasts* ($n = 98$) und *Adopters Unsure About Impact* ($n = 62$). Während die *Digital Sceptics* eine geringe Akzeptanz (Faktor 1) gegenüber DHAs aufwiesen, zeigten die drei weiteren Cluster hohe Akzeptanzraten. Auch hatten diese drei Cluster hohe Zustimmungsraten bezüglich ihrer Kompetenz im Vergleich zu den Skeptikern (Faktor 2). Während die *Digital Enthusiasts* und die *Adopters Unsure About Impact* niedrige Unsicherheiten bei der Verwendung von DHAs aufwiesen (Faktor 3), ist die Zustimmung zu Items innerhalb dieses Faktors bei den beiden anderen Clustern (*Digital Sceptics* und *Cautious Adopters*) vergleichsweise hoch. Im vierten Faktor (*Positive Impact of DHIs*) zeigten die *Cautious Adopters* dagegen deutliche höhere Zustimmungsraten auf, während *Digital Sceptics* nahezu keine Zustimmung gegenüber diesem Faktor aufzeigen. *Adopters Unsure About Impact* zeigten niedrige Zustimmungsraten auf, während nahezu alle Personen der *Digital Enthusiasts* deutliche Vorteile bei der Verwendung von DHAs wahrnehmen. Die Mehrheit innerhalb aller Cluster gab an (siehe Abbildung 6), dass es möglich sein sollte, die erhobenen Daten mit dem behandelnden Arzt zu teilen. Auch gaben die Mehrheiten in den Clustern an, dass sie in der Lage sind, verlässliche von unverlässlichen Informationen zu unterscheiden und sie in der Lage sind, nützliche und zuverlässige Gesundheitsinformationen im Internet zu finden.

Digital Sceptics zeigten die geringsten Nutzungsraten über alle DHAs hinweg auf, während *Digital Enthusiasts* und *Adopters Unsure About Impact* die höchsten Nutzungsraten aufwiesen. Zum Beispiel verwendeten 43 % der *Digital Sceptics* ein online Informations- und Edukationsportal, während dies 74 % und 72 % der *Digital Enthusiasts* bzw. *Adopters Unsure About Impact* nutzten.

Des Weiteren konnte ein Zusammenhang zwischen den Clustern und der zukünftigen Verwendung von DHAs festgestellt werden. So gaben lediglich bei 7 der 11 vorgestellten DHAs max. ein Drittel der *Digital Sceptics* an, diese nutzen zu wollen. Bei den *Digital Enthusiasts* lagen die Zustimmungsraten bei 10 der 11 DHAs bei über 75 %. Die DHAs mit den höchsten Zustimmungsraten unter allen Patienten umfassten Edukationsportale (zwischen 65 % und 98 %), Erinnerung an Termine (zwischen 57 % und 95 %) und die Videosprechstunde (zwischen 33 % und 94 %).

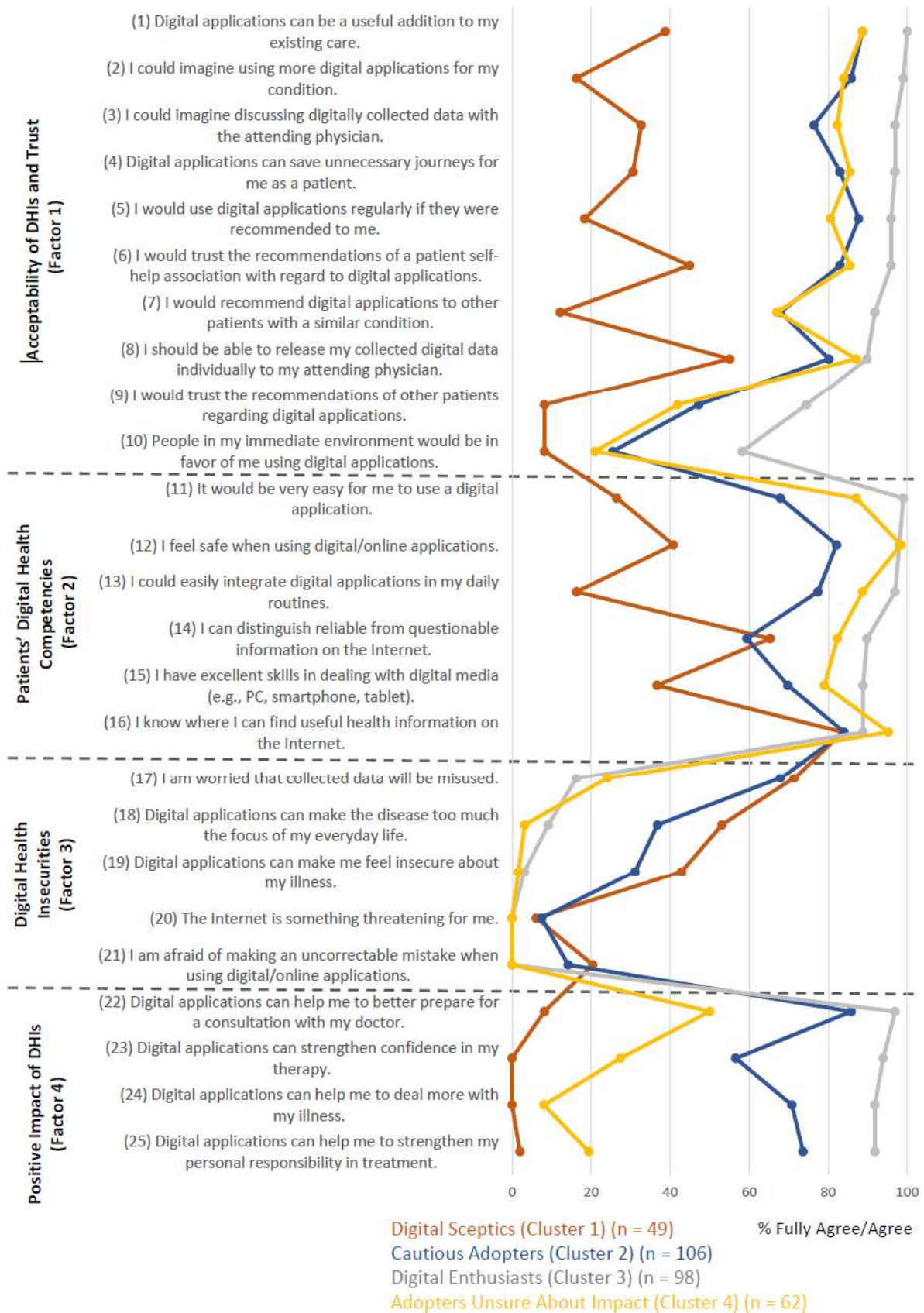


Abbildung 6 Clusterbezogene Akzeptanzprofile der befragten dermatologischen Patienten (n = 315) zu Digital Health-Anwendungen auf Item-Ebene

Anmerkung: Jeder Punkt im Liniendiagramm gibt den Anteil der dermatologischen Patienten im jeweiligen Cluster an, die dem jeweiligen Item zugestimmt ("Stimme voll zu" / „Stimme zu“) haben.

1.3.5. Nutzung und Akzeptanz von Digital Health-Anwendungen bei Dermatologen

Bei der deutschlandweiten Umfrage aus dem Jahr 2019 und 2021, bei welcher jeweils ca. 3.500 aktive Dermatologen angeschrieben wurden, nahmen 585 und 792 Dermatologen teil. Bei den Einstellungen gegenüber der digitalen Medizin konnte ein leichter Rückgang im Interesse (65 % vs. 58 %; Odds Ratio (OR): 0,8 95 % [0,6 – 1,0]) an dieser und im sicheren Umgang mit dieser (51 % vs. 42 %; OR: 0,8 [0,6 – 1,0]) festgestellt werden (siehe Abbildung 7). Die Kenntnisse in digitaler Medizin blieben unverändert: In beiden Jahren gab jeweils rund ein Drittel der Befragten an, über ausreichende Kenntnisse in diesem Bereich zu verfügen (2019: 38,9 % vs. 2021: 34,4 %; OR: 0,9 [95 %-KI 0,7–1,2]). Zwischen den Jahren konnte ein deutlicher Zuwachs in der Nutzung der Videosprechstunde, der Kommunikation in Echtzeit mit Kollegen, dem telemedizinischen Patienten-Monitoring und der elektronischen Erinnerung an Termine beobachtet werden. Obwohl es zum Teil deutliche relative Steigerungsraten (Videosprechstunde: OR 3,5 [95 % CI 1,8 – 6,5]) zwischen den Jahren gab, war die absolute Nutzung nach wie vor gering (Videosprechstunde: 8 % im Jahr 2021). Keine der vorgestellten Anwendungen wurden von mehr als der Hälfte der Dermatologen genutzt. In beiden Jahren bemaßen ca. zwei Drittel der Dermatologen der digitalen Medizin eine große Bedeutung bei, ungefähr ein Drittel sieht große Risiken in der Einführung der digitalen Medizin. Ebenfalls ist lediglich ein Drittel der Ansicht, dass Verfahren der digitalen Medizin ihren Arbeitsalltag erleichtern.

□

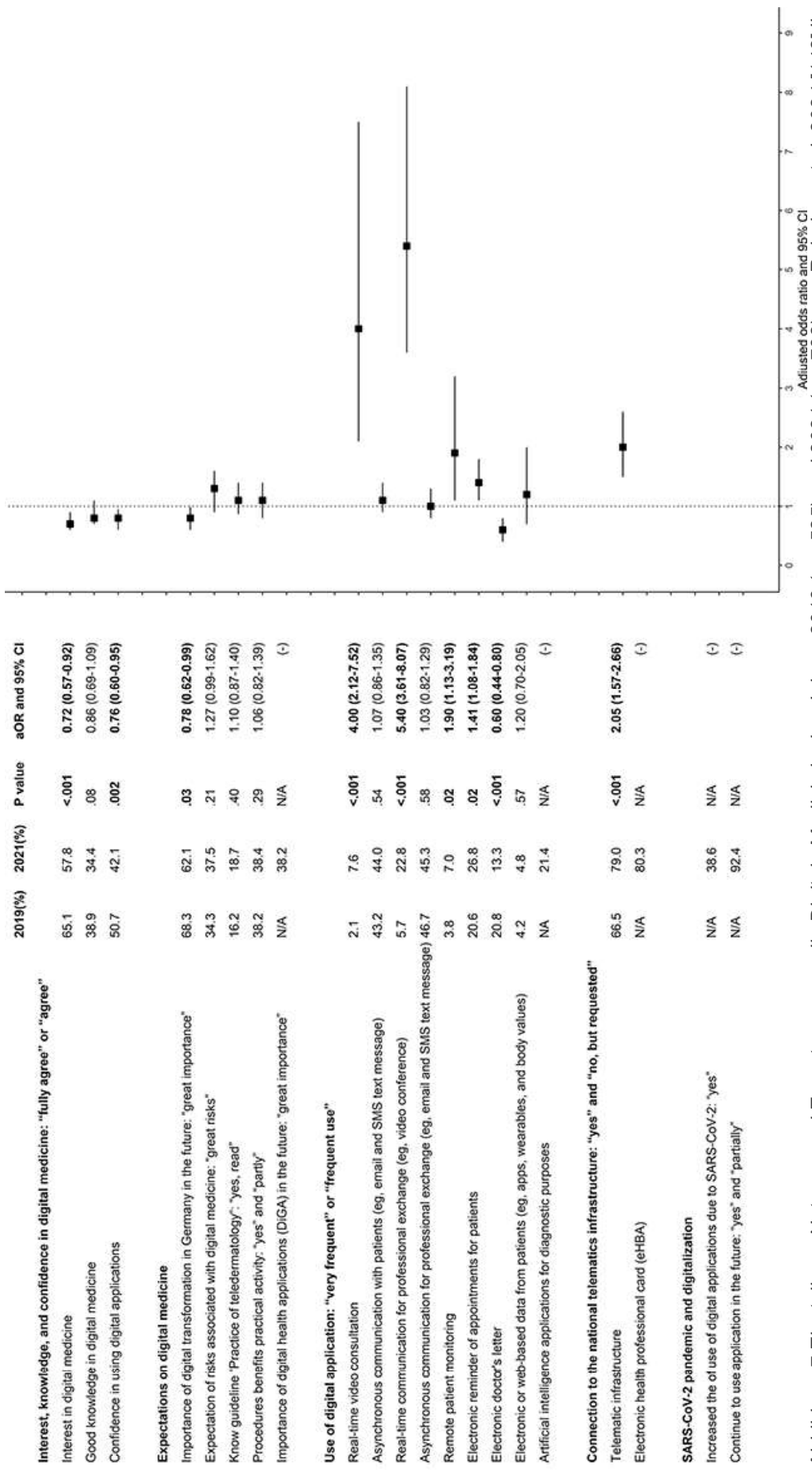


Abbildung 7 Einstellung, Nutzung und Erwartungen an die Digitale Medizin in den Jahren 2019 (n = 585) und 2021 (n = 792) aus Reinders et al. 2024 [142] lizenziert unter [CC-BY 4.0](#)

Anmerkung: Die Punkte im Diagramm zeigen die adjustierten Odds Ratios (aOR), die Linien die 95 %-Konfidenzintervalle (KI). Die aOR geben die relative Veränderung zwischen den beiden Zeitpunkten (2019 und 2021) an.

In den drei Subgruppenanalysen (Stadt/Land; Weiblich/Männlich; <50 Jahre / \geq 50 Jahre), welche für das Jahr 2021 berechnet wurden, wurden weitere Unterschiede aufgedeckt. Dermatologen, welche jünger als 50 Jahre alt waren, zeigten ein höheres Interesse (OR 2.2 [95 % CI 1.5 – 3.2]), höheres Wissen über (OR 1.8 [95 % CI 1.3 – 2.5]) und einen sicheren Umgang mit digitalen Anwendungen (OR 1.9 [95 % CI 1.3 – 2.7]). Auch kommunizierten sie häufiger asynchron mit Patienten und ihren Kollegen und nutzten häufiger elektronische Terminerinnerungen für Patienten. Sie erwarteten des Weiteren seltener Risiken im Kontext der digitalen Medizin und nahmen häufiger Vorteile bei der Nutzung dieser wahr.

Dermatologen aus städtischen Gebieten zeigten ein höheres Interesse, schätzten ihr Wissen als höher ein und beschrieben ihren Umgang mit digitalen Anwendungen als sicherer, im Vergleich zu Personen aus ländlichen Gebieten. Sie nutzten viele der Anwendungen deutlich häufiger, darunter die zeitversetzte Kommunikation mit dem Patienten, sahen die digitale Transformation als wichtiger an und benannten geringere Risiken im Zusammenhang mit Anwendungen der digitalen Medizin.

Im Subgruppenvergleich zwischen weiblichen und männlichen Dermatologen konnten wenige Unterschiede ausgemacht werden. Weibliche Dermatologen gaben seltener ein hohes Wissen und Sicherheit im Umgang mit der digitalen Medizin an. Dies hatte allerdings keine Auswirkungen auf den Einsatz digitaler Anwendungen im Praxisalltag. Weibliche Dermatologen sahen eine große Bedeutsamkeit der digitalen Transformation und nahmen seltener ein großes Risiko im Zusammenhang mit der digitalen Medizin wahr als ihre männlichen Kollegen.

1.3.6. Nutzung und Akzeptanz von Digital Health-Anwendungen bei Patienten

In der repräsentativen Umfrage, die das Forsa-Institut im Auftrag der Arbeitsgruppe „Digital Health“ des IVDP durchführte, gaben 630 von insgesamt 2101 Befragten an, in den letzten 12 Monaten von einer Hauterkrankung betroffen gewesen zu sein. In der Gesamtpopulation (n = 2101) zeigten sich 47,5 % der Befragten aufgeschlossen gegenüber der Nutzung einer DHA (Akzeptanz), während 36,4 % auch bei einer speziell für Hauterkrankungen entwickelten DHA eine entsprechende Offenheit signalisierten. In beiden Fällen hatten Personen mit einer Hauterkrankung häufiger eine hohe Akzeptanz als Personen ohne eine Hauterkrankung (generelles DHA: 45,5 % vs. 52,33 %; p: < 0.001; DHA für Hauterkrankung: 34,2 % vs. 41,6 %; p: <0.001).

Die Gesamtpopulation wies insgesamt eine geringe Nutzungsrate verschiedener DHAs auf (siehe Abbildung 8). Innerhalb der letzten zwölf Monate nutzten lediglich 14,3 % der Patienten eine Anwendung für passives Gesundheitsmonitoring, während lediglich 2,5 % auf Store-and-Forward-Telemedizin zurückgriffen. Insgesamt nutzten 33,5 % der Teilnehmenden mindestens eine der vorgestellten DHAs. Die meisten Anwendungen wurden häufiger von Personen mit einer Hauterkrankung verwendet, zum Beispiel die Videokonsultation (Ohne: 3,5 %; Mit 7,5 %, $p < 0.001$).

In Tabelle 3 sind die adjustierten Odds Ratios (aOR) als Ausgabe der multivariaten logistischen Regression dargestellt, jeweils für die Gesamtpopulation und für Personen mit einer Hauterkrankung. Sowohl innerhalb der Gesamtpopulation als auch bei Personen mit einer Hauterkrankung erhöht ein Alter jünger 60 Jahre, eine hohe Schulbildung, eine hohe Sicherheit in der Nutzung von DHAs und geringe Datenschutzbedenken die Wahrscheinlichkeit für die Akzeptanz und Nutzung einer DHA. Darüber hinaus ist das Vorliegen einer Hauterkrankung mit einer erhöhten Akzeptanz und Nutzung eines DHAs assoziiert. Auch hatten in dieser Population Frauen zwar eine geringere Wahrscheinlichkeit für eine hohe Akzeptanz gegenüber DHAs, nutzten diese aber häufiger als Männer. Bei Personen mit einer Hauterkrankung erhöhte eine hohe Krankheitslast der Hauterkrankung die Wahrscheinlichkeit für eine hohe Akzeptanz und Nutzung eines DHAs.

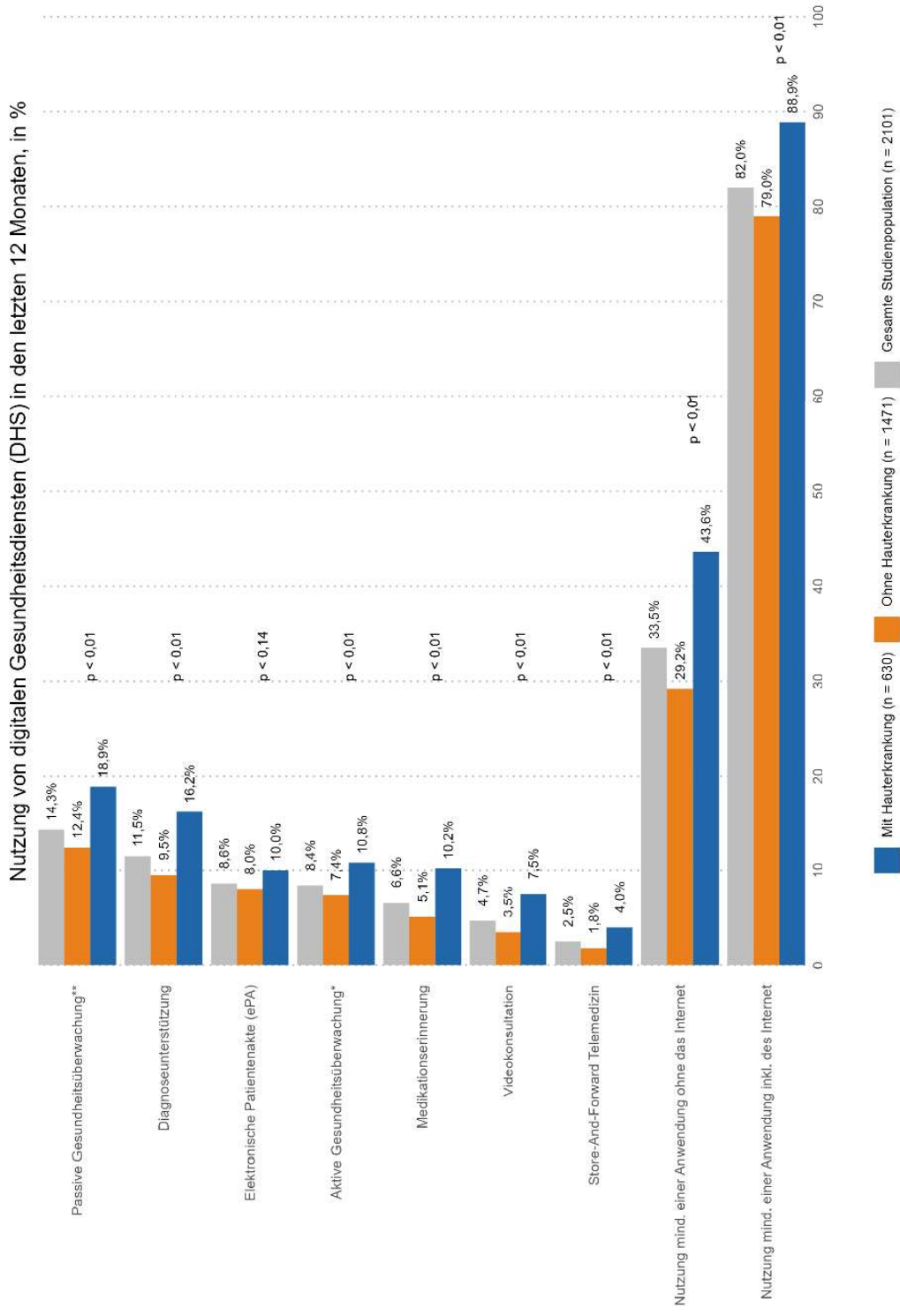


Abbildung 8 Nutzung von DHAs von Personen mit (n = 630) und ohne Hautkrankung (n = 1471) in den letzten 12 Monaten aus Reinders et al. 2024 [142] lizenziert unter [CC-BY](https://creativecommons.org/licenses/by/4.0/) (Lizenznummer: 5937730604065)

Tabelle 3 Multivariate Analyse zur Akzeptanz und Nutzung von DHAs der Gesamtpopulation (n = 2101) und Personen mit einer Hauterkrankung (n = 630) (logistische Regressionen)

	Akzeptanz von DHAs		Nutzung von DHAs	
	Total	Hauterkrankung	Total	Hauterkrankung
	aOR (95 % CI)	aOR (95 % CI)	aOR (95 % CI)	aOR (95 % CI)
Hauterkrankung in den letzten 12 Monaten				
Ja	1,34 (1,09 - 1,66)	-	1,90 (1,54 - 2,34)	-
Alter, Gruppe (Referenz: ≥60 Jahre)				
18 – 29 Jahre	3,25 (2,37 - 4,45)	2,93 (1,69 - 5,09)	2,23 (1,64 - 3,03)	3,12 (1,82 - 5,36)
30 – 44 Jahre	2,88 (2,22 - 3,74)	4,17 (2,47 - 7,04)	2,12 (1,63 - 2,76)	2,76 (1,68 - 4,54)
45 – 59 Jahre	1,99 (1,54 - 2,56)	1,73 (1,05 - 2,83)	1,38 (1,06 - 1,80)	1,68 (1,03 - 2,75)
Geschlecht (Referenz: Männlich)				
Weiblich	0,76 (0,63 - 0,93)	0,83 (0,57 - 1,20)	1,53 (1,26 - 1,87)	2,02 (1,39 - 2,92)
Regionale Variation (Referenz: Ländlich)				
Urbaner Kreis oder Stadt	0,96 (0,78 - 1,19)	1,09 (0,73 - 1,62)	0,98 (0,79 - 1,20)	0,97 (0,66 - 1,43)
Schulbildung (Referenz: Niedrig)				
Mittel	1,45 (1,07 - 1,96)	1,27 (0,71 - 2,26)	1,23 (0,91 - 1,68)	1,09 (0,62 - 1,93)
Hoch	2,08 (1,56 - 2,77)	1,89 (1,07 - 3,32)	1,39 (1,04 - 1,87)	1,43 (0,82 - 2,50)
Sicherheit im Umgang mit DHA (Referenz: Gering)				
Neutral	0,93 (0,65 - 1,33)	1,58 (0,80 - 3,11)	1,16 (0,80 - 1,67)	1,27 (0,66 - 2,46)
Hoch	2,01 (1,48 - 2,73)	2,80 (1,56 - 5,03)	1,46 (1,06 - 2,00)	1,89 (1,07 - 3,32)
Datenschutzbedenken (Referenz: Hoch)				
Neutral	1,40 (1,07 - 1,83)	1,27 (0,75 - 2,14)	1,25 (1,00 - 1,57)	1,52 (0,91 - 2,54)
Gering	1,96 (1,57 - 2,46)	2,52 (1,64 - 3,86)	1,44 (1,11 - 1,89)	1,82 (1,21 - 2,73)
Arztkontakt bei Hauterkrankungen (Referenz: Kein Kontakt)				
Ja	-	1,14 (0,76 - 1,71)	-	1,29 (0,87 - 1,90)
Schweregrad der Hauterkrankung (Referenz: Mild (1 – 3))¹				
Keine (0)	-	1,03 (0,56 - 1,87)	-	1,08 (0,60 - 1,92)
Moderate (4 – 6)	-	1,19 (0,76 - 1,85)	-	1,15 (0,74 - 1,77)
Hoch (7 – 10)	-	2,16 (1,22 - 3,81)	-	2,11 (1,23 - 3,64)
Nagelkerkes R²	0,208	0,239	0,099	0,164

aOR: bereinigte (adjusted) Odds Ratio; aOR > 1 bedeutet eine höhere Wahrscheinlichkeit für die Akzeptanz/Nutzung von DHA; CI = Konfidenzintervall; fett gedruckte Werte sind signifikant (95 % CI schließt den Wert 1 nicht ein), Nagelkerkes R²: Anpassungsgüte - je höher der Wert, desto besser die Modellanpassung. *Moderat wurde als Referenzwert gewählt, da nur 24 Personen keinen Schweregrad der Hauterkrankung aufwiesen.

1.3.7. Präferenz von Patienten mit einer Psoriasis zur teledermatologischen Versorgung

Insgesamt stimmten 378 Personen mit einer Psoriasis der Teilnahme an der Umfrage zu, wobei 221 Personen das DCE komplett durchführten. Die Haupteffektmodelle zu den Präferenzen von Patienten mit einer Psoriasis zur Versorgung mittels der Teledermatologie in einem akuten Szenario oder des Verlaufskontrollszenarios zeigten ähnliche Tendenzen auf (siehe *Abbildung 9*).

In beiden Szenarien präferierten Patienten generell die Standardversorgung gegenüber der Teledermatologischen. Die Art der Telemedizin (Store-And-Forward oder Videosprechstunde) hatte in beiden Szenarien keine signifikante Auswirkung auf die Präferenz. Die Präferenz für teledermatologische Versorgung erhöhte sich, wenn ein bekannter Arzt die Sprechstunde durchführt, die Möglichkeit Rückfragen zu stellen vergleichbar mit der Vor-Ort-Versorgung war und der behandelnde Arzt sehr gut auf die Anliegen des Patienten eingeht. Zusätzlich präferierten Patienten telemedizinische Behandlungsoptionen in der akuten Versorgung, wenn sie eine zügige Versorgung innerhalb von 24h ermöglichten.

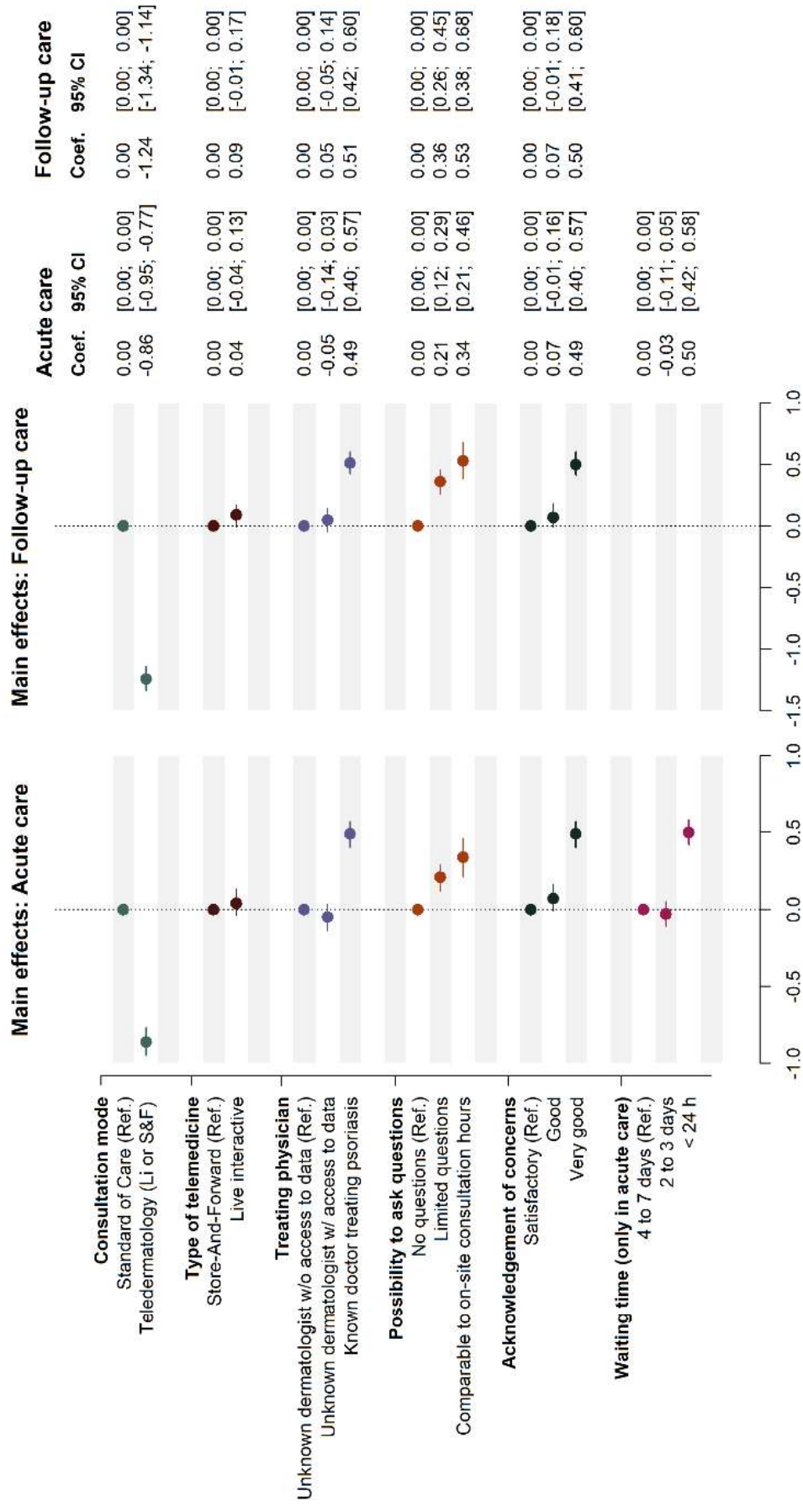


Abbildung 9 Präferenzschätzungen für den Einsatz der Tele dermatologie bei Patienten mit einer Psoriasis (n = 378) (Conditional Logit Model – Haupteffektmodell)

Anmerkung: Punktschätzungen (im Diagramm: Coef.) sind mit Punkten im Diagramm dargestellt und die 95% CI via Linien

Das Interaktionsmodell (siehe *Abbildung 10*) zeigte signifikante Interaktionen der Präferenz gegenüber der telemedizinischen Versorgung und soziodemografischen, erkrankungs- und versorgungsspezifischen Charakteristika auf. In den beiden Haupteffektmodellen ließen sich ähnliche Einflüsse der Attribute und Level auf die Präferenz nachweisen. Die Interaktionsmodelle hingegen zeigten teils voneinander abweichende Effekte der untersuchten Charakteristika in den beiden Szenarien. Während ein hohes Alter die Präferenz gegenüber der Teledermatologie im akuten Szenario erhöhte, reduzierte es die Wahrscheinlichkeit der Präferenz für diese in der Verlaufskontrolle. Während das Geschlecht im akuten Szenario keine signifikanten Auswirkungen hatte, hatten Frauen bei der Verlaufskontrolle eine geringere Präferenz für die Telemedizin. Ähnliches war auch bei Personen aus ländlichen Gebieten zu beobachten: keine signifikante Auswirkung auf die Präferenz für die Teledermatologie im akuten Szenario und eine signifikante Negative bei der Verlaufskontrolle.

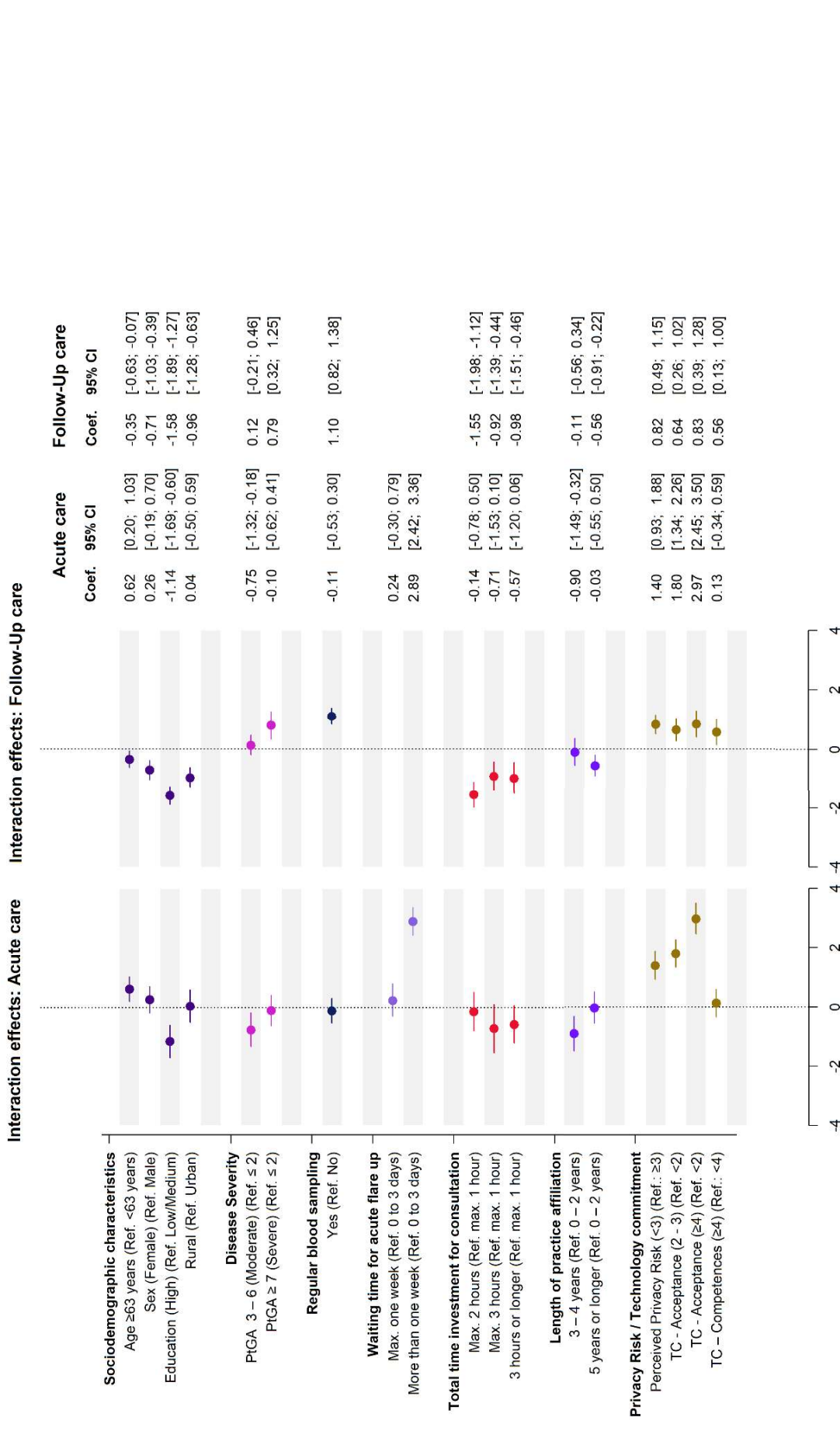


Abbildung 10 Analyse der Interaktionseffekte auf die Präferenz für den Einsatz der Tele Dermatologie bei Patienten mit Psoriasis (n = 378) (Conditional Logit Model – Interaktionseffekte)

Anmerkung: Punktschätzungen (im Diagramm: Coef.) sind mit Punkten im Diagramm dargestellt und die 95% CI via Linien.

1.4. Diskussion

In diesem Kapitel werden die wichtigsten Ergebnisse der einzelnen Publikationen, publikationsübergreifend und im Kontext der wissenschaftlichen Literatur diskutiert und Implikationen für die Praxis abgeleitet. Daran anschließend werden die Stärken und Limitationen der einzelnen Publikationen behandelt.

1.4.1. Evidenz und Verfügbarkeit von Digital Health-Anwendungen in der Dermatologie

Die systematische Übersichtsarbeit lässt erkennen, dass es zwar zahlreiche Forschungsarbeiten zu DHAs in der Dermatologie gibt, diese sich aber schwerpunktmäßig auf die Store-And-Forward Teledermatologie und die KI-Bildererkennung fokussieren [132]. Beide Technologien zielen hier wiederum in einem hohen Maße auf die Diagnosestellung und Überweisungen / Triage ab und sind vor allem für das Gesundheitspersonal als primäre Zielgruppe entwickelt worden [132]. Angesichts der großen Anzahl an Apps in den beiden App-Stores (Google Play Store und Apple App Store), die sich direkt an Patienten richten [63], ist es äußerst wahrscheinlich, dass viele dieser Anwendungen keinen ausreichenden wissenschaftlichen Nachweis ihrer Wirksamkeit und Validität erbringen können. Eine weitere Übersichtsarbeit bestätigt diese Erkenntnis und zeigt, dass für viele dermatologiespezifische Apps, die auf KI-Algorithmen basieren, keine ausreichende Evidenz vorliegt. Dies kann ein Risiko für die Anwender darstellen – sowohl für Patienten als auch für Dermatologen (siehe Kapitel 2.2.3.2) [65]. Die geringe Verfügbarkeit von Evidenz kann eine Erklärung für die geringe Nutzung seitens der Patienten [152] und Dermatologen [135] darstellen. Wissenschaftliche Evidenz stellt eine wichtige Grundlage für die Implementierung von gesundheitlichen Interventionen und somit eben auch DHAs dar. Ein positiver Nachweis einer Intervention gewinnt das Vertrauen von Ärzten für diese Anwendungen, erlaubt eine Empfehlung durch Fachgesellschaften via wissenschaftlichen Leitlinien, wie bereits zur Teledermatologie geschehen [109], und ermöglicht zumindest die Diskussion zur Vergütung einer DHA [154]. Der Fund kann als Bestätigung für die eingangs (siehe Kapitel 2.2.3.2) aufgezeigte nicht ausreichende Evidenzlage in der digitalen Medizin werden, welche durch hohe Kosten für die klinische Evidenz und nicht ausreichende Regulierung in diesem Bereich erklärt werden kann [68,69].

1.4.2. Wichtige Barrieren von Digital Health aus Perspektive der Dermatologenschaft

Neben der fehlenden Evidenz konnten in den weiteren Publikationen viele weitere Barrieren aufgezeigt werden. Aufseiten der Dermatologen waren hier vor allem drei Barrieren auffällig, welche in den Fokusgruppen und der Clusteranalyse aufgezeigt wurden. Erstens die nicht ausreichende Vergütung. Zweitens der Hinweis, dass die eHealth-Infrastruktur aus Perspektive der Dermatologen nicht ausreichend ist und drittens, dass DHAs den Arbeitsaufwand für die Versorgung erhöhen könnten [135].

Wie bereits eingangs beschrieben, ist die Vergütung für DHAs derzeit nicht flächendeckend gegeben [117–120]. Die Vergütung von DHAs sollte dabei von der Komplexität der jeweiligen Intervention und deren Auswirkungen auf den Praxisalltag abhängen und für jede einzelne DHA individuell entschieden werden. DHAs wie die Teledermatologie, welche zumindest in der Theorie eine Vor-Ort-Sprechstunde ersetzen können [35], müssen einem anderen Vergütungsansatz folgen, wie DHAs für Patienten, die einen Mehraufwand für die Praxis erzeugen, zum Beispiel um Patienten auf die Anwendung zu schulen oder Auswertungen mit dem Patienten zu besprechen [155]. In jedem Fall können finanzielle Anreize für die Dermatologenschaft einen wichtigen Baustein für die Implementation von evidenzbasierten DHAs schaffen [101].

Die Implementierung von DHAs setzt eine leistungsfähige eHealth-Infrastruktur voraus, die den effizienten Datenaustausch und die sichere Speicherung von Daten durch Ärzte und Patienten ermöglicht und so eine nahtlose Integration der DHAs in die IT-Infrastruktur von Dermatologen unterstützt [156]. Dies ist aus Perspektive von Dermatologen nicht gegeben. Die eHealth-Infrastruktur wurde als zu kostenintensiv, mit geringem Zusatznutzen für die Dermatologen und die Versorgung beschrieben. Zu ähnlichen Erkenntnissen kommen ebenfalls andere Befragungen unter niedergelassenen Ärzten [157]. Auch wird die eHealth-Infrastruktur, vor allem im internationalen Vergleich, als nicht ausreichend beschrieben [101].

Die Sorge der Dermatologen vor einem Arbeitsmehraufwand kann aus mehreren Perspektiven betrachtet werden und ist nicht unbegründet. Zum einen können bisherige Aufgaben aufgrund einer unzureichenden Integration in die täglichen Abläufe mehr Zeit in Anspruch nehmen als gewohnt. Zum anderen kann die Menge an Aufgaben auch durch eine zusätzliche Nachfrage steigen, die aufgrund eines verbesserten bzw. vereinfachten Zugangs zur Praxis für Patienten entsteht. Es gibt Anhaltspunkte, dass sowohl die eAU als auch das eRezept mit einem Mehraufwand für Ärzte verbunden sind, da diese Bearbeitung mehr Zeit in Anspruch nimmt als die analogen Verfahren [158,159]. Das es zu einem Mehraufwand durch die Telemedizin

kommen kann, da diese einen vereinfachten Zugang zur Versorgung ermöglicht, konnte ebenfalls bereits aufgezeigt werden [160].

Des Weiteren kann sogar ein Arbeitsmehraufwand erzeugt werden, bei Anwendungen, welche den Arbeitsalltag zunächst effizienter gestalten. Gemäß der sozialen Beschleunigungstheorie von Hartmut Rosa sorgen technologische Beschleunigungen, zum Beispiel effizientere Arzt-Patienten-Kontakte mit der Einführung der Telemedizin, nicht für eine Entlastung der Ärzte, sondern dazu, dass diese mehr Aufgaben (z.B. mehr Patientenkontakte) pro Zeiteinheit ausführen und dies wiederum zu Stress und Zeitdruck führen kann [35,161].

Alle genannten Aspekte tragen zur Erklärung bei, wieso ein geringer Anteil von lediglich ca. 40 % einen Vorteil der Digitalisierung für die eigenen Praxisabläufe sieht, und wieso eine geringe Akzeptanz gegenüber digitalen Angeboten besteht [142].

1.4.3. Verbreitung von Digital Health-Anwendungen in der Bevölkerung

Aufgrund der geringen Verfügbarkeit (siehe Kapitel 2.5) scheinen viele DHAs in der Dermatologie auch noch keinen hohen Verbreitungsgrad aufzuzeigen. Im Jahr 2021 gaben lediglich etwa 8 % der Dermatologinnen und Dermatologen an, die Videosprechstunden häufig oder sehr häufig zu nutzen, 7 % ein telemedizinisches Monitoring und 5 % den Online-Austausch von Patientendaten [142]. Damit stimmen diese Werte mit den Annahmen aus Kapitel 2.5 überein. Auch aus Perspektive der Bevölkerung und der Patienten lässt sich dies bestätigen [152], so nutzten nur ca. 7 % des digital affinsten Clusters (*Digital Enthusiasts*) der Patientenbefragung eine zeitversetzte Sprechstunde und nur 3 % eine Videosprechstunde in den letzten 12 Monaten für ihre Hauterkrankung. In der Allgemeinbevölkerung – und somit unabhängig vom dermatologischen Kontext – ist die Verbreitung von Anwendungen, die ohne ärztliche Beteiligung genutzt werden können, wie etwa zur passiven Gesundheitsüberwachung, zur Diagnoseunterstützung oder zur aktiven Gesundheitsüberwachung, bereits deutlich weiter fortgeschritten. Es nutzten bereits ca. 14 % der Personen eine Anwendung zur passiven Überwachung ihres Gesundheitszustandes [152]. Die Angabe, dass 30 % der Allgemeinbevölkerung mindestens eine DHA verwendet haben, deckt sich mit anderer Forschungsliteratur [52].

1.4.4. Fehlende Akzeptanz und Kompetenz - Arzt oder Patient?

Ein weiterer Aspekt, welcher in den Fokusgruppen aufgedeckt und durch die anderen Arbeiten zumindest zum Teil bestätigt wurden, ist die gegenseitige Abhängigkeit bei der Einführung und Verwendung von DHAs von Arzt und Patient [135]. Beide Stakeholdergruppen (Arzt und

Patient) berichten über die jeweils andere Gruppe mangelndes Interesse an DHAs. Patienten stellten zum Beispiel dar, dass es wenig sinnvoll ist, eine Patienten-Dokumentationsapp zu führen, wenn der Arzt diese Daten für die Behandlung nicht nutzen würde. Dermatologen deuteten dagegen darauf hin, dass es keine nennenswerte Nachfrage nach der Videosprechstunde geben würde und dies ein Grund für die Nicht-Einführung in der eigenen Praxis darstellt [135].

Die Fokusgruppen deuteten darauf hin, dass Dermatologen in der Tendenz eine geringere Akzeptanz gegenüber digitalen Anwendungen haben als dermatologische Patienten. Dieser Eindruck lässt sich zumindest in Teilen in der Literatur und auch mit den weiteren Umfragen wiederfinden [144].

Daneben wurde in der Cluster-Analyse deutlich, dass ein hoher Anteil der Dermatologen ihren Patienten weder die Akzeptanz gegenüber digitalen Anwendungen noch eine ausreichende Kompetenz derer Nutzung zutraut. Dagegen spricht, dass sich etwa 40 % der Bevölkerung, die in den letzten 12 Monaten an einer Hauterkrankung gelitten hat, die Verwendung einer DHA vorstellen könnten, was auf eine vorhandene Akzeptanz hinweist [152]. In Bezug auf die Kompetenz kann die Wahrnehmung der Dermatologen belegt werden, so kommt die *Health Literacy Survey Germany-2* (HLS-GER 2) Studie zu dem Schluss, dass knapp 70 % der Bundesbevölkerung keine ausreichende digitale Gesundheitskompetenz aufweisen [52].

Man könnte von einem Kausalitätsdilemma sprechen, nachdem Ärzte keine DHAs in den Behandlungsalltag einführen, da Patienten diese nicht nachfragen und keine Kompetenzen mitbringen. Diese wiederum zeigen eine geringe bis mittlere Akzeptanz und Kompetenzen auf, da sie keine DHAs angeboten bzw. erläutert bekommen. Mehrere Ansätze könnten dieses Paradox auflösen. Dermatologen können Verantwortung übernehmen und ihren Patienten die Verwendung von evidenzbasierten DHAs empfehlen und diesen nahebringen. Die Fokusgruppen zeigten auf, dass Patienten den Empfehlungen ihrer Ärzte vertrauen [135], ein Befund, den auch das DCE stützt, da Patienten eine Behandlung ihres eigenen Arztes bevorzugen, was auf ein Vertrauensverhältnis hindeutet. Auch gibt es Anzeichen in der Literatur, dass die Akzeptanz und daraus resultierenden Empfehlungen seitens der Dermatologenschaft essenziell für die Einführung von DHAs sind [162,163]. Die Cluster-Analyse hat bereits eine solche Gruppe identifiziert – die *Adopters*, also die digitalaffinste Gruppe der Dermatologen –die zwar skeptisch hinsichtlich der Akzeptanz und Kompetenz von Patienten ist, ihnen jedoch trotzdem eine DHA empfehlen würde.

Viele Anwendungen, darunter die ePA oder das Patiententagebuch, entfalten ihren Mehrwert erst durch die gemeinsame Nutzung und Interaktion zwischen Arzt und Patient (siehe Kapitel 2.2.2), was eine hohe Akzeptanz auf beiden Seiten voraussetzt [164].

1.4.5. Digital Divide durch die Digitale Dermatologie

Ein weiterer Aspekt, der mit der fehlenden digitalen Gesundheitskompetenz zusammenhängt und sich durch nahezu alle Publikationen zieht, ist die ungleiche Nutzung, Akzeptanz und Präferenz gegenüber DHAs in Abhängigkeit von Alter, regionalen Aspekten (Stadt/Land) und Bildung [135,142,152].

Auf der Seite der Versorger waren es Jüngere und Dermatologen mit einer Praxis in einer städtischen Region, welche häufiger DHAs nutzten, aufgeschlossener gegenüber der digitalen Medizin waren und häufiger einen Zusatznutzen in diesen Angeboten sahen [142]. Ähnliche Ergebnisse lieferte die Cluster-Analyse, welche aufzeigte, dass ältere Dermatologen häufiger in der Gruppe der *Rejectors*, also der Gruppe mit einer ablehnenden Haltung gegenüber der Digitalisierung, vertreten waren.

Auf der Seite der Patienten zeigte sich ein ähnliches Bild: Junge Personen mit einem hohen Bildungsgrad und einer hohen digitalen Kompetenz nutzten und akzeptierten die Verwendung von DHAs mit einer höheren Wahrscheinlichkeit [152]. Gleichzeitig beschrieben sowohl Dermatologen als auch Patienten die nicht vorhandenen Kompetenzen bei älteren Patienten [135].

Diese Aspekte sprechen für das Vorliegen eines, wie eingangs beschrieben (siehe Kapitel 2.2.3.1), *second order Digital Divide*, der sich bei zunehmenden Anwendungen von DHAs bei nicht ausreichenden Gegenmaßnahmen auch auf die Versorgung und somit auf die Gesundheit der Patienten auswirken kann [165]. So gibt es Anzeichen, dass Ärzte aufgrund eines *Implicit Tech Bias* (deutsch etwa: implizite Technik-Verzerrung) gegenüber einzelnen Personengruppen (Ältere Personen, Frauen und nicht Muttersprachler) seltener eine Empfehlung für eine DHA aussprechen und somit diesen den Zugang zu DHAs seltener ermöglichen [165,166].

Zusammengefasst ergibt sich somit ein Paradoxon: Vor allem Personen mit bereits gutem Zugang zur Gesundheitsversorgung und besserem Gesundheitsstatus profitieren von DHAs, während jene, die potenziell überproportional davon profitieren könnten, diese seltener nutzen bzw. empfohlen bekommen. Daher ist ein Monitoring erforderlich, welches den Zugang zu DHAs in verschiedenen Bevölkerungsgruppen aufzeigt.

Des Weiteren ist es essenziell, das Thema *Digital Health Literacy* als soziale Determinante der Gesundheit anzuerkennen und Maßnahmen auf der individuellen (z.B. Förderung der digitalen Kompetenz durch Krankenkassen [167,168]), der interpersonellen (z.B. Aufklärung über digitale Angebote durch Ärzte), der Gemeinde (z.B. Unterstützung via Bibliotheken und Volkshochschulen) und auf der gesellschaftlichen Ebene (z.B. via Designstandards, die den Zugang für alle Personen ermöglichen) zu entwickeln, um allen Teilen der Gesellschaft einen gleichen Zugang zur digitalen Versorgung zu ermöglichen [165]. Dies steht im Einklang mit dem Konzept *People-Centred Health Care* der WHO, das fordert, dass alle Menschen – über das klinische Setting hinaus – mit Gesundheitsthemen erreicht werden müssen, um ihre Gesundheit zu fördern und zu schützen [169].

1.4.6. Datenschutz und Datensicherheit

Der Datenschutz und die Datensicherheit wurden in den Umfragen und Fokusgruppen als ein zentraler Punkt für die Implementation bestätigt (siehe auch Kapitel 2.2.3.3). Während Ärzte in den Fokusgruppen aufzeigten, dass der Datenschutz und die Datensicherheit die Anforderungen an die IT und die Praxisabläufe deutlich erhöht haben [135], deuten die Umfrage unter Patienten und der Bevölkerung darauf hin, dass Bedenken gegenüber dem Datenschutz bestehen und dieser die Akzeptanz und Nutzung von DHAs verringert [152]. Für die Perspektive der Dermatologen gibt es zahlreiche Belege, die aufzeigen, dass die Einführung der DSGVO zu deutlichen Zusatzkosten in den niedergelassenen Praxen geführt hat [80]. Der Zusammenhang zwischen Datenschutzbedenken und der Akzeptanz gegenüber DHAs wurde ebenfalls bereits nachgewiesen [79]. Die aufgezeigten Bedenken sind dabei in Deutschland gegenüber anderen Ländern der EU deutlicher ausgeprägt. [170,171].

Ein Weg, den Datenschutzbedenken der Patienten zu begegnen, ist die Evaluation von DHAs in Bezug auf ihren Datenschutz und -sicherheit und die transparente Darstellung der Ergebnisse. Die Feststellung des Datenschutzes und -sicherheit ist integraler Bestandteil von nationalen und internationalen Evaluationsrahmen, wie dem DIGA-Fast-Track-Verfahren des BfArM [73], des NICE [72] oder der American Psychologists Association (APA) [172]. Bisher sind viele DHAs, die in den App-Store (Apple und Google Play Store) verfügbar sind nicht ausreichend transparent bezüglich des Datenschutzes und -sicherheit [173]. Anwendungen, welche von Dermatologen eingesetzt werden bzw. von ihnen empfohlen werden, sollten bezüglich dieses Aspektes geprüft werden, um das Vertrauen in die Verwendung zu stärken.

Der Datenschutz muss als hohes Gut bewahrt werden und darf trotzdem die Benutzerfreundlichkeit der Nutzung von DHAs nicht negativ beeinträchtigen. Als ein Negativbeispiel gilt hier das Anmeldeverfahren zur ePA, welches den Datenschutz

sicherstellen soll, allerdings von vielen Patienten als zu Komplex angesehen wird [156]. Dass die Beachtung des Datenschutzes, bei gleichzeitiger hoher Akzeptanz gelingen kann, zeigen Länder wie Estland, die bereits weit fortgeschritten in der Digitalisierung des Gesundheitswesens sind und zudem die DSGVO beachten [174].

1.4.7. Präferenzen für Digital Health-Anwendungen

Die Präferenz gegenüber einer DHA wurde exemplarisch an der teledermatologischen Versorgung von Patienten mit einer Psoriasis mittels eines Discrete Choice Experiment (DCE) untersucht. Das DCE hat aufgezeigt, dass Patienten in der Tendenz eine Vor-Ort-Behandlung gegenüber einer Fernbehandlung bevorzugen würden. Bestimmte Aspekte, wie die Behandlung durch einen bekannten Arzt, die Möglichkeit Rückfragen zu stellen, die Wahrnehmung von Anliegen des Patienten und die zeitige Versorgung innerhalb von 24h, erhöhen die Präferenz gegenüber der Telemedizin. Vergleichbare Präferenzen konnten auch in der Literatur identifiziert werden [129,175].

Fragwürdig ist allerdings, ob diese Präferenzen in der Versorgung berücksichtigt werden können, da die Teledermatologie ebenfalls Ressourcen bindet, die, wie in Kapitel 2.1 beschrieben, für die derzeitige Versorgung bereits als unzureichend beschrieben werden können. Dennoch hilft diese Art der Forschung herauszuarbeiten, unter welchen Umständen Patienten sich die Versorgung mithilfe von *Digital-Health* Anwendungen vorstellen könnten [148].

Da es, wie in Kapitel 4.4 aufgezeigt, der Akzeptanz der Dermatologen eine besondere Bedeutung bei der Implementierung von DHAs zukommt, ist die Analyse der Präferenzen seitens der Dermatologen ebenfalls von hoher Bedeutung. Anhand der Präferenzen beider Anwendergruppen können dann Versorgungsprogramme entwickelt werden, welche beide Perspektiven berücksichtigen und in Einklang miteinander bringen. Vor allem bei der Teledermatologie besteht die Kritik, dass Vorteile für den Patienten (z.B. keine Anreisekosten), für die Krankenversicherungen (z.B. geringere Anzahl an Folgeterminen) und aus gesellschaftlicher Perspektive (z.B. geringere Produktivitätsverluste aufgrund kürzerer Reisezeiten) bestehen, diese sich aber nicht zwangsläufig in einem (monetären) Vorteil für Dermatologen widerspiegeln [35].

1.4.8. Stärken und Limitationen der Arbeiten

Die Stärke dieser Dissertationsarbeit liegt in der methodischen Vielfalt, welche qualitative, quantitative Methodiken, sowie eine systematische Literaturarbeit umfasst und somit das

Thema der Digitalisierung in der Dermatologie aus unterschiedlichen Gesichtspunkten und Detailtiefe betrachten konnte. Dabei stehen die einzelnen Publikationen nicht für sich, sondern bauen systematisch aufeinander auf. Die Ergebnisse der systematischen Literaturübersicht haben so Eingang in die Umfragen (Publikation 3, 4 und 6) und die Fokusgruppen (Publikation 2) erhalten. Die Fokusgruppen wiederum waren ebenfalls essenzieller Bestandteil für alle weiteren Umfragen, inkl. des Discrete Choice Experiments.

Eine wesentliche Limitation der Gesamtarbeit ist die externe Validität und Generalisierbarkeit der Umfragen und Fokusgruppen (Publikation 2, 3, 4, 5 und 7), mit Ausnahme der FORSA-Umfrage (Publikation 6), aufgrund der fehlenden Repräsentativität der Stichprobe zur Grundgesamtheit. Patienten wurden weitestgehend via Patientenselbsthilfegruppen rekrutiert, welche nachweislich informierter und besser gebildet sind, als die zugrundeliegende Gesamtpopulation [176,177]. Die angeschriebenen Dermatologen wurden zwar entweder zufällig aus der Mitgliederdatenbank der Deutschen Dermatologischen Akademie ausgewählt, die nahezu die Gesamtheit der Dermatologen in Deutschland darstellt (Publikation 3), oder es wurden alle Mitglieder angeschrieben (Publikation 5). Dennoch entsprach die Verteilung nicht der Grundgesamtheit [142]. In beiden Fällen waren Frauen und junge Dermatologen (<35 Jahre) in den Umfragen unterrepräsentiert.

In der qualitativen Fokusgruppe wurden Patienten weitestgehend am Universitätsklinikum Hamburg-Eppendorf rekrutiert, was ggf. Aspekte aus anderen Versorgungssettings nicht ausreichend reflektiert hat [135].

Die Teilnahme basierte zudem weitestgehend auf Freiwilligkeit der Patienten und Dermatologen, dies kann nicht nur zu soziodemografischen Unterschieden zwischen der Stichprobe und Grundgesamtheit führen, sondern ebenfalls zu Unterschieden im Interesse an einem Thema [178]. All diese Aspekte können die Unterschiede zwischen der Grundgesamtheit und der Stichprobe im DCE erklären. In der Studie waren die Patienten mit Psoriasis älter und wiesen einen höheren Männeranteil auf als die Vergleichsgruppe von Patienten mit einer Psoriasis in Deutschland [179]. Auch die bevölkerungsrepräsentative Forsa-Umfrage ist mindestens von der Freiwilligenverzerrung beeinflusst [178].

Ein weiterer Aspekt ist die Verwendung von weitestgehend nicht validierten Fragebögen bzw. theoretischen Rahmenkonzepten, wie dem UTAUT-Modell zur Erhebung der Akzeptanz [137]. Zwar diente Letzteres als Rahmenkonzept für die Fokusgruppen, die Umfragen jedoch basierten nur zu Teilen auf diesem Modell, da die Erkenntnisse der Fokusgruppen berücksichtigt wurden. Dies mindert vor allem die Vergleichbarkeit mit anderen Arbeiten aus diesem Bereich [137,140]. Die Größe der Stichproben in den beiden Cluster-Analysen und

dem DCE hat das statistisch methodische Vorgehen eingeschränkt. Es besteht die Empfehlung, dass infolge einer explorativen Faktorenanalyse, wie in den Cluster-Analysen vorgenommen, eine konfirmatorische Faktorenanalyse folgen sollte [180].

Akzeptanz- und DCE-Erhebungen sind zudem vom *Intention-Behavior Gap* betroffen, d.h. der Diskrepanz zwischen der Absicht, eine Anwendung in Zukunft zu nutzen, und der tatsächlichen Nutzung/dem tatsächlichen Verhalten [181]. Somit kann die Intention in der befragten Population, eine teledermatologische Anwendung zu nutzen, höher sein als die tatsächliche Nutzung.

Bei der systematischen Literaturübersicht ist es wichtig zu beachten, dass weder die Qualität/Validität der Studien, zum Beispiel via *Risk of Bias* [182], überprüft noch die Effektivität oder Validität der einzelnen DHAs zusammengefasst wurde. Dies muss in weiteren systematischen Reviews zu den einzelnen DHAs vorgenommen werden, wie zum Teil auch schon passiert [34].

1.4.9. Implikationen für die Praxis

Die 10 wichtigsten Implikationen für die zukünftige Implementation von *Digital Health*-Anwendungen:

1. **Die Evaluation von *Digital Health*-Anwendungen fördern**, wodurch DHAs identifiziert werden können, die ein positives Risiko-Nutzen Verhältnis für die Versorgung aufzeigen und somit die Akzeptanz für alle Beteiligten erhöhen, dabei sind Anforderungen an den Datenschutz und -sicherheit essenzieller Bestandteil der Evaluation.
2. **Anforderungen an den Datenschutz beachten und transparent kommunizieren**, bei gleichzeitiger Sicherstellung, dass die Anwendung eine hohe Benutzerfreundlichkeit für alle Anwendergruppen aufweist.
3. **Einbezug aller Anwendergruppen bei der Entwicklung –Patienten und Versorger** – um sicherzustellen, dass diese den Bedürfnissen und Präferenzen aller Gruppen entsprechen und allen Anwendergruppen einen umfassenden Mehrwert bieten.
4. **Beachtung der einfachen Integration von *Digital Health*-Anwendungen in den Arbeitsalltag von Dermatologen**, um eine hohe Akzeptanz in dieser wichtigen Anwendergruppe zu fördern.
5. **Gewährleistung einer angemessenen Vergütung** für evidenzbasierte *Digital Health*-Anwendungen, welche den Mehraufwand für Dermatologen berücksichtigt.
6. **Anerkennung der zentralen Rolle von Dermatologen bei der Implementierung von *Digital Health*-Anwendungen**, da das Vertrauensverhältnis zwischen Arzt und Patient eine entscheidende Brücke zur Akzeptanz dieser Anwendungen für Patienten darstellt.
7. **Förderung des Ausbaus der nationalen eHealth-Infrastruktur und Sicherstellung der Interoperabilität** mit *Digital Health*-Anwendungen, um eine nahtlose Integration in die Versorgung zu ermöglichen.
8. **Förderung der digitalen Kompetenzen von Dermatologen**, um den flächendeckenden Zugang zu DHAs sicherzustellen und den *Digital Divide* zu schließen.
9. **Entwicklung von Maßnahmen, um dem *Digital Divide* bei Patienten entgegenzuwirken**, wozu die Förderung von digitalen Gesundheitskompetenzen zählt, als auch das Einhalten von Designstandards, welche die einfache Nutzung für alle Patienten sicherstellt.
10. **Regelmäßige Überprüfung des *Digital Divides***, um festzustellen, ob digitale Gesundheitsanwendungen die Patientengruppen erreichen, die am meisten davon profitieren könnten.

1.5. Fazit

Die Digitalisierung der Dermatologie in Deutschland befindet sich nach wie vor in einem frühen Stadium. Obwohl auf internationaler Ebene bereits umfangreiche Forschungsergebnisse vorliegen (vgl. Publikation 1), hat deren Umsetzung in die Versorgung bislang nicht ausreichend stattgefunden (vgl. Publikation 3, 4, 5 und 6). Zahlreiche Barrieren erschweren die Implementierung, darunter eine oft unzureichende Evidenzlage, Bedenken hinsichtlich eines erhöhten organisatorischen Aufwands für Leistungserbringende sowie eine begrenzte digitale Gesundheitskompetenz bei Patienten (vgl. Publikation 1 und 2, 3, 4, 5). Demgegenüber existieren jedoch auch fördernde Faktoren, wie das hohe Vertrauen in behandelnde Ärzte, ein hoher Anteil an Patienten und Ärzten, die digitalen Gesundheitslösungen offen gegenüberstehen, sowie die wachsende Wahrnehmung der Vorteile digitaler Angebote (vgl. Publikation 2, 3 und 4).

Aufgrund der heterogenen Verteilung digitaler Gesundheitskompetenz in der Bevölkerung besteht die Gefahr eines *Digital Divide*, sodass der Zugang zu innovativen digitalen Anwendungen und deren Auswirkungen auf die gesundheitliche Versorgung kontinuierlich evaluiert werden müssen (vgl. Publikation/Manuskript 4, 5 und 6). Zusätzlich ist es erforderlich, Maßnahmen zu entwickeln, welche diesen Effekten entgegenwirken. Dabei ist es entscheidend, dass die *Digital Health Literacy* als eine wesentliche soziale Determinante der Gesundheit Beachtung findet. Darüber hinaus stellt der Themenkomplex Datenschutz und Datensicherheit einen weiteren zentralen Faktor dar, der das Vertrauen und die Akzeptanz gegenüber digitalen Angeboten maßgeblich prägt (vgl. Publikation 2, 4, 5, 6 und 7). Um die Akzeptanz in der dermatologischen Versorgung zu erhöhen, ist daher ein ausgewogener Umgang mit den Anforderungen an Datenschutz und Datensicherheit einerseits und der praktischen Umsetzbarkeit andererseits essenziell. Ebenso ist eine Ausrichtung digitaler Angebote an die Präferenzen von Nutzern von entscheidender Bedeutung, da sie die Wahrscheinlichkeit der Inanspruchnahme erhöht (vgl. Publikation 7).

Abschließend lässt sich festhalten, dass eine nachhaltige Digitalisierung der dermatologischen Versorgung nur dann gelingen kann, wenn Nutzerpräferenzen, Datenschutz und -sicherheit bei der Entwicklung berücksichtigt werden. Es bedarf zudem einer Evaluierung von Anwendungen im Rahmen einer evidenzbasierten Medizin. Des Weiteren müssen fördernde Faktoren, wie die Vergütung von Leistungserbringern, aufgebaut und die digitale Gesundheitskompetenz der Patienten gestärkt werden.

2. Artikel oder Manuskript mit Letter of Acceptance

2.1. Publikation 1

Reinders P, Augustin M, Kirsten N, Fleyder A, Otten M. *Digital health interventions in dermatology-Mapping technology and study parameters of systematically identified publications. J Eur Acad Dermatol Venereol* 2023;37(12):2440-2449. PMID:37528462

SYSTEMATIC REVIEW

Digital health interventions in dermatology—Mapping technology and study parameters of systematically identified publications

Patrick Reinders  | Matthias Augustin  | Natalia Kirsten  | Anastasia Fleyder | Marina Otten 

Institute for Health Services Research in Dermatology and Nursing (IVDP), University Medical Center Hamburg-Eppendorf (UKE), Hamburg, Germany

Correspondence

Patrick Reinders, Institute for Health Services Research in Dermatology and Nursing (IVDP), University Medical Center Hamburg-Eppendorf (UKE), Christoph-Probst-Weg 3, D-20246 Hamburg, Germany.
Email: preinders@uke.de

Funding information

Novartis

Abstract

Digital health interventions (DHI) potentially improve the efficiency and effectiveness of dermatological care. Currently, an overview clustering and characterizing the evidence on DHIs is missing. This systematic mapping of the literature aims to analyse published research on DHIs in dermatology to identify trends and gaps in research. For this purpose, a systematic search of the MEDLINE database was conducted in August 2022 to identify original publications on DHIs in dermatology. Data on country, targeted audience, DHI category, indication, outcome parameter and study design were extracted. Out of 12,009 records identified in MEDLINE, 403 studies were included in the final analysis. Studies on DHIs mainly performed in western countries, headed by the United States ($n = 133$), Germany ($n = 32$) and Spain ($n = 23$). Of all identified DHIs, 261 targeted healthcare providers (HCP), 66 clients (e.g. patients, caregivers, healthy individuals) and 67 both clients and HCPs. A majority of DHIs focussed on establishing a diagnosis ($n = 254$). Every other study analysed store-and-forward teledermatology ($n = 187$), followed by artificial intelligence applications for image analysis ($n = 65$). The most often analysed DHI category for clients was a support of health behaviour change ($n = 31$). Monitoring of clients was targeted by 77 studies. Skin cancer ($n = 148$), wounds ($n = 29$) and psoriasis ($n = 29$) were the most targeted indications by DHIs. Most studies analysed diagnostic performance ($n = 166$), fewer studies analysed acceptance ($n = 92$) and effectiveness ($n = 98$). Usability ($n = 32$) and efficiency ($n = 36$) were investigated only to a small extent. Studies on DHIs in dermatology have focused on teledermatology and AI applications, with an emphasis on skin cancer diagnosis. Apart from that, a range of DHIs for different user groups, purposes and indications were identified, demonstrating the broad potential for DHIs in dermatology. Further research with a wider set of outcome parameters is needed to fully understand the potential of DHIs and ensure their sustainable implementation into dermatological care.

INTRODUCTION

Digital health interventions (DHIs) are interventions based on eHealth technologies, so the use of information and communication technologies to support health and health-related fields.¹ Thereby, DHIs cover known concepts such as artificial intelligence (AI) algorithms, wearable technologies, mobile health and telemedicine.¹ A first classification on DHIs was

published by the World Health Organization (WHO) in 2018.² DHIs can improve health outcomes and increase time and cost efficiency in healthcare systems around the globe. They are thought to lead to more sustainable and equitable healthcare systems and are therefore recognized and promoted.^{3–5} The improvements can be achieved by data-supported decision-making in diagnosis and treatment, enhanced communication between individuals involved in the process of care, improved

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self-management by patients with long-term conditions, but also through effective promotion of healthy behaviours.⁴

Visual aspects are crucial for the diagnosis of skin diseases. Thus, DHIs are particularly suitable in dermatology involving digital images or videos such as teledermatology or AI applications. Moreover, DHIs can also support other aspects of the patient's journey. For patients, this incorporates various smartphone and web applications to self-monitor a skin disease, remind patients of medications or introduce a health behaviour change.^{6–8} These applications can empower patients to actively engage in treatment decisions or in considering positive health choices.⁹ For healthcare providers (HCP), this includes online trainings, the ability to remotely monitor patients or receive a decision-making support by smart algorithms.^{10,11}

For teledermatological interventions, sufficient evidence is already available for several indications demonstrating high patient satisfaction, reduced waiting times for assessment and diagnostic accuracy comparable to standard of care.^{12–14} Artificial intelligence applications to classify skin cancer also show positive evidence.¹⁵ However, a general and comprehensive overview of studies on DHIs in dermatology does not exist.

Consequently, this systematic mapping of the literature characterizes and clusters studies on DHIs in dermatology regarding the type of DHI, indication, aim, study country, outcome parameter, target group and study design.

MATERIALS AND METHODS

On 5 August 2022, the MEDLINE (PubMed) database was searched for all original studies analysing the use of DHIs in dermatology. The search term consisted of common terms and their synonyms in digital health, including eHealth, online health, mHealth or artificial intelligence and a dermatological string including common dermatological diseases. The full search string is displayed in Appendix S1. The systematic mapping of the literature has not been pre-registered.

Study selection

Studies were selected according to developed inclusion and exclusion criteria (Table 1). The decision to exclude publications prior to 2010 has been made as older technologies do not longer correspond to today's status. We decided to only include studies that used quantitative methods for the evaluation of a DHI. For AI, only studies that compared the algorithm to standard of care (e.g. AI vs. dermatologist), studied the algorithm prospectively in a real-world setting, or utilized an application available at the market, to avoid inclusion of studies that primarily focus on the mathematical development process of an AI were considered.¹⁶

Two researchers reviewed all titles and abstracts. In case of disagreement or ambiguity, records were discussed with

TABLE 1 Inclusion and exclusion criteria of the systematic review.

Inclusion:
<ul style="list-style-type: none"> • A digital health intervention in the field of dermatology including any digital health intervention described by the World Health Organization classification of digital health interventions. • For artificial intelligence only: The study compared the algorithm to standard of care, studied the algorithm prospectively in a real-world setting or utilized a market available application. • The study uses quantitative methods for evaluation. • The study is an original study published in a peer-reviewed journal. • The study was published between August 2010 and August 2022. • The study was published in English or German.
Exclusion:
<ul style="list-style-type: none"> • The study is a case report or series. • The study focuses primarily on the development process with no or minimal focus on a quantitative evaluation. • For artificial intelligence only: focus on the mathematical development process.¹⁶

a third researcher until consensus was reached. Following, the remaining full texts were always reviewed by at least two researchers for eligibility discussing results in case of disagreement.

Data extraction

A standardized data extraction sheet based on a systematic review on teledermatology¹² was refined and adapted to the content of included studies in this mapping of the literature.

First, general study characteristics were extracted: year of publication, countries in which the study was performed, number of included patients or cases, if it was a follow-up study and length of follow-up. Study designs were categorized according to the following categories: randomized trials (controlled or crossover), non-randomized trials (controlled or crossover), cross-sectional studies, surveys following an intervention, one-group pre-post-studies, cohort studies or feasibility/pilot trials. In addition, study designs were classified as comparative or non-comparative.¹⁷

Second, DHI-specific information was extracted: The identified DHIs were largely categorized according to the WHO classification of digital health interventions.² After inspection of included papers, we refined and renamed the classification in certain aspects to be able to characterize the findings more precisely (Appendix S2). The extracted targeted aim of the DHI contained: (i) diagnosis/diagnostics, (ii) triage/referral, (iii) monitoring/follow-up (iv) prevention, (v) therapy or therapy support and (vi) education for healthcare personnel. One DHI could have multiple targeted aims. We also coded the skin disease related to the intervention. In case the DHI did not target any specific disease or more than three different skin diseases, we coded these studies as 'multiple skin diseases targeted'. Next, the targeted groups were coded for each DHI: (i) clients (e.g. caregivers, patients, healthy individuals, screening population), (ii) HCPs (e.g. dermatologists, primary care physicians, pathologists, nurses, medical

students) and (iii) clients and HCPs if both applied together. The three categories were mutually exclusive.

Finally, we derived the following outcome parameters from included studies:

1. Efficacy/effectiveness was assigned, when the study researched the potential benefits of a DHI either under optimal conditions (efficacy) or under real-world conditions (effectiveness) in comparison to the standard of care.¹⁸ The parameter covered constructs such as morbidity, quality of life indices, test scores for educational interventions or habitual indices, for example on treatment adherence.
2. Efficiency was considered for parameters measuring the effect of an intervention in relation to the invested resources (i.e. cost, waiting time, travel time, consultation time or reduced number of referrals)¹⁹—we only considered efficiency in comparative studies.
3. Diagnostic performance covered sensitivity, specificity, accuracy and related scores (e.g. F1 score), but also the diagnostic concordance between the standard of care and the digital intervention.
4. Usability was considered if the definition of the International Organization for Standardization (ISO) (2013) was met: ‘the extent to which a product can be used by specified users to achieve goals with effectiveness, efficiency and satisfaction’.²⁰
5. For acceptance, no consensus definition is available. Hence, a broad definition was considered covering the attitude towards a new DHI, the willingness to use an intervention, the actual usage or the satisfaction after engaging with the technology.²¹

Multiple researchers extracted the data from eligible studies. To ensure consistency of data extraction, researchers were trained on a pre-established data extraction manual. We performed multiple data checks in around 10% of all papers per researcher. In addition, plausibility checks (e.g. efficiency in non-comparative study) were investigated and corrected. No risk of bias of studies was assessed, while this mapping of the literature was intended to provide an overview of studies without a focus on the effectiveness of these interventions. Hence, no methodological quality or risk of bias was assessed.

Statistical data analysis

The extracted data of included studies were analysed descriptively. In addition, multiple cross-tables were plotted to visualize links between extracted parameters. All analyses were conducted in Microsoft Excel. Graphical presentations were designed using R version 4.2.1 (R Core Team, Vienna, Austria).

RESULTS

The search algorithm identified 12,009 records on PubMed (Figure 1). After screening all titles and abstracts, 1063 reports

were assessed for eligibility. Of those, 659 were removed as they did not meet the inclusion and exclusion criteria. Finally, 403 studies were included in the review (Appendix S3).

The studies derived in 52 countries, representing all continents (Figure 2). Countrywise, most of the studies were conducted in the United States ($n=133$), followed by Germany ($n=32$), Spain ($n=23$) and Australia ($n=19$). The median of included participants was 133 with a minimum of ten and a maximum of 59,279 participants. Studies that reported cases included 233.5 as the median with a minimum of 15 cases and a maximum of 83,100 cases. Out of the 403 studies, 106 reported a follow-up of participants. The mean follow-up was 5.9 months (SD = 7.5 months).

Digital health interventions by year and target group (both, HCP, client)

A general increase in studies on DHIs was identified in the last 12 years (Figure 3). The trend was especially driven by S&F teledermatology between HCPs and AI image analysis for HCPs. The number of studies that evaluated DHIs for clients did not follow this trend. More than half of all studies evaluated DHIs for HCPs only ($n=261$), whereas a minority targeted clients alone ($n=66$) or were used by a client and an HCP ($n=76$).

Digital health interventions by indication and target group (both, HCP, client)

Overall, skin cancer was most often targeted by the DHIs in the identified studies ($n=148$; Figure 4a). Here, S&F teledermatology (between HCPs as well as between HCP and client) and AI image analysis accounted for two-thirds of these studies. Other studies on skin cancer evaluated client-centred messaging and health messaging to populations regardless of health status. Both interventions are designed to promote health or a health behaviour change. Store-and-forward teledermatology explained the large number of studies on multiple diseases ($n=93$), others were live-interactive teledermatology ($n=13$) and AI ($n=8$). In comparison to DHIs on skin cancer, other indications were less often analysed: wounds, psoriasis, atopic dermatitis (AD) and acne vulgaris. Within these indications, no particular focus on a DHI function was identified.

Digital health interventions by aim and target group (both, HCP, client)

Supporting the diagnostic process was the main aim in the majority of identified studies (Figure 4b). These studies mostly analysed S&F teledermatology (between HCPs as well as HCP and clients) and AI for image analysis. Monitoring was often facilitated via teledermatology in several forms (live-interactive or S&F; HCPs as well as HCP and clients), but also by AI applications, client-centred messaging and active data documentation applications.

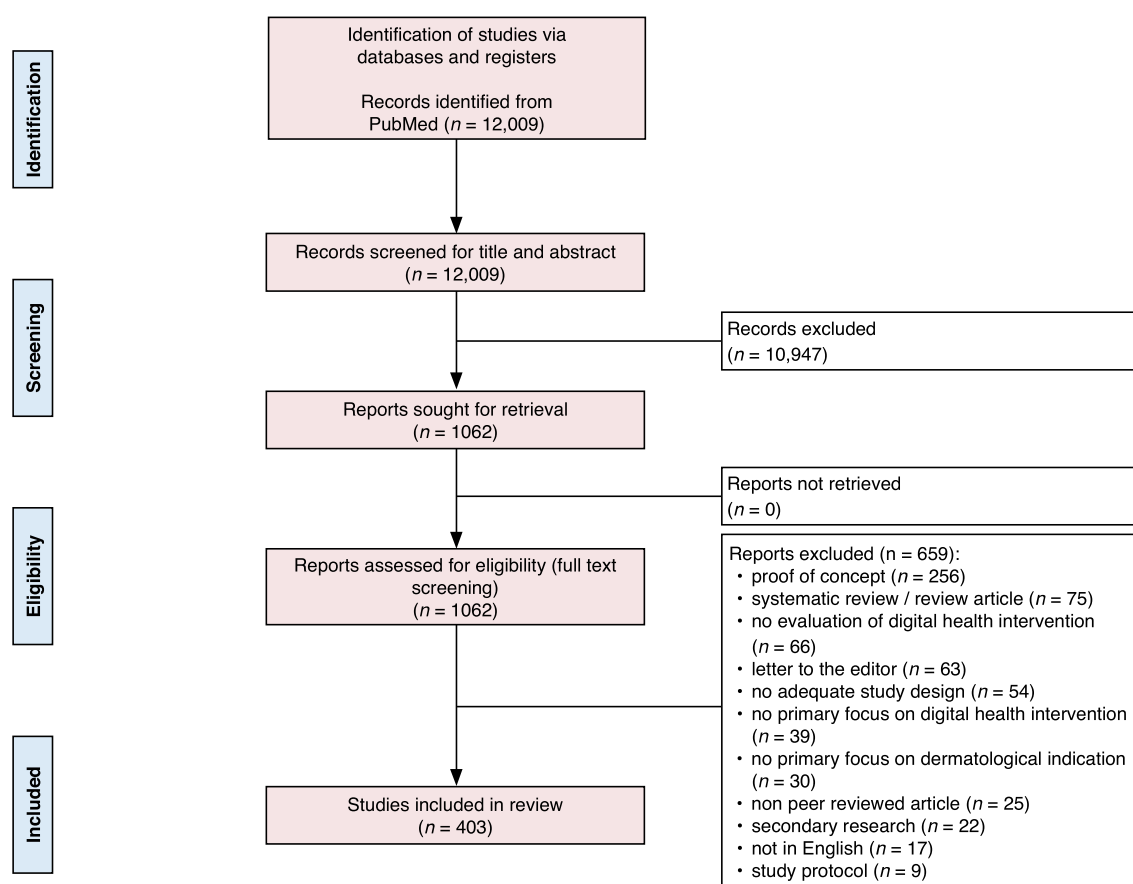


FIGURE 1 PRISMA diagram.

Digital health interventions by outcome parameter and target group (both, HCP, client)

As a consequence, to the strong focus on diagnosis support, diagnostic performance was frequently analysed by studies (Figure 4c), especially studies on S&F teledermatology between HCPs and between HCPs and clients, as well as AI imaging for HCPs and clients. Within studies on AI, the diagnostic performance was nearly the only parameter analysed. Acceptance was the second most studied parameter and commonly included in studies on teledermatology and client-targeted applications, but rarely in studies on AI. The effectiveness of a DHI was analysed relatively often in client-targeted applications, but less often in applications for HCPs. Efficiency was almost only included in studies on S&F teledermatology.

Digital health interventions by study design and target group (both, HCP, client)

The most frequently applied comparative study design was a cross-sectional design ($n = 215$), followed by

a randomized ($n = 75$) and a one-group pre-post design ($n = 31$; Figure 5). For non-comparative study designs, a cross-sectional, a survey or a pilot design was common to assess a DHI. Reasonably, the distribution of designs varied between sections of DHI categories and target groups. Whereas non-comparative and comparative designs were evenly distributed for DHIs targeting HCPs, comparative studies were predominantly used to assess DHIs for clients. Almost two-thirds of cross-sectional studies, comparative or non-comparative were applied to analyse AI for imaging analysis and S&F consultation between healthcare HCPs. For AI imaging, only one randomized controlled trial was identified.

DISCUSSION

In this systematic mapping of the literature, we clustered and characterized studies on digital health interventions in dermatology. We identified a strong upward trend towards more studies in recent years. The trend was especially driven by studies on S&F teledermatology and artificial intelligence applications. Furthermore, the studies were largely aimed at

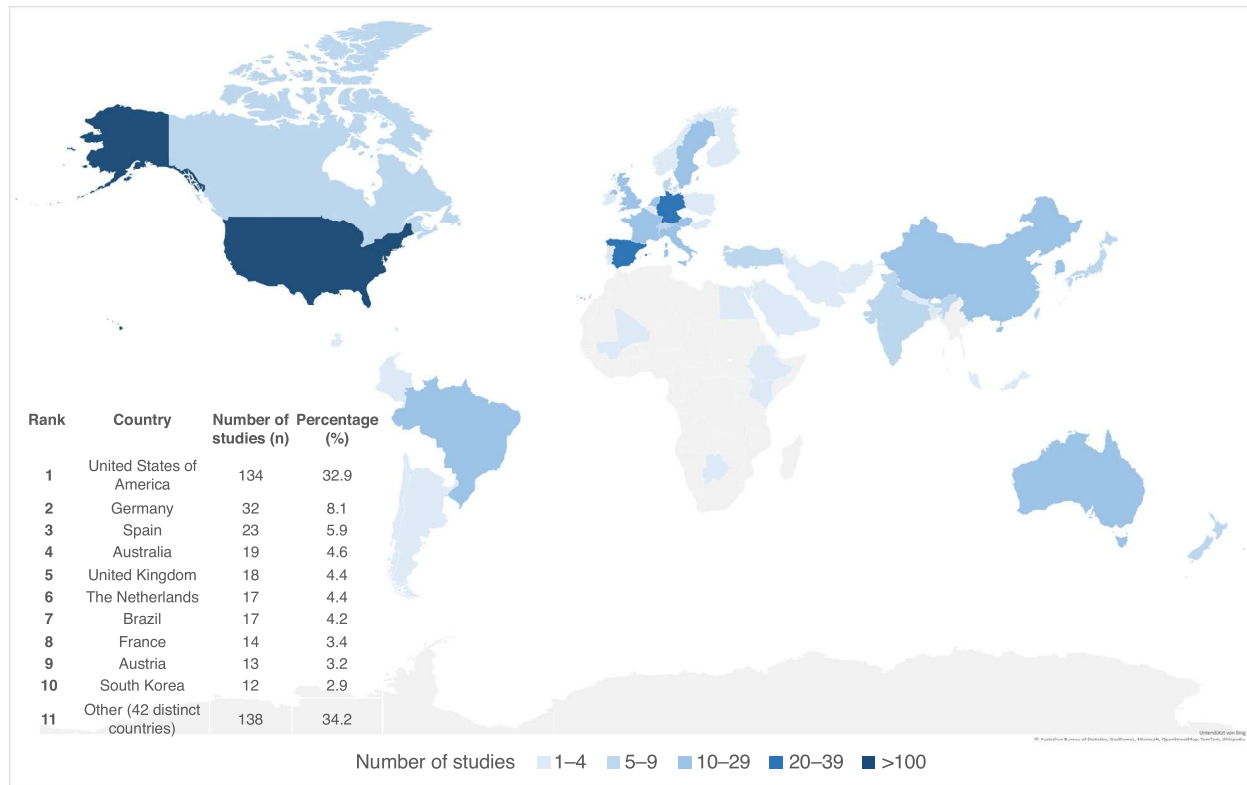


FIGURE 2 Number of digital health intervention studies by countries.

skin cancer and often targeted healthcare providers as DHI users.

The incidence of skin cancer and the resource-intensive nature of current screening strategies have driven attention towards the development of DHIs that support a diagnosis or referral. Especially teledermatology and AI are thought to improve screening efficiency.²²⁻²⁴ Fewer studies have investigated the use of DHIs in managing chronic skin conditions such as chronic wounds, psoriasis, atopic dermatitis and acne vulgaris, despite the large burden they place on healthcare systems and the recommended use of comprehensive documentation and monitoring.²⁵⁻²⁸ Positive examples of DHIs for chronic conditions include S&F telemedicine for long-term monitoring of atopic dermatitis¹⁰ and electronic education of general practitioners on atopic dermatitis.²⁹

The systematic literature analysis identified several studies on DHI aimed at triaging patients, particularly through the use of S&F teledermatology. With the demographic shift and its impact on the demand and supply of dermatological healthcare services, it is more important to increase access to and efficiency of healthcare. The implementation of these DHIs into the healthcare system is essential in the future.³⁰ Already, patients with more serious and acute conditions are often seen sooner in dermatological clinics than those with less pressing symptoms,³¹ and DHIs may help to support this transition.

Store-and-forward teledermatology was more often studied than live-interactive teledermatology likely due

to the inherent advantages of S&F, including lower reliance on high-speed internet and greater time flexibility.³² Still, live-interactive teledermatology has gained attention more recently, particularly since the COVID-19 pandemic, with studies that focus mainly on acceptance parameters. Although positive evidence exists for live-interactive dermatology, there have been no recent studies published on the effectiveness or efficiency of it.¹² There is a need for an update of the evidence, while technology, infrastructure and competencies of users significantly improved during that time.

DHIs for clients have been proposed to facilitate self-care, self-management and active engagement in decision-making.⁹ We identified several DHIs that are promising in achieving these goals, such as active data documentation by clients to support disease monitoring,⁷ client-centred messaging to support treatment adherence⁸ or applications that promote the prevention of skin cancer.³³ However, considering the availability of more than 400 dermatology-related smartphone applications for patients and clients in the United States alone,³⁴ the evidence supporting their use and understand their mode of action cannot be considered sufficient. Interventions that focus on client-centred messaging based on health status seem to be the most promising as 19 randomized controlled trials exist, which should be closely analysed in a separate systematic review.

A strong concentration on diagnostic performance was noticed, especially within studies on S&F teledermatology and AI applications for image analysis including dermoscopy

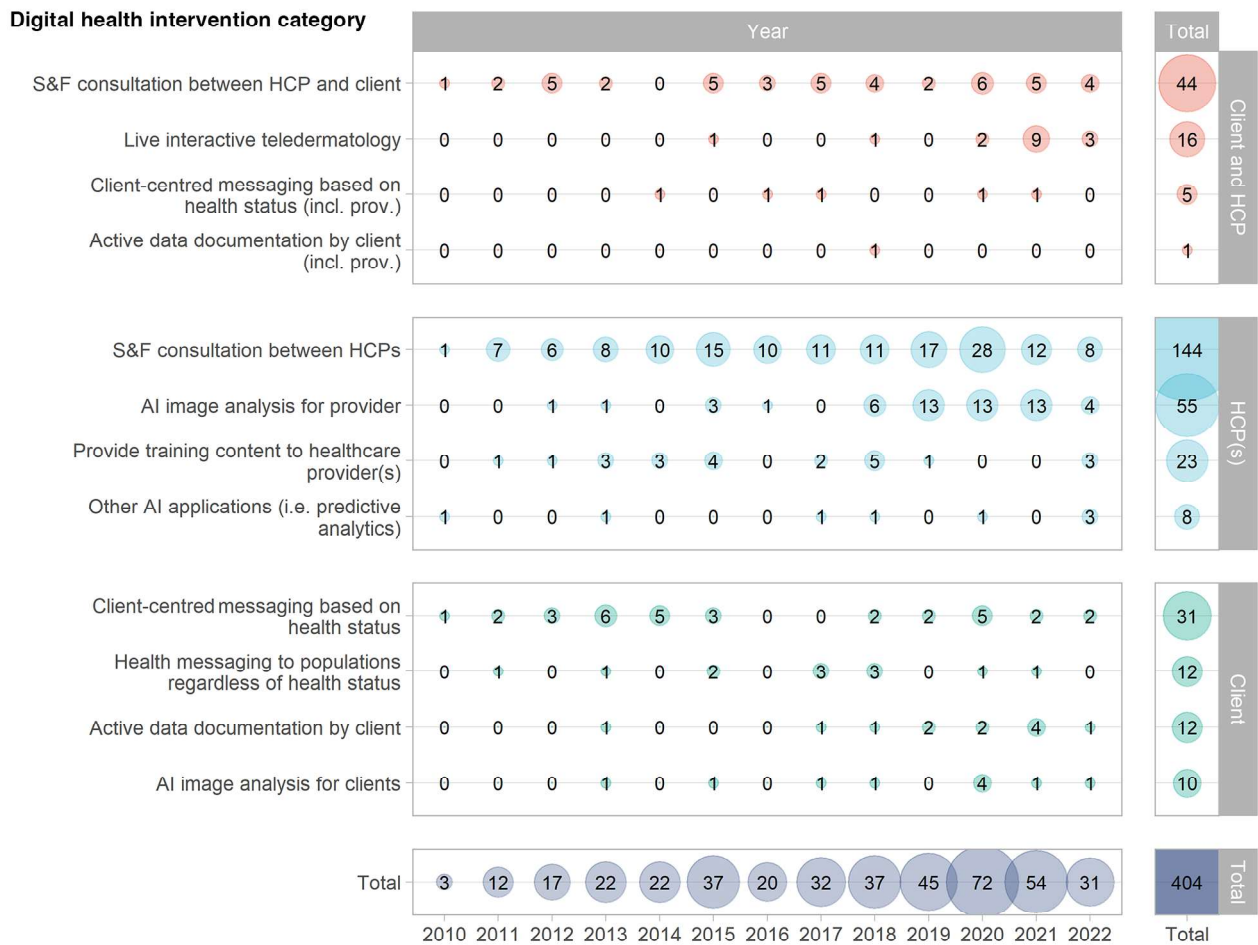


FIGURE 3 Digital health intervention studies by indication and year of publication. AI, artificial intelligence; HCP, healthcare provider; S&F, store-and-forward.

or histology. Many of these studies focused on the diagnostic performance and used a cross-sectional study design. Yet, it is crucial to assess the clinical efficacy or performance of these interventions through comparative studies. Ideally, this should be done by randomized controlled trials to comprehend the impact on access to care, clinical decision-making and outcomes, such as mortality and morbidity.^{34,35} While there have been some studies on the effectiveness of S&F teledermatology for diagnostic purposes,^{36,37} there is currently only one randomized controlled trial on the effectiveness of AI for image analysis in dermatology.³⁸ The impact of AI on dermatology and healthcare is increasing, particularly in diagnostic, but also in healthcare communication between patients and dermatologists (as exemplified by ChatGPT). Yet, all AI technologies carry the risk of introducing systematic errors that may impact patient outcomes and safety.³⁹ Therefore, careful evaluation and consideration of AI applications in healthcare are essential to ensure safe and effective patient care.

Apart from diagnostic performance and effectiveness, other outcome parameters are also important for the assessment of DHIs. Acceptance was commonly assessed since a high acceptance rate is considered as a positive predictor for

the actual uptake of DHIs by patients and HCPs in routine care.⁴⁰ Inclusion of the parameter in future research can hence only be endorsed. Efficiency and usability have not been extensively studied in the context of DHIs, though both are important for a full assessment of these technologies. Usability, in particular, is emphasized by regulatory authorities as it can ensure the effectiveness, efficiency and satisfaction of DHI use for a specific audience and is often identified as a major facilitator of DHIs.⁴¹⁻⁴³ Efficiency, including cost and time efficiency, are a key promise of DHIs⁴ and will affect decision-making for adoption on an individual HCP level as well as the healthcare system level. At the system level, efficiency is crucial for assessing the value (outcomes in relation to costs) of a DHI and determining appropriate reimbursement levels.⁴⁴ At the individual provider level, perceived added workload is an identified barrier to the adoption of DHIs, making it important to understand the impact on workflows.⁴³

The observed geographical disparities of published studies were already found within other reviews on teledermatology and digital applications for elderly patients.^{14,45} The low number of studies evaluating DHIs in low and middle-income countries is likely influenced by various factors, including infrastructure, funding and competencies.⁴⁶ Efforts

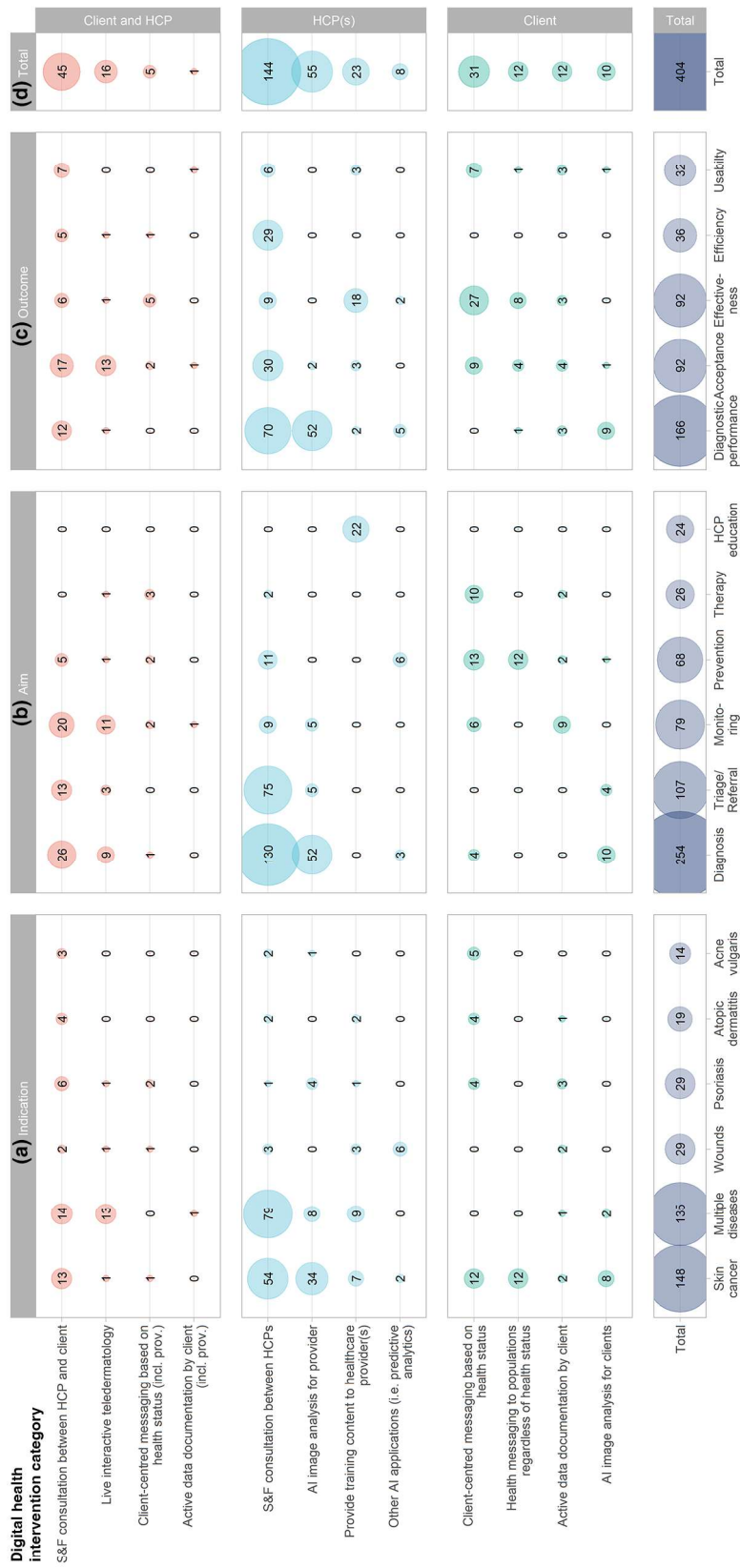


FIGURE 4 Digital health intervention studies by indication, aim and outcome. AI, artificial intelligence; HCP, healthcare provider; S&F, store-and-forward.

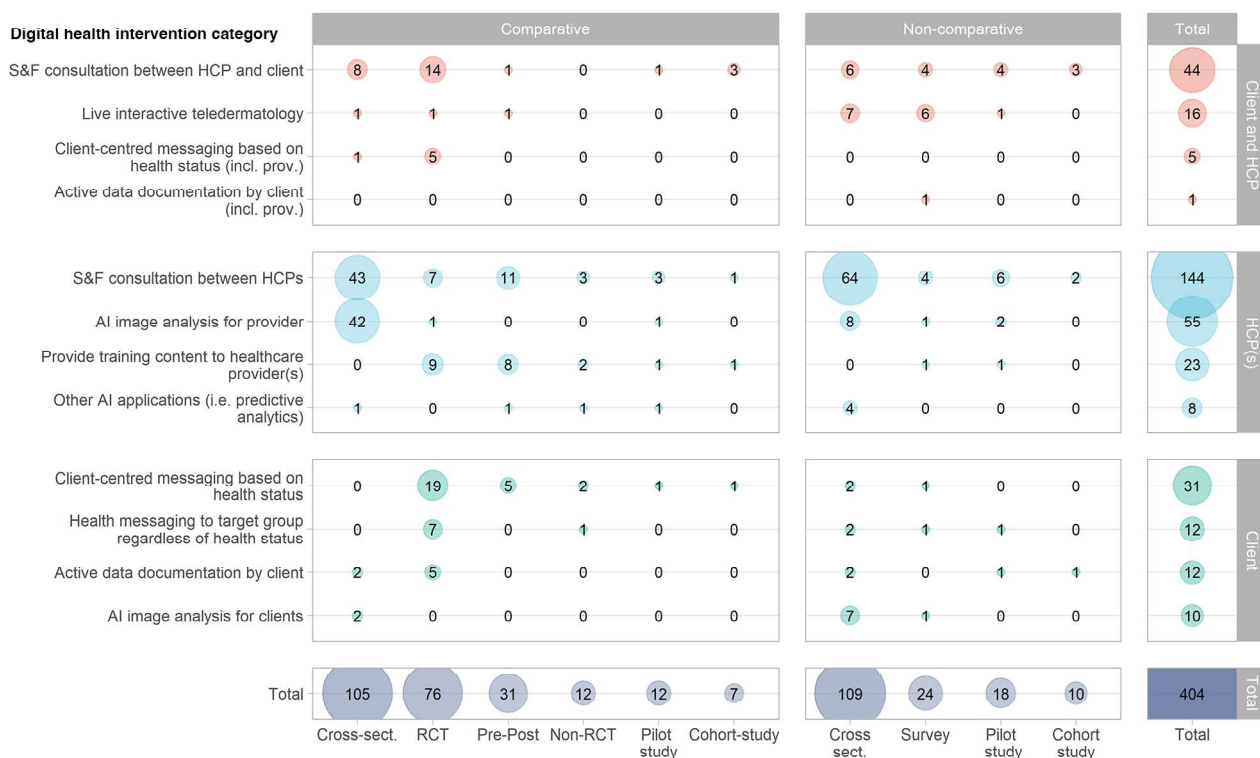


FIGURE 5 Digital health intervention studies by study design. AI, artificial intelligence; HCP, healthcare provider; RCT, randomized controlled trial; S&F, store-and-forward.

to address these issues are underway, but more research on DHIs in these countries is necessary to consider the specific context and healthcare systems.^{47,48} Disparities have to be carefully assessed as language barriers may have biased the geographical distribution of findings.

Other limitations apply, when interpreting the findings of our systematic literature search: First, the trends and findings identified in this review will not reflect real-world utilization of identified DHIs, as this is influenced by preferences of patients and HCPs, regulations, availability of services and reimbursement policies. Second, the number of studies included in this review should not be taken as an indicator of either the effectiveness of a DHI category or the quality of the evidence available, as this was not assessed in the present mapping of the literature but should be done in future reviews of individual DHI categories. Third, the effort to establish evidence for different DHIs may vary based on factors such as data availability and ethical considerations, which also influences the number of studies per category. For example, many comparative AI studies are conducted on retrospective image datasets and do not require ethical approval, whereas studies on an innovative patient app may require such approval and are often based on prospective data collection.

CONCLUSION

The present review analysed the current landscape of digital health interventions in the field of dermatology. A

significant increase in the number of studies was observed, particularly in the areas of teledermatology using store-and-forward technology and artificial intelligence applications in skin diagnosis and cancer detection. A diverse range of DHIs targeting different user groups for various purposes and indications were evaluated, highlighting the vast potential for future use of DHIs in dermatology.

Nevertheless, to fully comprehend the capabilities of DHIs, additional research is necessary in promising areas such as the management and monitoring of chronic skin diseases and triage of patients. Additionally, the assessment of DHIs for clients is essential, as these technologies are widely available, yet they are not supported by a large evidence base. Furthermore, the examination of various outcome parameters, including efficiency, effectiveness, usability and acceptance, is crucial in determining the true value of DHIs and promoting their successful integration into healthcare systems.

ACKNOWLEDGEMENTS

The authors thank the Scientific Communication Team of the IVDP, especially Merle Twesten and Mario Gehoff, for editing the article. Open Access funding enabled and organized by Projekt DEAL.

FUNDING INFORMATION

The research project was financially supported via research grant by Novartis. Novartis did not influence the design, data collection, analysis and publication decision or development.

CONFLICT OF INTEREST STATEMENT

M Otten, P Reinders and A Fleyder declared no conflicts of interest. N Kirsten is advisor for Novartis. M Augustin is scientific advisor for the teledermatology platform derma2go AG, A+ Videoclinic GmbH and Novartis.

DATA AVAILABILITY STATEMENT

Data are available on reasonable request from the corresponding author.

ETHICS STATEMENT

Not applicable.

ORCID

Patrick Reinders  <https://orcid.org/0000-0002-2961-2698>
 Matthias Augustin  <https://orcid.org/0000-0002-4026-8728>
 Natalia Kirsten  <https://orcid.org/0000-0003-2390-2309>
 Marina Otten  <https://orcid.org/0000-0003-3767-1548>

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Reinders P, Augustin M, Kirsten N, Fleyder A, Otten M. Digital health interventions in dermatology—Mapping technology and study parameters of systematically identified publications. *J Eur Acad Dermatol Venereol*. 2023;37:2440–2449. <https://doi.org/10.1111/jdv.19392>

2.2. Publikation 2

Reinders P, Augustin M, Fleyder A, Otten M. *Exploring Acceptability, Barriers, and Facilitators for Digital Health in Dermatology: Qualitative Focus Groups With Dermatologists, Nurses, and Patients*. JMIR Dermatol. 2024;7:e57172. Published 2024 Sep 3.

doi:10.2196/57172

Original Paper

Exploring Acceptability, Barriers, and Facilitators for Digital Health in Dermatology: Qualitative Focus Groups With Dermatologists, Nurses, and Patients

Patrick Reinders, MA; Matthias Augustin, Prof Dr Med; Anastasia Fleyder, BA; Marina Otten, PhD

Institute for Health Services Research in Dermatology and Nursing (IVDP), University Medical Center Hamburg-Eppendorf (UKE), Hamburg, Germany

Corresponding Author:

Marina Otten, PhD

Institute for Health Services Research in Dermatology and Nursing (IVDP)

University Medical Center Hamburg-Eppendorf (UKE)

Martinistraße 52

Hamburg, 20246

Germany

Phone: 49 40 7410 ext 24723

Email: m.otten@uke.de

Abstract

Background: Although several digital health interventions (DHIs) have shown promise in the care of skin diseases their uptake in Germany has been limited. To fully understand the reasons for the low uptake, an in-depth analysis of patients' and health care providers' barriers and facilitators in dermatology is needed.

Objective: The objective of this study was to explore and compare attitudes, acceptability, barriers, and facilitators of patients, dermatologists, and nurses toward DHIs in dermatology.

Methods: We conducted 6 web-based focus groups each with patients (n=34), dermatologists (n=30), and nurses (n=30) using a semistructured interview guide with short descriptions of DHIs described in the literature. A content analysis was performed using deductive constructs, following the unified theory of acceptance and use of technology framework, and inductive categories.

Results: Patients identified many positive performance expectancies, such as reduced travel times and improvement in follow-up appointments. Dermatologists also stated positive effects (eg, promotion of standardized care), but also negative implications of health care digitalization (eg, increased workload). All stakeholders reported that a DHI should bring additional value to all stakeholders. A lack of digital competence among patients was identified as the major barrier to adoption by all 3 groups. Nurses and dermatologists want apps that are easy to use and easy to implement into their daily routines. Trust in selected institutions, colleagues, and physicians was identified as a facilitator. Patients reported their dependence on the dermatologists' acceptance. All groups expressed concerns about data privacy risks and dermatologists stated insecurities toward data privacy laws.

Conclusions: To ensure successful digitalization in dermatology, apps should be user-friendly, adapted to users' skill levels, and beneficial for all stakeholders. The incorporation of dermatologists' perspectives is especially important as their acceptance may impact use among patients and nurses. DHIs should ensure and be transparent about data privacy. The found barriers and facilitators can be used for implementation strategies.

(*JMIR Dermatol* 2024;7:e57172) doi: [10.2196/57172](https://doi.org/10.2196/57172)

KEYWORDS

digitalization; digital health interventions; UTAUT; unified theory of acceptance and use of technology; barriers and facilitators; dermatology; qualitative research; focus groups; mobile phone

Introduction

Skin diseases, such as atopic dermatitis, psoriasis, acne, skin cancer, and urticaria, are among the most frequent medical conditions in Europe [1,2]. In Germany, about 26.75% (11,291/42,215) of adults have a dermatological condition that requires

further examination by a dermatologist, causing high use of health care services [2-4]. The resulting time constraints restrict possibilities for shared decision-making and impair timely access to care [5,6]. Demographic change will put additional pressure on the system in the near future [7].

Digital health interventions (DHIs) through information and communication technologies can support the provision of care [8]. In dermatology, a wide array of DHIs is available to patients and health care providers across numerous indications, each offering various features [9]. Given the visual nature of many dermatological assessments, the integration of telemedicine and artificial intelligence can support diagnoses [10,11]. Digitally supported self-management strategies may be beneficial, as many chronic dermatological conditions such as atopic dermatitis and psoriasis exist, where lifestyle adjustments can lead to positive outcomes [12]. Disease monitoring apps could also become essential in dermatology. These apps support both patients and physicians by enabling them to track disease progression through image documentation, patient-reported outcomes, and access to digital medical records, including laboratory results [13,14]. All apps can improve communication, data availability, efficiency, patient-centered care [15], and treatment adherence in dermatology [16].

Despite the variety of DHIs in the literature, their adoption in the field of dermatology remains limited. Although a guideline and reimbursement for teledermatological services exist, only 40% of dermatologists offered these services during the height of the COVID-19 pandemic in Germany [17-19]. In other countries, the number exceeded 80% [19,20]. When considering actual usage, published data indicate that only 7.6% (60/792) of dermatologists frequently used real-time teledermatology, with more precise statistics currently unavailable. Other DHIs are used more commonly, such as the electronic appointment reminder ("frequently used" by 212/792, 27% of dermatologists), but still used by a minority of dermatologists [21].

A recent systematic literature analysis identified key barriers to the implementation of DHIs in general health care worldwide including limited knowledge of DHIs among physicians and patients, unclear benefits for participants, and financing issues related to reimbursement and cost coverage for patients [22]. Acceptability and attitude of stakeholders, including patients, nurses, and dermatologists, play an important role in the adoption of DHIs. Whereas patients in Germany have a general interest in digital health and a willingness to share their data with dermatologists [23,24] the acceptability of German dermatologists on electronic health records is lower [25]. Nurses' acceptability and competencies are vital for the successful implementation of DHIs because they play a pivotal role in assisting physicians by processing patient data, coordinating, and communicating with patients, educating them on DHIs, preparing data for consultations, and seamlessly integrating DHIs into clinical workflows [26]. Yet they are frequently overlooked and inadequately addressed in the literature [26]. To gain a deeper understanding of the acceptability of the 3 groups, an in-depth analysis of patients' and health care providers' barriers and facilitators in dermatology is needed. The perspectives identified can then be used to develop tailored interventions and implementation strategies for DHIs [27].

The objective of this study was to explore and exploratively compare attitudes, acceptability, barriers, and facilitators of

patients, dermatologists, and nurses toward DHIs in dermatology.

Methods

Study Design

We conducted web-based focus groups with dermatologists, dermatology nurses, and patients with skin conditions via a video conference platform Cisco Webex (Cisco Systems). Focus groups are a qualitative research method that provides a deeper understanding of shared experiences and opinions by facilitating an interaction between participants [28]. We ensured the quality of the web-based focus groups by following the STEER (Stability of Group Numbers, Technology, Environment, Evaluation, and Recruitment) guidelines [29]. The COREQ (consolidated criteria for reporting qualitative research) was followed in this study reporting when applicable (Multimedia Appendix 1) [30].

Material

The focus groups were conducted using a semistructured interview guide based on literature research and developed among a team of health scientists and dermatologists (Multimedia Appendix 2). First, questions were asked on the current status and issues in providing or receiving dermatological care. After that, a short description of five common DHIs was given (1) treatment reminders for adherence [16], (2) self-support tools and webpages [12], (3) store-and-forward teledermatology in different settings (with known and unknown dermatologists) [31,32], (4) eHealth portals for disease monitoring via active data collection (including patient-reported outcomes) [13], and (5) live-interactive video consultations [10].

In all focus groups, participants were asked to express whether they could imagine using the presented DHI, identify additional features they deemed necessary from their perspective, and pinpoint any aspects that might deter them from using the DHI (Multimedia Appendix 2). In addition, general aspects of DHIs were investigated with questions on data security, data ownership, evidence, and their impact on the patient-physician relationship.

Participant Selection and Recruiting

To gather a broad range of perspectives on DHIs, we purposefully selected participants: dermatologists and nurses (German: Medizinische Fachangestellte or Gesundheits- und Krankenpfleger*innen) were selected based on type of workplace (clinic or practice), location of workplace (East, West, North, or South Germany and urban or rural), age group (<39, 40-49, and +50 years), and gender. Participants were invited to participate by field managers of Novartis Pharma GmbH and were compensated for their participation. A total of 33 dermatologists and 34 nurses were willing to participate, out of which 7 did not attend a focus group and without providing a specific reason.

Patients were selected based on diagnosis: psoriasis, atopic dermatitis, skin cancer, acne, hidradenitis suppurativa, and chronic wounds. Decision on indications was made to cover a

wide range of dermatological care from chronic inflammatory skin diseases (eg, psoriasis and atopic dermatitis) via chronic wounds to skin cancer. Patients were invited from two sources: (1) offline via the dermatological outpatient clinic at the University Medical Center Hamburg-Eppendorf (UKE) and rural dermatological practice in the Hamburg area and (2) web-based via a patient association (Deutscher Psoriasisbund eV) by sending out an email to members. Inclusion criteria were aged ≥ 18 years and proficiency in German and technical equipment to participate in a video conference. Patients received an allowance for their participation. We enlisted 41 patients willing to participate, out of which 7 patients did not participate in the focus groups. Of those, 3 cited scheduling conflicts and 4 did not state any specific reason.

The researchers had no personal acquaintance with any of the participants before the focus groups.

Ethical Considerations

The local psychological ethics committee at the UKE (Lokale Psychologische Ethikkommission am Zentrum für Psychosoziale Medizin des University Medical Center Hamburg-Eppendorf) approved this study (LPEK-0250). Participants received study information via email and gave their informed consent in a mandatory 1:1 video call before the respective focus group. Their anonymity was ensured by a personally chosen acronym during the video conference. The study was conducted following the Declaration of Helsinki.

Data Collection

Preceding the focus groups, we conducted a mandatory 1:1 video call to (1) introduce the researcher and explain their motivation for the research project, (2) ensure participants' technical proficiency, (3) provide information about the research project, (4) answer any questions, (5) record oral consent as described above, (6) explain ground rules for the web-based focus groups, and (7) collect sociodemographic data.

In total, 2 researchers of the UKE (health scientists) participated in each focus group: one to moderate the session and guide the discussion; the other to ensure a smooth organizational procedure and take field notes. MO (PhD and lead of research group telemedicine and digital health at UKE) or PR (PhD student and research associate in research group telemedicine and digital health at UKE) moderated the focus groups. All focus groups were scheduled with 5 to 7 participants for 1.5

hours and were conducted between February and April 2021. The recordings had an average length of 1:28 hours (SD 0.19) with a range from 0:49 hours and 1:59 hours.

We initially planned at least 6 focus groups per stakeholder group with the option to conduct further groups until data saturation would have been reached. The data saturation was discussed among the researchers during the analysis and was defined as "the degree to which new data repeat what was expressed in previous data" [33]. After the fourth focus group, approximately 70%-80% of topics were repeated within all 3 stakeholder groups, resulting in the conduction of 6 focus groups each.

Data Analysis

All focus groups were fully recorded via audio and transcribed for qualitative content analysis. Data analysis was conducted following the recommendations by Elo and Kyngäs [34] using content analysis and the software NVivo (version 12; Lumivero). Overarching constructs were deductively based on the unified theory of acceptance and use of technology (UTAUT) model (Textbox 1). The UTAUT model aims to explain the acceptance and usage of technology and is based on 4 major constructs: performance expectancy, effort expectancy, facilitating conditions, and social influence. Another relevant construct associated with the model is the attitude toward using technology [35]. The UTAUT was chosen, as the model is one of the most frequently applied theories to explain acceptance toward technology [36] in the health care context and has proven itself in qualitative research (Textbox 1) [37,38]. Main categories and subcategories were initially derived inductively on an individual DHI (eg, treatment reminder) or topic level (eg, evidence or data privacy). In a subsequent step, a category system was developed (constructs deductively based on UTAUT), where individual DHI and topic-specific inductive categories were abstracted to identify attitudes, acceptability, barriers, and facilitators. For this study, the main and subcategories for the individual DHIs were not further analyzed, categories were formed across all. Constructs, main categories, subcategories, and quotations were openly discussed in multiple sessions between researchers (MO, PR, and AF). Similar main categories and subcategories across the 3 stakeholder groups were aligned in wording to allow for comparison between groups. The coding was carried out by PR supported by AF and MO.

Textbox 1. Description of deductive constructs according to the unified theory of acceptance and use of technology model.

Attitudes toward technology

- Liking or disliking digital health interventions (DHIs), seeing the need for DHI, and willingness to use DHI in the future.

Performance expectancy

- Expected usefulness of technology, productivity, and career prospects.

Effort expectancy

- Expected ease or difficulty of use from an individual perspective.

Facilitating conditions

- Facilitator or barrier associated with resources, knowledge, compatibility with current routines, availability of assistance, and special features of the DHI.

Social influence

- Opinion of important others, organizational support, trust in recommendations of colleagues, societies (eg, patient or medical societies), or patients.

Results

Characteristics of Participants

The number of participants per focus group ranged between 4 and 7 participants. The 30 dermatologists who participated in 1 of the 6 focus groups were between 34 and 69 (mean 51.3, SD 8.4) years, and 12/30 (40%) were women (Table 1). Dermatologists predominantly worked in an outpatient practice (23/30, 77%), a minority in both settings (6/30, 20%), or in an outpatient clinic (1/30, 3%). All 4 regions were represented with a range from 12 (40%) dermatologists from western German states to 5/30 (17%) dermatologists from eastern German states. The 30 nurses were between 23 and 60 (mean

37.5, SD 12.2) years, almost entirely women (29/30, 98%), working in an outpatient practice (29/30, 98%), and mainly having a medium school education (21/30, 68%). Nurses from all 4 regions were included with a range of 9 (30%) nurses from northern and 5 (16.7%) nurses from southern Germany. Patients (n=34) had a mean age of 47.7 (SD 16.8) years with a range between 20 and 77 years, 47% (16/34) were female. The majority of patients had a high school education (24/34, 71%) and were from northern federal states (29/34, 85%). Patients from eastern Germany did not participate. Each targeted indication was covered. The indications hidradenitis suppurativa, atopic dermatitis, and acne were represented by 4 participants, respectively. Psoriasis was represented by 10, chronic wounds by 6, and skin cancer by 5 participants (Table 1).

Table 1. Demographic characteristics of participants.

	Dermatologists (n=30)	Nurses (n=30)	Patients (n=34)
Range of participants per focus group			
Minimum	5	4	5
Maximum	6	7	6
Age (years)			
Minimum	34	23	20
Maximum	69	60	77
Mean (SD)	51.3 (8.4)	37.5 (12.2)	47.7 (16.8)
Female participants, n (%)	12 (40)	29 (98)	16 (47)
Regional variation, n (%)			
West	12 (40)	7 (23.3)	3 (8.8)
North	6 (20)	9 (30)	29 (85.3)
South	7 (23)	5 (17)	2 (6)
East	5 (17)	7 (23)	0 (0)
Rural area, n (%)	7 (23)	10 (33)	11 (32)
Health care sector, n (%)			
Outpatient practices	23 (77)	29 (98)	— ^a
Outpatient clinic	1 (3.3)	1 (3.3)	—
Both	6 (20)	0 (0)	—
School education, n (%)			
Low	—	0 (0)	2 (3)
Medium	—	21 (68)	8 (23)
High	—	9 (32)	24 (71)
Use of digital devices at least once a week, n (%)			
PC	29 (97)	28 (93)	30 (88)
Tablet	15 (50)	15 (50)	15 (44)
Smartwatch	6 (20)	8 (27)	6 (18)
Smartphone	30 (100)	30 (100)	33 (97)
Use of digital apps, n (%)			
Search engine	30 (100)	30 (100)	34 (100)
Social media	13 (43)	24 (80)	23 (68)
Instant messenger	29 (97)	30 (100)	32 (94)
Podcasts	16 (53)	13 (43)	10 (30)
Videos (eg, YouTube or Netflix)	29 (97)	21 (70)	31 (91)
Encyclopedia (eg, Wikipedia)	28 (93)	19 (63)	28 (82)
Online banking	27 (90)	26 (87)	30 (88)
Sports and fitness apps (eg, Strava or Garmin)	14 (47)	18 (60)	23 (70)
Use of DHIs ^b , yes	17 (57)	14 (47)	2 (6)
Recommendation of DHIs, yes	17 (57)	9 (33)	2 (6)
Indications, n (%)			
Psoriasis	—	—	11 (32)
Hidradenitis suppurativa	—	—	4 (12)

	Dermatologists (n=30)	Nurses (n=30)	Patients (n=34)
Chronic wounds	—	—	6 (15)
Atopic dermatitis	—	—	4 (12)
Acne	—	—	4 (12)
Skin cancer	—	—	5 (18)

^aNot applicable.

^bDHI: digital health intervention.

Nearly every participant of each stakeholder group used a personal computer or smartphone at least once a week and digital apps such as online banking, instant messengers, and search engines (Table 1). Every second dermatologist had used or recommended DHI within the last 12 months before participating in the focus groups (17/30; 57%). Among nurses, 47% (14/30) worked in practices that had used DHIs within the last 12 months, but only a minority of patients had any experiences with DHIs (2/34; 6%).

Categories of the Focus Groups

The following section describes all deductively used constructs and inductively identified main and subcategories. For some subcategories, we provide representative quotes. All constructs (A-E), main categories, and subcategories are presented in Tables 2-6. Further, 1 representative quote per subcategory is presented in Multimedia Appendix 3. The letters and numbers in front of the quotes indicate the focus group (G1 to G6) and participant number in the respective stakeholder group (P1 to P6: patient, D1 to D6: dermatologist, and N1 to N6: nurse).

Table 2. Construct A: attitude toward technology.

Main and subcategories	Physicians	Nurse	Patients
Positive			
Interest in using digital health interventions	— ^a	—	✓ ^b
Digitalization in the medical field is deemed necessary	—	✓	—
Dermatologists are required to participate in digitalization to have a voice in shaping the system	✓	—	—
Higher acceptability among younger patients	✓	—	—
Acceptability of digital health intervention if used complementary to in-person consultation	✓	✓	✓
Negative			
Not willing to switch dermatologists for lack of offering digital health interventions	—	—	✓
Fast pace of digitalization makes life more difficult	✓	—	—
Fear of being replaced by digital health intervention	✓	—	—
Older patients prefer personal consultation	—	✓	—
Nurses prefer personal consultation	—	✓	—
Fear of data misuse by third parties	✓	✓	✓
Neutral			
Patients are unrestrained toward their data privacy	✓	—	—
Economic concerns are important for decision-making	—	✓	—
Physicians rate personal impressions over evidence	✓	—	—
The dermatologist sees no need for adjustments	✓	—	—

^a“—”: statement related to this subcategory did not occur for this group.

^b“✓”: statement related to this subcategory did occur in this group.

Table 3. Construct B: performance expectancy.

Main and subcategories	Physicians	Nurse	Patients
Positive			
Greater involvement of patient in treatment	✓ ^a	✓	✓
Improvement of patient-physician relationship	✓	— ^b	✓
Promotion of need-based care	✓	—	—
Promotion of standardized care	✓	—	—
Improvement of follow-up consultations	—	—	✓
Support of treatment process through digitized patient data	—	✓	—
Reduction of unnecessary travel to medical appointments	—	—	✓
Time savings during the treatment process	—	✓	—
Usefulness of data for research purposes	—	—	✓
Negative			
Impersonal patient-physician relationship	✓	✓	✓
Additional workload	✓	✓	—
Overload of information	✓	—	—
Requirement			
Technical functionality should result in an added value	✓	—	—
Additional value for both patient and physician	✓	✓	✓

^a“✓”: statement related to this subcategory did occur in this group.

^b“—”: statement related to this subcategory did not occur for this group.

Table 4. Construct C: effort expectancy.

Main and subcategories	Physicians	Nurse	Patients
Positive			
High digital competencies among nurses	✓ ^a	— ^b	—
High digital competencies among younger patients	—	✓	—
Decreasing proportion of patients with low digital competencies over time	—	✓	—
Negative			
Low digital competencies among older patients	✓	✓	✓
Difficulties in assessing the integrity of apps	✓	—	—
Low digital competencies among nurses	✓	—	—
Initial high effort to implement digital health interventions	—	✓	—
Low digital competencies among older physicians	—	✓	—
Exclusion of digital illiterate patient groups from care	✓	—	—
Requirements			
Easy-to-use apps	✓	✓	—
Easy integration into daily routines	—	✓	—

^a“✓”: statement related to this subcategory did occur in this group.

^b“—”: statement related to this subcategory did not occur for this group.

Table 5. Construct D: social influence.

Main and subcategories	Physicians	Nurse	Patients
Positive			
Trust in physicians' recommendations	— ^a	✓ ^b	✓
Trust in colleagues' recommendations	✓	✓	—
Physicians rate colleagues' recommendations over evidence	✓	—	—
Trust in recommendations or digital health developments of or by trustworthy institutions	—	—	✓
Trust in recommendations of physician associations	✓	—	—
Negative			
Dependence on physicians' acceptance	—	✓	✓
Dependence on patients' acceptance	✓	—	—
No trust in nurses' recommendations by patients	—	✓	—

^a“—”: statement related to this subcategory did not occur for this group.

^b“✓”: statement related to this subcategory did occur in this group.

Table 6. Construct E: facilitating conditions.

Main and subcategories	Physicians	Nurse	Patients
Facilitators			
A single app for different purposes	— ^a	✓ ^b	✓
A single app for the same purpose used by all physicians	✓	—	—
Clear data access permissions	—	—	✓
Possibility to choose between analog and digital health intervention	—	—	✓
Engagement of nurses in digital processes	—	✓	—
Patients possess digital devices	—	✓	—
General trust in data protection and security	✓	—	—
Sufficient reimbursement	✓	✓	✓
Pandemic has accelerated the progress of digitalization	—	✓	—
Barriers			
Difficult to integrate digital health interventions into busy daily routines	✓	✓	—
Use of outdated technology in practices	—	—	✓
High-maintenance of IT infrastructure	✓	—	—
Current data protection regulations impede the functionality of digital health interventions	✓	—	✓
Insecurity toward data privacy laws	✓	—	—
Neutral			
Data privacy is very important in medical practices	—	✓	—

^a“—”: statement related to this subcategory did not occur for this group.

^b“✓”: statement related to this subcategory did occur in this group.

Attitude Toward Technology

In general, all groups found DHIs acceptable if they serve as a complement to rather than a replacement of in-person consultations with dermatologists (Table 2):

So I would find such an app good, but it must be complementary to the physicians' consultation and

not that a doctor would say, “Just look on the app,” so to speak, in order to shorten parts of the consultation or the treatment time. [G2, P2]

In addition, patients stated a general interest in using DHI in the future but would not change dermatologists for not offering DHIs at their practice (Table 2). Dermatologists also saw acceptability among patients but mainly in younger patients.

Nurses emphasized the necessity of digitalization due to the limited availability of time and resources. However, some nurses underscored the preference for in-person consultations from their own and older patients' perspectives. They additionally highlighted the importance of economic concerns for a decision on a DHI.

All groups expressed a fear of data misuse by third parties, but dermatologists also observed patients having low standards for their own data protection practices.

So patients are self-indulgent when it comes to privacy. Of their own accord. They send you naked photos via WhatsApp. When you get a cell phone, everyone thinks I'm a child pornographer, because there are so many baby bums from vacation with diaper dermatitis on it. So, they are completely, completely uninhibited. [G5, D1]

Furthermore, for some dermatologists, their personal impression of a DHI is more important than the scientific evidence. Some dermatologists thought they were required to participate in the digitalization process to have a say in shaping the health care system (Table 2). Other dermatologists expressed pessimism regarding the digitalization process and emphasized how the rapid pace of digitalization makes their work more challenging.

They even voiced concerns about digitalization leading to the replacement of health care professionals.

On the other hand, even as a doctor, you must worry that this digitalization will eventually replace us. For example, we know that rheumatologists and radiologists will soon no longer be able to work properly because artificial intelligence can make much better assessments than radiologists. [G6, D4]

Performance Expectancy

Nurses, dermatologists, and patients collectively mentioned positive performance expectations regarding greater patient engagement in their treatment and care:

But if it goes the other way, as we just discussed that we as patients then take a little more responsibility, and then you can present a condensed summary to the doctor, then maybe it will make sense. [G5, P2]

All groups also required that DHIs should result in an additional value for both patients and physicians. On one hand, all 3 stakeholders expected a more impersonal patient-physician relationship whereas on the other hand, an improvement of the relationship was discussed by some patients and dermatologists. Patients mentioned other positive performance expectations such as reduced unnecessary travel, improved follow-up sessions (eg, better-prepared patients and practitioners), and the usefulness of data for additional purposes, such as research. Although dermatologists recognized potential positive impacts of DHIs, such as enabling standardized treatment and promoting need-based care, they stressed the need for technical functionalities to result in added value. For them, existing functionalities did not consistently meet this requirement. Negative effects on dermatologists' daily work were also anticipated by this group. For instance, they indicated the

potential overload of information and additional workload associated with DHIs:

So I think, that will not be a relief. There will be additional work. For example, most of the patients with a video consultation, must come into the office afterwards [...]. So, it costs more time and maybe you could do it in the evening when you really need to relax. I already have an (exhausting) day anyway, and then a video consultation in the evening? [G3, D6]

This additional workload was also mentioned by some nurses. Other nurses noted the potential for time savings for both physicians and patients:

... when it's digital, the doctor can immediately write in the medical history, I can prepare the prescription, the doctor is sitting in the treatment room, I'm sitting at the reception. He writes it in the medical history, and I can prepare it at the same time, so ... For the patient, too, it's much, much, much shorter in terms of time. [G5, N5]

The potential of digitized patient data to support a patient's treatment process, for example through optimized therapy decisions, was also identified by nurses.

Effort Expectancy

All 3 stakeholder groups articulated the existence of low digital competencies among older patients. Dermatologists even concluded that digitalization would result in the exclusion of digitally illiterate patient groups from care (Table 4):

In my opinion, 20-30 percent of humanity is still digitally illiterate. That includes people like my mother, who somehow managed to crash the Internet I think three times by now. Not the computer, the Internet. [G6, D2]

Some dermatologists believe that nurses possess high digital competencies which are crucial for implementing DHIs, while others perceive nurses to have low digital competencies. Nurses, in turn, observed that physicians also exhibited low digital competencies. Another barrier to the adoption of DHIs, as stated by some dermatologists, is the challenge of assessing the credibility and trustworthiness of apps. Nurses described the high effort that is required to adapt to a DHI in a practice, yet they emphasized the considerable advantage once the DHI is successfully implemented:

As with everything that is new at first, it is of course a lot of work, a huge amount of work for those involved, but then I think there is also a great benefit underneath. [...]at the beginning, of course, it was new and incredibly difficult, and everyone said, "oh God, oh God, oh God," and now everyone expresses their gratitude, saying, "thank God, we have it better now." [G6, N6]

According to nurses, DHIs should be easy to integrate into daily routines. Dermatologists and nurses agreed on the importance of ease of use for DHIs.

Social Influence

Social influence played a role in discussing DHIs for all stakeholder groups, especially regarding trust (Table 5). Dermatologists expressed their trust in recommendations from their physician associations as well as colleagues. Dermatologists even emphasized trusting the opinions of their colleagues over scientific evidence:

The most important evidence is still colleagues you trust and who also have experience, and there you listen to three, four opinions, and if that goes in one direction, then you try that. [G2, D5]

Patients place their trust in the opinions of trustworthy institutions (eg, patient organizations) and dermatologists. Patients and nurses shared the viewpoint that usage of DHI is highly dependent on dermatologists' acceptance:

The physicians [...] play the main role. Because with him is the main interaction and he is the main person to whom one would turn, be it digital or otherwise. So, if the- if the doctor rejects digitalization, then there's no point in any of this. So, then it's a side event. [G2, P2]

This is supported by patients' lack of reliance on nurses' recommendations:

It doesn't matter if it's a recommendation for something, if it's just a cream for something, if it's something I say at the front, it's only something she says. But ...uh... if the doctor says it in the treatment room, then, then it's great and then it's like that and then we'll definitely buy it. [G3, N2]

Facilitating Conditions

Sufficient reimbursement of DHIs emerged as an important facilitator for all stakeholder groups. As additional facilitators patients and nurses stated that they would like to have a single app for multiple purposes:

The described applications are all scattered pieces. I can make a constellation here, I can get a second opinion here, I can at best download my prescription to my cell phone instead of in paper form. Um, I have to lug doctor's letters from A to B, then there's faxing, so I would prefer an integrated solution, whether that's for dermatology or anything else. [G1, P3]

Patients identified technical barriers as hindrances to the implementation of DHIs such as outdated technology in medical practices (Table 6). They also emphasized the importance of clear access permissions to transfer data between physicians. Nurses were willing to participate in digital processes to support an easy integration of DHIs in their practices:

I would have liked to offer video consultation hours. You can also really do it in such a way that a doctor is present, a nurse is present, and that all the other things, i.e., writing and doing, i.e., writing materials, etc., are taken over by the nurse, that's not a problem. And so that the communication of doctor and patient takes place, that could have worked. But it shouldn't be. So yes, too bad. [G3, N3]

The nurses positively pointed out that nearly all patients possess digital devices, and they described how the pandemic has accelerated the digitalization in their practices. Dermatologists preferred a single, standardized app for a specific purpose that would be used by all physicians instead of several platforms with diverse accounts and handling. They identified the considerable effort required for the IT infrastructure as a key barrier to the implementation of DHIs. Additionally, both dermatologists and nurses highlighted the challenge of integrating DHIs into their already demanding daily workloads in medical practices:

Well, I haven't done it [store-and-forward telemedicine] either. I won't do it either. But that's usually because of the time factor. If you have so many functions in addition to your work in the practice, then you think: Do I still sit down there in the evening and answer something like that? [G5, D2]

Nurses generally describe that data privacy is very important in medical practices. Some dermatologists generally trust whereas others feel insecure about data protection and security. Moreover, dermatologists highlighted the negative effect of current data regulations on the functionality of DHIs.

Discussion

Principal Findings

The current use of DHIs in Germany, both in general and dermatological care, remains low. Therefore, we conducted a qualitative focus group study to explore and exploratively compare patients', nurses', and dermatologists' attitudes, acceptability, barriers, and facilitators on the implementation of DHIs in dermatology. Additionally, we exploratively compared their perspectives. Patients and nurses had a generally positive stance and optimistic attitude toward digitalization and assumed largely positive performance expectancies. In contrast, dermatologists showed more different opinions with some expressing positive performance expectations, while others anticipated increased workload and information overload with the implementation of DHIs. While sufficient reimbursement and patients owning digital devices were identified facilitators, insecurity regarding data privacy laws and the difficulty of integrating DHIs into an already busy day were identified barriers.

Although our research identified a more negative stance of dermatologists toward DHIs in comparison to patients and nurses, quantitative research yielded mixed results [23,39]. It is important to consider that the acceptability of DHIs is influenced by the context in which they are used. For instance, willingness to use teledermatology is lower for severe and acute conditions compared to minor problems [39].

Independent of the context, dermatologists' acceptability is crucial for actual usage, as patients and nurses also pointed out, and can mitigate barriers, including low patient demand, problems with the technology, and lack of financial resources [33,40]. The influential role of dermatologists stems from their function as gatekeepers in introducing medical innovations,

including DHIs, into care. Additionally, their positive stand on a DHI can signal credibility to patients, nurses, and colleagues. The low acceptability by dermatologists seems to be a barrier to the implementation of many DHIs. However, improving physicians' acceptability could become a facilitator, particularly as they trust their colleagues' recommendations and patients trust their health care providers. To increase acceptability among physicians, reimbursements should be clarified, and patient benefits should be aligned with an added value for dermatologists as proposed by all stakeholder groups in our study and as found in the literature [41].

In recent years, physicians were required to make financial investments in the IT infrastructure without a clear perceived benefit leading to hesitance in adopting new DHIs in clinical practice [42,43]. Both, the missing positive financial perspective and missing benefits are established barriers to the introduction of eHealth interventions [22]. While 98% of outpatient medical practices are connected to the nationwide telematic infrastructure, only a minority are satisfied with its services [44]. Other countries, especially Estonia and Canada were more successful in establishing an eHealth-infrastructure that allowed a fast uptake of DHI services by physicians and other health care providers [45,46]. In addition, physicians in both countries were financially incentivized to adopt DHIs [45,46].

The infrastructure in Germany is therefore considered a barrier to the seamless adoption of many DHIs [41]. This resonates with the cautious perspectives of dermatologists on DHIs in our study. In addition, the economic and resource advantages for society, health insurance, or patients, such as reduced follow-up appointments or travel costs, may not necessarily translate into added value for dermatologists [47]. These concerns should be addressed so that physicians are more likely to adopt and recommend new technologies [48].

Dermatologists and nurses expressed concerns about an increased workload. Other nurses also identified time savings as an effect of DHIs. Both perspectives were identified across other medical fields [22]. The potential increased workload for dermatologists may be explained by the DHIs not aligning with working routines or dermatologists needing additional time for patient care, such as explaining DHI to patients [49]. From another angle, even successfully implemented DHIs may result in additional workload as technological progress enables faster completion of tasks (eg, accelerated patient consultation per store-and-forward teledermatology), but increases in the number of tasks (eg, more patients per day). Consequently, actual time being spent inactive is reduced and time pressure is amplified (theory of social acceleration) [50]. Yet, the ability to complete tasks faster may also result in a reduced workload for dermatologists and nurses.

The true impact of DHIs on the patient-physician relationship remains uncertain and will largely depend on the extent and the specific context in which the DHI is introduced [51]. Following the social acceleration theory, using DHIs can result in increased but less relationship-building communication between dermatologists and patients [50]. Time savings, possibly leading to more available time for individual patients, can also foster a trusting patient-physician relationship.

An identified barrier to using DHIs in dermatology is the lack of digital competencies and knowledge among patients, practitioners, and nurses. Although internet use and competencies have increased in the last decade [52,53], a recent European survey estimated that 22% (Norway) to 58% (Germany) of Europeans have inadequate digital health literacy levels. Among older and less educated individuals, the percentage is even higher [54]. To avoid the exclusion of patient groups (digital divide) [55], participants in our study even emphasized the need for analog alternatives to DHIs. To increase adoption rates, digital health literacy skills need to be improved and services must be adapted to the digital competency levels of intended users and should always be easy to use [56]. For physicians, knowledge of DHIs and their evidence base should be incorporated into medical curricula and continued medical education [57].

Participants in our study discussed data privacy and security from different perspectives. For some, data privacy risk was a reason for the nonusage of DHIs, consistent with findings in the literature [58]. Conversely, others noted that the enforcement of data privacy laws hindered the development of effective DHIs. This might not be generalizable to other countries, as German citizens have generally stronger concerns regarding data privacy and protection [59,60].

Furthermore, dermatologists complained about the considerable maintenance burden of the IT infrastructure, partially driven by data privacy regulations. Increasing IT costs and dissatisfaction with IT were also identified in the literature [43,61]. The difficulties assessing the integrity of DHIs may be explained by the missing transparency of data privacy policies of many DHIs [62]. Health data are one of the most sensitive data requiring an enforced data privacy regulation. However, the enforcement of data security policies should be balanced in the sense that data are protected while the usage of the app remains convenient and useful. Other European countries under the same regulatory framework, including Estonia, seem to have achieved this balance [45].

While our study provided valuable insights into the attitudes toward DHIs from patients', dermatologists', and nurses' perspectives, it is important to acknowledge several limitations when interpreting our findings. The digital conduction of our focus groups may have excluded individuals with limited or no digital competencies. To at least mitigate this limitation, we followed the STEER recommendations by conducting test calls to enable individuals with limited competencies to participate [29]. Furthermore, we established ground rules to ensure a comfortable and private setting for all participants [29]. Thereby, we also ensured a smooth discussion. The possibility of social desirability cannot be completely excluded, but it may have been low due to the private setting, ensured confidentiality, and anonymity of the focus groups, as well as the nonsensitive topic of digital health [63]. Moreover, participants with a digital background or interest in the topic may have been more motivated to join the web-based focus groups. Despite efforts to recruit a diverse range of participants through purposeful sampling [42], it should be noted that the majority of patients in our study were well-educated. Additionally, it is important to mention that the apps discussed in our study were hypothetical

limiting participants' ability to fully assess the practical implications of using these interventions in real-life scenarios, as only a minority of patients had actual experience with a DHI. Considering all limitations, including the general qualitative nature of this study and the fact that it was carried out in Germany only, the results may not be completely generalizable to other medical fields and health care systems. However, as shown, many aspects are also described in the international literature and the findings may, therefore, be relevant to a wider audience.

Conclusions

To ensure a successful digitalization process in dermatology, it is essential to develop easy-to-use apps that bring additional value to all stakeholders involved. Dermatologists' acceptance is crucial as dermatologists can serve as a facilitator in their role. Incorporating their perspectives during the development phase can help align future digital interventions with clinical practices, increasing acceptance and usage.

Due to the lack of digital health literacy among the population DHIs should be designed to accommodate different levels. Analog access options should be provided to prevent the exclusion of less digitally literate patient groups in the near future.

Data privacy and security concerns must be taken seriously, as they are crucial for maintaining trust in digital interventions. They can function as barriers to interventions' effectiveness and cause users' insecurities. Successful digitalization in dermatology requires striking a balance on data privacy to allow for the development of effective interventions.

In summary, our findings can aid researchers, developers, and decision makers in comprehending diverse stakeholder perspectives. This can help create successful DHIs and subsequent implementation strategies, thereby enhancing the acceptability and uptake of DHIs.

Acknowledgments

The authors would like to thank the scientific communication team of the Institute for Health Services Research in Dermatology and Nursing, especially Amber Hönning, BA, for editing this paper. We acknowledge financial support from the Open Access Publication Fund of UKE. The research project was financially supported via a research grant by Novartis. Novartis did not influence the design, data collection, analysis, publication decision, or development.

Conflicts of Interest

PR and AF declare no conflicts of interest. MA is a scientific advisor for the teledermatology platform derma2go AG, A+ Videoclinic GmbH, and Novartis, and author of the German guideline on teledermatology. MO is a coauthor of the German guideline on teledermatology.

Multimedia Appendix 1

COREQ (consolidated criteria for reporting qualitative research) checklist.
[\[PDF File \(Adobe PDF File\), 486 KB-Multimedia Appendix 1\]](#)

Multimedia Appendix 2

Semistructured interview guide (German version and English translation).
[\[DOCX File , 56 KB-Multimedia Appendix 2\]](#)

Multimedia Appendix 3

Overview of categories per stakeholder group and representative quote for the category.
[\[DOCX File , 44 KB-Multimedia Appendix 3\]](#)

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Abbreviations

COREQ: consolidated criteria for reporting qualitative research

DHI: digital health intervention

STEER: Stability of Group Number, Technology, Environment, Evaluation, and Recruitment

UKE: University Medical Center Hamburg-Eppendorf

UTAUT: unified theory of acceptance and use of technology

Edited by R Dellavalle; submitted 07.02.24; peer-reviewed by S Meister, M Rakers, S Ziehfrend ; comments to author 14.03.24; revised version received 16.04.24; accepted 10.06.24; published 03.09.24

Please cite as:

Reinders P, Augustin M, Fleyder A, Otten M

Exploring Acceptability, Barriers, and Facilitators for Digital Health in Dermatology: Qualitative Focus Groups With Dermatologists, Nurses, and Patients

JMIR Dermatol 2024;7:e57172

URL: <https://derma.jmir.org/2024/1/e57172>

doi: [10.2196/57172](https://doi.org/10.2196/57172)

PMID: [39226097](https://pubmed.ncbi.nlm.nih.gov/39226097/)

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2.3. Publikation 3

Reinders P, Augustin M, Otten M. (2025) *Understanding Dermatologists' Acceptance of Digital Health Interventions: Insights From a Cross-Sectional Survey and Cluster Analysis*. In JMIR Human Factors [im Druck]

Letter of Acceptance JMIR Human Factors (31.12.2024)

Letter of Acceptance JMIR Human Factors (31.12.2024)

19.02.25, 08:45

Editor/Author Correspondence

2024-12-31 04:06 PM

Subject: [JHF ms#59757] Editorial Decision/Comments on [Delete](#)
"Understanding Dermatologists' Acceptance of Digital Health
Interventions: Insights From a Cross-Sectional Survey and Cluster Analysis"

Decision A: (accept/non-member)

Dear Patrick Reinders,

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Original Paper

Understanding Dermatologists' Acceptance of Digital Health Interventions: Insights From a Cross-Sectional Survey and Cluster Analysis

Patrick Reinders; Matthias Augustin, Prof Dr Med; Marina Otten, DPhil

Institute for Health Services Research in Dermatology and Nursing (IVDP), University Medical Center Hamburg-Eppendorf (UKE), Hamburg, Germany

Corresponding Author:

Patrick Reinders

Institute for Health Services Research in Dermatology and Nursing (IVDP), University Medical Center Hamburg-Eppendorf (UKE)

Martinstraße 52

Hamburg, 20246

Germany

Phone: 49 40741024721

Email: patrick.reinders@uni-hamburg.de

Abstract

Background: Digital health interventions (DHIs) have the potential to enhance dermatological care by improving quality, patient empowerment, and efficiency. However, adoption remains limited, particularly in Germany.

Objective: This study explores German dermatologists' attitudes toward DHIs, clustering them by acceptance levels and analyzing differences in sociodemographics and current and future DHI use.

Methods: We conducted a cross-sectional survey, randomly inviting 1000 dermatologists in Germany to participate. The questionnaire consisted of Likert scale items rating the acceptability of DHIs from 1 to 5. Items on the current and future use of DHIs were also included. Exploratory factor analysis was used to identify factors and reduce data as input for a 2-step clustering algorithm.

Results: The survey with 170 dermatologists (mean age 50.8, SD 10.3 y; 55.7% female) identified four factors through the exploratory factor analysis: (1) "Positive Expectancies and Acceptability of DHIs," (2) "Dermatologists' Digital Competencies," (3) "Negative Expectancies and Barriers," and (4) "Dermatologists' Perspectives on Patients' Acceptability and Competencies." The analysis identified three distinct clusters: Cluster 1: Indecisives (n=69)—moderate intentions to use DHIs and moderate negative expectations toward them. Cluster 2: Adopters (n=60)—high intentions to use DHIs and high digital competencies. Cluster 3: Rejectors (n=26)—low intentions to use DHIs and low digital competencies. Adopters were significantly younger, more often based in urban centers, and exhibited the highest adoption rates of DHIs compared to the other clusters. Across all clusters, inadequate reimbursement and perceived structural barriers were cited as significant challenges to DHI adoption. Still, only one-third of the Adopters used DHIs including teledermatology or artificial intelligence.

Conclusions: Dermatologists in Germany exhibited varied levels of acceptance and readiness for DHIs, with demographic and structural factors influencing adoption. Addressing barriers such as reimbursement and investing in digital literacy could promote wider use, potentially reducing health inequalities by improving access to digital health care.

JMIR Hum Factors 2025;12:e59757; doi: [10.2196/59757](https://doi.org/10.2196/59757)

Keywords: dermatology; digital health; cross-sectional survey; cluster analysis; acceptability; digital health interventions; eHealth; Germany; attitude; dermatologist; digital health intervention; acceptability; teledermatology; digital; intervention

Introduction

Dermatology is marked by the presence of prevalent chronic conditions, including acne, psoriasis, atopic dermatitis, and

skin cancer [1,2]. In Germany, approximately 27% of adults suffer from at least one dermatological condition requiring specialized care each year, resulting in long waiting times for patients [3,4]. Additionally, limited capacity also impacts

comprehensive patient consultations and the demographic shift could exacerbate these challenges [5-7].

Digital health interventions (DHIs) are proposed as one mitigating solution to sustain health care by enhancing quality of care, efficiency, and empowering patients [8,9]. In this study, DHIs are defined as health services that use information and communication technologies for patients, consumers, or health care professionals [9,10]. In dermatology, numerous promising DHIs have already been developed [11], including artificial intelligence [12], teledermatology, diagnoses or monitoring tools [13-16], and patient-targeted applications for medication adherence [17]. The 2020 consensus guideline for teledermatology recommends its use for certain indications but also stresses the necessity for stronger evidence to evaluate benefits and risks [18]. Currently, no guidance exists for other applications.

Digitalization of health care in Germany lags behind that of other European nations [19]. Teledermatology, for example, is less frequently adopted in Germany [20]. The complexity of the situation is grounded in the intricacies of the German health care system, encompassing aspects, such as missing interoperability, missing incentives for physicians, and high standards of data protection [21,22].

Apart from the system perspective, the reluctance of medical professionals to embrace digital health may be another potential barrier for the implementation [21,22], but can also function as a facilitator. Their acceptability can compensate for low patient demand or financial resource limitations and can additionally improve patient adherence to these interventions [23-26]. Dermatologists' overall acceptability of DHIs appears to be lower than that of dermatological patients [27]. Nevertheless, it is noteworthy that dermatologists differ in their perspectives and adoption of DHIs, shaped by various factors including younger age, practicing in urban settings, positive prior experiences with DHIs, or the social influence of colleagues [28-30].

The objective of this study was to explore the acceptability and current and future use of DHIs among dermatologists. Additional objectives included identifying and describing clusters of dermatologists based on their acceptability and examining differences between these clusters and sociodemographic variables, as well as the current and future use of DHIs.

Decision makers or developers of DHIs can use these results to tailor strategies for a successful implementation.

Methods

The consensus-based Checklist for Reporting of Survey Studies and the Checklist for Reporting Results of Internet E-Surveys were applied [31,32]. The full checklist is displayed in [Checklist 1](#).

Study Design and Questionnaire

An anonymous cross-sectional survey among German dermatologists was conducted in June 2022. The

questionnaire was based on existing questionnaires from the literature, and in particular, on pre-conducted focus groups among dermatologists, patients, and nurses (not yet published). The focus groups dealt with the acceptability, barriers, and facilitators of digital health interventions in dermatology using the Unified Theory of Acceptance and Use of Technology (UTAUT) [33,34]. The questionnaire development resulted in 27 items related to the acceptability of DHIs in general (eg, "I could imagine using more digital applications for the care of my patients"). Five items on the potential future use of specific DHIs (eg, "medication reminder application") and four items on the benefits and costs of the nationwide eHealth Strategy (eg, "The eHealth Strategy has strengthened patient care") were added to the survey. All items were answered on a 5-point Likert scale (5=strongly agree; 1=strongly disagree). The survey also included 10 items about dermatologists' current use (>1 per wk) of available DHIs (eg, live-interactive teledermatology or electronic doctor letters) with a simple "check all that apply" option.

In addition, sociodemographic information covering age, sex, type of employment (eg, working in an outpatient clinic or medical practice), and postcode of the clinic or practice were collected. The postcode was used to assign additional regional data to participants (eg, urban or rural areas). The questionnaire was tested with 5 dermatologists of the Institute for Health Services Research in Dermatology and Nursing (German: IVDP). The final questionnaire is provided in [Multimedia Appendix 1](#).

The offline version of this survey was designed to fit two DIN-A4 pages, while the online version was adapted to six screens or pages.

Study Population, Recruitment, and Data Entry

In order to conduct an exploratory factor analysis (EFA; statistical analysis), we aimed for a minimum sample size of 150 dermatologists [35]. To reach the required sample size, the questionnaire was randomly distributed to 1000 members of the German Dermatological Academy (DDA with ~3500 active dermatologists) in June 2022. The DDA comprises members of the Federal Association of German Dermatologists (German: Berufsverband der Deutschen Dermatologen), representing dermatologists from medical practices, and of the German Dermatological Society (German: Deutsche Dermatologische Gesellschaft), representing dermatologists from both outpatient clinics and medical practices. Dermatologists were asked to participate online via email (Unipark) receiving one reminder or offline via mail on paper. The online survey was an open survey (no password protection). Additionally, participants could review their responses before submission. The survey was voluntary and no incentives were offered. The survey was terminated after 8 weeks. The paper-based data were digitized, double-checked, corrected, and combined with the online data. To prevent multiple entries by a single dermatologist in the online survey, participation was tracked using Unipark's cookie system. To identify and eliminate further duplicate entries

from the online and offline survey, demographic information and postcodes were cross-referenced and thoroughly checked. No duplicate entries were identified.

Ethical Considerations

The study was submitted to the local ethics committee and was waived due to its noninvasive and anonymous research. The study was conducted in accordance with Good Scientific Practice and the Declaration of Helsinki [36,37].

Statistical Analysis

After conducting a descriptive analysis of all sociodemographic and geographic parameters, an EFA including all 27 items related to acceptability was performed for two reasons: (1) for data reduction by identifying underlying factors, also commonly used and recommended prior to running a cluster analysis; and (2) to use the underlying factors to closer describe and explore dermatologists' acceptability toward DHIs [38,39].

Adequacy of the EFA for factor analysis was assumed with a Kaiser-Meyer-Olkin criterion (KMO) ≥ 0.8 and Bartlett's test of sphericity < 0.05 . All factors with an eigenvalue ≥ 1.0 were considered. Criteria for retaining an item was a substantial factor loading (> 0.4) on one factor and no strong cross-loading onto other factors. Cross-loading was defined as loadings (> 0.3) on another factor and a difference of at least 0.2 between the loading on the main factor and the strongest loading on any other factor [40]. Internal consistencies of the factors were measured by Cronbach α , where values > 0.7 are acceptable, > 0.8 are good, and > 0.9 are considered excellent.

To identify distinct clusters of dermatologists that differ in their acceptability, a combination of hierarchical and K-means cluster analysis was applied. The mean scores (using Likert scale ratings: 1-5) of the factors were used as

input variables for the 2 approaches. The hierarchical cluster approach was used to identify the optimal number of clusters. Subsequently, a K-means cluster analysis was conducted with this optimal number. To test on differences between the identified clusters based on mean scores, a one-way ANOVA was performed. In order to create a profile of the identified clusters, first, each item of the EFA (acceptability items) was binary coded (1=strongly agree or agree; 0=neither, disagree, strongly disagree). Then, a descriptive analysis was conducted, analyzing each item for each cluster. Next, chi-square tests were applied for categorical variables to identify differences in sociodemographic parameters, as well as current and potential future use of DHIs between clusters. In case more than 20% of cells had a count below five, Fischer's exact tests were used. For continuous variables, one-way ANOVAs were used. A significance level of .05 was applied. Missing rates were reported for all variables. No imputation methods or weighting methods were applied.

Results

Overview

In the survey, 170 dermatologists participated resulting in a response rate of 17% (170/1000 invited dermatologists). In 131 (77.1%) cases, participation took place online. The online participation rate was 75.7%, calculated as the ratio of unique visitors who agreed to participate (131) to the total number of unique visitors who viewed the first survey page (173). Participants had a mean age of 50.8 (SD 10.3) years, 55.7% were female, and of 84.2%, the practice or clinic was located in an urban county or city (Table 1). Missing data on all items was below 5%, with the exception of sex (10.5%), regional variation (18.2%), and outpatient clinic or medical practice (10%).

Table 1. Sociodemographic characteristics of the total population and identified clusters.

	Total population ^a (n=170)	Rejectors (Cluster 1; n=26)	Indecisives (Cluster 2; n=69)	Adopters (Cluster 3; n=60)	P value
Age group (years), n (%)					<.001
25-39	24 (14.9)	0 (0)	5 (7.8)	17 (29.3)	
40-49	33 (20.5)	2 (8.3)	14 (21.9)	13 (22.4)	
50-59	71 (44.1)	9 (37.5)	39 (60.9)	18 (31)	
60 and older	33 (20.5)	13 (54.2)	6 (9.4)	10 (17.2)	
Missing	9	2	5	2	
Age, mean (SD)	50.8 (10.3)	58.8 (6.7) ^{b,c}	51.4 (7.9) ^{b,d}	46.9 (11.7) ^{b,d}	<.001
Sex, n (%)					.33
Female	74 (55.7)	12 (46.2)	25 (37.9)	32 (53.3)	
Male	93 (44.3)	14 (53.8)	41 (62.1)	28 (46.7)	
Missing	18	0	3	0	
Regional variation, n (%)					.01
Urban county or city	117 (84.2)	11 (61.1)	46 (82.1)	51 (91.1)	
Rural county	22 (15.8)	7 (38.9)	10 (17.9)	5 (8.9)	

	Total population ^a (n=170)	Rejectors (Cluster 1; n=26)	Indecisives (Cluster 2; n=69)	Adopters (Cluster 3; n=60)	P value
Missing, n	31	8	13	4	
Outpatient clinic or medical practice, n (%)					<.001
Medical practice	108 (70.6)	26 (100)	54 (80.6)	28 (46.7)	
Outpatient clinic	45 (29.4)	0 (0)	13 (19.4)	32 (53.3)	
Missing	17	0	2	0	

^a15 participants could not be used in the cluster analysis, due to missing values of the used subscores.

^bDifferent from Cluster 2 (Adopters); $P < .05$.

^cDifferent from Cluster 1 (Indecisives); $P < .05$.

^dDifferent from Cluster 3 (Rejectors); $P < .05$.

Factors of Acceptability

The KMO criterion (0.92) and Bartlett's test of sphericity ($\chi^2_{210}=2264$; $P < .001$) revealed that the data were appropriate to conduct an EFA. Four factors with an eigenvalue >1 were identified (Table S1 in [Multimedia Appendix 2](#)). Cronbach α values (0.93, 0.90, 0.73, and 0.80) indicated at least an acceptable internal consistency for all factors. The explained total variance of the EFA was 67.6%. A total of 6 items were excluded with a factor loading below 0.4. We named the factors as follows:

- Factor 1: "Positive Expectancies and Acceptability of DHIs" comprised of 10 items.

- Factor 2: "Dermatologists' Digital Competencies" comprised of 5 items.
- Factor 3: "Negative Expectancies and Barriers of DHIs" comprised of 4 items.
- Factor 4: "Dermatologists' Perspectives on Patients' Acceptability and Competencies" comprised of 2 items.

The four mean scores of the factors ranged between 2.9 (SD 0.8) for Factor 4 and 3.5 (SD 0.8) for Factor 2 (Table 2). Ranging from 1 to 5, higher scores indicate a higher agreement with the items of a factor, except for Factor 3, where it is the other way around.

Table 2. Differences in identified mean scores on acceptability between the clusters.

	Total population (n=170), mean (SD) ^a	Rejectors (Cluster 1) (n=26), mean (SD)	Indecisives (Cluster 2) (n=69), mean (SD)	Adopters (Cluster3) (n=60), mean (SD)	P value (ANOVA)
Factor 1: Positive expectancies and acceptability of DHIs ^b	3.4 (0.9)	2.0 (0.6) ^{c,d}	3.2 (0.6) ^{c,e}	4.1 (0.3) ^{c,e}	<.001
Factor 2: Dermatologists' digital competencies	3.5 (0.8)	1.9 (0.7) ^{c,d}	3.4 (0.6) ^{c,e}	4.3 (0.4) ^{c,e}	<.001
Factor 3: Negative expectancies and barriers	3.4 (0.5)	3.8 (0.3) ^{c,d}	3.5 (0.4) ^{c,e}	3.0 (0.5) ^{c,e}	<.001
Factor 4: Dermatologists' perspectives on patients' acceptability and competencies	2.9 (0.8)	2.2 (0.7) ^{c,d}	2.7 (0.6) ^{c,e}	3.5 (0.6) ^{c,e}	<.001

^a15 participants could not be used in the cluster analysis, due to missing values of the used subscores.

^bDHI: digital health intervention.

^cDifferent from Cluster 2 (Adopters); $P < .05$.

^dDifferent from Cluster 1 (Indecisives); $P < .05$.

^eDifferent from Cluster 3 (Rejectors); $P < .05$.

Clusters of Dermatologists According to Acceptability Levels

After exploring 2-, 3-, and 4-cluster solutions, the hierarchical cluster analysis recommended the 3-cluster solution as it provides the best fit based on the K-means evaluation. The performed ANOVA and subsequent post hoc tests revealed that all differences between the four mean scores of the three clusters were significant.

Cluster 1 (n=26, 16.7%) exhibited the lowest willingness (Factor 2: mean 1.9, SD 0.7) and digital competencies (Factor

2: mean 1.9, SD 0.7). Correspondingly, this cluster demonstrated the highest negative expectancies of DHIs (Factor 3: mean 3.8, SD 0.3) and low expectations regarding patients' adequate competencies and willingness to use DHIs (Factor 4: mean 2.2, SD 0.7).

Cluster 2 (n=69, 44.5%) showed moderate positive expectancies toward DHIs (Factor 1: mean 3.2, SD 0.6), along with moderate digital competencies (Factor 2: mean 3.4, SD 0.6) and also moderate negative expectancies (Factor 3: mean 3.5, SD 0.4). Cluster 2's expectations of patients'

intention to use DHIs and of patients' digital competencies were low (Factor 4: mean 2.7, SD 0.6).

Cluster 3 (n=60, 38.7%) had higher intentions (Factor 1: mean 4.1, SD 0.3), greater competencies (Factor 2: mean 4.3, SD 0.4), and lower, though still moderate, negative expectancies (Factor 3: mean 3.0, SD 0.5) compared to Clusters 1 and 2. The cluster's opinion about patients' intention and competencies was higher, though still moderate (Factor 4: mean 3.5, SD 0.6).

Based on these differences, we will henceforth refer to Cluster 1 as Rejectors, Cluster 2 as Indecisives, and Cluster 3 as Adopters in the subsequent sections.

Differences in Sociodemographic Information Between Clusters

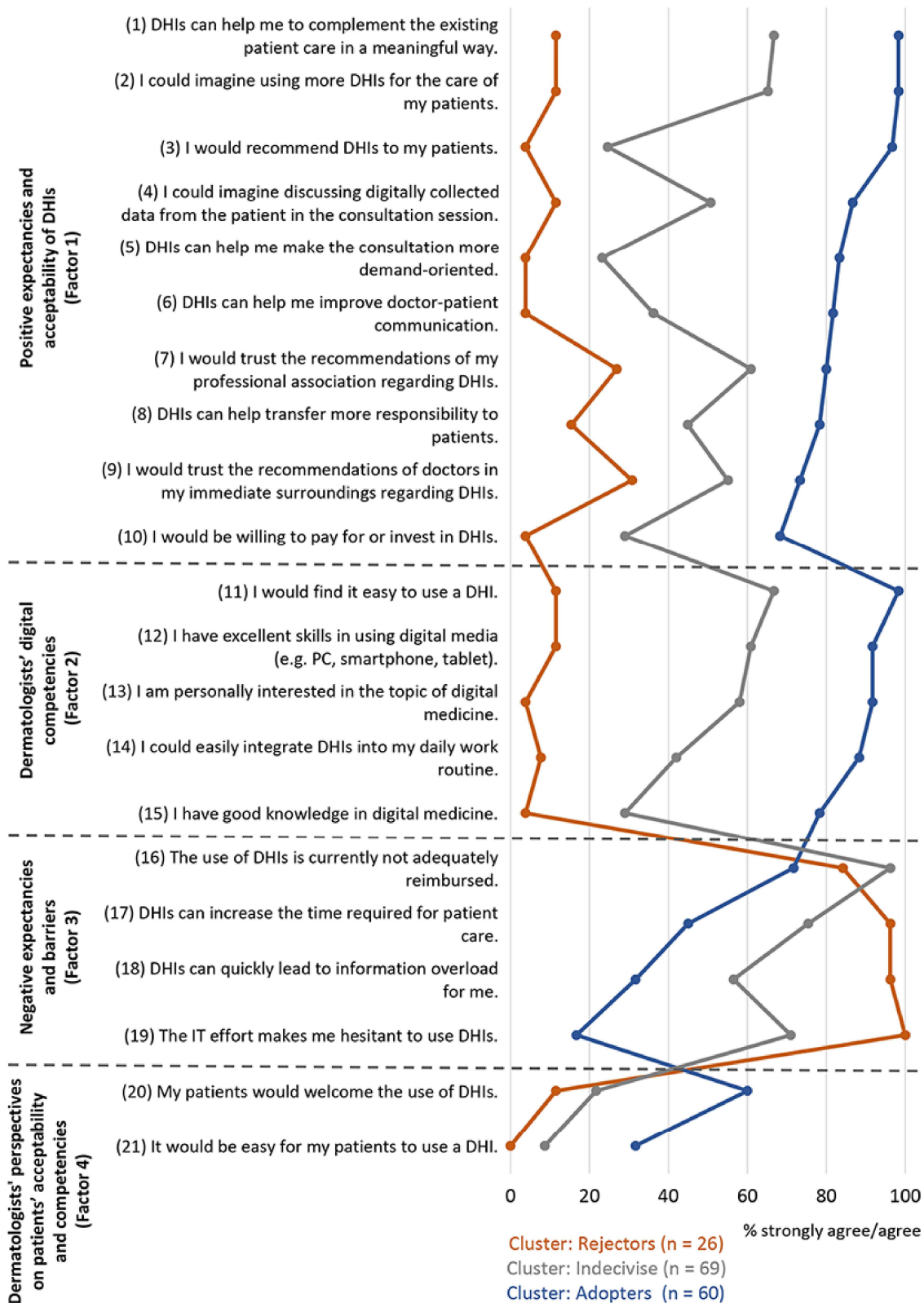
The Adopters (mean age 46.9, SD 11.7 y) were significantly younger compared to both the Indecisives (mean age 51.4,

SD 7.9 y; $P=.03$) and Rejectors (mean age 58.8, SD 6.7 y; $P<.001$). No significant differences in sex were observed among the clusters ($P=.33$). Notably, an association between regional variation (urban or rural) and the three clusters was identified ($P=.01$): the Rejectors had the highest proportion of participants from rural counties (38.9%), while the Adopters had the highest percentage of participants from urban counties or cities (91.1%). In addition, Indecisives (80.6%) and Rejectors (100%) performed their services primarily in medical practices, whereas Adopters (53.3%) performed theirs in outpatient clinics ($P<.001$).

Acceptability Profiles of the Clusters

The analysis of individual items revealed distinct profiles of the three clusters on their attitude toward DHIs. The following paragraphs describe selected items for each factor and cluster. A comprehensive overview of all item ratings is presented in [Figure 1](#).

Figure 1. Cluster profile analyses on an item-by-item level. DHI: digital health intervention.



Nearly all Adopters expressed openness to using (Item 2: 98.3%) and recommending DHIs (Item 3: 96.7%) in the future (Figure 1; Factor 1). However, a lower proportion was willing to pay for DHIs (Item 10: 68.3%). They rated themselves highly in digital media skills (Item 12: 91.7%) and expressed confidence in the easy integration of DHIs into

daily routines (Item 14: 88.3%; Factor 2). About 45% (Item 17) feared an increase in the time required for patient care due to DHIs, but only a minority saw the effort for IT as a burden (Item 19: 16.7%; Factor 3). A majority agreed that patients would accept DHIs (Item 20: 60.1%), while a minority agreed

that patients would find using DHIs easy (Item 21: 31.7%; Factor 4).

About two-thirds of Indecisives were willing to use DHIs in the future (Item 2: 65.2%), but a minority would recommend (Item 3: 24.6%) or invest in DHIs (Item 10: 29%; Factor 1). Although the majority would find it easy to use a DHI (Item 11: 66.7%), few considered themselves knowledgeable in digital medicine (Item 15: 29%; Factor 2). The majority perceived IT effort as a burden (Item 19: 71%), expressed concerns about DHIs increasing consultation time (Item 17: 75.4%), and causing information overload (Item 18: 56.5%; Factor 3). Only 21.7% believed patients would welcome DHIs (Item 20) and 8.7% (Item 21) thought patients would find them easy to use (Factor 4).

Rejectors scored low in Factor 1, with the highest agreement rates in trust toward recommendations of other physicians (Item 9: 30.8%) and professional associations (Item 7: 26.9%; Figure 1; Factor 1). Only 11.5% (Item 15) agreed to have high competencies in digital medicine (Factor 2). Almost all Rejectors worried about increased time requirements for patients (Item 17: 96.2%) and information

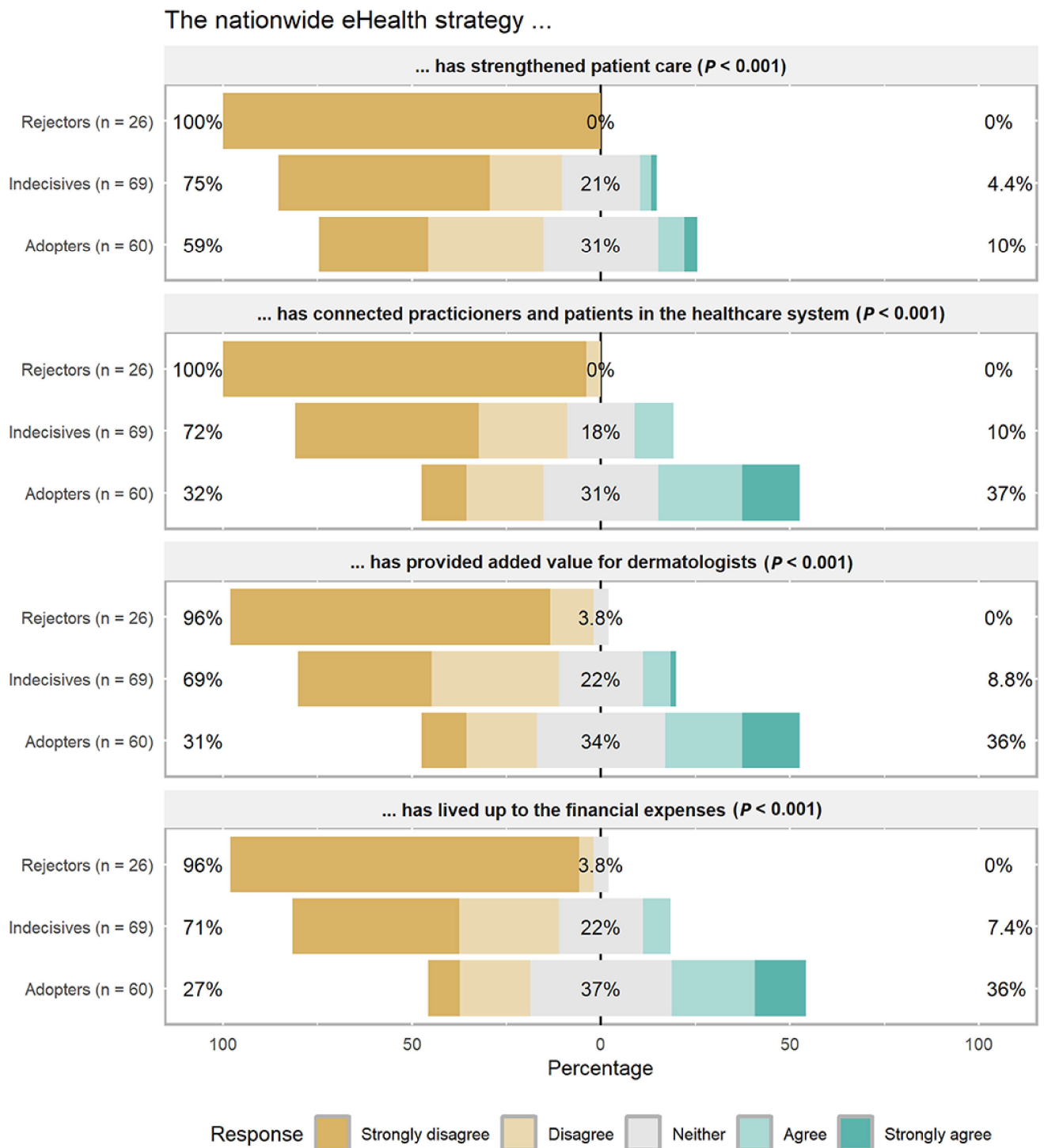
overload (Item 18: 96.2%). They perceived high IT effort as a barrier to DHIs (Item 19: 100%; Factor 3). Only 11.5% (Item 20) believed patients would welcome DHIs and none (Item 21: 0%) thought patients would find them easy to use (Factor 4).

Overall, ratings on items in Factors 1, 2, and 3 were distinctly different among the three clusters, with the exception that the majority within all clusters agreed that DHIs are inadequately reimbursed (Figure 1; Factor 3). For Factor 4, Indecisives and Rejectors showed similar low agreement rates on a per-item level (Figure 1).

Assessment of the Nationwide eHealth Strategy

In the assessment of the nationwide eHealth Strategy, most dermatologists across all clusters did not perceive the strategy as successful (Figure 2). A majority within each cluster concluded that the eHealth Strategy did not enhance patient care (Indecisives: 75%; Adopters: 59.3%, and Rejectors: 100%).

Figure 2. Assessment of the nationwide eHealth strategy by cluster. *P* values indicate the outcome of a chi-square test or Fischer exact tests.



However, significant variations could still be observed among the three clusters. All Rejectors disagreed on the strategy being effective in fostering connections between patients and providers (100%). The Indecisives shared similar doubts (75%). This behaved similarly with regard to the strategy being cost-effective (70.6% disagreement for Indecisives; 100% for Rejectors) and providing added value to dermatologists (69.1% disagreement for Indecisives; 96.2% for Rejectors). In contrast, the “Adopters” were more divided in their assessment: one-third of the cluster agreed with

the statements, another third disagreed, and the remaining third was inconclusive. For example, 37.1% agreed, 32.3% disagreed, and 30.6% were inconclusive on the statement regarding whether the strategy has connected patients and physicians.

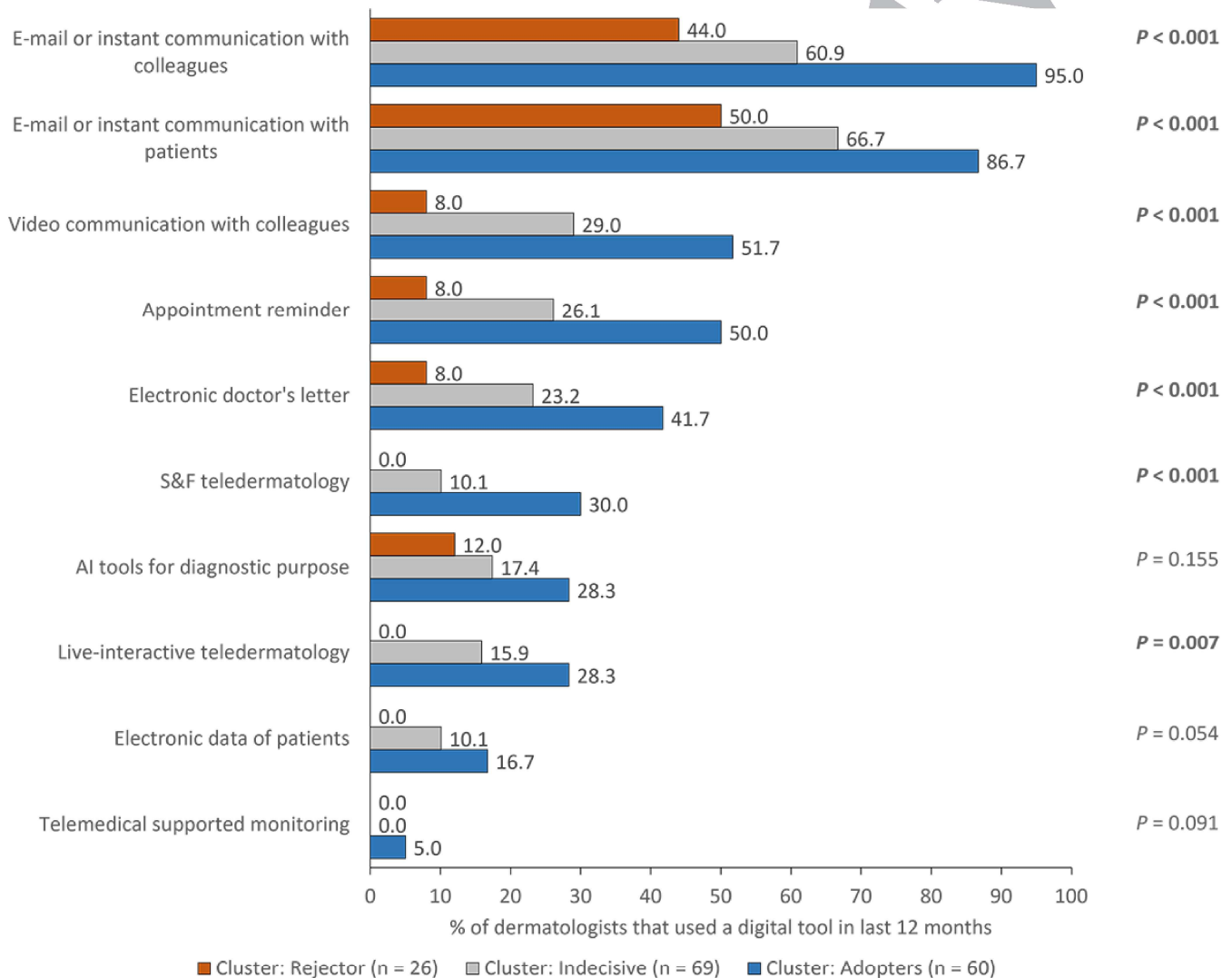
Current Use of DHIs Within Identified Clusters

The use of common DHIs varied significantly between the three clusters, except for artificial intelligence (AI) tools for

diagnostic purposes (range: Rejectors 12%-Adopters 28.3%; $P=.15$), electronic patient data (range: Rejectors 0%-Adopters 16.7%; $P=.05$), and telemedical supported monitoring (range: Rejectors 0%-Adopters 5%; $P=.09$; Figure 3). The Adopters demonstrated the highest and the Rejectors the lowest utilization rates across all presented DHIs. A total of 95% of the Adopters reported to communicate via email or instant messaging with colleagues and 86.7% used email to communicate with patients. In contrast, only 44% and 50%

of the Rejectors engaged in these communication methods. Apart from email communication, less than half of the Adopters and one-third of the Indecisives used other DHIs. For example, "Appointment Reminders" were used by 50% of the Adopters and 26.1% of the Indecisives. The Rejectors did not use many of the DHIs at all, such as S&F (0%) and live-interactive teledermatology (0%). Additionally, their utilization of AI for diagnostic purposes was very low (12%).

Figure 3. Use of digital technology in the last 12 months by clusters. P values indicate the outcome of a chi-square test or Fischer exact tests. AI: artificial intelligence.

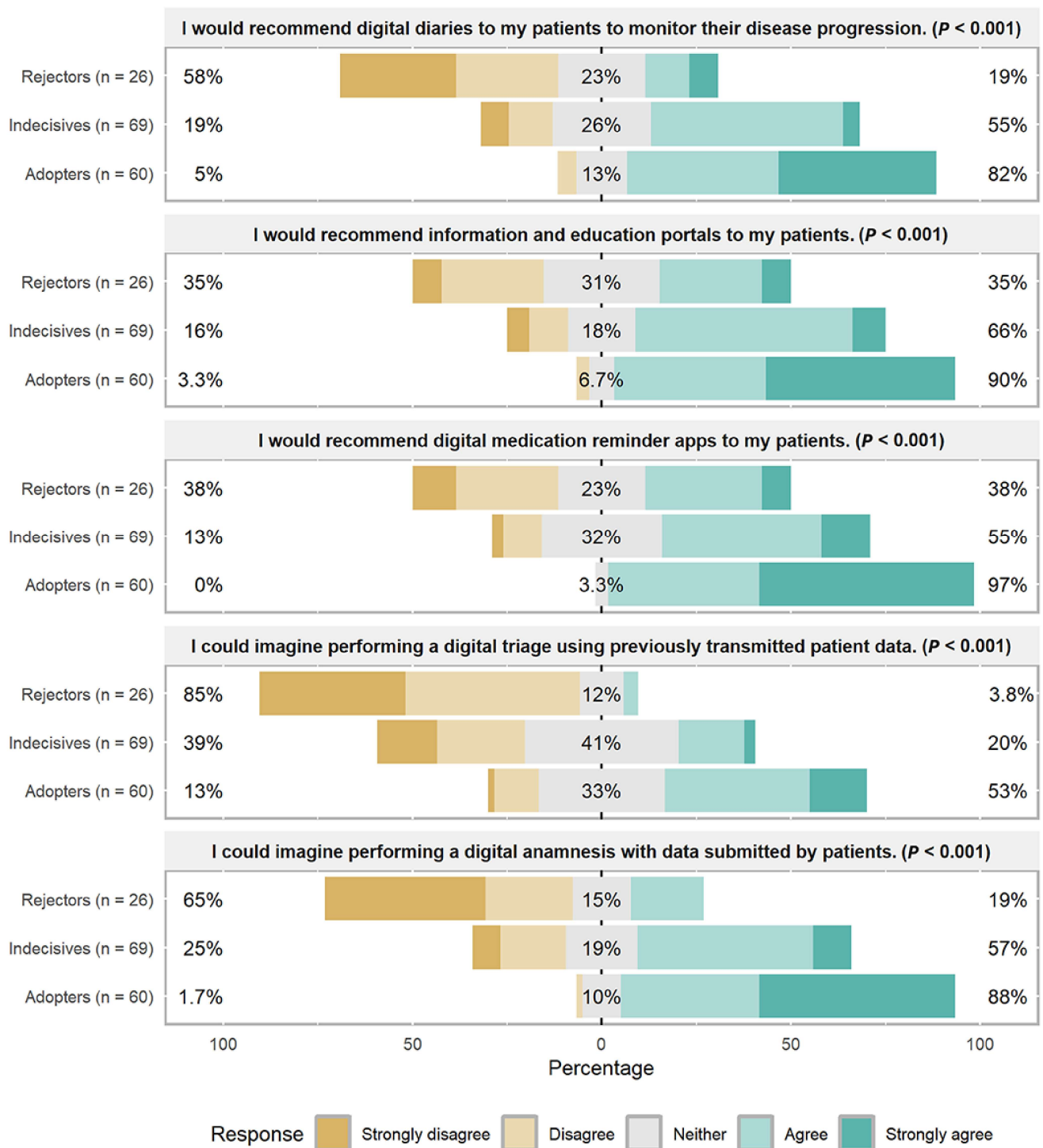


Future Intention to Use DHIs Within Identified Clusters

When considering the potential use of DHIs for their patients in the future, significant differences were identified among the three clusters (Figure 4). Between 80% (patient diaries) and 97% (medication reminder) of Adopters were willing to use 4 out of 5 described interventions. In contrast, only 55% (medication reminders) to 66% (education portals) of

Indecisives can imagine using or recommend specific DHIs more often than currently. Rejectors had low potential use rates ranging from 19% (for digital anamnesis) to 35% (for education portals). While a slight majority of Adopters (53%) could envision to use digital triage, 33% were undecided. However, 20% of the Indecisives could imagine using digital triage, while 41% were undecided. In contrast, 85% of the Rejectors disagreed on using digital triage in the future.

Figure 4. Potential future use of digital health interventions by clusters. *P* values indicates the outcome of a chi-square test.



Discussion

Principal Findings

This study aimed to explore dermatologists' acceptability of DHIs, as well as their current and potential future use. Further, clusters were identified according to their level of acceptability and differences were examined between the clusters and sociodemographics, as well as DHI current and future use. The current use barely exceeded 30%

for interventions like teledermatology, AI for diagnostic purposes, and electronic patient data, even among willing dermatologists.

Overall, acceptability was moderate but varied significantly among the identified clusters. We recognized a cluster of dermatologists with high acceptability (Adopters), another similar-sized cluster with moderate acceptability (Indecisives), and a third minority with low acceptability (Rejectors). Indecisives and Rejectors perceived negative expectancies following the introduction of DHIs (eg, workload increase)

and mostly questioned patients' willingness and competence to use them. Adopters were younger, and more commonly practicing in urban settings and outpatient clinics compared to Rejectors. Satisfaction with the nationwide eHealth strategy was generally low, although perspectives among Adopters were more divided. Current and future use of DHIs depended on the type of DHI and cluster, with Adopters showing higher rates.

Significant inequalities in DHI adoption between clusters indicate the presence of a second-order digital divide (disparities in digital competencies and acceptability toward DHIs) [41,42]. The more common adoption of DHIs among younger and urban dermatologists has already been identified [30]. This difference can contribute to existing health inequities, by impacting access to health care and potentially even health outcomes [43]. It is crucial to closely monitor the impact of further DHI adoption in dermatology and address any potential health disparities.

In general, inadequate knowledge, as perceived in the survey, is a recognized barrier to the adoption of DHIs [22,44]. Integrating education on digital medicine into medical curricula and continuing medical education programs is, therefore, a potential approach to increase use and mitigate the digital divide [45]. As the health care system undergoes digital transformation, investing in digital health education is crucial [46].

The survey identified structural barriers to the widespread adoption of DHIs, including inadequate reimbursement and incentives, workload concerns, and IT infrastructure challenges. In addition, the inadequate nationwide eHealth infrastructure [47], as also noted by dermatologists in our survey, hinders the seamless integration of DHIs, for example, in teledermatology due to problems with electronic prescriptions and lack of access to patient records [21,48]. These factors may help explain why the adoption rate of innovative technologies, including teledermatology, remained below 30% even among willing adopters. To address these challenges, developers and decision makers must prioritize aligning the eHealth infrastructure with practitioners' needs, as seen in other European countries [19]. Incentivizing physicians, alongside involving them in the development process more frequently to reduce concerns, can be a focus to increase DHI uptake [21].

The limited availability of DHIs may also contribute to the relatively low adoption rates, even among those categorized as Adopters. In Germany, for instance, store-and-forward teledermatology platforms primarily focus on diagnosis [15,16,49], with limited emphasis on triage or referrals [14] and follow-up of patients with chronic conditions [13]. This limitation restricts the broader use of the technology for different patient groups. Additionally, patient electronic health records remain incompletely implemented [19] and there is a shortage of patient applications capable of either generating (eg, heart rate) or supporting patients in generating (eg, patient-reported outcomes) health data. Conversely, the swift uptake of AI applications, even among those categorized as Rejectors, underscores the benefits of this technology

for dermatologists [50]. Our research suggests that most Adopters and the majority of Indecisives express a desire to use and recommend specific DHIs more frequently, highlighting the need for increased availability of evidence-based DHIs.

The perspective that patients would not welcome or find DHIs easy to use aligns with evidence that over 70% of the German population lacks adequate digital health competencies [51]. Patients also demonstrate low to moderate acceptability toward DHIs [34,52-54]. Other research contradicts those findings suggesting that dermatological patients even have a higher acceptability toward DHIs in comparison to dermatologists [27]. Nevertheless, physicians and nurses can provide vital guidance, given their significant influence on patients [23,25,26]. Notably, Adopters recognized this role, expressing a willingness to recommend DHIs despite acknowledging patients' overall lack of digital competencies. This proactive stance should be complemented by health insurers, who also have a responsibility to promote DHIs and enhance digital literacy to ensure their appropriate utilization [55]. Such efforts are aligned with insurers' interests in supporting cost-effective health care services [55].

One key distinction we found is that Adopters are more commonly affiliated with a hospital-connected outpatient clinic, while the majority of the other clusters involve self-employed dermatologists in medical practices. This may explain the differences in opinions on costs, reimbursements, or investments. Physicians in outpatient clinics may be less concerned with IT costs and IT investments than physicians in private practices as they do not have to organize or pay themselves [57].

Similar to other studies on acceptability toward digitalization, it is important to consider the Intention-Behavior gap when interpreting the survey results. Here, intending to adopt to DHIs in the future may not guarantee increased actual adoption in the future [58]. Additionally, while an association has been observed between a group exhibiting high acceptability (Adopters) and their current adoption of DHIs, the cross-sectional nature of the study means that the direction of this association remains ambiguous and cannot be extrapolated into the future.

Limitations

The survey has further limitations. Only 170 dermatologists participated out of over 6000 practicing dermatologists, of which 3500 were organized in the DDA and 1000 were invited [59]. Additionally, while dermatologists were randomly invited, our survey exhibited an overrepresentation of dermatologists in the medium age group (50-59 years), with younger dermatologists (40-49 years) and older dermatologists (60+) being underrepresented [59]. This observation is particularly significant considering the age differences identified between the clusters, where younger participants are more commonly affiliated with the Adopters cluster and older participants with the Rejectors cluster. The survey is also prone to voluntary participation, which might have attracted dermatologists with more extreme views on

health care digitalization. Hence, the sizes of the clusters and other findings may not be fully generalizable to the real world. We also did not account for the potential integration of certain DHIs, such as the use of AI to preanalyze images submitted through store-and-forward teledermatology. Future research should therefore explore the impact of AI on perceptions and attitudes toward DHIs [54].

A factor analysis was conducted, as recommended, to reduce data dimensionality before performing the cluster analysis [39]. Exploratory factor analysis was chosen instead of confirmatory factor analysis, as no theoretical assumptions about item interactions were made. The approach limits the comparability with other research on acceptability [33,34]. In addition, it is often recommended to conduct a confirmatory factor analysis following an EFA [60]. However, our sample size was not large enough to split the dataset to allow for a subsequent analysis. Despite this limitation, EFA calculations were deemed appropriate based on the KMO criterion and Bartlett's test of sphericity, resulting in factors with acceptable internal consistency [40]. To validate the findings of our research, the results could be further explored by conducting qualitative interviews with dermatologists and employing a mixed methods approach [61].

Conclusions

The survey results indicate that dermatologists' overall acceptability toward digital health interventions is moderate. However, a sizable cluster expresses a high willingness to incorporate these interventions and recommend them to

patients. Two other distinct clusters exist: one indecisive about health care digitalization and another rejecting digital health interventions.

The observed variation in actual adoption rates among clusters suggests a nuanced relationship between willingness and the implementation of DHIs. Dermatologists who express willingness are more inclined to adopt DHIs more frequently. However, despite this willingness, overall use rates remain moderate. This may be attributed, in part, to several structural barriers, including inadequate reimbursement, insufficient IT infrastructure, limitations of the nationwide eHealth infrastructure, and the limited availability of DHIs.

A notable perception among dermatologists, especially those with low acceptability, is the perceived low patient willingness and competency regarding digital health. This points to efforts needed to enhance digital literacy among patients. It is imperative for all stakeholders in the health care system, including health insurers, to invest in initiatives to improve patient education and empowerment in digital health.

Additionally, prioritizing education for health care providers on digital health and involving them early in the development of DHIs could mitigate potential disparities in digital health.

Addressing all the mentioned barriers could improve the acceptability and use of DHIs among dermatologists, particularly among those who are indecisive, thereby enhancing the integration of DHIs to support patient care.

Acknowledgments

The authors thank the Scientific Communication Team of the IVDP, in particular Merle Twesten, for copyediting. We acknowledge financial support from the Open Access Publication Fund of UKE—Universitätsklinikum Hamburg-Eppendorf and DFG—German Research Foundation. This text was revised using ChatGPT-3.5/4.0 to enhance readability and ensure grammatical accuracy. The research project was financially supported via a research grant by Novartis Pharma GmbH. Novartis did not influence the design, data collection, analysis, publication decision, or development of this study.

Conflicts of Interest

MO is a coauthor of the German AWMF guideline on teledermatology. MA is a coauthor of the German AWMF guideline on teledermatology and a scientific advisor for the teledermatology platform derma2go AG, A+ Videoclinic GmbH, and Novartis Pharma GmbH.

Multimedia Appendix 1

Overview of the items of the survey.
[DOCX File (Microsoft Word File), 34 KB-Multimedia Appendix 1]

Multimedia Appendix 2

Results of the exploratory factor analysis.
[DOCX File (Microsoft Word File), 22 KB-Multimedia Appendix 2]

Checklist 1

Checklist for Reporting of Survey Studies (CROSS)
[DOCX File (Microsoft Word File), 22 KB-Checklist 1]

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Abbreviations

- AI:** artificial intelligence
- DHI:** digital health interventions
- EFA:** exploratory factor analysis
- KMO:** Meyer-Olkin criterion
- UTAUT:** Unified Theory of Acceptance and Use of Technology

Edited by Andre Kushniruk; peer-reviewed by Bell Eapen, Hans Thulesius; submitted 22.04.2024; initial comments to author 07.11.2024; final revised version received 17.12.2024; accepted 31.12.2024; published 28.03.2025

Please cite as:

Reinders P, Augustin M, Otten M

Understanding Dermatologists' Acceptance of Digital Health Interventions: Insights From a Cross-Sectional Survey and Cluster Analysis

JMIR Hum Factors 2025;12:e59757

URL: <https://humanfactors.jmir.org/2025/1/e59757>

doi: [10.2196/59757](https://doi.org/10.2196/59757)

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FOR REVIEW ONLY

2.4. Manuskript 4 (Nicht akzeptiert; Stand 10.05.2025)

Reinders P, Augustin M, Otten M. *Attitudes of Patients with Skin Diseases towards Digital Health Interventions: A Cross-Sectional Survey and Cluster Analysis*

Eingereicht bei JDDG (Stand 10.05.2025)

Nicht veröffentlicht

1 **Title: Attitudes of Patients with Skin Diseases towards Digital Health Interventions:**
2 **A Cross-Sectional Survey and Cluster Analysis**

3 **Patrick Reinders¹, Matthias Augustin¹, Marina Otten¹**

4 ¹Institute for Health Services Research in Dermatology and Nursing (IVDP), University Medical
5 Center Hamburg-Eppendorf (UKE), Hamburg, Germany

Words:	Tables:	Figures:
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7 **Corresponding Author:**

8 Marina Otten

9 Institute for Health Services Research in Dermatology and Nursing (IVDP)

10 University Medical Center Hamburg-Eppendorf (UKE)

11 Martinistrasse 52

12 D-20252 Hamburg

13 Tel.: +49 (0) 40 7410–24723

14 E-Mail: m.otten@uke.de

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18 **Abstract (max. 350 words)**

19 **Background:** Germany's adoption of Digital Health Interventions (DHIs) in care lags behind other
20 nations. One reason may be patient concerns. This study aimed to assess patients' acceptability
21 of DHIs in dermatology and to identify related patient clusters .

22 **Methods:** A cross-sectional, quantitative survey on acceptability and (future) usage of DHIs was
23 conducted nationwide among patients with chronic dermatological conditions based on prior
24 qualitative research. Exploratory Factor Analysis (EFA) identified key constructs and patients
25 were grouped using a two-step clustering algorithm.

26 **Results:** The EFA used data of 344 patients (M 52.5 years, SD 14.8; 74.0 % female) and revealed
27 four factors (F): (F1) "Acceptability of DHIs and Trust", (F2) "Patients' Digital Health
28 Competencies", (F3) "Digital Health Insecurities", and (F4) "Positive Impact of DHIs". Cluster
29 analysis resulted in four groups: "Digital Sceptics" (n = 49) showed low usage intentions (F1),
30 moderate competencies (F2), and insecurities (F3). "Cautious Adopters" (n = 106) exhibited high
31 acceptability (F1; M 3.9; SD 0.4) and competencies (F2), alongside moderate insecurities (F3).
32 "Digital Enthusiasts" (n = 98) demonstrated the highest intention (F1), competencies (F2), and
33 perception of positive impact (F4). "Adopters Unsure About Impact" displayed high usage
34 intentions (F1; M 3.9; SD 0.6), but moderate perception of positive impact (F4). "Digital
35 Enthusiasts" were significantly younger than "Digital Sceptics" and "Adopters Unsure About
36 Impact". Overall, only a minority of patients used DHIs, including store-and-forward
37 tele dermatology (Sceptics: 2.0 % to Enthusiasts: 7.0 %) or electronic patient records (Skeptics:
38 6.4 % to Enthusiasts: 19.4 %). Usage varied among clusters, with "Digital Enthusiasts" and

39 “Adopters Unsure About Impact” showing the highest usage rates. With the exception of the
40 “Digital Sceptics”, the majority of clusters was willing to use all presented DHIs more commonly.

41 **Conclusions:** Four patient clusters with varying attitudes towards DHIs were identified. Despite a
42 general willingness to adopt DHIs in three out of the four clusters, actual usage remains low,
43 suggesting the need to address systemic barriers such as availability of DHIs and digital
44 competencies.

45

46 **Keywords:** Acceptability, Digital Health Interventions, Patients, Dermatology, Patients’
47 Perspective

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55 **Background**

56 Dermatology is characterized by the widespread occurrence of skin conditions, including chronic
57 frequent skin diseases such as acne, psoriasis, atopic dermatitis, and skin cancer^{1,2}. In Germany,
58 approximately 27 % of adults are affected by at least one dermatological condition annually. This
59 results in a high caseload, causing prolonged waiting times for appointments^{3,4}. Moreover, the
60 restricted capacity is considered to be intensified by the demographic transition⁴⁻⁷.

61 Proposed as a solution for sustainable health care, digital health interventions (DHIs) aim to
62 improve the quality of care, enhance efficiency, and empower patients^{8,9}. In this study, DHIs refer
63 to health services that use information and communication technologies for patients, consumers,
64 or healthcare professionals^{9,10}. In dermatology, many promising DHIs have already emerged¹¹,
65 including artificial intelligence applications¹², teledermatology for referrals, diagnoses, or the
66 monitoring of skin diseases¹³⁻¹⁵, and patient-oriented applications aimed at improving
67 medication adherence¹⁶. While the 2020 teledermatology consensus guideline supports the use
68 of teledermatology for certain indications, it also emphasizes the need for more robust evidence
69 to assess associated benefits and risks¹⁷.

70 Despite the presence of existing DHIs, healthcare digitalization in Germany lags behind that of
71 other Western nations¹⁸. In Dermatology, even in the height of the COVID-19 pandemic only a
72 limited number of dermatologists integrated DHIs into care^{19,20}. In addition, the usage by patients
73 with skin diseases is relatively low, for example only 10 % used an electronic patient record²¹. The
74 intricacies of the German healthcare system contribute to the complexity of low DHI

75 implementation rates, involving factors such as the absence of interoperability, high standards
76 of data protection, or the lack of incentives for clinics and outpatient practices²².

77 Other reasons for the low usage rate of DHIs described by dermatologists may be low patients'
78 acceptability for DHIs and limited patients' digital competencies²³. Some publications, however,
79 reveal a sufficient to high acceptability for DHIs and sufficient digital competencies^{21,24,25}.
80 However, studies are limited either by a small sample size, the focus on one dermatological
81 indication, highly selected patients or by limited items to closer explore patient acceptability.

82 With our study, we seek to add to the existing literature by examining the acceptability and
83 current/future usage of DHIs among patients with chronic skin diseases. Additional objectives
84 include identifying distinct patient clusters based on their acceptability and exploring their
85 associations with sociodemographic variables and DHI adoption.

86

87 **Methods**

88 The Consensus-Based Checklist for Reporting of Survey Studies was used to report the study²⁶.

89 The checklist is available in Supplement 1.

90 **Study Design and Questionnaire**

91 In March 2022, an anonymous cross-sectional survey was distributed among patients with
92 chronic skin diseases in Germany. The survey was constructed based on results from previously
93 conducted focus groups involving dermatologists, patients, and nurses as well as findings from
94 existing literature. The objective of the focus group study was to explore the acceptability of,

95 barriers to, and facilitators of DHIs in dermatology²³. Building upon these outcomes, we
96 developed statements and matched them with questionnaires from the literature^{21,27,28}.
97 Thereby, we developed 31 items related to acceptability (e.g., “I could imagine using more digital
98 applications for my condition”). Based on the systematic literature mapping¹¹, eleven items on
99 the potential future usage of specific DHIs were incorporated (e.g., teledermatology or electronic
100 patient diary). Respondents rated all items on a five-point Likert scale (1 – strongly disagree; 5 –
101 strongly agree); the numbers were not visible while responding. In addition, the survey asked
102 about the current usage of the same eleven specific DHIs, to be answered with “Yes”, “No”, or “I
103 do not know”.

104 Sociodemographic items included age, sex, education, and postal code. The latter was used to
105 allocate supplementary regional information (e.g., urban or rural classification) to the
106 participants. The survey also included items about the patients’ dermatological conditions (such
107 as psoriasis, atopic dermatitis, vitiligo, skin cancer, and hidradenitis suppurativa), duration since
108 the onset of symptoms and diagnosis, self-perceived health using the first item of the SF-36²⁹,
109 and details regarding the attending physician.

110 The questionnaire was pretested with members of a patient association named Deutscher
111 Psoriasis Bund e.V. (engl.: German psoriasis association). The items of the final survey are
112 provided in Supplement 2.

113 Study Population, Recruitment, and Data Entry

114 To conduct an exploratory factor analysis (EFA), as described in the statistical analysis section,
115 we aimed for a minimum sample size of 150 patients³⁰. To enhance the generalizability of our

116 findings, we included patients diagnosed with several chronic skin diseases, including psoriasis,
117 vitiligo, hidradenitis suppurativa, atopic dermatitis, and skin cancer. Patient recruitment was
118 conducted online through various patient self-help organizations and patient advocacy groups,
119 namely the

- 120 • Deutscher Psoriasis Bund (engl.: German psoriasis association) for psoriasis
121 (approximately 1700 members invited via email),
- 122 • Deutscher Vitiligo Bund (engl.: German Vitiligo Association) for vitiligo (approximately 250
123 members invited via mail),
- 124 • MulleWupp e. V. (engl.: local dialect for mole) for hidradenitis suppurativa (post in
125 Facebook-group with approximately 900 members),
- 126 • Deutscher Allergie und Asthmabund (engl.: German Allergy and Asthma Association) for
127 atopic dermatitis (approximately 1000 members invited via mail),
- 128 • SHG Hautkrebs Hamburg.info (engl.: Self-help group skin cancer Hamburg.info) for skin
129 cancer (approximately 400 members invited via mail),
- 130 • and Melanom-Info Deutschland (engl.: Melanoma-Info Germany) for skin cancer (post in
131 Facebook group with approximately 8000 members).

132 The online survey was conducted via Unipark and terminated 12 weeks after the first
133 organization invited its participants. To prevent multiple entries by a single patient, participation
134 was monitored using Unipark's cookie system.

135 Ethics Approval

136 The study was submitted to the local psychological ethics committee (Lokale Psychologische
137 Ethikkommission am Zentrum für Psychosoziale Medizin) and received approval (LPEK-0407). It was
138 conducted in adherence to the principles of Good Scientific Practice and the Declaration of
139 Helsinki^{31,32}.

140 Statistical Analysis

141 Following a descriptive analysis of all sociodemographic and geographic parameters, an
142 exploratory factor analysis (EFA) was conducted on all 31 items related to acceptability for two
143 primary reasons: (1) data reduction by identifying underlying factors and (2) using the factors to
144 better describe the acceptability of patients³³. Adequacy for EFA was assumed with a Kaiser-
145 Meyer-Olkin (KMO) criterion ≥ 0.8 and Bartlett's test of sphericity < 0.05 . Factors with an
146 eigenvalue ≥ 1.0 were considered and items were retained based on substantial factor loading
147 ($>|0.4|$) on one factor, without strong cross-loading onto other factors. Cross-loading was
148 defined as loadings ($>|0.3|$) on another factor, with a difference of less than 0.2 between the
149 loading on the main factor and the strongest loading on any other factor³⁴. Internal consistencies
150 of factors were assessed using Cronbach's alpha, with values > 0.7 considered acceptable, > 0.8
151 considered good, and > 0.9 considered excellent.

152 To detect distinct clusters among patients with chronic skin diseases varying in acceptability, a
153 combination of hierarchical and K-means cluster analyses was employed. The mean scores (using
154 Likert scale ratings: 1 – 5) of the factors served as input variables for both approaches. The
155 hierarchical cluster method determined the optimal number of clusters, and subsequently, a K-
156 means cluster analysis was conducted based on this optimal number. To examine the differences

157 among the identified clusters in terms of mean scores, a one-way analysis of variance (ANOVA)
158 was performed. To profile the identified clusters, each item from the EFA was binary coded (1:
159 fully agree/agree; 0: partly, disagree, fully disagree). Then, a descriptive analysis was performed,
160 examining each item for each cluster. Chi-squared tests were applied for categorical variables to
161 reveal associations between clusters and sociodemographic parameters. If more than 20 % of
162 cells had a count below five, Fisher's exact tests (FET) were used. The one-way ANOVA was
163 employed for continuous variables. A significance level of 0.05 was used and missing rates were
164 reported for all variables. No imputation or weighting methods were applied.

165

166 **Results**

167 A total of 344 patients with at least one of the pre-defined dermatological conditions participated
168 in the survey. They were on average 52.5 years old (SD 14.8), with 74.0 % being female, 75.9 %
169 residing in an urban county or city, and 58.9 % having a high level of education (see Table 1). The
170 five included dermatological indications included psoriasis (39.0 %), atopic dermatitis (23.3 %),
171 hidradenitis suppurativa (21.2 %), vitiligo (9.0 %), and skin cancer (7.6 %). A significant proportion
172 of the participants (65 %) had been living with their dermatological condition for over 10 years,
173 with an average duration of 23.9 years (SD 19.5). Only 18 % rated their health as excellent or very
174 good, while 36.6 % rated it as fair or poor. The rate of missing data was below 5 % for all items,
175 except for regional variation (21 missings, 6.1 %), education (18 missings, 5.2 %), and time since
176 the first diagnosis (18 missings, 5.2 %).

177

>>> *Please insert Table 1 here.* <<<

178 **Factors of Acceptability**

179 The suitability of the data for conducting an EFA was confirmed by the KMO criterion (0.90) and
180 Bartlett's Test of Sphericity (X^2 (df: 171) = 3335, $p < 0.001$). Four factors with eigenvalues greater
181 than 1 were identified (see Supplement 3), with calculated Cronbach's Alpha values (0.89, 0.82,
182 0.79, and 0.91) indicating at least acceptable internal consistency. The following factor names
183 were assigned:

- 184 • Factor 1: "Acceptability of DHIs and Trust" comprised 10 items
- 185 • Factor 2: "Patients' Digital Health Competencies" comprised 6 items
- 186 • Factor 3: "Digital Health Insecurities" comprised 5 items
- 187 • Factor 4: "Positive Impact of DHIs" comprised 5 items

188 Mean scores could range from 1 to 5, where higher scores indicated a higher agreement with the
189 underlying items. In factors 1, 2, and 4, higher scores reflect more positive perceptions, whereas
190 in factor 3, higher scores reflect more negative perceptions, in line with the connotations of the
191 underlying items. The mean scores for factor 1 and factor 4 were moderate to high (Factor 1: M
192 3.9, SD 0.7; Factor 4: M 3.6, SD 1.0), while the mean score for factor 2 was high (M 4.0, SD 0.7),
193 and the one for factor 3 was low (M 2.4, SD 0.4) (see Table 2).

194 >>> *Please insert Table 2 here.* <<<

195 **Clusters of Patients Based on Acceptability Levels**

196 The optimal solution, determined through hierarchical cluster analysis, resulted in a four-cluster
197 classification. Subsequent ANOVA and post hoc tests confirmed significant variations across all
198 four subscales (Table 2).

199 Cluster 1 (n = 49; 15.6 %) demonstrated moderate ratings for acceptability and trust (Factor 1; M
200 2.8, SD 0.6) and competencies (Factor 2: M 3.2, SD 0.7), along with low expectancies for a positive
201 impact of DHIs (Factor 4: M 2.2, SD 0.6). All factors were rated significantly lower compared with
202 the other three clusters. Additionally, digital insecurities were moderate (Factor 3: M 3.0, SD 0.6)
203 and significantly higher than those in clusters 3 and 4.

204 Cluster 2 (n = 106; 33.7 %) showed moderate to high mean scores in acceptability and trust
205 (Factor 1: M 3.9, SD 0.5), competencies (Factor 2: M 3.8, SD 0.5), and expectancies of a positive
206 impact (Factor 4: M 3.8, SD 0.5). Acceptability and trust were significantly lower than in Cluster
207 3, and competencies and positive expectancies were lower compared to clusters 3 and 4. Digital
208 insecurities (Factor 3: M 2.9, SD 0.5) were moderate and significantly higher than those in clusters
209 3 and 4.

210 Cluster 3 (n = 98; 31.1 %) displayed the highest ratings on acceptability and trust (Factor 1: M 4.5,
211 SD 0.3) as well as expectancies of a positive impact of DHIs (Factor 4: M 4.5, SD 0.5) among all
212 clusters. Digital competencies were also rated high (Factor 2: M 4.5; SD 0.4), whereas digital
213 insecurities were low (Factor 3: M 1.8, SD 0.5). Both mean scores were significantly higher than
214 those of clusters 1 and 2.

215 Cluster 4 (n = 62; 18.0 %) was similar to cluster 2 in terms of acceptability of DHIs and trust
216 (Factor 1: M 3.9; SD 0.6), and to cluster 3 in terms of competencies and insecurities (Factor 2: M
217 4.3, SD 0.5; Factor 3: M 1.7, SD 0.5). However, cluster 4 (Factor 4: M 2.8, SD 0.6) had a significantly
218 lower perception of the potential positive impact of DHIs than clusters 2 (M 3.8, SD 0.5) and 3 (M
219 4.5, SD 0.5) .

220 For clarity, we refer to clusters 1, 2, 3, and 4 as "Digital Sceptics", "Cautious Adopters", "Digital
221 Enthusiasts", and "Adopters Unsure About Impact" in subsequent sections.

222 Sociodemographic and Health-Specific Differences of Clusters

223 In terms of sociodemographic parameters, the cluster analysis revealed significant differences
224 among the identified groups (Table 1). "Digital Enthusiasts" (M 47.1 years; SD 13.8) were notably
225 younger than both "Digital Sceptics" (M 59.2 years; SD 13.0) and "Adopters Unsure About
226 Impact" (M 55.5 years; SD 13.6) (see Table 3). "Cautious Adopters" were younger compared to
227 "Digital Sceptics" (M 49.8; SD 14.5 vs. 59.2 years; SD 13.0). No statistically significant sex or
228 geographical variations were observed. A significant association was noted in the educational
229 level with "Digital Enthusiasts" and "Adopters Unsure About Impact" having a higher level of
230 education (70.4 % and 71.9 %) compared with "Digital Sceptics" and "Cautious Adopters" (45.8
231 % and 46.5 %).

232 A significant association was identified between the cluster assignment of psoriasis and
233 hidradenitis suppurativa. Participants diagnosed with psoriasis were more prevalent in the
234 "Digital Sceptics" (46.9 %) and "Adopters Unsure About Impact" (50.0 %) clusters, whereas those
235 diagnosed with hidradenitis suppurativa had a larger proportion in the "Cautious Adopters" (25.5
236 %) and "Digital Enthusiasts" (29.6 %) clusters. The time since first diagnosis varied significantly
237 among the four clusters. Specifically, "Digital Sceptics" had a significantly longer time since first
238 diagnosis (M 34.7 years; SD 21.2) compared to "Cautious Adopters" (M 23.0 years; SD 19.7) and
239 "Digital Enthusiasts" (M 17.8 years; SD 17.1) (Table 1). In addition, "Adopters Unsure About
240 Impact" had a significantly longer time since diagnosis than "Digital Enthusiasts" (M 26.9 years;
241 SD 16.6 vs. 17.8; SD 17.1).

242 **Acceptability of DHIs Within Identified Clusters**

243 The subsequent paragraphs offer a detailed description of items revealing unique profiles for
244 each of the four clusters in their acceptability towards DHIs. A comprehensive summary of the
245 ratings for all items is presented in Figure 1.

246 >>> *Please insert Figure 1 here.* <<<

247 “Digital Sceptics” demonstrated low agreement rates on items within factor 1, ranging from 8.2
248 % (Item 9: trust in recommendations of other patients) to 55.1 % (Item 8: release of data to my
249 attending physician) (Figure 1; Factor 1). Regarding factor 2, participants self-reported low digital
250 skills (Item 11: 26.5 %) but also proficiency in finding useful online information (Item 16: 83.7 %)
251 and the ability to distinguish reliable from questionable information (Item 14: 65.3 %) (Figure 1;
252 Factor 2). “Digital Sceptics” expressed concerns about the potential misuse of their data (Item
253 17: 71.3 %) (Figure 1; Factor 3). However, the group did not feel intimidated by the internet (Item
254 21: 14.2 %) (Figure 1; Factor 3). Ratings on the positive impacts of DHIs were low, with no one in
255 the cluster expecting DHIs to enhance confidence in therapy for their disease (Item 23: 0.0 %)
256 (see Figure 1; Factor 4).

257 The "Cautious Adopters" and "Adopters Unsure About Impact" displayed high ratings in factor 1.
258 Both believed that applications could be a useful addition to existing care (Item 1; "Cautious
259 Adopters": 88.7 %; "Adopters Unsure About Impact": 88.7 %) but were uncertain about support
260 from their immediate environment to use DHIs (Item 11: " Cautious Adopters ": 25.5 %, "
261 Adopters Unsure About Impact ": 21.0 %). Among "Adopters Unsure About Impact", ratings on
262 competency items in factor 2 (see Figure 1) were high, while the "Cautious Adopters" had lower

263 agreement rates with items in this factor. For example, 59.4 % of "Cautious Adopters" considered
264 themselves able to distinguish reliable from questionable data (Item 14), whereas 82.3 % agreed
265 among the "Adopters Unsure About Impact" (Figure 1; Factor 2). In factor 3, the "Cautious
266 Adopters" expressed significant concerns about potential data misuse (67.9 %; Item 17),
267 compared to the "Adopters Unsure About Impact" (22.3 %). Overall, this latter group showed low
268 agreement rates across factor 3. For example, only 1.6 % agreed with the statement that DHIs
269 could make them feel insecure about their disease (Item 19). In contrast, regarding the positive
270 impact of DHIs (Figure 1; Factor 4), "Cautious Adopters" revealed higher agreement rates, ranging
271 from 56.6 % (Item 23: strengthening confidence in therapy) to 85.8 % (Item 22: better
272 preparation for consultations with their doctor). In comparison, "Adopters Unsure About Impact"
273 reported lower rates, varying from 8.1% (Item 24: support in managing their disease) to 50.0 %
274 (Item 22: strengthening confidence in therapy).

275 The "Digital Enthusiasts" showed high acceptability ratings in all factors (see Figure 1). Agreement
276 rates for most items in factors 1, 2, and 4 ranged from 85 % to 100 %. An exception was noted in
277 factor 1, where 74.5 % trusted recommendations from other patients (Item 9), and 58.2 %
278 believed that people in their environment would support DHIs (Item 11). Ratings on items in
279 "Digital Health Insecurities" (see Figure 1; Factor 3) were generally low; e.g., only a minority
280 expressed concerns about possible data misuse (Item 17: 16.3 %).

281 Overall, the majority of participants across all clusters agreed that they should be able to grant
282 their attending physician access to read their data (Item 8; Factor 1; Range: 55.1 % – 89.9 %) and
283 that they are aware of where to find useful health information online (Item 16; Factor 3; Range:
284 83.7 % – 95.2 %).

285 **Usage of DHIs Within Identified Clusters**

286 "Digital Sceptics" consistently demonstrated low usage rates across all DHIs. In contrast, both
287 "Adopters Unsure About Impact" and "Digital Enthusiasts" had the highest usage rates (see
288 Figure 2). For example, 72.6 % ("Adopters Unsure About Impact") and 74.2 % ("Digital
289 Enthusiasts") used online information portals. "Cautious Adopters" showed comparable rates to
290 "Adopters Unsure About Impact" in certain DHIs, such as online applications for patient exchange
291 (38.7 % vs. 36.8 %), but markedly lower adoption in others, such as email communication with
292 treating physicians (40.3 % vs. 24.5 %). DHIs that facilitate communication with physicians,
293 excluding e-mail, were generally infrequently used. For instance, S&F teledermatology was used
294 by 7.1 % of "Digital Enthusiasts" and 2.0 % of "Digital Sceptics". The official electronic patient
295 record (ePA) also demonstrated low usage across all clusters, ranging from 6.4 % in "Digital
296 Sceptics" to 19.4 % in "Digital Enthusiasts".

297 >>> *Please insert Figure 2 here.* <<<

298 **Potential Future Usage of DHIs within Identified Clusters**

299 When contemplating the potential future usage of interventions, only about one-third of the
300 "Digital Sceptics" (Cluster 1) showed interest in using 7 out of the 11 DHIs more frequently.
301 Exceptions included education portals (65.3 %), appointment reminders (57.1 %), the online
302 pollen count forecast (43.8 %), and email communications (42.9 %). In contrast, the clear majority
303 within the three adopters' clusters (Clusters 2 – 4) expressed a willingness to more often use DHIs
304 (see Figure 3). For 5 out of the 11 presented DHIs, at least two-thirds within each adopter's cluster
305 indicated an openness to increased usage. The DHIs with the highest agreement rates among

306 adopters' clusters were online information and educational portals ("Cautious Adopters": 86.7 %
307 to "Digital Enthusiasts": 97.9 %), appointment reminders ("Cautious Adopters": 84.9 % to "Digital
308 Enthusiasts": 95.9 %), and the ePA ("Cautious Adopters": 75.2 % to 90.7 %). Within the "Digital
309 Enthusiasts", rates for 10 out of the 11 presented DHIs consistently exceeded 75 %, reaching as
310 high as 97.9 % for the potential future usage of education portals for their disease.

311 >>> *Please insert Figure 3 here.* <<<

312

313 **Discussion**

314 The objective of this study was to investigate the level of acceptability as well as the current and
315 potential future usage of DHIs among patients with skin diseases. Further, clusters were
316 identified according to their level of acceptability as well as their associations between
317 sociodemographic characteristics, current, and future usage of DHIs. A majority of patients and
318 three out of four identified clusters ("Cautious Adopters", "Digital Enthusiasts", "Adopters
319 Unsure About Impact") expressed a willingness to embrace DHIs more often in the future.
320 Furthermore, the cluster "Digital Enthusiasts" possessed sufficient digital competencies and
321 expressed low levels of digital health insecurities. The "Cautious Adopters" showed a positive
322 attitude toward DHIs but expressed concerns about data misuse. The "Adopters Unsure About
323 Impact" did not expect any positive effects of DHIs on their disease handling. The other cluster,
324 the "Digital Sceptics", demonstrated a general unwillingness to use DHIs, had limited digital
325 competencies and a low perceived benefit of these interventions. Even among patients who were
326 open to adopt DHIs, the current utilization rates for existing interventions, such as

327 teledermatology, electronic patient records, and electronic patient diaries, remained relatively
328 modest.

329 Our findings emphasize a high interest of patients with skin diseases in using DHIs, but for
330 example, only 7.1 % of the most digitally minded cluster have already used S&F teledermatology.

331 There may be systemic barriers as such as the limited availability of services. So even at the
332 height of the COVID-19 pandemic, only a minority of dermatologists in Germany (21 %) offered
333 S&F teledermatology to their patients^{19,20}. In addition, S&F teledermatology solutions are
334 currently not designed for chronic patients but focus on the initial assessment of patients^{15,35,36}.

335 In regards to other DHIs, only a minority of DHIs discovered in the medical literature were
336 designed specifically for patients with skin diseases¹¹, and only 2 % of disease-specific health apps
337 were designed for dermatological purposes³⁷.

338 Interestingly, many physicians attribute their reluctance to introduce DHIs to a perceived lack of
339 interest among patients^{38,39}. Our data revealed that many patients with chronic dermatological
340 diseases would endorse using these services. One possible explanation for this discrepancy may
341 be the insufficient integration of current DHIs into the existing care, leading patients and
342 physicians to prefer the standard of care. However, DHIs capable of ensuring continuity of care
343 while reducing waiting times and integrating seamlessly with current care are more likely to be
344 preferred by patients^{40,41}.

345 Digital insecurities, especially regarding data misuse, emerged as another significant barrier for
346 the “Cautious Adopters” and “Digital Sceptics”. The negative association was already identified
347 in previous research⁴²⁻⁴⁴. Enhancing the uptake of DHIs necessitates not only ensuring data

348 security and privacy but also actively informing patients about the security measures and use of
349 their data.

350 The discovery of a patient cluster with a high intention to use DHIs (“Adopters Unsure About
351 Impact”), possessing sufficient digital skills and having low digital insecurities, but still expecting
352 low impact of DHIs on their care is interesting. Performance expectancy, in our study titled
353 “Positive Impact of DHIs”, is often the most robust predictor of DHI acceptability²⁷. This cluster,
354 with 74 % of patients having their skin condition for over 10 years, may already have adapted to
355 the demands of their chronic skin conditions, resulting in lower expectations towards the
356 additional value offered by DHIs.

357 Our research identified a second-order digital divide characterized by disparities in digital
358 competencies, acceptability, and usage instead of infrastructure and access devices (e.g.,
359 smartphones and computers)⁴⁵. In alignment with previous studies^{46,47}, our findings underscored
360 that advanced age and lower education were associated with lower use of DHIs. This finding is
361 concerning because access to and usage of digital health is an increasingly important determinant
362 of health, especially since the COVID-19 Pandemic^{46,48}. Some researchers even proposed a
363 comprehensive framework for Digital Health Equity⁴⁹. Potential actions include ensuring the
364 usability of DHIs for marginalized populations, educating health care professionals, and providing
365 digital literacy programs within local communities, such as through libraries^{48,49}. Health insurers
366 could support such efforts as they already have a responsibility to promote DHIs and enhance
367 digital literacy to ensure their appropriate use⁵⁰. Further data are essential to better understand
368 the relationship between digital inequities and health disparities, enabling the development of
369 effective countermeasures.

370 The cross-sectional survey employed has several limitations. As patients were invited to
371 participate through patient organizations they may possess a more comprehensive
372 understanding of their disease, have higher educational levels, and experience a greater disease
373 burden⁵¹. Thus, they may not be representative of the broader population affected by chronic
374 skin conditions. Furthermore, 74 % of the study population emerged being female, which
375 contrasts with the higher prevalence of many skin conditions typically observed in males^{3,52}.
376 Furthermore, the study focussed on persons with chronic skin diseases of rather high severity
377 being the most important target group of digital interventions. The results may not account for
378 acute and mild skin diseases. Taking all aspects into account, the actual size of the different
379 clusters may vary in the general skin disease population.

380 Although a relationship between clusters and adoption rates has been identified, e.g., high
381 adoption by 'Digital Enthusiasts' and low by 'Digital Sceptics,' this cannot be projected into the
382 future. First, the cross-sectional design prevents from establishing the direction of the identified
383 relationship. Second, the survey is susceptible to the Intention-Behavior gap⁵³. Therefore, even
384 if acceptability drives adoption, the found intention to adopt DHIs in the future may not
385 necessarily translate into an actual increase.

386 Exploratory factor analysis was chosen instead of confirmatory factor analysis for data reduction
387 because no theoretical assumptions about item interactions were made. The exploratory
388 approach limits its comparability with other research on acceptability, which often uses the
389 UTAUT framework as methodological foundation^{27,54}. Another limitation is that, as
390 recommended, no confirmatory factor analysis was applied as the sample size did not permit a
391 split for such an analysis⁵⁵. Despite this limitation, EFA calculations were deemed appropriate

392 based on the KMO criterion and Bartlett's Test of Sphericity, resulting in factors with acceptable
393 internal consistency³⁴.

394

395 **Conclusions**

396 The results of our survey revealed that patients with chronic skin conditions can be attributed to
397 four different types of digital users. Most patients within the identified clusters are willing to use
398 digital health interventions more often in the future. However, the current use of interventions
399 is low to moderate, likely because of several barriers, including the limited availability of such
400 DHIs that are inadequately implemented into the health system. Data privacy concerns and
401 limited digital competencies among patients should be acknowledged by developers,
402 researchers, and even health insurers to improve the uptake of DHIs and reduce differences in
403 access to DHIs that may lead to digital health inequities. Patients belonging to the more sceptical
404 group of digital users deserve special attention in practice, including more empowerment and
405 shared decisions before use of digital technology. Ongoing research and collaborative efforts are
406 essential to enhance the adoption and inclusivity of digital health solutions in dermatology.

407

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409

410

411

412 **List of abbreviations**

413 **DHI:** digital health intervention

414 **EFA:** exploratory factor analysis

415

416 **Declarations**

417 **Ethics Approval**

418 The study was submitted to the local psychological ethics committee (Lokale Psychologische
419 Ethikkommission am Zentrum für Psychosoziale Medizin) and received approval (LPEK-0407). It was
420 conducted in adherence to the principles of Good Scientific Practice and the Declaration of
421 Helsinki^{31,32}.

422

423 **Consent for publication**

424 Not applicable.

425

426 **Availability of data and materials**

427 **The datasets used and/or analysed during the current study are available from the**
428 **corresponding author on reasonable request.**

429

430 **Competing Interests**

431 Marina Otten is a co-author of the German AWMF guideline on teledermatology.

432 Patrick Reinders declares no conflicts of interest.

433 Matthias Augustin is a co-author of the German AWMF guideline on teledermatology and a
434 scientific advisor for the teledermatology platforms derma2go AG, A+ Videoclinic GmbH, and
435 Novartis Pharma GmbH.

436

437 **Funding**

438 This research project was financially supported by a research grant from Novartis Pharma GmbH.
439 Novartis did not influence the design, data collection, analysis, publication decision, or
440 development of this study.

441

442 **Author's contributions**

443 **PR and MO conceptualized the questionnaire and methodology jointly, supported by MA's**
444 **expert knowledge. MA, MO, and PR facilitated contact with patient organizations. PR analysed**
445 **and interpreted the data, supported by MA and MO's expert knowledge. PR wrote the first**
446 **draft of the manuscript. MO and MA reviewed and revised the manuscript. PR administrated**
447 **the project and MO supervised it. All authors read and approved the final manuscript.**

448 **Acknowledgements**

449 The authors thank the Scientific Communication Team of the IVDP, in particular Paula Willer, for
450 copy editing. We acknowledge financial support from the Open Access Publication Fund of UKE
451 – University Medical Center Hamburg-Eppendorf.

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607 **Tables**

608 **Table 1** Sociodemographic Characteristics of the Total Study Population and Identified Clusters

	Total Study Population* (n = 344)	Digital Sceptics (Cluster 1) (n = 49)	Cautious Adopters (Cluster 2) (n = 106)	Digital Enthusiasts (Cluster 3) (n = 98)	Adopters Unsure About Impact (Cluster 4) (n = 62)	p
Age in years, n (%)						<0.001
18–44	105 (31.5)	9 (18.4)	38 (35.8)	42 (44.7)	14 (23.3)	
45–64	147 (44.1)	18 (36.7)	49 (46.2)	43 (45.7)	29 (48.3)	
65+	81 (24.3)	22 (44.9)	19 (17.9)	9 (9.6)	17 (28.3)	
Missing	11	0	0	4	2	
Mean (SD)	52.5 (14.8)	59.2 (13.0) ^{b,c}	49.8 (14.5) ^a	47.1 (13.8) ^{a,d}	55.5 (13.6) ^c	<0.001
Sex, n (%)						0.45
Female	247 (74.0)	35 (72.9)	84 (80.0)	68 (71.6)	43 (70.5)	
Male	87 (26.0)	13 (27.1)	21 (20.0)	27 (28.4)	18 (29.5)	
Missing	10	1	1	3	2	
Regional variation, n (%)						
Urban or city	245 (75.9)	38 (82.6)	77 (74.8)	66 (72.5)	46 (75.7)	0.62
Rural county	78 (24.1)	8 (17.4)	26 (25.2)	25 (27.5)	14 (23.3)	
Missing, n	21	3	3	7	2	
Education, n (%)						<0.001
Low	28 (8.1)	6 (12.5)	11 (10.9%)	8 (8.2%)	1 (1.8%)	
Medium	106 (30.8)	20 (41.7)	43 (42.6)	21 (21.4)	15 (26.3)	

High	192 (58.9)	22 (45.8)	47 (46.5)	69 (70.4)	41 (71.9)	
Missing	18	1	5	0	5	
Indication, n (%)						
Psoriasis	134 (39.0)	23 (46.9)	37 (34.9)	26 (26.5)	31 (50.0)	0.010
Atopic dermatitis	80 (23.3)	16 (32.7)	23 (21.7)	22 (22.4)	13 (21.0)	0.43
Vitiligo	31 (9.0)	4 (8.2)	10 (9.4)	9 (9.2)	5 (8.1)	0.98
Skin cancer	26 (7.6)	2 (4.1)	8 (7.5)	12 (12.2)	3 (4.8)	0.23
Hidradenitis suppurativa	73 (21.2)	4 (8.2)	27 (25.5)	29 (29.6)	12 (19.4)	0.025
Time since the first diagnosis in years, n (%)						0.010
0–4	66 (21.8)	4 (8.9)	24 (24.2)	30 (30.9)	8 (12.9)	
5–9	40 (13.2)	3 (6.7)	15 (15.2)	14 (14.4)	8 (12.9)	
10 +	197 (65.0)	38 (84.4)	60 (60.6)	53 (54.6)	46 (74.2)	
Missing	18	4	7	1	0	
Mean, SD	23.9 (19.5)	34.7 (21.2) ^{b,c}	23.0 (19.7) ^a	17.8 (17.1) ^{a,d}	26.9 (17.6) ^c	<0.001
General health perception (SF-36; 1 Item), n (%)						0.20
Excellent or Very good	62 (18.0)	5 (10.2)	16 (15.1)	24 (24.5)	14 (22.6)	
Good	152 (44.2)	23 (46.9)	48 (45.3)	35 (35.7)	30 (48.8)	
Fair or poor	126 (36.6)	21 (42.9)	42 (39.6)	39 (39.8)	18 (29.0)	
Missing	4	0	0	0	0	

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aDifferent from Cluster 1 (Digital Sceptics), P<.05.

611 bDifferent from Cluster 2 (Cautious Adopters), $P < .05$.

612 cDifferent from Cluster 3 (Digital Enthusiasts), $P < .05$.

613 dDifferent from Cluster 4 (Adopters Unsure About ImpactAdopters Unsure About Impact), $P < .05$

614 *29 participants could not be used in the cluster analysis because of missing values of the mean scores

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630 **Table 2** Differences in Identified Subscales Between Clusters

	Total	Digital	Cautious	Digital	Adopters	p-Value
	Study	Sceptics	Adopters	Enthusiasts	Unsure	(ANOVA)
	Population	(Cluster 1)	(Cluster 2)	(Cluster 3)	About	
	(n = 344)*	(n = 49)	(n = 106)	(n = 98)	Impact	
					(Cluster 4)	
					(n = 62)	
Mean, SD						
Factor 1:						
Acceptability of DHIs and Trust	3.9 (0.7)	2.8 (0.6) ^{b,c,d}	3.9 (0.4) ^{a,c}	4.5 (0.3) ^{a,b,d}	3.9 (0.6) ^{a,c}	<0.001
Factor 2: Patients'						
Digital Health Competencies	4.0 (0.7)	3.2 (0.7) ^{b,c,d}	3.8 (0.5) ^{a,c,d}	4.5 (0.4) ^{a,b}	4.3 (0.5) ^{a,b}	<0.001
Factor 3: Digital						
Health Insecurities	2.4 (0.4)	3.0 (0.6) ^{c,d}	2.9 (0.5) ^{c,d}	1.8 (0.5) ^{a,b}	1.7 (0.4) ^{a,b}	<0.001
Factor 4: Positive						
Impact of DHIs	3.6 (1.0)	2.2 (0.6) ^{b,c,d}	3.8 (0.5) ^{a,c,d}	4.5 (0.5) ^{a,b,d}	2.8 (0.6) ^{a,b,c}	<0.001

631 aDifferent from Cluster 1 (Digital Sceptics), P<.05.

632 bDifferent from Cluster 2 (Cautious Adopters), P<.05.

633 cDifferent from Cluster 3 (Digital Enthusiasts), P<.05.

634 dDifferent from Cluster 4 (Adopters Unsure About Impact), P<.05

635 *29 participants could not be used in the cluster analysis because of missing values of the mean scores

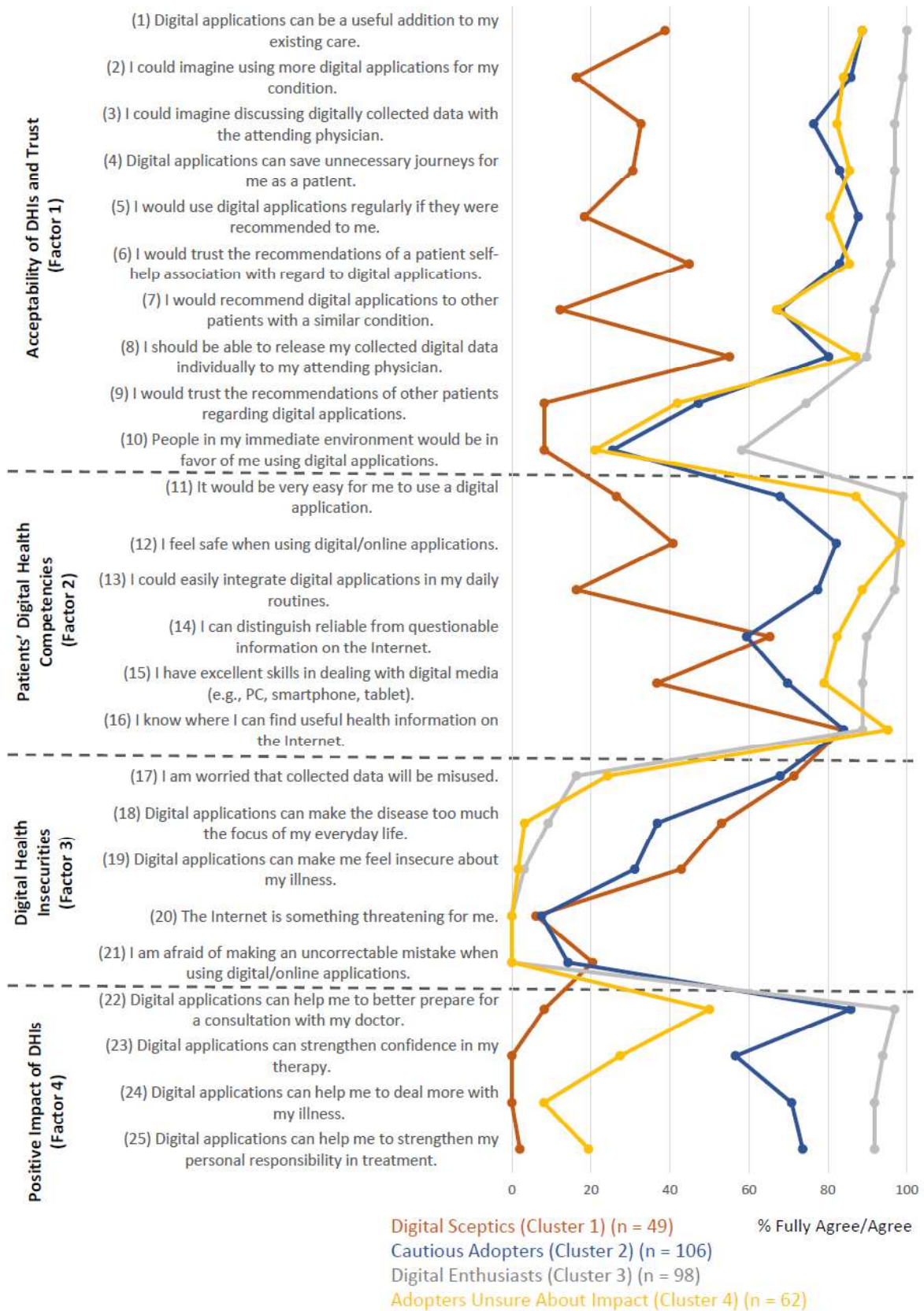
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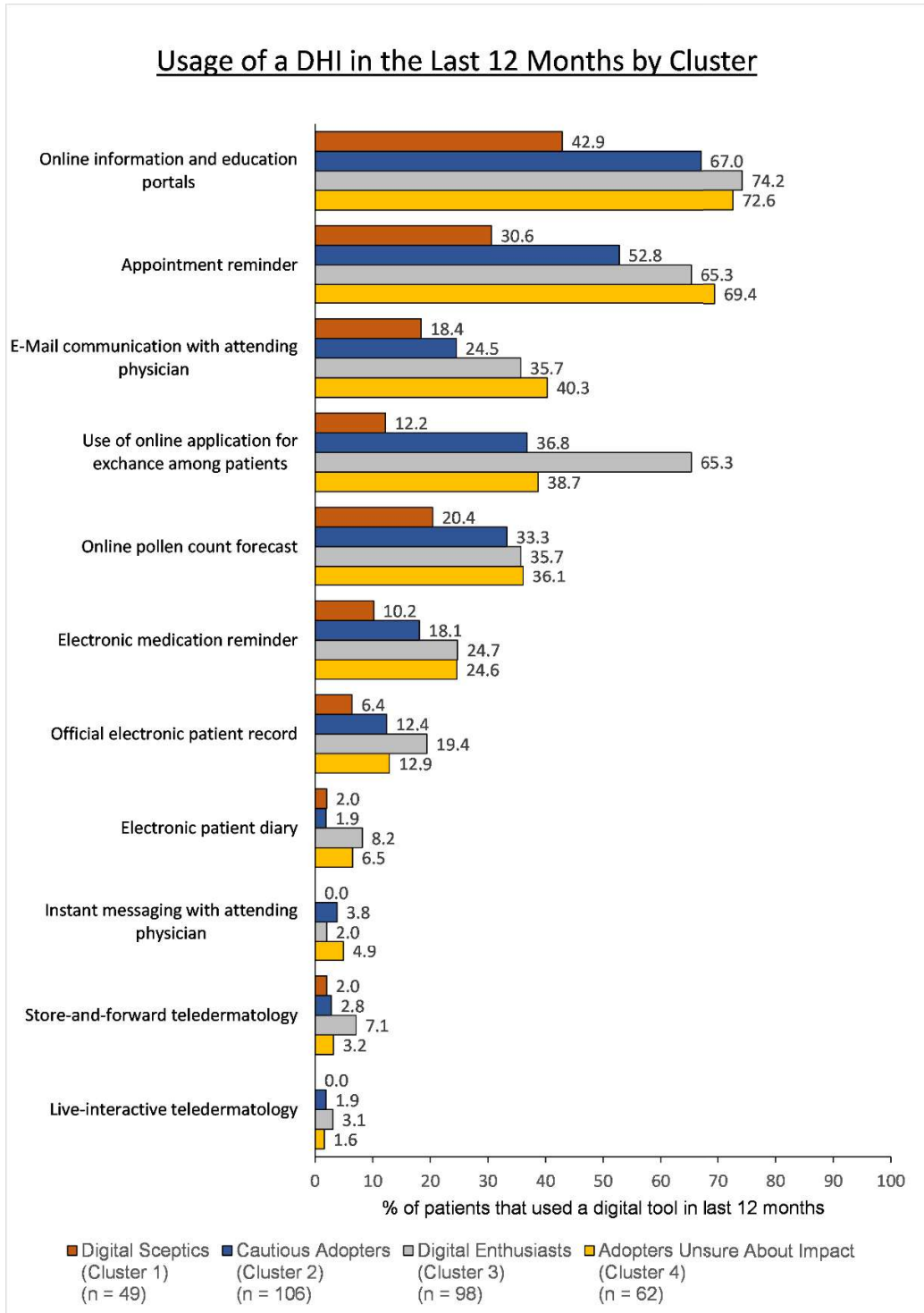
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639 **Figure titles**

640 **Figure 1** Cluster Profile Analysis at the Item-By-Item Level.



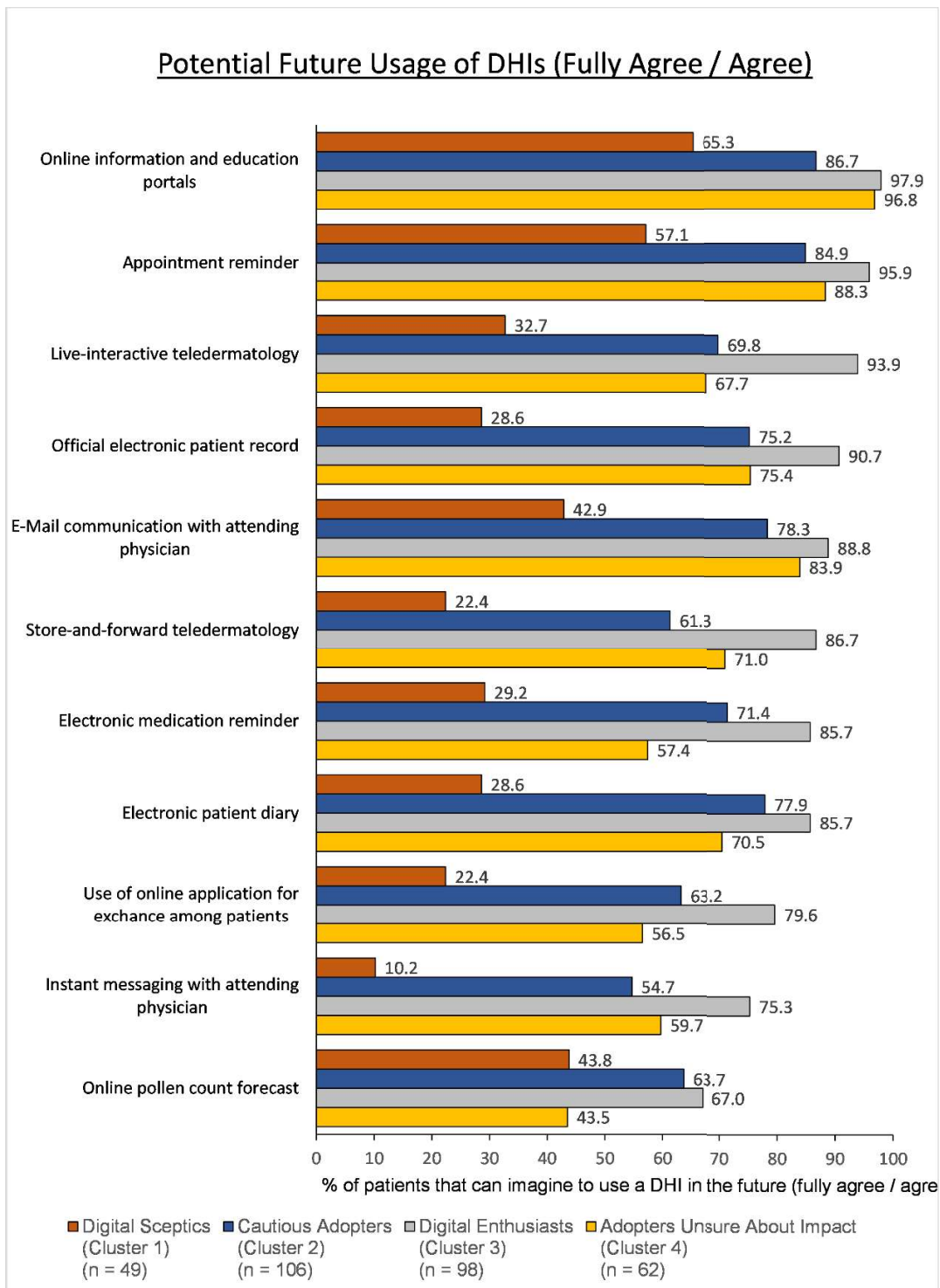
642 **Figure 2** Usage of a DHI in the Last 12 Months by Cluster.



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645 **Figure 3** Potential Future Usage of DHIs.



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647 **Additional files**

648 **File formats:** .docx

649 **Supplement 1** Checklist for Reporting Of Survey Studies (CROSS)

650 **Supplement 2** Overview of the Items of the Survey

651 **Supplement 3** Results of the Exploratory Factor Analysis

2.5. Publikation 5

Augustin M, Reinders P, Janke TM, et al. *Attitudes Toward and Use of eHealth Technologies Among German Dermatologists: Repeated Cross-Sectional Survey in 2019 and 2021*. J Med Internet Res. 2024;26:e45817. Published 2024 Feb 12. doi:10.2196/45817

Original Paper

Attitudes Toward and Use of eHealth Technologies Among German Dermatologists: Repeated Cross-Sectional Survey in 2019 and 2021

Matthias Augustin^{1*}, MD; Patrick Reinders^{1*}, MSc; Toni Maria Janke¹, MSc; Klaus Strömer², MD; Ralph von Kiedrowski³, MD; Natalia Kirsten¹, MD; Alexander Zink⁴, PD; Marina Otten¹, PhD

¹Institute for Health Services Research in Dermatology and Nursing (IVDP), University Medical Center Hamburg-Eppendorf (UKE), Hamburg, Germany

²Private Dermatological Practice, Ahaus, Germany

³Dermatology Specialty Practice, Selters, Germany

⁴Department of Dermatology and Allergy, School of Medicine Technical University of Munich, Munich, Germany

*these authors contributed equally

Corresponding Author:

Patrick Reinders, MSc

Institute for Health Services Research in Dermatology and Nursing (IVDP)

University Medical Center Hamburg-Eppendorf (UKE)

Martinstraße 52

Hamburg, 20251

Germany

Phone: 49 40741024721

Email: p.reinders@uke.de

Abstract

Background: In recent years, legal and infrastructural conditions have been set to improve the adoption of digital applications in health care in Germany. The impact of these actions was amplified by the COVID-19 pandemic. So far, no studies have confirmed this progress in dermatology.

Objective: The aim of this study was to measure changes in knowledge, interest, expectation, and use of digital applications in health care among dermatologists in Germany in 2019 and 2021.

Methods: We administered a repeated cross-sectional survey among dermatologists in medical practices and clinics in Germany at 2 time points: t_1 (2019; before the COVID-19 pandemic) and t_2 (2021; during the COVID-19 pandemic). We used a standardized questionnaire, including items on respondents' knowledge, interest, expectation, and use of digital applications, as well as their demographics. The survey was distributed by post and email. The data were analyzed descriptively as well as with multiple logistic regressions.

Results: At t_1 , 585 (272/571, 47.6% female; mean age 52.4, SD 8.9 years) dermatologists and at t_2 , 792 (360/736, 48.9% female; mean age 54.3, SD 8.6 years) dermatologists participated in this survey. Interest in digital medicine was higher at t_1 than at t_2 (381/585, 65.1% vs 458/792, 57.8%; $P \leq .001$). Nevertheless, 38.6% (306/792) had used digital applications more often since the beginning of the pandemic. For example, real-time telemedicine with patients (12/585, 2.1% vs 160/792, 7.6%; $P \leq .001$) and other specialists did increase (33/385, 5.7% vs 181/792, 22.8%; $P \leq .001$). Almost one-third expressed great concerns about digitalization (272/792, 34.3% vs 294/792, 37.1%; $P = .21$). Spatial analysis revealed higher interest in, more positive expectations toward, and higher use of digital applications in urban areas in comparison to rural areas. For instance, dermatologists from urban areas assessed future applications as having less risk (adjusted odds ratio [aOR] 0.51, 95% CI 0.35-0.76) than did dermatologists from rural areas. The situation was similar with the age groups, as, for example, dermatologists aged <50 years also expected lower risks (aOR 0.51, 95% CI 0.34-0.77) than those aged ≥ 50 years. There were no differences between sexes in use, but there were differences in knowledge and expectation; for example, male participants assessed their confidence in using digital applications as higher (aOR 1.44, 95% CI 1.01-2.04) than did female participants.

Conclusions: During the pandemic, the use of digital applications in dermatology increased but still remained at a moderate level. The regional and age-related disparities identified indicate the need for further action to ensure equal access to digital care.

KEYWORDS

acceptance; adoption; attitude; COVID-19; dermatology; digital medicine; digitalization; pandemic; perception; teledermatology; telehealth; telemedicine

Introduction

Digital health, or eHealth, can improve the effectiveness, efficiency, and equity in the delivery of health care services. The term was defined by the World Health Organization (WHO) and encompasses traditional information and communication technologies, mobile phone-based apps, artificial intelligence (AI), and computer science-driven genomics in health care [1]. Many digital health applications are nowadays established in health care environments in Europe, ranging from administrative solutions, such as practice or hospital information systems, to telemedical applications in some medical areas (eg, radiology) [2,3].

In terms of health care digitalization, Germany, along with France and Poland, is lagging behind other European countries [4]. Therefore, many legal and reimbursement conditions have been set to foster a nationwide implementation of digital health, for example, the eHealth Act in 2016 [5-8]. These initiatives enabled the reimbursement of video consultations in 2019, following the eased ban on remote treatments in 2018 [9]. Another initiative from 2019 enabled the introduction of digital health applications (Digitale Gesundheitsanwendungen; DiGAs). DiGAs are medical device-classified smartphone apps or web applications that practitioners can prescribe for patients. In terms of digital infrastructure, the nationwide telematics infrastructure (TI) is another important key element in health care digitalization in Germany. The TI aims to network all health care providers (eg, clinics, pharmacies, and outpatient practices) and thereby foster efficiency in the system by making patient data more easily available for all stakeholders [10].

Dermatology is a visual field enabling the adoption of applications such as AI, teledermatology, or patient monitoring for chronic dermatological diseases [9,11-13]. The implications of the COVID-19 pandemic rapidly amplified the adoption and use of digital applications in dermatology worldwide, but also in Germany. For example, every third German dermatologist used some form of teledermatology in May 2020, and of those, 75% had introduced it during the pandemic [14]. Yet, limited data are available on the actual uptake and acceptance of digitalization in dermatology in Germany.

Therefore, the primary aim of our survey was to measure developments in knowledge, interest, expectation, and use of digital applications among dermatologists in practices and clinics from 2019 to 2021, that is, before and after the onset of the pandemic. Our secondary aim was to analyze age, sex, and regional differences on these factors in 2021.

Methods

Study Design and Questionnaire

The Consensus-Based Checklist for Reporting of Survey Studies (CROSS) [15] was used for reporting this study. In June 2019 (t_1), an anonymous, quantitative cross-sectional survey both on the web [16] and offline through a paper-based version was conducted among all German dermatologists that provided care in medical practices and clinics. The questionnaire contained items on knowledge, interest, expectation, and use of digital applications. The following demographic data were collected: the dermatologist's age, sex, and postal code of the office or clinic. The survey was also conducted in June 2021 (t_2), including a few additional items; the t_1 survey had 23 items, while the t_2 survey had 29 items (23 items were identical to t_1 and 6 items were related to developments due to the COVID-19 pandemic, medical device-classified smartphone apps, ie, DiGAs, AI, the electronic health care professional card [elektronischer Heilberufsausweis; eHBA], and the physician's place of work (outpatient medical practice or hospital clinic).

The majority of items were on a 5-point Likert scale. Further items with 2-4 response categories were used (eg, great importance, moderate importance, and no importance). The full questionnaires are provided in [Multimedia Appendix 1](#). Participants had the opportunity to provide written reasons for their responses.

Study Population, Recruitment, and Data Entry

At both time points, all members of the Federal Association of German Dermatologists (BVDD) and the German Dermatological Society (DDG) providing care in medical practices and clinics were invited to anonymously answer one of the questionnaires (on the web or offline). During the recruitment period of 4 weeks, the dermatologists received multiple reminders for participation. The total pool of addresses in both years was approximately 5900 dermatologists, but this also included members who did not practice dermatologic care anymore or had an outdated address. After considering 350 undeliverable mails or emails and an additional 30% of retirees or nonactive dermatologists in the pool, we assumed a sample of 3500 active dermatologists. No sample size calculation was conducted. To reduce errors in data entry regarding the paper-based questionnaires, 25% of all data entries were randomly checked. No errors were identified. During data cleaning, we also checked demographics for duplicates in the web-based survey-generated data.

Statistical Analysis

Statistical analysis was performed with SPSS (version 27; IBM Corporation) for Windows, starting with descriptive statistics. For items with more than 2 answer categories, responses were binary-coded: for items with 5 answer categories, "very often"

and “often” were coded as 1, while “rarely,” “never, but planned,” and “never, not planned” were coded as 2; for items with 4 answer categories, “yes and “no, but ordered” were coded as 1, while “no, not ordered” and “no, I reject a connection” were coded as 2; for items with 3 answer categories, “great importance” was coded as 1, while “moderate importance” and “no importance” were coded as 2.

Based on the postal code, participants were assigned to urban and rural regions using data from the Federal Institute for Research on Building, Urban Affairs, and Spatial Development (Bundesinstitut für Bau-, Stadt- und Raumforschung; BBSR) [17]. Age was categorized as 25-39 years, 40-49 years, 50-59 years, 60-66 years, and ≥ 67 years. For subgroup analysis, age was binary coded: ≥ 50 years and < 50 years.

To test for differences between t_1 and t_2 (the primary aim of the study), t tests (2-tailed) for interval-scaled variables and chi-square tests for ordinal and nominal-scaled variables were performed (significance level of $P=.05$). Due to the exploratory nature of this research, no correction of the P value for multiple testing (eg, Bonferroni adjustment) was applied to prevent an increased likelihood of type II errors [18,19]. Additional adjustment for demographic and geographic differences between t_1 and t_2 was done through multivariate logistic regression models. Each model included age, sex, urban or rural area, and

type of survey (paper or internet-based). Derived from the models, adjusted odds ratios (aORs) and the associated 95% CI are presented. Items that were introduced at t_2 were analyzed descriptively.

To reach the secondary aim of the study, unadjusted differences between subgroups (age ≥ 50 vs < 50 years, sex, and urban or rural) were calculated at t_2 . Additionally, aORs and 95% CI were obtained using logistic regressions.

Missing Data

Missing data are reported for items with a rate $> 5\%$. We identified high missing values for some variables (age, sex, and region; Table 1). The Little test of missingness [20] was performed and was significant ($\chi^2_{3072}=3,704,038$; $P<.001$). Hence, it was assumed that data were not missing completely at random but were missing at random [20,21]. As recommended, 20 data sets were imputed with fully conditional specification through the multiple imputation algorithm within SPSS (version 22) [22]. Thereby, linear regression was used for age, and logistic regressions were used for binary-coded variables (eg, urban or rural and sex), using all variables. After imputation, all analyses were run on each data set, and the results were pooled in accordance with the Rubin rules [23]. As there were minimal differences in the distribution of values before and after imputation, the imputed values are reported.

Table 1. Demographic and geographic distribution of participating dermatologists at both time points.

	t ₁ (June 2019; n=585)	t ₂ (June 2021; n=792)	P value
Age (years), mean (SD)	52.4 (8.9)	54.3 (8.6)	<.001 ^a
Age groups (years), n (%)			<.001 ^b
25-39	51 (9.3)	40 (5.6)	
40-49	139 (25.5)	162 (22.6)	
50-59	241 (44.1)	294 (41.2)	
60-66	95 (17.4)	181 (25.4)	
≥67	20 (3.7)	37 (5.2)	
Missing values	40 (6.8)	78 (9.9)	
Sex, n (%)			
Female participants	272 (47.6)	360 (48.9)	.64 ^b
Missing values	14 (2.4)	56 (7.1)	
Activity, n (%)			
Activity in outpatient medical practice	N/A ^c	640 (87.9)	
Missing values	N/A ^c	60 (7.6)	
Region, n (%)			
Participants from urban areas	398 (76)	471 (76.1)	.97 ^b
Participants from eastern federal states	112 (21.4)	130 (21)	.83 ^b
Missing values	62 (10.6)	173 (21.8)	
Web-based participation, n (%)	284 (48.5)	261 (33)	<.001 ^b

^a2-tailed *t* tests were performed.

^bChi-square tests were performed.

^cN/A: not applicable; item was first introduced in 2021.

Ethical Considerations

For this study, no ethical review was necessary as the study was anonymous and noninterventional. The Ethics Committee of the Medical Association in Hamburg states that no ethical approval is necessary for studies in which data have already been collected anonymously (Ethik-Kommission; Sonstige Studien: Ärztekammer Hamburg [24]). The study was conducted in accordance with the principles of the Declaration of Helsinki and the Guidelines for Good Clinical Practice.

Results

At t₁, a total of 585 dermatologists participated, and at t₂, a total of 792 dermatologists participated in the survey (Table 1). Considering approximately 3500 eligible dermatologists in both years, the participation rate is thereby estimated to be 16.7% (585/3500) and 22.6% (792/3500), respectively.

Sex and geographic distribution were comparable (no significant differences) between the 2 time points (Table 1), except for a mean age difference of 1.9 years between t₁ and t₂ (*P*≤.001). There was also a significant difference in the mode of participation: while in 2019, about 48.5% (284/585)

dermatologists participated through the web-based survey, only 32.9% (261/792) did so in 2021 (*P*≤.001).

Most dermatologists expressed interest in digital medicine in both years, and half of them also felt confident in using it, but interest (381/585, 65.1% vs 458/792, 57.8%; *P*<.001) and confidence (297/585, 50.7% vs 333/792, 42.1%; *P*=.002) significantly decreased from t₁ to t₂ (Figure 1). The self-assessed knowledge of digital medicine was rather low in both years (228/585, 38.9% vs 272/792, 34.4%; *P*=.08).

The importance of the digital transformation within the health care system was rated highly by the participants. Yet a slight negative trend was noticed (t₁: 400/585, 68.3% vs t₂: 492/792, 62.1%; *P*=.03) (Figure 1). For around one-third of participants, digital medicine harbors a high risk (t₁: 201/585, 34.3% vs t₂: 294/792, 37.1%; *P*=.21) and supports daily activities (223/585, 38.2% vs 304/792, 38.4%; *P*=.93). Only a small number of dermatologists had read the guideline on teledermatology (t₁: 95/585, 16.2% vs t₂: 148/792, 18.7%; *P*=.40). DiGAs were seen as important in the future by 38.2% (303/792) of participants at t₂.

The most often used digital applications in dermatology at both survey time points were those ensuring asynchronous

communication (store-and-forward) with patients (t_1 : 253/585, 43.2% and t_2 : 348/792, 44%; $P=.54$) and other specialists (t_1 : 273/585, 46.7% and t_2 : 359/792, 45.3%; $P=.58$). Real-time video consultation with a patient was used 4 times more frequently in 2021 compared with 2019 but was still used rarely (t_1 : 12/585, 2.1%, and t_2 : 60/792, 7.6%; aOR 4.00, 95% CI 2.12-7.52) (Figure 1). Real-time communication with other specialists was used nearly 6 times more often (t_1 : 33/585, 5.7%, and t_2 : 181/792, 22.8%; $P<.001$). Remote patient monitoring (22/585, 3.8% vs 55/792, 7%; $P=.02$) and electronic appointment reminders (t_1 : 121/585, 20.6% vs t_2 : 212/792, 26.8%; $P=.02$) were also used more regularly by dermatologists in 2021. In contrast, electronic physician letters were sent significantly less often in 2021 compared with 2019 (t_1 : 122/585, 20.8% vs t_2 : 105/792, 13.3%; $P<.001$). Incorporation of web-based patient data into patient care was rarely used at both time points (t_1 : 25/585, 4.2% vs 38/792, 4.8%; $P=.57$) (Figure 1).

Connection to the nationwide TI has progressed further, with 79% (626/792) of participants being connected or having requested a connection in comparison to 66.5% (389/792) in 2019 ($P<.001$). The eHBA was available or at least requested by 80.3% (636/792), and AI methods for diagnosing were used by 21.4% (169/792) of participating dermatologists at t_2 . For the last 2 items, no data were available for t_1 .

According to respondents, 38.6% (306/792) had used digital medicine procedures more frequently since the onset of the

COVID-19 pandemic. Of these, 92.4% (283/306) estimated to make at least partial continued use of the newly introduced digital applications.

Younger dermatologists indicated higher interest, knowledge, and confidence in using digital applications (aORs in Table 2). They saw more of a benefit in using applications for their daily activities than older dermatologists. Younger participants also used asynchronous communication methods with patients and physicians and electronic appointment reminders for patients more often, whereas older dermatologists more often expected high risks regarding the implementation of digital medicine.

Participants practicing in urban areas had a higher likelihood of reporting a good level of knowledge, interest, and confidence in using digital applications (aORs in Table 3). Furthermore, they used many of the digital applications more often, including asynchronous communication with patients and colleagues and electronic patient reminders, and rated the risks associated with digital medicine as lower. In contrast, they were less likely connected to the TI.

Only a few significant differences in sexes were identified (aORs in Table 4). Male dermatologists were more likely than female dermatologists to state a good level of knowledge and confidence in using digital applications. Female dermatologists more often expected the great importance of DiGAs and the digital transformation in the future.

Figure 1. Forrest plot depicting the development of knowledge, use, and expectations of digital medicine in dermatology. Odds ratios were adjusted using logistic regressions for age groups (25-39, 40-49, 50-59, 60-66, and ≥ 67 years), sex (male or female), and region (urban or rural). The values in bold are significant. A chi-square test was performed to obtain P values. Percentages present crude or unadjusted values.

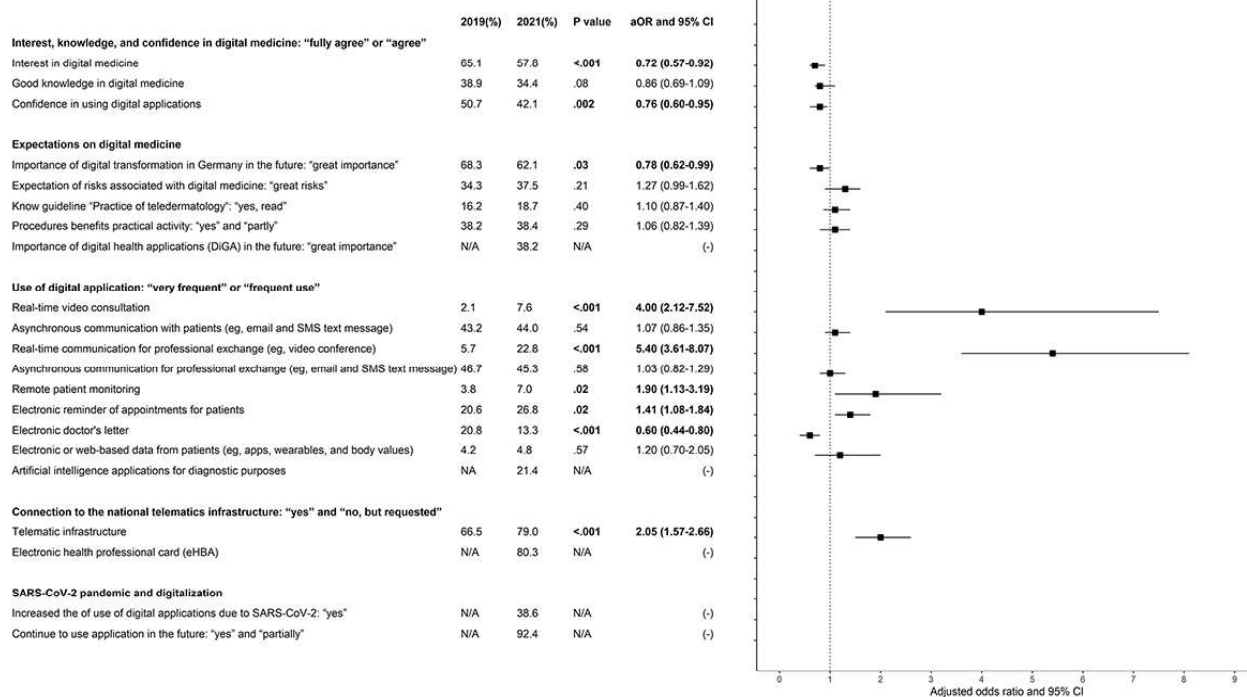


Table 2. Adjusted odds ratios (aORs) for associations between age groups (≥ 50 years vs < 50 years) and knowledge, interest, expectation, and use of digital applications in dermatology (survey date: 2021). The values in italics are significant.

	Age ≥ 50 years (n=566 ^a), n (%) ^b	Age < 50 years (n=223 ^a), n (%) ^b	P value ^{c,b}	aOR (95% CI) for age ≥ 50 / < 50 years; reference ≥ 50 years ^d
Interest, knowledge, and confidence in digital medicine: “fully agree” or “agree”				
Interest in digital medicine	304 (53.7)	158 (70.9)	<i><.001</i>	2.15 (1.47-3.15)
Good knowledge of digital medicine	180 (31.8)	96 (43.0)	<i><.001</i>	1.78 (1.25-2.54)
Confidence in using digital applications	220 (38.9)	118 (52.9)	<i><.001</i>	1.91 (1.33-2.72)
Use of digital application: “very frequent” or “frequent”				
Real-time video consultation	40 (7.1)	22 (9.9)	.24	1.29 (0.68-2.46)
Asynchronous communication with patients (eg, email and SMS text message)	235 (41.5)	121 (54.3)	<i><.001</i>	1.65 (1.16-2.34)
Real-time communication for professional exchange (eg, video conference)	118 (20.8)	66 (29.6)	<i><.001</i>	1.45 (0.98-2.47)
Asynchronous communication for professional exchange (eg, email and SMS text message)	237 (41.9)	127 (57.0)	<i><.001</i>	1.73 (1.23-2.44)
Remote patient monitoring	36 (6.4)	20 (9.0)	.22	1.47 (0.72-2.99)
Electronic reminder of appointments for patients	140 (24.7)	77 (34.5)	.005	1.63 (1.11-2.38)
Electronic doctor’s letter	77 (13.6)	32 (14.3)	.62	0.97 (0.56-1.67)
Electronic or web-based data from patients (eg, apps, wearables, and body values)	26 (4.6)	13 (5.8)	.28	1.63 (0.70-3.83)
Artificial intelligence applications for diagnostic purposes	115 (20.3)	52 (23.3)	.35	1.07 (0.72-1.60)
Expectations of digital medicine				
Importance of digital transformation in Germany in the future: “great importance”	341 (60.2)	159 (71.3)	.007	1.43 (0.98-2.10)
Expectation of risks associated with digital medicine: “great risks”	247 (42.6)	58 (26.0)	<i><.001</i>	0.51 (0.34-0.77)
Know guideline “Practice of teledermatology:” “yes, read”	117 (20.7)	34 (15.2)	.10	0.85 (0.51-1.40)
Procedures benefits practical activity: “yes” and “partly”	222 (39.2)	118 (52.9)	<i><.001</i>	1.68 (1.19-2.39)
Importance of digital health applications (DiGA ^e) in the future: “great importance”	211 (37.3)	90 (40.4)	.43	0.97 (0.68-1.38)
Connection to the national telematics infrastructure: “yes” and “no, but requested”				
Telematic infrastructure	473 (83.6)	173 (77.6)	.08	0.75 (0.47-1.18)
Electronic health professional card (eHBA ^f)	461 (81.4)	171 (76.7)	.09	0.82 (0.52-1.31)
SARS-CoV-2 pandemic and digitalization				
Increased the use of digital applications due to SARS-CoV-2: “yes”	184 (32.5)	111 (49.8)	<i><.001</i>	1.85 (1.26-2.71)
Continue to use application in the future: “yes” and “partially”	173 (94.0)	104 (93.7)	.78	0.91 (0.28-2.93)

^aDoes not add up to the overall total of 792, as data for an average of 3 participants were not imputed.

^bUnadjusted or crude values.

^cChi-square tests were performed.

^dLogistic regressions were performed. Following items were included as independent variables: sex (male or female) and regional allocation (urban or rural).

^eDiGAs: Digitale Gesundheitsanwendungen.

^feHBA: elektronischer Heilberufsausweis.

Table 3. Adjusted odds ratios (aORs) for associations between region (urban or rural) and knowledge, interest, expectation, and use of digital applications in dermatology (survey date: 2021). The values in italics are significant.

	Urban (n=600), n (%) ^a	Rural (n=192), n (%) ^a	P value ^b	aOR (95% CI) for urban/rural; reference: rural ^c
Interest, knowledge, and confidence in digital medicine: “fully agree” or “agree”				
Interest in digital medicine	372 (62)	91 (47.4)	<.001	1.70 (1.17-2.47)
Good knowledge of digital medicine	228 (38)	50 (26)	.01	1.64 (1.06-2.49)
Confidence in using digital applications	279 (46.5)	61 (31.8)	.002	1.73 (1.17-2.58)
Use of digital application: “very frequent” or “frequent”				
Real-time video consultation	55 (9.2)	7 (3.6)	.05	2.68 (0.95-7.51)
Asynchronous communication with patients (eg, email and SMS text message)	295 (49.2)	63 (32.8)	.01	1.79 (1.20-2.68)
Real-time communication for professional exchange (eg, video conference)	154 (25.7)	30 (15.6)	.02	1.90 (1.13-3.17)
Asynchronous communication for professional exchange (eg, email and SMS text message)	297 (49.5)	70 (36.5)	<.001	1.62 (1.10-2.39)
Remote patient monitoring	45 (7.5)	12 (6.3)	.58	1.19 (0.56-2.52)
Electronic reminder of appointments for patients	185 (30.8)	33 (17.2)	<.001	2.01 (1.24-3.27)
Electronic doctor’s letter	89 (14.8)	20 (10.4)	.22	1.54 (0.83-2.86)
Electronic or web-based data from patients (eg, apps, wearables, and body values)	32 (5.3)	8 (4.2)	.51	1.31 (0.49-3.56)
Artificial intelligence applications for diagnostic purposes	132 (22.0)	38 (19.8)	.52	1.12 (0.70-1.82)
Expectations of digital medicine				
Importance of digital transformation in Germany in the future: “great importance”	400 (66.7)	104 (54.2)	<.001	1.64 (1.08-2.48)
Expectation of risks associated with digital medicine: “great risks”	205 (34.2)	101 (52.6)	<.001	0.51 (0.35-0.76)
Know guideline “Practice of teledermatology:” “yes, read”	84 (14.0)	25 (13.0)	.79	1.23 (0.74-2.08)
Procedures facilitate practical activity: “yes” and “partly”	270 (45.0)	72 (37.5)	.10	1.28 (0.86-1.93)
Importance of digital health applications (DiGA ^d) in the future: “great importance”	185 (39.8)	48 (33.3)	.14	1.30 (0.87-1.95)
Connection to the national telematics infrastructure: “yes” and “no, but requested”				
Telematic infrastructure	473 (78.8)	175 (91.1)	<.001	0.37 (0.21-0.68)
Electronic health professional card (eHBA ^e)	471 (78.5)	163 (84.9)	.06	0.61 (0.35-1.31)
SARS-CoV-2 pandemic and digitalization				
Increased the use of digital applications due to SARS-CoV-2: “yes”	237 (39.5)	59 (30.7)	.05	1.37 (0.91-2.06)
Continue to use application in the future: “yes” and “partially”	221 (93.2)	57 (96.6)	.50	0.63 (0.14-2.95)

^aUnadjusted or crude values.^bChi-square tests were performed.^cLogistic regressions were performed. Following items were included as independent variables: age (≥50 years or < 50 years) and sex (male or female).^dDiGAs: Digitale Gesundheitsanwendungen.^eeHBA: elektronischer Heilberufsausweis.

Table 4. Adjusted odds ratios (aORs) for associations between sex and knowledge, interest, expectation, and use of digital applications in dermatology (survey date: 2021). The values in italics are significant.

	Female (n=388), n (%) ^a	Male (n=404), n (%) ^a	P value ^b	aOR (95% CI) for male/female; refer- ence: female ^c
Interest, knowledge, and confidence in digital medicine: “fully agree” or “agree”				
Interest in digital medicine	224 (57.7)	240 (59.4)	.94	1.22 (0.87-1.74)
Good knowledge of digital medicine	<i>119 (30.7)</i>	<i>158 (39.1)</i>	.02	<i>1.71 (1.18-2.46)</i>
Confidence in using digital applications	154 (39.7)	186 (46.0)	.09	<i>1.44 (1.01-2.04)</i>
Use of digital application: “very frequent” or “frequent”				
Real-time video consultation	31 (8.0)	31 (7.7)	.86	1.01 (0.52-1.97)
Asynchronous communication with patients (eg, email and SMS text message)	174 (44.8)	184 (45.5)	.86	1.19 (0.84-1.67)
Real-time communication for professional exchange (eg, video conference)	100 (25.8)	85 (21.0)	.10	0.79 (0.53-1.19)
Asynchronous communication for professional exchange (eg, email and SMS text message)	187 (48.2)	179 (44.3)	.24	0.92 (0.65-1.29)
Remote patient monitoring	30 (7.7)	27 (5.7)	.45	0.94 (0.48-1.86)
Electronic reminder of appointments for patients	98 (25.3)	119 (29.5)	.34	1.35 (0.92-1.98)
Electronic doctor’s letter	53 (13.7)	56 (13.7)	.89	0.79 (0.48-1.31)
Electronic or web-based data from patients (eg, apps, wearables, and body values)	16 (4.1)	23 (5.7)	.30	1.57 (0.69-3.57)
Artificial intelligence applications for diagnostic purposes	93 (24.0)	77 (19.1)	.09	0.87 (0.57-1.31)
Expectations of digital medicine				
Importance of digital transformation in Germany in the future: “great importance”	<i>267 (68.8)</i>	<i>237 (58.7)</i>	.04	<i>0.67 (0.49-0.93)</i>
Expectation of risks associated with digital medicine: “great risks”	<i>132 (34.0)</i>	<i>173 (42.8)</i>	.02	1.39 (0.97-1.97)
Know guideline “Practice of tele dermatology:” “yes, read”	58 (14.9)	79 (19.6)	.09	1.32 (0.85-2.05)
Procedures eases practical activity: “yes” and “partly”	175 (45.1)	167 (41.3)	.34	1.13 (0.80-1.60)
Importance of digital health applications (DiGA ^d) in the future: “great importance”	<i>167 (43.0)</i>	<i>134 (33.2)</i>	.05	<i>0.57 (0.40-0.80)</i>
Connection to the national telematics infrastructure: “yes” and “no, but requested”				
Telematic infrastructure	322 (83.0)	326 (80.7)	.43	0.96 (0.63-1.47)
Electronic health professional card (eHBA ^e)	314 (80.9)	320 (79.2)	.41	0.97 (0.64-1.49)
SARS-CoV-2 pandemic and digitalization				
Increased the use of digital applications due to SARS-CoV-2: “yes”	<i>162 (41.8)</i>	<i>135 (33.4)</i>	.02	0.82 (0.32-2.10)
Continue to use applications in the future: “yes” and “partially”	151 (93.2)	127 (94.1)	.50	0.40 (0.13-1.28)

^aUnadjusted or crude values.^bChi-square tests were performed.^cLogistic regressions were performed. The following items were included as independent variables: age (≥ 50 years or < 50 years) and regional allocation (urban or rural).^dDiGAs: Digitale Gesundheitsanwendungen.^eeHBA: elektronischer Heilberufsausweis.

Discussion

Overview

This trend analysis is the first to measure developments in knowledge, interest, expectation, and use of digital applications

in dermatology during the events of the COVID-19 pandemic. First, we identified a moderate increase in the use rate of digital applications in dermatological care, while interest in the topic decreased slightly; one-third of practitioners expect great risks with the introduction of digital medicine. Second, we noticed regional and age-related disparities in self-assessed knowledge,

confidence, expectations of digital medicine, and the use rate of digital applications. The survey also revealed differences between sexes in self-assessed knowledge and confidence in digital medicine among dermatologists in Germany.

The decline in interest in using digital applications might be explained by the more widespread implementation of digital applications, as verified by this survey. We hypothesize that digital applications may have moved from extraordinary to ordinary daily routines, resulting in a reduction of interest. Confidence and knowledge may have declined as practitioners were more often confronted with the actual use of applications in their daily routine, potentially disclosing the limits of their knowledge in digital medicine.

Interestingly, only one-third of physicians stated that digital applications support their daily activities, which is one of the main promises of health care digitalization. The outcome could be caused by the long, costly, and not yet fully implemented nationwide eHealth initiatives in Germany [25]. The overall perception will, however, differ depending on the type of digital application. The benefit of AI for diagnostic purposes, for example, might be high, as the technology could potentially improve the efficiency of screening and the diagnostic confidence of practitioners [26].

We observed an increase in real-time communication technologies to communicate with patients and other physicians, which could also be shown by other studies [14]. Compared to the United States, where nearly 42.6% of offices stated using video consultations, this service is rarely offered by dermatologists in Germany, as identified within our results (160/792, 7.6%) [27]. Reasons for the low use may involve insufficient reimbursement for providers and a 2019-loosened ban on remote treatments, which also explains the low use rate for this year [14]. In the future, it can be assumed that video consultation with patients may decline after the pandemic fades into the background again, as the main reason for its use was protection from infections [2]. Lower use of video consultations in times of low COVID-19 infection rates could already be shown in Germany [28]. Nevertheless, it is not assumed that the use rates of video consultation will go back to the use rates of the prepandemic era.

On the contrary, the use of asynchronous communication technologies was not affected by the pandemic or other changes during the observed period, which contradicts other results from Elsner [14] at first glance, wherein 75% of dermatologists in 2020 did introduce the technology with the onset of the pandemic. Within our survey, all purposes—administrative (eg, appointments and invoices), medical-related (eg, diagnosis), and technologies (eg, email, SMS text messages, or teledermatological platforms)—were covered by the item, whereas the item in the survey by Elsner [14] was specific to store-and-forward teledermatology, so a medical-related purpose. As the number of dermatologists adopting store-and-forward teledermatology substantially increased, we assume that the purpose of asynchronous communications has partly shifted from administrative purposes to medical-related purposes with the onset of the pandemic.

In terms of the TI, dermatologists are a bit behind other specialist groups: 14% of all practitioners that responded to a nationwide survey [2] and 21% (166/792) of dermatologists within our survey are not yet connected to the TI. Regarding DiGAs, they see a similar importance to other physicians: 40% nationwide of all physicians versus 38.2% (303/792) in our survey. We found a reduction in use of the electronic physician's letter in dermatology, although most outpatient physicians stated that it eases the administrative workload in clinical practice [2].

Within the survey, age, sex, and regional differences were identified. The lower self-assessed knowledge and confidence in digital medicine by female dermatologists could be confounded by social expectations. In other areas of life, no or only marginal differences in digital literacy between sexes could be measured when accounting for education and employment status [29]. Nevertheless, female dermatologists could thus have similar knowledge of digital medicine, resulting in similar use rates, as shown.

The phenomenon of regional and age disparities, noted in our survey, has generally been noted with the advent of digitalization in all areas of life and is known as the digital divide. Thus, not only access to the internet, internet speed, and availability of appropriate hardware, but also digital competencies among practitioners and patients are related to inequalities in the use of digital tools [30]. In Germany, the average use rates of the internet, as well as digital competence and openness to use digital applications, are more pronounced in urban regions and younger age groups in comparison to rural regions and older groups [31], partially explaining the differences identified within our survey. Consequently, digital applications have the potential to increase unequal access to care, at least in the short term. To ensure equity in the delivery of care in dermatology, all disparities related to sex, age, or region should be addressed by legal, infrastructure, and reimbursement initiatives. In addition, implementation strategies for evidence-based digital applications should be customized to specific target groups [32].

The response rates of our surveys were slightly lower than in previous surveys among German dermatologists [33]. Hence, a certain selection bias among participants cannot be excluded. Considering the official physician statistics, dermatologists aged between 50 and 59 years were slightly overrepresented, whereas dermatologists aged 35 years or younger were slightly underrepresented. In addition, female dermatologists were underrepresented in the survey in comparison to the federal statistic (360/736, 48% in our survey vs 60% at the national level) [34]. Although our surveys were not representative, the sample sizes were large enough to detect trends and variations among demographic and geographic parameters. To improve comparability between survey waves, an adjustment of demographic and geographic differences was performed through multiple logistic regressions. Groups at t_1 and t_2 may differ for unmeasured characteristics (eg, professional expertise, number of consultations per week, socioeconomic patient groups in the area, and the number of private and statutory insured patients), thus resulting in underestimated or overestimated differences. Nevertheless, the same population was contacted at both time

points, and important baseline characteristics did not present any larger differences.

Conclusions

The repeated survey revealed an increase in the adoption of the majority of digital applications in dermatology, amplified by the COVID-19 pandemic. However, regional and age-related disparities in the use of digital applications exist, reducing equal access to innovative health care solutions for patients. In the future, policy strategies must be developed to counteract these

disparities and improve nationwide implementation. Developers of digital innovations should incorporate physicians' perspectives more commonly to ensure feasibility and use. Future research should support policymakers and developers by identifying barriers to implementation, monitoring disparities, and ensuring an evidence base for digital applications. Widespread implementation and acceptance among patients and physicians can then improve the efficiency, equity, and effectiveness of care.

Acknowledgments

The authors would like to thank the scientific communication team of the Institute for Health Services Research in Dermatology and Nursing, especially Merle Twesten and Mario Gehoff, for editing this manuscript.

Data Availability

The data sets generated during and/or analyzed during this study are available from the corresponding author on reasonable request.

Authors' Contributions

MA was responsible for the conceptualization, methodology, software, supervision, writing, review, and editing of this study. PR handled data curation, formal analysis, investigation, project administration, visualization, and writing the original draft. TMJ supported the formal analysis. KS, AZ, and RVK supported the conceptualization of the survey and reviewed the manuscript. NK was responsible for the methodology, writing, review, and editing of the manuscript. MO initially developed the survey and supported data curation, formal analysis, investigation, methodology, project administration, validation, visualization, writing, review, and editing of the manuscript.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Survey: Digital medicine in German dermatology practices and clinics 2019 and 2021.

[\[DOCX File, 19 KB-Multimedia Appendix 1\]](#)

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Abbreviations

AI: artificial intelligence
BBSR: Bundesinstitut für Bau-, Stadt- und Raumforschung
BVDD: Federal Association of German Dermatologists
CROSS: Consensus-Based Checklist for Reporting of Survey Studies
DDG: German Dermatological Society
DiGAs: Digitale Gesundheitsanwendungen
eHBA: elektronischer Heilberufsausweis
TI: telematics infrastructure
WHO: World Health Organization

Edited by T de Azevedo Cardoso; submitted 20.01.23; peer-reviewed by S Xu, G Tobias; comments to author 16.06.23; revised version received 29.06.23; accepted 17.10.23; published 12.02.24

Please cite as:

*Augustin M, Reinders P, Janke TM, Strömer K, von Kiedrowski R, Kirsten N, Zink A, Otten M
Attitudes Toward and Use of eHealth Technologies Among German Dermatologists: Repeated Cross-Sectional Survey in 2019 and 2021*

J Med Internet Res 2024;26:e45817

URL: <https://www.jmir.org/2024/1/e45817>

doi: [10.2196/45817](https://doi.org/10.2196/45817)

PMID:

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2.6. Publikation 6

Reinders P, Augustin M, Otten M. *General and dermatological population's use and acceptance of digital health in Germany – a representative survey*. J Deutsche Derma Gesell 2024. doi:10.1111/ddg.15454

General and dermatological population's use and acceptance of digital health in Germany – a representative survey

Patrick Reinders  | Matthias Augustin  | Marina Otten 

Institute for Health Services Research in Dermatology and the Nursing Professions (IVDP), University Medical Center Hamburg-Eppendorf (UKE), Hamburg, Germany

Correspondence

Patrick Reinders, Institute for Health Services Research in Dermatology and the Nursing Professions (IVDP), University Medical Center Hamburg-Eppendorf (UKE), Christoph-Probst-Weg 3, 20246 Hamburg, Germany.
Email: p.reinders@uke.de

Summary

Background and Objectives: Adoption and acceptance of digital health services (DHS) in the German population and in persons with skin diseases is unclear. Both factors were analyzed in this survey.

Methods: A standardized survey with items on digital competences and attitudes, use and acceptance of DHS was applied to a representative sample of the German adult population. Bivariate and multivariate analyses were conducted.

Results: Out of 2,101 participants, 29.9% reported having had skin diseases in the last 12 months. Among them, adoption and acceptance were at 43.6% and 52.3%, respectively. Both values are significantly higher compared to participants without skin diseases (29.2%; $p < 0.01$ and 45.5%; $p < 0.01$). 18.9% of participants with a skin disease used digital diagnostic support, but only 9.7% applied it for a skin disease ($p < 0.01$). For all participants, with and without skin disease, the DHS most commonly used were passive health monitoring (14.3%) and diagnostic support (11.5%), telemedicine was least used (4.7% video-consultation, 2.5% store-and-forward). Use and acceptance were associated with young age, education, low data privacy concerns, digital confidence, having a skin disease, and high severity of skin disease.

Conclusions: DHS for skin diseases are used rarely but have a high potential.

KEYWORDS

Acceptance, Digital health, Digital health literacy, Skin disease, Usage

INTRODUCTION

The widespread adoption of digital devices such as smartphones, tablets, laptops and wearables has made digital health services (DHS) more accessible to patients and consumers. The implementation of DHS into the healthcare system is thought to bring a shift towards patient- and consumer-centered healthcare by enabling individuals to access their health data and information online. In addition, communication between physicians, patients, and other healthcare providers regardless of time and location can be improved.^{1,2} An implementation may lead to more sustainable, cost and time-efficient healthcare systems.³

The current state of dermatological care in Germany is characterized by a high volume of consultations, resulting in long waiting times and brief appointments which impair shared decision-making.^{4–7} Due to demographic changes this situation is expected to worsen in the upcoming years. The proliferation of DHS, particularly tele dermatology, may help mitigate these challenges.⁸ Evidence of high quality supports the use of tele dermatology in routine clinical practice.^{9,10} Other DHS offer features such as self-monitoring, medication adherence support and interventions for psychological comorbidities.^{11–13} By incorporating these DHS into dermatological routine care, patients and dermatologists may improve the management of dermatological conditions.

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A recent study found that 31% of Germans used a health app, 64% searched for health-related content online, and 15% communicated with their doctor digitally at least once a year.^{14,15} While several studies have shown positive attitudes towards DHS among populations with dermatological conditions, these studies are often restricted to a single condition or conducted in a tertiary hospital setting.^{16,17} However, there is limited information on the current use and acceptance of DHS in the German population, in particular among dermatological patients. Such insights would be essential to develop and optimize DHS and to enforce specific implementation strategies.

Hence, this study aims to explore the use and acceptance of DHS in the German population including people affected with dermatological conditions, addresses the following research questions:

- What is the prevalence of DHS use in Germany?
- How commonly are different DHS used?
- What is the acceptance of DHS?
- To what extent do medical and demographic factors influence the use and acceptance of DHS?

METHODS

Study design

A cross-sectional population representative survey was conducted in August 2022. The survey was developed by the Institute for Health Services Research in Dermatology and Nursing (IVDP) and carried out in collaboration with the FORSA Institute (Forsa Gesellschaft für Sozialforschung und statistische Analysen mbH) using a validated population panel. Participants answered the questions once at one timepoint.

Survey questionnaire

The questionnaire was developed after screening published literature on already used items and on further relevant topics. The survey covered five main themes: (1) General use of digital devices and internet applications: measured by adapted items of the *Federal Statistical Office* (Destatis) designed to assess the use of information and communication technologies in the general population.¹⁸ (2) Competences and attitudes towards digitalization: measured using items from the *German eHeals questionnaire*, a survey on data privacy risks and the digital confidence score.^{19–21} (3) Performance expectancies and acceptance of DHS: measured using items from the *Unified Theory of Acceptance and Use of Technology* (UTAUT) Model and previous research.^{22–24} (4) Use of consumer- and patient-targeted DHS: measured by self-developed items based on DHS identified in the literature.^{9,12,25–27} (5) Skin disease and associated healthcare utilization: measured by items on

the existence and severity of a skin disease in the previous 12 months, the type of skin disease and consultation of a physician due to the skin disease identified in the literature.

The full questionnaire including the source of each item and the used answer categories/scales can be obtained from online supplementary Table S1.

In addition, socio-demographic data on age, gender, region (urban/rural) and level of education (lower secondary school education [Hauptschule], intermediate secondary school education [Realschule], high school degree [Abitur]) were collected.

Study population and recruitment

The target population included all German residents (with sufficient knowledge of the German language) aged 18 years and older. Half of the study population was surveyed through computer-assisted telephone interviews (CATI), while the other half was recruited from the *forsa.omninet household panel*. For CATI, the recruitment followed a structured multistage random sampling process developed by the *Arbeitskreis Deutscher Markt- und Sozialforschungsinstitute e.V.* (ADM). Of all included participants, 30% were recruited via landline and 70% via mobile phone. The *forsa.omninet household* is a standing panel that includes 100,000 participants that are recruited via telephone on a random basis to ensure representativity. A representative selection of participants from the panel was invited to participate in our study via e-mail. The combined sample (CATI and *forsa.omninet*) was weighted for age, gender, and region based on data from the Federal Statistical Office (Destatis).

Ethics approval

This study was conducted anonymously and was non-interventional, so no ethical review was required. The study was conducted in accordance with the principles of the Declaration of Helsinki and Good Clinical Practice (GCP).

Statistical analysis

A descriptive analysis was conducted on the general population and on the population with a skin disease in the last 12 months. Missing rates on all items were below 5%, therefore these were not considered further.²⁸ Subgroup analyses were conducted for both groups by gender, age, and region (rural/urban). Differences between presence/non-presence of a skin disease were additionally assessed in the general population. Chi-square test was used to test for significance of associations among subgroups. Multivariate logistic regression analysis was used to identify potential predictors of acceptance (Item 8; online supplementary

Table S1) and current use of DHS among participants. Actual use was defined, if at least one described DHS (Item 15–20; online supplementary Table S1) has been used by participants in the last 12 months. The independent variables were the presence of a skin condition, socio-demographic factors, region (urban/rural), digital competences and data privacy concerns. In addition to these independent variables, severity of skin disease and access to a physician were additionally included in logistic regression models for the population with a skin disease. The results of the regressions are presented as adjusted odds ratios (OR) with 95% confidence intervals (CI). Statistical significance was set at $p < 0.05$ and the analysis was performed using SPSS Statistics v. 22 (IBM, Armonk, NY, USA) for Windows.

RESULTS

Demographics

From the forsa.omninet panel, 2,379 panelists were invited of whom 1,100 participated resulting in a response rate of 46.2%. For the telephone survey (CATI), 2,612 persons were invited and 1,001 completed the survey leading to a response rate of 38.3%. Both arms of the survey were conducted within one week in August 2022. In total, 2,101 adults participated in the survey, half being female (49.8%), two thirds being older than 45 years (60.8%), and every second having a high school education (49.9%) (Table 1).

Most of the participants (65.4%) lived in an urban area. Smartphones (90.8%) and PCs (84.9%) were widely used by the study population and internet use, including online banking (75.3%), online shopping (71.5%), and communication via internet services (71.6%), was common. One third of the population (29.9%) reported having had a skin condition in the last 12 months which of 61.1% had consulted a physician. The most common dermatological conditions were skin rash or unspecified eczema (20.9%), atopic dermatitis (10.4%), and fungal infections (8.1%).

Competences and attitudes towards digitalization

About two-thirds of the general population reported being generally confident in using DHS (66.2%) and knowing where to find health information online (69.0%) (Table 2).

Half of the participants reported concerns about data privacy (49.1%). Competences and attitudes were not associated with the presence of a skin condition. Younger participants had significantly higher confidence, were more aware of where to find health information, and had lower data privacy concerns than older participants (online supplementary Table S2). Women were generally less confident in using DHS, but more aware of where to find health

information. No further significant differences between the subgroups with and without skin diseases were found (online supplementary Table S3).

Performance expectancies and acceptance of DHS

Of all participants, 57.4% agreed that DHS can be beneficial for the diagnosis, treatment, or monitoring of a disease, but only 38.6% agreed that a DHS can be beneficial for a skin condition (Table 2). A similar discrepancy was found between the acceptance of using a DHS for any disease/health problem (47.5%) or for a skin condition (36.4%). Two-thirds of all participants (66.5%) said they could imagine discussing the data from a DHS with a physician. The willingness to pay for an intervention was not common (12.7%). Participants with a skin condition were more likely to expect a benefit from using DHS, had higher acceptance, and were more willing to discuss data with doctors.

The logistic regression models (one for the general population and one for the population with a skin condition) (Table 3) indicated several significant associations between the acceptance of a DHS and explanatory variables: Acceptance was positively associated with younger age, a high level of education, low concerns about data privacy, high confidence in using DHS, and presence of a skin condition. Younger age was the strongest predictor of high acceptance to use a DHS in both models. In the general population the youngest age group had the strongest association with acceptance (18–29 years; adjusted Odds Ratio [aOR] 3.25 [95% confidence interval (CI) 2.37–4.45]), whereas the association was strongest for the middle age group (30–44 years; aOR: 4.17; 95% CI 2.47–7.04) among participants with a skin condition. Among the latter group, a high severity of skin disease was associated with acceptance of DHS.

Utilization of DHS in the last 12 months

A high proportion of respondents (80%) reported to have consulted the internet for a health problem within the last 12 months (Figure 1).

In addition, 33.5% of participants used at least one DHS for any disease. The most frequently used types of DHS were those for passive health monitoring (14.3%), diagnosis support (11.5%), electronic patient record (8.6%), and active health monitoring (8.4%). Telemedicine solutions (video consultation: 4.7%; store-and-forward telemedicine: 2.5%) were less commonly used by participants. All the digital services were significantly more often used by participants with a skin disease, including passive health monitoring (with: 18.9% vs. without: 12.4%; $p < 0.001$), with the exception of the electronic health record (with: 10.0%

TABLE 1 Descriptives of participants.

	General population (n = 2101)	Participants with a skin disease* (n = 630)	Participants without a skin disease (n = 1471)
Age group (n = 2101)	n (%)	n (%)	n (%)
18–29 years	337 (16.0)	119 (18.9)	218 (14.8)
30–44 years	489 (23.3)	149 (23.7)	340 (23.1)
45–59 years	514 (24.5)	142 (22.5)	372 (25.3)
60 years and older	762 (36.3)	220 (34.9)	542 (36.8)
Type of survey (n = 2101)			
Telephone survey (CATI)	1001 (47.6)	266 (26.6)	
Internet survey (forsa.omninet)	1100 (52.3)	364 (33.1)	
Gender (n = 2101)			
Female	1028 (48.9)	340 (54.0)	733 (49.8)
Male	1073 (51.1)	290 (46.0)	739 (50.2)
Regional variation (n = 2101)			
Urban	1396 (66.4)	437 (69.6)	959 (65.4)
Rural	699 (33.3)	191 (30.4)	508 (34.6)
Missing	6 (0.3)	2 (0.3)	4 (0.3)
School education (n = 2000)			
Low	365 (17.4)	105 (16.7)	260 (18.7)
Middle	637 (31.9)	197 (31.3)	440 (31.7)
High	998 (49.9)	307 (48.7)	690 (49.6)
Missing	101 (4.8)	21 (3.3)	81 (5.5)
Use of digital devices (n = 2101)			
Smartphone	1909 (90.8)	576 (91.6)	1332 (90.9)
PC	1784 (84.9)	549 (87.3)	1235 (83.9)
Tablet	956 (46.7)	270 (42.9)	687 (46.7)
Smartwatch	278 (18.9)	124 (19.7)	278 (18.9)
Smart home assistant (e.g., Google Home, Alexa, Apple HomePod)	258 (17.5)	107 (17.0)	124 (19.7)
None of the devices	35 (2.4)	10 (1.6)	25 (1.7)
Use of internet applications, (n = 2101)			
Online banking	1108 (75.3)	496 (78.9)	1108 (75.3)
Online shopping	1052 (71.5)	481 (76.3)	1052 (71.5)
Communication (messenger, videocall)	1054 (71.6)	471 (74.9)	1054 (71.6)
Social media (private and business related)	813 (55.3)	364 (57.8)	813 (55.3)
Entertainment (e.g., podcast, movies, music, videos)	909 (61.8)	400 (63.6)	909 (61.8)
Research and information (news portal, Wikipedia, online newspaper)	1260 (85.7)	559 (88.7)	1260 (85.7)
Other purpose	396 (26.9)	189 (27.9)	396 (26.9)
Type of skin disease (out of n = 630 persons reporting a skin condition in the previous 12 months)			
Skin rash, eczema		129 (20.6)	
Atopic dermatitis		65 (10.4)	
Fungal infection		51 (8.1)	
Skin cancer		47 (7.5)	

(Continues)

TABLE 1 (Continued)

	General population (n = 2101)	Participants with a skin disease* (n = 630)	Participants without a skin disease (n = 1471)
Psoriasis		47 (7.5)	
Acne vulgaris		43 (6.8)	
Warts		40 (6.4)	
Common skin spots		38 (6.0)	
Allergies, hay fever		37 (5.8)	
Mole inspection or removal		31 (4.9)	
Alopecia		20 (3.1)	
Other		66 (10.5)	
Missing		16 (2.5)	
Severity of the skin disease (0 = No Severity to 10 = High Severe), (n = 630)			
No severity (0)		24 (3.7)	
Mild severity (1–3)		251 (39.8)	
Moderate severity (4–6)		180 (28.6)	
High severity (7–10)		149 (23.6)	
Missing		27 (4.2)	
Consultation of a physician due to skin disease in last 12 months (n = 630)			
No		244 (38.7)	
Yes		385 (61.1)	
Missing		1 (0.1)	
If yes, which type of physician was consulted? (n = 385)			
Dermatologist		313 (81.5)	
Primary care physician		54 (14.0)	
Other		17 (4.5)	
Missing information		1 (0.1)	

*Considered, if presence of a skin disease in the last 12 months was answered with "Yes".

TABLE 2 Subgroup analysis for the general population: digital competences, attitudes and expectancies, acceptance of and usage of DHS.

(Fully Agree/Agree)	General (n = 2101)	Skin Disease (N/Y)		p
		Without (n = 1471)	With (n = 630)	
Competences and attitude towards digitalization				
Confidence in using digital applications	66.2%	66.2%	66.0%	0.94
Aware where to find health information on the internet	69.0%	67.8%	71.9%	0.66
Data privacy/security concerns	49.1%	48.1%	51.4%	0.16
Performance expectancies and acceptance of DHS for a disease				
Performance expectancies of DHS for any disease	57.4%	55.6%	61.7%	< 0.01
Performance expectancies of DHS for skin disease	38.6%	36.0%	44.4%	< 0.01
Acceptance to use DHS for any disease	47.5%	45.5%	52.3%	< 0.01
Acceptance to use DHS for a skin disease	36.4%	34.2%	41.6%	< 0.01
Willingness to discuss digital data in doctors' consultation	66.5%	64.7%	70.8%	< 0.01
Willingness to pay for DHS	12.7%	12.2%	13.6%	0.38

vs. without 8.0; $p < 0.14$). 43.6% of participants with a skin condition used at least one of the DHS and hence more often than participants without a skin condition (29.2%) ($p < 0.01$).

In the general population, age, female gender, a high level of education, low concerns about data privacy, and a high confidence in using DHS were significantly associated with higher use of a DHS (multivariate logis-

TABLE 3 Multivariate logistic regression analysis of acceptance and use of DHS.

	Acceptance of DHS		Use of DHS	
	Total aOR (95% CI)	Skin disease aOR (95% CI)	Total aOR (95% CI)	Skin disease aOR (95% CI)
Skin disease in the last 12 months (reference: no)				
Yes	1.34 (1.09–1.66)	–	1.90 (1.54–2.34)	–
Age group (reference: ≥ 60 years)				
18–29 years	3.25 (2.37–4.45)	2.93 (1.69–5.09)	2.23 (1.64–3.03)	3.12 (1.82–5.36)
30–44 years	2.88 (2.22–3.74)	4.17 (2.47–7.04)	2.12 (1.63–2.76)	2.76 (1.68–4.54)
45–59 years	1.99 (1.54–2.56)	1.73 (1.05–2.83)	1.38 (1.06–1.80)	1.68 (1.03–2.75)
Sex (reference: male)				
Female	0.76 (0.63–0.93)	0.83 (0.57–1.20)	1.53 (1.26–1.87)	2.02 (1.39–2.92)
Regional variation (reference: rural)				
Urban county or city	0.96 (0.78–1.19)	1.09 (0.73–1.62)	0.98 (0.79–1.20)	0.97 (0.66–1.43)
School education (reference: low)				
Medium	1.45 (1.07–1.96)	1.27 (0.71–2.26)	1.23 (0.91–1.68)	1.09 (0.62–1.93)
High	2.08 (1.56–2.77)	1.89 (1.07–3.32)	1.39 (1.04–1.87)	1.43 (0.82–2.50)
Confidence in using DHS (reference: low)				
Neutral	0.93 (0.65–1.33)	1.58 (0.80–3.11)	1.16 (0.80–1.67)	1.27 (0.66–2.46)
High	2.01 (1.48–2.73)	2.80 (1.56–5.03)	1.46 (1.06–2.00)	1.89 (1.07–3.32)
Data privacy concerns (reference: high)				
Neutral	1.40 (1.07–1.83)	1.27 (0.75–2.14)	1.25 (1.00–1.57)	1.52 (0.91–2.54)
Low	1.96 (1.57–2.46)	2.52 (1.64–3.86)	1.44 (1.11–1.89)	1.82 (1.21–2.73)
Physician contact for skin disease (reference: no contact)				
Yes	–	1.14 (0.76–1.71)	–	1.29 (0.87–1.90)
Severity of skin disease (reference: mild [1–3])*				
No severity (0)	–	1.03 (0.56–1.87)	–	1.08 (0.60–1.92)
Moderate severity (4–6)	–	1.19 (0.76–1.85)	–	1.15 (0.74–1.77)
High severity (7–10)	–	2.16 (1.22–3.81)	–	2.11 (1.23–3.64)
Nagelkerkes R ²	0.208	0.239	0.099	0.164

Abbr.: aOR, adjusted odds ratio (aOR > 1 present a higher chance for accepting/using DHS); CI, confidence interval (95% CI does not include the value 1)

Nagelkerkes R²: goodness of fit – the higher the value, the higher the model fit.

*Mild chosen as reference, as only 24 people had no severity of skin disease.

tic regression) (Table 3). Among the group with a skin condition, age and gender had an even stronger impact on DHS use. The use of a DHS was also positively associated with a high severity of skin disease and female gender.

Among the respondents with a skin disease who used DHS, only a minority used them for their skin disease (Figure 2). For example, 86% consulted the internet with a health problem/disease but only 44.8% did so for their skin disease ($p < 0.01$). Diagnosis support related to skin diseases was only used in 9.7% (for all health conditions: 18.9%; $p < 0.01$), store-and-forward telemedicine in 2.0% (for all health conditions: 16.2%; $p < 0.01$) and video consultation in 1.5% (for all health conditions: 10.8%; $p < 0.01$). All differences were significant. Additional subgroup analyses are presented in the supplements (online supplementary Tables S2,S3).

DISCUSSION

This study aimed to explore the use and acceptance of DHS in the German population and in dermatological patients. The data reveal that about half of respondents would be willing to use digital health services for diseases or health problems with a majority expecting benefits. Internet searches for health information were already common and a third of respondents had used a specific DHS. Respondents with skin conditions reported higher use and acceptance rates of DHS than respondents without skin conditions, but a minority used DHS for their skin condition. Younger, better-educated people with low concerns about data privacy and digital competencies were more likely to use and accept DHS.

In our survey, we found that 70% of respondents had both confidence in using digital services and awareness

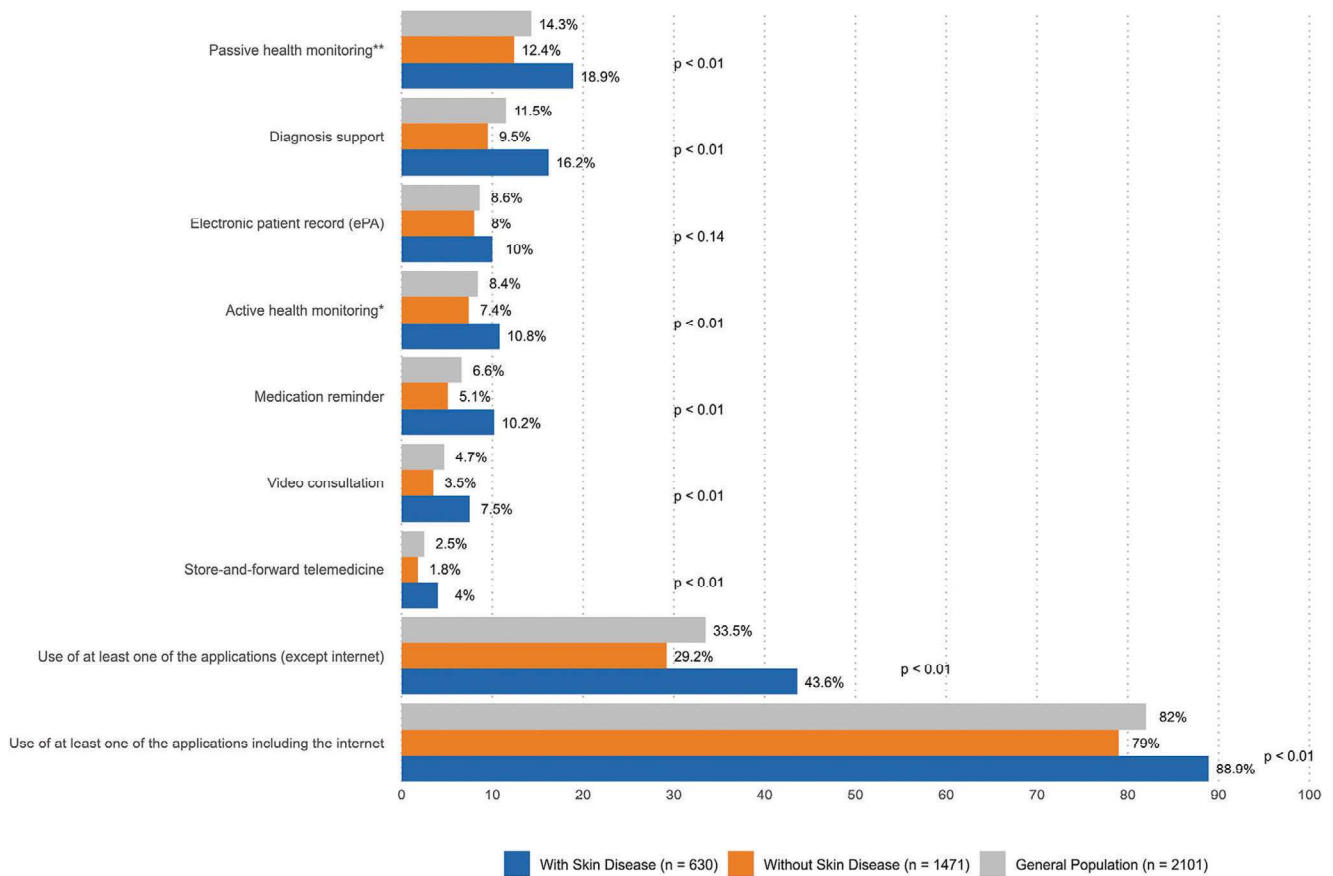


FIGURE 1 Utilization of DHS in the last 12 months (General Population and Population with/without skin disease). *Applications that require active patient input (e.g., with the help of questionnaires). **Applications that passively collect data on an ongoing basis, for example with the help of wearables or sensors.

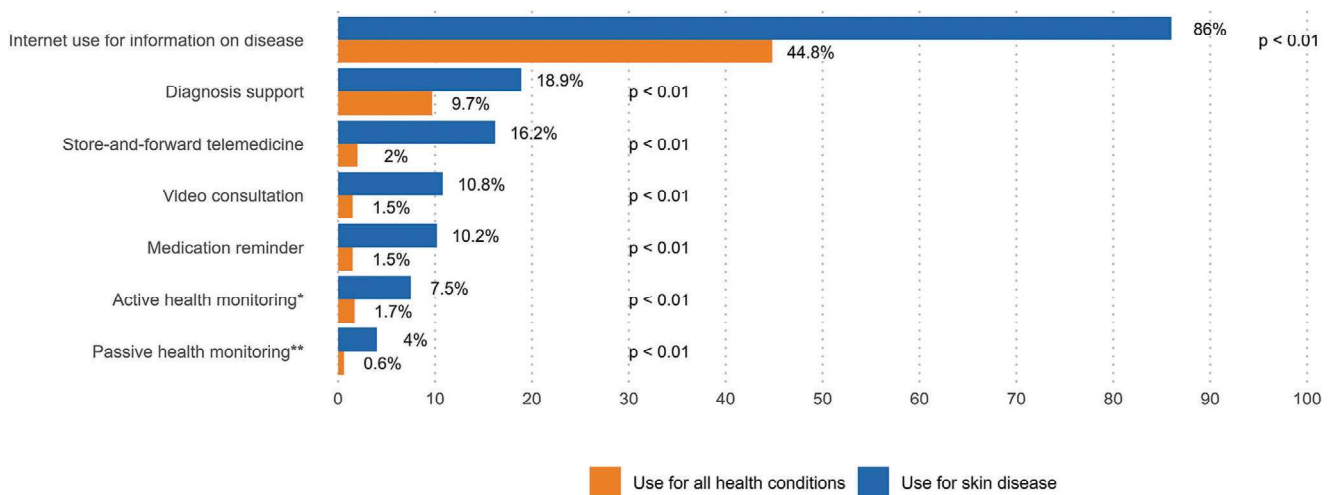


FIGURE 2 Population with a skin disease (n = 630): Use of DHS for all health conditions versus for a skin disease. *Applications that require active patient input (e.g., with the help of questionnaires). **Applications that passively collect data on an ongoing basis, for example with the help of wearables or sensors.

of how to find health information online. This aligns with another survey from De Santis et al. 2021 (81% with an awareness on how to find health information online), but contrasts with the HLS-GER 2 (2020) survey, where only 55% of respondents were aware of how to find online health information.^{15,29} This difference may be due to the survey design, time period, and population included in each study.^{15,29} The increased reliance on digital services in private and work-related environments during the COVID-19 pandemic could explain the increased confidence and awareness in our survey compared to the HLS-GER 2.

Apart from competencies, our survey identified acceptance rates of 50% in the general population, which were higher compared to the survey of De Santis et al. 2021,²⁹ where the rate was 42.3%. For skin disease-specific applications, the acceptance rate in our survey were lower in comparison to the general acceptance rate. One potential explanation may be the lack of apps, as only 2% of disease-specific apps focus on dermatology.³⁰

Our survey found that data privacy concerns were negatively associated with the utilization and acceptance of DHS, which aligns with prior research indicating them as a barrier to digital health adoption.^{31,32} Addressing such reservations about data privacy may hence increase utilization and acceptance of digital health applications.

A significant portion of the general population in Germany used DHS for a disease or health problem (29.2%) comparable to the rate reported in the HLS-GER 2 study (31%).¹⁵ Utilization reported by De Santis et al. 2021 (61%) may not be directly comparable as the definition also covered apps for physical activity.²⁹ We observed a more common use of DHS that do not require interaction with a healthcare provider such as passive health monitoring (14.3%) in comparison to telemedicine (video: 4.7 and store-and-forward: 2.5%). One hypothesis is that most non-interactive applications are designed to complement in-person consultations or are for patients use only, whereas interactive DHS, especially telemedicine, are designed to substitute for in-person physician visits. Patients tend to prefer in-person consultations over telemedicine, explaining the difference.^{33,34} Furthermore, the constrained adoption of telemedicine among dermatologists and other physician groups likely contributes to the relatively modest adoption rate among patients.^{35,36} Improving the adoption of telemedicine services in dermatological practices is therefore important to increase usage among patients.

Another crucial determinant of acceptance and usage is the willingness to pay for services, which is often low for DHS as evident from both our and other surveys.^{37,38} This situation is primarily attributable to the prevailing coverage of most health services by Statutory Health Insurances (SHI), which tends to keep out-of-pocket expenses and co-payments at a minimum. However, it is worth noting that, at present, there is no dermatology-specific application listed

in the official directory for evidence-based digital health applications (DIGA-Verzeichnis des BfArM), which lists all applications that are covered across all SHIs.³⁹ In terms of telemedicine, video consultations are covered by SHI, while store-and-forward telemedicine services lack such coverage, which could explain its lower usage rate in comparison to video consultations. In some cases, insurance companies have established direct agreements with providers of dermatological applications and store-and-forward teledermatology platforms,^{40,41} that cover the cost to the insured.^{40,41} To bolster the adoption of DHS, it becomes imperative to enhance insurance coverage for evidence-based DHS and minimize patient co-payments.⁴²

The survey revealed that participants with a skin disease have higher acceptance and usage rates in comparison to a population without a skin disease, which is in line with other previous conducted surveys analyzing the association of chronic conditions on the usage and acceptance of DHS.^{15,43} Nonetheless, our results also reveal that people with skin conditions use DHS more often than the general population, but infrequently for skin conditions. This may be attributed to a combination of factors including the low availability of dermatological apps and services and the need for DHS in other medical fields of this group, as comorbidities are more common in a skin disease population, including psychological disorders, cardiovascular diseases and infections.^{44–46} Additionally, people with poor self-perceived health status are more likely to seek health information online,⁴⁷ which is consistent with our findings of higher use of DHS among those with a high severity of skin disease.

Previous research, as well as our own, has found that younger and more educated individuals tend to have higher usage and acceptance rates of digital health applications.^{29,48} However, these applications may not confer the greatest benefit to these groups, given their relatively lower disease burdens in comparison to more disadvantaged segments of the population.^{49,50} Nowadays, factors such as digital competencies, experience with technology, personal resources and social environment play a larger role in determining utilization than access to devices and the internet.^{51,52} To increase participation and acceptance of DHS among groups with a lower acceptance and use, it may be necessary to adopt design elements that increase usability, train healthcare providers to become multipliers for DHS and design interventions that directly promote digital competencies among disadvantaged groups.^{15,53} To ensure equity in access and quality of care for all patients in the future, the effects of the introduction of DHS into the healthcare system should be closely analyzed.

An additional discrepancy we identified was that women were more likely to use DHS, including internet usage for health information, but men had higher acceptance rates towards the use. Another study observed a similar discrepancy,⁵⁴ whereas the HLS-GER 2 study contradicts

our findings, showing similar rates of digital health literacy and use of apps between genders.¹⁵ Gender stereotypes on technology may play a role in acceptance with society perceiving technology often as manly.⁵⁵ The actual utilization, however, may resonate from the lower utilization rates of general and preventive health care services among men.⁵⁶

Several limitations apply to our study. First, the data relies on self-reports by participants. Some items, utilization of DHS or presence of a skin disease, are therefore prone to a recall bias. Items, such as digital competencies (e.g., gender differences), and actual participations in the survey, might be prone to cultural and societal expectations as already discussed. However, following the research objectives, this study needed to focus on subjective opinion from the people interviewed. Second, some items of the survey were not validated, but were either self-developed or items adapted to our research question based on available questionnaires. Still, the majority of items is based on appropriate literature. Third, many themes were based on a single item, which does not allow to analyze these aspects from different angles or in-depth. We decided to reduce the number of items per theme to avoid survey fatigue among participants, but still be able to analyze associations between themes. Nevertheless, a major proportion of our findings is backed by literature from other countries and indications.

CONCLUSIONS

Our study indicates that although respondents with a skin disease have higher usage and acceptance rates of DHS in comparison to a population without a skin condition, a minority of this population used a DHS for their skin disease. The identified gap can be read as a significant potential for DHS in the field of dermatology as patients are already familiar with applications from other medical fields. In the general population, the utilization of DHS is moderate to low. The survey also revealed digital inequalities, highlighting the need to address these disparities and ensure that evidence-based DHS are accessible to all members of society. To ensure that DHS are effectively integrated into dermatological care, it is crucial to develop strategies that promote the implementation of evidence-based DHS in clinical routines. It is imperative to closely monitor the effects of implementing DHS on already existing health inequities and conduct further research to identify unmet patient needs.

ACKNOWLEDGEMENT

The authors thank the Scientific Communication Team of the IVDP, especially Merle Twesten, for editing the article.

Open access funding enabled and organized by Projekt DEAL.

FUNDING SOURCE

The research project was financially supported via a research grant by Novartis. Novartis did not influence the


design, data collection, analysis and publication decision or development of this study.

CONFLICT OF INTEREST STATEMENT

Marina Otten is a co-author of the German AWMF guideline on teledermatology. Patrick Reinders declares no conflict of interest. Matthias Augustin is a co-author of the German AWMF guideline on teledermatology and a scientific advisor for the teledermatology platform derma2go AG, A+ Videoclinic GmbH and Novartis.

ORCID

Patrick Reinders  <https://orcid.org/0000-0002-2961-2698>

Matthias Augustin  <https://orcid.org/0000-0002-4026-8728>

Marina Otten  <https://orcid.org/0000-0003-3767-1548>

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Reinders P, Augustin M, Otten M. General and dermatological population's use and acceptance of digital health in Germany – a representative survey. *JDDG: Journal der Deutschen Dermatologischen Gesellschaft*. 2024;22:1221–1231. <https://doi.org/10.1111/ddg.15454>

2.7. Publikation 7

Reinders P, Augustin M, Stephan B, Otten M. Understanding patient priorities in teledermatology for psoriasis: A discrete choice experiment. *J Eur Acad Dermatol Venereol*. Published online April 19, 2025. doi:10.1111/jdv.20701

Understanding patient priorities in teledermatology for psoriasis: A discrete choice experiment

Patrick Reinders | Matthias Augustin  | Brigitte Stephan  | Marina Otten 

Institute for Health Services Research in Dermatology and Nursing (IVDP), University Medical Center Hamburg-Eppendorf (UKE), Hamburg, Germany

Correspondence

Marina Otten, Institute for Health Services Research in Dermatology and Nursing (IVDP), University Medical Center Hamburg-Eppendorf (UKE), Christoph-Probst-Weg 3, Hamburg D20246, Germany.
Email: m.otten@uke.de

Abstract

Background/Objective: Despite supporting guidelines and evidence, teledermatology adoption in Germany is low, also possibly due to a lack of services that reflect patients' preferences. This study investigates these preferences in psoriasis care and the influence of sociodemographic, geographic and disease-related factors.

Methods: A discrete choice experiment was conducted. The attributes included the two teledermatology modes (live-interactive, store-and-forward), treating physician, possibility to ask questions and acknowledgment of concerns. The opportunity to prefer the standard of care was given. Participants were randomly assigned to two scenarios: consultation for acute flare-ups or follow-up. Conditional logit models were used for analysis.

Results: Among 221 patients with psoriasis (mean age: 58.9 years, 39.8% female), a general preference for the standard of care was observed (acute: $\beta = -0.86$, $p = 0.001$; follow-up: $\beta = -1.24$, $p = 0.001$). Factors that positively influenced preference for teledermatology were medical care provided by the known physician (acute: $\beta = 0.49$, $p < 0.001$; follow-up: $\beta = 0.51$, $p < 0.001$), the possibility to ask questions (acute: $\beta = 0.35$, $p < 0.001$; follow-up: $\beta = 0.52$, $p < 0.001$) and a very good acknowledgment of patients' concerns (acute: $\beta = 0.48$, $p < 0.001$; follow-up: $\beta = 0.50$, $p < 0.001$). Immediate feedback (<24h) was crucial in acute consultations ($\beta = 0.51$, $p < 0.001$). No preference for a teledermatology mode was noted in either scenario. In both scenarios, lower privacy concerns and higher technology acceptance positively influenced teledermatology preference. In acute care, current long waiting times, whereas in follow-up care, current regular blood sampling positively influenced the preference for teledermatology.

Conclusion: Patients with psoriasis generally preferred standard-of-care over teledermatology. However, certain attributes positively influenced their preference for teledermatology, including consultations with their known treating physician, acknowledgment of patient concerns and prompt consultation during acute flare-ups. Adapting services to these preferences could increase the use of teledermatology.

INTRODUCTION

Despite advancements in treatment for psoriasis,^{1,2} approximately 45% of patients opt out of treatment and 60% are dissatisfied with their current medication.³ Factors such as high caseloads in dermatological care leading to long waiting times for appointments and time constraints

during consultation hours hinder effective patient-provider collaboration and could be associated with dissatisfaction.³⁻⁷ The situation will be intensified by demographic transition that may also increase regional disparities in care.⁷

Teledermatology utilizes communication technologies to exchange medical information, overcoming geographic and temporal barriers.⁸ It is considered to improve care

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efficiency, flexibility and patient-centredness, particularly in rural areas and mitigate the upcoming challenges.^{8,9} Communication can be either synchronous (live interactive; LI), often conducted as video consultation, or asynchronous (store-and-forward; S&F), similar to instant messaging or email. Each mode offers distinct benefits and challenges.^{8,10} Both options offer various use cases for psoriasis management, including consultations for follow-ups, acute care and referrals.⁸ In 2020, the German consensus-based guideline on teledermatology especially recommended its use for follow-ups of patients with psoriasis, as sufficient evidence is available.^{8,11–17} In addition, several studies report high satisfaction among patients and physicians with teledermatology services^{18,19} and research exists that describes sufficient acceptability to use digital health services among dermatological patients.^{20–22}

Nevertheless, the uptake of teledermatology in Germany remains limited. In 2023, only 16,000 LI-teledermatology consultations took place, and fewer than 5% of dermatological patients used these services.^{20,23–25} One contributing factor is the insufficient reimbursement for LI-teledermatology and the absence of general reimbursement for S&F teledermatology.²⁶ Currently, S&F services are paid out of pocket, with only a few existing contracts between providers and statutory health insurers.²⁷

Another reason could be the missing fit between teledermatology offerings and patient preferences. Yet, studies exploring preferences were primarily conducted outside Europe and less in the context of chronic dermatological conditions.^{28–30} One recent study from Germany examining telemedicine preferences in primary care used the discrete choice experiment (DCE) methodology^{31,32} and found that patients prefer telemedicine when the consultation is conducted by their general practitioner.³³ It is still unclear whether these findings extend to chronic skin conditions.

To address these research gaps, we developed a DCE to identify the preferred characteristics of teledermatological care among patients with psoriasis. In addition, we aimed to examine how these preferences interact with demographic, socioeconomic, geographical, disease-specific and care-specific parameters. The findings can help design teledermatology services that better align with patients' perspectives.²⁸

METHODS

In a DCE, patients choose between several hypothetical care scenarios, usually two or three, each differing in specific attributes (e.g. waiting time), which vary according to pre-defined levels (e.g. 30 min, 1 h, 2 h). By selecting their preferred scenario, patients indirectly indicate the relative importance of these attributes, enabling the identification of their preferred way of care.³¹

The study was approved by the local ethics committee at the University Medical Center Hamburg-Eppendorf and conducted in accordance with Good Scientific Practice and the Declaration of Helsinki.^{34,35}

Why was the study undertaken?

- Despite available guidelines and evidence, teledermatology adoption in Germany remains low, possibly because current services do not fully meet patient preferences. This study explores what patients with psoriasis prefer in teledermatology and examines how factors like age, location and disease severity influence these preferences.

What does this study add?

- This discrete choice experiment revealed that while patients with psoriasis generally prefer standard-of-care, certain factors—such as continuity with their treating physician, addressing patient concerns and timely consultations during flare-ups—make teledermatology more appealing.

What are the implications of this study for disease understanding and/or clinical care?

- When tailoring teledermatology services to identified patient preferences, it could help boost adoption in psoriasis care.

To ensure that the DCE was both realistic and relevant for patients, we reviewed existing literature,^{8,11,29,30,33,36–44} consulted experienced dermatologists and analysed focus group transcripts from a study on digital health—including LI and S&F teledermatology—among dermatologists, nurses and dermatological patients.²¹

Use case scenarios

Several teledermatology use cases exist, and we selected the most applicable scenarios for patients using the described data. We excluded initial consultations (not recommended by the consensus guideline on teledermatology),¹¹ secondary opinions (considered irrelevant within the focus groups) and referrals (patients are not actively involved in the process).

Instead, we included follow-up consultations (supported by the consensus guideline)¹¹; and acute care (used by patients with urgent symptoms to bypass waiting times).⁴¹ We added an explanation of electronic prescriptions to both scenarios, noting that while mandatory in Germany from 1 January 2024, most patients likely had no prior experience or awareness during data collection.^{3,45}

Attributes and levels

The literature review and analyses of focus groups were used to construct a list of potential attributes (Table S1).

TABLE 1 Discrete choice attributes and levels.

Attribute	Level
1. Type of consultation	<ul style="list-style-type: none"> Store-And-Forward teledermatology Live-interactive teledermatology
2. Treating physician	<ul style="list-style-type: none"> Unknown dermatologist without access to patient data Unknown dermatologist with access to patient data Known doctor treating psoriasis
3. Possibility to ask questions	<ul style="list-style-type: none"> No questions (blocked for LI TD) Limited questions Comparable to on-site consultations (blocked for S&F TD)
4. Acknowledgment of concerns	<ul style="list-style-type: none"> Satisfactory Good Very good
5. Waiting time (acute scenario only)	<ul style="list-style-type: none"> 4–7 days 2–3 days Up to 24 h

We conducted semi-structured qualitative interviews with six patients, two digital health entrepreneurs and two dermatologists experienced in teledermatology. Interviews recommended by the International Society for Pharmacoeconomics and Outcomes Research (ISPOR)³¹ were conducted to validate, refine and prioritize attributes from the patient's perspective. To achieve the latter, participants were asked to identify and justify their five most important attributes (Table S2). After reviewing all data sources, we selected five attributes (with corresponding levels) for the acute care scenario and four for the follow-up care scenario (Table S2; Table 1). Waiting time was deemed crucial only in the acute scenario because of the nonurgent nature of follow-ups. Costs were not considered because LI is covered by statutory health insurance in Germany, and patient feedback indicated a reluctance to pay for S&F.

Choice sets and the questionnaire

Each choice set comprised two unlabelled teledermatology options (Option A and B) alongside an opt-out choice (Option C: standard-of-care) to enhance realism (Figure 1).⁴⁶ To streamline the number of choice tasks, a fractional factorial design was employed, optimizing precision through a D-efficient Bayesian design within the R-statistic Idefix package.^{46,47} The attribute level 'no patient questions possible' was blocked for LI and the level 'comparable to on-site consultation' was blocked for S&F because both were considered implausible. Attributes were effect-coded to facilitate a clearer interpretation of the results.^{31,46} The construction resulted in 16 choice sets per scenario that patients had to evaluate.

The survey collected sociodemographic data (age, sex), geographic information (by postcodes), disease/health-specific items (disease duration, SF-36 general health item)⁴⁸

Acute scenario introduction:

You have an acute flare-up of your psoriasis, i.e. a sudden increase in itching, redness and inflammation of your skin. Your condition is very unpleasant but not so bad that you need to go to the hospital or the emergency room. Please decide on the following pages for the treatment option that offers you the greatest added value during an acute flare-up.

OR

Follow-up scenario introduction:

You would like to attend your next check-up appointment for your psoriasis. On the following pages, please choose the treatment option that offers you the greatest added value for your next check-up appointment. If you need a blood test for your treatment, this can be done without an appointment at a GP office and takes about 15 minutes. The results of the test will then be forwarded to you and the physician treating you.

Example of choice set for the acute scenario:

	Option A	Option B	Option C
Type of consultation	Store-and-Forward teledermatology	Live-interactive teledermatology	
Treating physician	Unknown dermatologist with access to my data	Unknown dermatologist without access to my data	Usual consultation on-site with my physician
Possible to ask questions	Limited questions	Comparable to on-site consultations	
Acknowledgment of concerns	Good	Very good	
Waiting time	Up to 24h	2 to 3 days	
Your decision	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

FIGURE 1 Scenario description and choice set example.

and the Patient Global Assessment in Psoriasis (PtGA).⁴⁹ This was followed by the DCE (acute or follow-up care scenario) and items to evaluate the difficulty of the DCE. Further items covered patients' current care situation, including type of treatment, regular blood sampling due to treatment, length of patient-physician relationship, waiting time for an appointment or for an acute flare-up, total time required to attend a consultation (waiting time in the clinic/practice, consultation and travel time) and the total number of appointments per year. We also gathered data on type of insurance, educational level and household income. General acceptance of technology and technological competencies was assessed using the first two scales of the 'Technology Commitment' instrument.⁵⁰ Privacy concerns were gathered using two items from a recently published study.⁵¹

Cognitive interviews using probing and thinking aloud were conducted to refine the questionnaire in two rounds, with at least five patients.⁵²

Recruitment and conduction

Using Johnson and Orme's rule of thumb,^{53,54} we calculated a sample size of 125 patients per scenario. We recruited participants through two psoriasis patient associations: Deutscher Psoriasis Bund e.V. (German Psoriasis Association, DPB, approximately 1700 members invited) and Psoriasis Netz e.V. (Psoriasis Network Association, around 3000 members invited). Additionally, we shared

the survey link in a German Facebook group for psoriasis, 'Schuppenflechte (Psoriasis Deutschland)' with approximately 18,000 members. Participants were randomly assigned to either the acute or follow-up scenario. The survey was conducted via Unipark in January and February 2024.

Data analysis

Patient characteristics were analysed descriptively. To assess the randomization process, we compared group characteristics using *t*-tests for continuous variables and chi-square and *F*-tests for categorical variables. For the analysis of DCE data, main-effects and interaction-effects conditional logit models (CLM) were fitted, as these are recommended by ISPOR.⁴⁶ For this purpose, we used the clogit function in the survival package in R statistics.^{55,56} Significance level was set at 5%.

Main-effects models were used to estimate the influence of each attribute on patients' consultation preferences. In this model, a significant coefficient indicates the impact of an attribute on patients' choice of consultation.

Interaction-effect models were used to estimate the interaction of sociodemographic, disease-specific and health-care service-related characteristics on the decision to use or reject tele dermatology (Option A/B vs. Option C).

RESULTS

Participants' characteristics

Of the 674 visitors to the survey page, 378 agreed to participate, and 221 (58.5%) completed the DCE. Responder and non-responder characteristics did not differ significantly (Table S3). Responder rates varied by organization/group utilized for invitation: 8.9% (151/1700) for DPB, 1.4% (48/3500) for Psoriasis Netz e.V. and 0.1% (22/18,000) for the Psoriasis Facebook Group (Table S4). Responders from the DPB were younger than overall DPB members (60+ years: 61.7% of responders vs. 70.5% of all DPB members; Table S5). No comparable demographic data was available for the two other organizations/groups. No differences in collected characteristics were found between the acute and follow-up scenario groups (Table 2). Hence, the following descriptions summarize the overall study population data (Tables 2 and 3). The mean age was 58.9 years (SD 13.0); 60.2% were female, 73.9% were urban residents, 67.5% had high school education and 86.5% had statutory health insurance.

The mean PtGA (0–10, higher scores indicate greater psoriasis severity) was 4.1 (SD 2.6), with 22.3% scoring ≥ 7 , reflecting severe psoriasis (Table 3). In the past year, 85.4% had at least one psoriasis-related consultation (median = 4; Interquartile Range [IQR] = 2–4). In 67.6% of participants, a dermatologist treated the psoriasis and 60.1% had the same treating physician for over 5 years. Over

80.3% required more than an hour to attend a consultation (including arrival, departure, waiting and consultation time); 29.7% exceeded 3 h. During acute flares, 38.8% waited over a week for a consultation, whereas only 17% waited between 1 and 3 days. Topical therapies were most common (64.0%), followed by systemic therapies (subcutaneous 41.1%; oral 18.9%); 6.3% received no therapy. Most injections (82.1%) were self-administered. Nearly two thirds (63.9%) regularly underwent blood sampling for laboratory controls as part of their treatment.

The overall study population rated their perceived privacy risk associated with using a tele dermatology solution as low ($M = 2.4$; $SD = 1.0$), their general technology acceptance as moderate to high ($M = 3.3$; $SD = 0.9$) and their technological competencies as high ($M = 4.2$; $SD = 0.9$), all on a scale from 1 (low agreement) to 5 (high agreement) (Table 4). Only 24.8% had any experience with telemedicine, with 11.8% reporting positive, 9.0% neutral, and 4.2% negative experiences. Participants rated the choice set description ($M = 3.6$; $SD = 1.0$), task understanding ($M = 3.7$; $SD = 1.0$) and ease of choice making ($M = 3.5$; $SD = 1.0$) as moderate to high. Willingness to pay for both tele dermatology modes was low (S&F, median = 0, IQR = 0–20; LI, median = 0, IQR = 0–20).

Preference estimates

Results from the main effects CLMs are detailed in Figure 2 and Table S6. In the two scenarios, participants generally preferred their standard of care. All attributes except for telemedicine mode (S&F or LI) significantly influenced decision-making in both scenarios. Tele dermatology options were preferred if they involved their known physician, the possibility to ask a limited number of questions and very good acknowledgment of concerns. For acute care, a response time of <24 h was significant, with no significant preference for response times of 2–3 days over 4–7 days.

Figure 3 displays the interaction effects (full model provided in Table S7). In acute care, current waiting times longer than 1 week, low privacy risk concerns, high technology acceptance and age over 63 years significantly increased preference. In contrast, a high level of education, moderate disease severity and medium length of physician relationship reduced interest.

In follow-up care, a high level of education and a consultation time investment of more than 1 h had a strong negative impact on the preference. Regular blood sampling had the strongest positive effect on the preference towards tele dermatology, where the scenario allowed patients to have their blood sample drawn by their general practitioner. Severe disease, low privacy risk perception and greater technology competence also increased the preference. Factors including age >63 years, female sex, high education, rural residence and long physician relationship lowered the preference.

TABLE 2 Patient demographics.

	Overall population (<i>n</i> = 221)	Acute care scenario (<i>n</i> = 121)	Follow-up care scenario (<i>n</i> = 100)	<i>p</i>
Age, mean (SD)	58.9 (13.0)	59.4 (12.2)	58.5 (14.0)	0.60
Age group, <i>n</i> (%)				0.36
18–39 years	16 (7.3)	6 (5.0)	10 (10.0)	
40–62 years	113 (51.6)	66 (55.5)	47 (47.0)	
63 years and older	90 (41.1)	47 (39.5)	43 (43.0)	
Missing	2	2	0	
Sex, <i>n</i> (%)				0.82
Male	86 (39.8%)	47 (40.5%)	39 (39.0%)	
Female	130 (60.2%)	69 (59.5%)	61 (61.0%)	
Missing	5	5	0	
Regional variation, <i>n</i> (%)				0.99
Urban	153 (73.9%)	85 (73.9%)	68 (73.9%)	
Rural	54 (26.1%)	30 (26.1%)	24 (26.1%)	
Missing	14	6	8	
School education, <i>n</i> (%)				0.215
Low	13 (6.2)	10 (8.8)	3 (3.2)	
Middle	54 (26.2)	27 (23.9)	27 (29.0)	
High	139 (67.5)	76 (67.3)	63 (67.7)	
Missing	15	8	7	
Health insurance, <i>n</i> (%)				
Statutory Health Insurance (SHI)	151 (72.6)	83 (72.8)	68 (72.3)	
SHI + private health insurance	29 (13.9)	14 (12.3)	15 (16.0)	
Private health insurance	28 (13.5)	17 (14.9)	11 (11.7)	
Missing	13	7	6	
Net income per household person, <i>n</i> (%)				0.33
<1.300 €	31 (20.5%)	17 (20.2%)	14 (20.9%)	
1.300 € and 2.599 €	62 (41.1%)	34 (40.5%)	28 (41.8%)	
2.600 € and 3.599 €	15 (9.9%)	12 (14.3%)	3 (4.5%)	
3.600 € and 4.999 €	13 (8.6%)	7 (8.3%)	6 (9.0%)	
>5.000 €	30 (19.9%)	14 (16.7%)	16 (23.9%)	
Number of persons in household, mean (SD)	2.1 (0.9)	2.0 (1.0)	2.2 (0.9)	0.12
Missing	68	35	33	

DISCUSSION

This discrete choice experiment is the first to explore teledermatology preferences of patients with psoriasis. Findings indicate a general preference for standard-of-care, though preferences shifted towards teledermatology when it involved the known physician, allowed questions and when physicians thoroughly acknowledged concerns. A consultation within 24 h during flare-ups also increased teledermatology preference. Patients with fewer privacy concerns, higher technology acceptance and longer waiting times in acute scenarios were more likely to prefer teledermatology. Notably, there was no preferred teledermatology mode (S&F; LI).

In both care scenarios, continuity with the known physician was crucial, as highlighted by several DCEs.^{33,57,58} Most

patients in our study have a long-standing relationship with their physician, which seems to outweigh the option of consulting with an unknown dermatologist that has access to the medical records, even in acute situations.

In the acute care scenario, short waiting times was crucial, aligning with previous DCEs.^{33,57,58} However, only responses within 24 h positively influenced preference towards teledermatology. This reflects that patients with long appointment waits (>1 week), benefited from all DCE teledermatology options, as the longest waiting period in the DCE was '4–7 days'. Those with shorter waits (<1 week) only favoured teledermatology, if response was given in less than 24 h.

Acknowledgment of patient concerns and the possibility to ask questions were crucial for patients, aligning with

TABLE 3 Healthcare status quo of patients.

	Overall population (<i>n</i> = 221)	Acute care scenario (<i>n</i> = 121)	Follow-up care scenario (<i>n</i> = 100)	<i>p</i>
General health (SF-36), <i>n</i> (%)				0.77
Excellent or very good	26 (12.0)	13 (11.1)	13 (13.0)	
Good	121 (55.8)	64 (54.7)	57 (57.0)	
Fair or poor	70 (32.3)	40 (34.2)	30 (30.0)	
Missing	4	4	0	
PtGA (NRS 0–10), mean (SD)	4.1 (2.6)	4.0 (2.8)	4.2 (2.4)	0.70
PtGA, Groups, <i>n</i> (%)				0.42
PtGA ≤2 (minimal)	76 (34.5)	44 (36.7)	32 (32.0)	
PtGA 3–6 (moderate)	95 (43.2)	47 (39.2)	48 (48.0)	
PtGA ≥7 (severe)	49 (22.3)	29 (24.2)	20 (20.0)	
Missing	1	1	0	
Duration since the first onset, mean (SD)	30.5 (19.7)	30.7 (19.7)	30.36 (19.7)	0.88
Missing	3	3	0	
Patients with at least one consultation, <i>n</i> (%)	181 (85.4)	96 (82.1)	85 (89.5)	0.13
Missing	9	4	5	
Number of consultations, median (IQR)	4 (2–4)	4 (2–4)	4 (2–5)	0.18
Missing	4	2	2	
Psoriasis treating medical specialty (primarily), <i>n</i> (%)				0.64
General practitioner	10 (5.6)	7 (7.4)	3 (3.6)	
Dermatologist	121 (67.6)	61 (64.2)	60 (71.4)	
Rheumatologist	34 (19.0)	19 (20.0)	15 (17.9)	
Another medical specialty	14 (7.8)	8 (8.4)	6 (7.1)	
Missings	2	0	2	
Length of physician relationship, <i>n</i> (%)				0.26
<1 year	17 (8.2)	13 (11.8)	4 (4.2)	
1–2 years	30 (14.4)	16 (14.5)	14 (14.7)	
3–4 years	30 (14.4)	18 (16.4)	12 (12.6)	
5 years or longer	125 (60.1)	62 (56.4)	63 (66.3)	
Missing	13	8	5	
Total time required for consultation, <i>n</i> (%)				0.10
<1 h	40 (19.7)	23 (20.4)	17 (17.9)	
Max. 2 h	74 (36.5)	32 (28.3)	42 (44.2)	
Max. 3 h	47 (23.2)	26 (23.0)	21 (22.1)	
>3 h	42 (20.7)	28 (24.8)	14 (14.7)	
Missing	18	12	6	
Regular waiting time in case of acute flare, <i>n</i> (%)				0.07
<1 day	12 (5.7)	10 (8.8)	2 (2.1)	
1–3 days	23 (11.0)	16 (14.0)	7 (7.4)	
Max. 1 week	44 (21.1)	20 (17.5)	24 (25.3)	
More than 1 week	81 (38.8)	40 (35.1)	41 (43.2)	
Do not know	49 (23.4)	28 (24.6)	21 (22.1)	
Missing	12	7	5	
Regular blood sampling due to psoriasis treatment, <i>n</i> (%)	115 (63.9)	66 (69.5)	49 (57.6)	0.09
Missing	1	1	0	

TABLE 3 (Continued)

	Overall population (n = 221)	Acute care scenario (n = 121)	Follow-up care scenario (n = 100)	p
Current treatment of psoriasis, n (%)				
Tablet	36 (17.3)	18 (15.9)	18 (18.9)	0.57
Injection	82 (39.4)	43 (38.1)	39 (41.1)	0.66
Infusion	3 (1.4)	2 (1.8)	1 (1.1)	>0.99
Phototherapy	16 (7.7)	11 (9.7)	5 (5.3)	0.23
Topical therapy	139 (62.9)	75 (62.0)	64 (64.0)	0.86
Currently, no therapy	13 (6.3)	9 (8.0)	4 (4.2)	0.25
Missing	13	8	5	
If injection, who is applying the injection, n (%)				
Staff in clinic/practice	7 (8.5)	4 (9.3)	3 (7.7)	0.96
Patient himself	67 (81.7)	35 (81.4)	32 (82.1)	
Third person	8 (9.8)	4 (9.3)	4 (10.3)	

TABLE 4 Difficulty, privacy risk and technology commitment.

	Overall population (n = 221)	Acute care scenario (n = 121)	Follow-up care scenario (n = 100)	p
Privacy risk and technology commitment (1: do not agree; 5: fully agree)				
Perceived privacy risk (1–5), mean (SD)	2.4 (1.0)	2.5 (1.1)	2.3 (0.9)	0.08
Technology commitment (1–5) – acceptance, mean (SD)	3.3 (0.9)	3.2 (0.9)	3.4 (0.9)	0.20
Technology commitment (1–5) – competencies, mean (SD)	4.2 (0.9)	4.1 (0.9)	4.3 (0.8)	0.05
Missing	20	11	9	
Experience with telemedicine, n (%)				
Positive experience	25 (11.8)	16 (13.7)	9 (9.5)	0.35
Neutral experience	19 (9.0)	13 (11.1)	6 (6.3)	0.22
Negative experience	9 (4.2)	6 (5.1)	3 (3.2)	0.36
No experience	161 (75.2)	83 (70.3)	78 (81.3)	0.06
Missing	7	3	4	
Difficulty of discrete choice (1: do not agree; 5: fully agree)				
Description of choice sets was clear (1–5), mean (SD)	3.6 (1.0)	3.7 (0.9)	3.5 (1.1)	0.09
Task was easy to understand (1–5), mean (SD)	3.7 (1.0)	3.8 (0.9)	3.7 (1.1)	0.59
It was easy to make a choice (1–5), mean (SD)	3.5 (1.0)	3.6 (1.0)	3.6 (1.1)	0.47
Missing	7	2	5	
Willingness to pay for teledermatology in € (median, IQR)				
Store-And-Forward	0 (0–20)	2.5 (0–20)	0 (0–11)	0.20
Live-Interactive	0 (0–20)	7.5 (0–25)	0 (0–20)	0.20
Missing	58	31	27	

previous DCEs^{58,59} and reflecting patients' dissatisfaction with insufficient time and attention from physicians for their condition.³

The lack of a preference between S&F and LI teledermatology modes might stem from patients' limited telemedicine experience, making it difficult to assess each mode's advantages. Despite explanations, benefits such as flexibility (e.g. no scheduled appointments)¹⁰ might become clear with actual use.

It appears counterintuitive that patients with higher education and larger time requirements for a consultation preferred standard-of-care. Especially, as both higher education and potential time savings are associated with a higher acceptance and preference for telemedicine.^{20,58,60} However, two key considerations are relevant: First, patients with large time requirements become tolerant to long travel distances.⁶¹ Second, highly educated patients with psoriasis often travel farther for appointments and actively participate

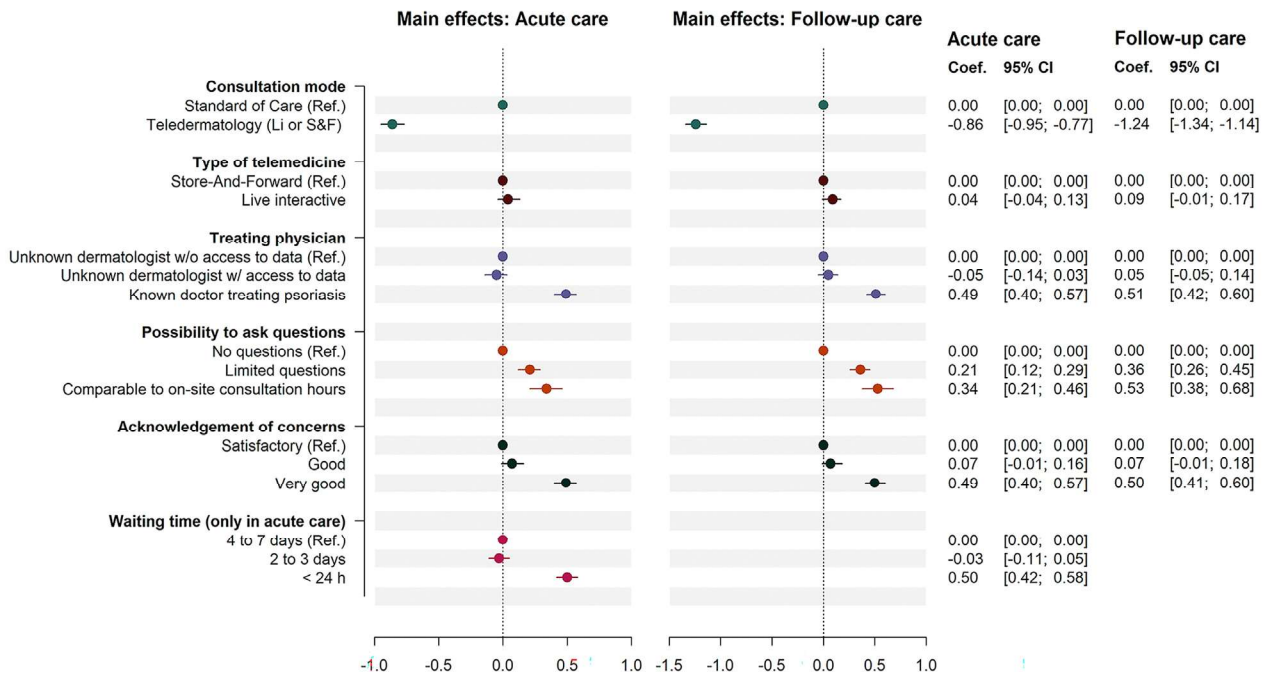


FIGURE 2 Main effects models: acute and follow-up care.

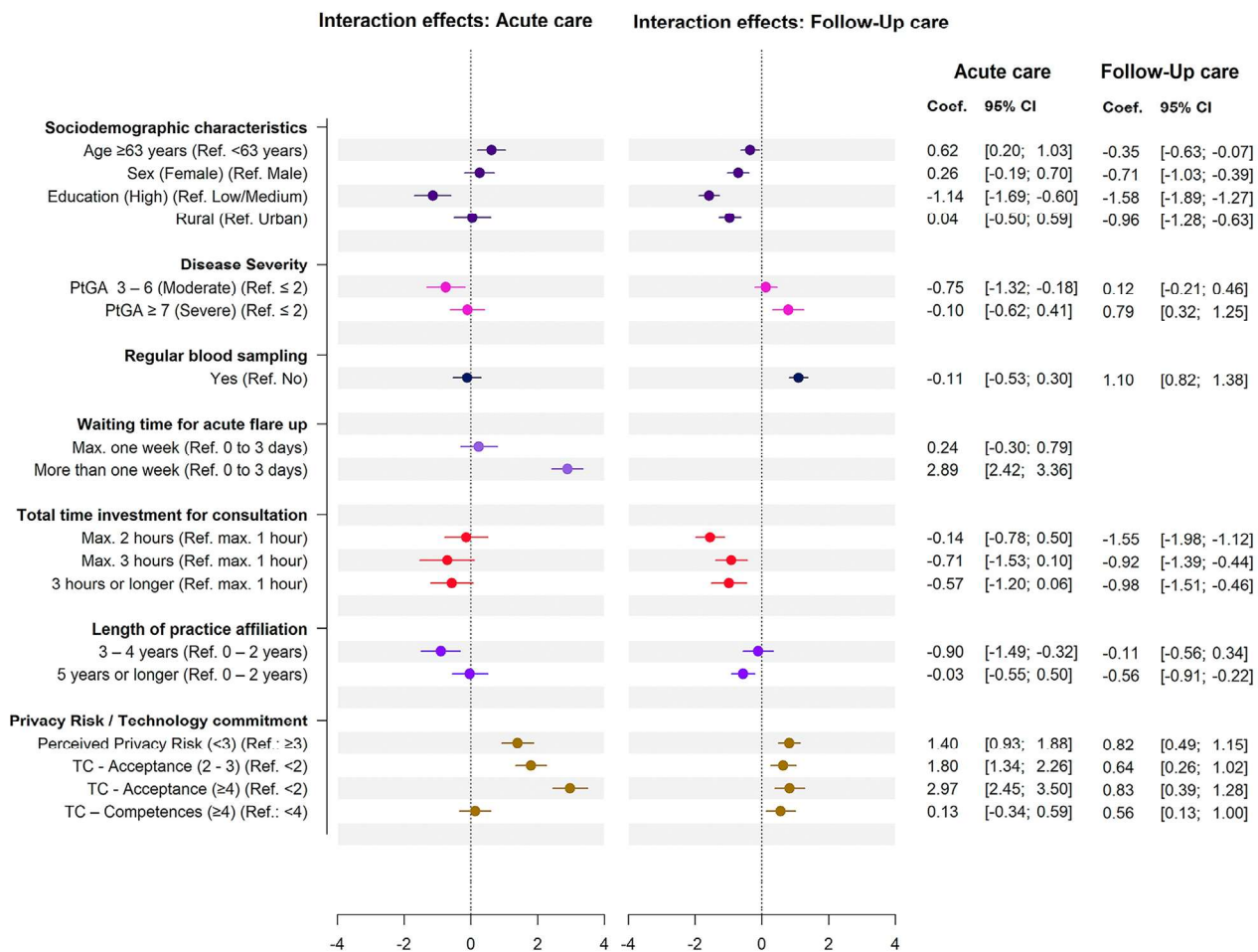


FIGURE 3 Interaction effect model: acute and follow-up care.

in decision-making, which could be perceived as restricted in teledermatology.^{62–64}

Age, sex, urban/rural residency, disease severity and length of physician relationship impacted preferences for teledermatology differently in the two scenarios. The underlying reasons can only be hypothesized. Older participants may favour telemedicine in acute situations to avoid the physical strain of visiting healthcare facilities, whereas younger individuals may prefer it for follow-ups to fit their work schedules. The non-significant sex-based preference for acute situations aligns with previous DCEs in primary care,^{33,58} unlike in follow-up care situations. Here, teledermatology may ease integrating quarterly visits into daily routines, particularly for full-time employees—predominantly male in Germany.⁶⁵ Disease activity was irrelevant in acute scenarios because all participants imagined a similar flare-up, whereas in follow-up situations, high disease severity could make travel to a physician more burdensome. Finally, urban residents were more likely to embrace teledermatology, a trend already noted in previous research.^{66,67}

Concerns on data privacy, lower technological competencies and lower acceptance of technology negatively affected preferences towards telemedicine, which aligns with existing literature.^{33,51} These findings align with the concept of a second-order digital divide, wherein disparities in the use of technologies are driven not by lack of access, but by differences in acceptance and competencies.⁶⁸ Because teledermatology can offer faster, more accessible treatment and is already used to bypass waiting times,⁴¹ it may impact existing healthcare inequities, highlighting the need for monitoring and proactive interventions.⁶⁹

In addition to patient preferences, structural constraints within the healthcare system must be considered. While patients favour a fast response (within 24h) and continuity of care, our analysis revealed that 40% of patients currently wait more than a week for treatment. This raises the question of whether teledermatology alone can realistically meet patient preferences.

These challenges are likely to intensify due to three factors: (1) Demographic transition: A declining number of physicians paired with an increasing patient population.⁷ (2) Physicians' work–life balance: A growing demand for reduced and more flexible working hours.⁷⁰ (3) Shift towards medical care centres (Medizinische Versorgungszentren) employing multiple physicians,⁷¹ which reduces the likelihood that patients are continuously treated by the same physician. However, because challenges also affect in-person consultations, patient preferences for teledermatology might adapt over time.

Although private teledermatology platforms in Germany are moving towards faster response times (approaching 24h) and offering the ability to choose a physician,^{41,72} the scalability of this approach remains uncertain.

We excluded costs from the DCE because LI-teledermatology is covered by health insurance in Germany and S&F in exceptions. Patients are generally unaccustomed to out-of-pocket expenses, as evidenced by the low

willingness to pay also observed in our survey and previous research.⁷³ Therefore, covering costs by health insurances is crucial for a successful implementation in Germany.^{21,74}

This study has several limitations and may not be applicable for all patients with psoriasis. First, patients from patient organizations, which are typically more informed and critical, do not accurately represent the broader patient population.^{75,76} Our sample was older and more female-dominated than the psoriasis patient population.⁷⁷ Second, the low response rate, varying by invitation group, suggests potential nonresponse and volunteer bias. This is further suggested by the inclusion of relatively younger members of the DPB who participated, indicating an underrepresentation of patients with lower digital competence. DCEs are constrained by the number of attributes they can include, leaving out potentially relevant attributes such as costs.^{39,78} Despite these limitations, this study is the first DCE on teledermatology for psoriasis. Further research to validate and expand our findings is necessary.

CONCLUSION

The discrete choice experiment explored patient preferences that could improve teledermatology adoption in Germany. While standard-of-care was generally preferred, preference for teledermatology improved when patients were consulted by their known physician, had their concerns acknowledged and could ask questions. A consultation within 24h was important for acute situations. High technology acceptance and competencies, along with low perceived privacy risks, notably enhanced preferences for teledermatology. These results offer valuable insights for policymakers, researchers and healthcare providers to develop patient-valued teledermatology models.

AUTHOR CONTRIBUTIONS

Patrick Reinders: Conceptualization, methodology, data collection, data analysis and interpretation, writing—original draft, project administration and visualization; **Brigitte Stephan:** Conceptualization, review and editing and data interpretation; **Matthias Augustin:** Supervision, data interpretation, data collection, writing—review and editing; and **Marina Otten:** Supervision, methodology, conceptualization, data interpretation, and writing—review and editing.

ACKNOWLEDGEMENTS

The authors thank the Scientific Communication Team of the IVDP, in particular Julia Zechlin for copy editing. Open Access funding enabled and organized by Projekt DEAL.

FUNDING INFORMATION

None.

CONFLICT OF INTEREST STATEMENT

Marina Otten is a co-author of the German AWMF guideline on teledermatology. Patrick Reinders declares no

conflicts of interest. Matthias Augustin is a co-author of the German AWMF guideline on teledermatology and a scientific advisor for the teledermatology platform derma2go AG and Videoclinic GmbH. Brigitte Stephan supports the A + Videoclinic with health care service and scientific advice.

DATA AVAILABILITY STATEMENT

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

ETHICAL APPROVAL


Reviewed and approved by Lokale Psychologische Ethikkommission am Zentrum für Psychosoziale Medizin (LPEK); approval #LPEK-0611.

ETHICS STATEMENT

All participants were informed about the survey and their data privacy rights, and informed consent was obtained prior to participation.

ORCID

Matthias Augustin  <https://orcid.org/0000-0002-4026-8728>

Brigitte Stephan  <https://orcid.org/0000-0001-6127-3692>

Marina Otten  <https://orcid.org/0000-0003-3767-1548>

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Reinders P, Augustin M, Stephan B, Otten M. Understanding patient priorities in tele dermatology for psoriasis: A discrete choice experiment. *J Eur Acad Dermatol Venereol.* 2025;00:1–12. <https://doi.org/10.1111/jdv.20701>

3. Zusammenfassung

3.1. Zusammenfassung Deutsch

Die dermatologische Versorgung in Deutschland steht aufgrund des demografischen Wandels vor erheblichen Herausforderungen. Ein Fachkräftemangel bei gleichzeitiger steigender Krankheitslast erfordert innovative Lösungen. Die Digitalisierung und der Einsatz von *Digital Health*-Anwendungen (DHAs) bieten Potenzial, um negative Effekte abzumildern. DHAs können die Patientenzentrierung durch personalisierte Gesundheitsdaten (*Health in Our Hands*), den Zugang zu Gesundheitsleistungen durch digitale Kommunikation (*Interacting for Health*) sowie die Diagnostik und Therapieentscheidungen durch Datenverarbeitung (*Data Enabling Health*) unterstützen. Neben diesen Vorteilen bestehen jedoch Herausforderungen: Der sogenannte *Digital Divide* führt zu ungleichen Nutzungsmöglichkeiten in Abhängigkeit von sozialen Faktoren (z. B. Alter, Bildung, Einkommen) und fehlende Evidenz und Validierung bergen Risiken wie die Weiterleitung von Fehlinformationen an Patienten und Leistungserbringer. Des Weiteren sind die Themen Datenschutz und -sicherheit von zentraler Bedeutung. Trotz zahlreicher gesetzlicher Initiativen, etwa zur elektronischen Patientenakte, ist die Digitalisierung im deutschen Gesundheitswesen bislang unzureichend umgesetzt. Für die Dermatologie fehlen zudem belastbare Daten zur Nutzung, Akzeptanz und Verfügbarkeit von DHAs. Diese Dissertation untersucht daher den Status quo der Digitalisierung in der Dermatologie. Dies umfasst:

1. Eine systematische Übersicht der Evidenz zu DHAs,
2. Die systematische Untersuchung von Barrieren und fördernden Faktoren,
3. Die Ermittlung der Akzeptanz von Dermatologen und Patienten gegenüber DHAs,
4. Die Verbreitung von DHAs bei Patienten und Dermatologen sowie
5. Die Präferenzen von Patienten hinsichtlich der Teledermatologie.

Die Methodik umfasste unterschiedliche Erhebungsmethoden: systematisches Review, Fokusgruppen, querschnittserhebende Umfragen sowie ein Discrete-Choice-Experiment. Die Umfragen wurden zudem mit den statistischen Methoden der Clusteranalyse, der Faktorenanalyse und Regressionsanalyse ausgewertet.

Die systematische Übersichtsarbeit hat aufgezeigt, dass obwohl zahlreiche Studien zu DHAs existieren, sich diese vor allem auf die Teledermatologie (205 von 404 Publikationen), KI-Anwendungen zur Diagnosestellung (65 von 404 Publikationen) und DHAs für

Gesundheitsberufe (262 von 404 Publikationen) konzentrieren. Die Fokusgruppen identifizierten verschiedene Herausforderungen, darunter die Sorge von Dermatologen vor einer Informationsflut ohne Mehrwert für Patienten. Einigkeit bestand bei allen drei Gruppen (Patienten, Dermatologen, Pflegekräfte) darüber, dass ältere Patienten Schwierigkeiten bei der Nutzung von DHAs haben könnten. Die Clusteranalysen zeigten, dass sowohl Patienten als auch Dermatologen heterogene Einstellungen gegenüber DHAs aufweisen. Während große Cluster in beiden Gruppen (Dermatologen: *Adopters*; Patienten: *Digital Enthusiasts*) die Vorteile von DHAs anerkennen und deren Nutzung positiv gegenüberstehen, wurden ebenso ablehnende Gruppen identifiziert (Dermatologen: *Rejectors*; Patienten: *Digital Sceptics*). Die weiteren Umfragen konnten aufzeigen, dass DHAs bislang im geringen Umfang genutzt wurden, so verwendeten im Jahr 2023 lediglich 4 % der Allgemeinbevölkerung mit einer Hauterkrankung eine teledermatologische Anwendung. Akzeptanz gegenüber und die Nutzung von DHAs hängen signifikant von soziodemografischen Faktoren (Alter, Geschlecht, Bildung), Datenschutzbedenken und dem Schweregrad der Erkrankung ab. Auch unter Dermatologen zeigte sich eine höhere Aufgeschlossenheit gegenüber DHAs bei jüngeren sowie in Städten praktizierenden Fachärzten. Das DCE zeigte auf, dass Patienten zwar die Vor-Ort-Behandlung gegenüber der Teledermatologie bevorzugen, jedoch steigte die Präferenz, wenn der behandelnde Arzt bekannt ist, Rückfragen möglich sind, individuelle Bedürfnisse berücksichtigt werden und eine schnelle Rückmeldung – insbesondere in akuten Fällen – gewährleistet wird.

Die Dissertation zeigt, dass der aktuelle Stand der digitalen Dermatologie als unzureichend einzustufen ist, mit einer geringen Nutzung sowohl durch Patienten als auch Dermatologen. Dennoch gibt es positive Entwicklungstendenzen: Eine hohe Anzahl an Patienten und Dermatologen würde DHAs im Behandlungsverlauf akzeptieren, und ein bedeutender Anteil von Patienten hat eine Präferenz für den Einsatz der Teledermatologie als Alternative zur Vor-Ort-Behandlung. Gleichzeitig wurden jedoch zahlreiche Barrieren und Risiken identifiziert. Dazu zählen die unzureichende Evaluierung von DHAs, fehlende digitale (Gesundheits-)Kompetenzen – insbesondere auf Patientenseite –, der bereits beschriebene *Digital Divide*, fehlende finanzielle Anreize für Dermatologen sowie Herausforderungen bei der Umsetzung des Datenschutzes. Letzteres führt einerseits zu erhöhten Anforderungen an IT und Praxisabläufe mit hohen Kosten für niedergelassene Dermatologen, andererseits zu Unsicherheiten bei Patienten hinsichtlich des Schutzes ihrer Daten.

Für eine erfolgreiche Digitalisierung in der Dermatologie müssen Nutzerpräferenzen frühzeitig in die Entwicklung einfließen, um einen Mehrwert für alle Beteiligten sicherzustellen. Der Datenschutz und -sicherheit müssen sichergestellt werden und sollten gleichzeitig einen minimalen negativen Einfluss auf die Bedienfreundlichkeit von Anwendungen haben. Zudem

sind eine Evaluierung von DHAs sowie die gezielte Förderung digitaler (Gesundheits-)Kompetenzen bei Dermatologen und Patienten essenziell.

3.2. Summary English

Dermatological care faces significant challenges in Germany due to the demographic change. A regional shortage of specialists, combined with an increasing burden of disease, calls for innovative solutions. Digitalization and the use of Digital Health Applications (DHAs) offer potential to mitigate negative effects. DHAs can enhance patient-centered care through personalized health data (“Health in Our Hands”), improve access to healthcare services through digital communication (“Interacting for Health”), and support diagnostics and treatment decisions through data processing (“Data Enabling Health”).

However, several challenges remain: the “Digital Divide” leads to unequal usage opportunities depending on social factors (e.g., age, education, income), lack of evidence and validation poses risks such as misinformation, and data protection and security continue to be critical issues. Despite numerous legislative initiatives, such as the introduction of the electronic patient record, digitalization in the German healthcare system remains insufficient. Furthermore, there is a lack of reliable data regarding the use, acceptance, and availability of DHAs in dermatology.

This dissertation examines the status quo of digitalization in dermatology. The key objectives include:

1. A systematic review of DHAs,
2. The investigation of barriers and enabling factors,
3. The assessment of acceptance of DHAs among dermatologists and patients,
4. The prevalence of DHA use among patients and dermatologists, and
5. Patient preferences regarding tele dermatology.

The methodology included a systematic review, focus groups, cluster analyses, cross-sectional surveys, and a discrete-choice experiment.

Although numerous studies on DHAs exist, many focus on tele dermatology (205 out of 404 publications), AI-based diagnostic applications (65 out of 404 publications), and DHAs for healthcare professionals (262 out of 404 publications). The focus groups identified various challenges, including concerns among dermatologists about an information overload without

significant added value for patients. There was consensus among all three groups (patients, dermatologists, and healthcare professionals) that older patients may face difficulties using DHAs.

Cluster analyses revealed that both patients and dermatologists exhibit heterogeneous attitudes towards DHAs. While large clusters in both groups (dermatologists: *Adopters*; patients: *Digital Enthusiasts*) recognize the benefits of DHAs and are open to their use, opposing clusters were also identified (dermatologists: *Rejectors*; patients: *Digital Sceptics*).

The adoption of DHAs remains low. In 2023, only 4% of the general population with a skin condition used a teledermatology application. Acceptance and usage are significantly influenced by sociodemographic factors (age, gender, education), data protection concerns, and disease severity. Among dermatologists, younger professionals and those practicing in urban areas demonstrated greater openness towards DHAs.

While patients generally prefer in-person treatment over teledermatology, acceptance increases when the treating physician is known, opportunities for follow-up questions are available, individual needs are considered, and rapid response times—especially in acute cases—are ensured.

The dissertation concludes that the current state of digital dermatology remains insufficient, with low adoption rates among both patients and dermatologists. However, there are positive trends: a significant proportion of both groups would accept the usage of DHAs, and patients show a growing preference for teledermatology as an alternative to in-person treatment.

At the same time, several barriers and risks have been identified. These include the lack of evaluation of DHAs, insufficient digital (health) literacy—especially among patients—the previously mentioned Digital Divide, a lack of financial incentives for dermatologists, and challenges in implementing data protection measures. The latter leads to increased IT and practice workflow requirements, resulting in high costs for private dermatology practices, while also causing uncertainty among patients regarding data security.

For the successful digitalization of dermatology, user preferences must be considered early in the development process to ensure added value for all stakeholders. Data protection and security must be guaranteed while minimizing their impact on the ease of use of digital applications. Additionally, thorough evaluation of DHAs and the targeted promotion of digital (health) literacy among dermatologists and patients are essential.

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5. Abkürzungsverzeichnis

aOR	adjusted Odds Ratio
BfArM	Bundesinstitut für Arzneimittel und Medizinprodukte
DAAB	Deutscher Allergie- und Asthmabund
DCE	Discrete Choice Experiment
DDA	Deutsche Dermatologische Akademie
DHA	Digital Health-Anwendung
DiGA	Digitale Gesundheitsanwendung
DiGAV	Digitale-Gesundheitsanwendungen-Verordnung
DiPA	Digitale Pflegeanwendung
DPB	Deutscher Psoriasisbund e.V.
DSGVO	Datenschutzgrundverordnung
eAU	elektronische Arbeitsunfähigkeitsbescheinigung
EBM	einheitlicher Bewertungsmaßstab
EFA	Explorative Faktorenanalyse
ePA	elektronische Patientenakte
FORSA	Forsa Gesellschaft für Sozialforschung und statistische Analysen mbH
G-BA	Gemeinsamer Bundesausschuss
GEMATIK	Gesellschaft für Telematikanwendungen der Gesundheitskarte mbH
GKV	Gesetzliche Krankenversicherung
HCP	Health Care Provider
HLS-GER 2	Health Literacy Survey Germany-2

ISPOR	International Society of Pharmacoeconomics
IVDP	Institut für Versorgungsforschung in der Dermatologie und bei Pflegeberufen
KI	Künstliche Intelligenz
LTE	Long Term Evolution
MBO-Ä	(Muster-)Berufsordnung für die in Deutschland tätigen Ärztinnen und Ärzte
NICE	National Institute for Health and Care Excellence
S&F	Store-And-Forward
SGB V	Sozialgesetzbuch V
STEER	Stability of Group Number, Technology, Environment, Evaluation und Recruitment
UTAUT	Unified Theory of Acceptance and Use of Technology
WHA	World Health Assembly
WHO	World Health Organization

6. Abbildungsverzeichnis

Abbildung 1 "A conceptual model for eHealth" von Shaw et al. 2017 [27] lizenziert unter CC BY 4.0	11
Abbildung 2 Weitere Einsatzmöglichkeiten und Vorteile von DHAs in der Dermatologie (Eigene Abbildung).....	13
<i>Abbildung 3 Beispiel eines von 16 sogenannten Choice Sets, das Teilnehmern im Anwendungsszenario ‚Akut‘ vorgelegt wurde.</i>	<i>34</i>
Abbildung 4 Übersicht der identifizierten Digital-Health-Anwendungen nach Kategorien (n = 404) aus Reinders et al. 2023 [132] lizenziert unter CC-BY (Lizenznummer: 5937721328143)	37
Abbildung 5 <i>Clusterbezogene Akzeptanzprofile der befragten Dermatologen (n = 155) zu Digital Health-Anwendungen auf Item-Ebene</i>	<i>40</i>
Abbildung 6 Clusterbezogene Akzeptanzprofile der befragten dermatologischen Patienten (n = 315) zu Digital Health-Anwendungen auf Item-Ebene	42
Abbildung 7 Einstellung, Nutzung und Erwartungen an die Digitale Medizin in den Jahren 2019 (n = 585) und 2021 (n = 792) aus Reinders et al. 2024 [135] lizenziert unter CC-BY 4.0	44
Abbildung 8 Nutzung von DHAs von Personen mit (n = 630) und ohne Hauterkrankung (n = 1471) in den letzten 12 Monaten aus Reinders et al. 2024 [135] lizenziert unter CC-BY (Lizenznummer: 5937730604065).....	47
<i>Abbildung 9 Präferenzschätzungen für den Einsatz der Teledermatologie bei Patienten mit einer Psoriasis (n = 378) (Conditional Logit Model – Haupteffektmodell) Anmerkung: Punktschätzungen (im Diagramm: Coef.) sind mit Punkten im Diagramm dargestellt und die 95% CI via Linien</i>	<i>50</i>
<i>Abbildung 10 Analyse der Interaktionseffekte auf die Präferenz für den Einsatz der Teledermatologie bei Patienten mit Psoriasis (n = 378) (Conditional Logit Model – Interaktionseffekte).....</i>	<i>52</i>

7. Tabellenverzeichnis

Tabelle 1 Übersicht über alle Publikationen.....	35
Tabelle 2 Attribute und Ausprägungen der Choice Sets zum Discrete Choice Experimente zur Tele Dermatologie.....	33
Tabelle 3 Multivariate Analyse zur Akzeptanz und Nutzung von DHAs der Gesamtpopulation (n = 2101) und Personen mit einer Hauterkrankung (n = 630) (logistische Regressionen) ..	48

8. Erklärung des Eigenanteils an den Publikationen

Die Konzeption des Projektes und die Erstellung des Exposees wurden maßgeblich von mir gemeinsam mit Dr. Marina Otten entwickelt. Die Durchführung der Umfragen und Fokusgruppen wurden von mir und Dr. Marina Otten gemeinsam in enger Abstimmung koordiniert. Der Fragebogen zu Publikation 5 wurde von Marina Otten im Jahr 2019 entwickelt und von mir mit Unterstützung von Dr. Marina Otten und Prof. Dr. Matthias Augustin erweitert für die Umfrage im Jahr 2021. Für die Aussendung der Fragebögen im Jahr 2019 war Dr. Marina Otten verantwortlich. Alle weiteren Fragebögen und semi-strukturierten Leitfäden wurden initial von mir entwickelt und zusammen mit Dr. Marina Otten überarbeitet. Das Datenmanagement wurde von mir durchgeführt. Das methodische Vorgehen, sowie die Durchführung der Berechnungen der Umfragen und qualitativen Auswertung der Transkripte der Fokusgruppen wurde von mir geplant und mit Unterstützung von Dr. Marina Otten ausgeführt. Ich erstellte die Erstfassungen aller Manuskripte und überarbeitete diese nach Kommentaren der Ko-Autoren und Reviewer bis zur finalen Publikation.

9. Eidesstattliche Versicherung

Ich versichere ausdrücklich, dass ich die Arbeit selbständig und ohne fremde Hilfe, insbesondere ohne entgeltliche Hilfe von Vermittlungs- und Beratungsdiensten, verfasst, andere als die von mir angegebenen Quellen und Hilfsmittel nicht benutzt und die aus den benutzten Werken wörtlich oder inhaltlich entnommenen Stellen einzeln nach Ausgabe (Auflage und Jahr des Erscheinens), Band und Seite des benutzten Werkes kenntlich gemacht habe. Das gilt insbesondere auch für alle Informationen aus Internetquellen.

Soweit beim Verfassen der Dissertation KI-basierte Tools („Chatbots“) verwendet wurden, versichere ich ausdrücklich, den daraus generierten Anteil deutlich kenntlich gemacht zu haben. Die „Stellungnahme des Präsidiums der Deutschen Forschungsgemeinschaft (DFG) zum Einfluss generativer Modelle für die Text- und Bilderstellung auf die Wissenschaften und das Förderhandeln der DFG“ aus September 2023 wurde dabei beachtet.

Ferner versichere ich, dass ich die Dissertation bisher nicht einem Fachvertreter an einer anderen Hochschule zur Überprüfung vorgelegt oder mich anderweitig um Zulassung zur Promotion beworben habe.

Ich erkläre mich damit einverstanden, dass meine Dissertation vom Dekanat der Medizinischen Fakultät mit einer gängigen Software zur Erkennung von Plagiaten überprüft werden kann.

Unterschrift:

10. Danksagung

Hiermit möchte ich mich herzlich bei allen bedanken, die mich im Rahmen meiner Doktorarbeit unterstützt haben. Ein besonderer Dank geht an meine Forschungsgruppenleiterin Dr. Marina Otten, welcher mir eine grobe Projektidee gegeben hat und diese mit mir weiter erarbeitet und mich in der Umsetzung der Arbeit unterstützt hat. Sie hat mich gefördert, mir Kongressreisen und Fortbildungen ermöglicht und mir die Welt der qualitativen Wissenschaft nähergebracht. Herzlichen Dank an dieser Stelle.

Zusätzlich möchte ich mich noch herzlich bei allen anderen Kollegen und Kolleginnen am IVDP und den Mitgliedern der Prüfungskommission für die Unterstützung und den Austausch bedanken. An erster Stelle bei unserem Direktor und meinem Doktorvater, Prof. Dr. Matthias Augustin, der mit großzügiger Bereitstellung von Ressourcen, Unterstützung und Ideen diese Arbeit erst möglich gemacht hat. Ein besonderer Dank gilt auch Anastasia Fleyder, welche mich in vielen großen und kleinen Projektschritten unterstützt hat. Vielen Dank!

Schließlich möchte ich mich herzlich bei meiner Familie und meinen Freunden für die bedingungslose Unterstützung und Motivation während der Promotion bedanken. Insbesondere bei meiner Frau, welche immer ein offenes Ohr für mich hatte und Verständnis dafür hatte, dass ich meine Wochenenden zum Teil hinter dem Schreibtisch verbracht habe.