



# Marine and Coastal Environments: Challenges, Impacts, and Strategies for a Sustainable Future

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**Abstract:** Marine and coastal environments are critical interfaces of biodiversity and ecological significance, encompassing estuaries, mangroves, coral reefs, seagrass meadows, and beaches. This article examines the historical evolution, current challenges, and future prospects of these vital ecosystems, utilizing extensive literature review and online research to analyze the impacts of climate change and human intervention. This study reviews the historical evolution of these ecosystems, highlighting their significance as centers of human sustenance, trade, and culture. It evaluates the severe impacts of global warming—rising sea levels, ocean acidification, and habitat destruction—and human activities such as overfishing, pollution, and coastal development, which exacerbate ecosystem degradation. Methodologies include an extensive literature review and online research to assess ecosystem services, threats, and conservation strategies. The research underscores the socio-economic implications of deteriorating marine habitats, such as threats to fisheries and heightened vulnerability to extreme weather events. The findings advocate for proactive conservation through marine protected areas, habitat restoration, and sustainable practices. International cooperation, guided by initiatives like the United Nations Decade on Ecosystem Restoration, is emphasized as critical for enhancing resilience. Looking ahead, the article discusses adaptation and mitigation strategies essential for safeguarding marine environments against the escalating impacts of global warming, ensuring their sustainability for future generations.

**Keywords:** Climate change; Coastal environment; Ecosystem; Global warming

## Introduction

Marine and coastal environments are dynamic interfaces where terrestrial and marine ecosystems converge, creating areas of immense ecological significance and biodiversity. These regions encompass a variety of habitats, including estuaries, mangroves, coral reefs, seagrass meadows, and sandy beaches, each supporting unique communities of flora and fauna. Collectively, they play a crucial role in maintaining ecological balance, supporting fisheries, protecting shorelines, and regulating climate. Estuaries, where freshwater merges with seawater, serve as nurseries for numerous marine species, providing shelter and abundant nutrients essential for the early stages of life. Mangrove forests, found in tropical and subtropical inter-tidal zones, act as buffers against coastal erosion

and storms, while offering habitats for species such as crabs, shrimp, and fish.

Coral reefs, often referred to as the "rain forests of the sea," are among the most diverse ecosystems on the planet, supporting a vast array of marine life and contributing to carbon and nutrient cycling. Seagrass meadows, underwater grasslands in shallow coastal waters, provide food and habitat for species like fish, crabs, sea turtles, and dugongs, and play a significant role in carbon sequestration. These ecosystems offer invaluable services to human societies. They act as natural water filters, improve water quality, and sequester carbon, mitigating climate change impacts. Additionally, they support fisheries that are vital for food security and livelihoods, and protect coastal communities by attenuating wave energy, thus reducing

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the impact of storms and preventing erosion (Ocean Panel, 2019).

Furthermore, they provide recreational opportunities and support tourism industries, contributing significantly to local and national economies. Despite their importance, marine and coastal environments face numerous threats. Human activities such as overfishing, pollution, and coastal development have led to habitat degradation and loss of biodiversity. Climate change exacerbates these challenges through sea-level rise, ocean pacification, and increased frequency of extreme weather events, further stressing these ecosystems. For instance, the State of the Environment Report 2024 for Tasmania highlights significant environmental challenges, including rising sea temperatures, coastal erosion, and the disappearance of kelp forests, with sea surface temperatures and kelp forests deteriorating faster than global average rates.

Conservation and restoration efforts are imperative to safeguard these vital ecosystems. Establishing marine protected areas, enforcing sustainable fishing practices, and restoring degraded habitats are among the strategies employed to preserve marine biodiversity and maintain the ecosystem services they provide. International initiatives, such as the United Nations Decade on Ecosystem Restoration (2021–2030), aim to accelerate global restoration efforts, recognizing the need to restore degraded ecosystems to combat climate change, enhance food security, and protect biodiversity. Marine and coastal environments are indispensable to the health of the planet and human well-being. Their preservation requires coordinated global efforts, informed by scientific research and supported by sustainable policies and practices. Research Objective: Marine and coastal environments are indispensable for ecological balance, economic well-being, and climate regulation. However, they remain under significant threat from human activities and environmental changes. Comprehensive research, sustainable practices, and global cooperation are essential to ensure the preservation and resilience of these critical ecosystems. The primary objective of research on the marine and coastal environment is to understand the dynamics of these ecosystems, assess the anthropogenic and natural pressures they face, and identify sustainable strategies to protect and restore them.

Specific objectives include: Evaluating Ecosystem Services: Quantify the economic and ecological value of marine and coastal ecosystems to guide conservation policies; Assessing Threats: Investigate the impacts of pollution, climate change, and human activities on these ecosystems; Enhancing Conservation Efforts: Develop strategies for habitat restoration, sustainable resource use, and biodiversity preservation; Informing Policy and Advocacy: Provide scientific data to support policy-

making and raise awareness about the importance of marine and coastal ecosystems.

Numerous international initiatives aim to safeguard marine and coastal environments. The United Nations Decade on Ecosystem Restoration (2021–2030) focuses on reversing ecosystem degradation worldwide, including marine and coastal habitats. Marine protected areas (MPAs) have been established globally to conserve biodiversity and regulate resource use. Sustainable fishing practices, pollution control, and community-driven conservation programs are integral to these efforts.

## Method

### *Online Research*

Online research accessing digital resources for gathering information, data, or knowledge about a certain topic. It uses the internet and numerous online platforms to access, analyse, and synthesize data for study. Online research is the process of gathering information and data for a research topic over the internet. It entails gathering information from websites, databases, online publications, and other digital sources. We utilized search engines, academic databases, and a variety of web applications. Online research involves using digital technology and online resources to gather data, information, or knowledge related to a study issue or investigation. This strategy has grown in popularity due to the ease of use and enormous amount of data available online. We gathered background material by reviewing current internet sources, scholarly publications, and pertinent websites. Here are some crucial characteristics of internet research.

### *Steps*

*Identify research objectives and questions:*

*Accessing information*

Researchers can obtain information from a variety of online sources, including academic databases, digital libraries, institutional repositories, websites, blogs, social media platforms, and online forums. These resources offer access to scientific papers, books, reports, databases, and other sorts of information. We used these sources to carry out our research.

*Use search engines and databases to discover relevant sources:*

*Searching and retrieving data*

Online research usually starts with creating search queries in search engines (e.g., Google Scholar, PubMed) or particular databases. To quickly obtain relevant material, researchers utilize keywords, Boolean operators, and complex search strategies. We used these sources and approaches to carry out our research.

### *Assess the credibility and accuracy of online resources Evaluating sources*

Critical evaluation of online sources is essential for maintaining credibility, accuracy, and relevance. Authorship, publication date, peer-review status (for academic works), and bias are all characteristics considered by researchers when determining the credibility of information. We thoroughly evaluated the web sources to guarantee their trustworthiness, correctness, and relevance to our research.

### *Extract and compile data from websites, articles, or digital resources*

#### *Tools and techniques*

Various tools and techniques support online research, such as reference management software (e.g., EndNote, Zotero), data analysis software (e.g., SPSS, NVivo), and online survey platforms (e.g., SurveyMonkey, Qualtrics). I used these tools to enhance efficiency in data collection, analysis, and documentation.

### *Analyze and synthesize the gathered information for research Analyzing and synthesizing*

Data After collecting data and information, researchers analyse and synthesise the findings to answer research questions or objectives. This is analysing many sources, recognising patterns or trends, and developing conclusions from the data gathered. We used the data and information obtained, analysed, and synthesised to answer research questions or objectives. Ethical Considerations: Respecting intellectual property rights, gaining data usage permits when applicable, protecting data privacy and confidentiality, and disclosing findings in a transparent manner are all ethical aspects in online research. We took these ethical issues seriously and carried out the research accordingly.

### *Reporting and Disseminating Results*

Researchers document their results in reports, academic papers, articles, and presentations. They appropriately reference sources to recognise prior studies' contributions and offer context for their own study. To perform our study, we followed correct reporting and results dissemination protocols. Online research has various benefits, including easy access to a wealth of material, convenience, and the chance to interact with a global network of academics and specialists. However, researchers must deal with issues such as information overload, quality control of internet sources, and ethical considerations in data collecting and usage. Researchers may successfully use internet resources to enhance knowledge and contribute to their

particular professions by applying rigorous techniques and critical thinking.

### *Literature Review*

A literature review is a comprehensive summary and analysis of the existing research on a particular topic. It identifies key themes, debates, and gaps in the literature, and provides a context for new research. Its main purposes are to provide an overview of what is already known, to identify patterns and trends, to highlight areas where knowledge is lacking, and to establish a theoretical foundation for further research.

### *The process of conducting a literature review involves several steps*

#### *Identifying research questions and objectives*

We started by explicitly stating the goal of the literature review. Enquire as to what precise questions or objectives are being pursued. This helps to keep focused and directs the search for relevant literature. It outlines the study topics and objectives.

### *Searching for Relevant Literature*

To acquire relevant material, we used a number of sources, including academic databases (e.g., PubMed, JSTOR, Google Scholar), library catalogues, and reference lists from related papers. To restrict the search results, use search tactics such as keyword searches, Boolean operators (AND, OR, NOT), and filtering result by publication date or type. To gain a full understanding of the issue, consider key publications as well as contemporary investigations. I searched databases and other sources for relevant material using keywords and filters.

### *Screening and Selecting Sources*

Once we had a list of probable sources, we assessed each one for relevance and quality. Examine the abstract, introduction, and conclusion to assess whether the source is relevant to the research issue. Assess the writers' and publication's legitimacy, as well as the technique and findings. Exclude sources that are out of date, irrelevant, or of poor quality. Evaluate and choose high-quality, relevant sources from the search results.

### *Organizing the Literature*

We categorise chosen materials according to topics, ideas, approaches, or chronological sequence. This can assist uncover study patterns, trends, and gaps. Use reference management software like as EndNote, Zotero, or Mendeley to keep track of sources and properly structure citations. Create an outline to help frame the review rationally. Categorize your sources

and utilise reference management tools to organize them.

### *Analyzing and Synthesizing the Literature*

We carefully analyse the content of the chosen sources. Compare and contrast the findings, methods, and theoretical frameworks. Identify major topics, disputes, and gaps in the literature. Synthesise the data by combining insights from many studies and emphasizing how they contribute to an understanding of the research issue. Look for agreement and disagreement among scholars. Critically assess and integrate the findings from the sources.

### *Writing the Literature Review*

We organized the literature review into three sections: introduction, body, and conclusion. In the opening, offer a summary of the issue and express the reason for the review. In the body, explore the literature in organized topics or categories, providing a critical analysis and summary of the findings. Use subheadings to increase clarity. In conclusion, we summarized the important findings, identified research gaps, and proposed topics for further investigation. Make sure the text is clear, simple, and free of jargon. Write a literature review with a clear introduction, body, and conclusion.

### *Revising and Editing*

We spent hours revising and editing the literature review once we finished the first draft. Checked for clarity, coherence, and logical flow. I ensured that the arguments were properly supported by the literature. I looked for grammatical problems, typos, and correct source reference. Considered soliciting comments from peers or advisers to improve the quality of the review. Ensure that it follows the relevant formatting and style rules. Revise and modify the literature review to ensure it is clear, coherent, and correct. A literature review is a critical assessment of current research that serves as a basis for future research endeavors. It illustrates the researcher's expertise of the topic, suggests areas where more study is required, and places new findings in the context of current knowledge.

## **Result and Discussion**

### *Historical Aspects of Marine and Coastal Environment*

Marine and coastal environments have played a pivotal role throughout human history, serving as hubs of sustenance, trade, and cultural development. Early human societies were intricately connected to these areas, relying on abundant marine resources and establishing settlements along coastlines. The evolution of these environments has been significantly influenced by both natural processes and human activities. Marine

and coastal environments have long been a cornerstone of human civilization, serving as sources of sustenance, trade routes, and centers of cultural exchange. These environments, encompassing diverse ecosystems such as estuaries, mangroves, coral reefs, and sandy beaches, have provided critical resources and shaped the development of societies across the globe. Understanding their historical significance offers insights into the intricate interplay between humans and nature, shedding light on how these relationships have evolved over time.

### *Early Human Interaction with Coastal Areas*

Coastal regions have always been magnets for human settlements due to their accessibility and resource richness. Early civilizations capitalized on these environments for food, utilizing the abundance of fish, shellfish, and other marine organisms. Archeological evidence suggests that fishing and shellfish gathering were practiced as far back as 100,000 years ago, marking one of the earliest interactions between humans and the marine world (Lotze et al., 2004). Coastal areas also served as strategic hubs for trade and cultural exchanges, facilitating the spread of goods, ideas, and technologies across regions.

### *Transformation through Human Activities*

As societies evolved, so did their impact on coastal environments. The construction of harbors, ports, and coastal cities transformed natural shorelines, altering sediment transport patterns and reshaping ecosystems. Historical overfishing practices led to the depletion of key marine species, disrupting food webs and diminishing biodiversity. By the Industrial Revolution, pollution from coastal urbanization and maritime activities began significantly degrading water quality, further stressing marine ecosystems.

### *Natural Events Shaping Coastal Landscapes*

In addition to human activities, natural phenomena have played a pivotal role in shaping coastal areas. Tsunamis, hurricanes, and rising sea levels have periodically altered the geography of coastlines, displacing human settlements and reshaping habitats. For instance, studies of pale shorelines reveal how past sea-level changes have influenced human migration and settlement patterns, offering valuable lessons for current coastal management (Barrett, 2017).

### *Conservation and Restoration Efforts*

The historical degradation of marine and coastal environments has prompted global efforts to preserve and restore these vital ecosystems. Legislative initiatives, such as the United States' Coastal Zone Management Act of 1972, aim to regulate human



activities and protect coastal resources. Internationally, the establishment of marine protected areas has been instrumental in safeguarding biodiversity and promoting sustainable practices. Restoration efforts, including mangrove reforestation and coral reef rehabilitation, highlight the commitment to reversing centuries of damage. Current Scenario of Marine and Coastal Environments Marine and coastal environments are experiencing immense pressure from human activities and climate change. These ecosystems are critical for biodiversity, providing habitat and sustenance to countless species, while also playing a vital role in supporting human livelihoods and regulating global climate systems. Below, we elaborate on key challenges and responses in this context. Marine and coastal environments are vital to the planet's health, supporting diverse ecosystems and providing essential services to human societies. However, these areas are currently facing unprecedented challenges due to human activities and climate change.

#### *Climate Change Impacts*

Climate change is one of the most profound threats to marine and coastal ecosystems. Rising sea temperatures are causing widespread coral bleaching, reducing the biodiversity of reef ecosystems that act as nurseries for marine life. Warmer waters are also shifting species distributions, disrupting traditional fishing zones and threatening food security for communities reliant on marine resources. Furthermore, the melting of polar ice is contributing to rising sea levels, endangering low-lying coastal areas and leading to the loss of vital habitats like mangroves and wetlands. Ocean acidification, driven by increased carbon dioxide absorption, weakens the shells of mollusks and coral skeletons, further undermining marine ecosystems.

#### *Pollution and Habitat Degradation*

Marine environments are heavily affected by pollution, including agricultural runoff, plastic waste, and chemical contaminants. Nutrient-rich runoff from agriculture causes eutrophication, leading to algal blooms and hypoxic conditions, which create "dead zones" where marine life cannot survive. Plastic pollution is a growing crisis, with millions of tons entering the oceans annually, harming wildlife through entanglement and ingestion. Coastal development and industrial activities destroy critical habitats such as mangroves, seagrasses, and coral reefs, reducing the resilience of these ecosystems to environmental changes.

#### *Overfishing and Biodiversity Loss*

Overfishing has led to the depletion of key species, such as tuna, cod, and sharks, which play crucial roles in maintaining the balance of marine food webs. The

removal of top predators triggers trophic cascades, destabilizing ecosystems and diminishing their productivity. Illegal, unreported, and unregulated (IUU) fishing exacerbates this issue, undermining conservation efforts and sustainable fisheries management. The loss of biodiversity diminishes ecosystem services, including the natural carbon sequestration provided by healthy marine ecosystems.

#### *Conservation Efforts*

In response to these challenges, governments, organizations, and communities are working toward the conservation and restoration of marine and coastal environments. Marine Protected Areas (MPAs) have been established worldwide to restrict harmful activities and allow ecosystems to recover. International agreements, such as the Paris Agreement, aim to limit greenhouse gas emissions to mitigate the effects of climate change on oceans. Coastal restoration projects, including mangrove reforestation and coral reef rehabilitation, are being implemented to strengthen ecosystem resilience. Efforts to reduce plastic use, improve waste management, and promote sustainable fishing practices are gaining traction globally.

#### *The Impact of Global Warming on Marine and Coastal Environments*

Global warming, characterized by the gradual increase in Earth's average surface temperature due to rising levels of greenhouse gases, has profound implications for marine and coastal environments. These ecosystems, which encompass a diverse range of habitats such as coral reefs, mangroves, estuaries, and coastal wetlands, are experiencing significant transformations as a result of climate change. This article delves into the multifaceted effects of global warming on marine and coastal ecosystems, drawing on current research and observations.

#### *Rising Sea Temperatures and Marine Heatwaves*

One of the most immediate consequences of global warming is the increase in sea surface temperatures. Elevated temperatures have led to more frequent and intense marine heatwaves, which can cause widespread coral bleaching events. Coral reefs, often referred to as the "rainforests of the sea," are highly sensitive to temperature changes. Prolonged exposure to elevated temperatures disrupts the symbiotic relationship between corals and their zooxanthellae algae, leading to bleaching and, if persistent, coral mortality. The loss of coral reefs has cascading effects on marine biodiversity, as they provide habitat and shelter for numerous marine species.

### *Sea-Level Rise and Coastal Erosion*

Global warming contributes to sea-level rise through the thermal expansion of seawater and the melting of polar ice caps and glaciers. Rising sea levels pose a significant threat to coastal communities and ecosystems, leading to increased flooding, erosion, and the loss of habitat for species that depend on coastal environments. Low-lying areas are particularly vulnerable, with some regions facing the prospect of becoming uninhabitable. The encroachment of seawater also leads to the salinization of freshwater resources, impacting agriculture and drinking water supplies.

### *Ocean Acidification*

The absorption of increased atmospheric CO<sub>2</sub> by the oceans leads to ocean acidification, a process that decreases the pH of seawater. This change in acidity adversely affects calcifying organisms, such as mollusks, echinoderms, and corals, by reducing their ability to produce and maintain calcium carbonate structures. The weakening of these organisms has broader implications for marine food webs and the overall health of marine ecosystems.

### *Alterations in Marine Biodiversity and Species Distribution*

As ocean temperatures rise, many marine species are shifting their geographical ranges toward the poles in search of suitable habitats. This redistribution can lead to changes in local biodiversity, with potential consequences for ecosystem services and human industries such as fisheries. Species that cannot migrate or adapt quickly enough face increased risks of population decline or extinction.

### *Impacts on Fisheries and Coastal Economies*

The effects of global warming on marine ecosystems directly impact fisheries and the economies that depend on them. Changes in species distribution, reproductive cycles, and the health of marine populations can lead to reduced fish stocks, affecting food security and livelihoods. Additionally, the degradation of coastal ecosystems such as mangroves and wetlands diminishes their role as nurseries for many commercially important fish species, further exacerbating the challenges faced by fisheries.

### *Increased Frequency of Extreme Weather Events*

Climate change is associated with an increased frequency and intensity of extreme weather events, including hurricanes and typhoons. These events can cause significant damage to coastal infrastructure, ecosystems, and human communities. The destruction of habitats such as coral reefs and mangroves, which act as natural barriers against storm surges, leaves coastal areas more vulnerable to future events.

### *Mitigation and Adaptation Strategies*

Addressing the impacts of global warming on marine and coastal environments requires a multifaceted approach. Mitigation efforts focus on reducing greenhouse gas emissions to limit further climate change, while adaptation strategies aim to enhance the resilience of ecosystems and human communities. This includes the establishment of marine protected areas, restoration of degraded habitats, sustainable fisheries management, and the development of infrastructure designed to withstand rising sea levels and extreme weather events. The scenario of marine and coastal environments in the context of global warming is complex and dynamic. The interconnected nature of these ecosystems means that changes in one aspect can have far-reaching implications. Ongoing research and monitoring are essential to understand the full extent of these impacts and to inform effective policy and management strategies aimed at preserving the health and productivity of marine and coastal environments for future generations.

### *The Future Prospects of Marine and Coastal Environments in the Face of Global Warming*

Global warming poses significant challenges to marine and coastal environments, with profound implications for biodiversity, human societies, and the global economy. This article explores the anticipated future prospects of these vital ecosystems as they confront the escalating impacts of climate change.

### *Projected Impacts on Marine and Coastal Ecosystems*

The Intergovernmental Panel on Climate Change (IPCC) projects that, under high-emission scenarios, global mean sea levels could rise by up to 1.1 meters by 2100, intensifying coastal flooding and erosion (IPCC, 2019). This rise threatens to inundate low-lying areas, displacing human populations and disrupting coastal ecosystems. Additionally, increasing sea surface temperatures are expected to exacerbate coral bleaching events, leading to widespread coral mortality and the loss of biodiversity hotspots (NOAA, 2021). Ocean acidification, resulting from higher CO<sub>2</sub> absorption, is projected to impair calcifying organisms, disrupting marine food webs and fisheries (European Environment Agency, 2022).

### *Socioeconomic Implications*

The degradation of marine and coastal environments due to global warming has far-reaching socioeconomic consequences. Coastal communities face heightened risks from storm surges and sea-level rise, threatening infrastructure, livelihoods, and cultural heritage (EPA, 2021). The fishing industry, vital for food security and employment, is at risk due to shifting

species distributions and declining fish stocks (NOAA, 2022). Furthermore, the loss of coastal ecosystems like mangroves and wetlands diminishes natural coastal defenses, increasing vulnerability to natural disasters (C2ES, 2021).

#### *Adaptation and Mitigation Strategies*

Addressing the future challenges of marine and coastal environments necessitates comprehensive adaptation and mitigation strategies. Adaptation measures include the restoration of coastal habitats, the construction of resilient infrastructure, and the implementation of sustainable fisheries management practices (C2ES, 2021). Mitigation efforts focus on reducing greenhouse gas emissions to limit further climate change, thereby alleviating pressure on marine ecosystems (Ocean Panel, 2019). International cooperation and policy frameworks play crucial roles in coordinating these efforts and mobilizing resources for effective action. The future prospects of marine and coastal environments are intricately linked to the trajectory of global warming and human responses to this pressing challenge. Proactive adaptation and mitigation strategies are essential to safeguard these ecosystems and the services they provide. Through concerted global efforts, it is possible to enhance the resilience of marine and coastal environments, ensuring their sustainability for future generations.

#### *Research Analysis and Findings*

##### *Key Challenges and Threats Climate Change Impacts*

Rising sea temperatures and ocean acidification are causing coral bleaching, threatening biodiversity hotspots. Sea-level rise leads to coastal erosion and habitat loss, while shifting species distributions disrupt marine ecosystems and human livelihoods.

##### *Human Activities*

Overfishing has depleted key species, destabilizing food webs. Pollution from agricultural runoff and plastics exacerbates habitat degradation, while coastal development has led to the destruction of critical ecosystems like mangroves and coral reefs.

##### *Ecosystem Services*

Marine and coastal environments provide essential services, including carbon sequestration, water filtration, and habitat for marine species. These ecosystems also underpin fisheries vital for global food security and protect coastal areas from natural disasters.

##### *Conservation Efforts*

Marine Protected Areas (MPAs) and international initiatives like the United Nations Decade on Ecosystem Restoration have been pivotal in preserving biodiversity

and promoting sustainable practices. Restoration efforts, including mangrove reforestation and coral reef rehabilitation, are critical for enhancing ecosystem resilience.

## **Conclusion**

Marine and coastal environments are indispensable for ecological balance and human well-being. However, they remain under significant threat from human-induced and climate-driven pressures. This study emphasizes the urgent need for coordinated global efforts, informed by scientific research and supported by sustainable policies. Proactive adaptation and mitigation strategies are essential to enhance the resilience of these ecosystems and ensure their sustainability for future generations. Ongoing research and monitoring are essential to understand the full extent of these impacts and to inform effective policy and management strategies aimed at preserving the health and productivity of marine and coastal environments for future generations. These ecosystems are indispensable for the planet's ecological balance and human well-being. Collaborative efforts, strengthened policies, and community engagement are essential to ensure the preservation and sustainable use of these invaluable resources for generations to come.

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## **Author Contributions**

Conceptualization, methodology, validation, formal analysis, investigation, resources, data curation, writing—original draft preparation, writing—review and editing, visualization, R. A; MD. T. R. T. All authors have read and agreed to the published version of the manuscript.

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## **Conflicts of Interest**

The authors declare no conflict of interest.

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