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Mapping the Importance of Pink Teeth in Forensic Medicine for Determining Cause of Death: Protocol of a Scoping Review

تحديد أهمية الأسنان الوردية في الطب الشرعي لتحديد سبب الوفاة: بروتوكول مراجعة نطاقية

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Abstract

Postmortem pink teeth have been described in forensic casework for more than a century and are frequently reported in association with deaths involving drowning, asphyxiation, trauma, or electrocution. Despite recurrent mention in forensic literature, the underlying mechanisms, prevalence, and diagnostic value of this phenomenon remain unclear and inconsistently interpreted. The aim of this scoping review is to map the existing evidence on postmortem pink teeth and to explore their potential relevance in determining the cause of death in forensic medicine. Specifically, this review seeks to identify how the phenomenon has been reported, which pathophysiological mechanisms have been proposed, and which contextual or en-vironmental factors may influence its occurrence. Particular attention will be given to the challenges of differentiating postmortem pink teeth from antemortem dental discolora-tions, such as those resulting from trauma or congenital conditions. This protocol was developed in accordance with the Joanna Briggs Institute (JBI) meth-odology for scoping reviews and the PRISMA-ScR guidelines. A comprehensive search strategy was predefined and applied across multiple databases. The study selection pro-cess was conducted at the protocol

Keywords: forensic sciences, human, tooth discoloration, postmortem changes

المستخلص

لقد وُصفت ظاهرة الأسنان الوردية بعد الوفاة في قضايا الطب الشرعي لأكثر من قرن، وغالباً ما يتم الإبلاغ عنها في حالات الوفاة المرتبطة بالغرق، أو الاختناق، أو الصدمات، أو الصعق الكهربائي، وبالرغم من ذكرها المتكرر في أدبيات الطب الشرعي، إلا أن الآليات الكامنة وراءها، ومدى انتشارها، وقيمتها التشخيصية لا تزال غير واضحة وتُفسر بشكل غير متسق. وتهدف هذه المراجعة الإستكشافية النطاقية إلى تحديد الأدلة الموجودة حول الأسنان الوردية بعد الوفاة واستكشاف مدى صلتها المحتملة بتحديد سبب الوفاة في الطب الشرعي، وتسعى هذه المراجعة تحديداً إلى معرفة كيفية الإبلاغ عن هذه الظاهرة، والآليات الفيزيولوجية المرضية المقترحة، والعوامل السياقية أو البيئية التي قد تؤثر على حدوثها، مع إيلاء اهتمام خاص لتحديات التمييز بين الأسنان الوردية بعد الوفاة وتصبغات الأسنان التي تسبق الوفاة، مثل تلك الناتجة عن الصدمات أو الحالات الخلقية. تم تطوير هذا البروتوكول وفقاً لمنهجية معهد جوانا بريغز (JBI) للمراجعات النطاقية وإرشادات PRISMA-ScR، حيث تم تحديد استراتيجية بحث شاملة وتطبيقها عبر قواعد بيانات متعددة، كما أجريت عملية اختيار الدراسات في مرحلة

الكلمات المفتاحية: علوم الأدلة الجنائية، إنسان، تغير لون الأسنان، تغيرات بعد الوفاة

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stage, and the results of identification, screening, and eligibility assessment are documented using a PRISMA-ScR flow diagram. A total of twelve studies met the predefined inclusion criteria and were identified as eligible for in-clusion in the final scoping review. Data extraction and synthesis will be performed following protocol publication, using a standardized JBI-based data extraction tool. The extracted data will be presented in narrative and tabular formats, enabling a structured mapping of the current evidence base, identification of knowledge gaps, and clarification of the potential forensic significance of postmortem pink teeth.

البروتوكول، وتوثيق نتائج التحديد والفحص وتقييم الأهلية باستخدام مخطط تدفق PRISMA-ScR، وقد استوفت ما مجموعه اثنتا عشرة دراسة معايير الاشتمال المحددة مسبقاً واعتُبرت مؤهلة للإدراج في المراجعة النهائية. سيتم إجراء استخراج البيانات وتوليفها بعد نشر البروتوكول باستخدام أداة استخراج بيانات موحدة قائمة على معايير JBI، وستُعرض البيانات المستخرجة في تنسيقات سردية وجدولية، مما يتيح رسم خرائط مهيكلة لقاعدة الأدلة الحالية، وتحديد الفجوات المعرفية، وتوضيح الأهمية الجنائية المحتملة للأسنان الوردية بعد الوفاة.

1. Introduction

Forensic dentistry is a dentistry field with a critical role in victims identification and analysis of circumstances of death, particularly in situations where other methods of identifi-cation are insufficient or impossible. Due to their resistance to decomposition and ability to withstand extreme conditions, such as high temperatures and the action of decomposing agents, dental pieces have been widely used as a reliable source of forensic evidence. This resistance makes teeth one of the most important structures in homicide investigations, mass disasters, and other situations where human identification is required. Forensic den-tistry covers several areas, such as comparing dental records, analysing bite marks, as-sessing dental conditions to estimate the post-mortem (PM) interval, among others [1,2].

The accurate establishment of the cause and circumstances of death is a primary goal of forensic medicine. This process often relies on the observation and interpretation of postmortem changes and signs that may offer insights into the physiological events sur-rounding death. Among these findings, postmortem pink teeth, characterized by a reddish or pink dentin discoloration, particularly in anterior teeth, have been sporadically documented in forensic casework for over a century [3,4,5].

Thomas Bell [6], in 1829, was the first scientist to describe the pink teeth phenomenon, by observing the change to pink colour of teeth in individuals who died by hanging or drowning. Since then, various studies [7,8,9] have attempted to understand the causes and mechanisms underlying this colouration. While often considered a minor or anecdotal finding, pink teeth have been consistently linked to specific mechanisms of death, includ-ing asphyxia, drowning, cranial trauma, and electrocution, raising questions about their potential forensic significance [10,11].

A recent narrative review by Braga et al. [10] on postmortem pink teeth confirmed the long-standing view in the literature that this phenomenon is primarily caused by the infil-tration of hemoglobin into the dentinal tubules. These authors corroborate that environ-mental factors, particularly humidity and the decomposition stage, play a more significant role in pink teeth appearance than the specific cause of death. This aligns with the frag-mented and often anecdotal evidence mentioned in our protocol, where a clear link to the cause of death remains elusive. However, the work of Braga et al. [10], being a narrative review, differs methodologically from our proposed scoping review, which will employ a systematic, reproducible, and deep search strategy to map the entirety of available evi-dence, including grey literature, as per the JBI and PRISMA-ScR guidelines. The study of Braga et al. [10] highlights

the knowledge gaps among dental professionals point to the need of systematic analysis of data to allow the clarification of the real forensic importance of this phenomenon.

The aetiology of the pink teeth phenomenon is still a focus of scientific debate, being the most consensual hypothesis that the observed discoloration results from intravascular hemolysis followed by infiltration of blood pigments into the dentinal tubules. This is probably facilitated by the increase in intrathoracic pressure or changes in vascular per-meability that occur postmortem. Some authors suggest that this may be triggered under specific environmental or physiological conditions, such as humid environments or due to high intracranial or intrathoracic pressure before death [10]. However, standard forensic guidelines regarding the interpretation of this phenomenon are still not available, remain-ing poorly studied in terms of prevalence, diagnostic value, and specificity.

Thus, although rare, the pink tooth phenomenon may have important value in forensic medicine, since it might help in the determination of the cause of death (for example as-phyxiation, drowning or trauma) and the time elapsed after death. However, since this teeth discoloration does not occur in all human bodies with similar death circumstances, the scientific community still debates the specificity of the phenomenon and its relation-ship to the cause of death [4,12].

Despite its long-standing presence in forensic literature, the existing body of evidence on pink teeth is notably fragmented and methodologically heterogeneous. Most of the pub-lished data come from isolated case reports, small-scale observational studies, and narra-tive reviews, with limited consistency in the methods used to identify, document, and an-alyze this finding [10]. Furthermore, a clear absence of large-scale empirical studies or systematic approaches to evaluate the relevance of pink teeth in forensic investigations is observed. As a result, the forensic value of pink teeth remains unclear, and the field lacks a comprehensive synthesis of the available knowledge.

Given this context, a scoping review is the most appropriate methodological tool to ex-plore the current state of research on this topic. Scoping reviews are particularly suited to areas where literature is emerging, diverse, or poorly consolidated, as they aim the char-acterisation of the extent, range, and nature of evidence and the identification of knowledge gaps rather than to assess the quality or effectiveness of interventions [13,14]. In contrast to systematic reviews, scoping reviews offer a broad overview of available research, serving as a foundation for future investigations or more focused evidence syn-theses.

This scoping review protocol is designed following Joanna Briggs Institute (JBI) meth-odology for scoping reviews [14], and the PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews) guidelines [15] will be used.

The overarching objective of this review is to map the current evidence base on postmor-tem pink teeth, with a specific focus on their association with the cause of death, diagnos-tic utility, proposed physiological mechanisms, and contextual variables that may influ-ence their occurrence. By synthesizing what is currently known, this work wants to sup-port the development of more informed and evidence-based forensic practices and to guide the direction of future research in forensic pathology. Moreover, this review has as specific objectives: to systematically identify and categorize the scientific literature re-garding the occurrence, mechanisms, and forensic interpretation of the pink

teeth phe-nomenon; to synthesize existing data on the contextual and environmental variables, such as humidity, that may influence the development of postmortem pink teeth; to detect knowledge gaps in the current published studies and provide clear directions for future research to help develop standardized forensic protocols for this finding.

2. Materials and Methods

A research protocol will be developed in accordance with Joanna Briggs Institute (JBI) model [16-18], through the formulation of the question: Is the presence of pink teeth im-portant to identify the cause of death in forensic medicine? Hence, the PCC acronym will be Population (P): Humans; Concept (C): Tooth Discoloration; Context (C): Postmortem Changes.

The methodology applied will be based on a search for scientific articles without any time or language limits.

The databases to be used in this study are Pubmed, ScienceDirect and Medline (via BVS), where the Mesh term (humans AND (tooth discoloration)) AND (Postmortem Changes) will be applied. An additional citation tracking search will also be used.

The articles will be selected through Rayyan after being retrieved from the aforementioned databases.

The final review will use the guidance of systematic reviews and the extension of me-ta-analyses (PRISMA-ScR). This protocol was registered in the Open Science Frame-work (OSF), being available at https://osf.io/8qw2b/.

2.1. Inclusion and exclusion Criteria

Inclusion criteria: publications that address the proposed theme; studies published with no restrictions; studies in English, Portuguese or French, and with no time limit.

Exclusion criteria: articles that do not address the proposed theme; narrative, systematic or scoping reviews; animal studies; articles that mention pink teeth without any forensic rel-evance.

2.2. Search strategy

The search strategy was planned by two reviewers and will be peer-reviewed by an expert third reviewer considering the Peer Review of Electronic Search Strategies (PRESS) checklist [17].

In this scoping review, the search will be performed in the following databases: PubMed, ScienceDirect and Medline (via BVS). The research strategy recommended by JBI will be implemented.

A preliminary search was done in PubMed, ScienceDirect and Medline (via BVS) data-bases with the goal of identifying keywords and index terms used in the publications concerning the theme. This allowed the development of the search strategy for each data-base (Table 1). This initial search was performed on 13 January 2025.

Table 1- *Bibliographic research strategy.*

Database	Articulations of keywords	Number of articles
PubMed	(((((humans[MeSH Terms]) OR (humans[Title/Abstract])) AND (Tooth Discoloration[MeSH Terms])) OR (Tooth Discoloration[Title/Abstract])) AND (Postmortem Changes[MeSH Terms])) OR (Postmortem Changes[Title/Abstract])	382
Science Direct	humans AND Tooth Discoloration AND Postmortem Changes	1011
Medline (via BVS)	Human AND Tooth Discoloration AND Postmortem	14

Table 2- *Form used for data collection.*

Scoping Review Title	Mapping evidence on the importance of pink teeth in determining the cause of death in forensic medicine.
Review objective(s)	- Map the evidence to prove the importance of pink teeth to determine the cause of death with case reports. - Systematically identify and categorize scientific literature regarding the occurrence, mechanisms, and forensic interpretation of the pink teeth phenomenon. - Synthesize existing data on the contextual and environmental variables, such as humidity, that may influence the development of postmortem pink teeth. - Identify knowledge gaps in the current research and provide clear directions for future studies to help develop standardized forensic protocols for this finding.
Review Question(s)	Is the presence of pink teeth important in determining the cause of death in forensic medicine?
Inclusion/Exclusion Criteria:	Inclusion criteria: articles that address the proposed theme; studies published with no restrictions; studies in English, Portuguese or French, and with no time limit. Exclusion criteria: articles that do not address the proposed theme; narrative, systematic or scoping reviews; articles that do not explore cause of death; articles that mention pink teeth without any forensic relevance; animal studies.
Population	Humans
Context	Tooth discoloration
Concept	Postmortem Changes
Types of Evidence Sources	
Evidence Source Details and Characteristics	
Author(s)	
Year of Publication	
Origin/Country of Origin (where the source was published or conducted)	
Aims/Purpose	
Population and Sample size	
Details/Results extracted from the Source of Evidence	

Bibliography of publications to be included in this review will be checked for possible inclusion of other papers. Following the search, articles will be deposited in the END-NOTE program. Search results will be exported to Rayyan® [19], and duplicates will be removed. The developer of the software is Rayyan Systems Inc. from Cambridge, MA, USA and will be a support tool to collect articles from the different used databases and detect duplicates.

2.3. Study selection

Two reviewers, independently, will collect the data from the articles to decide their inclu-sion in this scoping review. Doubts and disagreements will be discussed using a third reviewer in accordance with

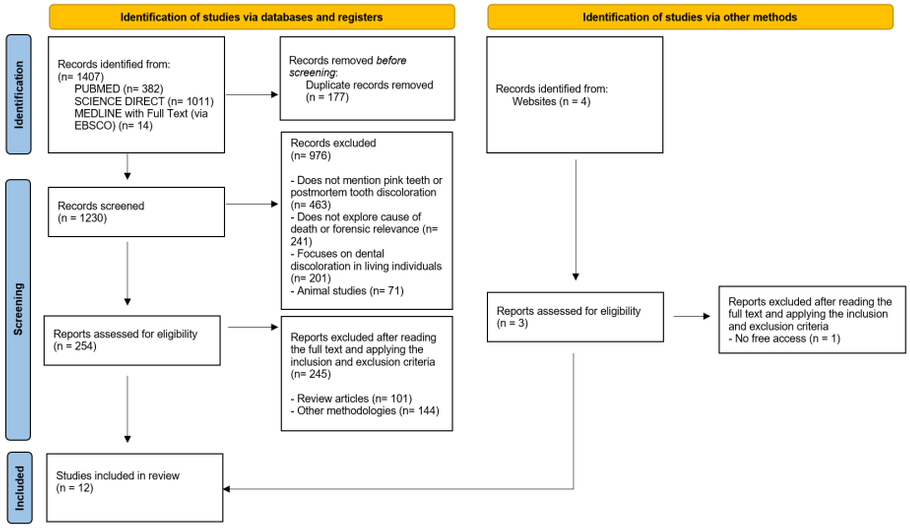

Figure 1- *Flowchart of the article's selection process, adapted from PRISMA 2000 flow diagram [15].*

the peer review of the Electronic Search Strategies (PRESS) checklist [20].

Two independent reviewers will perform the preliminary test, through the analysis of ti-tle/ abstract of articles followed by full text. Following this analysis, 5% of the total articles will be used to get at least 75% consensus between reviewers. In the next step of the re-search, 2% of full-text articles will be used to get the same degree of consensus.

Publications that address the key goal of this review will be identified through the selec-tion, eligibility and use of the inclusion and exclusion criteria and research limiters.

Once the required consensus is reached, the full screening process will proceed. The same two reviewers will independently evaluate all titles and abstracts based on the predefined inclusion criteria. Full texts of potentially relevant articles will then be retrieved following JBI guidelines. Any disagreements between the two reviewers will be solved by discus-sion with the third reviewer. The data of each selected article will include specific details as shown in Table 2.

The study selection process was defined a priori and applied during the protocol devel-opment stage, in accordance with the PRISMA-ScR guidelines. The PRISMA-ScR flow diagram (Figure 1) illustrates the application of the predefined search strategy and eligibil-ity criteria, providing a transparent account of the records identified and selected at this stage.

A PRISMA-ScR flow diagram [15] will document the selection process (Figure 1).

A total of 1407 records were identified through database searching, including PubMed (n=382), ScienceDirect (n=1011), MEDLINE with Full Text (via EBSCO) (n=14). After removing duplicate records (n=177), 1230 records were screened based on titles and ab-stracts.

During the screening process, 976 records were excluded in accordance with the prede-fined exclusion criteria: publications that did not address the post-mortem pink teeth phe-nomenon or its forensic relevance; ineligible publication types; studies conducted in non-human populations; or studies lacking a post-mortem or forensic context. Subse-quently, 254 full-text articles were assessed for eligibility.

Following full-text assessment, 245 articles were excluded for failing to meet the inclu-sion criteria, most often because they were review-based, had ineligible methodological designs, or lacked forensic relevance. In parallel, 4 additional records were identified through other sources, such as citation tracking and website searches. Of these, three full-text reports were assessed for eligibility and excluded using the same predefined cri-teria.

At the protocol stage, 12 studies met the inclusion criteria and were therefore eligible for inclusion in the final scoping review.

After inclusion, data extraction will be conducted in line with the objectives and research questions of the present review, using a standardised data extraction tool developed in accordance with the Joanna Briggs Institute methodology [16–18]. The extracted data will include bibliographic and methodological characteristics of the included studies, namely title, author(s), year of publication, country of origin, study design, objectives, and main results, as outlined in Table 2.

The extracted information will be organised into a structured table containing the prede-fined data items, and the findings will be synthesised and presented in narrative form. This approach will enable a systematic mapping of the existing evidence on postmortem pink teeth and facilitate the identification of patterns, gaps, and methodological limitations in the current literature.

2.4. Data analysis and Presentation

After reading selected full articles, data will be extracted according to goals and research questions of the present review. The tool used for that will be conducted by the method-ology proposed by Joanna Briggs Institute [16-18], and will include the following: title, author(s), year of publication, country of origin, type of study, objective(s) and results, as shown in Table 2. The collected data will be presented in narrative form.

To collect the information of each of selected articles, a table will include the details de-scribed above.

3. Discussion

The phenomenon of pink teeth in postmortem examinations remains an underexplored yet potentially valuable finding in forensic medicine. Although several case reports and ob-servational studies have described its occurrence, particularly in deaths involving asphyxia or submersion, the forensic significance of pink teeth has not been systematically assessed. This scoping review aims to fill that gap by mapping the existing literature on the topic, identifying patterns, and highlighting methodological approaches used to report and ana-lyse this postmortem feature.

It is believed that the pinkish colour results from the extravasation of blood from the pulp capillaries into the dentinal tubules. This alteration seems to be triggered by increased in-tracranial or localized pressure, that lead to the rupture of small vessels within the tooth pulp. This is followed by permeation of haemoglobin and its breakdown products to den-tine, causing discoloration. Although pink teeth are frequently associated to asphyxia deaths such as strangulation, hanging, and drowning, this discolouration has also been observed in other causes of death, like drug overdose or carbon monoxide poisoning. Environmental factors, particularly high humidity, also seem to have an important role in the development of this phenomenon, since moisture can facilitate the haemolytic process and consequently the diffusion of pigments. The intensity of the pinkish colour can vary from a light pink to a deep reddish-purple, and may affect a single tooth, multiple teeth, or

the entire dentition. This variability complicates the establishment of a correlation with the cause of death. Therefore, a systematic evaluation of published data is crucial to allow distinguishing between coincidental observations and forensically relevant patterns.

In this way, this review wants to provide a deep overview on the conditions that lead to the development of pink teeth, and the techniques used for their detection, as well as elu-cidate whether pink teeth are being considered as a potential forensic indicator in contem-porary practice.

This review also aims to understand the need for a differential diagnosis, since pink dis-coloration should be carefully distinguished from other antemortem colour changes. For instance, congenital erythropoietic porphyria, a rare metabolic disorder, can cause a red-dish-brown discoloration of teeth (erythrodontia) throughout life. Similarly, dental trauma experienced during life can lead to intrapulpal haemorrhage, resulting in a pink or dark discolouration0 of a single tooth that may be mistaken for the postmortem phenomenon. Furthermore, the use of certain endodontic filling materials containing resor-cinol-formaldehyde, can provoke a pinkish colour to the tooth structure. In this way, it is fundamental the capacity to distinguish the postmortem changes from these antemortem factors for the correct forensic interpretation.

As already mentioned, it is observed high variability in the circumstances that lead to the progression and stability of the pink colour. The development of this discolouration does not always start immediately after death, may take several days or weeks to develop and sometimes it even fades over time probably due to advanced decomposition. Moreover, one of the problems that might arise from the studies that will be selected is the lack of control of the environmental conditions that play a role in the development of pink teeth (temperature, humidity, pH, exposure environment, oxygen levels, local microbiota). This factor does not allow the analysis of the effect of each environment factor, making diffi-cult to interpret results. One possible strategy to address this problem can be the perfor-mance of in vitro laboratory studies using human or animal teeth. In this way, this ap-proach will allow the control of each variable, isolated or in combination, to quantify its direct impact on the development of the pink teeth phenomenon.

Scientific data inconsistencies also arise from the lack of standardized protocols for doc-umenting this phenomenon, such as the use of colour scales. Another important gap is the lack of information regarding the establishment of a timeline for the appearance and dis-appearance of pink teeth under various environmental conditions. Without this knowledge, its utility in estimating the postmortem interval remains very limited, reinforcing the need for controlled experimental studies.

This review is expected to guide future research, including the establishment of standard-ized guidelines for the documentation and interpretation of pink teeth. Moreover, through the identification of gaps in dental professional knowledge may help the planning of ex-perimental studies aiming the understanding of the pathophysiological mechanisms un-derlying this phenomenon.

Besides studies having controlled environmental conditions, animal models can provide important data on the cellular and biochemical aspects related to the development of this discolouration. Histological and immunohistochemical analyses can also help to identify the specific haemoglobin derivatives responsible for the colour. Only through rigorous scientific experimental studies will be possible to determine if pink teeth is a scientifically robust tool in the forensic sciences.

4. Conclusions

This scoping review aims to map scientific data related to the occurrence of postmortem pink teeth and its forensic significance, by exploring the conditions in which pink teeth are reported and their association with different causes of death.

The results of this review will clarify if pink teeth are relevant in forensic cases and whether they can be used to complement other methods for determining the cause of death. This knowledge is critical for increasing the precision of forensic diagnostics.

Moreover, this review will help to identify research gaps and guide future studies, proba-bly allowing the establishment of standardized forensic protocols regarding this finding.

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Conflicts of Interest

The authors declare no conflicts of interest.

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