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Fingerprint change as a consequence of anticancer treatments: A systematic integrative review

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ABSTRACT

Objective: While it is widely acknowledged that fingerprint recognition has played an essential part in policing and forensic science, little is known about fingerprint alterations in medical science, specifically as a consequence of anticancer treatments. Thus, we aimed to analyze the extent of evidence between cancer treatments and fingerprint alterations in adults with cancer.
Methods: A systematic integrative review was conducted according to the PRISMA statement and the Cochrane guidelines for conducting a systematic review. PubMed, CINAHL, Web of Science, and Scopus were searched from the inception between August and November 2024. The quality appraisal was conducted to evaluate the methodological quality of the included articles, selecting the most appropriate tool based on the publication type and study design.
Results: Of 176 records, we selected five experimental studies articles and nine case reports publications. A correlation between specific anticancer treatments (capecitabine, taxanes, and tyrosine kinase inhibitors) and fingerprint alterations has been documented in individuals with various cancer diagnoses (mainly advanced breast and colorectal cancers). The majority of articles were of moderate to low quality.
Conclusions: Although fingerprint alteration as a consequence of specific anticancer treatments has been documented, further large and well-designed experimental studies are necessary to quantify the phenomenon burden in relation to specific anticancer regimens and populations.
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Introduction

Fingerprints are the impressions produced by the raised papillary or epidermal ridges (friction skin) at the fingertips' surfaces on the ends of the fingers and thumbs that contain rows of pores that connect to sweat glands [1]. When a person touches any surface, the sebaceous secretion and sweat smear the impression of fingertips [2]. Friction ridge skin is distinguished from other skin varieties by its elevated ridges, thicker and more complex epidermis, increased sensory capacity, lack of hair, and absence of sebaceous glands [1]. The scientific study of fingerprint and palm patterning is known as "dermatoglyphics" [3,4].

The use of biometric verification involving fingerprinting has been spreading worldwide in several social contexts, such as immigration, office attendance, bank account verification, granting citizenship, driver's licenses, and passports [5], as well as in healthcare, having advantages for broad scopes such as access control to restricted hospitals' areas, medication dispensing systems for reducing medication errors, patient identification at points of care and identity of patients availing themselves of remote healthcare services [6–8]. Along with the widespread use of fingerprints,

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more cases of "loss" or "absence" of fingerprints have been registered [9]. In the USA, 24 million visitors/year experienced a scanned rejection rate of 1%–2% [10]. In a survey conducted on the Lebanese population, the incidence of adermatoglyphia was 0.18%, predominantly affecting the geriatric and female populations [11].

In the field of acquired loss of dermatoglyphics, several dermatological or nondermatological causes have been investigated [11]. Considering the acquired nondermatological causes [9], certain drugs, such as anticancer treatments, may cause partial or total loss of fingerprint [11], representing a barrier to fingerprint biometric identification, especially if the condition is permanent or irreversible [9]. Denied access to fingerprint biometric identification systems may compromise the social and health needs of patients with cancer, resulting in some cases of immigration delays at airports and travel warnings [12], the inability to access promptly the smartphone [13], and denied authorization to perform a banking transaction [14] or in trouble in border [15]. These aspects become essential in the cancer population, where psychosocial needs are frequently compromised [16,17].

However, fingerprint changes seem not to be investigated and reported as a side effect of cancer treatments in routine clinical care [18], and chemotherapy's side effects remain one of the major concerns of individuals with cancer that impact treatment adherence [19]. In this regard, no systematic reviews have been conducted to analyze the literature regarding the relationship between fingerprint changes and anticancer treatments. In the context of health and social issues, fingerprint alterations and the inability to access identification systems could exacerbate the well-documented perception of loneliness and social isolation who encounter individuals with cancer throughout their cancer trajectory, where social functioning emerged as the most relevant aspect [20,21]. Psychosocial vulnerability may serve as an antecedent of more serious psychological disorders [22]. Furthermore, some physical initial alterations could be antecedents of more serious physical complications and precursors of health outcomes in cancer care as it was established, for example, with hand-foot syndrome (HFS) [23–25].

Adults with cancer encounter a variety of physical and psychological symptoms that lack appropriate management, suggesting that complete symptom screening and management are needed to deal with this complex setting [26]. Providing patients with comprehensive information about any potential treatment side effects is crucial for enhancing treatment adherence, providing accompaniment and support during treatment, and improving health outcomes [19]. In this regard, investigating the extent of literature about fingerprint changes as potential cancer treatments' side effects could be strategic for implementing the actual knowledge of symptom science in cancer care and empowering the educational and interventional programs for symptom management [27]. This information will also help to identify the problem's size and establish research and intervention priorities among institutions and professional associations [27,28]. Therefore, this study seeks to comprehensively summarize the extent of evidence between cancer treatments and fingerprint alterations in adults with cancer by addressing the following review questions: (1) What is the extent of evidence between cancer and fingerprint change? (2) Is there a link between cancer, cancer-related treatments, and fingerprint change? (3) Do cancer-related treatments cause fingerprint change? The review questions were consistent with the patients, exposure, and outcome (PEO) framework as follows [29]: (P) adults aged $\geq$ 18 with cancer (any type, including solid and hematological tumors), (E) cancer disease and cancer-related treatments, (O) fingerprint change (as primary or secondary endpoint).

Methods

Study design

An integrative systematic review followed Whittemore and Knafl's five-step approach: problem identification, literature search, data evaluation, data analysis, and presentation [30]. An integrative review allowed for a combination of disparate multimethod data collection approaches and studies' design into integrated findings and conclusions, resulting in a comprehensive portrayal of the fingerprint change phenomenon in cancer. Firstly, a rapid literature review was conducted to detect any existing reviews as well as the amount of evidence on this topic. The scarce available evidence on the topic guided us toward an integrative review design. To optimize the systematic process and reporting, we followed the requirements recommended by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [31–32] and the Cochrane guidelines for conducting a systematic review [33]. The systematic integrative review protocol was registered on Prospero first [CRD42024581192].

Definition of the outcome and condition to be examined

The congenital or acquired loss of the epidermal ridge pattern is called "adermatoglyphia" [34]. This condition can be limited to a few digits or all fingers, and it can also relate to the lack of ridge patterns on the plantar surfaces of the feet. Furthermore, adermatoglyphia can refer to either a partial loss of epidermal ridges (ridges are imperceptible on a broad examination but visible on a deep inspection or under a magnifying lamp) or a total lack of epidermal ridges (complete effacement). These scenarios make it complex to standardize the outcome in experimental studies or scientific publications. However, in our research, we considered any variation of fingerprint that could result in difficulties in accessing fingerprint identification systems. This choice was consistent with broadly summarizing the available literature that comprehensively describes the phenomenon.

Eligibility criteria

The PEO framework constituted the basis for records selection along with the following inclusion criteria [29]: (a) Any type of original research peer-reviewed articles focused on cancer and fingerprint change, including articles analyzing the relationship between HFS and fingerprint change (b) Records containing abstracts; (c) Any type of study design papers (including case reports and case studies), (d) Articles focused on individuals with cancer (any malignancy) who are under and off treatment, regardless of disease stage or treatment phase and type. We excluded letters to editors and commentary for analysis purposes, except letters that reported experimental studies data. No inclusion or exclusion criteria will be set for the setting and language.

Search strategy and sources

Multiple databases were searched between August 2024 (the first date of search) and November 2024 (when we re-run the search strategy) to identify papers published from the inception until the present: PubMed, CINAHL, Web of Science, and Scopus. The study's topic informed the databases' selection. The research question guided the selection of the keywords to be implemented in the research string with the boolean operator as follows: "neoplasm" OR "cancer" AND "chemotherapy" OR "treatment" OR "capecitabine" AND "fingerprint" OR "Adermatoglyphia". A search string was initially designed for PubMed using MeSH and

free-text words, and then it was adapted for the other databases according to their syntax. We adopted purposive sampling, limiting the search to the cancer subset and selecting methods-based filters (PubMed Clinical Queries) and topic-specific filters (Topic-Specific/Special Queries) [35,36]. To ensure that all relevant literature related to the research questions was intercepted, an additional search string was developed for PubMed without filters. An author with expertise in research methods, particularly in systematic reviews, created and implemented the search strategy.

Further methods and sources, such as hand-searching and reference checking, were used to maximize the results. No language or any other restrictions were applied. As recommended [37], a systematic search was conducted on Google Scholar for grey literature or additional relevant published results to supplement our findings. This choice was consistent with our primary aim to explore the amount of literature regarding fingerprint changes and anticancer treatments and confirm the relevance of this phenomenon. For quality and transparency purposes, we checked and reported (in the extraction table) each article source, considering that Google Scholar could sometimes identify articles from predatory journals and researchers are unable to search specifically for peer-reviewed or scholarly articles. Supplementary File 1 reports the search strategies for each database. The search was undertaken in all fields for all databases and sources.

Articles selection

Records were exported from the original databases to Zotero for removing duplicates. After removing duplicates, records were imported into Rayyan's review software, and two authors performed the entire screening independently. Firstly, records were screened based on the titles and abstract contents to obtain a list of papers for full-text screening. A hierarchical stepwise selection process was used to decide whether an article could be included and the reasons for exclusions, in which articles were excluded based on the PEO order criteria and then the aforementioned inclusion criteria order. This approach helped us standardize the process of inclusion and exclusion of papers and the reasons for exclusion. The following reasons were used to standardize the articles' exclusion process: "not congruent with the study aim" (in case the research question was completely different from ours, then all the PEO framework elements were discordant), "letter to editor" (letter to editors or commentary without experimental studies results relevant to the research question), "no abstract available" (as we could not perform the articles' screening according to the PRISMA statement steps), "wrong outcome" (in case of a study focused on cancer patients exposed to chemotherapy but assessing a different outcome, i.e., HFS only). Additional sentences were used to describe specific situations that were not congruent with our research question and eligibility criteria.

Data extraction

Two authors extracted data using a piloted electronic extraction form (Excel form) [38]. Then, two authors independently extracted data on an Excel form and merged the results into a unique file. Data extraction forms were created differently based on the study type: one for research studies and a further one for the case report results. Relevant information was extracted from each included experimental study, including first author, year, type of publication and source/journal, study design, sample, cancer localization, setting, data collection, primary and secondary endpoints, and results.

From case reports, we extracted the following details: First author and year, journal and source, patient age, sex, and country, tumor type, previous treatment, current treatment (potentially related to fingerprint changes), HFS occurrence, concomitant side effects, fingerprint changes characteristics, fingerprint change practical consequences and duration and cancer course. Considering the importance of case reports in accurately describing the sequence of the events in relation to the investigated outcome, we tried to preserve this advantage by highlighting the temporality of the facts with the main outcome. Therefore, information about events' timing and period were extracted. Further, we extracted any information that could be relevant for suggesting new hypotheses about the correlation between fingerprint change and certain variables for future investigations. In case of disagreement between the two reviewers, additional authors were planned to be involved in both articles' selection and data extraction phases.

The choice of extracting data about the source and publication journal was to describe the contexts where the fingerprint modifications are investigated, considering that studying this phenomenon necessitates the inclusion of different disciplines and professionals. This information allowed us to explore this phenomenon from different perspectives, understanding the intervention areas for future investigations.

Data synthesis

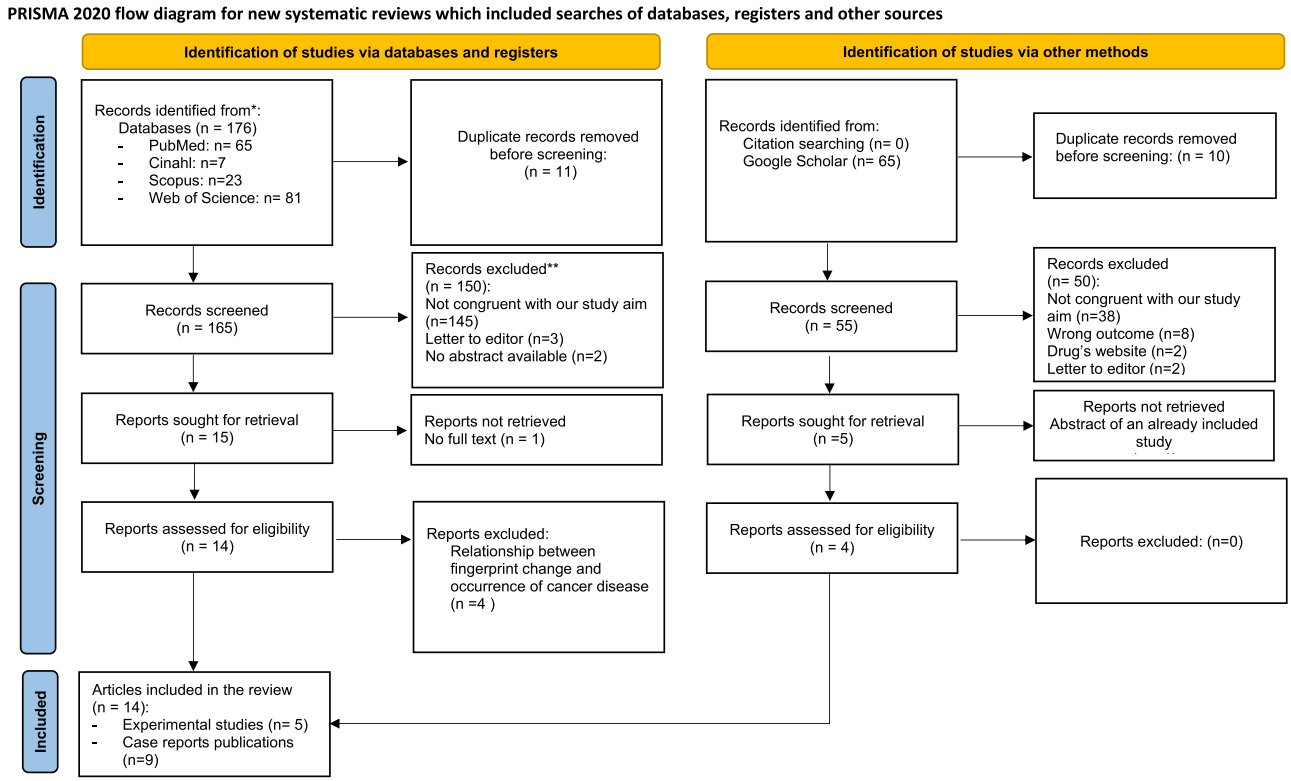
Considering the paucity of quantitative data to be pooled for performing a meta-analysis, we undertook a narrative synthesis according to a suggested framework [39]. In particular, the data collection procedure and fingerprint instruments were different across studies (i.e., digital fingerprint or ink fingerprint); therefore, performing a meta-analysis by pooling different outcome results would have been little informative about the generalizability of the findings. Rather than simply describing the main features, we explored the similarities and differences between studies and the relationships within the data [39]. This approach implies a homogenous description of studies, which enables the comparison of data and provides a summary of knowledge related to the specific review question that may be used to inform future research. Therefore, data from the primary sources in this review were ordered and categorized based on the type of publication and summarized to inform an integrated conclusion about the relationship between fingerprint change and cancer.

Quality appraisal

The lead author assessed the methodological quality of the included articles, which were independently reviewed by a second author. A consensus discussion with an additional author solved potential disagreements between the two reviewers regarding the quality of the rating process.

The Newcastle Ottawa Scale (NOS) [40] was used to evaluate the methodological quality of cohort and case-control studies. The NOS includes eight items within three domains: (1) selection (representativeness), comparability (due to design or analysis), and (3) outcomes (assessment and follow-up). Two points can be allocated to the comparability domain. Studies that obtained seven to eight stars were considered to be of high quality (low risk of bias), studies with five to six stars were of medium quality (moderate risk of bias), and studies with less than five stars were of low quality (high risk of bias) [41].

The Joanna Briggs Institute (JBI) Checklist for Case Reports [42] was used to evaluate the methodological quality of case reports and inform the synthesis and interpretation of the case reports' results. This tool includes eight items that should be evaluated as "yes", "no", "unclear" and "not applicable". The overall appraisal consisted of the following judgment: "include", "exclude", and "seek further info". However, according to the study aim, we planned not to exclude any article based on the methodological



*Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers).
**If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools.

Fig. 1. Selection process.

quality, but the strengths and limitations of studies were acknowledged within the analysis of the articles. Accordingly, we reported the evaluation of the items without giving a final report judgment. Swofford's case study [43] was excluded from this evaluation as its presentation was a hybrid form between a study and a report, and the recommended tool did not apply to all the items. Based on the items tool, we generated an Excel file to summarize and display the results.

Results

A total of 176 results were identified from the database search. After removing duplicates, 165 records were exported to Rayyan software for screening. The selection process identified 14 eligible different types of publications. Fig. 1 depicts the PRISMA flow diagram with sources, the entire selection process, and the reasons for excluding records. The second search strategy identified a total of 16 results, of which 12 were duplicates of the records eligible from the first search strategy, and four were new records; of these four new records, none were eligible. The systematic search on Google Scholar yielded four additional pertinent articles: one research letter [44] including results of a prospective study, an honor-awarded thesis [45] for a Bachelor of Science in the School of Criminal Justice, a case study [43] and a case report [46]. Finally, we found five experimental studies articles [44,45,47–49] and nine case reports publications [43,46,50–56] (for a total of 10 cases described). However, Azadeh's and Yaghobi Joybari's publications were part of the same experimental study. An additional publication [43] was found in the form of a case study. While acknowledging that a case study is methodologically different from a case report [57], we decided to include these findings in the case report section as the results' structure was consistent with the extraction table of case reports. All these articles described fingerprint changes as an effect of specific anticancer treatments or in relation to HFS occurrence.

Cohort studies: Characteristics of studies

The characteristics of the included cohort studies are presented in Table 1. The cohort studies evaluated the incidence of fingerprint changes in patients who received specific treatments (as monotherapy or in combination with other chemotherapy regimens) and its relationship with the occurrence of HFS. Overall, we selected three prospective cohort studies [44,45,48] and one case-control study resulting in two different publications [47,49]. All the case reports were published in scientific methodological peer-reviewed journals indexed at least in PubMed, except for one research [45], part of a published thesis for Degree of Bachelor of Science in the School of Criminal Justice. However, the source of this thesis was reliable as it was commended by the University of Southern Mississippi and included on the university's website. Except for one study (Hartung et al., 2020), all the research was published in journals committed to oncology clinical practice and pharmacology. Despite some studies were not original research articles (i.e., Doorn's study was a letter to editor containing research findings, and Lowe's study was part of a published thesis) all the investigations were undertaken after ethical approval from each local authority.

Female and male individuals of various ages (27-84 years) and cancer types (mostly colorectal cancer) were involved in these monocenter studies, which were undertaken in university hospitals in different countries worldwide: USA [45], Iran [47,49], Netherlands [44] and Germany [48]. The treatments under investigation

Table 1
Characteristics of the experimental research studies.

References	Study design	Sample	Cancer localization	Setting	Data collection	Primary endpoint	Secondary endpoint	Results
Lowe [45]	Prospective cohort: n = 5 received taxane class drugs 144 mg weekly to upward of 270 mg every 3 to 4 wk) and n = 2 received liposomal doxorubicin 60 mg every month (for 6 mo).	N = 7, 27–84 yr.	No information.	University of South Alabama Mitchell Cancer Institute (USAMCI), Alabama (USA).	Before treatment and at 3 and 6 mo, using a powder label technique.	Modification of the friction ridge skin. Impressions were inputted into AFIX Tracker software to determine the number of minutiae points by way of the Smart-Extract feature.	HFS	No decrease in fingerprint quality. One patient who received doxorubicin had a quality decrease which may have been related to HFS. No other significant results further certified the link between HFS and ridge degradation.
Azadeh et al. [47]	Case-control: n = 31 treated with Paclitaxel plus other therapies (cases) and n = 34 had no Paclitaxel but other chemotherapy regimens (controls). Study duration: 7 mo.	N = 65 Cases group: mean age 57,1 yr, 87,1% female, 71% were housewives.	Various (breast cancer, 58,1%).	University Hospital of Tehran (Iran).	Before treatment and after at least 3 cycles, using ink on paper cards.	Fingerprint changes (as >30% mismatching of 16 points after treatment in the right thumb or right index finger (evaluated by a forensic expert of the Iranian Society of Forensic Physicians).	HFS occurrence (according to the CTCAE) and the relationship between paclitaxel-induced HFS and fingerprint changes.	Fingerprint changes in 26,2% of Paclitaxel group patients. No cases of HFS. OR = 13.69, 95% CI: 2.05 to infinite, $P = .002$.
Doorn et al. [44]	Prospective cohort: n = 66 treated with Capecitabine, n = 30 with TKIs sorafenib, n = 10 with TKIs pazopanib hydrochloride, and n = 6 with TKIs sunitinib. Study duration: 2 yr.	N = 112 (no data on sample characteristics).	Various (mostly colorectal cancer, 43,75%).	Erasmus MC Cancer Institute, Rotterdam (Netherlands).	Before treatment, within 6–10 wk after the start of treatment, and after treatment discontinuation using a digital fingerprint scanner (MorphoLivescan; Morpho).	Fingerprint changes (as the overall quality of friction ridge details) on a 5-point Likert scale (evaluated by 3 dactyloscopists and 1 detective from the Netherlands National Police Agency).	HFS (according to the CTCAE version 4.03).	Severe quality loss of fingerprints in 14% treated with capecitabine and 2% treated with the TKI sunitinib. HFS in 70% treated with capecitabine and in 46% treated with TKIs. The grade for HFS was not associated with the incidence of severe fingerprint quality loss ($P = .43$). Severe fingerprint quality loss recovered completely within 2–4 wk after treatment discontinuation.
Yaghobi Joybari et al. [49]*	Case-control: N = 37 treated with Capecitabine (1000 mg/m^2 twice daily, day 1–14 every 21 d) (cases) and n = 34 had no Capecitabine but other chemotherapy regimens (controls). Study duration: 11 mo.	N = 71 Cases group: mean age 53 yr, 48,6% female, 43,2% were housewives.	Various (mostly rectum cancer, 45,9%).	University Hospital of Tehran (Iran).	Before treatment and after at least 3 cycles, using ink on paper cards.	Fingerprint changes (defined as >30% mismatching of 16 points after treatment in the right thumb or right index finger (evaluated by a forensic expert of the Iranian Society of Forensic Physicians).	HFS occurrence (according to the CTCAE) and the relationship between paclitaxel-induced HFS and fingerprint changes.	Fingerprint changes in 67,6% of Capecitabine group patients. 56,8% of Capecitabine group patients had HFS grade 1-4 but no correlation between HFS and fingerprint changes was found (r = 0.026, $P = .880$).
Hartung et al. [48]	Prospective cohort (all treated with Capecitabine). Study duration: 4 yr and 7 mo.	N = 50 (68% male, 39–82 yr).	Various (mostly colorectal cancer, 76%).	University Hospital Düsseldorf, Germany.	Before treatment, at 1, 2, and 4 mo after, using a ferromagnetic powder.	HFS incidence (according to WHO grading).	Fingerprint change in relation to HFS. Evaluations were done only in patients with HFS grade 2 or 3 (10%); for fingerprint low-quality results only 2 patients (4%) were analyzed.	HFS in 28% of the sample. Full conformity of the demanded minutiae before and after treatment and before and after HFS grade 3. HFS of grade 2 and 3 was associated with a temporary macroscopic loss of the epidermal ridges.

HFS = hand foot syndrome; CTCAE = National Cancer Institute's common terminology criteria for adverse events; TKIs = tyrosine kinase inhibitors.
* Data coming from the same original research study.

for their potential relationship with fingerprint modifications were taxanes drugs [45,47], capecitabine [44,48,49], and tyrosine kinase inhibitors (TKIs) such as sorafenib, pazopanib hydrochloride, and sunitinib [44]. The treatment dosages were not reported in most of the studies. The presence of conditions that could alter fingerprint patterns (i.e., eczema, acanthosis nigricans, scleroderma, dry and atrophic skin, skin tumors, leprosy, electric or radiation injury, dermabrasion, celiac disease, rickets, acromegaly) [47] or previous exposure to the treatments under investigation represented the exclusion criteria in all the studies.

The fingerprint collection procedure was different between the experimental studies. In Hartung's study [48], the fingerprints were collected using a ferromagnetic powder after the patients rubbed their fingers and palms against the skin of their forehead to moisten them. Analogously, in Lowe's thesis [45], the researcher used a powder label technique to collect the fingerprints. No details of procedures were described in these studies. In Azadeh's [47] and Yaghobi Joybari's [49] studies, the fingerprints were collected using ink on paper cards after hands were washed and dried using proper paper cards and ink according to forensic medicine rules and concepts. In this last study, prints were obtained by rolling the fingers on the paper cards from the outside to the inside to imprint the complete details of the finger ridges. In Doorn's study [44], the fingerprint was obtained using a digital fingerprint scanner (MorphoLivescan; Morpho).

Fingerprint changes or loss was assessed in all the studies as a primary endpoint and consequently its relationship with HFS (as a secondary endpoint), except in Hartung's study [48], which analyzed the fingerprint alterations during and after the occurrence of HFS. The fingerprints were collected in all the studies before treatment and then at different time points. HFS grading was assessed according to the National Cancer Institute's Common Terminology Criteria for Adverse Events (CTCAE) in the majority of the studies [44,45,47,49], whereas in the remaining research, we had no information about the evaluation criteria. Specialized professionals analyzed the fingerprints and images. In Azadeh's study, images of fingerprint examples of all patients were sent to the Iranian Society of Forensic Physicians to compare changes. In Doorn's study, three dactyloscopists and a detective from the Netherlands National Police Agency visually assessed fingerprints and images, respectively. In Yaghobi Joybari's research, a forensic expert from the Iranian Society of Forensic Physicians evaluated all fingerprint records for changes, blinded to the study groups. In Hartung's study, trained specialists performed the dactyloscopic examinations of images. Lowe's study used specific software to analyze the fingerprints at the University of Southern Mississippi School of Criminal Justice Fingerprint Laboratory.

Cohort studies: Outcome evaluation

Lowe's study [45] evaluated the effects of taxane-class drugs and doxorubicin on fingerprints. The results suggest no relevant decrease between taxane-class drugs and the quality of the fingerprints. A singular patient who had been prescribed doxorubicin, however, experienced a quality decrease, which may have been related to HFS. No other significant HFS findings were discovered, further certifying the link between HFS and ridge degradation.

Azadeh's study [47] evaluated the incidence of fingerprint changes in patients who received paclitaxel in combination with other chemotherapy regimens. Fingerprint changes were clinically observed in 17 of the 65 studied patients (26.2%). All patients with fingerprint changes were in the paclitaxel group (11 patients received only paclitaxel, and six were administered paclitaxel in combination with other drugs). In both groups, no cases of HFS were registered. After adjusting the confounding variables, there was a statistically significant difference between the case and control groups regarding the odds ratio (OR) of fingerprint changes ($P = .002$, OR 13.69, 95% CI 2.05 to infinite). A dose-response analysis in the paclitaxel group found no significant difference in the likelihood of fingerprint changes with paclitaxel dosage ($P = .591$) or chemotherapy course number ($P = .998$). There was a statistically significant difference in fingerprint changes between the two groups for the occupation variable (housewives).

Doorn's study [44] reported a severe quality loss within 8 weeks of treatment in nine patients (14%) treated with capecitabine and in one (2%) patient treated with TKI sunitinib. HFS was observed in 70% of patients treated with capecitabine and 46% treated with TKIs. The grade for HFS was not associated with the incidence of severe fingerprint quality loss ($P = .43$). Severe fingerprint quality loss recovered completely within 2–4 weeks after treatment discontinuation in all three patients who could provide post-treatment fingerprints.

Hartung's study [48] investigated the fingerprint alterations during and after the occurrence of HFS throughout longitudinal cohort studies over 4 years and 7 months. In total, 14 of the 50 patients developed HFS (28%) with HFS grades 1–3 observed. Fingerprint change evaluations were done only in patients with HFS grade 2 or 3 (10%). However, only two patients' (4%) fingerprints were evaluated for low-quality results. HFS of grades 2 and 3 was associated with a temporary macroscopic loss of the epidermal ridges, whereas no dactyloscopy microscopic changes were detected, which might have led to a false identification. Epidermal ridges did not return to macroscopically normal shape before chemotherapy was finished for at least 1 month.

Yaghobi Joybari's study [49] evaluated the incidence of fingerprint changes in patients treated with capecitabine plus other chemotherapy regimens and its relation to various grades of HFS. All patients with fingerprint changes were in the paclitaxel group. Twenty-one (56.8%) patients in the capecitabine group experienced HFS in grades 1, 2, and 3 in 4 (10.8%), 7 (18.9%), and 10 (27.0%) patients, respectively. Based on the Spearman correlation coefficient, there was no correlation between HFS and fingerprint changes ($r = 0.026$, $P = .880$). The total dose of capecitabine was not significantly different in the groups with and without fingerprint changes (2.79 ± 0.39 and 2.64 ± 0.36 g, $P = .256$). The effect of the number of capecitabine courses in patients without (11.33 ± 10.16) and with (12.04 ± 8.73) fingerprint changes was also not significant ($P = .822$). There were no statistically significant differences in demographic data between capecitabine-treated patients and those without fingerprint alterations.

Case reports: Characteristics and findings

The characteristics of the included case reports are presented in Table 2. All the case reports were published in scientific methodological peer-reviewed journals indexed at least in PubMed. Two case reports were published in journals addressing forensic medicine practice [43,54], and the remaining reports were part of journals addressing oncology clinical practice and medical science [46,50–53,55,56].

Overall, the individuals were male and female patients, with ages ranging from 47 to75 years, located in hospitals in different countries worldwide: Saudi Arabia [50], Brazil [55], Italy [54], USA [51], China [46,56], Africa [52] and Mexico [53]. All the case reports described cases of patients with metastatic or advanced cancer (different disease localization) who received specific anticancer treatments (mainly capecitabine, but also in combination with docetaxel and oxaliplatin) and then developed fingerprint change or loss, in terms of visual erasure of fingers ridges with troubles in using index finger scanning system for identification and then consequences in access to different utilities. In one case [46], fingerprint loss occurred during combination therapy using osimertinib and

Table 2
Characteristics of the included case reports.

References	Patient age, sex, and country	Tumor type	Previous treatments	Current treatment (related to fingerprint changes)	HFS	Concomitant side effects	Fingerprint changes characteristics	Fingerprint change practical consequences and duration	Cancer course
Swofford and Schenck [43]	62 yr, male, Singapore.	Breast cancer (metastatic at bones).	Capecitabin and radiation therapy.	Capecitabine (2500 mg/m^2 per day) for a total of 188 d.	Yes	Not reported.	The quality of the friction ridge skin impressions decreased by 32%. The fingerprint changes recovered after 65 d after cessation of therapy.	Not reported.	Not reported.
Al-Ahwal [50]	53 yr, male, Saudi Arabia.	Terminal rectum adeno-carcinoma (metastatic at liver and lungs).	No information.	Capecitabine, starting with 1,000 mg/m^2 twice daily) on days 1–15 followed by a 1-wk rest, with i.v. oxaliplatin (130 mg/m^2) on day 1 and then dose reduction for 6 cycles overall.	Yes, grade 3 (after the 5th and 6th cycle).	Nausea, vomiting, diarrhea.	Erasure of fingerprints. Palms and soles became swollen, painful, hyperpigmented, hardened, and desquamated.	The patient was unable to process required governmental documents on several occasions because of a lack of fingerprints (1 wk after the 5th–6th cycle). No information about duration.	The patient died 6 mo later.
Rovere and De Lima [55]	47 yr, male, Brazil.	Rectal cancer (metastatic).	Oxaliplatin and surgery.	Capecitabine 8 mo, starting with 2,000 mg/ m^2 daily and then reducing dosage for HFS toxicity.	Yes, grade 4 (after 8 mo).	Peripheral neuropathy (grade 3–4).	Erasure of fingerprints. No other macroscopical alterations of the skin.	Not allowed to receive a driver's license because of fingerprint lacking (just after 8 mo of therapy). HFS recovered and peripheral neuropathy was improved. No information about duration.	A few months later the patient died.
Negri et al. [54]	75 yr, male, Italy.	Colon adeno-carcinoma.	Surgery.	Capecitabine and oxaliplatin for 6 mo.	No skin toxicity.	Not reported.	Erasure of fingerprints. No other macroscopical alterations of the skin. A microscopical examination was also performed at the end of treatment and after 2 mo.	Denied access to bank and smartphone touch ID (after 6 mo of therapy). Two months later the end of treatment, this patient was once again able to access his bank account.	No treatment interruption or discontinuation for HFS or fingerprint loss. No information about the cancer course.
Cohen [51]	57 yr, female; USA. 73 yr, female; USA	Triple-negative breast cancer. Metastatic triple-negative breast cancer.	Paclitaxel; doxorubicin, cyclophos-phamide; radiation therapy. Surgery; cyclophos-phamide, methotrexate, and 5-fluorouracil; paclitaxel; radiotherapy.	Capecitabine 1500 mg twice daily and then increased to 1650 mg twice daily for 14 d on and 7 d off for 8 cycles. Capecitabine 2000 mg each morning and 1500 mg each evening for 1 wk on and 1 wk off.	Yes, grade 1 (after 1st cycle). Yes, grade 1 (after 1st cycle).	Not reported. Not reported.	Red skin, scaling, random fissures, and focal preservation of only some of the fingerprint ridges until their absence. Erasure of fingerprints, desquamation, fingertips, and thumb were red and rough, until 2 yr after the end of treatment.	Unable to gain entrance into a fitness center that required index finger scanning for identification and denied access to smartphone touch ID (after 1st cycle). Unable to access to laptop (after 1st cycle) until 2 yr after the end of treatment.	No treatment interruption or discontinuation for HFS or fingerprint loss. No information about the cancer course. No treatment interruption or discontinuation for HFS or fingerprint loss. No information about the cancer course.

(*continued on next page*)

Table 2 (*continued*)

References	Patient age, sex, and country	Tumor type	Previous treatments	Current treatment (related to fingerprint changes)	HFS	Concomitant side effects	Fingerprint changes characteristics	Fingerprint change practical consequences and duration	Cancer course
Zhao et al. [56]	75, female; China.	Breast cancer stage IIA, ER+, PR+, HER2-; it became metastatic in the left chest wall and lung.	Surgery; CMF chemotherapy; tamoxifen; TP chemotherapy; letrozole; exemestane.	Docetaxel and capecitabine (21-d cycles of docetaxel 120 mg on day 1 and oral capecitabine 1500 mg twice daily on days 1–14 and then reduced to 1,000 mg twice daily) for 6 cycles overall.	Yes, grade 4 (during the 4th cycle).	Not reported.	Loss of the texture of the palm and loss of fingerprints. Thinning and peeling of the skin of the fingers, toes, and interphalangeal joints, gradually worsened, resulting in chapping and bleeding.	Inability to open her fingerprint lock (after the 3rd cycle). No information about duration.	The patient stopped the therapy for HFS grade 4. No progression at 17 mo.
Dawood et al. [52]	62 yr, male; Africa.	Locally advanced rectal adenocarcinoma.	Surgery; Chemoradiation therapy with 5-fluorouracil.	Capecitabine 1000 mg/m^2, 1500 twice daily from days 1–14, and oxaliplatin 130 mg/m^2 every 3 wk for 6 cycles.	Yes, grade 1 (after the 5th cycle).	Not reported.	Loss of the texture of the palm and loss of fingerprints. Hyperpigmentation on the skin of the hands and soles along with numbness in the soles.	Inability to open a bank account as the patient's biometrics could not be done since he had lost fingerprints (after the 5th cycle). After 1 mo the end of the treatment fingerprints had started to appear again.	No treatment interruption or discontinuation for HFS or fingerprint loss. Complete remission by CT and PET.
Xie [46]	55 yr, male; China.	Metastatic (bones) lung adenocarcinoma, stage IV	Pemetrexed, cisplatin, icotinib.	Osimertinib (80 mg/day) plus anlotinib (12 mg/day).	No HFS or hands skin rash.	Brittle nails (grade 2), skin rash on his face and scalp (grade 2), and diarrhea (grade 3).	Loss of the texture of fingerprints.	Unable to unlock the electric lock of his home door, turn on his smartphone, and sign a contract that required fingerprint authentication. After 10 mo the fingerprint loss recovered; 2 mo thereafter it occurred again. The patient has continued to experience recurrent loss and recovery of his fin fingerprints despite anlotinib discontinuation. Fingerprint loss recovered during osimertinib monotherapy but subsequently recurred.	Anlotinib was discontinued. Stable lung lesion and stable disease for more than 20 mo.
Deneken-Hernandez et al. [53]	52 yr, female; Mexico.	Metastatic (bones) breast cancer, stage IV, HER-2 negative.	Radiotherapy; anthracycline chemotherapy; tamoxifen; paclitaxel; anastrozole.	Capecitabine 1500 mg twice a day (3 g daily total dose for 14 days followed by a week off) for lung metastasis and hepatic progression.	Yes, grade 1 (after 9 mo of treatment).	No concomitant relevant other side effects.	Fingertips smooth and shiny with no evidence of characteristic epidermal ridges on the fingertips (confirmed by dermatoscopy examination and biopsy).	Unable to get government aid due to fingerprint authentication failure (2 yr after treatment). No information about duration.	No treatment interruption or discontinuation for HFS or fingerprint loss. Stable bone disease and complete lung and liver response.

HFS = hand foot syndrome; CMF = cyclophosphamide, methotrexate, and fluorouracil; TP = docetaxel plus cisplatin; CT = computed tomography; PET = positron emission tomography.

anlotinib, although the correlation between fingerprint loss and osimertinib or nilotinib monotherapy could not be confirmed by these results. Macroscopical fingerprint changes or troubles with the authentication system were, in some cases a short-term outcome as occurred during therapy [51,52,56] and in other cases was a long-term effect as it appeared after the end of the treatment cycles [50,53–55]. In two situations [53,54], a microscopical examination was performed to confirm the fingerprint change. Overall, the duration of visual fingerprint changes or troubles with identification fingerprint systems varied over time, from 1 month to 2 years [46,51,52,54]; however, in most cases, we have no information about the recovery of the fingerprint change.

In all the cases, fingerprint changes occurred in association with HFS, except for two cases [46,54] in which the patient did not develop any hand or foot skin toxicities. The HFS grading ranged from grade 1 to 4; grade 1 HFS occurred just after the first cycle of chemotherapy [51,53], whereas the most severe grades (3–4) appeared between the 4th and 6th cycle [50,52,55,56]. However, in all cases, HFS appeared gradually. In the majority of cases, HFS or fingerprint changes did not require a treatment interruption or discontinuation [51–54]; in two cases, the patients died a few months after the end of treatment cycles [50,55] (however, they were in an advanced stage of the disease), and in one case the patient stopped the therapy for HFS grade 4 [56]. Only in Zhao's report [56] Vaseline was applied to the affected area.

Only three case reports described other concomitant side effects: in one case, the patient had nausea, vomiting, and diarrhea [50]; in the second case, the patient developed peripheral neuropathy grade 3–4 [55]; and in the third case [46], the patient experienced brittle nails (grade 2), skin rash on his face and scalp (grade 2), and diarrhea (grade 3). Comorbidities were reported only in Dawood's report, where the patient was affected by diabetes mellitus and hypertension [52]. One included report [43] was a case study of a male 62-year-old breast cancer patient evaluating the negative effects of capecitabine-induced HFS on the quality of friction skin for forensic and other comparative purposes. This study utilized multiple methods to record the friction skin's condition: Digital imaging, powder, ink, and livescan. This study found that capecitabine-induced HFS decreased the quality of friction skin impression, which recovered after 65 days of treatment cessation.

Quality appraisal

The NOS scale was used to evaluate the methodological quality of the cohort and case-control studies. One study [47] obtained seven stars and, therefore, was at a low risk of bias, whereas the others obtained five stars and thus were at a moderate risk of bias [48]. We did not include the Lowe's [45] study as part of an honor thesis in the risk of bias evaluation. The quality appraisal description of the cohort and case-control studies is reported in Supplementary File 2.

The quality appraisal of the case reports is reported in Table 3. The JBI Checklist was used to evaluate the case reports' methodological quality. Without stating a final judgment about the case reports' inclusion or exclusion (as it was not in our research scope), we used the checklist items to provide a comprehensive and constructive analysis of the existing gaps and recommendations for future research. The major deficiencies were found in the patients' demographic characteristics description, where the authors uniquely reported patient age and sex. Similarly, the descriptions of diagnostic tests and assessment methods were not accurately described by all the authors. Although the patient's main clinical condition at presentation was clearly described (tumor diagnosis and stage), additional clinical information, such as comorbidities or concomitant clinical conditions, was not provided. The condition under investigation (fingerprint modifications or loss) and the

Table 3
Quality appraisal of case reports.

	Al-Ahwal [50]	Rovere and De Lima [55]	Negri et al. [54]	Cohen [51]	Zhao et al. [56]	Dawood et al. [52]	Xie [46]	Deneken-Hernandez et al. [53]
1. Were patient's demographic characteristics clearly described?	No	No	No	No	No	No	No	No
2. Was the patient's history clearly described and presented as a timeline?	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
3. Was the current clinical condition of the patient on presentation clearly described?	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
4. Were diagnostic tests or assessment methods and the results clearly described?	No	No	Yes	No	No	No	No	Yes
5. Was the intervention(s) or treatment procedure(s) clearly described?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
6. Was the postintervention clinical condition clearly described?	Yes	Yes	No	No	Yes	Yes	Yes	No
7. Were adverse events (harms) or unanticipated events identified and described?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
8. Does the case report provide takeaway lessons?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Joanna Briggs Institute (JBI) checklist for case reports.

causes (specific anticancer treatments) were clearly described, as well as the sequence of the events, which is useful for reconstructing the cause-and-effect mechanism.

Discussion

This integrative systematic review is the first to summarize the existing literature on fingerprint change in adults who underwent anticancer treatments. Since we aimed to provide a narrative description regarding the occurrence of this phenomenon, this review encompasses different types of publications retrieved from various sources, including grey literature. This approach allowed a comprehensive examination of all available literature on the actual relevance of this phenomenon to base future more structured research that accurately describes the association between fingerprint change and specific anticancer treatment by including specific variables that may act as predictors or risk factors.

Although all the included studies and reports were settled in exclusively clinical settings (i.e., hospital wards and chemo day units), they were published by both legal and criminal justice disciplines and the clinical oncology branch. This disciplinary intersection reflects the importance of a multidisciplinary approach spanning all facets of cancer prevention and management [58]. Legal and criminal competencies must be integrated as an essential component of the cancer prevention and control workforce in evaluating and detecting specific consequences [58]. These interdisciplinary collaborations and professional contaminations enrich disciplines and allow a surrounding approach to the patients.

What we know from the case reports

The relevance of case reports as individual studies has been described in previous research as a complementing factor of other research methods in areas of medicine that are not specifically research-related [59,60]. The value of case reports lies in the ability to detect novelties, temporally describe events, and potentially generate new hypotheses for future research based on the cause-effect dynamics between one event and another [60]. This aspect is particularly relevant in the initial exploration phases of a phenomenon or rare disease [61]. However, case reports' findings might not be generalizable and could not be useful in establishing a cause-effect relationship, with a consequent high risk of over-interpretation [61].

The case report results concordantly describe the relationship between fingerprint alterations and specific anticancer treatments such as taxanes, TKIs, and capecitabine. Osimertinib and anlotinib are epidermal growth factor receptor (EGFR) tyrosine kinase inhibitors (TKI) approved for nonsmall cell lung cancer (NSCLC) in patients failing previous TKI therapy [62]. Evidence suggests the role of the EGFR pathway in the regulation of keratinocyte biology (survival, migration, and proliferation), including the inflammatory and immune reactions of the skin [63]. The skin barrier is maintained by the precise proliferation and differentiation of keratinocytes [64]. The blockade of epidermal growth factor signaling by EGFR-TKI induced severe disruption of the skin epidermis and apoptosis induced by inflammatory activation [65]. However, additional data are projected to be obtained from an underway clinical study (NCT04029350) that investigates the efficacy and safety of osimertinib combined with anlotinib as second-line treatment for stage IIIb- IV NSCLC in patients with EGFR-sensitive and T790M mutations [66].

Capecitabine is an oral prodrug of 5-FU that was designed to rapidly convert the fluorouracil in 5-FU and reduce several complications and toxicities [67]. The final step of this three-step enzymatic cascade conversion is mediated by thymidine phosphorylase (TP), an enzyme that aggregates at cancerous sites (significantly increased concentrations in a wide range of tumor types, including colorectal, breast, and gastric cancers) in large quantities and converts Fluorouracil to 5-FU [68]. Studies have shown that TP is more prevalent in friction ridge skin than other areas of the body, suggesting that the increased proliferation of keratinocytes in the epidermis draws 5-FU to these areas in much the same way that the substance is drawn to areas with high proliferation of cancerous cells [69–71].

From our summary, the fingerprint changes and troubles with identification fingerprint systems varied over time; they can appear during the first cycle of therapy and can recovered after 65 days after cessation of therapy or lasting from 1 month to 2 years after the end of treatment. These findings support previous research that estimates keratinocyte maturation to be between 40 to 56 days [72]. Over this time, once new cells are generated, older cells migrate toward the skin surface [73]. During the migration, the cells change in structure, eventually drying and dying off as they reach the uppermost layer [73]. Once at the uppermost layer, the dead skin cells are gradually sloughed off to create a place for newer cells [73]. However, several regulators (i.e., cytokines and growth factors) modulate keratinocyte migration and proliferation [74–76], and these may influence the overall period of reepithelialization, as we observed in our results. As a result, the decline of fingerprint observed quality is associated with significant disruption in the basal layer, implying that these areas are susceptible to 5-FU in a similar way to cancer cells and necessitate variable time to recover (at least 45 days). Although we tried to extract additional variables that could have a relationship with fingerprint changes, such as concomitant side effects, cancer course, and HFS remission, no sufficient data were available to document this data uniformly and generate assumptions.

What we know from experimental studies

The experimental studies' results were concordant in reporting fingerprint alterations as a consequence of specific anticancer treatments such as taxane therapies, capecitabine, and TKIs (sorafenib, pazopanib hydrochloride, and sunitinib) despite a variable occurrence of this disease was reported with some studies documenting a substantial proportion of affected patients whereas others no patients with a decrease in fingerprint quality and full conformity of the demanded minutiae before and after treatment. Sorafenib, pazopanib hydrochloride, and sunitinib are drugs targeting the vascular endothelial growth factor (VEGF), which promotes tumor angiogenesis by stimulating the proliferation and survival of endothelial cells [77]. The skin toxicity caused by VEGFR inhibitors is controversial as an increased keratinocyte proliferation has been described along with possible keratinocyte damage, keratinocyte vacuolar degeneration, and confluent keratinocyte necrosis associated with intraepidermal cleavage [78].

Only one study reported a quality decrease in the fingerprint in one patient after therapy with doxorubicin. The mechanism underlying this clinical outcome is unknown; however, recent research supports the use of doxorubicin on squamous cell carcinoma of the skin [79] as it can regulate the expression of the high-mobility group A1 (HMGA1) protein, which is responsible for cell cycle transition, cell motility, migration, and invasion [80]. This protein is highly expressed in numerous tumors as skin cancer; therefore, some underlying mechanism may influence skin proliferation, also considering that doxorubicin damages cellular components, causing cell damage and inducing apoptosis [81].

In all studies, the fingerprint changes were not significantly related to the total administered doses of anticancer treatments, the number of courses, or the occurrence of HFS. These results require further investigation, acknowledging that the small sample sizes

could impact the statistical significance of the results [82]. None of the studies reported comorbidities, concomitant therapies (except Azadeh's study, where all patients were taking dexamethasone), and toxicities (except for HFS), representing potential confounding variables that could influence the relationship between the variables under study [83]. In this regard, a case report documented epidermal ridge atrophy caused by corticosteroids [84].

Results on the occupational sociodemographic variable as a potential risk factor were discordant with one study [47] found a statistically significant difference in fingerprint changes between the two groups (paclitaxel therapy) for the occupation variable (housewives), whereas another [49] did not find any statistical difference in fingerprint changes between the two groups (capecitabine therapy). The literature identified some dermatological causes of loss of fingerprints, such as hand eczema [85], which is highly common among people with occupational exposure (80%), such as housewives, hairdressers, nurses, workers with repeated exposure to cement, mortar, cutting oils, or abrasive [85]. Precisely, 55% of all dermatological cases of adermatoglyphia were observed in housewives (58%) in the form of fingerprint dystrophy and abnormal white lines [86]. Accordingly, a national survey conducted among the Lebanese population found that the number of female patients with adermatoglyphia was 3.75 times greater than the number of male patients, and most of these female patients were housewives [11]. Hand dermatitis affects fingerprints by causing scaling, wrinkling/fissures, and destruction of finger ridges. Scaling corresponds to fingerprint dystrophy, most commonly the mottled form, which reduces the quality score by interfering with the ridge pattern and adding artifacts to the fingerprint [86]. Fissures and wrinkles correspond to irregular white lines in fingerprints; in severe cases, ridges may be obliterated, resulting in fingerprint dystrophy and the loss of minutiae points needed in fingerprint matching (Lee et al., 2013).

Limitations of included studies

The studies included in this review exhibited several methodological and reporting limitations that could impact the reliability and generalizability of the findings. First, most of the experimental studies were conducted with small sample sizes, and none determined a priori sample size calculation, which reduces the statistical power of their conclusions. Second, significant heterogeneity was observed in the methods used to collect and assess fingerprint alterations, ranging from ink-based techniques to digital imaging, which could introduce bias and limit the comparability of the results. Third, the definitions of the primary outcome—fingerprint changes—varied between studies, with terms such as "loss," "alterations," and "quality reduction" being inconsistently used. This inconsistency further complicates cross-study comparisons and interpretations. Additionally, potential confounding variables such as comorbidities, concurrent therapies, or other skin conditions may influence fingerprint changes and were rarely reported.

Limitations

We acknowledge that this study has several limitations. First, the choice of utilizing different sources (i.e., Google Scholar) rather than relying solely on indexed databases may affect the overall quality and rigor of the included findings. However, this approach aligns with our aim of comprehensively capturing all available evidence on the topic. To maintain transparency, the sources of all articles have been reported, and only authoritative publications from indexed journals or reliable sources were included. Second, the inclusion of case reports poses inherent challenges. Case reports are retrospective, nonblinded, and nonrandomized by design, which introduces biases and limits the generalizability of their findings. While we evaluated the methodological quality of the case reports to mitigate interpretive risks, their inclusion may not provide the level of evidence seen in experimental studies. Third, the variability in fingerprint data collection procedures and definitions of the primary outcome across studies represents a challenge for synthesizing the results. The studies inconsistently defined "fingerprint alterations," using terms such as "loss," "alterations," and "quality reduction," which complicates the comparability of findings. This heterogeneity reflects the broader need for standardized methodologies in this field of research. Fourth, the included experimental studies often featured small sample sizes, and none performed an a priori sample size calculation. This reduces the statistical power and limits the generalizability of their findings. Additionally, the studies provided limited details on confounding variables such as comorbidities, concurrent therapies, or other factors that could influence fingerprint alterations. Finally, the variability in outcome definitions and the lack of standardized fingerprint collection quality further complicate the interpretation of results. For instance, failure to access identification systems was not always associated with visible macroscopic changes in fingerprints, reflecting a complex interplay of factors influencing this condition.

Despite these limitations, our review provides a valuable foundation for future research by summarizing the current evidence and identifying critical gaps in knowledge.

Conclusions

Acknowledging the growing importance of fingerprint identification in several social contexts along with the imperative of addressing the physical and psychological burden of cancer, we aimed to comprehensively summarize the extent of evidence between cancer treatments and fingerprint alterations in adults with cancer. Our research yielded a considerable number of case reports and few experimental studies of fingerprint alterations following capecitabine, taxanes, and TKIs, suggesting the necessity of further investigating this phenomenon throughout original research studies on additional drugs that may share similar mechanisms of action. Although the relationship between some anticancer treatments and fingerprint change has been clearly documented in our synthesis, the occurrence of this toxicity may vary across populations and settings. Controversial results were found for the association between HFS and fingerprint changes, with two studies documenting this association, one study was unable to test this association for no cases of HFS, and two studies found no significant correlation.

Our results pose the rationale for a future assessment of fingerprint data within clinical trials as a potential side effect of selected anticancer treatments. A clear distinction in outcome definition and assessment is required to preventively identify and detect microscopical changes that could result in incapacity to access identification systems. Additional variables need to be investigated as potential influencing or predictive factors of fingerprint alterations, or conversely, to understand if fingerprint alterations could be a precursor of specific disorders. Thus, further large and well-designed experimental studies are necessary to quantify the phenomenon burden in relation to specific anticancer regimens and populations.

Practical implications

During the past few decades, biometric identification involving fingerprinting has become mandatory in several situations. Detecting high-risk populations based on specific sociodemographic and clinical risk factors will help to target educational and surveillance interventions for shaping the cancer care pathway and improving clinical outcomes. Since fingerprint identification systems have

been progressively utilized worldwide in different contexts, establishing contact paths with authorities in the hospital discharge phase for patients at high risk of fingerprint alterations will contribute to improving care continuity and assist patients in dealing with treatment side effects in the community. For this reason, legal and criminal competencies must be an essential component of the cancer prevention and control workforce in assessing and detecting nonestablished clinical and biological consequences, which require interdisciplinary collaborations for extending all facets of cancer prevention and management. However, legal issues must be considered for a successful operation of integrated medicine to enhance the overall quality of care.

To provide a 360-degree view of a patient, a culture of current treatment-related legal implications should be promoted, along with particular attention to skin care and assessment in these individuals. A call to action for the psychosocial and forensic implications of anticancer treatments is warranted to optimize cancer care pathways and guarantee the social integration of patients with cancer. Addressing the psychosocial needs of cancer patients, including the social and forensic implications of symptom burden, must be a global priority to ensure equitable access to facilities.

IRB approval

Not applicable.

Informed consent statement

Not applicable.

Declaration of generative artificial intelligence (AI)

A generative AI system was used in the writing process to improve the readability and language of the manuscript.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Silvia Belloni: Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Methodology, Data curation, Conceptualization. **Arianna Magon:** Writing – review & editing, Validation. **Rita de Sanctis:** Writing – review & editing, Validation, Conceptualization. **Paola Tiberio:** Writing – review & editing, Validation, Conceptualization. **Gianluca Conte:** Writing – review & editing, Validation. **Cristina Arrigoni:** Writing – review & editing, Validation, Supervision. **Rosario Caruso:** Writing – review & editing, Validation, Supervision, Methodology, Conceptualization.

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Supplementary materials

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