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How human decision-making biases influence health outcomes in patient care

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Purpose: Medical treatments and medical decision making are mostly human based and therefore in risk of being influenced by cognitive biases. The potential impact could lead to bad medical outcome, unnecessary harm or even death. The aim of this comprehensive literature study is to analyse the evidence whether healthcare professionals are biased, which biases are most relevant in medicine and how these biases may be reduced.

Approach/Findings: The results of the comprehensive literature based meta-analysis confirm on the one hand that several biases are relevant in the medical decision and treatment process. On the other hand, the study shows that the empirical evidence on the impact of cognitive biases on clinical outcome is scarce for most biases and that further research is necessary in this field.

Value/Practical implications: Nevertheless, it is important to determine the extent to which biases in healthcare professionals translate into negative clinical outcomes such as misdiagnosis, delayed diagnosis, or mistreatment. Only this way, the importance of incorporating debiasing strategies into the clinical setting, and which biases to focus on, can be properly assessed.

Research limitations/Future Research: Though recent literature puts great emphasis on cognitive debiasing strategies, there are still very few approaches that have proven to be efficient. Due to the increasing degree of specialization in medicine, the relevance of the different biases varies.

Paper type: Theoretical.

Keywords: medical decision making, decision biases, clinical debiasing strategies.

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Як людська упередженість при прийнятті рішень впливає на результат лікування пацієнтів

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Мета роботи: Лікування та прийняття медичних рішень в основному пов'язані з людським фактором і, безумовно, схильні до ризику впливу когнітивних упереджень. Потенційний вплив може призвести до несприятливого медичного результату, непотрібного збитку або навіть смерті. Мета цього всебічного дослідження літератури – проаналізувати докази того, чи упереджені медичні працівники, які упередження найбільш актуальні в медицині і як ці упередження можна зменшити.

Підходи/Результати дослідження: Результати масштабного метааналізу, заснованого на літературних джерелах, підтверджують, з одного боку, що деякі упередження мають безпосереднє відношення до медичного рішення і процесу лікування. З іншого боку, дослідження показує, що емпіричні дані про вплив когнітивних упереджень на клінічний результат недостатні для більшості упереджень і що в цій галузі необхідні подальші дослідження.

Цінність/Практичне значення дослідження: Важливо визначити, в якій мірі упередження з боку медичних працівників призводять до негативних клінічних наслідків, таких як неправильний діагноз, пізня постановка діагнозу або неякісне лікування. Тільки так можна буде належним чином оцінити важливість включення стратегій виключення систематичних клінічних помилок і визначити на яких упередженнях слід зосередити увагу.

Обмеження дослідження/Перспективи подальших досліджень: Незважаючи на те, що в літературі останніх років велика увага приділяється стратегіям когнітивної деградації, все ще існує дуже мало підходів, які довели свою ефективність. Через зростання ступеню спеціалізації в медицині значимість різних упереджень варіюється

Тип статті: Теоретичний.

Ключові слова: прийняття медичних рішень; упередженність при прийнятті рішень; стратегії виключення систематичних клінічних помилок.

Как предубеждения людей при принятии решений влияют на результаты лечения пациентов

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Цель работы: Лечение и принятие медицинских решений в основном связаны с человеческим фактором и, следовательно, подвержены риску влияния когнитивных предубеждений. Потенциальное воздействие может привести к неблагоприятному медицинскому исходу, ненужному ущербу или даже смерти. Цель этого всестороннего исследования литературы – проанализировать доказательства того, предвзяты ли медицинские работники, какие предубеждения наиболее актуальны в медицине и как эти предубеждения можно уменьшить.

Подходы/Результаты исследования: Результаты обширного метаанализа, основанного на литературных источниках, подтверждают, с одной стороны, что некоторые предубеждений имеют непосредственное отношение к медицинскому решению и процессу лечения. С другой стороны, исследование показывает, что эмпирические данные о влиянии когнитивных предубеждений на клинический результат недостаточны для большинства предубеждений и что в этой области необходимы дальнейшие исследования.

Ценность/Практическое значение исследования: Важно определить, в какой степени предубеждения со стороны медицинских работников приводят к негативным клиническим исходам, таким как неправильный диагноз, поздняя постановка диагноза или плохое лечение. Только так можно будет должным образом оценить важность включения стратегий исключения систематических клинических ошибок и определить на каких предубеждениях следует сосредоточить внимание.

Ограничения исследования/Перспективы дальнейших исследований: Несмотря на то, что в литературе последних лет большое внимание уделяется стратегиям когнитивной деградации, все еще очень мало подходов, которые доказали свою эффективность. Из-за растущей степени специализации в медицине значимость различных предубеждений варьируется.

Тип статьи: Теоретический

Ключевые слова: принятие медицинских решений; предвзятость в принятии решений; стратегии исключения систематических клинических ошибок.

1. Introduction

Behavioural economics describes how human decision-making is unconsciously influenced by several cognitive biases. While the consequences of biased thinking might not be so significant for the average person, health professionals' biased thinking may affect their decision-making regarding diagnosis and treatment of patients and could potentially lead to misdiagnosis or treatment errors. Such errors may have fatal outcomes, possibly even leading to death. A study by *Scopelliti et al. (2015)* shows, that on average, individual people assume to be unaffected or less affected by biases than the rest of the population. Due to this fact and the tremendous consequences of biased thinking in medicine, the research is necessary in order to identify whether healthcare professionals are, in fact, biased, which biases are relevant in medicine and how these biases may be reduced.

The objective of this literature-based study is to identify the relevance of human decision-making biases in medicine, analyse their impact as well as elaborate strategies on how to overcome these biases. Based on this objective, the paper aims to answer the following main research questions:

Research question 1: Which human decision-making biases are the most relevant in medical decision-making?

Research question 2: How do these biases influence healthcare professional's decision-making regarding diagnosis and treatment of patients?

Research question 3: What are potential strategies on how to reduce and prevent biases?

After a short introduction to the theoretical framework on medical decision making and on human decision biases, the following literature study will focus on the empirical evidence of human decision-making biases in medicine and the related impact as well as potential strategies of debiasing and their effectiveness.

2. Theoretical background

2.1. Decision-making in medicine

According to the dual process theory *(Evans, 2003)*, evidence shows that a crucial share of medical practice is based on quick and intuitive thinking *(Lucchiari & Pravettoni, 2012)*. It was found that in emergency medicine, for instance, the first judgements about the diagnosis were made even before the first encounter with the patient, and 75% of judgements were generated in the first five minutes of seeing the patient *(Pelaccia et al., 2014)*. There is also evidence that the majority of physicians base their correct diagnostic judgement solely on the patient's main complaint *(Gruppen et al., 1988)*. Evidence also discovers that processes that are considered as analytical thinking, like evaluating different potential diagnoses and gathering positive as well as negative evidence before concluding a final diagnosis, mostly either have a negative or no impact on diagnostic accuracy *(Norman et al., 2017)*. Some studies conclude that when participants were given increased time for the diagnostic decision-making process, the likelihood of reaching the correct diagnosis decreased *(Sherbino et al., 2012; Monteiro et al., 2015)*. There are also findings that the amount of time used on the diagnostic process does not have any impact on the accuracy of the diagnosis *(Lambe, Hevey & Kelly, 2018)*. Hence, the best clinical performance probably results from a balanced combination of analytical and intuitive thinking *(O'Sullivan & Schofield, 2018)*. In their research, Kahnemann and his colleagues identify that biases in human decision making could be detected in both ways of thinking and that even experienced people were found to be vulnerable to biases in their thinking *(Kahneman, Slovic & Tversky, 1982)*.

2.2. Human decision-making biases

There is a large variety of different biases influencing human decision-making. The following list shows a selection of cognitive biases that are of high relevance and can distort healthcare professionals' judgments and potentially influence their decision making.

- *Anchoring Bias:* The anchoring bias occurs when a person's opinion is influenced by the initial information found or provided to them *(Fadus, Odunsi & Squeglia, 2019)*.
- *Biases Regarding People's Characteristics*: Connected to the anchoring bias, there are several biases regarding a person's characteristics like race, gender, ethnicity, nationality, sexual orientation, socioeconomic status (SES), previous stigmatized diagnoses like AIDS, mental illness or disability. Biases towards these characteristics are often implicit, i.e. unconscious and uncontrollable. They are often displayed towards others in non-verbal manners.
- *Availability Bias*: In order to collect information and knowledge for a decision-making process, people tend to favour information that is more recent and prevalent in the memory since it is easy to recall. This is called the availability bias, as it can lead to an inaccurate perception of the information's relevance and result in a distorted view on the topic *(Kahneman et al., 1982)*.
- *Confirmation Bias:* The confirmation bias is present when selectively searching for information which confirms an already formed opinion rather than looking for contradicting evidence or weighing contradicting evidence less than conformational evidence *(Glick, 2017)*.
- *Base Rate Neglect / Base Rate Fallacy:* The base rate neglect, also called base rate fallacy, is present if the probability of the base rate, which is the original probability, is underweighted or neglected *(Kahneman et al., 1982)*.
- *Premature Closure / Search Satisfying:* A premature closure, also called search satisfying, arises when the search for further or alternative information is stopped upon finding the first reasonable answer *(O'Sullivan & Schofield, 2018)*.
- *Diagnostic Momentum:* Diagnostic momentum describes the acceptance of previous diagnoses made by other physicians, carrying on the current course of treatment or other actions without sufficiently investigating their accuracy *(O'Sullivan & Schofield, 2018)*.
- *Gambler's Fallacy:* If an outcome or an event has recently occurred several times, people are prone to think that it is now less likely to occur again due to the fact that it has already happened (too) many times before *(Clotfelter & Cook, 1993)*. In reality, however, the probability of having a specific outcome stays the same each time as it is independent of prior events or outcomes *(Clotfelter & Cook, 1993)*. This is called the gambler's fallacy.
- *Framing Bias / Framing effect:* People's judgement or actions can be influenced by the way a question is framed or information is presented *(Fadus, Odunsi & Squeglia, 2019)*. This is what is considered the framing effect.
- *Overconfidence:* The overconfidence bias is the tendency to have an inflated view of one's own judgement abilities *(Lucchiari & Pravettoni, 2012)*.
- *Publication Bias:* "[The] Publication bias is the tendency of the parts of investigators, reviewers, and editors to submit or accept manuscripts for publication based on the direction or strength of the study findings" *(Dickersin, 1990)*.

In the following chapter, empirical data on decision-making biases in a clinical setting will be identified and analysed. The aim is to explore whether health professionals are exposed to decision-making biases and the potential impact on patient care.

3. Empirical data on the prevalence of decision-making biases in medicine

Many recent empirical studies on anchoring biases in the medical setting focus on implicit racial, gender and socioeconomic biases in medical students and physicians. Evidence of implicit bias regarding race, socioeconomic status or gender varies, as some studies find biases in health professionals *(Haider et al., 2015, Hall et al., 2015; Johnson et al., 2017; Harris et al., 2018)* while others do not *(Williams et al., 2015)*. Another study by *Pettit et al. (2017)* do not show any statistically significant differences in clinical care for patients with different socioeconomic status. However, they do show different behavioural patterns towards patients with a higher socioeconomic status such as a better communication or an increased attentiveness to pain control. The research also found that medical students tend to physically touch patients with a low socioeconomic status more frequently. A recent study by *Yamauchi et al. (2019)* investigating in the psychiatric and social background of patients found significant differences in clinical decision-making by physicians when patients had a medical history of schizophrenia.

The availability bias has been found to be prevalent in healthcare professionals in several studies *(Weber et al., 1993; Hatala et al., 1999; Mamede et al., 2010; Schmidt et al., 2014; Rylander & Guerrasio, 2015)*, while the results have been consistent throughout the years. A contributing factor that might enhance the availability bias is the tendency of posting health articles on social media. Levels of confirmation bias in health professionals have been shown to influence which articles are shared on social media *(Zhao, Fu & Chen, 2020)*.

While there is not much empirical data on whether health professionals are influenced by the confirmation bias, the studies that do examine this bias in healthcare also find evidence of it *(Frotvedt et al., 2020; Atallah et al., 2020)*.

The findings regarding the base rate fallacy are diverse. While an older study by Weber and colleagues only showed little prevalence of base rate neglect *(Weber et al., 1993)*, a recent study by *Kinnear & Jackson (2016)* identified the major evidence of representativeness heuristic, resulting in base rate neglect. The latter study also identified that base rate neglect occurred despite a good understanding of statistical probability concepts. One possible explanation for this dissonance could be that the teaching of diagnostic decision-making foregrounds stereotypic presentations of diseases *(Kinnear & Jackson, 2016)*.

With regard to the bias of premature closure, both *Berbaum and colleagues (2013)* and *Rylander & Guerrasio (2015)* discovered a premature closure in medicine.

While the diagnostic momentum bias is mentioned as a potential source of an error in several studies, there is not much empirical evidence on the actual prevalence of this bias. In a study by *Heritage & McArthur (2019)*, 53% of treated diseases could be attributed to diagnostic momentum, while doctors even gave diagnoses without seeing the patient in 30% of the time.

Similar to the momentum bias, gambler's fallacy is mentioned in several studies, but the research on its prevalence in the medical field is scarce. One study, however, finds Greek medical residents to be significantly prone to the gambler's fallacy *(Msaouel et al. 2014)*.

Older studies on the prevalence of framing bias only show minimal evidence of bias *(Christensen et al., 1991; Christensen et al., 1995)*, more recent studies indicate that health professionals are more strongly influenced by framing *(Perneger & Agoritsas, 2011; Popovich, Szecket & Nahill, 2019)*. An interesting finding was, that when rating the efficiency of a new drug, participants were most impacted by framing when risk was presented in a relative format *(Perneger & Agoritsas, 2011)*.

Cucchetti and colleagues (2020) identified that the extent to which physicians are affected by the overconfidence bias seems to be influenced by their professional experience. While the best clinical performance was found in middle-aged doctors, younger and older health professionals were influenced stronger by overconfidence. The reason seems to be that medical students or junior doctors do not yet have complete knowledge for an accurate clinical assessment, not consciously being aware that they might lack in certain information *(Cucchetti et al., 2020)*. With growing experience and the realization that they do not know everything, doctors develop a more critical view of their own knowledge leading to more accurate judgements. With elderly physicians, however, this healthy criticism seems to decrease again with growing confidence in their knowledge due to years of experience. This possibly leads to ignoring or not informing themselves about novel relevant information, leading to lower judgement accuracy *(Cucchetti et al., 2020)*.

Since the thought behind Evidence-based medicine (EBM) is using the research as a base for clinical decision making and actions, it is highly relevant to know wheather published randomized controlled trials are influenced by selective publishing based on their outcomes. While there are some studies opposing this, numerous papers find strong indications that the publication of studies in medicine is biased towards positive outcomes, leaving negative or null results either unpublished or published later *(Melander et al., 2003; Polyzos et al., 2011; Kicinski, 2013; Chong et al., 2016; De Vries et al., 2018)*. A study by *van Aert, Wicherts & van Assen (2019)* found only minimal to no evidence of publication bias, just like *Lensen and collegues (2017)*, who found no differences in publication versus non-publication or publication time for studies with negative or null results versus positive results. Not only randomized controlled trials and metha-analyses are important sources of information for professionals in medicine, but also systematic reviews on these. Hence, the investigation into whether these systematic reviews of medical research are also biased by the publication bias is highly relevant. One study on systematic reviews in otolaryngology found that authors mostly failed to "mention, plan for, or formally evaluate for the presence of publication bias" *(Ross et al., 2019)*. Similar results were found in another study by *Hedin and colleagues (2016)*. Both studies conclude that the probability of publication bias being present in the reviews is very high.

In addition to these findings about the individual biases, they might be interdependent or linked to each other. The presence of confirmation bias, for example, could potentially induce a premature closure, making clinicians accept a diagnosis without considering plausible alternatives. The same can be said about overconfidence, as a diagnosis might be accepted before its complete verification *(Frotvedt et al., 2020)*. Overconfidence in health professionals does not seem to influence the tendency to be affected by the confirmation bias *(Frotvedt et al., 2020)*. Confidence, however, seems to increase when confirmatory search for information is used rather than searching the information contradicting a previously assumed diagnosis *(Frotvedt et al., 2020)*.

4. The Impact of Biases on Diagnosis and Treatment

When biases are prevalent in a clinical setting, the question arises whether, and if so, which impact decision-making biases have on the process of reaching a diagnosis, giving the correct diagnosis and on the course of treatment.

To start with the impact on the course of a diagnosis, the availability bias, for instance, could potentially increase the risk of unnecessary diagnostic steps as well as unnecessary exposure to

tests. Nevertheless, when the disease description of the current patient matches the previously experienced diagnosis, the availability bias can actually present an advantage of a faster diagnostic process *(Weber et al., 1993)*. Hence, the availability bias can have both negative and positive effects on the diagnostic process.

The confirmation and anchoring bias could also lead to unnecessary diagnostic processes as well as potential misdiagnoses. There is a great chance that clinicians overlook or disregard information that is important to make the right diagnosis with both biases. This could firstly lead to wrong and hence unnecessary diagnostic tests and, secondly, to potential misdiagnosis. A study by *O'Hagan et al. (2019)* showed that when health professionals were provided with observational data rather than a potential diagnosis, they were more likely to identify the correct diagnosis. On the contrary, if a potential diagnosis was provided, clinicians "anchored" for the presented diagnosis. Consequently, it can be concluded that the anchoring bias has a significant impact on the diagnosis of patients. Another bias that could easily lead to misdiagnosis is the gambler's fallacy. A premature closure can make healthcare professionals not only prone to misdiagnosing, but also to failing to notice potential coexisting diagnoses due to the premature ending of the diagnostic process. The same holds true for diagnostic momentum.

Additionally, there is the risk of wrong treatment as a result of an incorrect diagnosis. Even a delayed correct diagnosis can already cause avoidable harm to the patient as they might first receive either incorrect or no treatment at all, which can potentially worsen their condition. This might happen as a result of the overconfidence bias, when a physician overestimates their judgement ability, and possibly gives a wrong diagnosis and accordingly the wrong treatment. With the base rate neglect, there might be the opposite risk of treating a patient who does not need treatment.

A potential consequence of the framing effect is that it can influence the perception of risk and benefit of certain treatments *(Perneger & Agoritsas, 2011)*. As a result, the distorted perception may result in doctors over- or underestimating benefit and risk of a treatment or drug and hence choosing an option, which might not necessarily be ideal.

While there is no clear evidence that implicit bias in socioeconomic status has a direct influence on medical decision making (*Haider et al., 2015; Pettit et al. 2017*), it is found that implicit bias is rather expressed in the behaviour towards patients. Physicians have been found to pay more attention to pain control and had a better communication with patients of a higher socioeconomic status, while the opposite has been true for patients of a lower socioeconomic status (*Pettit et al., 2017*). Similar results have been found for implicit racial bias. As a result, implicit racial bias in health professionals leads patients to have lower confidence in treatment recommendations (*Penner et al., 2016*) and to struggle more to adhere to them (*Hagiwara et al., 2013; Penner et al., 2016*).

Regarding gender bias, the research has found the evidence of disparities in diagnostic and treatment decisions between men and women in healthcare. The extent of investigation as well as treatment differs between men and women, even when both present the same symptoms, leading to women being less likely to receive an appropriate diagnosis or treatment (*Bönte et al., 2008; Hamberg, 2008*). Women's symptoms have been found to rather be interpreted as psychosocial or non-specific symptom diagnosis, while men's symptoms have rather been interpreted as organic (*Bönte et al., 2008*).

5. Debiasing Strategies in Medical Decision-making / Mitigation Approach

Cognitive debiasing is the process of reducing or eliminating cognitive biases in order to make more rational and ideal decisions. Other words for this process are cognitive forcing strategies or cognitive bias mitigation (CBM). Recent research has a great emphasis on reducing and preventing decision-making biases in a medical setting. Based on this research, several CBM strategies for the previously identified biases in the clinical setting will be elaborated.

One attempt to reduce cognitive biases in clinical decision-making described in the literature is guided reflection intervention, where the more reflective and analytical type of reasoning is applied (*Norman et al., 2017; O'Sullivan & Schofield, 2018; Lambe, Hevey & Kelly, 2018*). This strategy motivates health professionals to consider other potential diagnoses and collect confirming as well as disconfirming data and evidence prior to giving a final diagnosis (*Lambe, Hevey & Kelly, 2018*). In other words, physicians should "slow down" when making the diagnosis (*O'Sullivan & Schofield, 2018*).

An example of a tool related to slowing down, examined by *O'Sullivan & Schofield (2019)*, is the so called "SLOW intervention" (*Fig. 1*). This cognitive forcing tool was applied after each clinical case which the participants of the study had to evaluate for a diagnosis. Additional to the word "slow" as a reminder to slow down, four questions, beginning with each letter of the word, are asked.

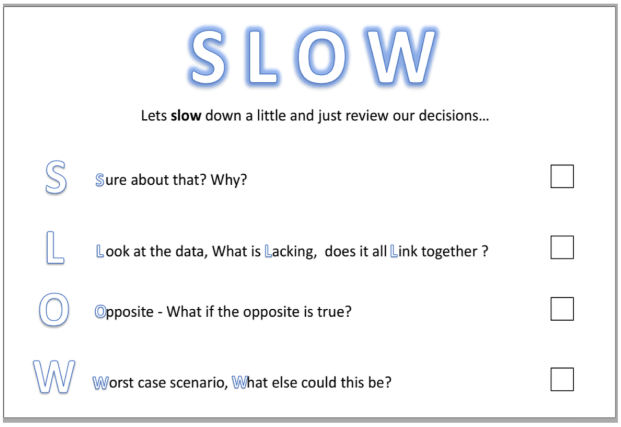

Figure 1: Cognitive mitigation tool by *O'Sullivan & Schofield (2019)*

These questions were supposed to function as a metacognitive trigger and improve diagnostic accuracy. Each question is aiming at mitigating different biases. The following biases were included in the study: "representative bias, conjunction fallacy, overconfidence, base rate neglect, diagnostic momentum, [...], the framing effect, conjunction rule and availability bias". Even though doctors involved in the study stated a perceived positive effect on the diagnostic accuracy, quantitative data could not support their subjective observation. Although this cognitive forcing tool led to diagnostic improvements in some cases, the overall results were not statistically significant. The SLOW intervention showed to be the most efficient in reducing the confirmation bias in this study (*O'Sullivan & Schofield, 2019*).

Bhatti (2018) suggests the use of a checklist to reduce bias and increase the diagnostic accuracy. The checklist includes steps like a diagnostic time-out, formulating several diagnostic hypotheses (differential diagnoses) as well as the removal of one's past form the patient. The latter may be useful to mitigate the framing bias. A study indicates that in 80% of cases of a diagnostic error, the absence of a differential diagnosis was considered the cause (*Bhatti, 2018*). Therefore, the formulation of several potential diagnoses could decrease diagnostic errors. The diagnostic time-out can potentially be beneficial to reduce the availability bias, the premature closure and the confirmation bias by having the time to gain a new perspective, rethinking the diagnosis and not ending the diagnostic process too fast. Similar to Bhatti, another study by *Kasick and colleagues (2019)* aimed to increase the diagnostic accuracy by a diagnostic time-out and using their Differential Diagnosis Scoring Rubric. The Differential Diagnosis Scoring Rubric is a scoring tool to increase documentation and quality of

differential diagnoses. Even though this study does not specifically aim to mitigate biases, their principle is similar to the above-mentioned ones. Their study indicates an increased quality of the documented differential diagnosis, which might increase the diagnostic accuracy.

A different approach on reducing bias, which is rather applicable for smaller groups, is discussing diagnostic examinations at meetings with other clinicians or medical students (*Bhatti, 2018*). As biases seem to be the result of unconscious thinking patterns, teaching better clinical reasoning and metacognitive skills appear to be a good approach to mitigate biases in clinical decision making. Metacognition is described as "the awareness of, and insight into one's own thought process" (*O'Sullivan & Schofield, 2018*). In addition, as many biases are based on statistical principals, educating medical students on these as well as statistical biases seems to be important, especially as statistics is currently lacking in the medical curricula (*O'Sullivan & Schofield, 2018*).

Although teaching about biases and critical thinking might not necessarily lead to less diagnostic errors, it helps to increase the awareness for biased decision making and improves professionals' critical thinking skills (*O'Sullivan & Schofield, 2019; Royce, Hayes & Schwartzstein, 2019*). A study by *Reilly et al. (2014)* found that case-based teaching of bias awareness caused "the development and implementation of algorithms and protocols for avoiding affective bias (bias due to an emotional response), the use of standardized neurological evaluations, and increased consultations for difficult cases" (*Royce, Hayes & Schwartzstein, 2019*).

Nevertheless, cognitive bias mitigation is a challenge due to various reasons. Since most human cognitive biases are implicit, it is very difficult to tackle them. *Bhatti (2018)* describes that "inherent psychological defence mechanisms shield our cognitive processes from self-analysis and critique", which illustrates the underlying problem. As many health professionals are prone to the bias blind spot and hence do not recognise their biases, getting them to integrate CBM strategies into their decision-making processes may be difficult. It is important and a challenge to transfer the evaluated mitigation strategies into a real-life setting where health professionals are eager to use them (*Ludolph & Schulz, 2017*). Another challenge in the research of cognitive debiasing is the lacking internal coherence in the terminology of biases as well as debiasing strategies (*Ludolph & Schulz, 2017*). In different studies, names of biases and especially names of debiasing strategies differ widely, even when describing the same concept. Additionally, the research studying the impact and efficiency of cognitive debiasing strategies is limited by methodological problems (*Royce, Hayes & Schwartzstein, 2019*).

6. Conclusion

6.1. Summary of Findings and Discussion

The first part of this article deals with the analysis of empirical data on the prevalence of cognitive biases in a clinical setting. The results show that availability bias, premature closure, framing bias, socioeconomic, racial/ethnic and gender bias have been confirmed to be prevalent in medical students and physicians. The publication bias towards positive outcomes as well as underrepresentation of women in medical trials and literature has also been noted to have a material impact as well as a great impact on evidence-based medicine. While there is only very limited research on the confirmation bias and diagnostic momentum, the available data also confirms their occurrence in medicine. The findings on the base rate neglect, anchoring bias and overconfidence bias are diverse, while the latter two seem to be dependent on the degree of experience of health professionals.

The empirical data on the impact of these biases on patient outcomes is scarce. Some studies documented the potential of misdiagnosis and mistreatment due to the availability and anchoring bias. Serious consequences due to an incorrect diagnosis or treatment could also result from the diagnostic momentum, premature closure and base rate neglect, even though this is not empirically confirmed. The research regarding the framing effect identifies a great impact on the judgement of treatments in both health professionals and patients. Moreover, the high prevalence of the publication bias can have a huge impact on physicians' decision-making. Since evidence-based medicine relies on empirical data, health professionals will have a distorted view and make imperfect decisions as a consequence of only fragmentary published data. Additionally, the continued underrepresentation of women in clinical trials, textbooks and other medical literature is likely to result in physicians missing diagnoses, misdiagnosing, or mistreating women.

Regarding cognitive bias mitigation approaches, there are still very few effective strategies to reduce biases in the clinical setting, even though recent research has a great focus on the mitigation research. Some effective debiasing strategies include framing risks differently (e.g. using frequency format and absolute numbers or using subsets) to reduce base rate neglect and the framing effect and "confidence-based assessment" to reduce overconfidence. The strategies encouraging the use of a more reflective thinking such as slowing down, considering the opposite or the use of checklists were found to be effective only for some biases. These include a premature closure, the confirmation, anchoring, and the availability bias. Bias specific teaching helps to increase awareness about biases and improve critical thinking. This approach, however, seems to fail to reduce diagnostic errors. The same applies to cultural competency training and sessions about gender to increase awareness and reduce health disparities. In order to challenge the publication bias, editors and authors must take measures to make sure that both positive and negative or null-result studies get published and represented in journals.

6.2. Limitations and Future Research

Some studies mentioned in the analysis are limited to a certain country or specific medical field. This is true especially for the evaluation of prevalence and impact of cognitive biases in the clinical setting as well as the effectiveness of mitigation strategies. Additionally, it is particularly relevant for studies evaluating biases where only little evidence is available, such as diagnostic momentum, gambler's fallacy, base rate neglect and confirmation bias. For instance, the two studies, by *Frotvedt (2020)* and *Atallah (2020)*, analysing confirmation bias are geographically limited to Norway and the US, respectively. The mentioned study by *Msaouel and colleagues (2014)*, examining Gambler's fallacy, includes only Greek medical residents, while *Heritage & McArthur's (2019)* study, investigating diagnostic momentum, solely includes US physicians. Studies exploring a premature closure and overconfidence are mostly limited to certain medical fields. *Berbaum and colleagues (2013)* exclusively enrolled radiologists in their study, while *Cucchetti and colleagues (2020)* focused on Gastroenterologists, Hepatologists and Surgeons. Consequently, the results of these studies cannot be generally applied as they may not be significant in other countries or different medical fields.

As the empirical evidence on the impact of cognitive biases on clinical outcome is scarce for most biases, especially on diagnostic momentum, premature closure and base rate neglect, further research is necessary in this field. It is important to determine the extent to which biases in healthcare professionals translate into negative clinical outcomes such as misdiagnosis, delayed diagnosis, or mistreatment. Only this way, the importance of incorporating debiasing strategies and tools into the clinical setting, and which biases to focus on, can be properly assessed.

Furthermore, even though recent literature puts great emphasis on cognitive debiasing strategies and suggests several methods how to reduce or prevent biases, there are still very few approaches that have proven to be efficient. Therefore, much more research is needed to identify and develop more successful strategies.

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The authors declare that they have no competing interests.

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