Review

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Posted Date: 5 December 2023

doi: 10.20944/preprints202312.0055.v1

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What Are the Most Common Types of Bias That Forensic Odontologists Face While Analyzing a Human Bitemark? A Scoping Review

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Abstract: Considering bitemark evidence, forensic dentists must give testimony that could have catastrophic consequences**.** A bitemark is often the only physical evidence on a body, and odontologists' testimony should be powerful and simple to understand. Given that perpetrators may be executed or imprisoned for life, a defective bitemark analysis is comparable to dentists' most crucial clinical decisions regarding diagnosis. Bias affects human bitemark analysis, and forensic dentists must examine its invisible impacts to avoid making mistakes. The aim of this study was to explore the potential of different types of bias in bitemark analysis and methods during analysis by conducting a scoping review. The majority of the 14 articles that were taken into consideration were published in 2019. USA, UK, Australia, New Zealand, and the Netherlands published the most articles. 36% of the publications addressed contextual bias, while 57% acknowledged cognitive bias. Preventive measures have been recommended to address bias in bitemark analysis. These consist of limiting the availability of unrelated data during the research, employing several comparison samples for a more impartial assessment, and repeating the analysis while being blind to past findings. These preventative measures reduce cognitive and contextual bias and improve bitemark analysis in forensic investigations.

Keywords: 'bites'; bite marks; human bite marks; bias; cognitive bias; contextual bias

1. Introduction

The field of forensic dentistry, also known as forensic odontology, is where dental evidence is used in legal proceedings. In general, forensic dentistry covers a wide range of scientific disciplines where dentistry and the judicial system intersect.[1] Keiser-Neilson defined forensic dentistry as "that branch of forensic dentistry concerned with the proper handling and examination of dental evidence and the proper evaluation and presentation of dental findings in the interest of justice."[2] Bitemark evidence is the most controversial aspect of forensic dentistry.[3] The bite mark is described as 1) a physical alteration in a medium caused by the contact of teeth and 2) a representation pattern left in an object or tissue by the dental structures of an animal or human, in accordance with the ABFO (American Board Of Forensic Odontology) handbook recommendations. Additionally, it defines a bitemark as a circular or oval-shaped wound with two symmetrical, opposite U-shaped arches that are separated at their bottoms by open spaces. Each abrasion, bruise, or laceration around an arch represents a different aspect of the contacting surface of a human tooth, such as its size, shape, arrangement, or distribution of class.[4]

Innocence project is a planned effort being spearheaded by the Innocence Project of New York, which was established in 1992. The Innocence Network is a coalition of non-profit legal organizations in the United States, Canada, the United Kingdom, Australia, and New Zealand committed to proving the innocence of wrongfully convicted individuals using DNA testing and the reform of criminal justice systems to prevent future injustices.[5] [43]. The Innocence Project worked towards exoneration of wrongfully convicted individuals in 9 cases. [44] The environment in which bitemark

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evidence is collected and analyzed is filled with irrelevant information that could influence decision-making by influencing expectation, motivation, perception, cognition, or emotion despite being irrelevant to the bitemark forensic work. This information is shared by numerous types of forensic science evidence.[6],[43]. Other potential sources of bias are more unique to bitemark analysis. As a result of the nature of crimes involving bitemarks, forensic odontologists often work in an emotionally charged atmosphere. Regardless of the interpretation method employed, the context of the bitemark is almost always presented immediately to the odontologist.[6]In other words, unlike fingerprints or shoe impressions, persistent bitemarks on skin indicate that violence has occurred; this contextual information cannot be denied. In cases involving significant trauma or injury, the forensic odontologist is likely to experience an emotional response – whether conscious or unconscious – that may play a significant role in subsequent decision-making.[6],[43]. Contextual bias is a subject of significant concern due to a lack of objective standards and statistics demonstrating alarming rates of reliability and mistake, even under "ideal" circumstances.[6, 7].According to President's Council of Advisory on Science and Technology (PCAST) 2016 report cognitive bias is defined as the term "cognitive bias" describes how human perceptions and judgments can be influenced by elements that are unrelated to the decision at hand. It includes "contextual bias," in which people are shifted by unimportant background information, "confirmation bias," in which people interpret information or search for new evidence in a way that confirms their preexisting beliefs or assumptions, and "avoidance of cognitive dissonance," in which people are hesitant to accept new information that is inconsistent with their tentative conclusion. For instance, the biomedical science community uses stringent methods, such as double blinding in clinical trials, to reduce cognitive bias.[8] In order to prepare, support, or enhance how forensic practitioners deal with "human perception, memory, context information, expertise, decision-making, communication, experience, verification, confidence, and feedback," psychology is incorporated into their work. The ultimate goal is to improve their performance and minimize their errors when comparing pieces of forensic identification evidence, examining how susceptible they are?[9] The timeline for bitemark comparison in forensic and legal literature starts with restrained professional conservatism and ends with the realization that the field's assertions must be disproven. Many assumptions and claims made by forensic dentists during bite-mark comparisons lack solid data to back them up. Bitemark testimony has been used in criminal prosecutions without any substantial scientific validation, estimation of mistake rates, or reliability testing. Forensic dentists may have the highest error rates of any forensic identification profession still in use.[10-12] Although there have been studies for and against bias in bitemark analysis there are few studies consolidating literature in a single article. The aim of this study was to explore the potential of different types of bias in bitemark analysis and methods during analysis by conducting a scoping review.

2. Materials and Methods

A scoping literature review was designed to focus on answering the question: 1) what are several types of bias during bitemark analysis? 2)How to avoid bias during the analysis? 3)What different protocols, guidelines or different investigations or ways of examinations should be followed in a bitemark analysis cases to avoid bias?

My search strategy was conducted on three academic databases such as PubMed, Scopus and Google scholar shown in the Table 1:

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Table 1. showing the Database and the search Strategy.

Database	Search Strategy (combination of key words)
PubMed https://pubmed.ncbi.nlm.nih.gov/	(humans [MeSH] OR humans [Title/Abstract]) AND (Bites, Human [MeSH] OR bitemark OR "bite mark*") AND (Observer Variation [MeSH] OR bias OR accuracy OR accurate OR variation OR error* OR mistake*)
Scopus https://www.scopus.com/	(TITLE-ABS-KEY (human*) AND TITLE-ABS-KEY (bitemark* OR "bite mark*") AND TITLE-ABS-KEY (bias, variation, OR accuracy OR accurate OR variation OR error* OR mistake* OR analysis))
Google scholar https://scholar.google.com/	(bitemark OR " human bite mark") AND (cognitive bias OR contextual bias OR accuracy OR accurate OR mistake)

Inclusion Criteria: Included academic and peer-reviewed original experimental studies only regarding the effects of bias in a bitemark analysis and methods to avoid it and looking for better methods. Unpublished scientific products circulated in diverse channels of communications such as proceedings of scientific conferences, within the topic of interest. Restrictions of language, (ENGLISH ONLY) time period from (1990-2022) and status of publication were applied.

Exclusion Criteria: books; book chapters; case reports letters to the editor and/or editorials; non-experimental studies

This present structured literature review was performed following the guidelines and checklist provided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses PRISMA ScR (www.prisma-statement.org)

Four steps made up the selection process. The first involved locating studies following a bibliographic search. In order to eliminate duplicate studies, the studies were later imported via the research information system (RIS) into EndNote X20.4.1 software for Windows. The remaining articles were then double checked using the same software by manually removing duplicates. Study exclusion based on title reading was the second stage. Exclusions were avoided at this stage in cases where there was a question as to the study's eligibility based on its title. The third phase established study exclusion based on abstract reading so that the articles could be further screened. After reading the entire text, the fourth phase involved exclusion based on eligibility criteria. Data Extraction of Included Articles was categorized per 1) title of paper 2) author 3) origin 4) year of publication 5) Types of study 6) types of bias 7) Suggestions to reduce bias 8) Good practice for bitemark analysis.

3. Results

A total of 523 number of articles were identified but 50 duplicates were removed resulting in 473 articles. These articles were reviewed and 436 were excluded and only 37 were sought for the retrieval. These thirty-seven articles were reviewed out of 23 were again removed as they don't fulfil the inclusion criteria. In the end only 14 articles were considered, and Figure 1 shows the Prisma 2020 flow diagram. The description of the 14 articles according to the eight categories can be seen in Table 2.

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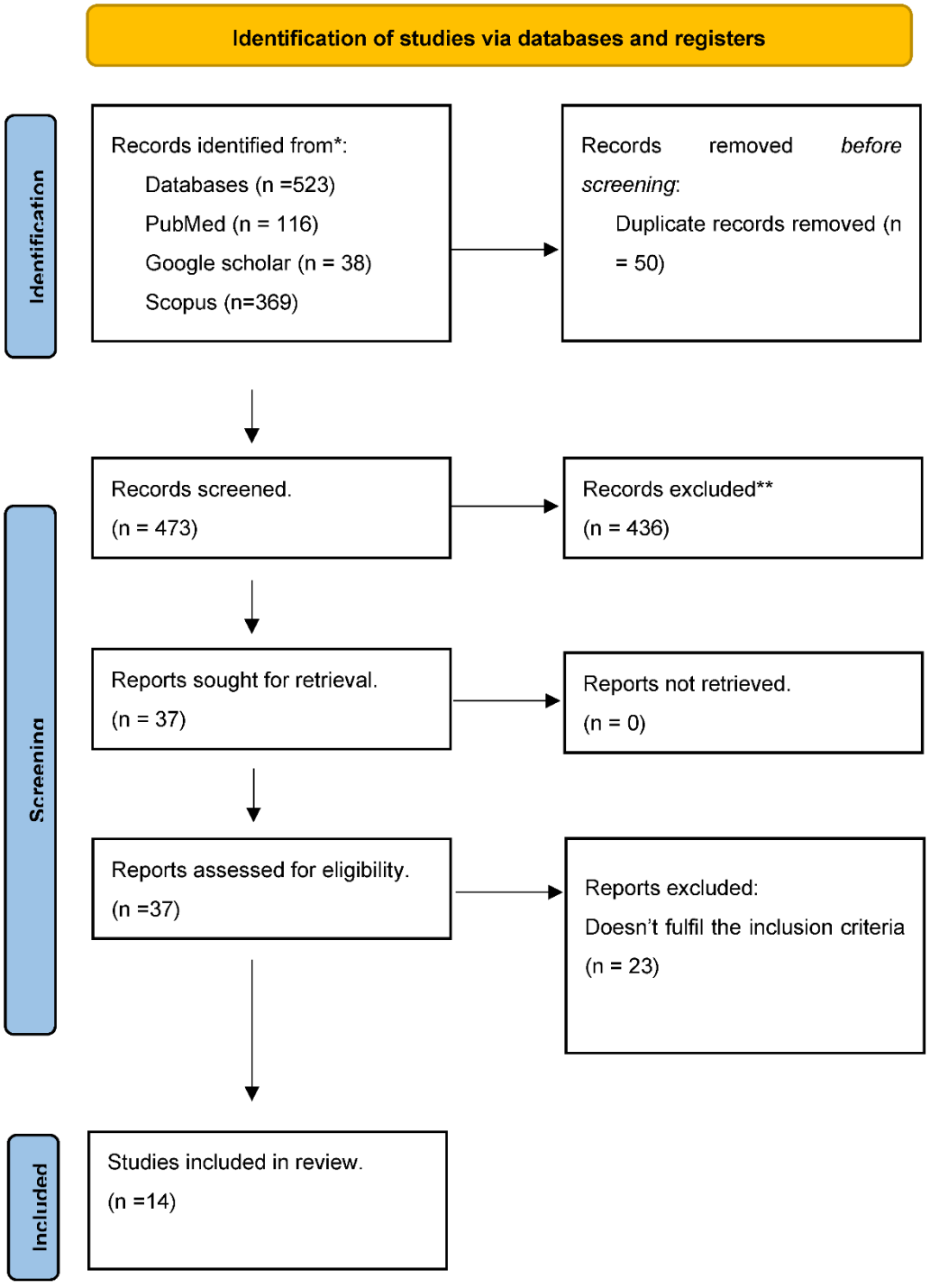

Figure 1. Prisma 2020 flow diagram for scoping review which included searches of databases only.

Table 2. shows the Name of articles, Authors, year of publication, type of study, type of bias, suggestions to remove bias and good practice for bitemark analysis.

No#	Title	Author	Source	Origin	year	Type of study (RA=Review article, ES=Experimental study, SR=Systematic review, S=Survey)	Types of bias (CB = cognitive bias; Cont. bias= Contextual bias, NO = no information, PB=Potential Bias, Conf.Bias=Confirmation bias EB=Emotional bias)	Suggestions to reduce bias	Good practice for bite mark analysis
1	Review of a forensic pseudoscience: Identification of criminals from bitemark patterns	C. Michael Bowers	Scopus	USA	2019	RA	*CB*	*No information*	No information
2	Inconsistency in opinions of forensic odontologists when considering bite mark evidence	Gowri Vijay Reesu Nathan Lee Brown	Scopus	UK	2016	S	NO	No information	Introduction of recognized system for validation or revalidation of bitemarks
3	Expert Disagreement in Bitemark Casework	C. Michael Bowers, Iain A. Pretty	Scopus	USA	2009	ES	NO	No information	Caution must be exercised while examining the bite mark.
4	Inquiry into the Scientific Basis for Bitemark Profiling and Arbitrary Distortion Compensation	Mary A. Bush et al	Scopus	USA	2010	ES	PB	No information	DNA evidence, consider crime scene context, timing of injury, perpetrator identification will make bitemark evidence important in court.
5	Context Effects and Observer Bias—Implications for Forensic Odontology	Mark Page et al	Scopus	Australia	2012	RA	Conf.bias, CB, Cont. bias	The odontologist who was involved in collecting the evidence should not be involved in analysis. Limit the amount of extraneous information to forensic odontologist. Avoid the analysis of poor-quality evidence	take measures to reduce potential biasing effects until there is a better understanding of the probable future path it will take. Experimental data are provided to specify the conditions and quantify the degree to which they affect the analysis and

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									interpretation of bitemark evidence.
6	The barriers to achieving an evidence base for bitemark analysis	Iain A. Pretty	PubMed	UK	2006	ES	NO	No information	Postgraduate programs in forensic training and research. Replication of unique features on human skin and a better understanding of force used in bitemark are essential, odontologist undergo proficiency test and aim to collect biological evidence whenever it is possible
7	Does contextual information bias bitemark comparisons?	Nikola K.P. Osborne et al	PubMed	New Zealand	2014	ES	*Cont. bias, EB*	*No information*	Address the questions raised by this research to gain further insight into the mechanism that underlie the interpretation of bitemark evidence
8	How Cross-Examination on Subjectivity and Bias Affects Jurors' Evaluations of Forensic Science Evidence	William C. Thompson et al	PubMed	USA	2019	S	*Cont. bias, CB*	Forensic scientists can reduce the contextual bias by adopting context management procedures that shield them from exposure to contextual information that is irrelevant in judgement, jurors also appreciate the blinding procedures	Further research should examine jurors view regarding other forms of contextual bias, using procedure like linear sequential unmasking to reduce level of contextual bias, future research might also use richer stimulus material such as presenting jurors with video of testimony rather than transcript
9	A practical tool for information management in forensic decisions: Using Linear Sequential	Adele Quigley-McBride	Google scholar	USA	2022	RA	CB, *Cont. bias*	Using (LSU-E) technique helps to reduce the cognitive bias while analyzing any evidence	This research helps in the practical implementation of (LSU-E) technique. More research among researchers to turn

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	Unmasking-Expanded (LSU-E) in casework								their research-based solutions into implementable tools for forensic analyst.
10	Cognitive bias research in forensic science	Glinda S. Cooper	Google scholar	USA	2019	ES	CB	No information	Future research provides additional data in understudied disciplines, assess the level of subjectivity in the analytical procedures in relation to presence of bias and assess sample complexity as an effective modifier, attention to guidelines for designing and reporting studies may result in strong and comprehensively described studies
11	Thinking forensics: Cognitive science for forensic practitioners	Gary Edmond	Google scholar	Australia	2017	SR	CB, *Cont. bias*	No information	To better understand their processes, capabilities, and limitations, forensic practitioners should read about cognitive science and experimental psychology. They might be able to improve output and come up with new, more efficient ways of producing goods, presenting evidence in a way that accurately reflects and communicates what is understood. These reactions would appear to be in line with the kind of

doi:10.20944/preprints202312.0055.v1

									expectations that a contemporary society has of both state-employed forensic practitioners and independent forensic science suppliers.
12	Legal psychologists as experts: guidelines for minimizing bias	Annelies Vredeveldt et al	Google scholar	Netherlands	2022	RA	PB, CB	Reducing bias by raising awareness enables implementation of bias reducing measures, awareness on its own is not effective. People frequently suffer from the "illusion of control," thinking that willpower alone can overcome their biases and mental patterns. However, to effectively reduce bias, practical measures must be put in place.	This seems especially important in situations where experts draw vastly diverse conclusions from the same data An examination of these issues would be extremely valuable from both a legal and scientific standpoint.
13	Human factors in forensic science: The cognitive mechanisms that underlie forensic feature-comparison expertise	Bethany Growns et al	Google scholar	USA	2020	RA	NO	No information	Should further investigate the human factors and cognitive mechanisms that play a role in forensic decision making to improve comparison performance and criminal justice outcomes
14	Cognitive neuroscience in forensic science: understanding and utilizing the human element	Itiel E. Dror	Google scholar	UK	2015	RA	CB	No information	These developments will improve forensic science, but they will necessitate some rethinking and reevaluation of existing procedures

doi:10.20944/preprints202312.0055.v1

									and ideas, just like any shift. Since cognitive neuroscience offers numerous insights into the human factor, it can greatly influence changes in and advancements in forensic science.

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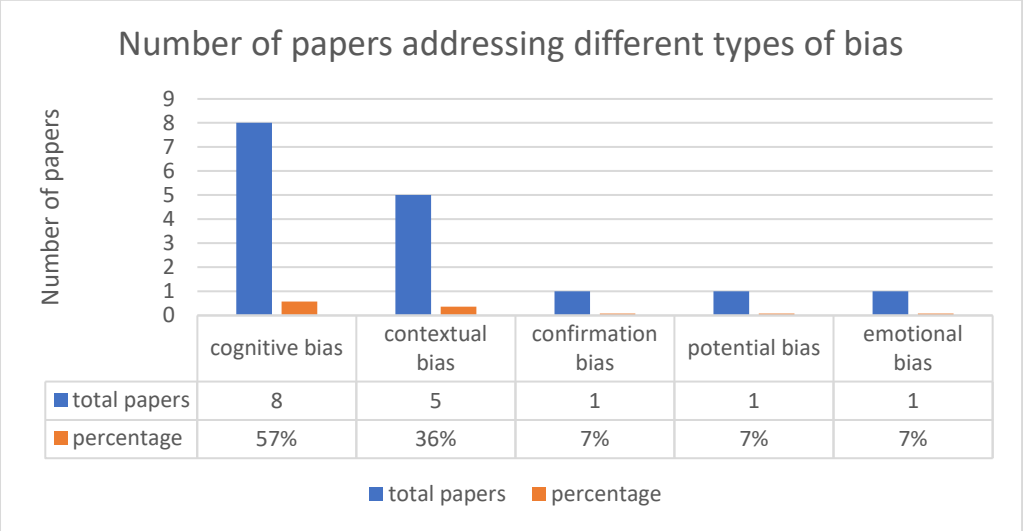

Figure 2. shows the number of papers addressing each type of bias.

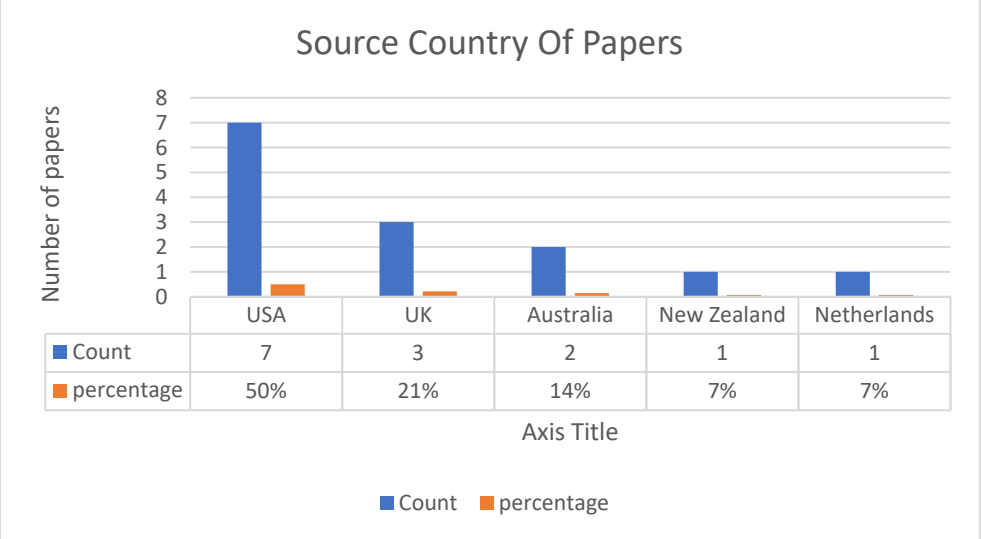

Figure 4. shows the source country of papers.

4. Discussion

Most articles about bias are from USA, Australia and other papers are from countries like UK, Netherlands, and New Zealand. Out of 14 papers 4 papers talk about different methods how to remove bias and while 13 papers suggest that there should be a specific technique or method to remove bias and further research can be done in this field. Few papers suggested that Introduction of recognized system for validation or revalidation of bitemarks should be introduced[13]before making an analysis many factors are considered before a decision is made like DNA evidence, consider crime scene context, timing of injury, perpetrator identification will make bitemark evidence important in court.[14] According to the results in the year 2019 three papers were published in USA and the main reason for this is the innocence project in USA where different cases of bitemark e.g. like Roy Brown was wrong fully convicted and that case was in the limelight and bias decisions during a bitemark analysis gained more attention when innocence project revealed the truth of many other cases[15] [44-45]. In the year 2022 two articles one is from USA and other is from Netherlands. The scientific basis and dependability of this forensic approach are seriously questioned when bias is examined in human bitemark analysis. In order to establish a relationship between the two people, bitemark analysis includes matching markings on the skin of a biting victim with the teeth of a suspected biter. However, a number of research and reviews have cast doubt on the reliability and

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accuracy of bitemark analysis, raising the possibility of skewed judgments in court cases. Bitemark evidence has been used in several high-profile cases to support incorrect convictions, raising more concerns about the validity of this forensic method. DNA exonerations have highlighted the limitations of bitemark analysis, underscoring the necessity for a careful evaluation of its scientific foundation and the dangers of biased judgment.[16]

As the identifiers of deceased human dental remains started to evolve in the 1960s and 1970s in the UK and US, bitemark comparison became an important addition to their historical forensic role. The seminal despite being labeled "unusual" by the testifying dentists, a legal case in the US from 1975 served as a catalyst for bitemark approval across all 50 US states.[11] The bitemark identification concept is based on the idea that human teeth are unique, and that skin makes an accurate impression of tooth marks.

Through the 1970s, there were no studies about human tooth shape variability and "dental uniqueness," and since then there have been scattered and superficial attempts. Despite this, given that the bitemark criminal case law dates from the 1980s, surprising behaviors can be observed. Dentists testifying in court and pledging loyalty to the idea of human "dental fingerprints" validated the "uniqueness" of the claim. The lack of substantial study wasn't enough to discourage defenders of bitemarks, and these "belief" statements without supporting facts were incorporated into the bitemark identification cases that were accepted in state and federal courts across the United States.[11] The ABFO issued stricter rules in February 2016 to restrict the members' use of bite mark testimony. Scientific doubts, incorrect beliefs, and the ethical and professional concerns of its members all played a role in this recent incident. This most recent set of Guidelines, which were released in March 2016, limit individualization testimony in any circumstances.

According to a 2009 report of National Academy of Science, USA (NAS) regarding bitemarks deep conversations with bitemark practitioners, bitemark researchers, and related science professionals were conducted by this interdisciplinary scientific collaboration. Additionally, they gathered all academic and professional research on bitemark analysis. The Committee was unable to find any reliable scientific data to back up the reliability and validity of bitemark methods. The lack of evidence for an established scientific rationale favoring one-person over-all others was reported to the committee. This makes the categorical assertion that Any choice of identity, whether it be one that is "highly probable," "possible," or "to the exclusion of all others," is not supported by science and so has the potential for error.[11, 17]

The most important type of bias in bitemark analysis is **cognitive bias** and when someone collects, perceives, or interprets information, cognitive bias can affect how they decide to do so. For example, two competent examiners with different mindsets or working in different contexts may come to conflicting conclusions about the same evidence. The methods utilized, the availability of information unrelated to the job at hand, prior experience in unrelated situations, or more general factors linked to motivation, training, laboratory culture, or human decision-making have all been highlighted as potential sources of cognitive bias in previous studies.[18] According to **Dror et al** there are 8 sources of cognitive bias in forensic science and they are divided into 3 categories **Category A** is case specific which include(Data, reference materials, contextual information) **Category B** is environmental, culture ,and experience which consist of (base rate, organizational factors, education and training) and **Category C** is human nature which include (personal factors, human and cognitive factors and brain).[18, 19] There are other sources of cognitive bias which include **observer effect** which can be defined as to the unintended transmission of behaviour from experimenters to test subjects via the researcher's expectations. The Hawthorne effect is a term for a phenomenon that results in participants doing more intentionally or better when they are aware that they are being examined. The fact that dental students frequently outperform regular dentists and, in some cases, forensic odontologists themselves is interesting in many interobserver odontology studies.[20-22].there is another source of cognitive bias which include contrast effect and the overconfidence effect [20].**Contrast effect** can be explained as this phenomenon, which is especially prevalent in subjective comparison work done by forensic odontologists, indicates the tendency to change the judgement standard following repeated exposure to stimuli of a given threshold. The odontologist

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progressively starts to 'see' the relationship between the mark and the dentition after thorough analysis, which demonstrates the susceptibility to contrast effects. Through a "target-shifting" mechanism, the fact that such analysis is carried out alongside a reference like the suspect dentition also creates bias.[20, 23] and **overconfidence is** the effect which is related to practitioners' tendency to overestimate their aptitude for performance, particularly when handling routine or often repeated activities. Eventually they become bias in the analysis.[20]

The second most common bias during human bitemark analysis is **contextual bias**. **Seven** different sources of contextual bias are 1)another examiners decision about the same material 2)explicit suggestion about what the conclusion should be or which person left the sample at the crime scene 3)the suspect provide the verified alibi 4)the suspect confess the crime 5)information about the type of crime or the photos of crime scene or relevant to the crime type 6)demographic information of victim or suspect 7) examiner was allowed access to other materials or forensic evidence that were not tasked with analyzing.[18, 24] There are two key reasons to believe that contextual bias may be a problem with bitemark analysis. The first is that a significant amount of emotional context is built into the evidence when a bitemark left on skin is subjected to forensic investigation. It is unlikely that all emotional context, such as the harm the perpetrator has caused, can be eliminated from crimes linked with sexual assault, child abuse, and homicide .A forensic odontologist's emotional response to the evidence, whether conscious or unconscious, could have a substantial impact on the subsequent forensic decision-making in situations when there has been significant trauma or injury.[25-27] Second, it is uncommon for bitemarks to leave crystal-clear impressions that may be easily analyzed. Instead, the bite's appearance may alter over time or include bruising, swelling, and broken skin, which will produce misleading patterns.[25, 28, 29] There is a method which can be used to avoid contextual bias is Make use of 'case manager'[30] In certain labs, a "case manager" mediates between the lab examiners and the criminal investigators. The case manager consults with the investigators to decide which pieces of evidence require examination, and then they are given to the examiners for inspection, testing, and comparison. Due to this division of labor, the case manager can be fully informed about the case's history, while the examiners are simply provided with the information required to carry out the desired examination or test. Once the examiners have documented their conclusions, they will eventually obtain the case's background information.[31-33].**LSU (Linear sequential Unmasking)** was recently expanded by **Dror and Kukucka** into LSU-Expanded (LSU-E), allowing the framework to be used in any forensic domain and enhancing decision making in general rather than concentrating only on reducing bias. Examiners decide in advance which pieces of information to consider and in what order under the LSU-E framework. The **relevance, objectivity, and biassing power criteria** are the three factors that determine these conclusions.[18, 19] A useful worksheet that is adaptable to any field of forensic science and can be used to implement LSU-E in lab settings. The user must first identify the data point in question (such as a suspect sample, demographic data, or other incriminating or exonerating evidence) and the information's source (such as the crime scene, an interview with the police investigator, an email from the prosecutor, or a database). After that, the user evaluates the information considering the three LSU-E criteria (biassing power, objectivity, and relevance), and rates it on a scale of 1 to 5 for each criterion.[18] Without our knowledge, contextual information can influence the choices we make. Contextual data might cause forensic professionals to make errors and even reverse their decisions. Even while forensic professionals are aware of the risks, they are unable to overcome or account for them. We frequently use contextual information to aid in our decision-making. Decision-making can be influenced and even improved by factors like mood, past experiences, and incidental information. Making decisions in the face of contextual information, however, can occasionally result in **confirmation bias**, in which we purposefully look for and interpret information in a way that is compatible with our preexisting ideas or expectations.[34-38] According to Dror et al there are 5 levels which contain irrelevant information for forensic scientist or examiner **level 1** is trace evidence, **level 2** is reference material**, level 3** is case information, **level 4** is base rate expectations. **level 5** is organizational and cultural factors.[12] Procedures for controlling the impact of context, like sequential unmasking (at a case or discipline level) or the use of blind

analytic techniques, can help to lessen the issue. Contextual bias can be lessened if techniques like these are used and forensic practitioners are not exposed to extraneous (i.e., domain irrelevant) information before reviewing evidence. To the greatest extent possible, forensic professionals should be blind to irrelevant information, even though this may be challenging to achieve in practice.[38] Determining the influence of forensic evidence on court procedures depends critically on the details and jargon used in forensic testimony. How forensic investigators should communicate their findings is a topic of continuous discussion. [12] While presenting the report in court of justice forensic examiner experience three issues. The first is disclosure, that is, what is actually reported, and how it is expressed within the forensic report. Again, this is affected by the adversarial system within which the forensic scientist works. Second, the thoroughness of the documentation in the report is necessary for the scientific accountability and transparency of the forensic examiner's work. The effects on cognition that come from writing a report itself come in third. To the greatest extent possible, forensic examiners should be thought of as laboratory scientists examining forensic evidence. According to this perspective, it is essential for them to focus on the science in their job and to keep it as far away from the adversarial legal system and the criminal investigation as feasible.[12] Given the possibility of contextual biases which we can refer to as "cognitive contamination" it is crucial that forensic examiners concentrate on the relevant scientific data, separating and blocking out irrelevant information that can bias their findings.[12] Base-rate expectations are another factor that might lead to biased forensic judgements Such biases result from patterns that cause the brain to process information in a particular way. The employment of database search technology in forensic science is an illustration of such bias.[12, 39] Feedback is necessary for the forensic odontologist as accurate feedback is beneficial for learning in many contexts, including learning how to interpret complicated visual patterns. Receiving feedback on a variety of challenging examples increases the likelihood of strong learning that generalizes to new stimuli. Although learning can take place in the absence of feedback, it often happens more rapidly, is more robust, and has a longer shelf life when it does. False feedback (the supply of misleading input) may lead to higher error rates. Learning can be hampered by the provision of incorrect selective, or unreliable feedback that is not directly tied to actual performance.[38, 40]

5. Conclusions

Results indicated that cognitive bias and contextual bias are the most common type of bias. As forensic science studies rely on human perception and judgement; they might be influenced by contextual information also known as contextual effects. From the above discussion bias in the bitemark analysis is unavoidable. Any forensic odontologist might be biased at any point of analysis either consciously or subconsciously. Forensic sciences are affected significantly by the realization that the human factor is crucial. Researchers studying forensic decision-making and cognitive bias should go above and above to make sure that their theories can be applied in practice. There is a need for further research and study in the area to solve the issues with biased judgments in bitemark analysis. To create a more solid basis for bitemark analysis, efforts are being made to raise the standard of forensic dental research. The goal is to lessen the possibility of biased judgments and increase the reliability and validity of forensic evidence used as evidence in court. In conclusion, careful examination of the scientific foundation for human bitemark analysis has raised serious concerns regarding its validity and dependability. Decisions may be biased as a result of insufficient scientific evidence for fundamental assumptions and the potential impact of environmental influences. The forensic science community is recommended to adopt an evidence-based strategy and carry out rigorous research to address these challenges in order to enhance the precision and dependability of bitemark analysis and lessen the possibility of skewed judgments in court processes.

Acknowledgement: I convey our utmost gratitude to the Center for Forensic Medicine and Dentistry, School of Dentistry, University of Dundee for their invaluable support to the completion of this research study. Disclosure: The authors do not have any financial interests, governmental conflicts, and commercial associations to disclose. All authors have viewed and agreed to the submission of this article.

Availability of data and materials: The data that support the findings of the study will be available from the Centre of Forensic Medicine and Dentistry University of Dundee, Scotland, United Kingdom. Data will be available from the authors upon reasonable request and with permission from the University of Dundee.

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