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Mala conducta en publicación científica: análisis de la situación y tipos específicos.

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TESIS DOCTORAL

MALA CONDUCTA EN PUBLICACIÓN CIENTÍFICA: ANÁLISIS DE LA SITUACIÓN Y TIPOS ESPECÍFICOS.

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DECLARACIÓN DE CONFLICTOS DE INTERESES

Mala conducta en publicación científica: Análisis de la situación y tipos específicos.

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PRESENTACIÓN

Esta tesis es la culminación de un periodo de investigación de tres años en el Área de Medicina Preventiva y Salud Pública de la Universidad de Santiago de Compostela.

El objetivo principal de esta tesis, presentada por compendio de artículos, es conocer la situación actual de la mala conducta científica en diferentes ámbitos geográficos y en diferentes facetas, así como tipos específicos de prácticas que afectan a la publicación científica. Esto se logró mediante la realización de once estudios, de los cuales siete han sido publicados en revistas nacionales e internacionales con revisión por pares indexadas en *Journal Citation Reports* (JCR). En cuanto a los cuatro artículos restantes, éstos se encuentran actualmente enviados a revistas científicas para su publicación. Dos de ellos se encuentran siendo evaluados por revisores y otros dos siendo evaluados por el editor de la revista.

Los resultados de esta tesis reflejan la importancia de cuantificar y monitorizar la mala conducta científica a nivel nacional, así como que las partes interesadas establezcan mecanismos que prevengan y detecten precozmente las prácticas ya conocidas de mala conducta científica y estén alerta ante los nuevos tipos de fraude que van surgiendo.

Este documento de tesis se compone de nueve secciones: introducción, justificación y objetivos, métodos, resultados, discusión, conclusiones, implicaciones, referencias y anexos.

En la introducción se define la retractación de publicaciones científicas y las causas de la misma, error o mala conducta científica, para luego profundizar en esta última mediante la descripción de su evolución y tipos más frecuentes. Además, se proporcionan ejemplos de nuevos tipos de fraude, así como de fenómenos que, si bien no se consideran mala conducta científica, tienen la capacidad de influir de manera negativa en la publicación científica. Finalmente, se hace referencia de forma breve a la regulación de la mala conducta científica desde las entidades pertinentes. La segunda sección de la tesis hace referencia a la justificación y objetivos planteados, mientras que en la tercera sección se detalla la metodología empleada para el desarrollo de este trabajo. La metodología se presenta dividida en los siguientes apartados: fuentes de datos, diseño de las investigaciones, variables a estudio, análisis estadístico y consideraciones éticas. Los apartados de la metodología hacen referencia a los métodos seguidos en las publicaciones

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incluidas en esta tesis. En la quinta sección se presentan los resultados, divididos en tres apartados para facilitar la lectura: entidades que regulan la mala conducta científica, instituciones de investigación y revistas científicas; análisis de la mala conducta científica por país; situaciones que afectan a la mala conducta científica; y nuevas formas de mala conducta científica. En esta sección se incluyen tanto los resultados ya publicados en revistas científicas, para los cuales se dispone del texto completo en el anexo 9.2, como los resultados en proceso de publicación, para los que se muestra el texto completo enviado a la revista en el anexo 9.3. La discusión de la tesis se divide en discusión de la metodología, donde se analizan detalladamente las ventajas y limitaciones metodológicas de los artículos de manera individual, y en discusión de los resultados, donde se abordan los principales resultados de la tesis. Adicionalmente, se presentan las limitaciones y fortalezas del conjunto de la tesis. Para finalizar, se presentan las conclusiones y las implicaciones del trabajo.

Respecto a la contribución en los estudios que forman parte de esta tesis, la doctoranda declara que ha sido responsable de la concepción y planificación de los estudios, la recogida y el análisis de los datos, la interpretación de los resultados, la redacción del primer borrador y la edición y revisión de las siguientes versiones hasta la versión final de cada manuscrito. Todos los coautores de las publicaciones incluidas en esta tesis han contribuido intelectualmente a los estudios, han revisado los borradores de los manuscritos y sus sucesivas versiones y han aprobado la versión final de los artículos.

Las tablas y figuras incluidas en esta tesis o bien han sido preparadas específicamente para este documento o cuentan con la correspondiente autorización de las revistas científicas donde han sido publicadas para su inclusión en el documento de tesis (Anexo 9.4).

Algunos de los coautores de los estudios incluidos en esta tesis presentan conflictos de interés. Joseph S. Ross recibe financiación de diferentes fuentes a través de la Universidad de Yale, ha actuado como testigo experto y es editor adjunto de la revista *JAMA*. David S. Egilman actúa como testigo experto. Ana Marušić recibe financiación por parte de la *Croatian Science Foundation* y de proyectos europeos, forma parte del consejo del *Committee on Publication Ethics* (COPE), es la presidenta de *The Embassy of Good Science Foundation* y es la editora de la revista *ST-OPEN*. Los demás coautores declaran la no existencia de conflictos de interés en relación con las publicación incluidas en esta tesis.

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RESUMEN

Mala conducta en publicación científica: análisis de la situación y tipos específicos.

La mala conducta científica hace referencia a las prácticas realizadas de forma intencionada que socaban los principios éticos de publicación científica. Esta tesis pretende generar conocimiento sobre la mala conducta científica, con el objetivo último de prevenirla y reducirla. Para ello, se ha evaluado cómo se regula la mala conducta científica a nivel europeo y nacional, mediante el estudio de las Oficinas Nacionales de Integridad Científica. Aunque la mayoría de los países europeos cuentan con una oficina, éstas tienen capacidad consultiva y no ejecutiva. España, por su parte, no cuenta con una oficina de estas características.

En esta tesis se ha abordado la mala conducta científica desde el punto de vista de otras partes interesadas: las instituciones de los investigadores y las revistas científicas. En los últimos años, las instituciones y revistas han avanzado en materia de prevención y detección de las prácticas entendidas como mala conducta, pero todavía hay margen de mejora. En esta tesis se presentan algunas medidas que se podrían implementar de cara a prevenir y detectar la mala conducta por estas entidades.

Estudios previos sugieren que los tipos de mala conducta científica más frecuentes varían en función del país del investigador. Por ello, esta tesis estudió la mala conducta científica a nivel nacional en España y en otros países (Brasil y Portugal), utilizando un mismo método y por tanto permitiendo la comparabilidad de resultados. Para ello, se han analizado las retractaciones de los autores afiliados a instituciones de cada uno de los países mencionados. El análisis de retractaciones es un indicador que permite aproximarse al fenómeno de la mala conducta. En todos los países analizados, la duplicación y el plagio fueron las principales causas de retractación por mala conducta científica, si bien se observan diferencias entre áreas de conocimiento.

Para complementar la información proporcionada por el análisis de retractaciones, se realizó una encuesta online anónima a investigadores afiliados a una institución de investigación biomédica española. El objetivo era conocer las percepciones, actitudes y experiencias de los investigadores en relación con la mala conducta científica. Se observó que la frecuencia autorreportada de mala conducta científica por los investigadores

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españoles es elevada y que los tipos más comunes parecen variar en función de algunas de las características de los investigadores (género o tipo de institución en la que trabajan).

Además, esta tesis abordó las situaciones que, si bien no se consideran mala conducta científica, pueden afectar de manera negativa a la publicación científica. Las situaciones específicas analizadas fueron las citas post-retractación y las características de las publicaciones durante la pandemia del COVID-19. En el primer caso, se observó que las citas de los artículos retractados aumentaban tras la retractación, en comparación con las recibidas durante el periodo que estuvieron publicados antes de ser retractados. En el segundo caso, se observó que los artículos COVID-19 publicados en los primeros meses de pandemia presentaban con mayor frecuencia características de baja calidad metodológica, en comparación con los artículos sobre otras temáticas científicas.

Esta tesis incluye, que sepamos, el primer estudio original publicado sobre paper mills. Los paper mills son organizaciones que se dedican a producir manuscritos científicos, en su gran mayoría fraudulentos, que luego venden a investigadores, profesionales o estudiantes. En nuestro estudio se observó que los paper mills están en auge y que tienen características distintivas, como provenir de una institución en China o incluir autores con email no institucional. Además, se observó un posible patrón fraudulento de citas en estos artículos, por lo que se realizó un segundo estudio analizando las citas y referencias de los artículos paper mills. Se observó que casi la mitad de los artículos paper mills habían citado o sido citados por otros artículos identificados como paper mills.

Para concluir, el estudio de la mala conducta científica ha sido históricamente muy limitado. Sin embargo, esta tesis corrobora que es posible generar conocimiento sobre la mala conducta científica a nivel de país. Esta información será de utilidad para las instituciones pertinentes de los países analizados para establecer mecanismos de prevención de la mala conducta científica a nivel nacional. Además, se propone un método para estudiar la mala conducta científica que se puede usar en otros contextos geográficos y que permite la comparación de los resultados entre países e incluso entre instituciones en un mismo país. Esta tesis también analiza situaciones y tipos de mala conducta científica específicos. Estos resultados también pueden ser de utilidad para el diseño e implementación de herramientas para la prevención y detección de situaciones que amenazan la publicación científica.

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Palabras clave: ética en publicación; integridad científica; mala conducta científica; citas post-retractación; paper mills.

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ABSTRACT

Misconduct in scientific publication: analysis of the situation and specific types.

Scientific misconduct refers to intentional practices that undermine the ethical principles of scientific publication. This dissertation aims to generate knowledge about scientific misconduct, with the objective of preventing and reducing it. To this end, we have assessed how scientific misconduct is regulated at the European and national levels by describing the existent National Scientific Integrity Offices. Although most European countries have an office, these are advisory and do not have executive power. Spain does not have such an office.

In addition to the National Office, in this dissertation, scientific misconduct has been addressed from the point of view of other stakeholders: research institutions and scientific journals. Although in recent years institutions and journals have made progress in the prevention and detection of misconduct, there is still room for improvement. This thesis presents some measures that could be implemented to prevent and detect misconduct by these stakeholders.

Previous studies suggest that the most frequent types of scientific misconduct vary by country. Therefore, this dissertation studied scientific misconduct by researchers at the national level in Spain and in other countries (Brazil and Portugal), using the same method and thus allowing comparability of results. For this purpose, the retractions of authors affiliated with institutions in each of the countries mentioned have been analyzed. The analysis of retractions serves as an indicator that allows us to approximate the phenomenon of misconduct. In all countries analyzed, duplication and plagiarism were the main causes of scientific misconduct, although differences were observed between areas of knowledge.

To complement the information provided by the retraction analysis, an anonymous online survey of researchers affiliated with a Spanish biomedical research institution was conducted. The aim was to learn about the perceptions, attitudes and experiences of researchers in relation to scientific misconduct. It was observed that the self-reported

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frequency of scientific misconduct by Spanish researchers is high and that the most common types seem to vary in accordance with some of the characteristics of the researchers (gender or type of institution where they work).

In addition, this work addressed situations that, while not considered scientific misconduct, may adversely affect scientific publication. The specific situations analyzed were post-retraction citations and publication during the COVID-19 pandemic. In the first case, it was observed that citations of retracted articles increased after retraction, in comparison to the citations they received before being retracted. In the second case, it was observed that COVID-19 articles published in the first months of the pandemic had a higher frequency of characteristics of low methodological quality compared to articles on other scientific topics.

To the best of our knowledge, this dissertation includes the first original published study on paper mills. Paper mills are organizations that produce scientific manuscripts, mostly fraudulent, which are then sold to researchers, professionals or students. Our study found that paper mills are on the rise and that they have distinctive characteristics, such as coming from an institution in China or listing authors with non-institutional email. In addition, a possible fraudulent citation pattern was observed in these articles, so a second study was carried out analyzing the citations and references of paper mill articles. It was observed that almost half of them had cited or been cited by other articles identified as originating from paper mills.

To conclude, the study of scientific misconduct has been historically very scarce. However, this dissertation corroborates that it is possible to generate knowledge on scientific misconduct at the country level. This information will be useful for the relevant institutions in the countries analyzed to establish mechanisms to prevent scientific misconduct at the national level and even at the institutional level. In addition, a methodology for studying scientific misconduct is proposed. This method can be used in other geographical contexts and allows comparison of the results between countries. This dissertation also analyzes specific situations and types of scientific misconduct. These results may also prove useful for designing and implementing tools to prevent and detect situations that threaten scientific publication.

Keywords: publication ethics; scientific integrity; scientific misconduct; post-retraction citations; paper mills.

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LISTA DE ABREVIATURAS

ALLEA: All European Academies

CoARA: Coalition for Advancing Research Assessment

CIBER: Consorcio en Investigación Biomédica en Red

COPE: Committee on Publication Ethics

CSIC: Consejo Superior de Investigaciones Científicas

D: Decil

DORA: San Francisco Declaration on Research Assessment

FI: Factor de Impacto

EE. UU.: Estados Unidos

ENRIO: European Network of Research Integrity Offices

IC95%: Intervalo de confianza al 95%

ICMJE: International Committee of Medical Journal Editors

IIS: Instituto de Investigación Sanitaria

JCR: Journal Citation Reports

OMS: Organización Mundial de la Salud

OR: Odds Ratio

P: Percentil

Q: Cuartil de la revista de publicación

RI: Rango intercuartílico

RMB: Research Misconduct Board

SMQ-R: Scientific Misconduct Questionnaire-Revised

U.S. ORI: United States Office of Research Integrity

WOS: Web of Science

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ÍNDICE DE LAS PUBLICACIONES INCLUIDAS

Tesis doctoral por compendio de publicaciones en revistas científicas con revisión por pares indexadas en *Journal Citation Reports* (JCR) (artículo 37 del Reglamento de Estudios de Doctorado de la Universidad de Santiago de Compostela). De los once estudios que componen esta tesis, siete han sido publicados en revistas con revisión por pares, tanto nacionales como internacionales, indexadas en JCR, mientras que los cuatro restantes se encuentran siendo evaluados para su publicación.

1. Candal-Pedreira C, Ruano-Ravina A, Pérez-Ríos M. **Should the European Union have an office of research integrity?** Eur J Intern Med. 2021; 94:1-3. doi: 10.1016/j.ejim.2021.07.009.
    - Contribución a esta publicación: conceptualización, investigación, visualización, escritura y edición (primer borrador y sucesivas revisiones).
    - European Journal of Internal Medicine: revista de primer cuartil en la posición 26/172 de la categoría *Medicine*, *General and Internal*, con factor de impacto de 7,749 (https://jcr.clarivate.com/jcr-jp/journal-profile?journal=EUR%20J%20INTERN%20MED&year=2021&fromPage=%2Fjcr%2Fhome). La revista permite la reutilización de este artículo como parte de la tesis de la doctoranda.
2. Candal-Pedreira C, Álvarez-Dardet C, Ruano-Ravina A, Pérez-Ríos M. **La Oficina de Integridad Científica en España. Una tarea pendiente [The Research Integrity Office in Spain. A pending issue]**. Gac Sanit. 2022;36(6):557-560. Doi: 10.1016/j.gaceta.2022.02.005.
    - Contribución a esta publicación: conceptualización, investigación, visualización, escritura y edición (primer borrador y sucesivas revisiones).
    - Gaceta Sanitaria: revista de cuarto cuartil en la posición 83/105 de la categoría *Public, Environmental and Occupational Health*, con factor de impacto de 1,9 (https://jcr.clarivate.com/jcr-jp/journal-

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profile?journal=GAC%20SANIT&year=2022&fromPage=%2Fjcr%2Fbrowse-journals). La revista permite la reutilización de este artículo como parte de la tesis de la doctoranda.

3. Candal-Pedreira C, Ross JS, Marusic A, Ruano-Ravina A. **Research misconduct as a challenge for academic institutions and scientific journals**. J Epidemiol Community Health. 2023: 1–4. doi: 10.1136/jech-2023-220554.
    - Contribución a esta publicación: conceptualización, investigación, visualización, escritura y edición (primer borrador y sucesivas revisiones).
    - Journal of Epidemiology and Community Health: revista de primer cuartil en la posición 30/207 de la categoría *Public, Environmental and Occupational Health*, con factor de impacto de 6,4 (https://jcr.clarivate.com/jcr-jp/journal-profile?journal=J%20EPIDEMIOL%20COMMUN%20H&year=2022&fromPage=%2Fjcr%2Fhome). La revista permite la reutilización de este artículo como parte de la tesis de la doctoranda.
4. Candal-Pedreira C, Ross JS, Freijedo-Fariñas F, Rey-Brandariz J, Ruano-Ravina A, Pérez-Ríos M. **Characteristics and reasons for retraction in Spanich scientific literature: a cross-sectional study.**
    - Contribución a esta publicación: conceptualización, investigación, metodología, extracción de datos, análisis de datos, validación, visualización, escritura y edición (primer borrador y sucesivas revisiones).
    - Science and Engineering Ethics: revista de primer decil en la posición 2/62 de la categoría *History and Philosophy of Science,* con factor de impacto de 3,7 https://jcr.clarivate.com/jcr-jp/journal-profile?journal=SCI%20ENG%20ETHICS&year=2022&fromPage=%2Fjcr%2Fsearch-results). Actualmente el artículo se encuentra siendo evaluado por revisores por pares.
5. Candal-Pedreira C, Ghaddar A, Pérez-Ríos M, Varela-Lema L, Álvarez-Dardet C, Ruano-Ravina A. **Scientific misconduct: Cross-sectional study of the perceptions, attitudes and experiences of Spanish researchers.**

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- Contribución a esta publicación: conceptualización, investigación, metodología, extracción de datos, análisis de datos, validación, visualización, escritura y edición (primer borrador y sucesivas revisiones).
- Accountability in Research: revista de primer cuartil en la posición 11/23 de la categoría *Medical Ethics*, con factor de impacto de 3,4 (https://jcr.clarivate.com/jcr-jp/journal-profile?journal=ACCOUNT%20RES&year=2022&fromPage=%2Fjcr%2Fsearch-results). Actualmente el artículo se encuentra siendo evaluado por revisores por pares.

6. Candal-Pedreira C, Ghaddar A, Pérez-Ríos M, Varela-Lema L, Álvarez-Dardet C, Ruano-Ravina A. **Disciplinary sanctions and alert signals of scientific misconduct from the perspective of spanish researchers.**
    - Contribución a esta publicación: conceptualización, investigación, metodología, extracción de datos, análisis de datos, validación, visualización, escritura y edición (primer borrador y sucesivas revisiones).
    - European Journal of Epidemiology: revista de primer decil en la posición 9/207 de la categoría *Public, Environmental and Occupational Health* con factor de impacto de 13,6 (https://jcr.clarivate.com/jcr-jp/journal-profile?journal=EUR%20J%20EPIDEMIOL&year=2022&fromPage=%2Fjcr%2Fsearch-results). Actualmente el artículo se encuentra enviado a la revista.
7. Candal-Pedreira C, Ruano-Ravina A, Rey-Brandariz J, Mourino N, Ravara S, Aguiar P, Pérez-Ríos M. **Evolution and characterization of health sciences paper retractions in Brazil and Portugal**. Account Res. 2022:1-18. doi: 10.1080/08989621.2022.2080549.
    - Contribución a esta publicación: conceptualización, investigación, metodología, extracción de datos, análisis de datos, validación, visualización, escritura y edición (primer borrador y sucesivas revisiones).

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- Accountability in Research: revista de primer cuartil en la posición 11/23 de la categoría *Medical Ethics*, con factor de impacto de 3,4 (https://jcr.clarivate.com/jcr-jp/journal-profile?journal=ACCOUNT%20RES&year=2022&fromPage=%2Fjcr%2Fsearch-results). La revista permite la reutilización de este artículo como parte de la tesis de la doctoranda.

8. Candal-Pedreira C, Ruano-Ravina A, Fernández E, Ramos J, Campos-Varela I, Pérez-Ríos M. **Does retraction after misconduct have an impact on citations? A pre-post study.** BMJ Glob Health. 2020;5(11):e003719. doi: 10.1136/bmjgh-2020-003719.
    - Contribución a esta publicación: conceptualización, investigación, metodología, extracción de datos, análisis de datos, validación, visualización, escritura y edición (primer borrador y sucesivas revisiones).
    - BMJ Global Health: revista de primer cuartil en la posición 27/203 de la categoría *Public, Environmental and Occupational Health*, con factor de impacto de 5,558 (https://jcr.clarivate.com/jcr-jp/journal-profile?journal=BMJ%20GLOB%20HEALTH&year=2020&fromPage=%2Fjcr%2Fhome)). La revista permite la reutilización de este artículo como parte de la tesis de la doctoranda.
9. Candal-Pedreira C, Ruano-Ravina A, Pérez-Ríos M. **Comparison of COVID-19 and non-COVID-19 papers.** Gac Sanit. 2022;36(6):506-511. doi: 10.1016/j.gaceta.2022.03.006.
    - Contribución a esta publicación: conceptualización, investigación, metodología, extracción de datos, análisis de datos, visualización, escritura y edición (primer borrador y sucesivas revisiones).
    - Gaceta Sanitaria: revista de cuarto cuartil en la posición 83/105 de la categoría *Public, Environmental and Occupational Health*, con factor de impacto de 1,9 (https://jcr.clarivate.com/jcr-jp/journal-profile?journal=GAC%20SANIT&year=2022&fromPage=%2Fjcr%2Fbrowse-journals). La revista permite la reutilización de este artículo como parte de la tesis de la doctoranda.

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10. Candal-Pedreira C, Ross JS, Ruano-Ravina A, Egilman DS, Fernández E, Pérez-Ríos M. **Retracted papers originating from paper mills: cross sectional study.** BMJ. 2022;379:e071517. doi: 10.1136/bmj-2022-071517.
    - Contribución a esta publicación: conceptualización, investigación, metodología, extracción de datos, análisis de datos, validación, visualización, escritura y edición (primer borrador y sucesivas revisiones).
    - BMJ: revista de primer decil en la posición 4/167 de la categoría *Medicine, General and Internal*, con factor de impacto de 105,7 (https://jcr.clarivate.com/jcr-jp/journal-profile?journal=BMJ-BRIT%20MED%20J&year=2022&fromPage=%2Fjcr%2Fsearch-results). La revista permite la reutilización de este artículo como parte de la tesis de la doctoranda.
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    - Contribución a esta publicación: conceptualización, investigación, metodología, extracción de datos, análisis de datos, validación, visualización, escritura y edición (primer borrador y sucesivas revisiones).
    - BMJ: revista de primer decil en la posición 4/167 de la categoría *Medicine, General and Internal*, con factor de impacto de 105,7 (https://jcr.clarivate.com/jcr-jp/journal-profile?journal=BMJ-BRIT%20MED%20J&year=2022&fromPage=%2Fjcr%2Fsearch-results). Actualmente el artículo está enviado a la revista.

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PARTE I: INTRODUCCIÓN

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1. INTRODUCCIÓN

La investigación científica es una herramienta fundamental para el progreso y mejora de la sociedad en cualquier ámbito. Un aspecto esencial de la investigación es la integridad científica. Los principios de la integridad científica fueron definidos por el *Singapore Statement on Research Integrity* (*World Conference on Research Integrity,* 2010) (1) y son la honestidad, la responsabilidad, la cortesía profesional, la equidad y la buena gestión de la investigación. La integridad científica se define por lo tanto como la adherencia a estos principios en la propuesta, realización y evaluación de la investigación y en la comunicación de los resultados de investigación (2).

Las investigaciones deben ser llevadas a cabo de manera ética y responsable para garantizar su valor e impacto positivo en la ciencia y en la sociedad. Los estudios científicos deben ser diseñados y realizados garantizando los principios éticos básicos, descritos en guías y declaraciones internacionales, como la declaración de Helsinki (3) o el Informe Belmont (4). Estos principios éticos básicos (beneficencia, no maleficencia, justicia y autonomía (4)) tienen por objetivo garantizar el bienestar y los derechos de los sujetos que participan en el estudio, pero también de asegurar la calidad e integridad de los datos obtenidos.

Cuando hablamos de ética en investigación, además de referirnos al cumplimiento de los principios éticos en la realización de los estudios, también nos referimos a la difusión de los resultados de dichas investigaciones. La comunicación y difusión de los resultados de investigación supone el último paso de la investigación científica y generalmente se realiza en forma de publicación en revistas especializadas. La comunicación y difusión de los resultados de investigación también ha de seguir los principios de integridad científica (1). Esta parte de la ética en investigación se conoce como ética en publicación científica.

La ética en la publicación científica es un componente fundamental de la investigación. Garantizar la integridad y transparencia en la difusión de los resultados de la investigación tanto a la población como al resto de la comunidad científica es esencial para asegurar la rigurosidad de la literatura científica y mantener la confianza de la

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población en la ciencia. Sin embargo, en ocasiones, una publicación científica ha de ser retractada.

1.1. RETRACTACIONES EN LA LITERATURA CIENTÍFICA: DEFINICIÓN Y RAZONES

Según el Comité de Ética en Publicación Científica (*Committee of Publication Ethics* - COPE) (5), la retractación es el mecanismo por el cual la ciencia se autocorrige. Cuando una publicación científica se retracta, alerta a la comunidad científica de que los resultados y/o las conclusiones que contiene esa publicación no son válidos y, por lo tanto, no se debe confiar en ellos ni usarlos de cara a investigaciones futuras. El principal objetivo de la retractación es asegurar la integridad y rigurosidad de la literatura científica (5). Cuando una publicación se retracta, la revista de publicación del artículo original debe emitir una nota de retractación, detallando la razón y quién retracta el artículo (los editores de la revista de publicación o los propios autores) (5). Además, la guía del Comité de Ética en Publicación Científica resalta que, para identificar fácilmente si una publicación está retractada o no, el artículo debe incluir una marca de agua bien visible en todos sus formatos y en todas las bases de datos en los que se encuentre indexado (5). A pesar de ello, se ha observado que el manejo de las retractaciones varía ampliamente entre revistas. Algunas de ellas retiran completamente el artículo tras las retractación, mientras que otras no identifican el artículo como retractado (6).

Las razones por las que una publicación debe ser retractada son dos: errores no intencionados y mala conducta científica. Los errores no intencionados, también conocidos como errores honestos o errores humanos, incluyen errores cometidos por los autores (por ejemplo, errores en texto, análisis estadístico o imágenes) y errores de las revistas científicas (por ejemplo, publicar por duplicado un artículo científico). En este último caso, uno de los artículos publicados por duplicado debe ser retractado. En el caso de que los autores cometan errores no intencionados que puedan invalidar los resultados y conclusiones del artículo, éste debe ser retractado (7).

La otra causa de retractación es la mala conducta científica, también conocida como mala conducta en investigación. La mala conducta científica es el conjunto de conductas o prácticas que socaban los principios de integridad científica de un trabajo. No existe una definición aceptada a nivel internacional sobre las prácticas que constituyen mala conducta científica (8). La definición tradicional es la adoptada por la Oficina de

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Integridad Científica de Estados Unidos (*U.S. Office of Research Integrity* - ORI): "la fabricación, falsificación o plagio en proponer, realizar o revisar una investigación o en la comunicación de sus resultados" (9). La fabricación consiste en inventar los datos o los resultados, mientras que la falsificación implica cambiar los datos o resultados mediante la manipulación de materiales, equipos o procesos. El plagio consiste en usar información o ideas de otra persona sin dar crédito por ello (10).

Fabricación, falsificación y plagio son los tipos de mala conducta científica más identificables, pero también existen otras conductas y prácticas no éticas o cuestionables (5). De hecho, en España, el Consejo Superior de Investigaciones Científicas (CSIC) menciona en su definición de mala conducta científica una "serie de prácticas inaceptables", además de fabricación, falsificación y plagio (11). En Europa, el Código Europeo de Conducta en Integridad en Investigación, publicado por la *All European Academies* (ALLEA), incluye un apartado de mala conducta científica y otras prácticas inaceptables. Dentro de las prácticas inaceptables más comúnmente señaladas, tanto a nivel nacional como a nivel internacional, se encuentra la duplicación, la publicación salami, la manipulación de autoría o la no declaración intencionada de conflictos de interés que puedan influir en las conclusiones del estudio. La duplicación consiste en la publicación de un artículo que se solapa sustancialmente con otro previamente publicado, sin que este último haya sido citado de forma evidente (7). La publicación salami se define como la fragmentación de los resultados de la investigación con el objetivo de aumentar el número de publicaciones de investigación (10). La manipulación de autoría puede darse principalmente de dos maneras: omitir de la lista de autores a un autor que ha contribuido sustancialmente a la investigación (autoría fantasma) o incluir en la lista de autores a un autor que no ha contribuido a la investigación (autoría de bulto) (7). Los mencionados anteriormente solo son algunas de las prácticas conocidas como inaceptables o cuestionables. No existe una lista estándar que defina claramente qué prácticas se incluyen dentro de la definición de mala conducta científica, de hecho, cada definición suele incluir diferentes prácticas.

1.2. EVOLUCIÓN DE LAS RETRACTACIONES Y DE LAS RAZONES DE RETRACTACIÓN

Aunque las retractaciones suponen un pequeño porcentaje del total de publicaciones, se ha observado un aumento en el número de retractaciones en los últimos años, incluso

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teniendo en cuenta el aumento exponencial en el número global de publicaciones. Este aumento en la frecuencia relativa de retractaciones con el paso de los años se puede observar en la Figura 1.

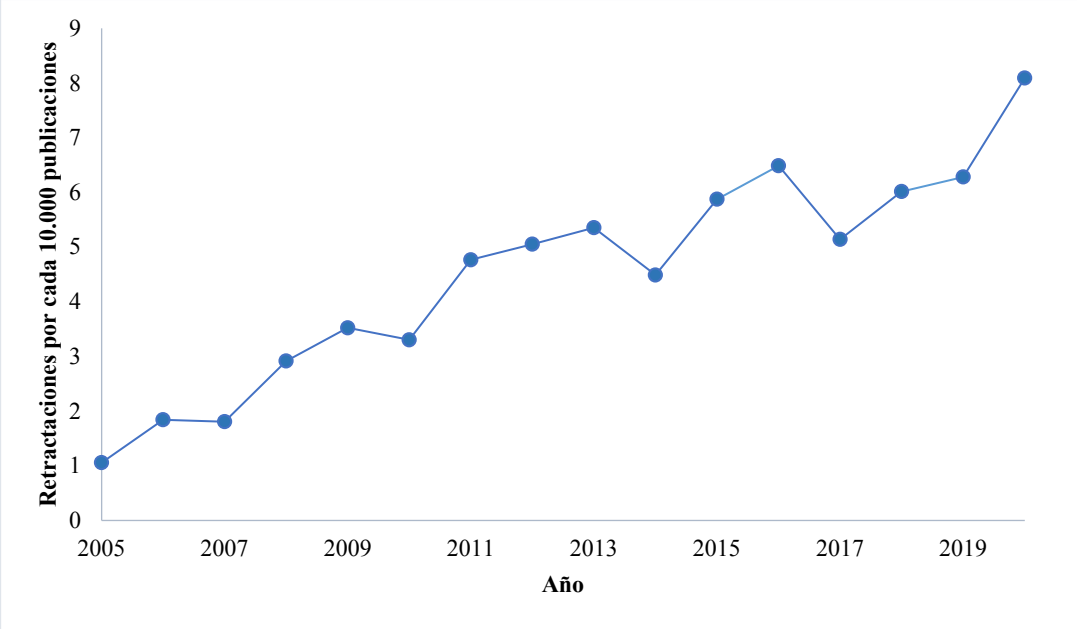


Figura 1. Número de retractaciones por cada 10.000 documentos publicados entre los años 2005 y 2020. Fuente: Elaboración propia usando datos de PubMed y Retraction Watch.

El aumento en el número de retractaciones se ha sido objetivado previamente. Entre 1966 y 1996 se retractaron 235 publicaciones y este número aumentó a 1.112 entre 1997 y 2009 (12, 13). En el periodo comprendido entre 2001 y 2010, el número de retractaciones aumentó un 44% (14). Entre los años 2013 y 2016, se retractaron 1.082 publicaciones (15). La ratio de retractaciones por 10.000 publicaciones pasó de ser 1 en 2005 a 8 en 2020 (16), mientras que en 2016 era de 4 retractaciones por cada 10.000 publicaciones (17). En Europa, el número de retractaciones pasó de 1,1 por cada 10.000 publicaciones en 2010 a 4,5 en 2020 (18). Además, diferentes estudios realizados en áreas de conocimiento específicas o en países concretos han reportado un aumento similar en las retractaciones (19, 20).

Diversos autores han teorizado sobre las causas asociadas al aumento en el número de retractaciones: por un lado, algunos investigadores declaran que no hay un aumento en las publicaciones con errores o mala conducta científica, sino que actualmente se

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detectan más. Esta mayor detección se debe a que hay una mayor disponibilidad de herramientas que antes no se tenían y al incremento en la atención prestada a este fenómeno (21, 22). Por otro lado, el actual sistema de evaluación y promoción de los investigadores, centrado en la cantidad de artículos científicos publicados en revistas de alto impacto, puede favorecer la proliferación de conductas y prácticas no éticas y cuestionables que pueden llevar a invalidar los resultados de los estudios (21, 23).

Además, se ha observado un cambio en las razones de retractación a lo largo del tiempo. Un estudio que analizó las razones de retractación en estudios publicados entre 1982 y 2002 reportó una mayor prevalencia de retractaciones debidas a errores (61,8%) en comparación con aquellas atribuidas a algún tipo de mala conducta científica (27,1%) (24). Estos resultados concuerdan con los de otro estudio que analizó datos hasta 2010 (25). Un estudio que incluyó artículos retractados hasta 2012 observó un patrón diferente, en el 21,3% de los artículos que fueron retractados, la retractación se debía a errores mientras que el 67,4% a mala conducta científica, sugiriendo así que se había producido un cambio en las razones de retractación entre esos años (26). Un estudio que analizó las retractaciones hasta el año 2018 (17) observó que a partir de finales de la década de los 90, las retractaciones por mala conducta comenzaron a aumentar en mayor medida que las retractaciones por error. Estudios recientes corroboran que, actualmente, la mala conducta científica es la principal causa de retractación y que supone aproximadamente el 60-70% de todas las retractaciones (27, 28).

Sin embargo, y aunque está claro que la mala conducta científica es la principal causa de retractación, el tipo más común de mala conducta científica difiere en función del ámbito geográfico. Según un estudio realizado por Fang et al. (26), que analizó datos hasta el año 2012, el tipo de mala conducta más común en Estados Unidos y Alemania fue fraude o sospecha de fraude, mientras que, en China, la mayoría de las retractaciones se produjeron por duplicación. Un estudio llevado a cabo en Brasil (29) concluyó que el tipo más frecuente de mala conducta científica fue el plagio, al igual que otro estudio realizado en la India (30). El estudio de Amos (31) realizado entre 2008 y 2012 sobre las diferencias en la prevalencia de plagio y duplicación por país, concluyó que Italia contaba con la mayor ratio de retractaciones por plagio, mientras que Finlandia contaba con la mayor ratio de retractaciones por duplicación. Por su parte, Bélgica reportó una prevalencia del 40% en problemas de autoría, concretamente la autoría de bulto (i.e. agregar el nombre de un individuo como autor en una publicación científica, a pesar de

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que ese individuo no haya realizado una contribución significativa) (32). Un estudio reciente que analizó las retractaciones en Europa observó que, en el año 2020, la principal causa de retractación por mala conducta científica varió en función del país. Así, en el Reino Unido, la principal causa de retractación era fabricación y falsificación (6,2 retractaciones por cada 100.000 publicaciones) y en Italia y España era la duplicación (15,6 y 13,2 retractaciones, respectivamente) (18).

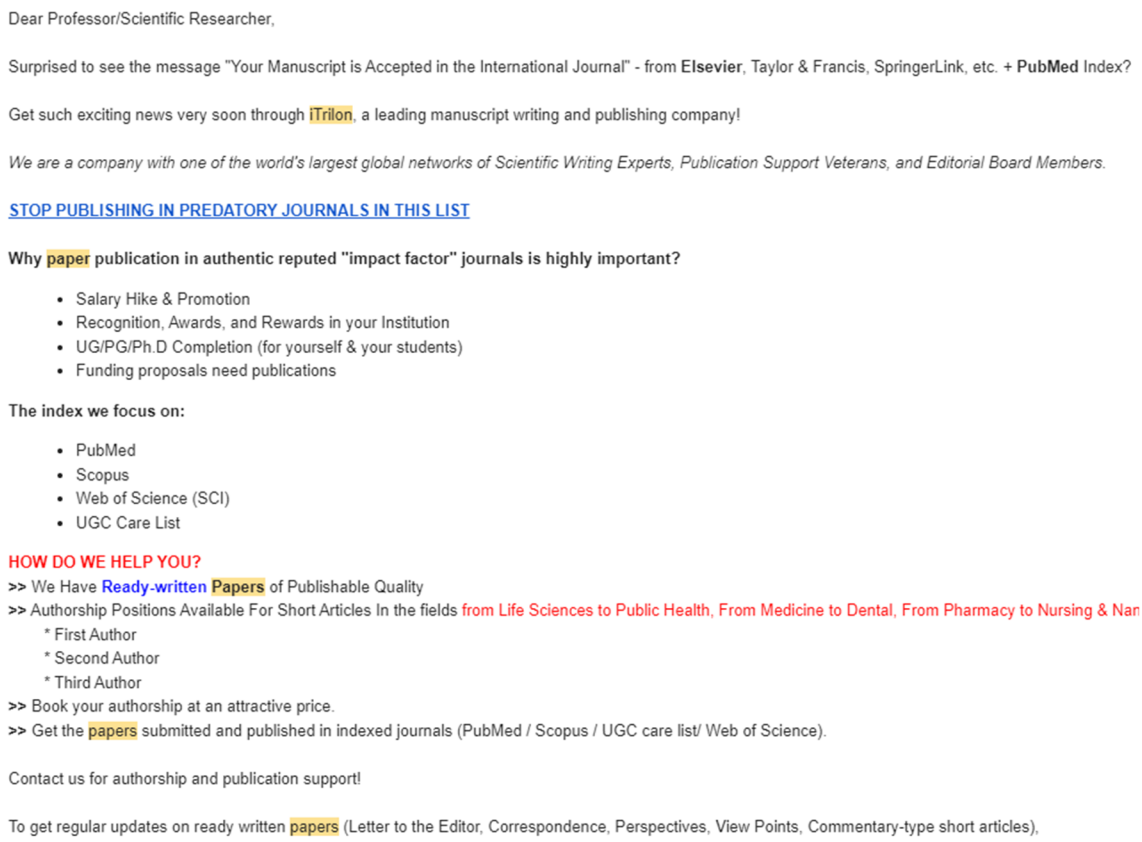
Los resultados previamente mencionados sugieren que las características y las razones de retractación, especialmente por mala conducta científica, son contexto-dependientes y varían en función de factores relacionados con la región geográfica de los autores. Fanelli et al. (33) comprobaron que el país de filiación de los autores puede influir en su actividad investigadora y es un predictor de la retractación y de conductas no éticas. Esto podría ser explicado por varias razones, entre las que se incluyen la existencia o no existencia de políticas nacionales contra la mala conducta científica o el contexto socioeconómico y cultural. Aquellos países que cuentan con políticas nacionales que regulen la mala conducta científica presentaron menor probabilidad de retractación y de mala conducta científica. Factores socioeconómicos, como un menor nivel de ingresos, también parecen aumentar la probabilidad de retractación y mala conducta científica (33, 34).

1.3. NUEVAS FORMAS DE MALA CONDUCTA CIENTÍFICA

A medida que la publicación científica evoluciona, surgen nuevos tipos de mala conducta científica y, por tanto, nuevas razones de retractación (35). Un ejemplo destacado es la falsificación de revisiones por pares. El artículo científico más antiguo retractado debido a este motivo se publicó en 2009, y no se tienen registros de casos anteriores de falsa revisión por pares. Otro ejemplo más actual es el fenómeno de los paper mills. El término "paper mill" en investigación científica hace referencia a organizaciones que se dedican a producir trabajos científicos fabricados, principalmente artículos de investigación, pero también tesis doctorales, que posteriormente venden a investigadores, profesionales o estudiantes (36). Estas organizaciones producen trabajos en apariencia originales, pero que en realidad son inventados o copias de trabajos previamente publicados (37-40). La actividad desarrollada por las organizaciones paper mills constituye una forma grave de mala conducta científica, pues supone la manipulación sistemática del proceso de publicación y socava los principios de integridad científica mediante la diseminación de

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resultados falsos (39). Desde su descubrimiento en el año 2020, este tipo de fraude ha dado lugar a retractaciones masivas (41-44). En la Ilustración 1 se muestra un email enviado desde una organización paper mills publicitando sus servicios para captar clientes.



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Ilustración 1. Email enviado a investigadores desde una organización paper mill.

1.4. SITUACIONES QUE PUEDEN AFECTAR A LA PUBLICACIÓN CIENTÍFICA

Además de la mala conducta científica, es esencial abordar otros fenómenos que, si bien no se consideran mala conducta científica como tal, pueden afectar la publicación científica.

En el contexto de la pandemia del COVID-19, se objetivó un aumento exponencial en el número de artículos publicados relacionados con la pandemia debido a la gran presión por publicar resultados de investigación relacionados con el virus de una forma rápida (45, 46). Sin embargo, esta urgencia y la competitividad entre revistas científicas en ser las primeras en reportar resultados de investigación, ha podido llevar a la relajación de los estándares de calidad editorial, lo que puede haber impactado de forma negativa en

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la calidad de la investigación científica (47-49). De hecho, evidencia de esto puede ser el número de retractaciones de artículos publicados sobre COVID-19 en los últimos tres años, que ascienden a 364 a 4 de septiembre de 2023 (50). Según la base de datos *Dimensions* (https://www.dimensions.ai/covid19/), se han publicado 1.659.446 documentos científicos sobre COVID-19, por lo que la ratio de retractaciones sería de 2,2. Diversos estudios se han retractado debido a la falta de rigurosidad en la metodología o en el análisis de los datos. La urgencia por publicar también ha llevado a algunos investigadores a incurrir en prácticas relacionadas con la mala conducta científica. Ejemplo de esto son las retractaciones por plagio y fraude asociadas a los artículos relacionados con el COVID-19 (51), encabezados por el caso *Surgisphere* (49). El caso *Surgisphere* (49) hace referencia a varios estudios científicos publicados en dos revistas científicas prestigiosas, *The Lancet* y *New England Journal of Medicine*, en 2020, durante la pandemia del COVID-19. Los autores trataban de comprobar la efectividad y seguridad de la hidroxicloroquina o cloroquina para el tratamiento de la enfermedad COVID-19, en el contexto de una crisis sanitaria global. En el estudio se incluyeron datos clínicos de 96.032 pacientes de 671 hospitales que se encontraban en continentes distintos y que eran propiedad de una compañía estadounidense llamada *Surgisphere Corporation*. Los resultados de este estudio sugirieron que el uso de este fármaco no aportaba beneficios en el tratamiento de los pacientes diagnosticados de COVID-19, y también afirmaron que había evidencia de que el tratamiento incrementaba el riesgo de arritmias ventriculares y muerte intrahospitalaria. Como resultado, la Organización Mundial de la Salud (OMS) paralizó los ensayos clínicos que se estaban llevando a cabo con esta medicación (52). En estudios posteriores se comprobó que este fármaco no tenía efectos beneficiosos ni perjudiciales en los pacientes COVID-19 (53).

Otro fenómeno que afecta a la publicación científica son las citas post-retractación. La citación de publicaciones retractadas, tanto por error como por mala conducta, es una práctica común en la literatura científica y se conoce como citación post-retractación. Cabe mencionar que, si bien es válido citar publicaciones retractadas, siempre que se aclare que el artículo que se está citando está retractado, no es recomendable. La citación post-retractación supone la perduración de información no válida en la literatura científica y puede tener consecuencias negativas (54), tanto para la comunidad científica como para la población general, sobre todo si la retractación se asocia a tipos de mala conducta científica como fabricación o falsificación de datos o resultados. Por ejemplo, continuar

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citando publicaciones sabiendo que están retractadas y no indicarlo puede suponer una aceptación de los resultados de la publicación retractada por parte de otros autores y que por tanto basen su investigación en ellos. Además, si los profesionales sanitarios confían en esos resultados no válidos, esto podría influir en su práctica clínica y en consecuencia en la salud de la población general. Adicionalmente, el uso de publicaciones retractadas en revisiones sistemáticas o metaanálisis puede distorsionar la interpretación de los resultados y comprometer la validez de los análisis. Según la evidencia científica disponible, esta práctica parece ser cada vez más frecuente (55).

Diferentes autores han analizado las citas recibidas por las publicaciones tras su retractación con resultados contradictorios. Así, un estudio previo ha observado una disminución de entre el 35% y el 69% en las citas post-retractación (56), mientras que otro no ha observado dicha reducción en el número de citas recibidas post-retractación (57). En cualquier caso, los estudios realizados hasta ahora han demostrado que las publicaciones retractadas se continúan citando.

La citación continuada de publicaciones retractadas se atribuye a dos causas principales. En primer lugar, es posible que haya autores que estén citando artículos retractados de forma inconsciente, al no saber que se encuentran retractados, debido a que el artículo citado se ha obtenido de un repositorio o de una biblioteca personal o directamente de las referencias de otro artículo (12). Por ejemplo, se ha observado que entre el 70% y el 90% de las referencias de los artículos publicados son copiadas de otros artículos (58). En segundo lugar, parece que las autocitas (i.e. citas que un autor hace de artículos propios en un trabajo posterior) pueden jugar un rol en la citación continuada de artículos retractados. Madlock-Brown et al. (35) concluyeron en su estudio que un 5% de las citas post-retractación eran autocitas y que solamente el 10% de los autores que citaban su propio trabajo mencionaban que éste se encontraba retractado. Además, se encontró una fuerte correlación entre autores que citan su propio trabajo y el número de citas post-retractación.

1.5. ENTIDADES ENCARGADAS DE REGULAR LA MALA CONDUCTA CIENTÍFICA

El aumento de las retractaciones por mala conducta científica hace evidente la necesidad de establecer mecanismos y estrategias que realmente sean eficaces para prevenir estas conductas no éticas, para detectarlas e incluso sancionarlas.

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Las principales partes involucradas en el manejo, regulación y control de la mala conducta científica son las revistas científicas, las instituciones que realizan investigación, las agencias financiadoras de investigación y los propios investigadores.

Actualmente, cuando existe una sospecha de mala conducta científica en una publicación, es la propia institución del autor de dicha publicación quien lleva a cabo las averiguaciones pertinentes (59). Sin embargo, esto es problemático por diferentes motivos. Por un lado, el potencial conflicto de interés. Es posible que a la institución no le interese que la relacionen con algún caso de mala conducta científica y por lo tanto no lleve a cabo una investigación transparente. Un ejemplo de esto sucedió en la *U.S. National Academy of Medicine* en 2021. Dicha institución tomó la decisión de expulsar a uno de sus miembros debido a mala conducta científica. La institución no difundió nada relacionado con esta medida ni los detalles detrás de ella e instó a sus miembros a mantener una completa confidencialidad (60). Por otro lado, los recursos, tanto económicos como humanos, con los que cuentan las instituciones para llevar a cabo este tipo de averiguaciones suelen ser muy limitados y escasos.

En este contexto, diferentes países han creado organismos y estructuras encargadas de regular y controlar la mala conducta científica a nivel nacional. El ejemplo más significativo de este tipo de organismo es la Oficina de Integridad Científica (ORI) de Estados Unidos (61), creada en 1993. La función de la ORI es supervisar las investigaciones relacionadas con una sospecha de mala conducta científica llevadas a cabo por las instituciones a los investigadores involucrados e imponer sanciones a los investigadores si se demuestra la mala conducta científica. Entre las sanciones impuestas por la ORI se encuentran la imposibilidad de servir como consultor a ninguna organización federal estadounidense durante un cierto periodo de tiempo o la supervisión de toda la investigación del investigador sancionado durante un periodo de tiempo (62).

En Europa, la Red Europea de Oficinas de Integridad Científica (*European Network of Research Integrity Offices* - ENRIO) (63) fue creada en el año 2007. Su principal función consiste en conectar las oficinas de integridad científica creadas en los países europeos, promoviendo la integridad científica y sirviendo como consultor de las instituciones que lo necesiten. A diferencia de la ORI, ENRIO no tiene autoridad para investigar ni para sancionar la mala conducta científica.

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PARTE II: JUSTIFICACIÓN Y OBJETIVOS

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2. JUSTIFICACIÓN Y OBJETIVOS

El incremento en la frecuencia de retractaciones y el hecho de que la mala conducta científica se postule como la principal razón de la retractación de publicaciones es preocupante para la comunidad científica y para la población general. Esto ha hecho que diferentes aspectos relacionados con la integridad científica se hayan comenzado a investigar más profundamente en los últimos años, sin embargo, el estudio de la mala conducta científica todavía es escaso.

Se han detectado diferencias importantes entre países en lo que atañe a las razones de retractación. Investigaciones previas han encontrado que los factores que incluyen en las retractaciones y en la mala conducta científica se encuentran directamente relacionados con el país de los autores. Debido a la influencia que tienen los factores socioculturales en las conductas investigadoras, es imprescindible monitorizar las retractaciones y categorizarlas a nivel nacional. Para ello, el análisis de las retractaciones constituye una herramienta importante, y nos permite identificar problemas relacionados con conductas no éticas dentro de un país concreto. Además, el análisis detallado de la mala conducta científica por país nos permite identificar aquellas áreas de conocimiento o el perfil de los investigadores más propensos a cometer errores o mala conducta científica.

Por lo tanto, si queremos avanzar en materia de integridad científica, resulta imprescindible conocer la situación de partida en relación con los tipos de mala conducta científica más prevalentes en cada país para poder actuar en consecuencia, así como la evolución de las retractaciones a nivel nacional. Algunos países han llevado a cabo análisis exhaustivos de las retractaciones de artículos científicos de los investigadores afiliados a una institución nacional (64, 65). Estos estudios son escasos en los países europeos. En el caso de España, dos estudios han analizado previamente las retractaciones el ámbito biomédico a nivel nacional y ambos llegaron a conclusiones diferentes a pesar de realizarse durante el mismo periodo temporal (de 1970 a 2018). La falta de acuerdo en los resultados se debió principalmente a diferencias en la metodología utilizada (64, 66). Por lo tanto, esta tesis pretende cuantificar y caracterizar todas las retractaciones en

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España, apoyándose en los esfuerzos previamente realizados en el contexto español por otros investigadores.

Los estudios basados en el análisis de las retractaciones como indicador de mala conducta científica proporcionan una visión global de los problemas de integridad científica existentes y sirven como base para el desarrollo de estrategias preventivas. Sin embargo, es crucial complementar estos análisis con la información proveniente de la propia comunidad científica, ya que los investigadores son testigos directos de las dinámicas asociadas con la mala conducta científica en su día a día. Para ello, existen herramientas validadas, como el cuestionario *Scientific Misconduct Questionnaire-Revised* (SMQ-R), desarrollado por Broome et al. (67), que nos permiten obtener información sobre las percepciones, actitudes y experiencias de los investigadores sobre la mala conducta científica. Las percepciones, actitudes y experiencias de la comunidad científica sobre la mala conducta científica se vienen estudiando desde hace décadas (68) y se han realizado estudios en varios países y también a nivel internacional utilizando tanto cuestionarios como entrevistas (23, 68-74). Sin embargo, la evidencia sigue siendo todavía escasa. En España no se ha realizado ningún estudio hasta ahora que analice las percepciones de los propios investigadores.

La información del análisis de retractaciones y de las percepciones de los investigadores de un país resulta valiosa para los organismos nacionales de cara a diseñar e implementar estrategias y políticas basadas en la evidencia encaminadas a prevenir y reducir las conductas no éticas, como por ejemplo la implementación de programas de formación en ética e integridad científica. Para el establecimiento de dichas estrategias, es necesario que cada país cuente con políticas contra la mala conducta científica y organismos nacionales que ofrezcan consejo en integridad científica, pero que tengan autoridad para investigar denuncias de mala conducta científica e imponer sanciones o medidas disciplinarias apropiadas. Que sepamos, ningún estudio ha evaluado la situación de las Oficinas Nacionales de Integridad Científica creadas en los países europeos y, más concretamente, en España.

Además, se hace necesario investigar y estar actualizado en los nuevos fenómenos que puedan tener un impacto negativo en la integridad y en la calidad de la investigación científica, así como en la confianza de la población general en la ciencia. Ejemplos recientes de este tipo de fenómenos incluyen la aparición y auge de las organizaciones paper mills, la publicación científica durante la pandemia del COVID-19 y las citaciones

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post-retractación. En cuanto al fenómeno de paper mills, es muy reciente y la información de la que disponemos es tremendamente escasa, por lo que aún no conocemos qué autores pueden estar incurriendo en este tipo de mala conducta científica, ni que áreas de conocimiento y revistas científicas están siendo afectadas. En cuanto a la publicación durante la pandemia del COVID-19, las características de los artículos COVID-19 no se han evaluado de manera formal con respecto a las de los artículos no COVID-19 publicados durante el mismo periodo, por lo que no tenemos información para establecer si existen diferencias significativas, especialmente en términos de calidad. Por otro lado, existen diferentes herramientas para tratar de evitar la citación de artículos científicos tras su retractación. Por ejemplo, el gestor bibliográfico Zotero, en colaboración con la base de datos de retractaciones Retraction Watch, ha configurado desde el año 2019 una alerta que salta cuando un artículo de la biblioteca de Zotero se retracta (75). Las últimas versiones del gestor bibliográfico EndNote también cuentan con esta herramienta e incluso informan sobre las causas de retractación del artículo (76). A pesar de esto, las citas post-retractación continúan siendo un hecho en publicación científica (56). Por lo tanto, es necesario generar evidencia rigurosa que nos permita entender la magnitud del problema y así desarrollar nuevas estrategias para prevenirlo. No existen investigaciones que hayan analizado de manera formal las citas recibidas por los artículos tras su retractación.

Debido a lo expuesto anteriormente, los objetivos establecidos en esta tesis se dividen de la siguiente manera:

1. Describir la situación de la mala conducta científica en España y en otros países.

    1.1. Describir los organismos que regulan la mala conducta científica en Europa.

    1.2. Describir la situación de la mala conducta científica en España en cuanto a mecanismos de prevención, investigación y penalización y proponer un organismo estatal encargado de la mala conducta científica en España.

    1.3. Cuantificar y caracterizar las retractaciones en España y en otros países, especialmente aquellas por mala conducta científica.

    1.4. Identificar las percepciones de los investigadores españoles sobre la mala conducta científica.

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2. Analizar tipos específicos de mala conducta científica y fenómenos que impactan en la integridad científica.

2.1. Analizar el impacto de la retractación de artículos por mala conducta científica en las citas recibidas tras la retractación.

2.2. Analizar las características de los artículos científicos sobre COVID-19 y compararlas con artículos no COVID-19.

2.3. Describir la evolución de las retractaciones de artículos por ser productos de paper mills, sus características y su visibilidad.

2.4. Analizar las citas y las referencias de los artículos que son productos de paper mills.

La presentación de los métodos y resultados de esta tesis se articula conforme las publicaciones incluidas. Así, para detallar los métodos y resultados, en el texto, en lugar de hacer referencia a los títulos de los artículos, se hará referencia al número de artículo. Esta información se detalla a continuación.

ARTÍCULO 1. Candal-Pedreira C, Ruano-Ravina A, Pérez-Ríos M. **Should the European Union have an office of research integrity?** Eur J Intern Med. 2021;94:1-3. doi: 10.1016/j.ejim.2021.07.009. Revista Q1 en la posición 26/172 de la categoría *Medicine, General and Internal*, con factor de impacto de 7,749.

Carta científica que tiene como objetivo analizar la situación de las oficinas de integridad científicas de los países europeos y proponer la creación de un ente supranacional que maneje la integridad científica a nivel europeo. Este estudio da respuesta al objetivo 1.1.

ARTÍCULO 2. Candal-Pedreira C, Álvarez-Dardet C, Ruano-Ravina A, Pérez-Ríos M. **La Oficina de Integridad Científica en España. Una tarea pendiente [The Research Integrity Office in Spain. A pending issue]**. Gac Sanit. 2022;36(6):557-560. Doi: 10.1016/j.gaceta.2022.02.005. Revista Q4 en la posición 83/105 de la categoría *Public, Environmental and Occupational Health*, con factor de impacto de 1,9.

Artículo especial que revisa las organizaciones que manejan la integridad científica en España y propone la creación de una oficina nacional de integridad científica. Este estudio da respuesta al objetivo 1.1.

ARTÍCULO 3. Candal-Pedreira C, Ross JS, Marusic A, Ruano-Ravina A. **Research misconduct as a challenge for academic institutions and scientific journals**. J Epidemiol Community Health. 2023: 1–4. doi: 10.1136/jech-2023-220554. Revista Q1

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en la posición 30/207 de la categoría *Public, Environmental and Occupational Health*, con factor de impacto de 6,4.

Ensayo en el que se analizan las estrategias y políticas que instituciones académicas y revistas científicas han implementado con el propósito de prevenir la mala conducta científica. Además, se proponen nuevas estrategias que podrían resultar útiles. Este estudio da respuesta al objetivo 1.1.

ARTÍCULO 4. Candal-Pedreira C, Ross JS, Freijedo-Fariñas F, Rey-Brandariz J, Ruano-Ravina A, Pérez-Ríos M. **Characteristics and reasons for retraction in Spanich scientific literature: a cross-sectional study.**

Artículo original de investigación que analiza las publicaciones retractadas en España. Este estudio es el producto de una estancia de investigación en la Universidad de Yale (Estados Unidos). Este estudio da respuesta al objetivo 1.3.

ARTÍCULO 5. Candal-Pedreira C, Ghaddar A, Pérez-Ríos M, Varela-Lema L, Álvarez-Dardet C, Ruano-Ravina A. **Scientific misconduct: Cross-sectional study of the perceptions, attitudes and experiences of Spanish researchers.**

Artículo original de investigación que analiza las percepciones, actitudes y experiencias en relación con la mala conducta científica de investigadores afiliados a una institución española del ámbito de la biomedicina. Este estudio da respuesta al objetivo 1.4.

ARTÍCULO 6. Candal-Pedreira C, Ghaddar A, Pérez-Ríos M, Varela-Lema L, Álvarez-Dardet C, Ruano-Ravina A. **Disciplinary sanctions and alert signals of scientific misconduct from the perspective of spanish researchers.**

Carta de investigación que analiza las percepciones, actitudes y experiencias de los investigadores españoles del ámbito de la biomedicina en cuanto a medidas disciplinarias y señales de alerta de mala conducta científica. Este estudio da respuesta al objetivo 1.4.

ARTÍCULO 7. Candal-Pedreira C, Ruano-Ravina A, Rey-Brandariz J, Mourino N, Ravara S, Aguiar P, Pérez-Ríos M. **Evolution and characterization of health sciences paper retractions in Brazil and Portugal**. Account Res. 2022:1-18. doi: 10.1080/08989621.2022.2080549. Revista Q1 en la posición 11/23 de la categoría *Medical Ethics*, con factor de impacto de 3,4.

Artículo original de investigación que analiza las publicaciones biomédicas retractadas en Portugal y Brasil. Este estudio es el producto de una estancia de

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investigación en la Universidad Nova de Lisboa (Portugal). Este estudio da respuesta al objetivo 1.3.

ARTÍCULO 8. Candal-Pedreira C, Ruano-Ravina A, Fernández E, Ramos J, Campos-Varela I, Pérez-Ríos M. **Does retraction after misconduct have an impact on citations? A pre-post study.** BMJ Glob Health. 2020;5(11):e003719. doi: 10.1136/bmjgh-2020-003719. Revista Q1 en la posición 27/203 de la categoría *Public, Environmental and Occupational Health*, con factor de impacto de 5,558.

Artículo original de investigación que describe las citas recibidas por artículos científicos tras su retractación y las compara con las citas recibidas por los mismos artículos antes de la retractación, utilizando un diseño pre-post. Este estudio da respuesta al objetivo 2.1.

ARTÍCULO 9. Candal-Pedreira C, Ruano-Ravina A, Pérez-Ríos M. **Comparison of COVID-19 and non-COVID-19 papers.** Gac Sanit. 2022;36(6):506-511. doi: 10.1016/j.gaceta.2022.03.006. Revista Q4 en la posición 83/105 de la categoría *Public, Environmental and Occupational Health*, con factor de impacto de 1,9.

Artículo original de investigación que compara las características de los artículos COVID-19 con las características de los artículos no COVID-19 publicados en el mismo periodo de tiempo y en la misma revista científica, utilizando un diseño de casos y controles. Este estudio da respuesta al objetivo 2.4.

ARTÍCULO 10. Candal-Pedreira C, Ross JS, Ruano-Ravina A, Egilman DS, Fernández E, Pérez-Ríos M. **Retracted papers originating from paper mills: cross sectional study.** BMJ. 2022;379:e071517. doi: 10.1136/bmj-2022-071517. Revista D1 en la posición 4/167 de la categoría *Medicine, General and Internal*, con factor de impacto de 105,7.

Artículo original de investigación que analiza el fenómeno de los paper mills mediante la inclusión de todos los artículos retractados por esta causa, centrándose en su evolución, características y visibilidad. Este estudio es el producto de una estancia de investigación en la Universidad de Brown (Estados Unidos). Este estudio da respuesta al objetivo 2.2.

ARTÍCULO 11. Candal-Pedreira C, Guerra-Tort C, Freijedo-Fariñas F, Rey-Brandariz J, Ruano-Ravina A, Pérez-Ríos M. **Retracted papers originating form paper mills: analysis of references and citations.**

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Artículo original de investigación que analiza las citas y referencias de los artículos retractados por proceder de paper mills en 2022. Este estudio da respuesta al objetivo 2.3.

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PARTE III: MÉTODOS

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3. MÉTODOS

3.1. FUENTES DE DATOS

3.1.1. Fuentes de datos institucionales

Para llevar a cabo la búsqueda de información sobre los organismos específicos que manejan la integridad científica a nivel europeo se consultaron los informes nacionales de la *European Network of Research Integrity Offices* (ENRIO) para cada uno de los 24 países que presentan un informe nacional en ENRIO. Se clasificaron los países en función de tener o no tener un organismo específico a nivel nacional con responsabilidad sobre la mala conducta científica. En el caso de países que lo tuvieran, se consultó cada uno de los organismos de forma individual, accediendo a las páginas web oficiales.

Para el caso de España, se consultó el informe nacional de ENRIO y, al no existir por el momento un organismo nacional en España, se identificó el organismo que se encarga de la integridad científica a nivel nacional y se consultaron sus políticas.

Las fuentes de datos institucionales mencionadas se utilizaron para los artículos 1 y 2.

3.1.2. Retraction Watch

Retraction Watch (https://retractionwatch.com) nació en 2010 como un blog que recogía noticias sobre las retractaciones de publicaciones científicas. Fue fundado por Ivan Oranksy y Adam Marcus. Retraction Watch se enmarca en el *Center for Scientific Integrity*, situado en Nueva York (Estados Unidos), cuya función es promover la transparencia e integridad en publicación científica. En 2018 se creó la base de datos Retraction Watch, en la que se incluyen publicaciones científicas que han sido retractadas, corregidas o tienen una *expression of concern*, independientemente del idioma. La base de datos Retraction Watch (http://retractiondatabase.org) es de acceso público y proporciona para cada publicación retractada incluida, los metadatos descritos en la Tabla 1. En septiembre de 2023, se anunció que CrossRef había adquirido la base de datos y que continuaría siendo actualizada por el equipo de Retraction Watch y mantendría el

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acceso libre (77). A día 27 de septiembre de 2023, esta base de datos incluía 43.041 publicaciones retractadas (78).

Según los fundadores de Retraction Watch, en 2022 la base de datos tenía más retractaciones que PubMed y CrossRef. Su gran cobertura se debe principalmente a las fuentes que utiliza Retraction Watch para detectar artículos retractados y notas de retractación. Retraction Watch realiza búsquedas manuales protocolizadas a diario, usando palabras clave como "*retraction*", "*withdrawn*" o "*retracted paper*", para localizar las retractaciones. Estas búsquedas se realizan en bases de datos como PubMed y *Web of Science*, así como en las páginas web de editoriales y revistas, informes de investigación de mala conducta científica, redes sociales y comentarios de otros investigadores.

Retraction Watch también proporciona la razón o razones de retractación para cada publicación incluida en la base. Para clasificar las publicaciones en razones concretas de retractación, Retraction Watch utiliza la información incluida en la nota de retractación publicada por la revista donde se publicó el artículo original. Además, se comprueban manualmente otras fuentes de datos, como los informes institucionales de investigaciones por sospecha de mala conducta científica o las oficinas de integridad científicas nacionales o institucionales. Como regla general, las publicaciones retractadas tienen más de una razón de retractación. Retraction Watch recoge todas las razones de retractación para cada publicación retractada. Las razones de retractación utilizadas por Retraction Watch, junto con su descripción, se pueden consultar en https://retractionwatch.com/retraction-watch-database-user-guide/retraction-watch-database-user-guide-appendix-b-reasons/.

En el caso específico de los artículos procedentes de paper mills, la identificación se basa en diferentes indicadores, como la nota de retractación. En algunos casos las notas declaran que el artículo se retractó por proceder de paper mills y en otros casos usan un eufemismo, como que procede de un "*third-party editing service*". En otros casos, las editoriales/revistas retractan un gran número de artículos al mismo tiempo, acompañando un editorial donde se indica que dichos artículos retractados proceden de paper mills. Para su detección, Retraction Watch también usa PubPeer y la lista de artículos sospechosos de proceder de paper mills creada por la Dra. Elizabeth Bik y otros investigadores (esta información fue proporcionada por los fundadores de Retraction Watch).

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Tabla 1. Información recogida por Retraction Watch para cada publicación retractada y su descripción.

Campo	Descripción
Autor/es	Nombre y apellidos de los autores
País/es	Los países se extraen de los países de filiación de los autores y se indican por orden alfabético en caso de haber más de uno.
Título	Título del artículo original.
Razón de retractación	La mayoría de los artículos cuentan con más de una razón de retractación. Retraction Watch las recoge todas y las incluye por orden alfabético.
Área de conocimiento	Hay diferentes categorías y generalmente los artículos retractados se asignan a más de un área de conocimiento. (B/T): Business and Technology (BLS): Basic Life Sciences (ENV): Environmental Sciences (HSC): Health Sciences (HUM): Humanities (PHY): Physical Sciences (SOC): Social Sciences
Tipo de publicación	Referido al tipo de publicación original.
Revista de publicación	El nombre de la revista de publicación se recoge de la página web de la revista.
Editorial	Al igual que el nombre de la revista, el nombre de la editorial se recoge de la página web correspondiente.
Filiación/es	Se extraen del texto completo de la publicación original.
Información sobre el artículo ogirinal	Se recogen identificadores únicos doi y PubMedID y la fecha de publicación.
Información sobre la retractación	Se recogen identificadores únicos doi y PubMedID y la fecha de retractación.
Tipo de nota de retractación	Se incluyen retractaciones, expressions of concern y correcciones.

Fuente: Retraction Watch.

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Para usar la base de datos de Retraction Watch en esta tesis, se realizaron acuerdos de explotación. La base de datos Retraction Watch se utilizó como fuente de datos principal de los artículos 4, 7, 10 y 11.

3.1.3. Web of Science

Web of Science (WOS) es una base de datos interdisciplinar perteneciente a *Clarivate Analytics*, que se utiliza para el seguimiento y análisis de publicaciones científicas de diferentes disciplinas y áreas de investigación (79). WOS contiene información bibliográfica de más de 21.000 revistas científicas, más de 134.000 libros y más de 300.000 congresos de todo el mundo (79, 80). Además de la información bibliográfica, WOS incluye herramientas de análisis de citas bibliográficas y métricas de impacto. WOS permite conocer el número y las características de las citas que ha recibido una publicación científica, siempre que esas citas provengan de publicaciones indexadas en WOS. Asimismo, WOS ofrece el índice H de un autor, que es una medida de la productividad y el impacto de sus publicaciones, entre otras métricas.

Web of Science se utilizó como fuente de datos en los artículos 4, 7, 8, 9, 10 y 11.

3.1.4. Journal Citation Reports

Journal Citation Reports (JCR) (81), también perteneciente a *Clarivate Analytitics*, es una herramienta bibliométrica que evalúa y analiza la influencia de las revistas científicas. Esta plataforma incluye una selección de revistas científicas de todo el mundo, categorizadas en función de su área de conocimiento. JCR publica informes anuales que proporcionan información sobre las métricas de impacto de las revistas científicas indexadas en la base de datos. La métrica de impacto más conocida y utilizada que se incluye en el informe es el Factor de Impacto (FI); su cálculo se basa en el número de citas que ha recibido una revista en un periodo de tiempo de dos años. Por ejemplo, para calcular el FI para una revista concreta en 2022 situamos en el numerador el número de citas recibidas en 2022 a ítems publicados en 2020 y 2021, mientras que en el denominador situamos el número de ítems citables publicados en 2020 y 2021. El término ítems citables hace referencia a artículos originales y revisiones y no tiene en cuenta otros tipos de publicación como cartas o comunicaciones a congresos. A partir del cálculo del FI de cada revista, para cada año JCR clasifica las revistas de cada categoría de conocimiento en cuatro cuartiles. El cuartil de una revista se utiliza como una medida relativa de su impacto dentro de su categoría de conocimiento. Una revista ubicada en el

primer cuartil de una categoría tiene una mayor relevancia en comparación con las revistas ubicadas en los cuartiles inferiores.

Journal Citation Reports se usó como fuente de datos en los artículos 4, 7, 8, 9, 10 y 11.

3.1.5. PubMed (MEDLINE)

PubMed es una base de datos ampliamente utilizada en el ámbito de la investigación en ciencias de la salud (82). La base de datos fue desarrollada en 1996 por la Biblioteca Nacional de Medicina de los Estados Unidos e incluye una amplia colección de publicaciones científicas en el campo de la medicina, la biología, la salud pública y disciplinas relacionadas, que se incrementa de forma exponencial con los años. A 2 de octubre de 2023, esta base de datos incluía más de 31 millones de documentos indexados. Las búsquedas en PubMed se basan en la combinación de términos MeSh y términos libres mediante el uso de operadores booleanos. Además, es posible utilizar diferentes filtros que permiten afinar la búsqueda.

La base de datos PubMed se usó como fuente de datos en el artículo 8.

3.1.6. Google Scholar

Google Scholar es un motor de búsqueda que permite localizar artículos científicos y otros tipos de publicaciones. Además, este motor de búsqueda proporciona el número de citas que un artículo ha recibido por otros artículos académicos. Para ello, Google Scholar recopila citas de una amplia variedad de fuentes, como revistas científicas, libros, tesis, informes, preprints, resúmenes a congresos y otras publicaciones (83).

Google Scholar se usó como fuente de datos en el artículo 4.

3.1.7. Encuesta a investigadores

Se diseñó una encuesta para ser aplicada online y de manera anónima a través de la plataforma *Google Forms*. La elaboración de la misma se basó en cuestionarios validados, principalmente el *Scientific Misconduct Questionnaire-Revised* (SMQ-R) (67), utilizados previamente en estudios de investigación con objetivos similares. Adicionalmente, el equipo investigador consideró añadir algunas preguntas relativas a aspectos no incluidos en el SMQ-R. Previamente al inicio del estudio, se realizó un

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pilotaje en una muestra de diez personas con características similares a las de las que iba dirigida la encuesta y se modificaron las preguntas o respuestas difíciles de entender o ambiguas.

Esta encuesta fue la fuente de datos utilizada en los artículos 5 y 6.

3.2. DISEÑO DE LAS INVESTIGACIONES

Los artículos 1, 2 y 3 no cuentan con una metodología específica ya que proceden de la revisión no exhaustiva de diferentes fuentes de información.

El artículo 4 es un estudio transversal que incluyó todas las publicaciones retractadas hasta el 23 de enero de 2023 (última fecha de acceso a la base Retraction Watch), que incluyesen al menos un autor afiliado a una institución española, sin limitación por área de conocimiento ni razón de retractación. Para identificar las publicaciones se realizó una búsqueda en Retraction Watch utilizando los filtros "*Spain*" en el campo País y "*Retraction*" en el campos Naturaleza de la nota de retractación.

Los artículos 5 y 6 parten de un estudio transversal en el que se aplicó una encuesta online anónima una muestra de investigadores españoles. La base del muestreo procedió de sociedades científicas españolas, Institutos de Investigación Sanitaria acreditados (IIS) y el Consorcio en Investigación Biomédica en Red (CIBER). La encuesta fue enviada a las directivas de 6 sociedades científicas españolas, 12 institutos de investigación y 13 grupos CIBER, quienes se encargaron de distribuirla a sus miembros mediante correo electrónico. Las organizaciones que accedieron a distribuir la encuesta fueron: Sociedad Española de Epidemiología, Sociedad Española de Salud Pública y Administración Sanitaria, Sociedad Española de Neumología y Cirugía Torácica, Sociedad Española de Oncología Médica, IIS Santiago, IIS Fundación Jiménez Díaz, CIBER en Epidemiología y Salud Pública, CIBER en Salud Mental y CIBER en Fisiopatología de la Obesidad y Nutrición. Se aplicaron estrategias de muestreo en bola de nieve.

El artículo 7 es un estudio transversal que incluyó todas las publicaciones retractadas por cualquier motivo con, al menos, un autor afiliado a una institución portuguesa o brasileña y que fueran retractadas entre el 1 de enero de 2000 y el 26 de septiembre de 2021. Se seleccionó el año 2000 como primer año de la serie por ser cuando se identificó la primera publicación retractada que cumplía con los criterios de inclusión. Se incluyeron aquellas publicaciones pertenecientes al ámbito de la biomedicina. Los filtros usados fueron "Brazil" o "Portugal" en el campo País, "*Retraction*" en el campo Naturaleza de

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la nota de retractación y "*Basic Life Sciences (BLS)*" o "*Health Sciences (HSC)*" en el campo Área de conocimiento.

El artículo 8 es un estudio cuasiexperimental de evaluación pre-post en el cual la intervención se definió como la retractación de la publicación incluida por una razón de mala conducta científica. Este estudio incluyó artículos originales de investigación y revisiones de la literatura publicados en revistas indexadas en JCR, recuperados a través de una búsqueda bibliográfica en PubMed (MEDLINE). Para ser incluidas, las publicaciones debían haber sido publicadas entre enero de 2013 y diciembre de 2016 y que hubiesen sido retractadas entre enero de 2014 y diciembre de 2017, ambos años incluidos. Se estableció un criterio adicional, las publicaciones incluidas debían de haber estado publicadas durante al menos 12 meses antes de ser retractadas por mala conducta científica. Para que todos los registros incluidos tuvieran la misma oportunidad de citación antes y después de la retractación, se estableció que el periodo de tiempo durante el cual hubiesen estado publicados antes y después de la retractación fuese el mismo. Esto significa que todos los registros incluidos estuvieron publicados un mínimo de 12 meses antes de la retractación estuvieron "a riesgo de citación" otros 12 meses después, con un seguimiento total mínimo de 24 meses.

El artículo 9 es un estudio de casos y controles. Los casos fueron definidos como artículos originales de investigación sobre COVID-19 publicados entre marzo de 2020 y enero de 2021. Los controles fueron definidos como artículos originales de investigación sobre otros temas publicados durante el mismo periodo de tiempo y en la misma revista. Para la selección de la muestra del artículo 9, en primer lugar, se identificaron las revistas científicas indexadas en las categorías JCR: "*Respiratory System*", "*Infectious Diseases*", "*Public, Environmental and Occupational Health*", "*General/Internal Medicine*" y "*Oncology*". Dentro de cada categoría, se seleccionó la primera revista de cada cuartil. Por lo tanto, se seleccionaron cuatro revistas en cada categoría. Para ser seleccionadas, las revistas tenían que haber publicado un número al mes y publicar artículos originales en inglés, español o portugués. Para la selección de los artículos, se revisaron manualmente todos los números mensuales publicados por cada revista incluida entre marzo de 2020 y enero de 2021. Por cada número, se seleccionó un artículo original relacionado con el COVID-19 y un artículo original no relacionado con el COVID-19 por orden de aparición. En el caso de que un número no contuviese ningún artículo COVID-19 que cumpliera con los criterios de inclusión, éste fue seleccionado de otro número de

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la misma revista si contaba con más de un artículo COVID-19. Para ser seleccionado, el artículo tenía que ser un original de investigación y realizado en humanos. Se excluyeron estudios de modelización, estudios de casos, estudios ecológicos, estudios cualitativos y retractados.

El artículo 10 es un estudio transversal que incluyó todos los artículos retractados por proceder de paper mills desde el 1 de enero de 2004, año en el que se identificó el artículo paper mills más antiguo, hasta el 26 de junio de 2022, fecha de último acceso a la base Retraction Watch. Para la identificación de las retractaciones que cumpliesen con los criterios de selección establecidos, se usó el filtro "Paper mills" en el campo Razón de retractación.

El artículo 11 es un estudio transversal que incluyó todos los artículos originales retractados, por proceder de paper mills, entre el 01/01/2022 y el 31/12/2022 que llevasen publicados al menos 12 meses antes de la retractación (la última fecha de acceso a la base Retractacion Watch fue el 23/01/2023). Para identificar los artículos, se seleccionó la opción "Paper mills" en el campo Causa de la retractación y "*Retracted*" en el campo Naturaleza de la nota de retractación.

3.3. VARIABLES A ESTUDIO

En general, las variables recogidas para los artículos 4, 7, 8, 9, 10 y 11 de esta tesis son consistentes y se centran en las características de las publicaciones analizadas, específicamente en el número y las características de los autores (número, país e institución de filiación) y las características del artículo (tipo de publicación, tiempo entre publicación y retractación y citas recibidas).

Además, de cada publicación retractada incluida, se recogieron las razones de retractación categorizadas por Retraction Watch. Para verificar la causa de retractación, se accedió a la nota de retractación de cada publicación. En el caso de no poder acceder a la nota de retractación, se utilizaron las razones de retractación proporcionadas por Retraction Watch. La razón de retractación se categorizó en:

- No hay mala conducta científica o error no intencionado: incluyendo errores por parte de los autores y duplicación por error por parte de la revista de publicación.
- Mala conducta científica:
    - Fabricación/Falsificación: incluye la fabricación/falsificación de imágenes, datos o resultados; y la manipulación de imágenes.

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  - Plagio: de texto, imágenes, datos o de una publicación completa.
  - Duplicación: de texto, imágenes, datos o de una publicación completa.
  - Problemas éticos/legales: incluye problemas sobre referencias/atribuciones; falsa revisión por pares; incumplimiento de la política por parte del autor; reclamaciones de derechos de autor; violaciones éticas por parte del autor; falta de aprobación del comité de ética institucional; conflicto de intereses; falta de aprobación de terceros; falta o retirada de consentimiento informado por parte de los participantes; autoría falsa/falsificada; afiliación falsa; problemas sobre la autoría.
  - Datos/resultados no fiables: problemas con imágenes, datos o resultados; datos poco fiables; imagen poco fiable; resultados poco fiables.
  - No especificado: mala conducta sin especificar el tipo.
- No especificado: no especifica si fue por error o por mala conducta.

En el caso de que un artículo tuviera varias razones de retractación por mala conducta, se seleccionó la más relevante en cuanto a su potencial impacto en la evidencia científica. Para ello, se creó un ranking ad hoc, detallado en la Tabla 2 con las causas más relevantes en los primeros puestos. Por ejemplo, si una publicación incluía como razones de retractación "fabricación" y "datos/resultados no fiables", se seleccionó "fabricación" como razón principal de retractación. Para el artículo 7, debido al limitado tamaño muestral, plagio y duplicación se categorizaron de forma conjunta.

Adicionalmente, se recogieron las siguientes características de la revista de publicación: factor de impacto (FI), categoría JCR, cuartil (Q) y modalidad de publicación (*Open Access*, por suscripción). En caso de que la revista de publicación perteneciera a más de una categoría, se seleccionó la más favorable en relación con el FI. En el caso de que la revista de publicación fuera híbrida (esto es, permite tanto publicar en acceso abierto como por suscripción), se categorizó como por suscripción en los artículos 7 y 10 y como no *Open Access* en el artículo 11.

Del texto completo de los artículos incluidos, se extrajeron las siguientes variables para los artículos 4 y 7: inclusión de una declaración de conflicto de interés (si/no), conflicto de interés declarado (si/no), inclusión de una declaración de financiación (si/no), financiación recibida declarada (si/no) y fuente de la financiación (pública/privada).

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Tabla 2. Escala diseñada *ad hoc* para la selección de la razón de retractación principal de las publicaciones incluidas.

Posición de relevancia	Razón principal de mala conducta
1	Falsificación y/o fabricación de datos o imágenes, incluyendo la manipulación de imágenes.
2	Plagio de toda la publicación o de una parte.
3	Duplicación de toda la publicación o de una parte.
4	Datos y/o resultados no fiables
5	Problemas éticos y legales

Para el artículo 8, además de las características de la publicación, se obtuvieron las siguientes variables de WOS: número total de citas recibidas por la publicación retractada en el periodo pre-retractación, número total de citas recibidas por la publicación retractada en el periodo post-retractación equivalente y número total de citas recibidas en el periodo post-retractación total (desde la publicación hasta diciembre de 2019). Se calcularon además las citas totales, entendidas como la suma de citas recibidas en el periodo pre y post-retractación.

Para el artículo 11, adicionalmente se recogió información sobre las referencias y citas de los artículos primarios (artículos originales retractados por paper mills). La información de las referencias y citas coincide con las variables recogidas para los artículos primarios. Adicionalmente, los artículos primarios, referencias y citas retractadas por duplicación e imposibilidad de comunicación con el autor se categorizaron como sospecha de paper mill. En el caso de las citas, también se registró si provenía de la propia nota de retractación del artículo primario correspondiente. De ser así, estas citas se eliminaron.

Para los artículos 5 y 6, se usó una encuesta de 27 preguntas, divididas en dos bloques. En el primer bloque se recogió información sobre el género del investigador (mujer, hombre, otro (no binario, no considera relevante responder)), edad, nivel de estudios, puesto de trabajo, tipo de institución, años de experiencia en investigación, publicaciones y rol en los procesos de publicación. El segundo bloque recopiló

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información sobre la percepción propia de la gravedad de diferentes tipos de mala conducta científica, la frecuencia percibida de mala conducta por parte de otros en revistas científicas, el conocimiento de la participación en diferentes tipos de mala conducta (frecuencia observada) y la participación (intencional o no intencional) en diferentes tipos de mala conducta (frecuencia autorreportada). La frecuencia observada se refiere a prácticas en las que otros investigadores han participado y de las cuales el investigador que completa la encuesta tiene conocimiento. En contraste, la frecuencia autorreportada se refiere a prácticas en las que el investigador que completa la encuesta ha participado. Adicionalmente, se preguntó por las medidas disciplinarias que los investigadores impondrían a cada tipo de mala conducta científica y las señales de alerta que les sugieren mala conducta científica. La encuesta completa se puede consultar en el siguiente enlace: https://forms.gle/rnXin9Lj2W6kmrPS8.

Para el artículo 9 se recopiló el diseño del estudio, categorizado como observacional descriptivo (transversal o serie de casos), observacional analítico (casos y controles o estudios de cohortes) o experimental (cuasi-experimental y ensayos clínicos); tamaño muestra (categorizado como 1-500 o mayor de 500); ámbito del estudio (regional, nacional o internacional); número de centros en los que se llevó a cabo el estudio (categorizado como unicéntrico o multicéntrico); y número de variables utilizadas para ajustar el resultado principal de cada uno de los artículos incluidos. De los números de cada revista incluida, se recogió el número de artículos COVID-19 y el número de artículos no COVID-19, así como el número total de artículos publicados en cada número.

3.4. ANÁLISIS ESTADÍSTICO

Para todos los artículos, en primer lugar, se realizó un análisis descriptivo de las variables de interés. Las variables cuantitativas se expresaron como mediana y rango intercuartílico (RI). Las variables cualitativas se expresaron como frecuencias relativas y absolutas.

Para el artículo 4, se analizó la evolución de las publicaciones retractadas a lo largo del tiempo usando el test de Mann-Kendall para evaluar las tendencias en las retractaciones durante el período de estudio. Se realizó un análisis descriptivo para analizar las características y razones de la retractación de las publicaciones incluidas. Para analizar el tiempo hasta la retractación, se realizó un análisis tiempo-dependiente utilizando el método de Kaplan-Meier. También se ajustó un modelo de riesgos

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proporcionales de Cox, ajustado por la razón de retractación y el cuartil de la revista de publicación.

Para los artículos 5 y 6 se llevó a cabo un análisis descriptivo de las variables sociodemográficas, de trabajo y relativas a las percepciones sobre mala conducta científica. Se usó el test chi-cuadrado para analizar las respuestas relacionadas con la frecuencia autopercibida de mala conducta científica en publicación científica y participación (intencionada o no) en prácticas no éticas en función del género, los años de experiencia en investigación (≤15 y >15 años) y tipo de institución de trabajo (para este análisis la categoría "otros" no se tuvo en cuenta debido al limitado número de respuestas en esta categoría (n=22)).

Para el artículo 7, se analizó la evolución de las retractaciones en términos absolutos y relativos para cada año y país (Portugal o Brasil). Se analizaron las características de las publicaciones retractadas y se desglosaron por país. Finalmente, se realizó un análisis descriptivo específico de aquellos autores afiliados a instituciones portuguesas o brasileñas que hubiesen cometido algún tipo de mala conducta científica.

Para el artículo 8 se compararon las citas recibidas durante el periodo pre-retractación con las citas recibidas en el periodo equivalente post-retractación. De igual forma, se compararon las citas pre-retractación con las citas totales recibidas tras la retractación, hasta diciembre de 2019. En ambos casos se aplicó la prueba de rangos de Wilcoxon. Posteriormente se analizó la asociación entre las citas recibidas pre y post-retractación en función del cuartil de la revista usando de nuevo la prueba de rangos de Wilcoxon. Adicionalmente y usando la misma prueba, se realizó un subanálisis incluyendo las 21 publicaciones más citadas antes de la retractación.

Para el artículo 9 se ajustó un modelo multivariante de regresión logística condicional para identificar las variables de interés asociadas con artículos COVID-19 o con artículos no COVID-19. En el modelo final se incluyeron las variables diseño del estudio y tamaño muestral. Además, el modelo fue ajustado por la revista de publicación y por tanto por el área de conocimiento y por el cuartil de la revista. Se calcularon los odds ratios (OR) acompañados de sus intervalos de confianza al 95% (IC95%).

Para el artículo 10 se analizó la evolución de los artículos retractados por proceder de paper mills. Se creó un ranking de revistas y editoriales basado en el número de artículos paper mills que hubiesen publicado. Se determinó si la revista de publicación era fiable, i.e. no ser sospechosa de ser depredadora, en una submuestra de las quince revistas que

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habían publicado el mayor número de artículos paper mill. Para ello, se utilizó la lista de verificación Think.Check.Submit (disponible en: https://thinkchecksubmit.org/journals/).

Para el artículo 11 se realizó un análisis bivariante para evaluar las diferencias en las características, en función de ser referencia o cita del artículo primario, usando la prueba Chi-cuadrado para variables categóricas y la prueba de rangos de Wilcoxon para las variables cuantitativas. Posteriormente, se restringió la muestra de citas y referencias a aquellas retractadas. Se llevó a cabo un análisis descriptivo de las causas de retractación de referencias y citas, comparándolas mediante la prueba Chi-cuadrado. Se construyeron dos redes de artículos primarios (retractados por paper mills) interconectados entre sí mediante sus citas y referencias. Cada nodo en la red representa un artículo (primario, cita o referencia). Las conexiones entre nodos (lazos) se establecieron usando el método *edge betweenness*. La primera red se construyó con el objetivo de establecer grupos o clústeres de artículos retractados que se referencian/citan entre sí. Para ello, esta red se restringió al análisis de los artículos primarios, sus citas y referencias retractadas. Esta red muestra los clústeres que incluyen más de cinco elementos relacionados entre sí (i.e. artículos primarios, citas y referencias retractadas que forman el clúster). La segunda red se construyó incluyendo artículos primarios, sus citas y referencias, con independencia de que estuviesen o no retractados. En esta red se clasificaron las citas y referencias en tres grupos: no retractada, retractada por proceder de paper mills o sospecha de paper mills y retractada por otra causa (problemas de autoría, plagio, error, problemas éticos, fabricación/falsificación, no especificado). Debido a la gran cantidad de datos, se representan los clústeres formados por más de 45 elementos (artículos primarios, citas retractadas o no y referencias retractadas o no). Las redes en formato interactivo se pueden consultar en el siguiente enlace: https://epideque.shinyapps.io/networks/.

Se consideró como estadísticamente significativo un p-valor<0.05 para todos los análisis. El análisis estadístico se llevó a cabo usando SPSS, Stata v.17, Excel y R.

3.5. CONSIDERACIONES ÉTICAS

Debido a que los artículos 1, 2, 3, 4, 7, 8, 9, 10 y 11 utilizaron materiales de acceso público y no implicaron a sujetos humanos, no se requirió la aprobación de un comité de ética de la investigación.

Para los artículos 5 y 6, debido a la naturaleza delicada de algunas de las preguntas de la encuesta, se aseguró que el cuestionario se cumplimentaba de forma totalmente

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anónima y que las preguntas no permitían la identificación de un determinado participante. Este estudio fue aprobado el 13/09/2022 por el Comité de Bioética de la Universidad de Santiago de Compostela (referencia USC 37/2022) (Anexo 9.1).

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PARTE IV: RESULTADOS

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4. RESULTADOS

La presentación de los resultados derivados de esta tesis doctoral se articula en once publicaciones científicas: siete artículos originales de investigación, dos cartas de investigación, un artículo especial y un ensayo por invitación.

4.1. ENTIDADES QUE REGULAN LA MALA CONDUCTA CIENTÍFICA, INSTITUCIONES DE INVESTIGACIÓN Y REVISTAS CIENTÍFICAS

Candal-Pedreira C, Ruano-Ravina A, Pérez-Ríos M. **Should the European Union have an office of research integrity?** Eur J Intern Med. 2021;94:1-3. doi: 10.1016/j.ejim.2021.07.009.

Candal-Pedreira C, Álvarez-Dardet C, Ruano-Ravina A, Pérez-Ríos M. **La Oficina de Integridad Científica en España. Una tarea pendiente [The Research Integrity Office in Spain. A pending issue]**. Gac Sanit. 2022;36(6):557-560. Doi: 10.1016/j.gaceta.2022.02.005.

Candal-Pedreira C, Ross JS, Marusic A, Ruano-Ravina A. **Research misconduct as a challenge for academic institutions and scientific journals**. J Epidemiol Community Health. 2023: 1–4. doi: 10.1136/jech-2023-220554.

De los 24 países europeos analizados, diez no contaban con un organismo nacional encargado de la integridad científica. De estos diez países, en tres eran las instituciones las únicas encargadas de manejar la integridad científica (Estonia, Grecia y Portugal). A pesar de no haber un órgano nacional, en República Checa, Lituania, España, Eslovaquia y Suiza cuentan con organizaciones de investigación y fundaciones públicas que se encargan de la integridad científica. En el caso de Croacia, se creó el *Croatian Committee on Ethics in Science and Higher Education,* pero no está en funcionamiento en este momento. En Eslovenia no se creó ningún organismo nacional y no se ha encontrado información sobre cómo se maneja la integridad científica.

De los 24 países analizados, 14 contaban con un organismo nacional encargado de la integridad científica, estas estructuras tienen diferentes funciones dependiendo del

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país. Así, en dos países el organismo puede investigar, dar opinión y mediar (Austria y Luxemburgo), tres países pueden investigar y dar opinión, pero no mediar (Bélgica, Finlandia, Países Bajos) y uno solamente mediar (Alemania). En el caso de Francia, Irlanda, Italia, Noruega, Polonia y Reino Unido, la entidad actúa como un consejo asesor. En el caso de Dinamarca, el *Danish Committee on Research Misconduct* tiene autoridad para investigar casos sospechosos de mala conducta científica y puede decidir medidas. En Suecia, la *Resarch Misconduct Board* (RMB) tiene autoridad para investigar y condenar, pero será la institución del investigador quien imponga medidas disciplinarias si así lo considera (en un plazo de seis meses tras la finalización de la investigación, se deben remitir las medidas tomadas a la RMB).

En el caso particular de España, no existe por el momento un organismo nacional que supervise la mala conducta científica. En lugar de eso, es el Consejo Superior de Investigaciones Científicas (CSIC) el que actúa como tal. Sin embargo, este organismo, aunque es público, solamente tiene autoridad para tratar casos sospechosos de mala conducta científica en el marco del CSIC. Además, al tratarse de un órgano de carácter consultivo, no tiene autoridad para imponer sanciones ni otras medidas disciplinarias. En España, son generalmente las propias instituciones a las que los investigadores están afiliados las que investigan casos en los que se sospecha de mala conducta científica.

Debido a lo anteriormente descrito, se propone la creación de una oficina nacional de integridad científica en España, cumpliendo con las recomendaciones de ALLEA. Esta oficina tendría la autoridad para supervisar la conducta científica de todos los investigadores afiliados a una institución española, actuando de forma independiente a dichas instituciones. La mencionada oficina pertenecería al Ministerio de Ciencia, pero siendo independiente de éste y tendría un mandato de 6 años preferiblemente. Es necesario que su composición sea multidisciplinar y que cuente con un comité ejecutivo que tome las decisiones en materia de medidas disciplinarias tras las investigaciones pertinentes, comunicando también dichas decisiones a las entidades e investigadores implicados en cada caso. Las funciones que se proponen se encuentran en la Tabla 3 y un posible organigrama se presenta en la Figura 2.

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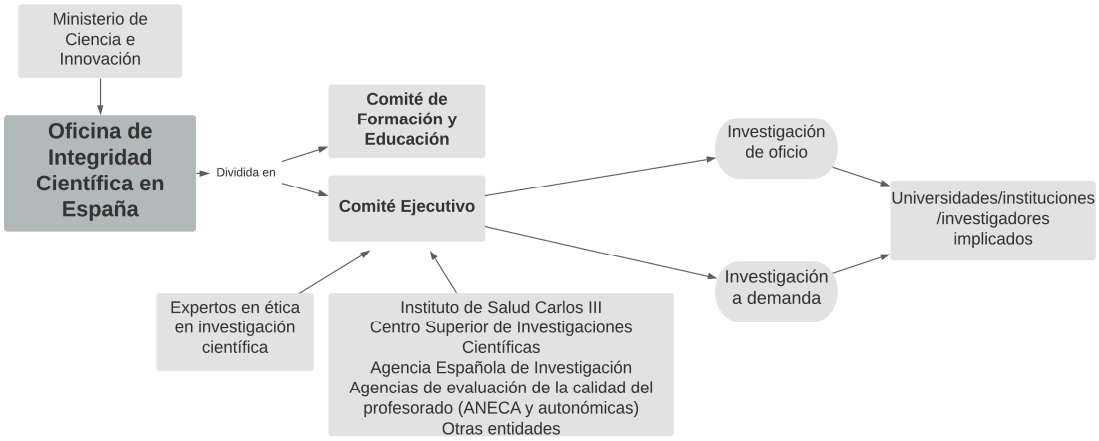


Figura 2. Posible organigrama y mecánica de actuación de la Oficina de Integridad Científica en España.

Tabla 3. Posibles funciones de la Oficina de Integridad Científica en España.

Posibles funciones de la Oficina de Integridad Científica en España.
Actuar como órgano consultivo de las instituciones que lo requieran
Asesorar y hacer informes y dictámenes a demanda de organismos que hacen investigación
Promover la integridad científica
Desarrollar actividades y programas formativos sobre conducta responsable en investigación, dirigidos a estudiantes de grado, postgrado e investigadores
Revisar y monitorizar investigaciones financiadas con fondos públicos
Llevar a cabo investigaciones, bien de oficio o bien previa solicitud, en aquellos casos en los que se sospecha de mala conducta científica
Imponer las sanciones correspondientes en cada caso en el que se haya probado, previa investigación, que hubiese mala conducta científica
Realizar memorias anuales de actividad para las Agencias financiadoras y Ministerio de Ciencia.
Cooperar a nivel internacional con el Comité Internacional de Editores de revistas Biomédicas y con otras Oficinas similares.
Promover su actividad en el marco del European Research Council y con la Dirección General de Investigación e Innovación de la Unión Europea.

A nivel global, las instituciones académicas han establecido políticas y procedimientos que buscan garantizar la integridad en la investigación realizada por sus miembros. Algunas instituciones han creado sus propias oficinas de integridad en la investigación y comités de investigación, como lo recomienda el Comité de Ética en Publicación (COPE), mientras que otras han implementado programas de educación en ética. Sin embargo, esto no es una norma común en todas las instituciones (84).

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Existen diferentes problemas relacionados con la integridad científica que no se tratan adecuadamente en muchas instituciones. Estos problemas están relacionados con el proceso de investigación de sospechas de mala conducta científica, la normalización de conductas no éticas en el ámbito académico y la falta de educación en ética. En la Tabla 4 se proponen propuestas para evitar los problemas mencionados.

Tabla 4. Estrategias propuestas para evitar cada uno de los problemas identificados. Instituciones académicas.

Problema	**Propuesta**
Transparencia en la investigación de sospecha de mala conducta científica llevada a cabo por instituciones de los investigadores	Hacer públicos los informes, empleando como mínimo identificadores personales anonimizados, en lugar de usar nombres, para garantizar la privacidad de todas las partes involucradas.
Conflicto de interés en la investigación de sospecha de mala conducta científica llevada a cabo por instituciones de los investigadores	Crear un organismo nacional que lleve a cabo la investigación relacionada con la sospecha de mala conducta científica y tenga autoridad para imponer sanciones. Este comité se podría crear como parte de los organismos nacionales ya existentes encargados de regular la integridad científica.
Normalización de conductas no éticas	Establecer auditorías externas periódicas para evaluar las políticas y regulaciones de la institución en materia de integridad científica.
Falta de educación en ética	Establecer programas de mentoría. Establecer programas de "rehabilitación" para investigadores de la institución que hayan cometido algún tipo de mala conducta científica.

Muchas revistas científicas y editoriales han adoptado políticas y estrategias destinadas a proteger la integridad científica y reducir la mala conducta. La mayoría de

ellas han respaldado directrices y códigos de conducta que delinean los estándares de integridad científica, como las Prácticas Fundamentales emitidas por COPE (5) o las Recomendaciones del ICJME para la Conducta, Información, Edición y Publicación de Trabajos Académicos en Revistas Médicas (85). Todas las editoriales principales también han creado equipos de integridad científica para gestionar específicamente este tema. Algunas revistas incluso han designado un editor específico para tratar la mala conducta en la investigación, como recomienda COPE.

En las últimas dos décadas, algunas revistas han desarrollado políticas editoriales innovadoras, particularmente en la promoción de la transparencia en la publicación, especialmente en relación con la Ciencia Abierta, que abarca compartir los datos y la revisión en abierto, entre otras prácticas. Muchas revistas han adoptado nuevas tecnologías, como el uso sistemático de *software* contra el plagio, lo cual se ha convertido en una práctica cada vez más común.

Tabla 5. Estrategias propuestas para cada uno de los problemas identificados en relación con la implantación de políticas y estrategias sobre integridad científica. Revistas científicas.

Problema	Propuesta
Escaso cumplimiento de las políticas de integridad científica implementadas	Hacer obligatorio el cumplimiento de las políticas de la revista para los autores que publiquen en ella
No implementación de políticas por falta de recursos	Establecer programas de financiación o subvenciones por parte de organizaciones internacionales centradas en integridad científica. Fomentar la colaboración entre revistas con recursos limitados y revistas con más recursos que hayan implementado dichas políticas de manera efectiva.
Escaso escrutinio de la investigación una vez publicada	Implementación de comentarios moderados en las versiones en línea de las publicaciones. Creación de una plataforma central, independiente de las revistas, que permita el debate entre investigadores en relación con una publicación.

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Los principales problemas identificados en cuanto a revistas científicas son el bajo cumplimiento con las políticas implementadas, la no implementación de dichas políticas

por falta de recursos y el escaso escrutinio de la investigación una vez publicada. En la y en la Tabla 5 y Tabla 6 se proponen estrategias para abordar los problemas identificados y nuevas estrategias a implementar por parte de las revistas científicas.

Tabla 6. Nuevas estrategias que implantar por parte de las revistas científicas.

Propuestas
Usar machine learning e inteligencia artificial para detectar posibles errores y anomalías en los datos de forma eficiente por parte de las revistas científicas.
Usar de nuevos programas informáticos que permitan detectar problemas específicos (análisis estadístico correcto, consistencia de los datos, duplicación de imágenes) en los artículos que recibe una revista para su publicación.
Requerir a los autores una identificación ORCID confirmada.
Verificar sistemáticamente si un autor que quiere publicar en la revista ha incurrido en mala conducta anteriormente, mediante la consulta de retractaciones.

4.2. ANÁLISIS DE LA MALA CONDUCTA CIENTÍFICA POR PAÍS

Candal-Pedreira C, Ross JS, Freijedo-Fariñas F, Rey-Brandariz J, Ruano-Ravina A, Pérez-Ríos M. **Characteristics and reasons for retraction in Spanich scientific literature: a cross-sectional study.**

Candal-Pedreira C, Ghaddar A, Pérez-Ríos M, Varela-Lema L, Álvarez-Dardet C, Ruano-Ravina A. **Scientific misconduct: Cross-sectional study of the perceptions, attitudes and experiences of Spanish researchers.**

Candal-Pedreira C, Ghaddar A, Pérez-Ríos M, Varela-Lema L, Álvarez-Dardet C, Ruano-Ravina A. **Disciplinary sanctions and alert signals of scientific misconduct from the perspective of spanish researchers.**

Candal-Pedreira C, Ruano-Ravina A, Rey-Brandariz J, Mourino N, Ravara S, Aguiar P, Pérez-Ríos M. **Evolution and characterization of health sciences paper retractions in Brazil and Portugal**. Account Res. 2022:1-18. doi: 10.1080/08989621.2022.2080549.

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En España, se identificaron 374 artículos retractados que incluían al menos un autor afiliado a una institución española. Estos artículos se publicaron entre 1998 y 2022 en 261 revistas científicas distintas. Cuatro artículos habían sido publicados en un servidor preprint.

En 2001, se retractó 1,0 artículo por cada 10.000 publicaciones, mientras que en 2022, hubo 2,2 artículos retractados por cada 10.000 publicaciones, un aumento estadísticamente significativo en la frecuencia relativa de retracciones (Tau de Kendall = 0,59; p <0,001) (Figura 1 del artículo, Anexo 9.2). Según la razón de la retractación, observamos una tendencia al alza más pronunciada en las retractaciones debido a mala conducta científica (Tau de Kendall = 0,58; p = 0,001), que en las retractaciones debido a error (Tau de Kendall = 0,32; p = 0,03), aunque ambas son significativas. En el caso de las retractaciones sin una razón especificada, la tendencia no fue significativa (Tau de Kendall = 0,25, p = 0,08).

Las principales características de los artículos, tanto en general como por razón de retractación, se describen en la Tabla 1 del artículo (Anexo 9.3).

La razón de retractación fue el error en 78 (20,9%) de los artículos, la mala conducta científica en 258 (69,0%) y en 38 (10,2%) no se especificó la razón de la retractación. El tipo más común de mala conducta científica en general fue la duplicación (28,9%), seguido de datos/resultados no fiables (26,1%). Entre los artículos biomédicos se obtuvieron resultados similares. Sin embargo, el plagio representa casi la mitad de los artículos no biomédicos retractados (42,9%), seguido de la duplicación (27,0%). Se observaron diferencias en todas las razones de retractación en función del área de conocimiento (p<0,001) (Tabla 7).

Tanto el cuartil de la revista de publicación como la razón de la retractación estuvieron asociados significativamente con el tiempo hasta la retractación. Los artículos publicados en las revistas del tercer y cuarto cuartil se retractaron 1,7 veces más rápido que los publicados en el primero y segundo cuartil (IC95% 1,3-2,6; p=0,001). Además, los artículos retractados debido a errores se retractaron 1,3 veces más rápido que los retractados debido a mala conducta científica (IC95% 1,1-1,7; p=0,018).

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Tabla 7. Descripción de los tipos de mala conducta científica, en global y en función del área de conocimiento.

Tipo de mala conducta	Total	Biomedicina	No biomedicina	Valor p
Fabricación/falsificación	42 (16,3%)	41 (20,6%)	1 (1,7%)	<0,001
Plagio	50 (19,4%)	23 (11,6%)	27 (45,8%)	<0,001
Duplicación	86 (33,3%)	69 (34,7%)	17 (28,8%)	<0,001
Problemas éticos/jurídicos	30 (11,6%)	24 (12,1%)	6 (10,2%)	<0,001
Datos/resultados no fiables	46 (17,8%)	39 (19,6%)	7 (11,9%)	<0,001
No especificado	4 (1,6%)	3 (1,5%)	1 (1,7%)	<0,001
Total	258 (100%)	199 (100%)	59 (100%)	

La mediana de citas recibidas por los artículos retractados incluidos fue de 10 (RI 2-36,5). Un total de 302 (81,2%) artículos recibieron al menos 1 cita durante el tiempo de seguimiento. Dos de los artículos retractados (0,5%) recibieron más de 1.000 citas. La figura 3 del artículo (Anexo 9.3) muestra la distribución de citas en función del cuartil de la revista de publicación. Los artículos publicados en revistas del primer cuartil recibieron más citas que los de revistas del tercer y cuarto cuartil (p=0,02), pero no hubo una diferencia significativa al comparar los artículos de revistas del primer cuartil con los del segundo cuartil (p=0,07).

En el análisis de las percepciones, actitudes y experiencias de los investigadores españoles del campo de la biomedicina respondieron, entre el 19/10/2022 y el 13/06/2023, 403 investigadores. En la tabla 1 del artículo se detallan las principales características de los participantes (Anexo 9.3).

El tipo de mala conducta percibido como que tiene más consecuencias negativas o se considera más grave fue la fabricación de resultados (16,6%), mientras que la falsa filiación fue identificada por los participantes como el tipo de mala conducta científica que presenta menos consecuencias negativas (19,8%) (Figura 1 del artículo, Anexo 9.3).

En la figura 2 del artículo (Anexo 9.3) se muestra la frecuencia autopercibida por los investigadores encuestados de los diferentes tipos de mala conducta que se produce en revistas científicas indexadas en JCR. El tipo más frecuente de mala conducta percibido fue falsa autoría; así, el 33,6% de los investigadores reportaron que se encontraban esta situación con frecuencia en las revistas científicas y el 39,0% con mucha frecuencia. No

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se observaron diferencias en la frecuencia percibida de ningún tipo de mala conducta científica en función del género ni de la institución de trabajo, pero sí en función de los años de experiencia (datos no mostrados). Los investigadores con más de 15 años de experiencia en investigación perciben menor frecuencia de falta de consentimiento informado, fabricación, falsificación y falsa autoría, en comparación con los que se han dedicado a la investigación 15 años o menos ($p<0,05$).

En cuanto al conocimiento de casos de mala conducta científica (frecuencia observada), el 78,8% de los investigadores tienen conocimiento de al menos un caso. Los investigadores encuestados destacan la falsa autoría, donde el 63,2% reportaron que conocían al menos un caso, y la falsificación de datos (36,0%) y de resultados (36,4%) (Tabla 2 del artículo, Anexo 9.3). Las respuestas no difieren en función del género excepto en el tipo "no declaración de conflictos de interés", en el que el 45,3% hombres reportaron tener conocimiento de al menos un caso, frente al 30,7% de las mujeres ($p<0,05$). Se encontraron diferencias estadísticamente significativas en función de los años de experiencia y del tipo de institución del encuestado en relación con los tipos de mala conducta específicos declarados, destacando de nuevo la no declaración de conflictos de interés (Tabla 2 del artículo, Anexo 9.3).

Casi la mitad de los investigadores encuestados refirieron que habían cometido algún tipo de mala conducta científica de manera intencionada (43,3%); de estos, un 34,7% reportó haber participado en falsa autoría y un 10,1% en falta de consentimiento informado, mientras que un 3,6% había participado al menos una vez en falsificación y/o manipulación de datos. De los investigadores que reportaron participar en falsa autoría, el 18,4% lo consideró como una práctica habitual. En función del género, se observaron diferencias en cuanto a la participación en mala conducta asociada a la aprobación de un comité ético, la falta de consentimiento informado y la no declaración de conflicto de interés, observándose un porcentaje más elevado en los hombres en todos los casos ($p<0,05$) (Tabla 2 del artículo, Anexo 9.3). Por tipo de institución de trabajo, se observan diferencias en cuanto a la declaración de haber falsificado o manipulado datos (mayor proporción en los sujetos que trabajan en un centro de investigación ($p<0,01$)) y no declaración de conflictos de interés (mayor proporción en los sujetos que trabajan en un centro hospitalario ($p=0,02$)).

En cuanto a la práctica de mala conducta científica de manera no intencionada, un 47,6% había participado en falsa autoría y un 19,7% en falta de consentimiento

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informado. Ocho personas (2,1%) reportaron haber contratado los servicios de organizaciones paper mills al menos una vez. En función del género, un mayor porcentaje de hombres reportaron haber participado de forma no intencionada en problemas relacionados con la aprobación de un comité ético, presiones de un patrocinador del estudio y no declaración de conflictos de interés ($p<0,05$). En función de los años de experiencia, aquellos que habían trabajado más de 15 años en investigación reportaron en mayor medida la no declaración de conflictos de interés ($p=0,02$). En cuanto a tipo de institución, se observaron diferencias en varios ítems: la participación en la falta de consentimiento informado y presiones de la industria fueron más frecuentes en sujetos que trabajan en centros hospitalarios; mientras que participar en falsificación de currículum y falsa autoría fue más frecuente en sujetos que trabajan en instituciones académicas ($p<0,05$).

En cuanto a las señales de alerta que sugieren mala conducta científica, la mitad de los investigadores encuestados destacaron no compartir la base de datos y el uso de cifras contradictorias (51,9% y 51,6%, respectivamente), mientras que el 43,7% y el 43,2% señalaron publicar sólo resultados positivos y publicar con mucha frecuencia, respectivamente. La sanción disciplinaria propuesta con menor frecuencia fue la de no recibir promoción, que osciló entre el 0% (problemas relacionados con la aprobación del Comité Ético de Investigación Clínica) y el 5,7% (falsificación del currículum vitae), seguida del despido de la institución, que se propuso con mayor frecuencia en los casos de falsificación de resultados (8,2%) y datos (7,5%).

En Brasil y Portugal, se identificaron un total de 182 artículos retractados publicados en 129 revistas diferentes fueron incluidos en este estudio, 34 artículos de autores afiliados a una institución portuguesa y 148 de autores afiliados a una institución brasileña.

Se observó un aumento en el número de retractaciones durante el período de estudio, tanto en Portugal como en Brasil, tanto en el total de retractaciones (línea punteada) como en las retractaciones de artículos en el campo biomédico (línea sólida) (Figura 3). No obstante, el número relativo de retractaciones en relación con el total de publicaciones se mantuvo estable durante el período de estudio, variando entre 2 y 4 retractaciones por cada 10.000 publicaciones en ambos países.

La Tabla 1 del artículo (Anexo 9.2) muestra las principales características de las publicaciones desglosadas por país.

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Independientemente del país de origen de los autores, la mayoría de las retractaciones se debieron a alguna forma de mala conducta científica. En el caso de los autores portugueses, la mayoría de las retractaciones debido a mala conducta fueron por plagio. De manera similar, en Brasil, las retractaciones debido a plagio superaron el 50% de las retractaciones debido a mala conducta científica. Cabe destacar que el 16,2% de las notas de retractación no especificaron la causa de la retractación en los artículos brasileños (Tabla 8).

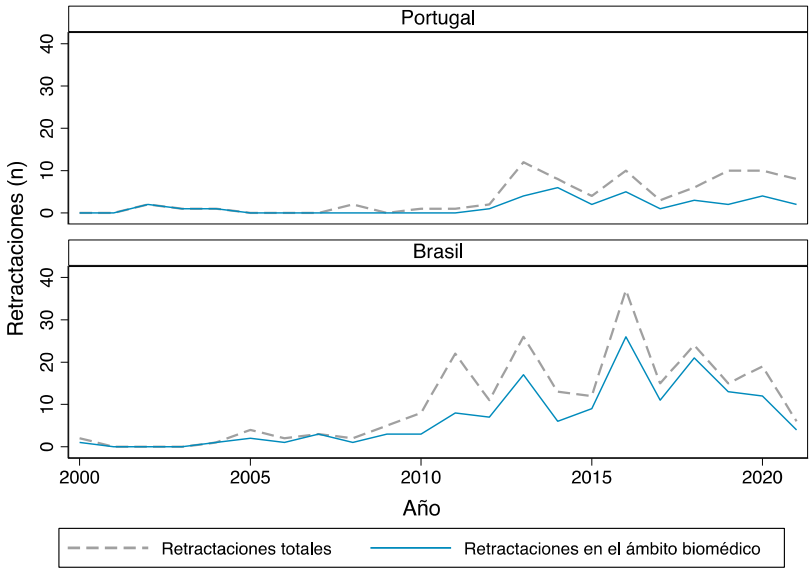


Figura 3. Evolución de las retractaciones totales (línea punteada) y de las retractaciones en ciencias biomédicas (en sólida).

Tabla 8. Razones de retractación, en función del país de los autores.

Razón de Retracción	**Portugal**	**Brasil**
Error honesto	12 (33,3%)	35 (23,7%)
Mala conducta	19 (55,9%)	89 (60,1%)
Falsificación/Fabricación	3 (13,6%)	9 (8,0%)
Plagio (incluye duplicación)	9 (40,9%)	57 (50,4%)
Datos no confiables	3 (13,6%)	7 (6,2%)
Resultados no confiables	1 (4,6%)	5 (4,4%)
Cuestiones éticas	2 (9,1%)	10 (8,9%)
No causa específica de mala conducta	4 (18,2%)	25 (22,1%)
No se indica causa de retracción	3 (8,8%)	24 (16,2%)

La mediana de días entre la publicación y la retractación debido a mala conducta fue mayor en comparación con la retractación debida a errores. Este patrón se observa en ambos países. En general, el tiempo desde la publicación hasta la retractación disminuye

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a medida que el cuartil de la revista aumenta. Sin embargo, en el caso de los artículos portugueses retractados por mala conducta, este período fue más largo en revistas del cuarto cuartil (Tabla 9).

Las publicaciones retractadas debido a mala conducta recibieron más citas que aquellas retractadas debido a errores (Tabla 10). Esto se observó principalmente en las publicaciones portuguesas en revistas del primer cuartil y en revistas sin factor de impacto. Se observó una asociación positiva entre el factor de impacto (FI) de la revista y el número de citas recibidas por las publicaciones tanto en Portugal (rho 0.50; p = 0.01) como en Brasil (rho = 0.60; p < 0.001).

Tabla 9. Tiempo transcurrido, expresado en días, entre la publicación y la retractación, en función de la razón de retractación, el cuartil de la revista donde se publicó el artículo y el país de los autores.

	Portugal		**Brasil**	
Cuartil de Revista	**Mala Conducta**	**Error**	**Mala Conducta**	**Error**
Q1	821 (664-923)	81 (48-114)	1831,5 (748,5-3292)*	448 (177-980)*
Q2	303 (252-519)	69 (69-69)	1513 (396-2223)	246 (0-1575)
Q3	135,5 (80,5-1.525,5)	0 (0-126)	384 (60-1004)	158 (0-590)
Q4	1.578,5 (154-3.003)	30 (30-30)	372,5 (210,5-522,5)	128 (92-366)
Sin Factor de Impacto	518 (441-939)*	7,5 (3,5-50,5)*	90 (62-212)	322,5 (72,5-496,25)

*Diferencias estadísticamente significativas (p < 0,05).

Tabla 10. Citas recibidas por las publicaciones retractadas en función de la razón de la retractación y el cuartil de la revista, por país de los autores.

	Portugal		**Brasil**	
Cuartil de Revista	**Mala Conducta**	**Error**	**Mala Conducta**	**Error**
Q1	46 (7-127)	1,5 (1-2)	8,5 (2-74,5)	8 (2-48)
Q2	3 (0-24)	2 (2-2)	17 (6-28)*	4 (1-5)*
Q3	0 (0-8)	2 (0-5)	2 (1-7)	3 (0-36)
Q4	4,5 (2-7)	7 (3-11)	0 (0-9)	0 (0-1)
Sin Factor de Impacto	27 (11-43)	1 (0-2)	1 (1-6)	3 (1-4)

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4.3. SITUACIONES QUE AFECTAN A LA MALA CONDUCTA CIENTÍFICA

Candal-Pedreira C, Ruano-Ravina A, Fernández E, Ramos J, Campos-Varela I, Pérez-Ríos M. **Does retraction after misconduct have an impact on citations? A pre-post study.** BMJ Glob Health. 2020;5(11):e003719. doi: 10.1136/bmjgh-2020-003719.

Candal-Pedreira C, Ruano-Ravina A, Pérez-Ríos M. **Comparison of COVID-19 and non-COVID-19 papers**. Gac Sanit. 2022;36(6):506-511. doi: 10.1016/j.gaceta.2022.03.006.

Para el estudio del impacto de la retractación en las citas, se incluyeron un total de 304 artículos retractados, publicados en 178 revistas biomédicas. Las principales características de los artículos se muestran en la Tabla 1 del artículo (Anexo 9.2). El análisis de citas se muestra en la Tabla 2 del artículo (Anexo 9.2). Los artículos retractados incluidos recibieron una media de 2 citas durante el período pre-retractación, al igual que durante el período equivalente post-retractación. En el caso del período post-retractación total, la mediana de citas recibidas llegó a 4.

La Tabla 11 y la Figura 4 muestran el análisis de citas en función del cuartil de la revista en la que se publicó el artículo retractado. Para todos los periodos estudiados (pre-retractación, post-retractación equivalente y post-retractación total), la mediana de citas fue mayor para los artículos retractados que se habían publicado en revistas del primer cuartil. Se observó una reducción significativa en las citas recibidas en el periodo post-retractación equivalente para los artículos publicados en primer cuartil (de 5 citas medianas a 4). Este fenómeno no se observó en el resto de los cuartiles. Al comparar las citas recibidas antes de la retractación con el periodo post-retractación total, el número de citas aumentó significativamente en el segundo y tercer cuartil.

Al analizar las citas de los 21 artículos retractados más citados, se observó una disminución significativa en el número de citas recibidas durante el periodo post-retractación equivalente, en comparación con el periodo pre-retractación ($p<0,05$). Sin embargo, se observó un aumento posterior de las citas, durante el periodo post-retractación, si bien no fue significativo ($p=0,06$) (Tabla 12).

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Tabla 11. Citas recibidas antes y después de la retractación, en función del cuartil de la revista donde se publicó el artículo.

Variables	Q1	Q2	Q3	Q4
Citas medianas totales (P25-P75)	14 (7-24,25)	6 (2,75-11)	5 (2-8)	5 (2-9)
Citas medianas pre-retractación (P25-P75)	5 (3-12,75)	1 (0-4)	1 (0-3)	1 (0-3)
Citas medianas post-retractación equivalentes (P25-P75)	4 (2-8)	2 (1-5)	1 (0-3)	2 (1-4)
Comparación entre el periodo pre-retractación y el periodo post-retractación equivalente	p<0,001	p=0,245	p=0,392	p=0,488
Citas medianas post-retractación totales (P25-P75)	7 (4-12)	4 (1-7)	3 (2-6)	3 (1-6)
Comparación entre el periodo pre-retractación y el periodo post-retractación total	p=0,332	p<0,001	p<0,001	p= 0,054

Q: cuartil de la revista de publicación; P25: percentil 25; P75: percentil 75.

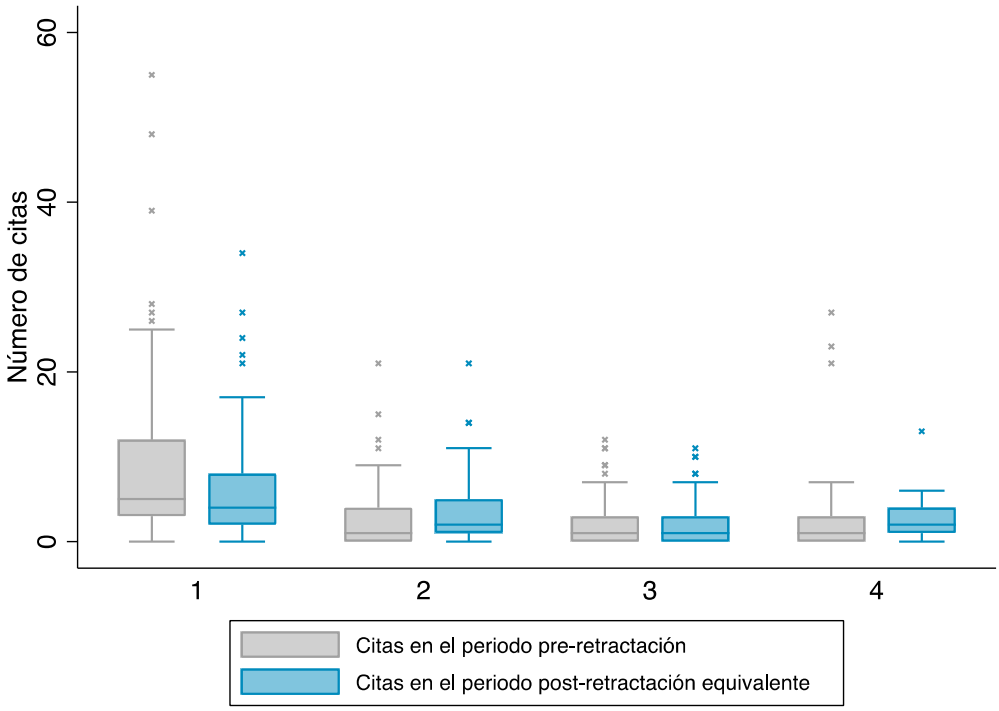


Figura 4. Citas de los artículos retractados durante el periodo pre-retractación y el periodo post-retractación equivalente.

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Para el análisis del impacto de la pandemia del COVID-19 en publicación científica, se incluyeron 301 artículos publicados en 20 revistas científicas desde marzo de 2020 a enero de 2021, ambos meses inclusive. En marzo, no se publicó ningún artículo sobre COVID-19 en las revistas seleccionadas. En los meses siguientes, la proporción de artículos sobre COVID-19 varió, alcanzando un 80% en el número de la revista *Lancet Respiratory Medicine* publicado en diciembre de 2020.

Tabla 12. Características asociadas a las citas recibidas por los artículos más citados antes de la retractación.

Variables	
Tiempo de seguimiento post-retractación equivalente, mediana y rango (meses)	27 (15-39)
Tiempo de seguimiento post-retractación total, mediana y rango (meses)	51 (37-59)
Citas medianas totales (P25-P75)	39 (30,5-70)
Citas medianas en el periodo pre-retractación (P25-P75)	24 (18-33,5)
Citas medianas en el periodo post-retractación equivalente (P25-P75)	13 (7,5-23)
Comparación entre el periodo pre-retractación y el periodo post-retractación equivalente	p=0,01
Citas medianas en el periodo post-retractación total(P25-P75)	17 (11-26,5)
Comparación entre el periodo pre-retractación y el periodo post-retractación total	p=0,06

Siete de las revistas seleccionadas no publicaron ningún artículo sobre COVID-19 durante todo el período de estudio. Para el análisis, se excluyeron los artículos no COVID-19 publicados en las siete revistas que no habían publicado ningún artículo sobre COVID-19, debido a la imposibilidad de emparejar estos controles con los casos por revista. Finalmente, el análisis incluyó un total de 224 artículos publicados en 13 revistas; de éstos, 81 eran artículos sobre COVID-19 y 143 eran no COVID-19.

La Tabla 13 describe las principales características de los artículos incluidos, diferenciando entre los artículos sobre COVID-19 y los que no lo son. Entre los artículos COVID-19, el 18,5% tenía más de 20 autores, mientras que entre los artículos no COVID-19, este porcentaje era del 12,8%. En el caso de los artículos COVID-19, el país con más publicaciones era China, mientras que en el 23,1% de los artículos no COVID-19, el país del primer autor era Estados Unidos. Mientras que el 63,0% de los artículos COVID-19

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tenían un diseño descriptivo y 3 (3,7%) eran estudios experimentales, entre los artículos que no COVID-19, el porcentaje de artículos con un diseño experimental fue del 24,9%.

Tabla 13. Características principales de los estudios incluidos, en función de su estado de caso (COVID-19) o control (no COVID-19).

Variables	COVID-19 (n=81) [n (%)]	No COVID-19 (n=143) [n (%)]
Variables Bibliométricas		
Número de autores		
1-5	16 (19,8%)	32 (22,4%)
6-10	26 (32,1%)	56 (39,2%)
11-15	17 (21,0%)	22 (15,4%)
16-20	7 (8,6%)	15 (10,5%)
21-25	5 (6,2%)	8 (5,6%)
26-30	3 (3,7%)	5 (3,5%)
>30	7 (8,6%)	5 (3,5%)
País de los autores		
EE. UU.	11 (13,6%)	33 (23,1%)
China	16 (19,8%)	5 (3,5%)
Dinamarca	9 (11,1%)	11 (7,7%)
Reino Unido	8 (9,9%)	9 (6,3%)
Brasil	7 (8,6%)	13 (9,1%)
Resto	30 (37%)	72 (50,3%)
Institución de los autores		
Universidad	28 (34,6%)	50 (35%)
Hospital	28 (34,6%)	37 (25,9%)
Universidad+Hospital	15 (18,5%)	28 (19,6%)
Centro de investigación	6 (7,4%)	15 (10,5%)
Otro	4 (4,9%)	13 (9%)
Otras características		
Diseño del estudio		
Observacional descriptivo	51 (63,0%)	50 (35%)
Observacional analítico	27 (33,3%)	51 (35,7%)
Experimental	3 (3,7%)	42 (29,4%)
Tamaño de la muestra		
1-500	56 (69,1%)	65 (45,5%)
>500	25 (30,9%)	78 (54,5%)
Ámbito del estudio*		
Local	48 (64,0%)	75 (56,8%)
Nacional	18 (24,0%)	31 (23,5%)
Internacional	9 (12,0%)	26 (19,7%)
Centros participantes**		
Unicéntrico	30 (50,8%)	49 (44,5%)
Multicéntrico	29 (49,2%)	61 (55,5%)
Número de variables de ajuste (mediana y rango)	2 (0-15)	2 (0-14)

*Valores perdidos: 6 casos y 11 controles. **Valores perdidos: 22 casos y 33 controles.

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La Tabla 2 y la Figura 2 del artículo (Anexo 9.2) muestran que el tiempo hasta la publicación de los artículos COVID-19 fue más corto que el de los artículos no COVID-19 ($p < 0.001$). Además, se observó que los artículos COVID-19 recibieron un mayor número de citas en comparación con los artículos que no COVID-19 ($p < 0.001$).

Los estudios observacionales descriptivos y los estudios observacionales analíticos tenían una probabilidad 56 veces mayor (OR: 56,43; IC del 95%: 9,40-338,67; $p < 0,001$) y 20 veces mayor (OR: 19,94; IC del 95%: 3,77-105,58; $p < 0,001$), respectivamente, de ser artículos COVID-19. Los estudios con el tamaño de muestra más pequeño (<500 individuos) tenían una probabilidad 6 veces mayor de ser artículos COVID-19 (OR: 5,96; IC del 95%: 2,19-16,28; $p < 0,001$) en comparación con los estudios con el tamaño de muestra más grande (>500 individuos incluidos en el estudio) (Tabla 3 del artículo, Anexo 9.2).

4.4. NUEVAS FORMAS DE MALA CONDUCTA CIENTÍFICA: PAPER MILLS

Candal-Pedreira C, Ross JS, Ruano-Ravina A, Egilman DS, Fernández E, Pérez-Ríos M. **Retracted papers originating from paper mills: cross sectional study.** BMJ. 2022;379:e071517. doi: 10.1136/bmj-2022-071517.

Candal-Pedreira C, Guerra-Tort C, Freijedo-Fariñas F, Rey-Brandariz J, Ruano-Ravina A, Pérez-Ríos M. **Retracted papers originating form paper mills: analysis of references and citations.**

Se identificaron un total de 1.182 retractaciones de artículos provenientes de paper mills hasta junio de 2022. El primer artículo retractado por esta causa se remonta a 2016. La proporción de artículos procedentes de paper mills publicados por año ha experimentado un aumento constante durante el período de estudio, pasando de un mínimo de 0,04 artículos de paper mills por cada 100.000 publicaciones en 2004 a un máximo de 10,6 artículos de paper mills por cada 100.000 publicaciones en 2019. La proporción de retractaciones atribuibles a paper mills con respecto al total de retractaciones se mantuvo baja hasta el año 2021, cuando alcanzó el 21,8% del total de retractaciones.

La Tabla 14 presenta las características clave de los artículos retractados debido a proceder de paper mills. Casi todos los autores de estos artículos tenían filiaciones en instituciones de China, y más de tres cuartas partes estaban vinculados a hospitales. La

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mayoría de los artículos fueron publicados en revistas clasificadas en el segundo cuartil y en la categoría Farmacología y Farmacia de JCR.

Tabla 14. Principales características de los papeles retractados por proceder de paper mills.

Variable	**n (%)**
Número de autores	
1-3	315 (26,7%)
4-6	602 (50,9%)
>6	265 (22,4%)
País de los autores	
China	1,143 (96,8%)
India	17 (1,4%)
China, EE.UU.	6 (0,5%)
China, Alemania	2 (0,2%)
Resto	13 (1,1%)
Filiación del primer autor	
Hospital	909 (76,9%)
Universidad	176 (14,9%)
Hospital+Universidad	66 (5,6%)
Centro de investigación	11 (0,9%)
Otro	20 (1,7%)
Cuartil JCR de la revista de publicación del artículo	
Q1	350 (29,6%)
Q2	529 (44,8%)
Q3	248 (21,0%)
Q4	25 (2,1%)
No FI	30 (2,5%)
Categoría JCR	
Farmacología y Farmacia	265 (22,4%)
Oncología	162 (13,7%)
Bioquímica y Biología Molecular	145 (12,3%)
Educación, Disciplinas Científicas	122 (10,3%)
Medicina, Investigación y Experimental	103 (8,7%)
Otro	356 (30,1%)
No indexado en JCR	29 (2,5%)

EE. UU.: Estados Unidos; Q: cuartil; JCR: Journal Citation Reports; FI: Factor de Impacto

Quince revistas científicas publicaron 812 artículos (63,5%) que posteriormente se retractaron por ser de paper mills. Un 14,0% de todos los artículos se publicaron en una revista específica: *European Review for Medical and Pharmacological Sciences*.

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El tiempo transcurrido entre el envío del artículo a la revista y su publicación varió según el cuartil de la revista. Así, este tiempo aumentó a medida que el cuartil de la revista fue más alto. Lo mismo se observó en el tiempo transcurrido entre la publicación y la retractación (Tabla 15).

El 93,8% de los artículos retractados por proceder de paper mills recibieron al menos una cita tras su publicación. Es relevante destacar que los artículos de paper mills publicados en revistas del tercer y cuarto cuartil recibieron más citas en promedio que los artículos publicados en revistas del primer y segundo cuartil (Figura 3 del artículo, Anexo 9.2).

Tabla 15. Tiempos de publicación y retractación de artículos retractados por proceder de paper mills, tanto en general como por cuartil de revista en la que se publicaron.

Tiempo transcurrido entre el envío y la publicación (en días)*						
	Total	Q1	Q2	Q3	Q4	No FI
Mediana (RI)	140 (93-217)	114,5 (80-144)	128 (81,5-189)	163 (119-288)	332 (189-447)	225 (158-244)
Tiempo transcurrido entre la publicación y la retractación (en días)**						
	Total	Q1	Q2	Q3	Q4	No IF
Mediana (RI)	890,5 (0-3,229)	828,5 (223-1,933)	792 (0-3,121)	1,350 (181-2,707)	1,564 (676-2,130)	907 (0-2,234)

*Valores perdidos: 659. **Valores perdidos: 2. FI: Factor de impacto; Q: cuartil; RI: rango intercuartílico.

Para el análisis de las citas y referencias de los artículos retractados por proceder de paper mills, se identificaron 416 artículos originales retractados por proceder de paper mills en 2022, de ahora en adelante artículos primarios, que cumplían con los criterios de inclusión. En la tabla 1 del artículo (Anexo 9.3) se describen sus características principales. Los artículos primarios incluidos en el análisis se publicaron en 85 revistas científicas diferentes y tardaron un tiempo mediano de 1.247 días en retractarse (RI: 907,8-1673,5). El 39,7% de los artículos primarios se publicó en revistas situadas en el segundo cuartil de su categoría y el 22,1% en revistas pertenecientes a la categoría Medicina, Investigación y Experimental. Las revistas en las que se han publicado el mayor número de artículos retractados en 2022 por proceder de paper mills fueron

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Biomedicine & Pharmacotherapy y *Molecular Medicine Reports*, con 35 y 33 artículos publicados y luego retractados, respectivamente.

Se identificaron 1.669 autores diferentes en los 416 artículos primarios incluidos. Dos de estos autores aparecen en 14 de los artículos cada uno, mientras que otros dos están listados en 10 artículos cada uno. En 384 de los artículos primarios (92,3%), todos los autores procedían de un mismo país (China), mientras que en los restantes 32 artículos (7,7%) los autores procedían de entre dos y cinco países diferentes. La filiación más frecuente entre todos los autores identificados fue la Universidad de Jilin, en China, registrada en 77 artículos diferentes (18,5%). En cuanto a la filiación del autor de correspondencia, en 389 artículos (92,8%) era una institución de China y en cuatro artículos (1,0%) era una institución de China y una institución de otro país (Filipinas, Rusia, EE. UU. o Italia). El 51,2% de los autores de correspondencia estaban afiliados a un hospital, mientras que el 28,4% estaban afiliados tanto a un hospital como a una universidad y el 16,7% solo a una universidad. En 14 artículos (3,4%) el autor de correspondencia había proporcionado un email institucional.

A partir de los 416 artículos primarios incluidos en este estudio, se identificaron un total de 15.437 referencias y 8.689 citas. Se lograron extraer los metadatos de 14.411 referencias y 8.479 citas, siendo por lo tanto el número de registros recuperados 22.890 (94,9% del total). La mediana de referencias por artículo primario fue de 35 (IR: 29-40) y la mediana de citas recibidas fue de 16 (RI: 9-25).

En la Tabla 16 se detallan las características principales de las referencias y de las citas recogidas.

El número mediano de autores fue seis tanto para los artículos referenciados como para los artículos que citaron a los artículos primarios. La mayoría de los autores de correspondencia estaban afiliados a una institución en China (54,0% de las referencias y el 78,3% de las citas). El 46,8% de los artículos referenciados se habían publicado en revistas de primer cuartil, mientras que el 28,6% de los artículos que citan a los artículos primarios se habían publicado en revistas de segundo cuartil. Las revistas pertenecientes a la categoría Oncología publicaron la mayor parte de las referencias y de las citas. Las revistas *Oncotarget* y *Plos One* son las revistas que han sido referenciadas con más frecuencia por parte de los artículos primarios (418 y 344 referencias en artículos primarios, respectivamente), mientras que las revistas *International Journal of Molecular*

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Science y *Frontiers in Oncology* son las revistas que más han citado a los artículos primarios (206 y 187 citas a artículos primarios, respectivamente).

De los artículos primarios, 178 (42,8%) habían recibido al menos una cita de un artículo retractado por cualquier causa y 169 (41,9%) referenciaron una publicación retractada por cualquier causa. De estos, 145 (81,5%) y 156 (92,3%) referenciaron o fueron citados, respectivamente, por al menos un artículo retractado por proceder de paper mills o con sospecha. No se observaron diferencias en el número de referencias o citas procedentes de paper mills o con sospecha, ni en global ni en función de la modalidad de publicación ni del cuartil de la revista del artículo primario.

Tabla 16. Principales características de las referencias y citas relacionadas con artículos paper mills retractados en 2022.

	Referencias		**Citas**		
	n=14.411		n=8.479		p-valor
Número de autores Mediana (RI)	6,00	(3,0-8,0)	6,00	(4,0-8,0)	0,27
País del autor de correspondencia*					<0,001
China	5.834	(54,0%)	5.587	(78,3%)	
EE. UU.	3.111	(28,8%)	331	(4,6%)	
Japón	456	(4,2%)	88	(1,2%)	
Alemania	365	(3,4%)	71	(1,0%)	
Corea del Sur	300	(2,8%)	129	(1,8%)	
Italia	310	(2,9%)	141	(2,0%)	
Irán	113	(1,1%)	334	(4,7%)	
Otro	307	(2,8%)	455	(6,4%)	
Factor de Impacto JCR (FI) Mediana (RI)	3,9	(2,5-6,0)	2,9	(1,6-4,2)	<0,001
Cuartil JCR de la revista de publicación del artículo					<0,001
Q1	6.749	(46,8%)	2.149	(25,3%)	
Q2	3.757	(26,1%)	2.422	(28,6%)	
Q3	1.523	(10,6%)	1.589	(18,7%)	
Q4	674	(4,7%)	806	(9,5%)	
No indexado	1.709	(11,9%)	1.513	(17,8%)	
Categoría JCR					<0,001
Bioquímica y Biología Molecular	1.001	(6,9%)	340	(4,0%)	
Medicina, Investigación y Experimental	935	(6,5%)	938	(11,1%)	
Ciencia Multidisplinar	803	(5,6%)	244	(2,9%)	
Oncología	2.803	(19,5%)	1.132	(13,4%)	
Farmacología y Farmacia	629	(4,4%)	679	(8,0%)	
No indexado	1.709	(11,9%)	1.513	(17,5%)	
Otro	6.531	(45,3%)	3.633	(42,8%)	

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* 3.616 referencias y 1.343 citas sin información. EE. UU.: Estados Unidos; FI: Factor de impacto; Q: cuartil; IR: rango intercuartílico; JCR: Journal Citation Reports.

Las causas de retractación de las referencias y citas retractadas (290 y 312, respectivamente) se detallan en la Tabla 17. Entre las referencias y citas analizadas, se identificaron 473 artículos retractados por proceder de paper mills o con sospecha de proceder de paper mills, suponiendo el 78,6% de todas las retractaciones encontradas. Se identificaron ocho artículos primarios con cuatro o más referencias/citas a otros artículos retractados por paper mills o con sospecha, sumando entre ellos 40 referencias/citas.

Tabla 17. Descripción de las referencias retractadas y citas de artículos primarios.

	Referencias		**Citas**	
Publicación retractada				
No	14.121	(98,0%)	8.167	(96,3%)
Sí	290	(2,0%)	312	(3,7%)
Razón de retractación				
Paper mill	167	(57,6%)	142	(45,5%)
Paper mill sospechoso	63	(21,7%)	101	(32,4%)
Problemas sobre datos/imágenes	13	(4,5%)	20	(6,4%)
Plagio	11	(3,8%)	2	(0,6%)
Error	8	(2,8%)	8	(2,6%)
Fabricación/falsificación	3	(1,0%)	1	(0,3%)
Problemas éticos	1	(0,3%)	0	(0,0%)
Problemas de autoría	0	(0,0%)	1	(0,3%)
No especificado	24	(8,3%)	37	(11,9%)

En el enlace https://epideque.shinyapps.io/networks/ se muestra la red de los artículos retractados por cualquier causa, restringido a los clústeres formados por más de cinco elementos relacionados entre sí mediante sus citas y referencias. En gris se muestran los artículos primarios y en naranja y verde las citas y referencias, respectivamente (

Figura **5**). Destacan tres grandes clústeres formados por 53, 48 y 44 artículos retractados relacionados entre sí. El análisis adicional restringido a clústeres formados por más de 45 elementos, incluyendo todas las referencias y citas independientemente de que se encontraran retractadas o no, arrojó un gran clúster de 2,530 artículos relacionados entre sí. Este clúster relaciona 174 artículos primarios (i.e. retractados por paper mills) (41,8% de los incluidos), 203 citas y referencias retractadas por paper mills o con

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sospecha (42,9% de las identificadas), y 38 citas y referencias retractadas por otra causa (27,3% de las identificadas).

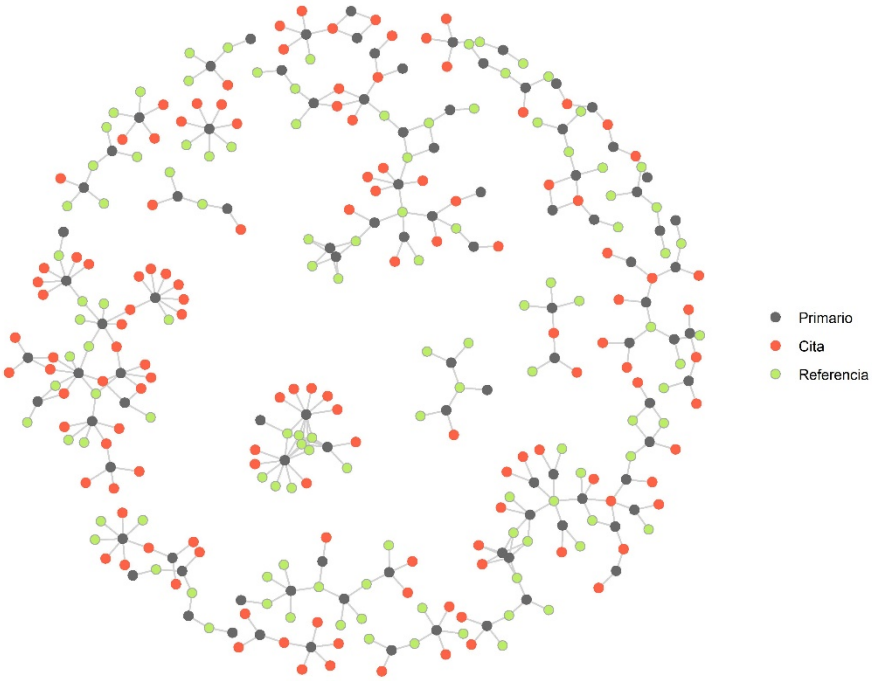


Figura 5. Red de artículos primarios interconectados entre sí mediante sus referencias y citas retractadas.

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PARTE V: DISCUSIÓN

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5. DISCUSIÓN

5.1. DISCUSIÓN DE LA METODOLOGÍA

Uno de los objetivos principales de esta tesis consiste en analizar la situación de la mala conducta científica en países específicos, así como analizar las características y el impacto de las propias retractaciones. Para ello, los resultados principales de la tesis provienen del análisis de retractaciones.

El análisis de las retractaciones puede funcionar como un indicador de la mala conducta científica. Anteriormente, diversos autores han utilizado el análisis de las retractaciones para describir la situación de la mala conducta científica en global (21, 27, 28, 86, 87), en un país específico (29-32, 64, 66, 88, 89) o en áreas de conocimiento específicas (90-93).

Sin embargo, el análisis de las retractaciones presenta limitaciones, por lo que los resultados de los estudios basados en este método se deben interpretar con cautela. Al analizar las características y causas de las retractaciones, estamos analizando solamente aquellos casos de mala conducta científica o error que han sido identificados tras la publicación y que han sido retractados. Las publicaciones retractadas podrían ser la punta del iceberg. Lo más probable es que muchas publicaciones con mala conducta científica o error no hayan sido identificadas por el momento, y que por lo tanto no hayan sido retractadas. Incluso es posible que muchos artículos que contienen mala conducta científica o error nunca sean retractados (94). No es posible conocer el número de publicaciones con mala conducta científica no detectadas que circulan por la literatura científica, pero Retraction Watch estima que deberían ocurrir al menos 100.000 retractaciones cada año (en 2022 se retractaron 5.500 artículos científicos), si bien otros investigadores creen que esta cifra es una infraestimación del alcance real (95). Podría ser que, en el hipotético caso de poder analizar todas las publicaciones con mala conducta científica o error susceptibles de ser retractadas, los resultados relativos a las características y causas más frecuentes de retractación y de mala conducta científica puedan cambiar.

Cabe mencionar que, a pesar de las limitaciones de este método, por el momento no existe ningún otro indicador que nos permita aproximar la realidad de la mala conducta

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científica de forma efectiva. Además, el análisis de retractaciones tiene la ventaja de permitir el análisis del fenómeno de mala conducta científica en función del país de los autores, de las instituciones y del ámbito de conocimiento, entre otros aspectos. Esto es interesante de cara a conocer la situación en contextos específicos y actuar con medidas ajustadas a dichos contextos (96). Además, hay que tener en cuenta que se ha utilizado la base de datos más completa en cuanto a retractaciones que existe por el momento. La base de datos Retraction Watch se considera la principal fuente de información en relación con las retractaciones y el *gold standard* en cuanto a información agregada sobre artículos retractados (86). Por lo tanto, consideramos que el número de retractaciones no identificadas o perdidas es mínimo.

Además del análisis de retractaciones, otra perspectiva útil y complementaria del fenómeno de la mala conducta científica es conocer las percepciones, actitudes y experiencias de los investigadores. Estos estudios, que se vienen realizando desde hace décadas (68), se basan en entrevistas o, como en el caso de esta tesis, en un cuestionario anónimo (23, 68-74, 97). El tema abordado en el cuestionario es delicado y considerado como un tema "tabú", lo que puede derivar en un sesgo de deseabilidad social. A pesar de que en el estudio realizado se ha logrado mantener el completo anonimato de los participantes, es posible que en algún caso no se haya reportado información sobre la participación en prácticas calificadas como mala conducta científica. Debido a esto, es posible que la frecuencia autorreportada de mala conducta científica observada en el estudio se haya infraestimado. Adicionalmente, la muestra analizada no es representativa de la población a estudio (investigadores de ciencias de la salud), principalmente debido al método de muestreo y a la tasa de participación. Desconocemos el volumen total de personas que recibieron la encuesta a través de las sociedades e instituciones de investigación y, por lo tanto, desconocemos la tasa de participación, aunque previsiblemente ha sido baja. La infraestimación de la mala conducta y la baja participación han sido previamente señaladas como limitaciones comunes en este tipo de estudios (32, 69, 73).

La definición de mala conducta científica y las prácticas que en ella se incluyen ha sido objeto de debate en la comunidad científica desde hace años (98, 99). No existe, por el momento, una definición universalmente aceptada por todos y cada institución tiene su propia definición (100). La definición conocida como tradicional es que incluye la fabricación, la falsificación y el plagio como mala conducta científica (98). Esta

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definición es la adoptada por la ORI estadounidense. Otras instituciones, como el CSIC de España (11) o ALLEA (10) entre otras (100, 101), hablan de otras prácticas que, si bien no son fabricación, falsificación o plagio, también constituyen mala conducta científica. Consideramos que limitar la mala conducta científica a la definición tradicional (fabricación, falsificación y plagio) no representaría adecuadamente el problema. Por ello, las causas de mala conducta científica utilizadas en los estudios incluidos en esta tesis son más amplias que las utilizadas en otros estudios similares de análisis de retractaciones (26, 65, 92) y de percepciones de los investigadores (73). Sin embargo, cabe mencionar que la mayoría de los estudios que analizaron percepciones, actitudes y experiencias de los investigadores también adoptaron una visión amplia de la mala conducta científica (32, 69, 89). Esto se podría deber a que gran parte de estos estudios se basaron en el cuestionario SMQ-R, que incluye un amplio abanico de prácticas más allá de fabricación, falsificación y plagio (67).

En esta tesis, la mala conducta científica se interpreta como cualquier práctica o conducta que socave los principios de integridad científica y que tenga potenciales consecuencias para la ciencia. En este sentido, la definición de mala conducta científica usada en esta tesis incluye fabricación, falsificación y plagio, pero también otras prácticas conocidas comúnmente como prácticas cuestionables o inaceptables (98). Creemos que la definición usada es una ventaja, pues permite una descripción más adecuada del problema. Si bien, también tiene una desventaja, pues limita la comparabilidad de nuestros resultados con los de otros estudios realizados sobre el mismo tema.

Que sepamos, nuestro estudio sobre el impacto de la retractación en las citas es el primero que analiza este fenómeno usando un diseño cuasiexperimental de evaluación pre-post. La principal ventaja de usar este tipo de diseño recae en la comparabilidad entre los periodos pre-retractación y post-retractación, eliminando la variabilidad en las características de los artículos. Otros estudios con el mismo objetivo han usado un diseño de casos y controles (54, 102), donde los controles eran artículos publicados y no retractados, por lo que existe la posibilidad de que haya variabilidad entre las características de los casos y de los controles, a pesar de estar emparejados. Junto con el diseño, el establecimiento de un periodo mínimo durante el cual el artículo debía estar publicado antes de la retractación es la principal fortaleza de nuestro estudio. Este criterio de inclusión no se ha encontrado en otros estudios relacionados con el tema. Por otro lado, la comparación entre el periodo pre-retractación y el periodo post-retractación

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equivalente nos permite comparar el número de citas recibidas por cada artículo durante el mismo periodo de tiempo antes de la retractación y después de la retractación. A diferencia de nuestro estudio, otras investigaciones con objetivos similares no han considerado los primeros meses tras la retractación como periodo post-retractación (12, 102-105). Esto se debe a que es posible que en el momento de la retractación de un artículo, ya haya otros artículos aceptados para su publicación que hayan hecho referencia al artículo retractado antes de que la retractación sea efectiva. Sin embargo, debido a los retrasos en la publicación, esto puede ser registrado como una cita posterior a la retractación. Es necesario mencionar que no hay consenso sobre lo que debería durar ese periodo. Investigaciones previas han usado un mes después de la retractación (102), mientras que otras usan seis meses (105) o un año (12, 104). Esto puede afectar a la comparabilidad de resultados entre estudios.

Los estudios relativos al análisis de los paper mills son novedosos. Este fenómeno es un tipo relativamente nuevo de mala conducta científica y que se ha comenzado a identificar masivamente a partir del año 2020 (106). Sin embargo, aunque existen algunos artículos e informes sobre el tema (37, 88, 107, 108), poco se conoce de las organizaciones, su modus operandi y sus revistas e investigadores objetivo. El primer estudio incluido en esta tesis sobre paper mills analiza la evolución y las características de estos estudios usando un diseño descriptivo. Es el primer estudio, que sepamos, que analiza formalmente este fenómeno. Para identificar los artículos procedentes de paper mills se usó la base de datos Retraction Watch, lo que constituye una ventaja. Tras el análisis de citas de dicho estudio, observamos un patrón extraño de citas en esos artículos. Debido a esto, se llevó a cabo el análisis de las citas y referencias de los artículos retractados por proceder de paper mills. Que sepamos, es el primer estudio que analiza de forma detallada este fenómeno. Cabe mencionar que el estudio que realizamos incluyó a los artículos originales retractados en 2022, a diferencia del estudio anterior que incluyó todos los artículos paper mills. Este criterio se debe principalmente a restringir el tamaño muestral para hacer los datos manejables. Aun así, dicho estudio incluyó 416 artículos primarios y más de 23.000 referencias y citas. Además, de cara a establecer un tiempo mínimo durante el cual el artículo habría podido recibir citas, se incluyeron aquellos que habían estado publicados al menos durante un año antes de la retractación. El periodo de un año puede haber resultado insuficiente, pues las publicaciones científicas suelen tardar años en recibir citas (109) y algunas nunca son citadas (110). Una ventaja de nuestro

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estudio es la representación de las redes formadas por los artículos retractados por paper mills y sus citas y referencias de manera visual. Además, las redes generadas en este estudio se encuentran disponibles para su consulta (https://epideque.shinyapps.io/networks/).

Cabe mencionar que las redes analizadas se enfocaron exclusivamente en las referencias y citas de los artículos primarios, sin incluir las referencias y citas de los "artículos secundarios" (i.e las referencias y citas de las referencias y citas de los artículos primarios). Esto podría infraestimar la relación de los diferentes artículos incluidos. En futuros estudios se debería valorar la inclusión de ambas direcciones en la red de referencias y citas para tener una visión más completa. Además, futuros estudios deberían valorar la inclusión de un grupo control de artículos no retractados con el objetivo de evaluar si los resultados difieren en cuanto al análisis de las referencias y citas de paper mills.

Las conclusiones de los estudios realizados sobre paper mills en el contexto de esta tesis pueden variar a medida que se vayan identificando y retractando más estudios procedentes de estas organizaciones. Por tanto, resultaría interesante llevar a cabo un seguimiento de las retractaciones relacionadas con este tema y actualizar periódicamente los resultados. Una posible forma de hacerlo sería mediante el uso de la misma aplicación desarrollada para el estudio de redes que se encuentra incluida en esta tesis. De esta manera, se podría actualizar la información extrayendo datos directamente de la base de datos de Retraction Watch y WOS. Esto permitiría crear mapas y redes interactivas similares a los que se utilizaron en el análisis bibliométrico de las publicaciones indexadas en PubMed realizado por González-Márquez et al. (111).

Finalmente, el estudio que analiza las publicaciones relacionadas con el COVID-19 presenta como principal ventaja el diseño de casos y controles. El diseño de casos y controles ha permitido la comparación de los estudios publicados en función de la revista, y por tanto del comité editorial, la posición relativa de la revista en JCR y el área de conocimiento. Este diseño ha facilitado la comparación de las características de los estudios COVID-19 y no COVID-19 al eliminar la variabilidad en el proceso editorial de cada revista. Sin embargo, el tamaño muestral de este estudio es bajo para su diseño. Esto se debe principalmente al bajo número de artículos científicos sobre COVID-19 identificados en las revistas, a pesar de que el periodo de estudio comenzó en marzo de 2020 y terminó en enero de 2021. Es posible que esto se deba principalmente al criterio

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de inclusión que establece que los artículos deben ser originales. Durante el periodo de estudio, una gran parte de las publicaciones sobre COVID-19 eran editoriales o cartas al editor (112), y por lo tanto, fueron excluidas de este estudio. Sin embargo, se ha establecido la inclusión de artículos originales pues estos deberían cumplir con estándares de calidad comunes. Habría sido interesante incluir otros aspectos relacionados con las características de los artículos y de los autores, como el sexo de éstos, sin embargo, este tipo de información es muy difícil de recoger (113). Si bien existen herramientas que usan inteligencia artificial para establecer, con un margen de error, el sexo de una persona en función del nombre, esto está todavía sujeto a errores, sobre todo en los sujetos con nombres de origen asiático (113), algo importante para tener en cuenta en este estudio, pues la gran mayoría de los autores procedían de China.

5.2. DISCUSIÓN DE LOS RESULTADOS

Los resultados de esta tesis ponen de manifiesto que las retractaciones de publicaciones científicas continúan mostrando una tendencia ascendente, tal y como han descrito investigaciones previas (14, 21, 86). Además, no parece que la frecuencia en las retractaciones vaya a disminuir por el momento. Al igual que en otros países (26, 114), en España se observa claramente que el aumento en el número total de retractaciones se debe principalmente al aumento de retractaciones por mala conducta científica, mientras que el número de retractaciones por error se mantiene constante y en números relativamente bajos. Sin embargo, otros estudios no coinciden con nuestros resultados. Por ejemplo, un estudio llevado a cabo por Steen et al. (115) analizó la evolución de las retractaciones por mala conducta y por error indexadas en PubMed entre 1970 y 2015, teniendo en cuenta el aumento en el número de publicaciones y observó que las retractaciones categorizadas como por error superaban a las de mala conducta. Esto puede deberse a que en dicho estudio la mala conducta se entendió como fabricación y falsificación, mientras que el resto de las prácticas se agruparon en la categoría error.

El análisis de las retractaciones de países específicos realizado en esta tesis, esto es en España, Portugal y Brasil, encuentran que la mala conducta científica es la principal causa de retractación de artículos científicos, especialmente entre los artículos pertenecientes al ámbito de la biomedicina. Nuestros resultados coinciden con los reportados por una revisión sistemática previa de estudios retractados en Brasil (65), con otro estudio científico realizado en el contexto español (64) y con un estudio llevado a

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cabo en países europeos (18). En el caso de Portugal, este es el primer estudio que analiza detalladamente las retractaciones de los autores portugueses; si bien, debido al limitado tamaño muestral, es necesario interpretar los resultados con cautela.

A pesar de que el aumento de las retractaciones por mala conducta científica parece ser universal, la causa no es clara. Una de las explicaciones que se encuentran a debate es la teoría de la manzana podrida (o *bad apple*, en inglés). Esta teoría establece que la mala conducta científica está siendo perpetuada por unos pocos individuos (manzanas podridas). Un estudio previo concluyó que los investigadores de China identifican la teoría de la manzana podrida como uno de los principales determinantes de la mala conducta científica (116). Sin embargo, en ese mismo estudio (116), los investigadores de Bélgica culpan a la presión por publicar, que surge de la presión que tienen los autores por producir artículos científicos para conseguir financiación o contratos de investigación, así como para progresar en la carrera académica. Si bien la presión por publicar está ampliamente aceptada como causa del aumento de retractaciones por parte de la comunidad científica, existen estudios previos, como el de Lacetera y Zirulia (117) o el de Fanelli (33), que establecieron que la presión por publicar no aumenta la mala conducta científica. Incluso Lacetera y Zirulia (117) refieren que puede ser un factor que disminuya el problema al aumentar el escrutinio de los investigadores.

La presión por publicar está relacionada con el sistema de evaluación de los investigadores. En España, al igual que en otros países, la evaluación recae en parte en el número de publicaciones, así como del número de citas recibidas (118). Esto podría aumentar la presión que sienten los investigadores por publicar y a su vez aumentar la probabilidad de que incurran en prácticas no éticas para tomar "atajos". Sin embargo, parece que algo está cambiando en el mundo académico en este sentido. Por ejemplo, muchos países e instituciones han adoptado la declaración DORA (*San Francisco Declaration on Research Assessment)* (119). La declaración DORA pretende cambiar la cantidad por la calidad en lo que refiere a las publicaciones científicas. En este contexto, también es importante mencionar la existencia de CoARA (*Coalition for Advancing Research Assessment*), que comparte objetivos similares a los establecidos en la declaración DORA (120). Ambas refieren que es más importante el impacto y la influencia de un investigador en un campo de conocimiento específico, y no tanto el número de publicaciones que tenga. En España, los proyectos de investigación biomédica del Instituto de Salud Carlos III han adoptado recientemente la declaración DORA. A partir

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de 2023, el investigador principal que solicita el proyecto deberá incluir las 10 aportaciones más relevantes en su área de conocimiento y serán esas las que se evalúen de cara a financiar un proyecto. Otros países, como el Reino Unido, han implementado recientemente iniciativas en este sentido, como el currículo vitae narrativo, que reduce la importancia de las métricas tradicionales (el índice H o el factor de impacto de las revistas), para centrarse en la calidad de las contribuciones científicas (121).

La duplicación y el plagio parecen ser los problemas más prevalentes en los países analizados. Esto es consistente con la literatura previa en el caso de Brasil (29, 122, 123). En España, Dal-Ré et al cuantificaron que el 35% de todas las retractaciones biomédicas entre 1970 y 2018 se debieron a duplicación, un porcentaje similar al obtenido en nuestro estudio, aunque nuestra investigación amplió el periodo de estudio hasta principios de 2023 (64). Curiosamente, Marco-Cuenca et al (15) identificaron la fabricación y falsificación como la principal causa de retractación en España en artículos biomédicos durante el mismo periodo de tiempo. Esto se debe principalmente a la categorización de mala conducta y error. Marco-Cuenca et al (15) dividieron la duplicación en dos motivos diferentes (duplicación de imágenes y duplicación de texto) y este es el motivo de las diferencias encontradas entre artículos. Cabe mencionar que los resultados de esta tesis sitúan la fabricación y falsificación como segunda causa más frecuente de retractación entre los artículos biomédicos. Esto es preocupante, pues la fabricación y falsificación se ha calificado como el tipo más extremo de mala conducta científica (124), que puede tener consecuencias negativas no solo para la evidencia científica, sino también para la población, especialmente si nos referimos al ámbito biomédico (125).

Aunque los resultados de esta tesis han identificado la duplicación y plagio como los tipos más frecuentes de mala conducta en España, Portugal y Brasil, esto parece variar entre países (26), y esta variabilidad puede deberse en parte a factores socioculturales y educativos (33, 34). Históricamente, los países del sur de Europa han estado asociados con una mayor presencia de duplicación y plagio, mientras que en países del norte de Europa y Norteamérica se registra una menor prevalencia de estos tipos de mala conducta científica (18, 26). Un estudio previo observó que los países del sur de Europa perciben la duplicación y el plagio de forma diferente a los países del norte (126). Destaca que un estudio estimó que casi la mitad de los estudiantes europeos reconocieron haber plagiado materiales (127). Sin embargo, es importante destacar que, el 82,7% de los investigadores españoles que participaron en nuestro estudio, percibieron el plagio como una práctica

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grave. A pesar de esto, el plagio fue considerado como una de las prácticas no éticas más comunes en publicaciones científicas por los investigadores españoles; los análisis de retractaciones realizados también coinciden con la elevada frecuencia de esta práctica en nuestro contexto. Esto podría sugerir que el plagio se encuentra en gran medida normalizado en el contexto académico. Los resultados de esta tesis también muestran esta normalización en cuanto a la falsa autoría. El 18,4% de los investigadores españoles encuestados consideran la falsa autoría normal y el 50,3% no lo ven bien pero no harían nada para evitarlo. En este contexto, se resalta la importancia de la educación en ética en todos los niveles académicos como una medida para abordar y prevenir la mala conducta científica y promover prácticas éticas en la investigación (33). Una herramienta útil podría ser la implementación sistemática de software anti-plagio desde niveles educativos tempranos, como la educación secundaria.

Además de por países, los principales tipos de mala conducta científica parecen variar dentro del mismo país en función de diferentes características de los investigadores. Los resultados de esta tesis muestran diferencias en el tipo más frecuente de mala conducta científica (tanto autorreportada como observada) en función del género y tipo de institución de filiación del investigador. En cuanto al género, nuestros resultados difieren con estudios previos, que no habían encontrado diferencias significativas (33, 69, 71). Otros estudios, al igual que el nuestro, habían observado diferencias según el tipo de institución (71). Así, nuestros resultados muestran que un mayor porcentaje de sujetos que trabajan en centros de investigación declararon haber participado intencionadamente en la fabricación y/o falsificación. En los centros hospitalarios, en cambio, la no declaración de conflictos de intereses, la falta de consentimiento informado y la presión de los patrocinadores del estudio parecen ser los tipos de mala conducta científica más frecuentes. Es posible que una interacción más directa entre los investigadores clínicos y la industria en el ámbito hospitalario aumente la influencia de la industria. De hecho, Ziai et al. (128) observaron que los investigadores del ámbito clínico son reacios a declarar conflictos de intereses con la industria. En las instituciones académicas, la falsificación del currículum vitae y la falsa autoría son los tipos más frecuentes de mala conducta. Estos resultados coinciden con los reportados por Godecharle et al. (32), que identificaron una prevalencia observada de falsa autoría del 76% en el ámbito académico frente al 50% en la industria, observándose también esta misma diferencia en la prevalencia autorreportada. Esto podría explicarse por la competencia por la financiación, el

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reconocimiento y las oportunidades de ascenso en la carrera investigadora, aspectos basados en el número de artículos publicados por los investigadores. Estos resultados subrayan la importancia de abordar la mala conducta científica teniendo en cuenta el contexto específico de cada institución, incluso dentro de un mismo país.

Los resultados de esta tesis confirman que el fenómeno de paper mills está en auge. Entre 2017 y 2019, el número de publicaciones procedentes de organizaciones paper mills se duplicó, pasando de 5 a 10 por cada 100.000 publicaciones. En cuanto a las características de los paper mills, la mayoría de los autores de estos artículos procedían de China, aunque también destacaron en número las autorías de Rusia, Bangladesh, Bulgaria, Irán o India. Este resultado indica que el uso de las organizaciones paper mills se ha extendido de forma global. En el caso de España, por el momento, no existe ninguna retractación de un artículo paper mills en el que aparezca un investigador español como autor. Sin embargo, en la encuesta realizada a los investigadores, 12 personas reconocieron que usaron los servicios de estas organizaciones. Este resultado indica la necesidad de una mayor vigilancia por parte de las instituciones y revistas científicas, con vistas a su detección.

El fenómeno paper mill afecta especialmente a los investigadores afiliados a un hospital y a las revistas legítimas, pues no parece ser exclusivo de las revistas depredadoras. Además, se ha observado que solo un 3,4% de los emails de correspondencia proporcionados por los autores están asociados a una institución (universidad, hospital o centro de investigación, entre otros). Estas características coinciden con las reportadas por otros investigadores (37, 106, 108, 129), así como por organizaciones internacionales como el ICMJE (107). La identificación de características típicas de artículos generados por paper mills puede ser clave para atajar el problema. La detección de estas características en los artículos enviados a una revista para su publicación puede alertar a los editores y revisores sobre la posibilidad de que el artículo provenga de un paper mills y, por tanto, de que no cumpla con los estándares científicos necesarios para su publicación. En consecuencia, se pueden tomar medidas para llevar a cabo una revisión más exhaustiva o incluso rechazar de entrada el artículo. Además de las características ya mencionadas, otras pueden ser la detección de "frases torturadas" (i.e. una frase extraña que aparece en lugar de la expresión comúnmente usada) (130), la inclusión de gráficos "muy limpios" (particularmente los gráficos *western blots*) o la falta de aprobación del estudio por parte de un comité de ética en investigación (107).

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Además, nuestro estudio resalta dos cuestiones relativas a las citas de los artículos paper mill. Por un lado, son artículos ampliamente citados, con las consecuencias que eso supone. Por otro lado, se observa que el patrón de cita de dichos artículos es extraño, pues la mayoría de las citas recibidas provienen de revistas en tercer y cuarto cuartil. Este hecho no se suele observar en los análisis de citas realizados hasta el momento, incluso de artículos retractados. Al analizar las referencias y las citas de los artículos retractados por proceder de organizaciones paper mills, hemos observado la existencia de una relación entre los artículos paper mills. De acuerdo con nuestros resultados, un 41,9% de los artículos paper mills referenciaron al menos a un artículo retractado, mientras que un 42,8% recibieron citas de artículos retractados. Al analizar las causas de retractación de estas citas y referencias, aproximadamente un 77% procedían de organizaciones relacionadas con paper mills o existía una sospecha de que así fuera. Estos hallazgos van en la línea de investigaciones previas (108). Basándonos en estos resultados, es conveniente considerar la presencia de alguna referencia retractada proveniente de un paper mills o ser citado por otro artículo que también haya sido retractado debido a vínculos con paper mills como una señal de alerta. Esto puede ser particularmente útil para las revistas científicas, y debe ser tenido en cuenta durante el proceso de revisión de los artículos. La identificación de estos indicadores puede ayudar a prevenir la publicación de artículos de baja calidad o que siguen prácticas poco éticas, así como ayudar a la identificación de artículos paper mills ya publicados.

No todas las prácticas que pueden afectar la integridad de la ciencia se deben a la mala conducta científica. Además de las prácticas intencionadas que constituyen mala conducta, existe el riesgo de que situaciones específicas puedan influir en la calidad de la investigación. Este podría ser el caso de las citas post-retractación. Los resultados de esta tesis ponen de manifiesto que las publicaciones retractadas continúan siendo citadas tras la retractación. Además, investigaciones previas han observado que el 94% las citas post-retractación no informan del estado de retractado de la publicación (12). Este hecho tiene implicaciones importantes, pues significa la perduración de información errónea y/o fraudulenta en la literatura científica. Esta tesis es la primera investigación que identifica una disminución en las citas durante el período inmediatamente posterior a la retractación de un artículo, seguida de un posterior aumento en las citas. Una posible explicación de los resultados obtenidos en esta tesis es que, si un artículo retractado es citado en una publicación sin mencionar su estado de retractado, esto puede dar lugar a citas "de

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segunda mano". Esto significa citar un artículo que ha sido citado previamente por otro autor, sin haber accedido al original y desconociendo, por tanto, que se está citando un artículo retractado. Según el estudio de Simkin et al. (58), entre el 70% y el 90% de las citas se copian de referencias utilizadas en otros artículos. Estos resultados coinciden con lo reportado recientemente por De Cassai et al. (131), que realizaron una encuesta a investigadores que habían citado un artículo retractado y el 89% de los mismos refirieron no ser conocedores del estado de retractado de la publicación que citaron. Esto podría provocar una reacción en cadena y aumentar las citas de un artículo retractado tiempo después de su retractación.

En la misma línea, la pandemia del COVID-19 ha impactado de forma importante la investigación científica. Según nuestros resultados, los estudios COVID-19 publicados en los primeros meses de la pandemia tienen una mayor probabilidad de tener un diseño descriptivo y un menor tamaño muestral que los trabajos no COVID-19. Diferentes estudios han analizado la calidad de los trabajos COVID-19 utilizando diferentes métodos y todos coinciden en que, en general, su calidad es baja (48, 132, 133). Accorsi et al. (134) han identificado numerosos sesgos en los estudios observacionales relacionados con COVID-19 en aspectos como la interpretación de los resultados o la inclusión de una muestra no representativa de la población de estudio, entre otros. Esto plantea un problema, ya que los trabajos con baja calidad metodológica y mayor presencia de sesgos pueden inducir a los lectores a extraer conclusiones erróneas, lo que constituye, en sí mismo, una potencial amenaza para la salud. Incluso las autoridades sanitarias pueden basar sus decisiones en dicha evidencia científica generada y resultar en decisiones perjudiciales para la salud de la población. Por lo tanto, de cara a nuevas situaciones que puedan impactar en la rigurosidad de la evidencia científica, es necesario establecer mecanismos que aseguren la calidad de la literatura científica con el objetivo de orientar la toma de decisiones. La urgencia con la que se necesita la información no debe ser excusa para llevar a cabo investigaciones de baja calidad, que en última instancia son de poca utilidad, conducen a un desperdicio de recursos de investigación, e incluso pueden suponer una amenaza para la salud.

Tanto la mala conducta científica como la denominada *bad science*, que se refiere a la investigación de baja calidad y sesgada, representan una amenaza creciente para el conocimiento científico. En este contexto, se hace necesario desarrollar y poner en marcha estrategias y mecanismos desde diversos ámbitos que contribuyan a prevenir,

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detectar e incluso sancionar estas prácticas. Idealmente, estas iniciativas deberían ser implementadas a nivel nacional (135), dado que cada región parece tener particularidades en cuanto a la mala conducta científica. Incluso hay autores que sugieren que dichas iniciativas se deberían implementar a nivel de institución (135). La recopilación de datos y la caracterización de las retractaciones a nivel nacional pueden resultar útiles para diseñar estrategias adaptadas a la situación y al contexto específico de cada país, que finalmente resulten más eficaces de cara a atajar el problema.

En esta línea, las oficinas nacionales de integridad científica desempeñan un papel esencial. En el contexto europeo, en 2007 se creó ENRIO (63), cuyo objetivo es hacer de unión entre las oficinas integridad en la investigación de todos los países europeos, si bien desempeña un papel principalmente consultivo. Por tanto, habría espacio para la creación de una oficina de integridad científica a nivel europeo, que también actúe como un enlace entre las oficinas nacionales pero que tenga la autoridad para investigar y aplicar sanciones en casos internacionales. Dicha oficina podría ejercer un efecto disuasorio sobre los investigadores europeos que puedan considerar la posibilidad de incurrir en mala conducta científica. La creación de una entidad de este tipo con poder ejecutivo podría contribuir a estandarizar y unificar el manejo y regulación de la mala conducta científica en toda Europa. No sería lógico que en diferentes países se apliquen sanciones diferentes para la misma práctica no ética. Además, una entidad europea de integridad científica podría desempeñar un papel fundamental en la homogeneización de los estándares éticos en la investigación científica.

Por otro lado, es importante destacar que algunos países aún no han establecido un organismo dedicado a supervisar la integridad de la investigación científica a nivel nacional. Este es el caso de España, donde la responsabilidad de supervisar la ética en la investigación recae en las instituciones de los investigadores y los centros de investigación, lo que conlleva ciertas desventajas, ya previamente mencionadas. Es relevante destacar en este punto que investigaciones previas han señalado que la ausencia de políticas nacionales contra la mala conducta científica está asociada con una mayor probabilidad de retractación debido a conductas impropias en la investigación (33). Considerando esto, así como el contexto a nivel español, se identifica la necesidad de establecer una oficina nacional en España encargada de supervisar la conducta en la investigación. Esta oficina debería actuar de manera independiente en los casos de mala conducta detectados y proponer sanciones públicas. Además, su labor debería incluir un

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componente educativo dirigido a investigadores y estudiantes, especialmente en el campo de las ciencias de la salud, con el propósito de promover las buenas prácticas en la investigación científica. Cabe mencionar que recientemente se ha creado el Comité Español de Ética de la Investigación por parte del Ministerio de Ciencia, Tecnología e Innovación. Sin embargo, en el Real Decreto 53/2023 (136), por el cual es establecen sus funciones, se especifica que este órgano es de carácter consultivo y no tiene poder ejecutivo. Dicho Comité podría suponer un buen punto de partida, sin embargo, es necesario que cuente con autoridad para investigar y sancionar, así como asuma la promoción de la integridad científica y la educación en ética de la investigación.

Más allá de la visión nacional, las diferentes partes responsables de mantener la integridad científica, incluyendo instituciones académicas, órganos que financian investigación y revistas científicas, deben colaborar estrechamente a nivel internacional.

Las instituciones académicas tienen una oportunidad fundamental para prevenir la mala conducta científica al promover la educación en ética y la investigación ética. Aunque en los últimos años algunas instituciones han comenzado a tomar medidas para abordar este problema, en parte impulsadas por iniciativas a nivel europeo (137), todavía hay mucho trabajo por hacer en este sentido. Es esencial promover la transparencia dentro de las instituciones académicas, un área que aún requiere atención (59). Además, la falta de recursos económicos y humanos supone un problema de cara a manejar las acusaciones de mala conducta científica de manera eficaz. Sería interesante que, de manera similar a las revistas científicas, que cuentan con organismos internacionales de referencia, las instituciones académicas también establecieran estructuras similares para garantizar la ética en la investigación.

Por otro lado, las revistas científicas también juegan un papel fundamental en la prevención de la difusión de información errónea o fraudulenta. Desde las revistas científicas, parece que cada vez hay más concienciación sobre este tema y muchas de ellas, principalmente las más importantes en su ámbito de conocimiento, han implementado acciones encaminadas a prevenir la mala conducta. Sin embargo, es necesario reconocer que las medidas implementadas no parecen tener el impacto deseado, pues no se ve un descenso en la frecuencia de mala conducta científica. Por ello, es posible que las estrategias adicionales que se han presentado en esta tesis tampoco sirvan para resolver el problema definitivamente. Por ejemplo, el uso de nuevas tecnologías, como la inteligencia artificial, podría beneficiar a las revistas científicas a la hora de detectar mala

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conducta científica y de realizar revisión por pares (138). A la vez, es imprescindible valorar estrategias que resuelvan la raíz del problema. Es esencial un compromiso para reducir la prevalencia de la mala conducta científica. Este compromiso debe extenderse no sólo a las revistas y las instituciones, sino también a los investigadores y a los órganos que financian investigación.

5.3. FORTALEZAS

La principal fortaleza de esta tesis radica en la diversidad de diseños epidemiológicos empleados en los artículos originales que la componen. Se han llevado a cabo diversos estudios transversales, un estudio de casos y controles y un estudio cuasiexperimental de evaluación pre-post. También se han utilizado diferentes fuentes de información, destacando grandes bases de datos y una encuesta diseñada específicamente para esta tesis.

Otra fortaleza significativa de este trabajo es su enfoque integral para abordar el problema de la mala conducta científica. Por un lado, mediante el análisis de retractaciones, se ha cuantificado la frecuencia del problema y los diferentes tipos de mala conducta científica en nuestro país, y se ha extrapolado esta metodología a otros contextos geográficos para mostrar su utilidad y facilitar la comparativa entre países. No obstante, es importante reconocer que es posible que muchos casos de mala conducta no hayan sido identificados ni retractados, lo que podría llevar a una subestimación del problema. Por esta razón, se realizó una encuesta a investigadores españoles para confirmar los resultados obtenidos en el análisis de retractaciones. Además del abordaje del problema desde el punto de vista del investigador, se exploraron las perspectivas y posibles estrategias que pueden implementar revistas científicas, instituciones académicas y oficinas nacionales de integridad científica. Es relevante mencionar que esta tesis abordó nuevas formas de mala conducta científica, como el fenómeno de los paper mills, así como otras prácticas que pueden afectar la integridad de la evidencia científica, como las citaciones posteriores a la retractación y el impacto de la pandemia del COVID-19 en la investigación. Este enfoque amplio contribuye a una mejor caracterización del problema.

Finalmente, esta tesis incorpora dos estudios científicos novedosos a nivel internacional relacionados con los paper mills, lo que aporta un valor adicional a la comprensión de este fenómeno, del que se sabe muy poco, en el contexto científico.

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5.4. LIMITACIONES

La principal limitación de esta tesis radica en la posibilidad de que los resultados y conclusiones de los estudios puedan evolucionar con el tiempo. Una de las principales limitaciones de los estudios basados en artículos retractados es que, a medida que se identifiquen y retracten más artículos en el futuro, las conclusiones pueden cambiar e incluso ser opuestas a las que se describen en este trabajo. Esta perspectiva debe ser tenida en cuenta, ya que, con la disponibilidad de herramientas cada vez más avanzadas y una creciente preocupación global por la integridad científica por parte de la comunidad científica, es probable que se identifiquen cada vez más artículos que contengan errores o incurran en mala conducta científica. Por lo tanto, es esencial reconocer la necesidad de actualizar los resultados de esta tesis con el tiempo.

Una limitación adicional de esta tesis es que no se han evaluado detalladamente todos los tipos de mala conducta científica. Con el objetivo de hacer más simple el análisis y la interpretación de resultados, los estudios que se basan en el análisis de citas han analizado la mala conducta científica por bloques o tipos, y no por prácticas específicas. De esta manera, la falsa revisión por pares o los problemas de autoría no se han analizado independientemente, sino dentro de un grupo que incluye otras prácticas similares. Adicionalmente, el análisis de retractaciones se ha realizado a nivel nacional en solo tres países: España, Portugal y Brasil.

En los estudios incluidos en esta tesis no se ha llevado a cabo una evaluación en profundidad del impacto de la mala conducta en la población general, en la comunidad científica y en la investigación en sí misma. Debido a los resultados de este trabajo, se hace necesario que en el futuro se realicen estudios científicos que analicen las potenciales consecuencias que la mala conducta científica puede tener en la credibilidad en la investigación, en la confianza de la población en la ciencia, en la evidencia científica y en la salud de la población.

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PARTE VI: CONCLUSIONES

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6. CONCLUSIONES

- España no cuenta con una Oficina Nacional de Integridad Científica con autoridad para investigar y sancionar mala conducta científica. La creación de una oficina nacional con la capacidad de prevenir, detectar, sancionar y supervisar la mala conducta científica supondría un importante avance en materia de integridad científica en España.
- Aunque la mayoría de los países europeos han creado una Oficina Nacional de Integridad de la Investigación, estas organizaciones son de carácter consultivo y carecen de poder ejecutivo. La creación de una Oficina Europea de Integridad Científica uniría las oficinas nacionales y tendría autoridad para investigar y sancionar la mala conducta científica dentro del marco europeo.
- La duplicación y el plagio son los tipos más comunes de mala conducta científica en España, aunque la fabricación es el segundo más común en el ámbito biomédico. Se han asociado los tipos de mala conducta científica con las características de los investigadores. En Portugal y Brasil, la duplicación y el plagio también se han identificado como los tipos más comunes de mala conducta. La información proporcionada por estos análisis podría ser útil para que las instituciones pertinentes establezcan mecanismos efectivos contra la mala conducta, adaptados al contexto nacional.
- Las organizaciones de paper mills están en aumento. Los artículos retractados procedentes de estas organizaciones suelen estar caracterizados por incluir autores afiliados a hospitales en China y con correos electrónicos no institucionales. Referenciar o citar un artículo retractado de una organización paper mill es un indicador de un posible artículo de este tipo. Esta información podría utilizarse para desarrollar herramientas que identifiquen tales artículos, con el objetivo de prevenir su publicación.
- Las citas a artículos retractados no disminuyen después de su retractación. Es necesario determinar las razones por las que se citan artículos retractados, identificar a los autores que citan tales artículos retractados y establecer mecanismos para que las revistas detecten dichas citas de antemano.

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- Los artículos originales sobre COVID-19 publicados durante los primeros meses de la pandemia eran más frecuentemente observacionales y tenían un tamaño de muestra limitado en comparación con los artículos originales no relacionados con COVID-19. Estas características se asocian con una baja calidad metodológica. Es fundamental asegurar la calidad de la evidencia científica, especialmente en situaciones que afectan a la salud pública global, como epidemias y pandemias.
- La investigación continua en ética en publicación es clave para reducir la incidencia de la mala conducta científica. Además, es necesario mejorar la formación ética de estudiantes e investigadores para prevenirla.

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CONCLUSIONS

- Spain does not have a National Research Integrity Office with the authority to investigate and sanction scientific misconduct. The creation of a national office with power to prevent, detect, sanction and monitor scientific misconduct would be an important step forward.
- Although most European countries have created a National Office of Research Integrity, these organizations are advisory and without executive power. The creation of a European Office of Research Integrity would integrate the national offices and be able to investigate and sanction unethical conduct within a European framework.
- Duplication and plagiarism are in general the most common types of misconduct in Spain, although fabrication is the second most common in the biomedical field. Moreover, different types of scientific misconduct have been associated with the characteristics of researchers. In Portugal and Brazil, duplication and plagiarism have been also identified as the most common types of scientific misconduct. The information provided by these analyses may be useful for the relevant institutions to establish effective mechanisms against scientific misconduct, based on the national context.
- Paper mill organizations are on the rise. Retracted articles from such organizations are mainly characterized by authors affiliated with hospitals in China and with non-institutional email accounts. Referencing or citing a retracted article from a paper mill is an indicator of potential paper mill article. This information could be used to develop tools to identify such papers.
- Citations to retracted articles do not decrease after retraction. It is necessary to ascertain the reasons why a retracted article is cited, to identify the authors who are citing such retracted articles and to establish mechanisms for journals to detect such citations in advance.
- Original COVID-19 articles published during the early months of the pandemic were more likely to be observational and of limited sample size than original non-COVID-19 articles. These characteristics are associated with low methodological quality. It is imperative to ensure the quality of scientific evidence, especially in situations that affect global public health, such as epidemics and pandemics.

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- Continued research in publication ethics is key to reduce the incidence of scientific misconduct. In addition, improvement should be made in ethics training for students and researchers to prevent unethical behavior.

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PARTE VII: IMPLICACIONES

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7. IMPLICACIONES

La integridad científica es un pilar fundamental de la investigación y es un componente imprescindible en la generación de evidencia científica de calidad. La ética en la publicación científica se entiende como una parte de la integridad científica. En general, la evidencia científica en torno a la integridad científica y, aún más, en lo que respecta a la ética en la publicación, es limitada.

Esta tesis, centrada en la ética en la publicación científica, tiene como objetivo principal generar conocimiento en este ámbito. Los resultados de este trabajo son valiosos para las partes interesadas relacionadas con la ética en publicación científica. Por un lado, el conocimiento generado sobre los tipos más frecuentes de mala conducta científica y el perfil de investigador que incurre en mala conducta científica es útil para las instituciones nacionales que regulan la mala conducta científica, facilitando el desarrollo e implementación de mecanismos eficaces orientados hacia su prevención, detección y sanción. Tanto las entidades reguladoras de mala conducta científica como las instituciones de los investigadores deben comprometerse en mayor medida con la lucha contra la mala conducta científica. Es necesario que se vuelquen en la formación en ética de sus investigadores, lo que hará que en el futuro parte de la mala conducta científica se pueda prevenir. Además, se hace evidente la necesidad de que las agencias financiadoras de investigación se impliquen en la supervisión de la ciencia.

Este trabajo aborda diversas prácticas no éticas que pueden afectar a la publicación en ciencia, como el auge de organizaciones paper mills. Los resultados de esta tesis pueden alertar a los editores de revistas científicas e instarlos a ser más vigilantes para evitar la difusión de artículos paper mills y otros tipos de mala conducta. Además, pone de manifiesto la necesidad de formación de editores y revisores de revistas científicas, no solo haciendo hincapié en la ética en publicación en general, sino también actualizando sus conocimientos sobre nuevos tipos de fraude en ciencia. Los resultados de esta tesis también pueden ser utilizados para desarrollar herramientas que faciliten la identificación de los artículos paper mills, que podrían ser utilizadas por las revistas científicas.

Finalmente, las publicaciones de esta tesis contribuyen a colocar la ética en la publicación científica en el centro de atención de la comunidad científica, tanto a nivel

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nacional como internacional. Esto es importante dado que, hasta hace poco, la ética en publicación científica era un tema relativamente desconocido y poco investigado. A medida que se avanza en la investigación en ética en publicación científica, se promueve el diálogo y la reflexión, no solo en medios de difusión de conocimiento científico, sino también en medios de comunicación. Esto hará que aumente la visibilidad y el reconocimiento de la ética en publicación como un pilar fundamental de la investigación y, consecuentemente, se reduzcan las prácticas no éticas.

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PARTE VIII: REFERENCIAS

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PARTE IX: ANEXOS

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9.3. APROBACIÓN DEL COMITÉ DE BIOÉTICA

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JOSÉ MANUEL CIFUENTES MARTÍNEZ, PRESIDENTE DO COMITÉ DE BIOÉTICA DA UNIVERSIDADE DE SANTIAGO DE COMPOSTELA,

INFORMA:

O Comité de Bioética da USC ten ponderado os aspectos metodolóxicos, éticos e legais do proxecto de investigación cuxos datos se refiren a continuación, e se teñen avaliado a cualificación do investigador responsable e do equipo investigador, así como as posibilidades do proxecto conforme a lexislación vixente.

Por todo elo o Comité **ACORDA** a emisión de **INFORME FAVORABLE**

Título do proxecto: **Fraude y mala conducta científica: la percepción de investigadores en ciencias de la salud en España/ Fraude e mala conduta científica: a percepción de investigadores en ciencias da saúde en España.**

Código: **USC 37/2022**

Investigador responsable: **Alberto Ruano Raviña**

Lugo, 13 de setembro de 2022.



9.4. ARTÍCULOS PUBLICADOS O ACEPTADOS

Artículo 1. Candal-Pedreira C, Ruano-Ravina A, Pérez-Ríos M. **Should the European Union have an office of research integrity?** Eur J Intern Med. 2021;94:1-3. doi: 10.1016/j.ejim.2021.07.009.

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Ideas and Opinions

Should the European Union have an office of research integrity?

Scientific misconduct is detrimental to both society and researchers, potentially resulting in a mistrust in science. When the results of a scientific publication are based on erroneous content or data, whether due to error or misconduct, the publication must be retracted. The retraction of a publication alerts the scientific community that its results and conclusions may not be valid [1]. Over the last 20 years, retractions due to misconduct have increased, surpassing the number of retractions due to honest error and becoming the leading cause of retraction at present [2]. Notorious cases of retraction in biomedicine have had a great impact on the public opinion and even on health policies. One example is the recent Surgisphere case which caused the World Health Organization (WHO) to suspend all clinical trials studying hydroxicloquine as a treatment against COVID-19 [3].

In addition, the costs associated with the retraction of a publication must be considered. Scientific misconduct entails direct costs, such as legal fees or costs related with institutional board meetings; and indirect costs, related to the damage caused to reputation of the institution and its members which could lead to less funding in the future. It has been estimated that each retraction of a publication costs $425,073 to the U.S. National Institutes of Health (NIH).

Recent cases of scientific misconduct have brought already existing breaches in the scientific integrity to light. This highlights the need for more efficient and strict mechanisms to prevent, detect and sanction misconduct. These mechanisms should focus on monitoring both publicly funded investigations and those conducted by contracted researchers. It is of particular importance in countries or supranational institutions, like the European Union (EU), which spend significant resources to fund research.

Retraction due to misconduct and entities which supervise ethics in scientific publication

Although it is true that retractions due to misconduct are more frequent in countries like USA or Japan, misconduct also occurs in European countries. According to Li et al, 14% of publications retracted due to misconduct between 1980 and 2016 were authored by German researchers [4].

In the database Retraction Watch, there are 923 publications retracted due to misconduct written by European authors, including some which attracted media attention like the Boldt or Reuben cases [5]. However, the number of fraudulent publications could be much higher. It is widely believed that retracted publications due to misconduct are just the tip of the iceberg.

Some countries have organisms exclusively dedicated to monitor scientific integrity. In the USA, the U.S. Office of Research Integrity (ORI) was created in 1993 to handle scientific misconduct nationally. The ORI has the authority to conduct investigations, supervise institutional investigations and impose sanctions in cases where misconduct is suspected [6]. Table 1 shows the latest cases of misconduct investigated by the ORI and the imposed sanctions.

On a European level, the European Network or Research Integrity Offices (ENRIO) was established in 2007, and its aim is to connect research integrity offices or committees among all the European countries. Its principal functions are to promote research integrity and to act as an advisory body to institutions which require it. However, not all the European countries have research integrity offices or committees. As a result, the European Federation of Academies of Sciences and Humanities (ALLEA) has recommended that European countries to configure such committees nationally [7]. Some countries, such as France or the UK, have followed this recommendation and have created structures to manage research integrity nationally (Table 2). However, these structures have different functions depending on the country. While several of them act simply as an advisory body in misconduct cases, some are authorized to conduct investigations when misconduct is suspected, but none have the function of imposing sanctions. On the other hand, there are some countries that have not created any organism to monitor research integrity. This is the case of Spain or Portugal, where the national institutions or research centres supervise ethics in science [8]. This is problematic because national institutions might not have the necessary resources nor the trained personal to execute this type of investigation. In addition, it is recommended that a third party execute such investigations to avoid any kind of influence or conflict of interest, as in other fraud investigations.

The need of a European Union Office of Research Integrity

In order to promote the scientific integrity, universities, research centres and national governments have developed codes of conduct. In Europe, there are at least 49 different codes of conduct about scientific integrity, including guidelines and laws, published by different organisms in 19 different countries. These codes differ greatly in both form and content [9,10]. This variability could result in important potential conflict since scientific research has become more international and collaborations between researchers from different countries are more frequent nowadays. In addition to this, the EU is a Higher Education Area, where there is a high mobility of students and researchers between countries.

The budget invested by the EU in research and innovation in the last three years amounts to 30 billion euro; however, just 4 million were destined for the development of guidelines which included effective and efficient procedures related to the prevention, detection and handling of misconduct cases. Apart from this, no other measures promoting

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Table 1
Last sanctions imposed by the U.S. ORI.

Researcher	Institution	Cause of the sanction	Imposed sanction
Yibin Lin	University of Texas Health Science Center	Falsification, fabrication and plagiarism of data and text. Use of fictitious authors' names and affiliations.	Exclusion from serving in any advisory capacity to U.S Public Health Service for a period of ten years. Exclusion for a period of ten years from any contracting or subcontracting with any agency of the United States Government.
Charles A. Downs	University of Arizona	Falsification and/or fabrication of date, images and graphs.	Supervision of his research for a period of four years. Exclusion from serving in any advisory capacity to U.S Public Health Service for a period of four years.
Logan Fulford	Cincinnati Children's Hospital Medical Center	Data falsification.	Supervision of his research for a period of two years. Exclusion from serving in any advisory capacity to U.S Public Health Service for a period of two years.
Anil Kumar Jaiswal	University of Maryland at Baltimore	Falsification of results. Manipulated images.	Exclusion for a period of ten years from any contracting or subcontracting with any agency of the United States Government for a period of three years. Exclusion from serving in any advisory capacity to U.S Public Health Service for a period of three years.
Rahul Dev Jayant	Texas Tech University Health Science Center	Plagiarism of images and graphs.	Supervision of his research for a period of three years.
		Falsification and fabrication of data and results.	Exclusion from serving in any advisory capacity to U.S Public Health Service for a period of three years.

research integrity and avoiding misconduct in Europe were developed. To our knowledge, there is no European institution similar to the U.S. ORI.

The creation of a research integrity office at the European level could prevent and identify misconduct cases and, consequently, reduce associated costs and facilitate international collaboration between researchers. This office could also have a dissuasive effect on potential researchers who were to engage in unethical conduct. The establishment of a research integrity office, efficiently connected to the correspondent entities located in each country, would need legislative framework at the European level in order to homogeneously manage information transmission and sanction mechanisms between countries. This could be framed within a single European Directive on scientific integrity which would apply to all EU countries.

A European office of research integrity is essential and should address all aspects related to research integrity. The functions of this office should include, but not limited to developing policies, procedures and regulations related to the prevention, detection, investigation and sanction of scientific misconduct; acting in cases of suspected misconduct; advising European institutions about research integrity when it is required; and implementing activities and programs to promote a responsible conduct in scientific research. This office could have binding action on all European scientific projects. In the same way that such

Table 2
Entities which supervise ethics in scientific publications in European countries.

Country	National Entity	Functions and authority
Austria	Austrian Agency for Research Integrity (OeAWI).	The Commission for Research Integrity, which is part of the OeAWI, is the only authorized organism to investigate, give an opinion and mediate in alleged cases of misconduct. It is an independent organism.
Belgium (Flandes)	Flemish Commission for Research Integrity (VCWI).	It has authority to investigate and give a second opinion in alleged cases of misconduct, but it cannot mediate.
Croatia	There is no national committee.	The Croatian Committee on Ethics in Science and Higher Education (CESHE) was created but it is not in function at the moment.
Czech Republic	There is no national committee.	A public research center acts as a national committee (Czech Academy of Science or CAS). It only has authority in alleged cases of misconduct within the CAS or its institutes.
Denmark	Danish Committee on Research Misconduct.	Its aim is to give advice to research institutions and process individual cases of misconduct. The institutions handle cases of alleged misconduct. It is financed by the Education and Science Ministry, but it is an independent organism.
Estonia	There is no national committee.	The institutions handle cases of alleged misconduct.
Finland	TENK.	It acts as an advisory body, but it has the authority to investigate and give opinion in cases of alleged misconduct, but not to act as a mediator. However, the institutions tend to handle misconduct cases. It was established by the Education and Culture Ministry, but it is an independent body.
France	French Office for Research Integrity (OFIS).	It has neither authority to investigate nor act as a mediator.
Germany	German Research Ombudsman	It acts as an advisory body and can mediate in cases of alleged misconduct.
Greece	There is no national committee.	The institutions handle the cases of alleged misconduct.
Ireland	National Research Integrity Forum.	It has the authority to guide and advise institutions regarding research integrity. It has no authority to investigate or mediate in cases of alleged misconduct.
Italy	Research Ethics and Integrity Committee	It acts as an advisory body and its function is to prevent misconduct through educational programs addressed to researchers.
Lituania	There is no national committee.	The promotion of research integrity in academia is divided among a few national public bodies.
Luxembourg	Luxembourg Agency for Research Integrity (LARI)	The Commission for Research Integrity, which is part of LARI, is authorized to investigate, give an opinion and mediate in cases of alleged misconduct.
Netherlands	Netherlands Board on Research Integrity (LOWI)	It has the authority to investigate and give a second opinion in cases of alleged misconduct. It cannot act as mediator.
Norway	National Commission for the Investigation of Research Misconduct.	Governmental organization which acts as advisory consultant, but it has no authority to impose sanctions.
Poland	Science Ethics Commission.	It acts as an advisory body.
Portugal		

(continued on next page)

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Table 2 (*continued*)

Country	National Entity	Functions and authority
	There is no national committee.	The institutions handle cases of alleged misconduct.
Slovak Republic	There is no national committee.	The Slovak Academy of Sciences (SAS) acts as national committee. It only has authority in alleged cases of misconduct within the SAS or its institutes.
Slovenia	There is no national committee.	
Spain	There is no national committee.	A Public Research Center (Consejo Superior de Investigaciones científicas or CSIC) in the country acts as such.
Sweden	Research Misconduct Board.	It handles cases of alleged misconduct due to fabrication, falsification and plagiarism.
Switzerland	There is no national committee.	A National Foundation acts as such. Its aim is to promote scientific investigation.
United Kingdom	UK Research Integrity Office (UKRIO)	It acts as an advisory body. It cannot act as intermediate nor has the authority to investigate.

projects have and economic audit, they could also be audited by the office to verify compliance with good scientific practices, a measure which would undoubtedly improve the quality of research.

Contributors

Alberto Ruano-Ravina and Mónica Pérez-Ríos had the original idea. Cristina Candal-Pedreira drafted the first versión of the manuscript. All authors made contributions in the final draft. All authors take public responsibility of the manuscript content and have approved the final version.

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Ethics approval

This study did not receive nor require ethics approval.

Declaration of Competing Interest

The authors declare they have no conflict of interest.

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Artículo especial

La Oficina de Integridad Científica en España. Una tarea pendiente

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RESUMEN

En los últimos años han salido a la luz muchos casos de mala conducta científica, algunos con importantes consecuencias, que han evidenciado las brechas que globalmente existen en cuanto a integridad científica. En España también se han dado casos notables de mala conducta científica en el ámbito de la investigación biomédica. Sin embargo, hasta el momento no se ha creado un organismo encargado de supervisar las fases de ejecución, análisis y publicación de las investigaciones biomédicas desde un punto de vista ético. Por lo tanto, en este contexto, consideramos que es necesaria la creación de una oficina que supervise la integridad científica en España y que actúe en caso de sospecha de mala conducta científica, llevando a cabo una investigación independiente y con capacidad sancionadora. La existencia de dicho organismo sería de especial importancia en el caso de las investigaciones financiadas con fondos públicos, ya que en ese caso el fraude en investigación supondría la malversación de dinero público. La creación de una oficina que realmente actúe frente a los casos detectados podría tener un efecto disuasorio sobre una potencial mala conducta de algunos investigadores, previniendo así situaciones de mala conducta científica.

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The Research Integrity Office in Spain. A pending issue

Keywords:
Scientific misconduct
Spain
Office of research integrity
Scientific research
Research ethics

ABSTRACT

In recent years, many cases of scientific misconduct have come to light, some with considerable consequences, highlighting the existing breaches in the scientific integrity globally. In Spain, there have also been high-profile cases of scientific misconduct. However, so far, no organism or agency has been created to monitor the execution, analysis and publication phases of biomedical research from an ethical point of view. Therefore, in this context, we consider that there is a need for the creation of an office which supervises research integrity in Spain which would act in cases of suspected scientific misconduct, carrying out an independent investigation and proposing public sanctions. The existence of such an organism would be of particular importance in the case of publicly funded research, since in that case research fraud would involve the misappropriation of public funds. The creation of an office that would act on detected cases could have a deterrent effect on potential misconduct by some researchers, thus preventing cases of scientific misconduct.

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Introducción

Cada vez se dedican más recursos a investigación en todo el mundo. En España, aunque la inversión en investigación es menor que la media de los países europeos[1], la tendencia a largo plazo es que estos recursos aumenten. Con el incremento de los recursos dedicados a la investigación, se espera que aumente el número de investigaciones y de publicaciones científicas, y en consecuencia las prácticas no éticas o cuestionables en investigación y difusión de resultados[2]. El peso que se da en muchas convocatorias públicas al número de publicaciones de los candidatos podría influir en un comportamiento indebido.

Las prácticas no éticas en investigación incluyen, pero no se limitan a ella, la mala conducta científica. La mala conducta científica es un término amplio que, además de incluir violaciones de los principios éticos en investigación, engloba falsificación y fabricación, conflictos de intereses no declarados, problemas de autoría, plagio, ocultación de resultados económicamente perjudiciales para alguna industria, publicación duplicada o falta de reproducibilidad de lo publicado, entre otros[3]. Las causas de estos comportamientos no éticos pueden ser múltiples: falta de formación en ética en pregrado y posgrado, presiones para publicar, afán de notoriedad o

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de enriquecimiento personal, intereses económicos o simplemente narcisismo.

Los ejemplos de mala conducta en la literatura científica son cada vez más frecuentes, más mediáticos y con más repercusiones poblacionales, como la aprobación y el uso del rofecoxib en el año 1999, el caso Wakefield en 1998 y más recientemente el caso Surgisphere en 2020. Algunos afectaron a cientos de miles de personas e incluso impactaron en las políticas sanitarias, y otros afectaron solo a la credibilidad de un científico, pero todos ellos menoscaban la credibilidad de la ciencia ante la sociedad.

Entidades que abordan la ética en investigación

Los estudios indican que la incidencia de conductas no éticas en investigación está creciendo. En los últimos 20 años, la mala conducta científica se ha situado como la causa principal de retractación de artículos biomédicos, desbancando al error no intencionado[4,5]. Igual de preocupante es el hecho de que la retractación de artículos, mecanismo por el cual la literatura científica se corrige, no evita que los resultados de investigaciones erróneas o fraudulentas se continúen difundiendo[6].

En este contexto, cada vez son más los países que están creando oficinas de ética en investigación encargadas de velar por que los científicos obren con rectitud en la realización y la difusión de sus investigaciones. En los Estados Unidos se creó la U.S. Office of Research Integrity (ORI), que además de ser un órgano consultivo supervisa investigaciones institucionales en los casos en que se sospecha mala conducta científica, e impone sanciones a los investigadores si se prueba que han cometido mala conducta. Actualmente, en Europa no hay ningún organismo similar a la ORI [7], pero 14 de los 46 países europeos han creado un comité ético nacional cuyas funciones principales son promover la integridad científica y actuar como un órgano consultor, y seis de ellos también tienen autoridad para investigar, pero ninguno puede imponer sanciones.

En España no hay un organismo nacional encargado de supervisar científicamente las fases de ejecución, análisis y publicación de las investigaciones biomédicas desde un punto de vista ético. Existen los Comités Éticos de Investigaciones Clínicas, pero tienen una función diferente, ya que tratan fundamentalmente de proteger los principios éticos de los participantes en investigaciones en humanos. Por otro lado, la Ley de Ciencia y Tecnología del año 2011[8] menciona la creación de un Comité Español de Ética de la Investigación. Sin embargo, en caso de crearse dicho comité, sería de carácter consultivo y no ejecutivo. Por su parte, el Consejo Superior de Investigaciones Científicas (CSIC) cuenta con un Comité de Ética, pero solo actúa en investigaciones científicas llevadas a cabo en el marco del CSIC.

En este momento nos encontramos con que las entidades que financian la investigación en el ámbito nacional, además de todos los organismos autonómicos financiadores de investigación, no cuentan con un órgano supervisor de la buena conducta científica de los investigadores que tenga capacidad ejecutiva. Cabe destacar que las entidades mencionadas financian investigación con fondos públicos, pero buena parte de la investigación en nuestro país es financiada por la industria privada[1], que también debería ser objeto de actuación de una potencial oficina de ética.

Generalmente, las propias instituciones y las universidades a las que los autores están afiliados son las encargadas de llevar a cabo la investigación si se sospecha mala conducta científica. Esto es problemático por varias razones. Por un lado, es posible que estas instituciones no cuenten con los recursos necesarios para realizar la investigación. Por otro, dichas investigaciones pueden no ser transparentes y podría haber algún tipo de influencia o conflicto de intereses. De hecho, las universidades y las instituciones son parte interesada en que no se difunda una potencial mala conducta científica de los académicos afiliados a ellas. Además de sancionar al investigador que ha cometido mala conducta científica, las instituciones tienen el deber de dar a conocer públicamente el caso, poniendo sobre aviso a la comunidad científica y a posibles futuros empleadores sobre las acciones no éticas de dicho investigador. Sin embargo, esto no siempre se hace. Recientemente ha salido a la luz que la U.S. National Academy of Medicine expulsó a un miembro por mala conducta científica, pero tanto la expulsión como su causa se trataron de manera confidencial por parte de la institución y sus miembros, y no se difundió públicamente[9].

Debido a estas razones, es posible que las instituciones que emplean a un investigador que ha cometido mala conducta no sean las entidades idóneas para llevar a cabo dichas investigaciones. Un ejemplo de esto tuvo lugar en Suecia en el año 2015, donde un cirujano que había sido acusado de mala conducta científica fue absuelto por su institución, el Instituto Karolinska de Estocolmo, en tres ocasiones. Tras esto, una investigación independiente descubrió que había cometido mala conducta, lo que hizo que los procedimientos de la institución se considerasen defectuosos[10]. Así, salieron a la luz pública las debilidades que presentaban las investigaciones realizadas en esa institución.

La necesidad de la creación de una oficina de ética de la investigación en España

Aunque la mala conducta científica se asocia principalmente a países como los Estados Unidos y China, en España también ha habido casos y algunos recibieron mucha atención por parte de los medios de comunicación, y por tanto de la sociedad, exponiendo así las brechas existentes en la integridad científica en nuestro país. Según la base de datos Retraction Watch (www.retractiondatabase.org), se han retractado 325 publicaciones de autores afiliados a instituciones españolas, lo que supone que se han retractado 5 publicaciones de cada 1000 correspondientes a autores españoles. De estas, 84 fueron retractadas por fabricación, falsificación o plagio. Algunos casos fueron muy mediáticos, como la reciente acusación a un rector de una universidad pública por haber cometido plagio en serie durante años, o el caso de una bióloga que cuenta con cinco artículos retractados por duplicación y manipulación de imágenes[11]. Sin embargo, aunque en estos casos hubo consecuencias para los autores, probablemente por tratarse de casos muy mediáticos, es posible que la mayoría de los investigadores que cometen mala conducta científica no se enfrenten a ningún tipo de sanción ni consecuencia. Por otra parte, los casos de mala conducta flagrante o reiterada son mucho más fáciles de identificar que aquellos en que los autores cometen mala conducta de forma aislada.

Teniendo en cuenta el contexto español y europeo, consideramos que existe un espacio muy importante que cubrir por parte de una oficina que supervise la conducta en las investigaciones financiadas con fondos públicos en España, y que actúe, de forma independiente, frente a los casos de mala conducta detectados, proponiendo sanciones públicas. Además, esta oficina no se limitaría a investigar y sancionar, sino que asumiría una labor educativa enfocada a investigadores y estudiantes, principalmente de ciencias de la salud, con el objetivo de promover las buenas prácticas en investigación biomédica. Por otro lado, esta oficina podría tener un efecto disuasorio sobre una potencial mala conducta. Esto podría prevenir casos de mala conducta científica y reducir los costes derivados, que se estiman en más de 360.000 euros por cada artículo retractado[12]. La existencia de dicho organismo sería de especial importancia en el caso de las investigaciones financiadas con fondos públicos. Si bien es cierto que las entidades financiadoras supervisan que la ejecución del gasto se adecúe a los recursos solicitados y al cronograma

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C. Candal-Pedreira et al. / Gac Sanit. 2022;xxx(xx):xxx–xxx

Tabla 1
Posibles funciones de una oficina de integridad científica en España

• Actuar como órgano consultivo de las instituciones que lo requieran.
• Asesorar y hacer informes y dictámenes a demanda de organismos que realizan investigación.
• Promover la integridad científica.
• Desarrollar actividades y programas formativos sobre conducta responsable en investigación, dirigidos a estudiantes de grado, posgrado e investigadores/as.
• Revisar y monitorizar investigaciones financiadas con fondos públicos.
• Llevar a cabo investigaciones, bien de oficio o bien previa solicitud, en aquellos casos en que se sospeche mala conducta científica.
• Imponer las sanciones correspondientes en cada caso en que se pruebe, tras la investigación, que ha habido mala conducta científica.
• Realizar memorias anuales de actividad para las agencias financiadoras y el Ministerio de Ciencia.
• Cooperar con el Comité Internacional de Editores de Revistas Biomédicas y con otras entidades similares.
• Promover su actividad en el marco del European Research Council y con la Dirección General de Investigación e Innovación de la Unión Europea.

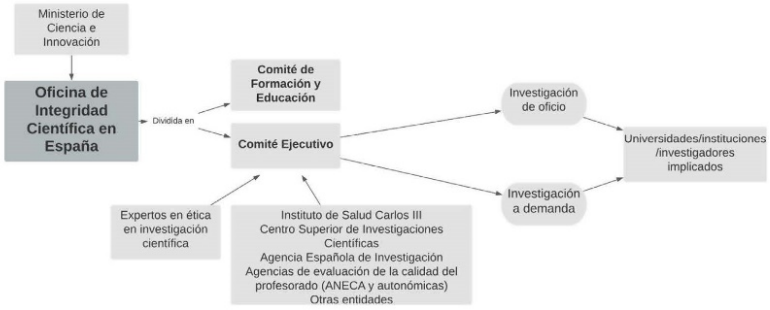


Figura 1. Posible organigrama y mecánica de actuación de una oficina de integridad científica en España.

propuesto, no entran en detalles que tengan que ver con una mala conducta científica.

Por lo tanto, las principales funciones que debería tener la oficina se describen en la tabla 1 y se podrían resumir en promoción de la integridad científica y actuación frente a la mala conducta científica. Las funciones que se proponen son amplias, y tras la puesta en marcha de la oficina sería imprescindible evaluar las debilidades y fortalezas que presentan, con el fin de precisar más estas funciones.

Dicha oficina pertenecería al Ministerio de Ciencia, siendo a su vez independiente de este, con un mandato preferiblemente limitado a 6 años para blindarse frente a vaivenes políticos. Debería tener una composición multidisciplinaria, con representación de las entidades que más fondos destinan a financiar investigaciones científicas, además de expertos en mala conducta científica. Sería imprescindible la constitución de un comité ejecutivo cuya función sería la toma de decisiones tras las investigaciones pertinentes de los hechos, y que sería el encargado de comunicar la decisión a las entidades implicadas en cada caso y a los propios investigadores (fig. 1).

La comunidad científica siempre ha sido muy respetada por parte de la sociedad. De hecho, los científicos se encuentran entre los profesionales más valorados por la ciudadanía. Sin embargo, en los últimos años se han ido sucediendo casos notables de mala conducta científica, lo cual puede cambiar la imagen pública de la ciencia y de los científicos, al igual que su credibilidad. Todos los casos de mala conducta científica menoscaban la confianza de una sociedad a la que, en último término, se rinden cuentas por los fondos públicos recibidos para investigar. Por esto, es imprescindible que España cree una oficina nacional independiente que se encargue de los distintos aspectos relacionados con la mala conducta y la integridad científica. Dicha oficina monitorizaría la mala conducta científica y llevaría a cabo investigaciones, con el objetivo de que los casos en que se sospeche mala conducta científica se traten de una manera justa, rápida, transparente y libre de conflictos de intereses.

Además de la creación de dicho organismo, sería de gran interés fomentar el desarrollo de normas éticas en las instituciones que gestionen investigaciones, incluyendo los programas de doctorado, las agencias financiadoras e incluso las revistas científicas. Cabe destacar que, en este sentido, la revista Gaceta Sanitaria fue pionera en España con la redacción de sus normas éticas que afectaban al modo de actuación de personas autoras, editoras y propietarias de la revista[13]. Otras revistas científicas están siguiendo los mismos pasos y han desarrollado sus propias normas éticas, como *Revista Española de Salud Pública*. Por otro lado, la proliferación de grupos y de investigadores vigilando la ética en investigación supone un cambio cultural relevante en España. Aunque por el momento son pocas las entidades de nuestro país que se han implicado activamente en la prevención y la detección de la mala conducta científica, se espera que aumente la concienciación sobre este problema y las consecuencias que supone para la credibilidad de la comunidad científica.

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Essay

Research misconduct as a challenge for academic institutions and scientific journals

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ABSTRACT

Research misconduct refers to a set of unethical practices in research and publication and is the main reason for retraction of articles published in the academic literature. Research misconduct has negative consequences and has generated public scepticism about research, which has led to increasing distrust in science. In this context, a joint effort by the scientific community, academic institutions, scientific journals and research funders is needed to identify and prevent research misconduct. In this paper, we will evaluate what has already been done and what is needed to do to better address research misconduct. The focus of this paper will be on the actions taken by academic institutions, as the first line of defence, and scientific journals, as the gatekeepers of science. However, scientific journals and academic institutions are only a part of a much larger and multistakeholder effort needed to address the challenges scientific research is facing.

Research misconduct refers to a set of unethical practices in research and publishing, which include, but are not limited to, data or image fabrication and falsification, plagiarism, intentional failure to declare conflicts of interest and duplicate publication. Currently, research misconduct is the main reason for the retraction of published articles in the academic literature, accounting for 60%–70% of all retractions.[1] However, detected cases of research misconduct likely represent only the tip of the iceberg as many fraudulent articles go undetected. Furthermore, research misconduct is constantly evolving, and new types of fraud are being identified, such as the phenomena of paper mills or fake peer review.[2 3]

Research misconduct has generated public controversy and scepticism about research, which has led to an increasing distrust in science. Research misconduct has other consequences as well[4]: it damages the scientific evidence by publishing incorrect or false research results; future research could be influenced by these practices since researchers base their new studies on already published evidence; and, specifically in biomedical research, fraudulent results can be integrated into clinical practice, which could directly harm patients and population health. Additionally, fraudulent research wastes resources that could have been used to carry out useful and effective research.[4] The magnitude of the effect of research misconduct on science depends greatly on the type of misconduct. The lone scientist putting his/her name on a research paper without contributing to it has little impact, but fabricating a whole field of research may affect research and clinical medicine for decades.

Researchers, scientific journals, academic institutions and funding entities are the main actors responsible for ensuring the quality and integrity of scientific literature. In this paper, we will evaluate what has been already done and what is needed to do to better address (i.e., prevent and identify) research misconduct. Our focus will be on the actions taken by academic institutions, as the first line of defence, and scientific journals, as the gatekeepers of science.

ADDRESSING RESEARCH INTEGRITY IN ACADEMIC INSTITUTIONS: CHALLENGES AND POTENTIAL APPROACHES

Academic institutions, such as universities, research centres or hospitals, have established policies and procedures that try to ensure integrity in the research conducted by their affiliates. Some institutions have created their own research integrity offices and research panels, as recommended by the Committee on Publication Ethics (COPE)[5] and others have implemented education programmes in ethics.[6] However, this is not the common rule across all institutions, although different initiatives have been aimed at guiding institutions in research integrity and education in ethics.[7] Many institutions have no policy enforced at all.

The responsibility for investigating cases of research misconduct typically falls on the institutions themselves, with research committees composed by colleagues of the researcher under scrutiny, and this affects any independent judgement. Even for independent committees, there may be a lack of adequate financial and human resources. To alleviate these limitations, the European Network of Research Integrity Offices has published in 2019 a set of recommendations to serve as guidance for institutions; however, we are unaware of their degree of application in European institutions.[8]

Moreover, there is a lack of transparency in research misconduct investigations conducted by academic institutions.[8] A recent example occurred when expert researchers in research integrity reached out to a French research institution after allegations of misconduct. However, no information was provided by the institution (available in: http://deevybee.blogspot.com/2023/02/open-letter-to-cnrs.html). By keeping such information confidential, institutions inadvertently protect

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Table 1 Strategies to address research misconduct in publishing and academic institutions

Stakeholder	Measures
Academic institutions	▶ Promotion and offering education and training in research integrity within all institutions; mentoring programmes. ▶ External audit of research integrity performance of the institution—creation of a 'rehabilitation' programme for researchers that committed research misconduct. ▶ Sanctioning when required. ▶ Promotion of transparency, publicly available reports on investigations of suspected misconduct ▶ Creation of research integrity committees within all institutions.
Scientific journals	▶ Creation of research integrity teams. ▶ Appointment of a research integrity editor. ▶ Implementation and promotion of open peer review. ▶ Adoption of data sharing policies (open data). ▶ Automatically checking for plagiarism, duplication, errors and inconsistent data using artificial intelligence and machine learning. ▶ Promotion of postpublication review. ▶ Use new technologies in peer review and postpublication review. ▶ Allow as authors only researchers with a confirmed ORCID identity. ▶ Systematic verification of previous history of misconduct.

ORCID, Open Researcher and Contributor ID.

the reputation of the individuals involved in the misconduct. Related to this, most institutions have not been straightforward in sanctioning members committing research misconduct. How many fraudulent papers are needed for an institution to sanction or fire a researcher? This is a process that may take years and in many cases without consequences for the fear of discredit of the institution affected. It is important to consider that institutions tend to protect their most prolific and successful researchers, who bring a significant amount of funding and prestige to the institution. In this context, improving transparency within institutions is crucial. Reports on investigations of suspected misconduct should be made publicly available, at least by publishing reports of research misconduct with anonymised personal identifiers, instead of using names, to ensure the privacy of all parties involved. Just as institutions promote the achievements of their researchers, they must also inform the academic community if any of them engage in research misconduct.[8] Ideally, an independent body separate from the institution should conduct the investigation and have the authority to impose sanctions when necessary. This committee could be created as part of countries' already existing national organisms managing research misconduct.

In addition to promoting transparency, academic institutions should play a role by actively encouraging a shift in the evaluation system of researchers to address research misconduct over the long term. The evaluation system currently focuses largely on the quantity of publications and not necessarily on the quality or real impact of the research. This approach creates disproportionate pressure to publish, which can lead to research misconduct. There is a growing recognition of the need for change in the scientific community, and progress is being made with the adoption of the DORA declaration (San Francisco Declaration on Research Assessment) and the CoARA agreement (Coalition for Advancing Research Assessment) by institutions in several countries.[9 10]

Closely related to the pressure to publish, is the normalisation of unethical practices to take shortcuts in research,[11] often common in academic institutions. In this case, research integrity training is key. One way could be to establish mentoring programmes. In such programmes, junior researchers would be paired with senior researchers who have demonstrated good ethical research performance and good behaviour.[12] Established researchers may face time constraints that limit their involvement in these activities. However, it remains crucial to prioritise and commit to mentoring and guiding the next generation of researchers in responsible and transparent research practices. To promote it, institutions could establish a formal but flexible programme and mentoring activities should be recognised in the training curricula for both researchers and students. Additionally, it has been previously proposed that academic institutions should be externally audited to evaluate their research integrity programmes, faculty-members training and involvement, institution policies and regulations.[8 13] It could be also proposed that academic institutions establish a form of 'rehabilitation' programme for researchers who have committed research misconduct.[14]

Institutions have the potential to significantly mitigate the occurrence of research misconduct. However, there is still much work to be done by institutions in this regard. Just as scientific journals have specific international organisations (such as COPE or the International Committee of Medical Journal Editors (ICJME)), why does not something similar exist for institutions? This committee could provide guidance and propose standards on how to proceed in cases of suspected research misconduct. Such organisation would be particularly relevant in countries where there is no dedicated office of research integrity for institutions to turn to.[15]

SCIENTIFIC JOURNALS: CURRENT INITIATIVES AND POTENTIAL APPROACHES

Scientific journals play an important role in the research ecosystem as both gatekeeper and guarantor of research results for the scientific community. As such, they should uphold high standards of quality and integrity in the research they publish.

Many scientific journals and publishers have adopted policies and strategies aimed at protecting research integrity and reducing misconduct.[16] Most of them have endorsed guidelines and codes of conduct that outline the standards for research integrity, such as the Core Practices issued by COPE[5] or the ICJME Recommendations for the Conduct, Reporting, Editing and Publication of Scholarly Work in Medical Journals.[17] All major publishers have also created research integrity teams to specifically manage research integrity and publication ethics. These teams investigate unethical behaviour, promote research integrity through training and act as a consulting body. Some journals are also appointing a specific editor to deal with research misconduct, as recommended by COPE.[5]

Some journals have developed innovative editorial policies in the last two decades, particularly in advocating for transparency in publication. Open Science, encompassing Open Data and Open Peer Review among other practices, has been widely recognised as a practical policy to mitigate many of the problems identified in scientific publishing.[18] It may help in identifying and preventing research misconduct by facilitating replication of studies, enabling detection of data fabrication or manipulation, and promoting transparency and accountability in research. For instance, Open Peer Review has been adopted for some decades now. That is, reviewers and authors know each other's names and their comments on different versions of the manuscript are published along with the final article.[19]

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This provides information about who the reviewers are, how many review rounds were conducted, and why the decision to accept the article was made, making the peer-review process more transparent. Some studies suggest that this policy does not detriment the peer-review process and may even improve the quality of reviews in some cases.[20 21] Furthermore, numerous publishers have actively supported the concept of Open Data, urging researchers to share both their data and code employed in analyses through publicly accessible repositories. The *BMJ*, for instance, which, since 2013, does not publish clinical trials of drugs or medical devices if their authors do not commit to sharing anonymised patient data on a reasonable request.[22] However, it should be acknowledged that sharing data is not yet a widespread practice in science. To promote this collaborative approach, open-source alternatives for submitting data and code have been created.[18]

A great number of journals have adopted new technologies, for example, the systematic use of anti-plagiarism software, which has become an increasingly common practice. Plagiarism detection software assists in identifying research misconduct by comparing manuscripts against a database of published materials, identifying potential instances of unattributed use of already published work.

Although policies promoting research integrity do exist, not all journals have implemented them and this greatly depends on the available resources, the administrative staff and the willingness of the editorial team to invest time (in many cases for free) on this specific issue. If only major publishers have access to these strategies and tools, they are not likely to be effective. Additionally, the journals with enough resources to implement such strategies may not be the ones where the preponderance of research misconduct is being published. One solution to address this issue and support journals with limited resources could be to establish funding programmes or grants from international research integrity organisations. Such programmes could cover costs associated with the implementation of such policies, such as staff training or the acquisition of specialised software. In addition, collaboration could also be encouraged between journals with limited resources and those with more resources that have successfully implemented policies in favour of research integrity.

However, even within those journals that have such policies and strategies in place, these are not applied consistently. Some studies have observed that Open Data policies are not being complied with as they should by authors.[23] In addition, many scientific articles do not include conflict of interest or funding disclosures,[24] which is essential to ensure that potential biases are identified and that readers can make informed decisions about the research. It is not enough to implement these policies and strategies, they must be enforced consistently, making them mandatory for all the authors publishing in such journals.

There are other strategies that scientific journals could adopt in this regard. One of them could be to promote postpublication review, which is not very common yet.[25] Although scientific journals usually have postpublication review in the form of letters to the editor, commentaries or rapid responses, this is highly controlled by journals and not many publications receive postpublication reviews in this traditional way. Postpublication review can help to identify errors and research misconduct and provide additional feedback and critical input into the published research. This could be done by having journals implement moderated comments in the online versions of publications or by creating a centralised platform for postpublication review. Such a platform could be independent of journals, allowing for a more objective and unbiased review process, and comments should be moderated. This platform could allow for easy discussion among researchers. More technological innovation is needed in this regard, making it easier for researchers to engage in constructive discussions about published research.

Other technology-based solutions are also being discussed among the scientific community, for instance, the use of artificial intelligence and machine learning for peer review. Artificial intelligence systems could assist editors and reviewers to identify potential errors and anomalies in data in a more efficient way. Although this type of technology is already being used to identify plagiarism, there are other potential applications such as the evaluation of the quality of statistical analysis to detect potential inconsistencies.[26] Furthermore, it has been observed that antiplagiarism software fails when detecting articles from paper mills. The 'tortured phrases' software could be helpful in this regard, serving as a screening element to target potential articles from paper mills.[27] Additionally, journals could allow as authors only researchers with a confirmed Open Researcher and Contributor ID (ORCID) identity, ensuring the authenticity of researchers' identities. This could be even more useful if ORCID indicated on each researcher's profile whether their email is institutional and verified, just like Google Scholar does. Another strategy could be the systematic verification of retractions due to misconduct by authors who submit their manuscript to a journal, and even establish a policy that authors who have engaged in serious research misconduct cannot publish in any of the publisher's journals. By establishing such a policy, journals and publishers would send a strong message that research misconduct will not be tolerated and that authors who engage in such behaviour will face consequences. A summary of the strategies proposed in the text can be seen in table 1.

CONCLUSIONS

Despite the strategies mentioned and their potential implementation in institutions and scientific journals, it is essential to recognise that these measures alone are not likely to completely solve the problem. Evidence suggests that some of the strategies already implemented are not achieving the desired impact, raising the possibility that new similar strategies may also face challenges.

Instead of relying solely on previous approaches, it is crucial to explore and develop additional solutions that address the root of the problem. Here, we have proposed new strategies and highlighted others not universally implemented. In addition to the new strategies proposed, others have been previously suggested, including training in error detection, protecting whistleblowers, and streamlining the processes of correction and retraction.[28] Other options may include learning the importance of adequate scientific behaviour at the schools of medicine or health-related sciences. A genuine commitment is essential to effectively curb the prevalence of research misconduct, and this commitment should extend not only to journals and institutions, but also to individual researchers and funding agencies.

Contributors CC-P: conceptualisation, original draft preparation. JSR: conceptualisation, review and editing. AM: conceptualisation, review and editing. AR-R: conceptualisation, review and editing, supervision, guarantor.

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Evolution and characterization of health sciences paper retractions in Brazil and Portugal

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ABSTRACT

The retraction of health sciences publications is a growing concern. To understand the patterns in a particular country-context and design specific measures to address the problem, it is important to describe and characterize retractions. We aimed to assess the evolution of health science retractions in Brazil and Portugal and to describe their features. We conducted a cross-sectional study including all health sciences retracted articles with at least one author affiliated to a Portuguese or Brazilian institution identified through Retraction Watch database. A total of 182 retracted articles were identified. The number of retractions increased over time, but the proportion related to the whole of publications remained stable. A total of 50.0% and 60.8% of the Portuguese and Brazilian retracted articles, respectively, were published in first and second quartile journals. Scientific misconduct accounted for 60.1% and 55.9% of retractions in Brazil and Portugal. In both countries, the most frequent cause of misconduct was plagiarism. The time from publication to retraction decreases as the journal quartile increases. The retraction of health sciences articles did not decrease over time in Brazil and Portugal. There is a need to develop strategies aimed at preventing, monitoring and managing scientific misconduct according to the country context.

KEYWORDS

Retractions; scientific misconduct; Brazil; Portugal

Introduction

The retraction of scientific articles is an increasing phenomenon at a global level (Fang, Steen, and Casadevall 2012; Campos-Varela and Ruano-Raviña 2019). It is necessary to distinguish between the two main causes of retraction, as they do not have the same consequences or implications. On the one

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hand, a retraction may be due to an error that occurs unintentionally. It should be borne in mind that all researchers can make mistakes. The other cause of retraction is scientific misconduct. In the later case, the unethical practice is intentional. Scientific misconduct includes multiple unethical practices such as the fabrication, falsification and plagiarism of data and images, among other practices (International Committee of Medical Journal Editors 2018). It has been estimated that each retracted article has an associated cost of over 360,000 euros (Stern et al. 2014). The economic impact is even higher in the case of publicly funded studies. Moreover, in health sciences errors or misconduct have a potential health and social impact. Fraudulent results and unreliable conclusions may lead to incorrect decisions by physicians or decision makers, causing potential harm for the health and well-being of the population (Furman, Jensen, and Murray 2012). Although it is a global phenomenon, retraction of articles, specifically due to misconduct, has been associated with specific countries, such as China, Iran or Brazil. In fact, the country of author affiliation is an important predictor of retraction (Fanelli, Costas, and Misconduct Policies 2015). This could be explained by the educational model and the national scientific policy context in each country. Countries that assumed the German model of higher education (hierarchical and less liberal) present a higher risk of committing misconduct than those with the Anglo-American model (prone to critical thinking) (Fanelli, Costas, and Misconduct Policies 2015; Lee and Schrank 2010). In addition, sociocultural conditions are one of the main determinants of misconduct in scientific research. Different studies have shown that the most frequent cause of scientific misconduct varies by country. Chen et al concluded that the principal cause of retraction in China was error, followed by plagiarism (Chen et al. 2018). A study conducted in 2019, showed that plagiarism was the main cause of retraction in India (Elango, Kozak, and Rajendran 2019). However, studies conducted at a global level have shown a higher prevalence of fabrication/falsification compared to plagiarism (Fang, Steen, and Casadevall 2012). In order to understand the different patterns of retractions due to errors and scientific misconduct in a particular country, it is important to describe and characterize the retractions. This is an important first step to design specific measures to address this problem. In addition, it is necessary to monitor how retraction trends evolve over time. Brazil and Portugal are responsible for an important part of the scientific publications in the biomedical field, and they share relevant cultural and economic ties in addition to language. A previous study showed that the publication patterns of Brazil are similar to those of Portugal (Guevara and Mendoza 2016). Regarding research investment, Brazil and Portugal invested 1.16% and 1.35% of GDP in 2018 respectively (Research and development expenditure (% of GDP) – Brazil, Portugal | Data 2022). Although these figures are lower than in other countries, investment in research is expected to increase

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globally. Research investment in Portugal has been on an upward trend since 2012, although it is still below the European average (2.23% of GDP) (R&D expenditure in the EU - Eurostat), while Brazil announced that by 2022 it would increase its research investment by 110% compared to 2021 (Brazil's science budget is rebounding. So why aren't scientists celebrating? | Science 2022). The increase in research funding increases the number of researchers and the competitiveness among them and consequently the pressure to publish (Van Dalen and Henkens 2012; Dal-Ré et al. 2020). Although the pressure to publish is a global phenomenon, it is more important in countries where the evaluation system of researchers is based on the number of publications to get a job in academia (Jordão 2019). To our knowledge and despite of the consequences and implications of retractions, especially on the health sciences, there is no study that has analyzed this phenomenon in Portugal. To date, two studies have analyzed retractions in Brazil (Santos-D'Amorim et al. 2021; Stavale et al. 2019). The first study reviewed retractions until 2017 and used a small sample size (Stavale et al. 2019). The most recent study included retractions in all knowledge areas, but not focusing on the health sciences (Santos-D'Amorim et al. 2021). Therefore, we aimed to assess the evolution of health science retractions in Brazil and in Portugal and to describe their features.

Methodology

Study design and data collection

A cross-sectional study was conducted. Publications retracted for any cause between 1 January 2000 and 26 September 2021 were included in this study. To be included, publications must have at least one author affiliated with an institution in Brazil or Portugal. Communications to congresses, corrections and abstracts were excluded.

The included publications were extracted from the Retraction Watch database (The Retraction Watch Database 2018) (www.retractiondatabase.org) selecting "Brazil" and "Portugal" in the field "Author country" and "Retraction" in the field "Nature of retraction." Using this search strategy, all retractions whose authors were affiliated to Brazilian or Portuguese institutions were retrieved.

In order to include health sciences retractions, we selected retracted publications categorized as "Basic Life Sciences (BLS)" and/or "Health Sciences (HSC)" in the field "Subject." The category "Basic Life Sciences (BLS)" includes subjects such as biology, microbiology, toxicology, environmental sciences, biochemistry, or virology. The category "Health Sciences (HSC)" includes all medical specialties (general medicine, oncology, endocrinology, etc).

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The information of interest for each included retracted publication has been collected from Retraction Watch database, Journal Citation Reports (JCR) (Clarivate Analytics) and Web of Science.

From Retraction Watch database, the total number of retractions and the number of retractions within the health sciences scope were collected by country and year. The proportion of health science retractions in relation to the total number of retractions was calculated for each country and year.

For each included publication the following variables were collected: title of the article; type of publication (original article, systematic review, meta-analysis, letter, guideline, case report); date of publication; date of retraction; journal where the article was published; JCR category of the journal; journal impact factor (JIF); quartile of the journal; type of journal (Open Access, Subscription); total number of authors; country of the authors (Brazil, Portugal); number of countries in affiliation field; citations received by the retracted publication until 15/10/2021. In the case where the journal was included in more than one category, we chose the most favorable according to the JIF. When the journal was hybrid (publishing open access and by subscription), that journal was categorized as "subscription." In addition, time in days elapsed between publication and retraction was calculated.

The cause of retraction for each article was extracted from Retraction Watch database. In order to verify the cause of retraction of the included articles, the notice of retraction was accessed. In the case where we couldn't access the notice of retraction of an article, we used the reason for retraction given by Retraction Watch database. In the case where one article was retracted for several reasons, the most prominent was selected. Causes of retractions were categorized as follow:

- Error: including non-intentional errors made by authors and by the journal.
- Scientific misconduct: fabrication/falsification of data and/or images; plagiarism (including self-plagiarism and duplication); data not reliable; results not reliable; ethical issues (including authorship issues, copyright, informed consent, or conflict of interest).

Funding and conflict of interest related variables were included: inclusion of a funding statement in the articles (yes/no); declared funding (yes/no); source of funding (public/private); name of the funding source; inclusion of a conflict-of-interest statement (yes/no); declared conflicts of interest (yes/no).

The name and institution from each author affiliated with a Portuguese or Brazilian institution was collected, as well as the number of retracted papers in which each is listed as an author. The institution of the author was

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categorized in the following categories: hospital, university, research center, others (including industry, associations, and governmental institutions).

Statistical analysis

A descriptive analysis was performed, expressing categorical variables as an absolute and relative frequency, and quantitative variables as a median, 25^{th} and 75^{th} percentile.

First, the evolution of retractions was analyzed in absolute terms; then the proportion of health sciences retractions in relation to the whole of retractions was calculated for each year and country.

The characteristics of the retracted publications were analyzed and broken down by country (Brazil or Portugal). The time elapsed between publication and retraction was calculated, as well as its correlation with the journal's quartile and the cause of retraction for each country. Since the data do not follow a normal distribution, the Spearman correlation was used. For each country, the period elapsed between publication and retraction and citations were compared by cause of retraction and by journal quartile, using the Kruskal-Wallis test.

Finally, it was performed a specific descriptive analysis of those authors affiliated with Portuguese or Brazilian institutions who have committed any type of scientific misconduct.

Statistical significance was established at $p < 0.05$. All statistical analysis were performed using Stata v.17.

Results

A total of 182 retracted articles published in 129 different journals were identified: 34 articles of authors affiliated with a Portuguese institution; and 148 of authors affiliated with a Brazilian institution. The number of retractions of health sciences articles by Portuguese and Brazilian authors accounts for 0.58% of the total number of retractions. The first article was published in 1997 and the first retraction took place in 2000. The type of publications were original articles (n = 140), systematic reviews (n = 26), meta-analysis (n = 6), case reports (n = 6), guidelines (n = 2) and letters (n = 2).

Retraction time trends, 2000-2021

As shown in Figure 1, a rise in the absolute number of retractions was observed over time. This increase is reflected both in Portugal and Brazil, in total retractions (dashed line) and in health sciences retractions (solid line). A peak in the number of retractions was seen in both countries, between 2013 and 2018 in Portuguese articles and between 2012 and 2020

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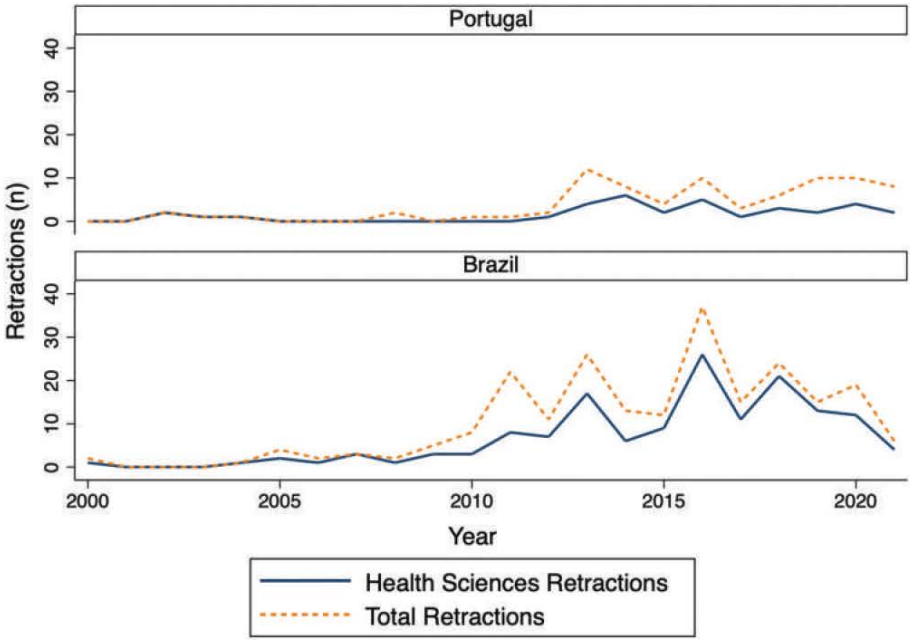


Figure 1. Evolution of total retractions (dashed line) and health sciences retractions (solid line) in Brazil and Portugal.

in Brazilian articles. Nevertheless, the relative number of retractions in relation to the whole of publications remained stable during the study period, varying between 2 and 4 retractions per 10,000 publications in both countries.

Health sciences retractions are accountable for a substantial percentage of the total retractions in both countries (Figure 2). In Portugal, health sciences retractions account for 20% to 75% of all retractions since 2012. In Brazil, this proportion is even higher as shown in Figure 2.

Characteristics of the retracted publications, 2000-2021

Table 1 shows the main publication characteristics broken down by country. In Portugal, the great majority of retracted articles (61.8%) included 5 or less coauthors. By contrast, in Brazil 53.7% included 6 or more coauthors. Collaboration of Portuguese and Brazilian authors with foreign authors was not very frequent as many of the articles only included authors from the same country. A total of 50.0% and 60.8% of the Portuguese and Brazilian articles, respectively, were published in first and second quartile journals. Most of the articles were published in non-Open Access journals.

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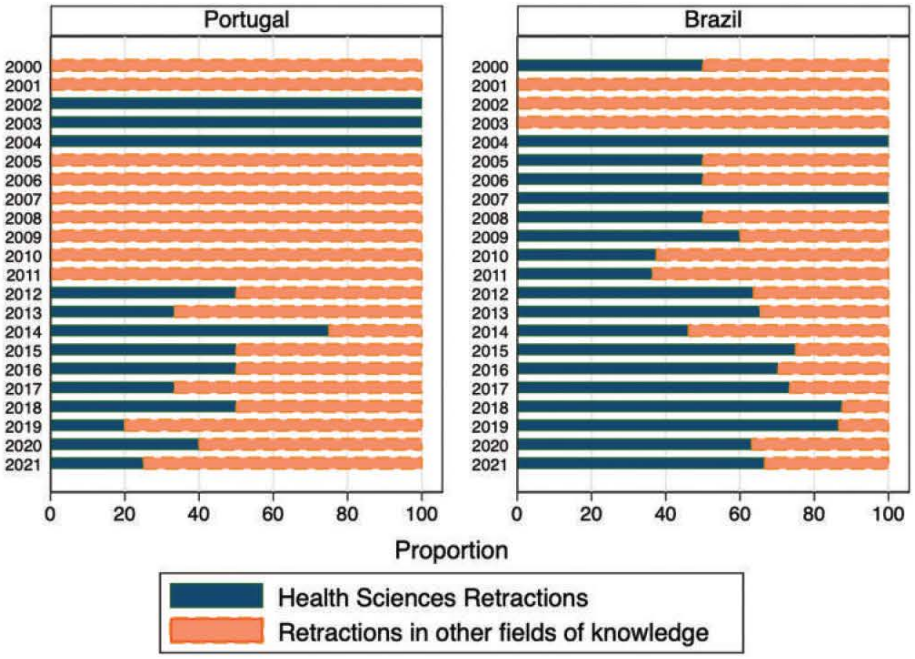


Figure 2. Proportion of health sciences retractions in relation to total retractions.

The cause of retraction is shown in Table 2. Regardless of the authors' country of origin, most retractions were due to some form of scientific misconduct. In the case of Portuguese authors, most retractions for misconduct were due to plagiarism. Similarly, in Brazil, retractions due to plagiarism exceeded 50% of retractions due to scientific misconduct. It should be noted that 16.2% of the retraction notices didn't state the cause of retraction in Brazilian articles.

The median number of days between publication and retraction because of misconduct was higher in the case of articles retracted for misconduct compared with those retracted due to error. This pattern is observed in both countries. However, as shown in Table 3, the differences are statistically significant only for Brazilian articles published in first quartile journals ($p = 0.002$).

In general, the median number of days from publication to retraction was higher in the case of articles published in first quartile journals, compared to other journals. However, in the case of Portuguese articles retracted due to misconduct, this period was longer in fourth quartile journals. Overall, the time from publication to retraction decreases as the journal quartile increases.

Publications retracted because of misconduct received more citations than those retracted because of error (Table 4). This was mostly observed in Portuguese publications in first quartile and journals without impact factor.

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Table 1. Main publication characteristics, according to the cause of retraction, by country.

	Portugal (n = 34)	Brazil (n = 148)
Article type		
Original article	27 (79.4%)	113 (76.4%)
Systematic review	1 (2.9%)	25 (16.9%)
Meta-analysis	2 (5.9%)	4 (2.7%)
Case report	2 (5.9%)	4 (2.7%)
Letter	1 (2.9%)	1 (0.7%)
Guideline	1 (2.9%)	1 (0.7%)
Number of authors		
1–5	21 (61.8%)	56 (46.3%)
>5	13 (38.2%)	65 (53.7%)
Number of countries		
1	21 (61.8%)	116 (78.4%)
2	8 (23.5%)	16 (10.8%)
3	3 (8.8%)	10 (6.8%)
4 or more	2 (5.9%)	6 (4.1%)
Journal quartile		
Q1	9 (26.5%)	63 (42.6%)
Q2	6 (17.6%)	27 (18.2%)
Q3	7 (20.6%)	19 (12.8%)
Q4	4 (11.8%)	15 (10.1%)
No IF	8 (23.5%)	24 (16.2%)
Type of journal		
Open Access	6 (17.6%)	43 (29.1%)
Subscription	28 (82.4%)	105 (70.9%)
Journal category		
Genetics and Heredity	3 (11.5%)	1 (0.8%)
Environmental Sciences	2 (7.7%)	1 (0.8%)
Medicine, General and Internal	2 (7.7%)	21 (16.9%)
Microbiology	2 (7.7%)	2 (1.6%)
Endocrinology and Metabolism	1 (3.9%)	12 (9.7%)
Other	24 (61.5%)	111 (70.2%)

Table 2. Publications retracted for any cause of scientific misconduct, by country.

	Portugal	Brazil
Reason of retraction		
Error	12 (33.3%)	35 (23.7%)
Misconduct	19 (55.9%)	89 (60.1%)
Falsification/Fabrication	3 (13.6%)	9 (8.0%)
Plagiarism	9 (40.9%)	57 (50.4%)
Data not reliable	3 (13.6%)	7 (6.2%)
Results not reliable	1 (4.6%)	5 (4.4%)
Ethical issues	2 (9.1%)	10 (8.9%)
No cause of misconduct is stated	4 (18.2%)	25 (22.1%)
No cause of retraction is stated	3 (8.8%)	24 (16.2%)

However, these differences are not statistically significant. In the case of Brazil, there are no major variations between the number of citations received as of the cause of retraction, except for those published in second

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Table 3. Time elapsed from publication to retraction (misconduct and error) by journal quartile and country, expressed in days (median, 25th percentile and 75th percentile).

	Portugal			Brazil		
Q	Misconduct	Error	p-val	Misconduct	Error	p-val
Q1	821 (664–923) n = 5	81 (48–114) n = 2	0.137	1831.5 (748.5–3292) n = 32	448 (177–980) n = 14	0.002
Q2	303 (252–519) n = 5	69 (69–69) n = 1	0.143	1513 (396–2223) n = 21	246 (0–1575) n = 5	0.078
Q3	135.5 (80.5–1,525.5) n = 4	0 (0–126) n = 3	0.154	384 (60–1004) n = 14	158 (0–590) n = 3	0.131
Q4	1,578.5 (154–3,003) n = 2	30 (30–30) n = 2	0.102	372.5 (210.5–522.5) n = 8	128 (92–366) n = 5	0.379
No IF	518 (441–939) n = 3	7.5 (3.5–50.5) n = 4	0.054	90 (62–212) n = 14	322.5 (72.5–496.25) n = 8	0.309

*Q: quartile; IF: Impact Factor; p-val: p-value; n = number of papers in each category and quartile.

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Table 4. Publication citations by cause of retraction and quartile journal, and by country. Median, 25th and 75th percentiles and p-value.

	Portugal			Brazil		
	Misconduct	Error	p-value	Misconduct	Error	p-value
Q1	46 (7–127)	1.5 (1–2)	0.108	8.5 (2–74.5)	8 (2–48)	0.321
Q2	3 (0–24)	2 (2–2)	0.766	17 (6–28)	4 (1–5)	0.025
Q3	0 (0–8)	2 (0–5)	0.817	2 (1–7)	3 (0–36)	0.589
Q4	4.5 (2–7)	7 (3–11)	0.439	0 (0–9)	0 (0–1)	0.717
No IF	27 (11–43)	1 (0–2)	0.171	1 (1–6)	3 (1–4)	0.591

quartile journals (p = 0.025). However, it should be noted that the sample size in these groups is very small, especially in the case of Portuguese articles.

In addition, a positive association between the journal IF and the number of citations received by publications was observed both in Portugal (rho 0.50; p = 0.01) and Brazil (rho = 0.60; p < 0.001).

Funding

The 61.8% and 53.4% of the Portuguese and Brazilian articles, respectively, included a funding declaration in the text of the article. Of those, 90.3% and 88.6% received funding (Table 5).

Of the Portuguese funded retracted articles due to misconduct, 33.3% received funding from one source. In contrast, 54.4% of Brazilian articles obtained funding from two different sources. In addition, most articles retracted for misconduct received funding from public sources. In Portugal, 8 (33.3%) of the publicly funded articles received funding from Fundação para a Ciência e a Tecnologia (FCT), 4.2% from Conselho Nacional de Desinvolvimento Científico e Tecnológico (CNPq) and 62.5% from other public sources. In the case of Brazil, 42.3% received funding from Fundação

Table 5. Funding and conflicts of interest.

	Portugal		Brazil	
	Misconduct	Error	Misconduct	Error
Included funding statement				
Yes	13 (68.4%)	5 (41.7%)	51 (57.3%)	22 (62.9%)
Received funding				
Yes	12 (92.3%)	5 (100%)	46 (90.2%)	18 (81.8%)
Number of sources				
1	4 (33.3%)	4 (80.0%)	11 (23.9%)	6 (33.3%)
2	4 (33.3%)	1 (20.0%)	25 (54.4%)	4 (22.2%)
3 or more	4 (33.3%)	0	10 (21.7%)	8 (44.5%)
Type of funding source				
Public source	10 (83.3%)	4 (80.0%)	45 (97.8%)	18 (100%)
Private source	2 (16.7%)	1 (20.0%)	1 (2.2%)	0

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de Amparo à Pesquisa (FAP), 40.5% from Conselho Nacional de Desinvolvimento Científico e Tecnológico (CNPq) and 17.2% from Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES).

Conflicts of interest

Of the retracted articles 45.6% have not included a conflicts of interest (COI) statement. These proportions are similar in both countries, as shown in Table 7. Of the 73 papers including a statement, 5 declared a COI, all in Brazilian publications.

Authors who committed scientific misconduct

This analysis was restricted only to articles retracted for scientific misconduct (108 articles). The great majority of authors who committed misconduct had one retraction (Brazilian authors: 75.0%; Portuguese authors: 88.1%) (Table 6). Two authors affiliated with Brazilian institutions have 16 and 17 retracted articles. Most authors with retracted publications were affiliated with universities.

In Portugal, the highest number of authors who committed misconduct were affiliated to Universidade de Lisboa and Universidade do Porto, followed by Universidade de Coimbra and Universidade Técnica de Lisboa. In Brazil, a quarter of the authors of articles retracted for scientific misconduct were affiliated to Universidade Estadual de Campinas, followed by Universidade de Sao Paulo, with the 18.3% of the retractions (Table 7).

Table 7. Main authors' institutions of affiliation of authors who committed misconduct, by country.

Institution	Number and percentage of retracted articles because of misconduct
PORTUGAL	
Universidade de Lisboa	8 (13.6%)
Universidade do Porto	8 (13.6%)
Universidade de Coimbra	6 (10.2%)
Instituto Politécnico de Lisboa	4 (6.8%)
Universidade Nova de Lisboa	3 (5.1%)
BRAZIL	
Universidade Estadual de Campinas	71 (26.5%)
Universidade de São Paulo	49 (18.3%)
Universidade Estadual Paulista	19 (7.1%)
Universidade Federal da Bahia	14 (5.2%)
Universidade Federal do Rio Grande do Sul	14 (5.2%)
Universidade do Extremo Sul Catarinense	11 (4.1%)
Universidade de Brasília	7 (2.6%)
Universidade Cruzeiro do Sul	6 (2.2%)
Universidade Federal de Viçosa	6 (2.2%)

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Table 6. Number of retractions for scientific misconduct per author and type of author's institution, by country.

	Portugal	Brazil
Number of retractions per author		
1	52 (88.1%)	201 (75.0%)
2	7 (11.9%)	35 (13.1%)
3	-	15 (5.6%)
4–9	-	13 (4.9%)
10–15	-	2 (0.8%)
>15	-	2 (0.8%)
Type of author's institution		
University	38 (65.4%)	242 (90.3%)
Hospital	15 (25.4%)	9 (3.4%)
Research Center	6 (10.2%)	11 (4.1%)
Other	-	6 (2.2%)

Discussion

The study findings show that misconduct is the leading cause of health sciences retractions in Brazil and Portugal. Although the absolute number of retractions has grown in the last two decades in both countries, the proportion of retractions regarding the total publications remains stable. To our knowledge, this is the first study which analyses the phenomenon of retractions in Portugal and the study with the largest sample size describing retractions in the health sciences in Brazil.

Previous works conclude that retractions and specifically those due to scientific misconduct have increased in recent decades (Fang, Steen, and Casadevall 2012; Campos-Varela and Ruano-Raviña 2019; Stavale et al. 2019; Van Noorden 2011). In the case of Brazil and Portugal the increase in the number of retractions could be attributed to an increase in the number of publications, as shown in this study. Some authors argue that the increase in scientific misconduct has been driven in part by the system through which researchers are currently evaluated, which is based on the number of publications a researcher has in high impact journals (Franzoni, Scellato, and Stephan 2011; Anderson et al. 2007). This system increases the pressure to publish, and might result in researchers deciding to commit scientific misconduct in order to achieve the publication quotas imposed to gain funding and promotions (Frias-Navarro et al. 2021; Johann 2022).

Scientific misconduct includes multiple questionable practices. Although its definition refers mainly falsification, fabrication and plagiarism (International Committee of Medical Journal Editors 2018), other unethical behaviors are also considered scientific misconduct, such as authorship issues or non-declaration of conflicts of interest, among others. Previous studies have shown an overall higher prevalence of falsification and fabrication (Fang, Steen, and Casadevall 2012), however our results identified plagiarism

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as the main cause of retraction in Brazil and Portugal. Our results are in line with other studies conducted in Brazil and Latin America (Santos-D'Amorim et al. 2021; Stavale et al. 2019; Almeida et al. 2016). Different cultural perceptions of plagiarism may play a role in the prevalence of this type of scientific misconduct, as well as the national policies against research fraud (Lee and Schrank 2010; Almeida et al. 2016). In addition, the lack of training of students and researchers in scientific integrity is a possible reason why plagiarism is so prevalent in Brazil and Portugal, as it is not usually recognized as scientific misconduct. A study showed that only 25% of medical students in Brazil recognized plagiarism as a type of scientific misconduct (Schmitz, Menezes, and Lins 2012). Moreover, our results show that the vast majority of authors who committed scientific misconduct was affiliated with universities, regardless of the country of affiliation. Thus, there is a need to improve training in ethics and scientific integrity at the undergraduate and graduate levels, especially in health sciences.

Citation analysis works as a proxy for the visibility and influence of an article. Retracted articles should not receive citations after the retraction. However, a recent study concluded that the retraction of articles has no impact on the citations they receive after the retraction. In addition, articles retracted for scientific misconduct receive more citations after they have been retracted than before (Candal-Pedreira et al. 2020). The results of our study show that retracted publications from Portuguese and Brazilian authors receive many citations. It is observed that those published in first and second quartile journals receive more citations in comparison to those published in low impact journals. This result is in line with previous works (Madlock-Brown and Eichmann 2015; Redman, Yarandi, and Merz 2008). Although citing retracted articles is currently a valid procedure, researchers should bear in mind that it may lead to the persistence of unreliable results in the literature and should therefore be avoided. Scientific journals should vet articles set to be published to ensure that no retracted articles have been cited and, if so, act accordingly. There are also resources available for authors to avoid the citation of retracted publications. For example, some reference management tools, such as EndNote or Zotero, alert the researcher if a cited reference has been retracted (Retraction Watch 2022; Morán, Santillán-García, and Herrera-Peco 2022).

Another worrying fact is that many retracted publications of authors affiliated to Portuguese or Brazilian institutions receive funding from public sources. The results of our study are in line with those from the study conducted by Santos-D'Amorín et al (Santos-D'Amorim et al. 2021). The most common source of funding varies from country to country. The most frequent source of funding in the case of Portuguese articles was the Fundação para a Ciência e a Tecnologia (FCT) while for Brazilian articles it was the Fundação de Amparo à Pesquisa (FAP), followed by the Conselho

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Nacional de Desinvolvimento Científico e Tecnológico (CNPq) and the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES). These are public institutions and consequently the funds used to support research are also public.

The fact that most of the retracted articles were publicly funded is problematic for several reasons. Most publicly funded retractions in this study were due to scientific misconduct, including various types of fraud. Although the percentage of funding invested in research which was eventually retracted is low, many fraudulent articles have not yet been identified. Therefore, the economic impact of research misconduct might be higher than previously though (Fang, Steen, and Casadevall 2012). It shoud be noted that civil society is accountable for public funds invested in research. The trust that society places in research and scientists has been recently undermined by multiple scandals like those perpetuated by Andrew Wakefield and John Darsee, among many others (Godlee, Smith, and Marcovitch 2011; Hospi- et al. 1983).

Funding institutions should have specific policies and procedures to handle allegations of scientific misconduct of researchers that they fund. This is especially important in the case of publicly funding sources, like governmental institutions. In addition, before providing funding, such institutions should check that researchers have not committed misconduct in the past or are under investigation at the current time. Moreover, specific organisms should be created to deal with scientific misconduct at the national level. Such an organism does not currently exist in Portugal. In Brazil, FAPESP updated in 2014 their Code of Good Scientific Practices and included sanctions to deal with retractions (invalidation of degrees, copyrights, loss of positions, etc.). However, this code is only applied to investigations funded by FAPESP (FAPESP 2014). A study conducted by Fanelli et al (Fanelli, Costas, and Misconduct Policies 2015) concluded that having such a national organization greatly prevents scientific misconduct. This organization should be responsible for investigating suspected scientific misconduct and imposing appropriate sanctions which depend on the seriousness of the problem.

The main strength of this study lies in the use of the Retraction Watch database (The Retraction Watch Database 2018) as a data source. The Retraction Watch database was created in 2010 and contains more than 30,000 retractions between 1940 and 2022. Other studies analyzing retractions reported difficulties in identifying retracted publications using traditional methods (such as Medline or Web of Science) (Stavale et al. 2019). However, the Retraction Watch database includes retracted publications both indexed in main databases and those that have not been indexed. Therefore, we consider the number of retracted publications missed in this study to be minimal.

This study also has limitations. One of them could be the lack of a comparison group. The selection of a comparison group would be difficult.

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For example, if we match articles by journal, we could not compare the journals' characteristics. It should be noted that many of the studies analyzing retractions do not have a comparison group. There are authors affiliated with more than one institution. In this study, the first institution of affiliation of each author was collected in order of appearance. In addition, we analyzed the articles that have already been retracted, we are unaware of the total number of flawed publications present in the scientific literature. Regarding the citation analysis, this study didn't differentiate between citations received before retraction and citations received after retraction.

The increase of health sciences retractions overtime in Portugal and Brazil is worrying, especially considering that most retractions are due to scientific misconduct and many of them have received funding from public sources. Considering the results of this study, it is necessary to establish mechanisms to prevent, detect, monitor, and deal with scientific misconduct. These mechanisms may include the promotion of students' training and engagement in scientific integrity by universities; the systematic use of plagiarism software by scientific journals; or the establishment of measures to prevent researchers who committed scientific misconduct from receiving funding by funding institutions. In addition, at the national level, the creation of a specific organism which would handle and sanction misconduct may help to deter researchers who are thinking of engaging in research misconduct (Candal-Pedreira, Ruano-Ravina, and Pérez-Ríos 2021; Candal-Pedreira et al. 2022).

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Disclosure statement

No potential conflict of interest was reported by the author(s).

Data availability statement

Data available on request from the authors.

Ethics statement

This study used publicly available materials and did not involve human subjects, so ethics committee approval was not required.

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Artículo 8. Candal-Pedreira C, Ruano-Ravina A, Fernández E, Ramos J, Campos-Varela I, Pérez-Ríos M. **Does retraction after misconduct have an impact on citations? A pre-post study.** BMJ Glob Health. 2020;5(11):e003719. doi: 10.1136/bmjgh-2020-003719.

Original research

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Does retraction after misconduct have an impact on citations? A pre–post study

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ABSTRACT

Background Retracted articles continue to be cited after retraction, and this could have consequences for the scientific community and general population alike. This study was conducted to analyse the association of retraction on citations received by retracted papers due to misconduct using two-time frames: during a postretraction period equivalent to the time the article had been in print before retraction; and during the total postretraction period.

Methods Quasiexperimental, pre–post evaluation study. A total of 304 retracted original articles and literature reviews indexed in MEDLINE fulfilled the inclusion criteria. Articles were required to have been published in a journal indexed in MEDLINE from January 2013 through December 2015 and been retracted between January 2014 and December 2016. The main outcome was the number of citations received before and after retraction. Results were broken down by journal quartile according to impact factor and the most cited papers during the preretraction period were specifically analysed.

Results There was an increase in postretraction citations when compared with citations received preretraction. There were some exceptions however: first, citations received by articles published in first-quartile journals decreased immediately after retraction ($p<0.05$), only to increase again after some time had elapsed; and second, postretraction citations decreased significantly in the case of articles that had received many citations before their retraction ($p<0.05$).

Conclusions The results indicate that retraction of articles has no association on citations in the long term, since the retracted articles continue to be cited, thus circumventing their retraction.

Key questions

What is already known?
- There is scarce evidence regarding if retracted articles continue to be cited after retraction.

What are the new findings?
- Our study suggests that retraction of articles has no association with the number of citations in the long term across all quartiles. However, our results have shown an association of retraction on citations received by articles highly cited before the retraction.

What do the new findings imply?
- To prevent this lack of effect on citations after retraction, more effective mechanisms to avoid citing retracted papers should be established by the scientific journals. Options available with reference managers should be used by authors.

INTRODUCTION

In recent years, there has been an increase in the number of retracted articles, even when the increase in the number of indexed publications is taken into account, a development that is of concern to the scientific community.[1] A paper's retraction informs the scientific community that the study in question is not considered reliable, ethical or both, should be effectively eliminated from the literature and should therefore cease to be cited, especially when its retraction is attributable to scientific misconduct.[2] Even so, there is evidence to indicate that retracted articles continue to be cited even after their retraction.[3] A classic example of this phenomenon is the case of the paper published in 1998 by Wakefield *et al*, which reported an association between the administration of measles, mumps and rubella vaccine and autism. According to a study conducted in 2019 by Suelzer *et al*, Wakefield's paper had been cited a total of 1211 times until March 2019, and of these citations, 881 occurred after a partial retraction of the article in March 2004.[4,5] This paper was finally retracted in 2010.[6]

Postretraction citations pose a problem and can have consequences, both for the scientific community and also for the general population, since they perpetuate the misconduct and/or erroneous results, and continue lending visibility and, implicitly, credibility to the research and its authors. On the one hand, citing retracted articles may lead to other researchers accepting this information as accurate and basing their studies on it; and on the other hand, if health professionals make use of and base themselves on dishonest or misinterpreted information in their own clinical practice, their patients'

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health could be put at risk.[7] Most postretraction citations may be attributed to two causes: first, the author's ignorance of the retraction because, in many cases, news of the retraction does not appear in the text or, alternatively, the author does not access the article but instead places their trust in the citations of other authors;[8 9] and second, under certain circumstances, the author may consider it useful to mention these results as erroneous in the context of their own study.

The frequency of retracted publications is an important indicator of both the quality of the peer-review process and the pressure on researchers to publish, widely known as 'publish or perish'.[1 10] The number of retracted papers has risen.[11 12] However, a decreasing trend can be observed for the first time in the number of retracted papers since 2016 to the present days. The total number of retracted publications in 2013 was 573 out of a total of 1 148 851, representing a proportion of 5 per 10 000 publications. However, in 2016, this proportion was 3.8 per 10 000 publications (484 retracted publications out of a total of 1 279 814). The proportions were calculated by dividing the total number of retracted publications by the total number of registries in PubMed for these 2 years.

Despite the reduction in the proportion of retracted publications in recent years, it should be highlighted that proportion of misconduct among retracted papers did not change over the time.[13] The situation is rendered more serious by the fact that only a small proportion of cases of scientific misconduct are known.[14 15] For these reasons, there is a need to generate scientific evidence that would allow for systematic and rigorous analysis of the characteristics of the retracted articles and the causes of their retraction.[1] A number of authors have conducted studies focusing on postretraction citations and the association of retraction on these, and report a reduction of 35%–69% in the number of citations received by such articles after their retraction.[7 16 17] However, these studies have neither focused on the characteristics of the journals in which the retracted articles are published, nor considered a minimum period of publication for retracted articles that would afford an opportunity for citations to be generated.

Accordingly, the main aim of this study was to analyse whether or not citations received by retracted articles decrease after retraction, and the association of such retraction on citations received according to the journal's relative position (impact factor, IF); and, to assess if the number of citations on articles that are highly cited prior to their retraction is reduced.

METHODS

Study design

This was a quasiexperimental, pre–post evaluation study in which the intervention consisted of an article's retraction for reasons of misconduct, and the unit of analysis was the article published and subsequently retracted. We selected original research papers and literature reviews published in journals included in Journal Citation Reports (citation-based research analytics tool belonging to Clarivate Analytics). By way of inclusion criteria, articles were required to have been published in MEDLINE from January 2013 through December 2015 and been retracted between January 2014 and December 2016, both inclusive. The cause of retraction must have been research misconduct, defined by the Office of Research Integrity as follows: "fabrication, falsification or plagiarism in proposing, performing or reviewing research, or in reporting research results… Research misconduct does not include honest error or differences of opinion'.[18]

The characteristics of retracted studies included have been described in other previous reports.[13 19] All types of publications that were not original research papers or literature reviews were excluded, as were those retracted for any reason other than misconduct. To ensure that any given retracted article enjoyed the same opportunity of being cited preretraction and postretraction, the period during which it was in print before and after retraction was required to be equal, with a minimum of 12 months each (preretraction and postretraction periods). This meant that all the studies included were published a minimum of 12 months prior to their retraction and were 'at risk of citation' for a further 12 months thereafter, with a minimum total time to retrieve citations of 24 months. An extra follow-up time for all papers included was added until December 2019. The time between retraction and such date was called 'total postretraction period' and we collected all citations received during such period.

Data collection

We designed our own database to include all information from the retracted papers included in this study. Some of this information was recorded manually and other was collected from Web of Science (Clarivate Analytics). The information used for this study was the following:

Data related to the retracted article: first author's country of affiliation, number of authors, institutional affiliation of author(s), date of publication and date of retraction.

Data about the journal in which the retraction occurred: category of area of knowledge (and in any case where a journal appeared in more than one such area, we selected the one in which it ranked best), IF, relative position (by quartile) and country of publication. Relative position by quartile was calculated for a specific journal publishing the retraction using the category where it ranked best at the Journal Citation Reports (Clarivate analytics) database. This database provides the quartile belonging to each journal for a given year.

Data on citations received: title of the citing article, name of its author(s) and name of the journal. Number of citations received by the retracted article across the total preretraction period, and number of citations received both in a postretraction period equivalent to the preretraction period and across the total postretraction period. In addition, we calculated total citations, defined as the sum of citations in the preretraction and postretraction

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periods. All citation data were obtained by conducting a manual search in the Web of Science database. All the information regarding the retracted paper characteristics, citations and time of citation was collected in a database designed to this end by the authors.

Statistical analysis

We performed a descriptive analysis of the characteristics of the retracted articles by reference to the variables of interest. We also showed descriptive information on retracted papers excluding those with the first author from China. To do this, we calculated absolute numbers distribution with percentages and medians with 25th and 75th percentiles. Afterwards, we analysed the association between citations received preretraction and postretraction stratified by journal quartile and also specifically for a smaller group of retracted papers comprising those most cited papers before retraction. For the quartile calculation, we only considered journals where retracted papers have been published. We first compared citations received during the preretraction period against those received during an equivalent postretraction period; and we then compared these preretraction citations against total postretraction citations received until December 2019. As these were matched data, the Wilcoxon signed-rank test was used for analysis. Using the same method, a specific analysis was performed on the 21 most cited articles prior to their retraction, in order to ascertain whether their postretraction citation pattern was affected to a relevant degree. All analyses were performed using IBM SPSS V.22 (IBM, Armonk, NY, USA).

RESULTS

A total of 304 articles fulfilled the inclusion criteria. The retracted articles included in the study were published in 178 different biomedical journals. A breakdown of the principal characteristics of the retracted articles is shown in table 1: 65.0% of retracted articles were written by more than four authors, and 77.0% of these came from university institutions; China was the country of affiliation of 45.7% of first authors, followed by the USA with 14.1% and finally, one-third of all retracted articles analysed were published in first-quartile journals. It can be observed that excluding retracted papers from China did not change importantly the number of authors of retracted papers and other variables, though the number of papers retracted in first quartile journals increased from 32.9% to 45.5%.

The citations received by retracted articles are shown in table 2. A median of 2 preretraction citations were received by the articles included, with this number being equal to that received in the equivalent postretraction period. In the case of median total postretraction citations, however, this figure rose to 4. These results did not differ when we excluded papers with the first author from China (data not shown).

Table 1 Characteristics of retracted articles (n=304)

Variables	N (%)	Papers from China excluded n (%)
Country of first author		
China	139 (45.7)	–
USAmerica	43 (14.1)	43 (26.1)
Iran	28 (9.2)	28 (17.0)
Other countries	94 (31.0)	94 (56.9)
Number of authors*		
1–2	37 (12.3)	27 (16.4)
3–4	69 (22.8)	39 (23.6)
>4	196 (64.9)	99 (60.0)
Institution†		
University	233 (77.0)	127 (77.4)
Hospital	39 (12.8)	8 (4.9)
Research centre	28 (9.2)	26 (15.9)
Other	3 (1.0)	3 (1.8)
Scope of the journal		
Biochemistry and molecular biology	43 (14.1)	11 (6.7)
Oncology	35 (11.5)	11 (6.7)
Medicine, research and experimental	23 (7.6)	1 (0.6)
Multidisciplinary sciences	22 (7.2)	15 (9.1)
Pathology	19 (6.3)	16 (9.7)
Other	162 (53.3)	121 (67.2)
Relative position of journal		
Q1	100 (32.9)	75 (45.5)
Q2	78 (25.7)	44 (26.7)
Q3	91 (29.9)	28 (17.0)
Q4	35 (11.5)	18 (10.8)
Country of journal		
USA	97 (31.9)	70 (42.4)
UK	91 (29.9)	56 (33.9)
The Netherlands	40 (13.2)	9 (5.5)
Other	76 (25)	30 (18.2)

*Missing information: two cases missing for all papers and two when papers from China are excluded.
†Missing information: one case missing for all papers.

Table 3 and figure 1 show the citations received by retracted articles according to the journal quartile in which they were published. In all cases (ie, in both the preretraction and postretraction periods), the median number of citations was higher for first-quartile (Q1) journals. While there was a significant reduction in citations in first-quartile journals comparing preretraction period to the equivalent postretraction period (five median citations; interquartilic range 3–13 to 4 median citations; interquartilic range 2–8), this was not the case

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Table 2 Characteristics of retracted articles linked to citations

Variables	All papers
Median preretraction follow-up time and range (months)	18 (12–39)
Median equivalent postretraction period follow-up time and range (months)	18 (12–39)
Median total postretraction follow-up time and range (months)	50 (37–72)
Median total citations (25th and 75th percentiles)	7 (3–15)
Median citations in the preretraction period (25th and 75th percentiles)	2 (1–5)
Median citations in the equivalent postretraction period (25th and 75th percentiles)	2 (1–5)
Median total postretraction citations (25th and 75th percentiles)	4 (2–8)

in the remaining quartiles. When comparing preretraction citations with the total postretraction period citations, we observed that the number of citations increased significantly for second and third quartiles (2–4 median citations for the second quartile and 1–3 for the third quartile), with the fourth quartile showing a close to significant difference (2–3 median citations). There was no significant difference for the first quartile for this comparison. Of note, the median number of citations for the total postretraction period were, for the first, second, third and fourth quartiles, 7, 4, 3 and 3, respectively. This means that these papers continue to be cited regardless of the quartile of publication.

Table 4 describes the characteristics of the 21 most cited articles in the sample, and analyses the citations received before and after retraction (during both the equivalent and total postretraction periods). There was a statistically significant decrease in the median number of citations between the preretraction and equivalent postretraction periods ($p<0.05$); thereafter, citations registered an increase, though this was not significant ($p=0.06$).

DISCUSSION

This study highlights the fact that articles retracted due to scientific misconduct continue to be cited, thus showing retraction to be an inadequate measure for eliminating invalid knowledge as a means of preventing its use by the scientific community. On the contrary, the results of this study suggest that retraction only leads to an initial decrease in the number of citations in first-quartile journals, and does not reduce the number of citations in articles published in second, third or fourth-quartile journals.

The potential effect of retraction on citations has been studied for over three decades, however, the published studies are not comparable with ours in terms of study design. Most of the studies analysing the association of retraction with citations do not have a pre–post design to be specifically targeted at analysing postretraction citations of individual articles retracted due to scientific misconduct, during a postretraction period equivalent to the preretraction period and also during the entire postretraction period.

Different authors have studied the association of retraction with the citations of retracted articles, with a reported reduction of 35%–69% in the number of citations received by articles following retraction.[7 16 17] Instead of a reduction, however, our results show a twofold increase in postretraction citations. Even so, our results coincide with other previous studies, in which most of the articles analysed received more citations following retraction.[9 20] It should be stressed here that these previous studies are not comparable with the present study in terms of the design included (ie, clinical trials),[16] knowledge areas, such as radiology or dentistry[9 21] or time of publication (some studies were published prior to 2006).[7 17]

In all, 32.9% of the retracted articles included in this study had been published in first-quartile journals. These results are in line with those of earlier studies.[9 22] This may be because papers that appear in high-IF journals and are retracted due to misconduct, are more likely to be detected, possibly owing to the additional postpublication scrutiny to which such articles are subjected as a result of being used more often than those published in lower-IF journals.[7 22]

With respect to citations of articles published in first-quartile journals, these decrease significantly during the equivalent postretraction period but then subsequently increase once again, receiving more citations than those received by articles in the other quartiles. This finding is in line with those of previous studies which report a positive correlation between IF and postretraction citations, namely, that the higher the journal's IF, the more citations an article will receive after its retraction.[17 23 24]

Different studies have found that papers which receive many citations prior to being retracted continue to be highly cited thereafter.[24 25] This study shows a significant decrease between the citations received by the most highly cited articles prior to retraction and those received in the equivalent postretraction period. After this period, the number of citations begins to rise again, though this increase is not significant with respect to the number received preretraction. However, despite the fact that there is a certain association on postretraction citations in these types of articles, the total postretraction citations they receive are almost double the number of postretraction citations received by the articles included in this study.

Bearing in mind that 94% of all postretraction citations refer to the article as valid, without mentioning its retracted status,[8] one possible explanation for the results obtained by us is that, if a retracted article is cited in a publication with no mention of its retracted status, this may give rise to 'secondhand' citations. This amounts to

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Table 3 Citations received preretraction and postretraction, by journal category

Variables	Q1	Q2	Q3	Q4
Median total citations (25th and 75th percentiles)	14 (7–24.25)	6 (2.75–11)	5 (2–8)	5 (2–9)
Median citations in the preretraction period (25th and 75th percentiles)	5 (3–12.75)	1 (0–4)	1 (0–3)	1 (0–3)
Median citations in the equivalent postretraction period (25th and 75th percentiles)	4 (2–8)	2 (1–5)	1 (0–3)	2 (1–4)
Comparison between preretraction period and equivalent postretraction period	p<0.001	p=0.245	p=0.392	p=0.488
Median total postretraction citations (25th and 75th percentiles)	7 (4–12)	4 (1–7)	3 (2–6)	3 (1–6)
Comparison between preretraction and total postretraction periods	p=0.332	p<0.001	p<0.001	p=0.054

citing an article that has previously been cited by another author, without having accessed the original and thus being ignorant of the fact that one is citing a retracted article.[9 20] According to Simkin and Roychowdhurys study, 70%–90% of all citations are copied from references used in other articles,[26] reflecting poor scholarship. This could cause a chain reaction and thus increase citations of a retracted article long after its retraction.

One possible explanation for the decrease in citations in the immediate postretraction period and the subsequent increase thereafter in first-quartile journals may be linked to the phenomenon of self-citations. According to the study undertaken by Madlock-Brown and Eichmann, authors may be capable of influencing the way in which their retracted paper is viewed by means of self-citation.[23] Hence, there is the possibility that, in some cases, authors, on observing a decrease in citations as a consequence of retraction, cite themselves without mentioning their article's retracted status, thereby boosting the number of citations that their retracted article receives.[23]

This study has some limitations, one of which could be the low number of retracted articles. This is due to the inclusion criterion that required retracted articles to have been in print for at least 1 year without having been retracted. However, this inclusion criterion meant that each article had the opportunity to receive a sufficient number of citations to analyse a potential association with retraction, something that would not have been feasible if the article had been published for a short time only. Furthermore, there is the possibility that a number of postretraction citations may have been incorrectly classified, since some came from articles accepted

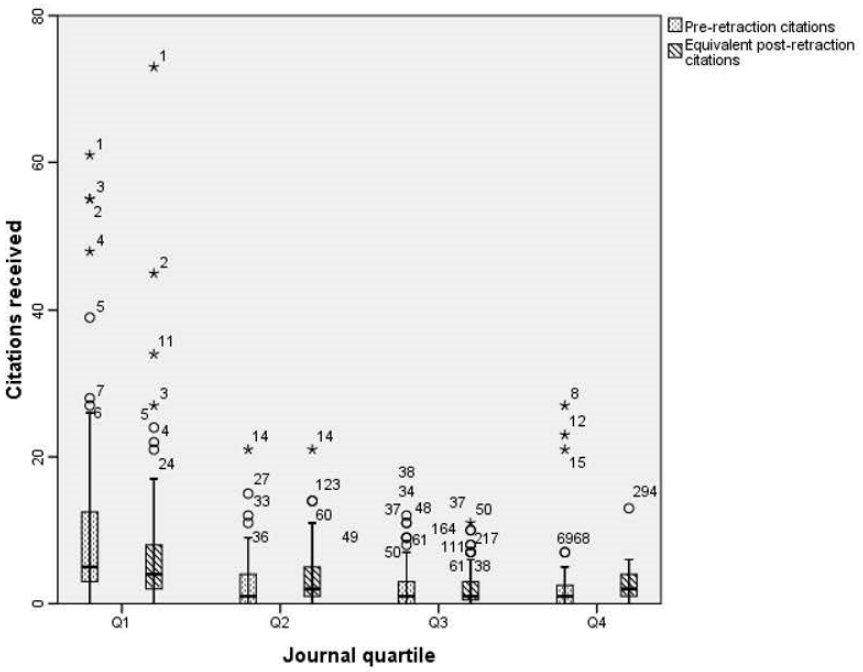


Figure 1 Preretraction and postretraction citations by journal quartile.

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Table 4 Characteristics of the most cited articles prior to retraction

Variables	
Median preretraction follow-up time and range (months)	27 (15–39)
Median equivalent postretraction period follow-up time and range (months)	27 (15–39)
Median total postretraction follow-up time and range (months)	51 (37–59)
Median total citations (25th and 75th percentiles)	39 (30.5–70)
Median citations in the preretraction period (25th and 75th percentiles)	24 (18–33.5)
Median citations in the equivalent postretraction period (25th and 75th percentiles)	13 (7.5–23)
Comparison between preretraction period and equivalent postretraction period	p=0.01
Median total postretraction citations (25th and 75th percentiles)	17 (11–26.5)
Comparison between preretraction and postretraction periods	p=0.06

for publication and already available online before the article cited had been retracted, consequently leaving the authors unable to delete the relevant citation. Yet even if this were so, we nonetheless observed that the number of citations increased in general and that there was only an association when the retracted paper was published on journals belonging to the first quartile. This means that authors who published in high-IF journals were aware of such retractions, in contrast to what happened in journals belonging to the other quartiles. Hence, while the period of time that elapsed between the dispatch and publication of a given article might have had some association with the results of this study, this can be assumed to have been the same across all quartiles. Additional limitations are having only included articles published in IF journals, and therefore we do not know the results of retraction in other types of journals and a further limitation is not having collected reasons for exclusion of excluded papers.

This study's principal advantage lies in its pre–post design, since, to the best of our knowledge, it is the first study to compare the citations received by retracted articles before retraction against those received during an equivalent postretraction period of time . Moreover, the number of citations received, both before and after retraction, was ascertained on an article-by-article basis, thereby making it possible to ascertain the association of different characteristics of the retracted papers on the number of citations.

In conclusion, this study indicates that retraction of articles has no association with the number of citations in the long term, since the retracted articles continue to be cited, thus circumventing their retraction. While it is true that, for a period of time, postretraction citations are seen to decrease in first-quartile journals, they ultimately do start to increase again.

Therefore, retractions must be announced and monitored to prevent spreading of retracted studies. One notable example of monitoring retractions is the Retraction Watch database that was created in 2010 and has a catalogue more than 20 000 retracted items.[27] Even though this database is not complete, it is available and can be used by any interested person to know different details of retracted papers.

However, more effective mechanisms should be established to prevent the citation of retracted articles in scientific papers: these could possibly include a warning in the publication guidelines of all scientific journals advising authors to check for citations of retracted articles.

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Contributors AR-R and MP-R designed the research. CC-P, AR-R and IC-V extracted information from the databases. CC-P, AR-R and EF designed the statistical analysis and provided ideas on how to present results. AR-R and JR wrote a proposal for the discussion section. CC-P and AR-R wrote a first draft of the manuscript. All authors provided intellectual input on the different versions of the draft. All authors have approved the final version of the manuscript and take public responsibility on its content.

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Original Article

Comparison of COVID-19 and non-COVID-19 papers

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ABSTRACT

Objective: The need to generate evidence related to COVID-19, the acceleration of publication and peer-review process and the competition between journals may have influenced the quality of COVID-19 papers. Our objective was to compare the characteristics of COVID-19 papers against those of non-COVID-19 papers and identify the variables in which they differ.
Method: We conducted a journal-matched case-control study. Cases were COVID-19 papers and controls were non-COVID-19 papers published between March 2020 and January 2021. Journals belonging to five different Journal Citations Reports categories were selected. Within each selected journal, a COVID-19 paper (where there was one) and another non-COVID-19 paper were selected. Conditional logistic regression models were fitted.
Results: We included 81 COVID-19 and 143 non-COVID-19 papers. Descriptive observational studies and analytical observational studies had, respectively, a 55-fold (odds ratio [OR]: 55.12; 95% confidence interval [95%CI]: 7.41-409.84) and 19-fold (OR: 19.28; 95%CI: 3.09-120.31) higher likelihood of being COVID-19 papers, respectively, and also a higher probability of having a smaller sample size (OR: 7.15; 95%CI: 2.33-21.94). COVID-19 papers had a higher probability of being cited since their publication (OR: 4.97; 95%CI: 1.63-15.10).
Conclusions: The characteristics of COVID-19 papers differed from those of non-COVID-19 papers published in the first months of the pandemic. In order to ensure the publication of good scientific evidence the quality of COVID-19-papers should be preserved.

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Comparación de los artículos COVID-19 y no COVID-19

Palabras clave:
SARS-CoV-2
Estudios de casos y controles
Ética en la investigación

RESUMEN

Objetivo: La necesidad de generar evidencia relacionada con la COVID-19, la aceleración del proceso de revisión por pares y publicación, y la competencia entre revistas, pueden haber influido en la calidad de los artículos sobre la COVID-19. El objetivo fue comparar las características de los artículos sobre la COVID-19 con las de los artículos no COVID-19 e identificar las variables en las que difieren.
Método: Se realizó un estudio de casos y controles emparejados por revista. Los casos eran artículos COVID-19 y los controles eran artículos no COVID-19 publicados en el mismo periodo. Se seleccionaron revistas pertenecientes a cinco categorías diferentes del *Journal Citations Reports*. Dentro de cada revista seleccionada, se escogió un artículo COVID-19 (cuando había uno) y otro artículo no COVID-19. Se ajustaron modelos de regresión logística condicional.
Resultados: Se incluyeron 81 artículos COVID-19 y 143 artículos no COVID-19. Los estudios observacionales descriptivos y los estudios observacionales analíticos tenían, respectivamente, una probabilidad 55 veces mayor (*odds ratio* [OR]: 55,12; intervalo de confianza del 95% [IC95%]: 7,41-409,84) y 19 veces mayor (OR: 19,28; IC95%: 3,09-120,31) de ser artículos COVID-19 y de tener un tamaño de muestra menor (OR: 7,15; IC95%: 2,33-21,94). Los artículos más citados desde su publicación tenían 5 veces más probabilidades de ser artículos COVID-19 (OR: 4,97; IC95%: 1,63-15,10).
Conclusiones: Los artículos COVID-19 parecen tener mayor impacto bibliométrico, a pesar de tener menor calidad metodológica. Para asegurar la publicación de buena evidencia científica se debe preservar la calidad de los artículos relacionados con la COVID-19.

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Introduction

Since January 2020, the disease caused by the new coronavirus (SARS-CoV-2), named COVID-19 by the World Health Organization, has spread rapidly causing a global pandemic, with multifold consequences and giving rise to an unprecedented worldwide health and economic crisis in times of peace.[1,2] The interest aroused by the new coronavirus, added to the urgent need to generate evidence about the disease and its treatment, among other things, has led to an exponential increase in COVID-19-related papers.[3] This has in turn produced an avalanche of information difficult to manage and apply, whether by health professionals or by bodies tasked with implementing public health policies.[4]

In the period from the outbreak of the pandemic to May 2021, a total of 419,950 publications on COVID-19 were published, and of these more than 47,000 (11.2% of the total) were pre-prints, i.e., publications published online before peer review (www.dimensions.ai/covid19). Both peer-reviewed papers and preprints have served to generate a great volume of information on COVID-19. Yet it has been observed that a substantial number of peer-reviewed papers have methodological limitations or give rise to erroneous conclusions, with the resulting potential harmful effect for public health.[5,6]

The need to generate evidence quickly in the case of COVID-19, coupled with the competition between scientific journals to be first to publish what might prove to be the results of greatest relevance, may have undermined the quality of the research papers published. Added to this is the fact that the filters in the editorial process, such as peer review, may be more lax in the case of COVID-19 papers, due to pressure to publish.[8–10] Evidence of the change in the editorial process can be seen in the number of retractions observed in COVID-19 papers.[7] By May 2021, a total of 108 COVID-19-related papers had been retracted according to the Retraction Watch database (www.retractiondatabase.org). Bearing in mind that the mean time for retracting a paper is long, this may probably be only the tip of the iceberg. What is more, the publication of papers which address other relevant scientific topics may well be affected by the lack of space for publishing them.

Since the outbreak of the pandemic, a number of authors have published bibliometric analyses aimed at describing the characteristics of COVID-19-related studies and analyzing publication trends.[3,4,8–13] Only one study has analyzed the quality of COVID-19 papers, comparing it against that of non-COVID-19 papers, using a case-control design covering the initial months of the pandemic.[14]

A comparative analysis of papers on COVID-19 with respect to those on other topics published in the same journals (therefore controlling the role of editorial teams) could inform us about methodological differences that might influence or determine the quality of such studies. The objective of this study, therefore, was to compare the methodological and bibliometric characteristics of COVID-19 papers against those of non-COVID-19 papers and identify the variables in which the two differed, using a purpose-made case-control design.

Method

Study design

We conducted a case-control study of published papers matched by journal of publication of the included papers. Cases were papers on COVID-19 published from March 2020 through January 2021, and controls were papers published during the same period on other topics in the same journal. A minimum of one control was matched with each case. The number of controls per case varies between one and ten, depending on the number of COVID-19 and non-COVID-19 papers published by the selected journals.

We selected indexed journals profiled in Journal Citation Reports (JCR), belonging to the categories "Respiratory System", "Infectious Diseases", "Public, Environmental and Occupational Health", "General/Internal Medicine" and "Oncology". We selected the four journals with the higher impact factor of each quartile from each category, yielding a total of 20 scientific journals (5 categories × 4 quartiles). As inclusion criterion, all journals selected were required to have published one issue per month and to publish original papers in English, Spanish or Portuguese. For each journal selected, we reviewed all the monthly issues published from March 2020 through January 2021.

From each issue included, we selected one COVID-19 paper and one non-COVID-19 paper by order of appearance. In any case, should a given number might not contain a COVID-19 paper that fulfilled the inclusion criteria, this was selected from another issue of the same journal. Hence, the first of the COVID-19 papers of that particular issue of the journal was extracted for the month of publication in question, and a second paper was then selected for the issue of journals which did not contain a COVID-19 paper.

By way of inclusion criterion, papers were required to report on original research conducted on human beings and be written in English, Spanish or Portuguese. We excluded modeling studies, case studies, ecological studies and qualitative studies. Retracted papers were not included.

Due to the nature of the study, ethics committee approval was not required.

Data-collection

From each journal selected the following variables were obtained from the JCR database: JCR category; relative position in 2019 (by quartile); journal name and abbreviation; country and impact factor. We also obtained the number of COVID-19-related papers from each of the journal issues included, as well as the number of non-COVID-19 papers, and the total number of papers published in each number, with the aim of calculating the proportion of COVID-19 papers and non-COVID-19 papers in each of the numbers.

The following bibliometric variables were obtained from the papers selected: paper's title; month of publication; type of paper (COVID-19 or non-COVID-19); number of authors; name of first author; country of first author; first author's institutional affiliation; date of submission of manuscript and date of acceptance (where available). We calculated the number of days elapsed between the manuscript's date of submission and the date of publication of the articles included. Using the Web of Science database, we kept a manual record of the citations received by the papers included, from the date of their publication until 31st January 2021.

Furthermore, the following design variables were sourced from each paper: study design, categorized as descriptive observational (cross-sectional and cases series studies), analytical observational (case-control and cohort studies) or experimental (quasi-experimental and clinical trials); sample size (1-500, >500); study scope (local, national or international); number of centers at which the study was undertaken (unicenter or multicenter); and number of adjustment variables.

All the above variables were entered into a database purpose-designed by the authors.

Statistical analysis

We performed a descriptive statistical analysis to identify the characteristics of the papers included, by reference to the variables of interest collected and case or control status. Quantitative

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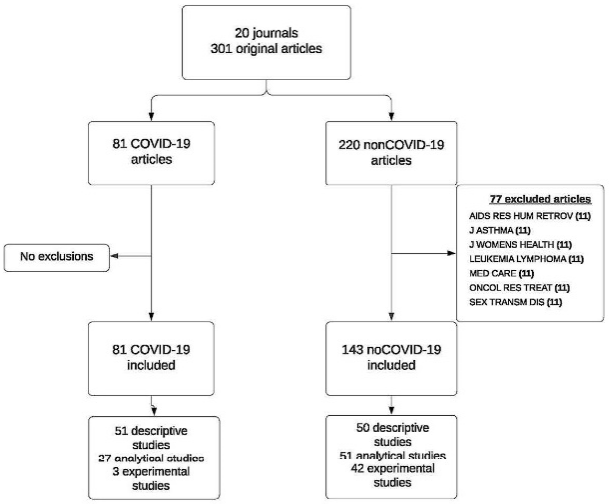


Figure 1. Flow chart.

variables were expressed in terms of median and interquartile range, while qualitative variables were expressed in absolute and relative frequencies.

A multivariate conditional logistic regression model was fitted to identify the bibliometric and study-design variables associated with COVID-19 or non-COVID-19 papers. In the final model the following variables were included: study design (descriptive observational, analytical observational, experimental) and sample size (1-500, >500). In addition, the model was adjusted by the journal in which the articles where published. Adjusted odds ratios (OR) were calculated along with their 95% confidence intervals (95%CI).

Values were deemed statistically significant at $p < 0.05$. All statistical analyses were performed using the Stata v17 computer software program.

Results

Data were collected on 301 papers published in 20 scientific journals across the period from March 2020 through January 2021, both inclusive. In March, no COVID-19 paper was published in the selected journals. In the following months, the proportion of COVID-19 papers varied, reaching 80% in the number of the Lancet Respiratory Medicine journal published in December 2020. Seven of the selected journals published no COVID-19 papers across the study period.

For analysis purposes, we excluded non-COVID-19 papers published in the seven journals which had not published any COVID-19 paper, due to the impossibility of matching these controls with cases by reference to the journal. Finally, the analysis included a total of 224 papers published in 13 journals; of these, 81 were COVID-19 papers and 143 were non-COVID-19 papers (Fig. 1). Table 1 describes the main bibliometric and design characteristics of the papers included, differentiating between COVID-19 and non-COVID-19 articles. Among the COVID-19 papers, 18.5% had more than 20 authors, whereas among the non-COVID-19 papers this percentage was 12.8%; for COVID-19 papers, the country with most publications was China, whereas in 23.1% of the non-COVID-19 papers the first author's country was the USA. While 63% of the COVID-19 papers had a descriptive design and 3 (3.7%) were experimental studies, among the non-COVID-19 papers, the percentage of papers included with an experimental design was 24.9%.

Table 2 and Figure 2 show that the time to publication of COVID-19 papers was shorter than that of non-COVID-19 papers ($p < 0.001$). In addition, it was observed that COVID-19 articles received a higher number of citations compared to non-COVID-19 articles ($p < 0.001$). COVID-19 articles received a median of 3 citations (interquartile range: 0-25), while non-COVID-19 articles received a median of 1 citation (interquartile range: 0-3).

As can be seen in Table 3, descriptive observational and analytical observational studies had a 56-fold (OR: 56.43; 95%CI: 9.40-338.67; $p < 0.001$) and 20-fold (OR: 19.94; 95%CI: 3.77-105.58; $p < 0.001$) higher likelihood of being COVID-19 papers, respectively, taking experimental design as the reference category. The studies with the smallest sample size (<500 individuals) had a 6-fold higher likelihood of being COVID-19 papers (OR: 5.96; 95%CI: 2.19-16.28; $p < 0.001$) as compared to studies with the largest sample size (>500 individuals included in the study).

Discussion

The results observed in this study suggest that there are differences among original research papers published in the first months of the pandemic, according to whether they report COVID-19 or non-COVID-19 studies. Despite receiving more citations, COVID-19 studies are more likely to have certain characteristics (study design, sample size) which are generally associated with low methodological quality than are non-COVID-19 studies, according to some quality assessment tools, such as GRADE.[15]

The process of scientific publication has been influenced by the COVID-19 pandemic. On the one hand, in line with the results of this study, a number of authors had already found evidence to show that time to publication is significantly shortened in the case of COVID-19 papers, in comparison with papers on other scientific topics.[7,16,17] This phenomenon is the result of scientific journals expediting the publication process and peer review of COVID-19 papers, with the aim of disseminating results more quickly. The results of the study conducted by Horbach indicate that COVID-19 papers are accepted after a single peer-review round, whereas non-COVID-19 papers require more rounds before being accepted by the journal, thus increasing the time between manuscript submission and publication.[16] In this context, doubts arise as to whether

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Table 1
Main characteristics of cases and controls.

	COVID-19 (n = 81) n (%)	Non-COVID-19 (n = 143) n (%)
Characteristics of the authors		
Number of authors		
1-5	16 (19.8%)	32 (22.4%)
6-10	26 (32.1%)	56 (39.2%)
11-15	17 (21.0%)	22 (15.4%)
16-20	7 (8.6%)	15 (10.5%)
21-25	5 (6.2%)	8 (5.6%)
26-30	3 (3.7%)	5 (3.5%)
>30	7 (8.6%)	5 (3.5%)
Country of author		
USA	11 (13.6%)	33 (23.1%)
China	16 (19.8%)	5 (3.5%)
Denmark	9 (11.1%)	11 (7.7%)
UK	8 (9.9%)	9 (6.3%)
Brazil	7 (8.6%)	13 (9.1%)
Rest	30 (37%)	72 (50.3%)
Author's institution		
University	28 (34.6%)	50 (35%)
Hospital	28 (34.6%)	37 (25.9%)
University + hospital	15 (18.5%)	28 (19.6%)
Research center	6 (7.4%)	15 (10.5%)
Other	4 (4.9%)	13 (9%)
Characteristics related to the study		
Study design		
Descriptive observational	51 (63.0%)	50 (35%)
Analytical observational	27 (33.3%)	51 (35.7%)
Experimental	3 (3.7%)	42(29.4%)
Sample size		
1-500	56 (69.1%)	65 (45.5%)
>500	25 (30.9%)	78 (54.5%)
Study scope[a]		
Local	48 (64.0%)	75 (56.8%)
National	18 (24.0%)	31 (23.5%)
International	9 (12.0%)	26 (19.7%)
Enrolment centers[b]		
Unicenter	30 (50.8%)	49 (44.5%)
Multicenter	29 (49.2%)	61 (55.5%)
Number of variables of adjustment (median and range)	2 (0-15)	2 (0-14)

[a] Missing values: 6 cases and 11 controls.
[b] Missing values: 22 cases and 33 controls.

Table 2
Time to publication (in days) and citations received by case or control status.

Variable	Total	COVID-19	Non-COVID-19	p
Time (in days) between manuscript submission and publication in days (median and range)[a]	240.5 (8-540)	144 (8-228)	291 (128-540)	p < 0.001
Citations received (median and range)	1 (0-2193)	3 (0-2193)	1 (0-46)	p < 0.001

[a] Missing values: 46 cases and 70 controls.

editorial teams apply the same quality criteria when it comes to evaluating COVID-19 and non-COVID-19 articles.

Added to this is the fact that, according to our results, COVID-19 studies published in the first months of the pandemic have a greater likelihood of having a descriptive design and smaller sample size than do non-COVID-19 papers. Different studies have analyzed the quality of COVID-19 papers using different methods and all agree on the fact that, generally speaking, their quality is low.[14,17,18] Accorsi et al.[19] have identified many biases in COVID-19-related observational studies in aspects such as interpretation of results or enrollment of a non-representative sample of the study population, among others. This poses a problem, since papers with a low methodological quality and a greater presence of biases can induce readers to draw erroneous conclusions, which is, in itself, a potential health threat. Associated with this is the fact that health professionals may base themselves on erroneous or invalid conclusions to guide their clinical practice, with the potential harm that this entails for patients; similarly, the health authorities could take decisions which might endanger population health.[20,21]

Mention should be made of the great popularity enjoyed by preprint servers during the pandemic. The use of preprint servers had already been on the rise before the pandemic, due to the criticisms leveled at scientific journals' current publication system, and peer review in particular, for slowing down the dissemination of results. In the context of the pandemic, a considerable number of COVID-19-related manuscripts were published as preprints.[7,22] It should be borne in mind that there is no mechanism which would verify that information published as a preprint is in fact genuine and reliable.[6] During the pandemic, results published in the form of preprints have led some political and medical personalities to promote certain treatments for COVID-19, without these having been validated in any way, with the potential harm that this could entail for the population.[5,22] A formal approach to the role of preprints in COVID-19 pandemic is clearly needed.

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Table 3
Characteristics associated with being a COVID-19 paper.

Variable	Cases n (%)	Controls n (%)	Adjusted OR (95%CI)	p
Study design				
Descriptive observational	51 (63.0%)	50 (35.0%)	56.43 (9.40-338.67)	<0.001
Analytical observational	27 (33.3%)	51 (35.7%)	19.94 (3.77-105.58)	<0.001
Experimental	3 (3.7%)	42 (29.3%)	1 (-)	
Sample size				
1-500	56 (69.1%)	65 (45.5%)	5.96 (2.19-16.28)	<0.001
>500	25 (30.9%)	78 (54.5%)	1 (-)	

95%CI: 95% confidence interval; OR: odds ratio.
Adjusted by the study design, sample size and the journal where the article was published.

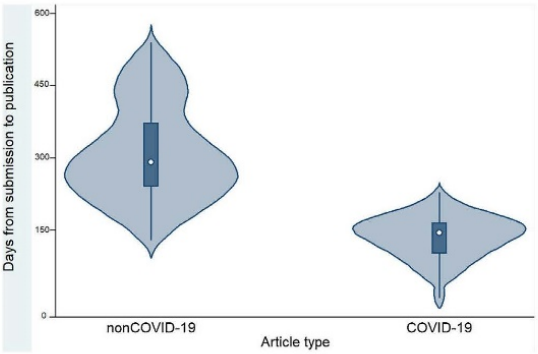


Figure 2. Time to publication by case or control status.

It should be noted that only 3.5% of COVID-19 studies included in the analysis had an experimental design versus 29.4% in the case of non-COVID-19 studies. During the first months of the pandemic, it was common for studies to have an observational design and small sample size, thus making them methodologically inferior.[23] With the passage of time, however, it is to be hoped that COVID-19-related studies may improve their methodological quality, since higher-quality studies require better planning and execution and, thus, more time.[4] Even so, the results of our study highlight the fact that almost one year after the outbreak of the pandemic, the number of experimental studies published on COVID-19 is still low in comparison with non-COVID-19 studies.

Another worrying phenomenon is the impact and visibility of COVID-19 studies. The results indicate that COVID-19 papers accumulate a higher number of citations than do non-COVID-19 papers. Our results are in line with the study conducted by Yang et al.[18] and by Zdravkovic et al.[14], which not only indicate that COVID-19 papers receive a higher number of citations, but also show that the citations received by papers on other scientific topics have decreased with respect to 2019.

The information which has been published on COVID-19 does not always make for any real advance in scientific knowledge. Encouragement should be given to the publication of systematic literature reviews which compile and summarize the information generated on different aspects of COVID-19, with the aim of making it more manageable.[4] It should likewise be borne in mind that there is an unnecessary overlapping of COVID-19-related scientific evidence, with the ensuing loss of time and resources (human and economic) that this entails.[5,21,24] However, there are COVID-19-related fields that are hardly being studied, such as the effects of the pandemic on other diseases or the use of new technologies.[11] One solution to this problem could be the pre-registration of studies on purpose-designed platforms.[6] It should also be noted that by prioritizing the publication of COVID-19 studies, relevant higher-quality studies addressing other scientific topics might possibly be overlooked or even ruled out.

It is important that editors be more alert to the quality of COVID-19 papers submitted for publication by using of checklists, such as STROBE or CONSORT[25] or by enhancing open peer reviews, making it known what reviews have been conducted and by whom these have been conducted. Open peer reviews could have some benefits as it might increase the transparency of the peer review process by shifting the responsibility to reviewers to perform more thoughtful reviews. Also, open peer review enables greater visibility for peer review activities.[26] It is worth mentioned that most authors, reviewers, and editors are in favor of this type of peer review, especially among younger generations. However, a large number of authors also believe that open identities could lead to worse and less critical peer reviews, mostly because of the potential consequences from the aggrieved authors.[27] Another strategy could be the promoting of unsolicited reviews carried out spontaneously after the publication of the paper in a peer reviewed journal as it might favor early detection of errors or scientific misconduct in all scientific papers, and not only in those pertaining to COVID-19.[6]

This paper has some limitations. On the one hand, the sample size is small for the design used. This is due to the inclusion criterion which determines the selection of original research studies. Rather than being original research studies, a good part of the COVID-19 articles published to date are in the form of letters or editorials.[3] We, however, chose to include original papers only, whether COVID-19 or non-COVID-19, since these must meet a single common standard of quality. On the other hand, this study included papers published in scientific journals which were subjected to peer review, and as a consequence other type of publication, such as preprints, are not taken into account. A further limitation is the number of missing values in some of the variables collected, due to lack of availability of data, especially on aspects such as time to publication and enrollment centers. Another limitation is that the selection of the papers where made based on the order of appearance of the articles in the selected issues. A further limitation is that we have not used any tool or scale to formally measure the methodological quality of the studies included and compare it between COVID and non-COVID studies. It would have been interesting to include the authors gender as a variable, however, it is difficult to determine it through the name and affiliation of the authors. Because of that, the collection of the variable gender could be prone to errors, especially in the case of Asiatic authors, and this is especially relevant in COVID-19 papers.

One of the strengths of this study is its design, established to favor comparison of the quality of studies in a single journal across the period analyzed, as well as between quartiles of different areas of JCR knowledge. This design facilitates comparison between COVID-19 and non-COVID-19 papers.

In conclusion, characteristics of COVID-19 papers differed from those of non-COVID-19 papers published in the first months of

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the pandemic. Many of the aspects relating to COVID-19 remain unknown, despite the effort of the scientific community to generate and disseminate information about the disease. Hence, more evidence of better quality must be generated with the aim of guiding decision-making in the context of the pandemic. That said, however, the urgency with which information is needed is no excuse for conducting low-quality research, which is ultimately of little use, leads to a waste of research resources, and may even pose a health threat and/or undermine scientific credibility. For all the above-mentioned reasons, measures are required that guarantee and improve the quality of COVID-19-related research studies.

Availability of databases and material for replication

These data are not public since they are being used for the PhD work of the first author. Data are available upon reasonable request (contact: A. Ruano-Ravina, alberto.ruano@usc.es).

What is known about the topic?

The COVID-19 pandemic has impacted in biomedical publishing. The rapid increase in COVID-19-related articles, as well as their rapid publication in scientific journals, may have meant that COVID-19-related studies have been of low methodological quality.

What does this study add to the literature?

The results show that COVID-19 studies period show different characteristics compared with those of non-COVID-19 papers, i.e. study design or sample size. The citations of COVID-19 studies were greater than that of non-COVID-19 studies.

What are the implications of the results?

It is necessary to ensure the quality of published studies in order to have the best possible evidence and to avoid the circulation of unreliable results and conclusions, which may have consequences for the population and the scientific community.

Editor in charge

Carlos Álvarez-Dardet.

Transparency declaration

The corresponding author on behalf of the other authors guarantee the accuracy, transparency and honesty of the data and information contained in the study, that no relevant information has been omitted and that all discrepancies between authors have been adequately resolved and described.

Authorship contributions

The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted. A. Ruano-Ravina and M. Pérez-Ríos had the original idea and designed the study. C. Candal-Pedreira collected and analyzed the data and drafted the first version of the manuscript. All authors made contributions in the final draft. All authors take public responsibility of the manuscript content and have approved the final version.

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Conflicts of interest

None.

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RESEARCH

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Retracted papers originating from paper mills: cross sectional study

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ABSTRACT

OBJECTIVES

To describe retracted papers originating from paper mills, including their characteristics, visibility, and impact over time, and the journals in which they were published.

DESIGN

Cross sectional study.

SETTING

The Retraction Watch database was used for identification of retracted papers from paper mills, Web of Science was used for the total number of published papers, and data from Journal Citation Reports were collected to show characteristics of journals.

PARTICIPANTS

All paper mill papers retracted from 1 January 2004 to 26 June 2022 were included in the study. Papers bearing an expression of concern were excluded.

MAIN OUTCOME MEASURES

Descriptive statistics were used to characterise the sample and analyse the trend of retracted paper mill papers over time, and to analyse their impact and visibility by reference to the number of citations received.

RESULTS

1182 retracted paper mill papers were identified. The publication of the first paper mill paper was in 2004 and the first retraction was in 2016; by 2021, paper mill retractions accounted for 772 (21.8%) of the 3544 total retractions. Overall, retracted paper mill papers were mostly published in journals of the second highest Journal Citation Reports quartile for impact factor (n=529 (44.8%)) and listed four to six authors (n=602 (50.9%)). Of the 1182 papers, almost all listed authors of 1143 (96.8%) paper mill retractions came from Chinese institutions and 909 (76.9%) listed a hospital as a primary affiliation. 15 journals accounted for 812 (68.7%) of 1182 paper mill retractions, with one journal accounting for 166 (14.0%). Nearly all (n=1083, 93.8%) paper mill retractions had received at least one citation since publication, with a median of 11 (interquartile range 5-22) citations received.

CONCLUSIONS

Papers retracted originating from paper mills are increasing in frequency, posing a problem for the research community. Retracted paper mill papers most commonly originated from China and were published in a small number of journals. Nevertheless, detected paper mill papers might be substantially different from those that are not detected. New mechanisms are needed to identify and avoid this relatively new type of misconduct.

WHAT IS ALREADY KNOW ON THIS TOPIC

Evidence regarding paper mills organisations and articles produced by them is scarce

Information is needed about the characteristics of paper mill articles to identify and retract them, thus allowing the scientific literature to be corrected

WHAT THIS STUDY ADDS

This study analyses the evolution of paper mill papers, their characteristics, and their visibility in the scientific community

Retractions of paper mill papers are increasing in frequency and some of them are of highly cited papers, with the potential consequences that this entails

Introduction

Scientific misconduct, which includes plagiarism, fabrication, and falsification of data or images, is the most common cause of retraction of biomedical papers.[1,2] Fraudulent papers have negative consequences for the scientific community and the general public, engendering distrust in science, false claims of drug or device efficacy, and unjustified academic promotion, among other problems. Moreover, misconduct encompasses other unethical practices that are often difficult to detect, such as undeclared competing interests, authorship issues, and duplicated publication.[3]

As scientific findings evolve and publication of science is modernised, new types of misconduct and fraud emerge. One example is the use of the so-called paper mills. In scientific publishing, the term paper mill refers to for-profit organisations that engage in the large scale production and sale of papers to researchers, academics, and students who wish to, or have to, publish in peer reviewed journals, both national and international. Many paper mill papers included fabricated data.[4] We refer to this process as ghost fabrication to distinguish the process from ghost writing.

According to the Committee on Publication Ethics (COPE), these organisations prepare manuscripts and seek to sell them. In some cases, they sell the authorship before publication, they then handle the submission and the peer review process. Other organisations sell the authorship after the manuscript has been accepted for publication in a legitimate scientific journal. When this scenario occurs, the organisation includes the author or authors who bought the authorship on the list of named authors, which amounts to a (sometimes total) change in authorship.[4] In addition to selling the authorship of scientific papers, these organisations offer other services, ranging from making available or fabricating a database on which a study can be based, to falsifying a journal peer review so as to enable a

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paper to be published more easily.[5] Paper mills have now broadened their service portfolio by offering citations to papers already published by researchers on their own studies.[6] Some of these organisations claim to have links with scientific journals, thereby ensuring publication of the manufactured manuscript.[7 8]

Paper mill papers are a growing problem with important potential consequences because they amount to systematic manipulation of the scientific publication process, as well as dissemination of false results. Additionally, publication of paper mill papers artificially inflates researchers' curriculum without merit and diminishes trust in the scientific enterprise. This type of fraud has already given rise to various retractions and Retraction Watch, a well known organisation with a blog of retractions that dates from 2010, maintains a database of retracted articles that includes paper mill publication as a reason for retraction since 2021.[9] As a relatively novel situation, the way of working and characteristics of these paper mills are not very well known, although Retraction Watch has published the results of a research into how the best known paper mill in Russia operates.[10] Even so, little is known about what types of authors use the services of paper mills, in what types of journals they publish, in which fields, and the prestige of the journals in which they publish, based on their impact factor.

Thus, our objective was to analyse the trend in papers retracted for originating from paper mills; to characterise the papers retracted for this reason, along with the journals in which they were published; and to analyse their impact and visibility by reference to the number of citations received.

Methods

Study design and data collection

We conducted a cross sectional analysis of all papers retracted for being paper mill papers, from 1 January 2004, the year of publication of the first paper mill paper identified, until 26 June 2022, the date when we last accessed the database. These papers were identified via the Retraction Watch database,[9] using the filter "Reason for retraction" and choosing the option "Paper mill." We included all papers retracted for this reason and excluded papers bearing an expression of concern, where scientific misconduct had not been confirmed.

All the variables of interest were collected and stored in a purposely designed database. To conduct this study, we used three main data sources: the Retraction Watch database, Web of Science, and Journal Citation Reports (both belonging to Clarivate Analytics). Additionally, we consulted the full text of the papers included to record information related to the characteristics of the paper, such as the date of submission and publication, authors' statement of funding, and competing interests.

Retraction Watch database

Retraction Watch tracks scientific publications, regardless of language, that have been retracted and aggregates them into a publicly available database, including different variables of interest extracted by their staff. This database includes more than 30 000 retractions and expressions of concern.[9]

The Retraction Watch database has higher coverage of retractions than PubMed and CrossRef because these databases use different sources to detect retracted articles and notices of retraction. The main sources for the identification of retractions are publishers' and editors' websites, but reports of scientific integrity investigations, social media sites, and tips from their blog followers are also checked. Staff at Retraction Watch use PubMed and Web of Science to double check the retractions. To identify retractions, staff at Retraction Watch run protocolised manual searches daily using keywords such as "retraction," "withdrawn," or "retracted paper."

Retraction Watch uses mainly the information included in the notice of retraction to classify retractions into different reasons. Retraction Watch also manually checks other sources for clarification of information, such as institutional investigation reports and US Office of Research Integrity reports.

In the specific case of paper mill products, Retraction Watch's identification is based on several indicators. One is the notice of retraction, some clearly state that the paper is from a paper mill, others use a euphemism for paper mill such as "third party editing service." In other cases, journals and publishers retract a large number of articles accompanied by an editorial indicating that the retracted papers were from paper mills. These editorials usually use a similar language, stating that the paper "resembles different papers from different authors." Retraction Watch also uses PubPeer and the list of probable paper mill papers published by Elisabeth Bik and other investigators.[11]

We sourced the total number of papers retracted for any reason per year and the total number retracted for originating from paper mills per year. For every paper retracted for the reason of originating from a paper mill, we collected the following: title of paper; number of authors; authors' affiliated country; first author's institution; type of institution of first author (hospital, university, research centre); and paper's date of publication and date of retraction. The last access to the database was 26 June 2022.

Web of Science

We retrieved the total number of papers published per year across the study period (1 January 2004 to 26 June 2022) with no exceptions. For every paper included, we collected the total number of citations received, both before and after retraction, from date of publication until 26 June 2022.

Journal Citation Reports

We gathered data for the journal that published each paper and its characteristics, such as its name, Journal Citation Reports impact factor, Journal Citation Reports category, and relative position by Journal Citation Reports quartile (ie, the highest impact factor of journals belonging to the first quartile (or Q1) and

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the lowest impact factor journals to the fourth quartile (or Q4)), and publication modality (open access or subscription). Where the journal was included in more than one category, we chose the highest position according to the journal impact factor. We categorised hybrid journals as non-Open Access journals.

Statistical analysis

We used a descriptive analysis of the characteristics of the retracted papers identified, by reference to the variables of interest, with continuous variables being expressed as median and interquartile range, and categorical variables as absolute number and relative frequency.

We calculated the publication rate of papers that were retracted because of paper mills per 100 000 papers published in a given year, over the total number of papers published for the same year. Therefore, we assessed the proportion of papers mill publications regarding the total number of publications in each year of the study period. Additionally, we calculated the percentage of paper mill papers retracted per year, with respect to the total number of retractions per year, to ascertain the proportion of paper mill retractions compared with retractions for any other reason.

We described the distribution of this type of papers by Journal Citation Reports category of the journal in which they were published. We created a ranking of journals and publishers based on the number of retracted paper mill papers they published during the study period. We have determined if the journal of publication was reliable, that is, not suspected of being a predatory journal, in the subsample of the scientific journals that published the most retracted paper mill papers. To assess the reliability of a journal, we used the ThinkCheckSubmit checklist (https://thinkchecksubmit.org/journals).

We calculated the time elapsed between the paper's submission and publication and the time elapsed between the paper's publication and retraction, in days. Analysis of the times elapsed between submission and publication and the times between publication and retraction were stratified by the Journal Citation Reports quartile of the journal in which the paper was published. Similarly, we analysed the total citations received by the papers, both overall and stratified by quartile. All statistical analyses were done using the Stata version 17.0 computer software programme.

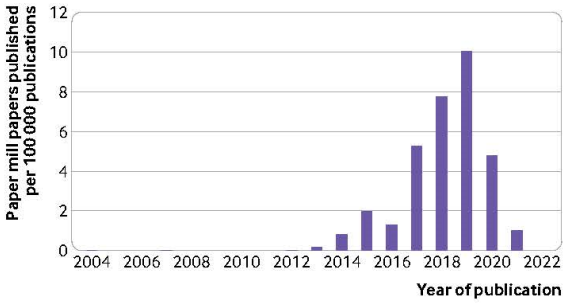


Fig 1 | Proportion, per 100 000, of paper mill papers published and then retracted per year with respect to total publications

Patient and public involvement

This research was done on agreement with Retraction Watch, where we committed to use a database under specific circumstances, including confidential uses, and to avoid sharing the downloaded database with third parties. We did not test any especific health intervention or drug, therefore, we did not think that patient or public involvement would be helpful in this research.

Results

We identified 1182 retractions of paper mill papers from the Retraction Watch database that fulfilled the predefined inclusion criteria. During the study period, 58 278 163 papers were published and 33 741 were retracted for any reason, including being a paper mill product; a rate of 57.9 retractions per 100 000 publications. Figure 1 shows the number of paper mill papers published per year (and then retracted) with respect to the total number of papers published in each year. The year of the first publication of an identified paper mill paper was 2004, and the first retraction for this reason took place in 2016.

The proportion of paper mill papers published per year in the scientific literature has increased. from 0.04 per 100 000 in 2004 to its peak of 10.6 per 100 000 publications in 2019 (fig 1). After 2020, the number of these papers decreased in comparison with the total number of papers published. The proportion of paper mill retractions to all-cause retractions was low until 2021, the year in which paper mill retractions accounted for 772 (21.8%) of the 3544 retractions (fig 2).

Table 1 shows the main characteristics of retracted paper mill papers. Just over half of these papers had four to six authors; almost all authors of paper mill retractions came from Chinese institutions, followed by far fewer authors from Indian institutions; and more than three quarters of papers had a first author who was affiliated with a hospital. The papers were mainly published in journals of the second Journal Citation Reports quartile and were mainly asigned to the Journal Citation Reports category of pharmacology and pharmacy.

Of the 1182 papers, 609 (51.5%) included a funding statement, and of these, 387 (63.5%) reported to have received external funding. Furthermore, 984 (83.2%) of papers included a declaration of the authors' competing interests.

Fifteen scientific journals published a total of 812 (68.7%) of all 1182 papers retracted for being paper mill papers, and 166 (14.0%) were published in one journal, the *European Review for Medicaland Pharmacological Sciences*. Of these, all journals appear to be non-predatory journals. Of all journals (n=99), 61 (61.6%) were open access journals (table 2): the highest number of papers published belonging to the

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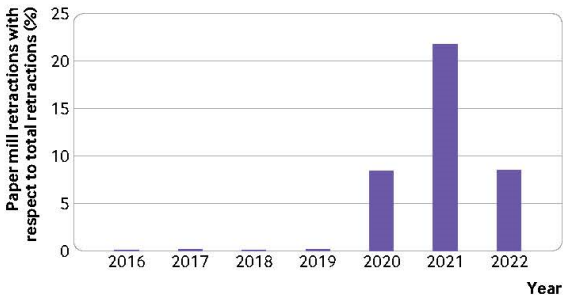


Fig 2 | Percentage of paper mill retractions with respect to total retractions

Wiley publishing group and then Verduci Editore (table 3). Supplementary tables 1 and 2 include information of all journals and publisher houses.

The time elapsed between the manuscript's submission to the journal and its publication varied according to journal quartile (table 4), from a median of 115 days (interquartile range 80-144), among journals of the first quartile, 128 (82-189) for journals in the second quartile, 163 (119-288) for those in the third quartile, and 332 (189-447) in fourth quartile journals. Likewise, the time between publication and retraction varied; shorter times were noted in journals of the first and second quartiles, and longer times in journals of the third and fourth quartiles and those with no impact factor.

Table 1 | Main characteristics of papers retracted for originatng from paper mills.

Variable	No (%) of papers (n=1182)
No of authors:	
1-3	315 (26.7)
4-6	602 (50.9)
>6	265 (22.4)
Authors' country:	
China	1144 (96.8)
India	17 (1.4)
China and USA	6 (0.5)
China and Germany	2 (0.2)
Rest of the world	13 (1.1)
First author's affiliation:	
Hospital	909 (76.9)
University	176 (14.9)
Hospital and University	66 (5.6)
Research centre	11 (0.9)
Other	20 (1.7)
JCR quartile:	
Q1	350 (29.6)
Q2	529 (44.8)
Q3	248 (21.0)
Q4	25 (2.1)
No IF	30 (2.5)
JCR category:	
Pharmacology and pharmacy	265 (22.4)
Oncology	162 (13.7)
Biochemistry and molecular biology	145 (12.3)
Education, scientific disciplines	122 (10.3)
Medicine, research, and experimental	103 (8.7)
Other	356 (30.1)
Not indexed in JCR	29 (2.5)

Q=quartile of journal in which the paper was published; JCR=Journal Citation Reports; IF=impact factor.

While 1086 (93.8%) of retracted paper mill papers received at least one citation, papers published in third and fourth quartile journals received a higher number of citations (fig 3). The median number of citations received by retracted paper mill papers from the date of publication was 11 (interquartile range 5-22), with the total ranging from 0 to 131 citations.

Discussion

Principal findings

Our cross sectional analysis of all papers retracted for originating from paper mills until June 2022, identified from the Retraction Watch database, suggests that these paper mill retractions are increasing in frequency. Nearly all authors of these papers came from China and were predominantly affiliated with hospitals. The median time for retraction of a paper mill paper was close to two years and increased with the ranking of the journal in which it was published, so that the higher the Journal Citation Reports impact factor, the shorter the period until retraction. These papers affect legitimate journals and does not seem to be exclusive to predatory journals. Furthermore, this study showed the impact and visibility of these retracted papers because some were highly cited, with the potential consequences that this entails. To our knowledge, this is the first study to analyse the growing phenomenon of paper mill retractions and their characteristics.

Our findings suggest that the publication of paper mill papers increased between 2017 and 2019, when about 5 to 10 were published and eventually retracted for this reason per 100 000 publications. In 2020, the number of identified paper mill papers published in the scientific literature fell sharply. This decrease may have occurred for a number of reasons. Firstly, papers published between 2020 and 2022 that might eventually be identified for retraction have not yet been identified or retracted. Retraction of a paper takes a long time, and more retractions will possibly appear in the future. Secondly, as a result of investigations initiated in early 2020 by a number of editors and researchers,[12] the scientific community have become aware of the problem, and guidelines have been published to help editors identify such papers.[4] Even though these guidelines do not enable a paper mill paper to be unequivocally recognised, they do make screening and identification of papers originating from paper mills possible. Hence, numbers might be smaller than would have been because scientific journals have improved methods for their identification during editorial review and peer review, thereby preventing their publication. Thirdly, the increased attention to this type of fraud might also have deterred authors from engaging the services of paper mills, because of the consequences of scientific fraud, especially in some countries such as China.[13] Then again, an increased exposure could have caused paper mill organisations to change their mode of operation, thus hindering detection.[14]

Although this issue is relatively new, particularly in The Americas and Europe, for some years now the use

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Table 2 | The fifteen journals with the largest number of papers retracted for originating from paper mills, according to their Journal Citation Reports quartile and whether or not they are open access

Journal	Journal Citation Reports quartile	Open access	No (%) of papers retracted for originating from paper mills (n=1182)
European Review for Medical and Pharmacological Sciences	2	Yes	166 (14.0)
Journal of Cellular Biochemistry	1	No	134 (11.3)
International Journal of Electrical Engineering and Education	1	No	122 (10.3)
RSC Advances	2	Yes	68 (5.8)
Biomedicine and Pharmacotherapy	1	Yes	50 (4.2)
Cellular Physiology and Biochemistry	1	Yes	49 (4.2)
Molecular Medicine Reports	2	Yes	42 (3.6)
Artificial Cells, Nanomedicine, and Biotechnology	1	Yes	40 (3.4)
Oncology Reports	3	Yes	40 (3.4)
Journal of Cellular Physiology	1	No	37 (3.1)
Experimental and Therapeutic Medicine	3	Yes	34 (2.9)
OncoTargets and Therapy	2	Yes	30 (2.5)
Bioscience Reports	3	Yes	24 (2.0)
Cancer Management and Research	3	Yes	22 (1.9)
Anatomical Record: Advances in Integrative Anatomy and Evolutionary Biology	3	No	21 (1.8)
Other journals	NA	NA	303 (25.6)

NA=not available.

of these types of organisations has been widespread in other countries, such as China.[10 15] China encouraged its researchers to publish papers in return for money and career promotions.[16] Furthermore, medical students at Chinese universities are required to produce a scientific paper in order to graduate.[15] In fact, these organisations openly advertise their services on the Internet and maintain a presence on university campuses, not only in China but also in other countries, such as Russia.[8 15]

Perhaps unsurprisingly, most papers retracted for being paper mill papers come from that same country. These results are in line with the findings of other researchers and editors of scientific journals, although paper mill papers have been reported in other countries, such as Iran or Russia.[8 12 17] The activity of the largest paper mill organisation in Russia named International Publisher has recently been acknowledged.[8 10] Although this paper mill has published approximately 1000 papers, its own website announces that more than 5000 authors have bought the coauthorship of at least one paper.[8]

Table 3 | Publishing houses of the journals in which papers retracted for originating from paper mills were published

Publishing house	No (%) of papers retracted for originating from paper mills (n=1182)
Wiley	205 (17.3)
Verduci Editore	166 (14.0)
SAGE Publications	153 (12.9)
Spandidos	152 (12.9)
Elsevier	93 (7.9)
Royal Society of Chemistry	70 (5.9)
Taylor and Francis	56 (54)
Taylor and Francis-Dove Press	54 (4.6)
Cellular Physiol Biochem Press	49 (4.2)
Portland Press	24 (2.0)
Mary Ann Liebert	21 (1.8)
Springer	21 (1.8)
Other publishing houses	118 (10.0)

Also, we note that most authors of identified paper mill papers were hospital affiliated, which is consistent with previous research.[15] The main reason for this might be that Chinese doctors are not affiliated with medical schools, but with hospitals. Of note, pressure to publish is greater in biomedical sciences than other specialties and publications are usually needed to get a university degree or a promotion in China.[15]

Most paper mill papers were published in pharmacy and clinical medicine journals, but many of them were published in basic science journals as well, such as cellular and molecular biology or biochemistry. Therefore, this problem not only affects clinical medicine areas. This research has not focused in analysing specifically if paper mill papers are published more frequently on clinical medicine topics or basic research. We are of the opinion that this aspect should be further analysed. According to our results, no major variations over time have been observed in the topics covered by the paper mill papers so far. However, the latest COPE report indicates that this pattern could change, for example in topic areas or types of journals, over time.[18]

The main problem which paper mill papers pose for editors and reviewers of scientific journals is the difficulty of identifying them through the peer review process because the papers appear to be legitimate. Analysis of images in a manuscript has been identified as one of the possible strategies for detecting paper mill papers because most images tend to be manipulated or duplicated, or both.[14] Although different softwares are capable of detecting image manipulation, paper mill papers often use duplicated images (or stock images)[5 19] because they are more difficult to detect than manipulated ones. At present, no software is capable of detecting image duplication in a reliable way, thus leaving this task to editors and reviewers. That said, however, not all papers contain images that allow for scrutiny. Another strategy for screening questionable papers is the Problematic Paper Screener software. This software identifies so-called "tortured phrases,"—that is, unusual phrases instead of established ones, which might be an indicator of suspected scientific misconduct.[20] Also, COPE has published a list of common indicators for paper mill papers that could serve as a screening tool for suspicious articles.[18]

With the aim of preventing and detecting scientific misconduct, some countries already have offices and specific bodies that address aspects relating to scientific integrity, but many others do not have structures of this type.[21] Countries that have no body or policies governing scientific misconduct incur a higher risk of producing fraudulent papers.[22] Countries such as Denmark, Sweden, and China, have passed laws against scientific fraud. Ironically, China has the most severe penalties for research fraud. The paucity of consequences that scientific misconduct has historically had in this country might have played an

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Table 4 | Time elapsed between publication and retraction of papers retracted for originating from paper mills, both overall and by quartile of journal in which they were published. Data are median (interquartile range)

	Overall time elapsed	Q1	Q2	Q3	Q4	No IF
Submission to publication (in days)*	140 (93-217)	115 (80-144)	128 (82-189)	163 (119-288)	332 (189-447)	225 (158-244)
Publication to retraction (in days)†	891 (0-3229)	829 (223-1933)	792 (0-3121)	1350 (181-2707)	1564 (676-2130)	907 (0-2234)

IF=Impact factor; IQR=interquartile range; Q=quartile of Journal Citation Reports.
*Missing values=659.
†Missing values=2.

important role in the increase in unethical behaviour, including the use of paper mills.[15] In 2018, after a number of scandals in China, the law against scientific fraud was strengthened by imposing sanctions that go beyond the purely academic and occupational sphere.[23] This tougher approach appears to have started yielding results and, in December 2021, more than 300 researchers were reportedly penalised for scientific misconduct. Among other things, the penalties included revocation of academic degrees and cancellation of promotions.[24] Because practically all paper mill papers come from China, these recent penalties policy might have contributed to the reduction in the number of paper mills since 2020.

Strengths and limitations

This study had limitations. Retractions of paper mill papers continue over time. Because of this, our investigation will need to be updated over time as the conclusions could well vary as the list of retractions grows. The characteristics of retracted and non-retracted paper mill papers can differ, which could explain why some papers were identified but not others, although all represent fraudulent science. Another limitation was the difficulty in assigning the cause of retraction in some cases, hence misclassification is a risk. In this study, we have included formally retracted paper mill papers, not taking into account suspicious papers (ie, those from the list elaborated by EB and others) and this might be a limitation of the present research. However, the inclusion of papers not formally retracted might incur in a risk of misclassification of those papers if they are not finally retracted as paper mill products. A limitation regarding the citation analysis is that citations before and after retraction have not been differentiated in this study and this issue should be considered in future research.

The main strength of this study was the use of the Retraction Watch database to identify retracted paper mill papers because this source is the main database on retractions and should currently be considered as the gold standard for aggregated information on retracted articles. The Retraction Watch database has three times the coverage of PubMed and five times the coverage of CrossRef (Retraction Watch, personal communication, 2022). Taking this into account, we consider that the number of missing retractions should be minimal.

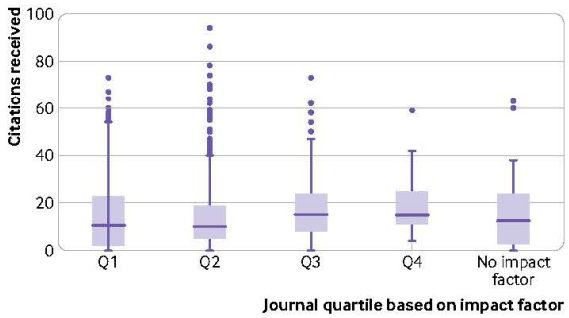


Fig 3 | Citations received by papers retracted for originating from paper mills, by quartile of journal in which they were published based on the impact factor. 24 values were missing. The box represents the interquartile range of the variable, the horizontal line inside the box indicates the median, the lower whisker indicates the lowest value excluding the outliers and the upper whisker indicates the highest value excluding the outliers. The circles represent the outliers of the variables

Conclusions

The paper mill papers that we have identified as retracted to date possibly represent only a small number of paper mill papers in total because potentially thousands of these papers could have been published in the scientific literature and not yet identified nor retracted. Some editors of international scientific journals have begun to systematically identify and retract paper mill papers, which has led to mass retractions.[25 26] The rise of paper mills is a new ethical problem in research and, more specifically, in publication ethics. Not only does this issue entail the sale of authorship, but these types of papers have also been observed to contain fabricated and manipulated data and images, thus disseminating false results in scientific literature. Efforts must be increased to prevent the use of these paper mill organisations, beginning with improved education in ethics and scientific integrity for editorial committees of scientific journals, students, and researchers.

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Competing interests: All authors have completed the ICMJE uniform disclosure form at https://www.icmje.org/disclosure-of-interest/ and declare: no support from any organisation for the submitted work; JSR receives research support through Yale University from Johnson and Johnson to develop methods of clinical trial data sharing, from the Medical Device Innovation Consortium as part of the National Evaluation System for Health Technology, the Food and Drug Administration for the Yale-Mayo Clinic Center for Excellence in Regulatory Science and Innovation program (U01FD005938), the Agency for Healthcare Research and Quality (R01HS022882), the National Heart, Lung and Blood Institute of the National Institutes of Health (R01HS025164, R01HL144644), and from the Laura and John Arnold Foundation to establish the Good Pharma Scorecard at Bioethics International. JSR is also an expert witness at the request of Relator's attorneys, the Greene Law Firm, in a qui tam suit alleging violations of the False Claims Act and Anti-Kickback Statute against Biogen Inc. DSE serves as an expert witness in asbestos, talc, opioid, and concussion litigation at the request of injured people. No other authors declared any potential competing interests.

Ethical approval: Because this study used publicly available materials and did not involve humans, ethics committee approval was not required.

Data sharing: The data that support the findings of this study are available from Retraction Watch. Restrictions apply to the availability of these data, which were used under contract license for this study.

The lead author affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

Dissemination to participants and related patient and public communities: We plan to disseminate our findings in public communities. Immediately after publication we will launch a press release with the help of the press office of our University, and we expect that these findings will be published in mass media including newspapers and radio interviews. We will also use social networks such as Twitter and LinkedIn and also communicate our results to Spanish Scientific Societies. Advocacy networks with interest in research integrity will also be contacted.

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Web appendix: Online appendix

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9.5. ARTÍCULOS ENVIADOS PARA SU PUBLICACIÓN

Artículo 4. Candal-Pedreira C, Ross JS, Freijedo-Fariñas F, Rey-Brandariz J, Ruano-Ravina A, Pérez-Ríos M. **Characteristics and reasons for retraction in Spanich scientific literature: a cross-sectional study.**

Characteristics and reasons for retraction in Spanish scientific literature: a cross-sectional study.

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Author contribution
CCP: Conceptualization, Methodology, Data Curation, Formal Analysis, Original draft preparation**.** **JSR:** Conceptualization, Methodology, Review and Editing**. FFF:** Data curation, Review and Editing.

JRB: Data curation, Review and Editing. **ARR:** Conceptualization, Methodology, Review and Editing, Supervision**. MPR:** Conceptualization, Methodology, Review and Editing.

The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

Ethics approval

Because this study used publicly available materials and did not involve human subjects, human subjects' ethics committee approval was not required.

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Potential Competing Interests

All authors have completed the ICMJE uniform disclosure form at http://www.icmje.org/disclosure-of-interest/ and declare:

Dr. Ross currently receives research support through Yale University from Johnson and Johnson to develop methods of clinical trial data sharing, from the Medical Device Innovation Consortium as part of the National Evaluation System for Health Technology (NEST), from the Food and Drug Administration for the Yale-Mayo Clinic Center for Excellence in Regulatory Science and Innovation (CERSI) program (U01FD005938), from the Agency for Healthcare Research and Quality (R01HS022882), from the National Heart, Lung and Blood Institute of the National Institutes of Health (NIH) (R01HS025164, R01HL144644), and from the Laura and John Arnold Foundation to establish the Good Pharma Scorecard at Bioethics International; in addition, Dr. Ross is an expert witness at the request of Relator's attorneys, the Greene Law Firm, in a qui tam suit alleging violations of the False Claims Act and Anti-Kickback Statute against Biogen Inc. No other authors declared any potential competing interests regarding the publication of this study.

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Data availability

The data that support the findings of this study are available from Retraction Watch. Restrictions apply to the availability of these data, which were used under contract license for this study.

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Characteristics and reasons for retraction in Spanish scientific literature: a cross-sectional study.

ABSTRACT

Objectives: The aim of this study is to analyze the characteristics and reasons for retraction of articles by authors affiliated with Spanish institutions.

Study design: Cross-sectional study.

Settings: All retracted publications up to 26/1/23 with at least one author affiliated with a Spanish institution, identified through the Retraction Watch database, were included. A descriptive analysis was performed. Time to retraction was analyzed using survival analysis and fitting a Cox regression model by retraction reason (honest error or misconduct) and journal quartile. We analyzed citations received, globally and by quartile of publication of the retracted article.

Results: 374 retractions were included: 79.9% were original articles; 77.0% were biomedical studies; 82.7% had an author affiliated with a Spanish institution as first, last or corresponding author; and 46.2% were university affiliated. Misconduct accounted for 78.2% and 72.4% of retractions in biomedicine and non-biomedicine, respectively. The most common types of misconduct were duplication and unreliable data/results (both 29.3%) in biomedicine and plagiarism (42.9%) in non-biomedicine. Articles retracted because of error were retracted faster than those containing misconduct (HR 1.3; 95%CI 1.1-1.7), as were those published in third and fourth quartiles based on impact factor (HR 1.7; 95%CI 1.2-2.4) compared to those in first and second quartiles. The median number of citations received was 10 and there were differences in citation numbers by quartile of the journal of publication, but not by retraction reason.

Conclusion: Research misconduct accounted for more than 70% of all retracted articles authored by individuals affiliated with Spanish institutions, especially for duplication, unreliable data/results, and plagiarism. The availability of this information at the national level is necessary to design and implement effective strategies aimed at reducing the incidence of unethical behavior among Spanish researchers.

Key words: Retraction, Scientific Integrity, Ethics, Research Ethics, Plagiarism, Spain.

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Characteristics and reasons for retraction in Spanish scientific literature: a cross-sectional study

Introduction

Scientific integrity is a critical aspect of research, not only in conducting scientific studies but also in disseminating research results through publication. However, publications must sometimes be retracted. Retraction serves as a self-correcting mechanism in science, alerting us that retracted publications contain invalid results and/or conclusions and should not be trusted, relied on, or used in future studies. The recently increased interest in scientific integrity and publication ethics among the scientific community may be partly attributed to the rise in the number of retractions (1). The rate of retractions increased by 44% between 2000 and 2011 (2), whereas 6 articles were retracted per 10,000 publications in 2019, 8 in 2020 (3). Various theories have been proposed to explain this growing trend. Some researchers conclude that better tools are available to detect errors or scientific misconduct, such as plagiarism-detection software (4, 5). Another hypothesis is that the pressure to publish and the competitiveness among researchers in the academic enterprise fuels misconduct (4, 6).

Multiple studies have analyzed the phenomenon of retractions to understand their causes and consequences. There are two main reasons for retraction: unintentional errors, either from the authors or the journal editors; and scientific misconduct, such as fabrication and falsification, plagiarism, or duplication (7). Scientific misconduct has been identified as the most common reason for retraction of scientific publications, surpassing unintentional errors and accounting for about 60%-70% of all retractions (8, 9). While all recent studies point to scientific misconduct as the main reason for retraction, the primary type of scientific misconduct appears to vary by geographic region, suggesting that the characteristics and reasons for retraction may be context-dependent. For example, Fang et al. concluded that over two-thirds of biomedical retractions due to fraud (i.e. fabrication and/or falsification) or suspected fraud came from the USA and Germany, while most of the retractions due to duplication came from China (8). A recent study conducted in Brazil and Portugal identified plagiarism as the most common type of scientific misconduct among biomedical articles (10). Plagiarism was also found to be the main cause for retraction in India (11). Fanelli et al. reported that the authors' country of affiliation can influence their research activity. Those countries that lack national policies against scientific misconduct and whose researchers are economically rewarded for publishing were more likely to have retractions (12). Sociocultural factors, such as educational factors or income level, may also influence the probability of scientific misconduct, as well as the most prevalent type of misconduct (12, 13).

In this context, it is important to study retractions and their reasons at the country level. This information will provide valuable insights for national institutions and agencies responsible for promoting scientific integrity to develop tailored and effective policies and interventions to prevent and reduce scientific misconduct among researchers. Two prior studies have analyzed retractions in Spain (14, 15). Dal-Ré analyzed publications from nine biomedical disciplines retracted between the years 1970 to 2018, while Marco-Cuenca et al examined retracted articles across all biomedical disciplines during the same time frame. Due to the contrasting scopes of these studies and different classification of the reasons for retraction, they reported different primary reasons. Moreover, to the best of our knowledge, no study has comprehensively analyzed retractions in Spain, regardless of the field of knowledge. Therefore, our study aims to build upon these efforts and quantify and characterize all retractions by authors affiliated with Spanish institutions, with a particular emphasis on those publications retracted due to scientific misconduct.

Methods

Study design and sample selection

We conducted a cross-sectional study that included all papers retracted until January 26th, 2023, and had at least one author affiliated with a Spanish institution. To identify these papers and their characteristics, we used four main data sources: Retraction Watch database, Web of Science (WOS), Google Scholar and Journal Citation Reports (JCR). We searched the Retraction Watch database using the "Country" filter and selecting "Spain." This enabled us to identify all papers with at least one affiliation with a Spanish institution. We included papers retracted for any reason and from any field of knowledge, but excluded expressions of concern and corrections.

Variables of interest

From the Retraction Watch database, the following information was gathered for each retracted paper: title of the paper; type of publication (research article, review article and metanalysis, case report, conference abstract and others (including commentary/editorial, letter, guideline and book chapter)); field of knowledge (those labeled as Basic Life Sciences (BLS) or Health Sciences (HSC) were categorized as biomedical sciences papers and the rest were categorized as non-biomedical sciences papers, including business and technology, environmental sciences, humanities, physical sciences and social sciences); authors and total number of authors; affiliation of the corresponding author and type (hospital, university, research center, industry or a combination of the previous); country of the corresponding author; total number of different countries in the affiliation field; journal of publication and publisher; publication date; retraction date; and reason/s for retraction. The time elapsed from publication to retraction in days was calculated using the date of retraction and the publication date.

The reason for retraction of each paper was extracted from Retraction Watch database. The notice of retraction was also assessed to double check them. Reasons for retraction were unified in the following categories: **No scientific misconduct or error**: unintentional errors made by the authors and/or by the journal of publication; and **Scientific misconduct,** classified in: a) Fabrication/falsification: including fabrication/falsification of images, data or results, and manipulation of images; b) Plagiarism: of text, images, data or an entire publication; c) Duplication: of text, images, data or an entire publication; d) Ethical/legal issues: including concerns/issues about referencing/attributions; fake peer review; breach of policy by author; copyright claims; ethical violations by author; lack of institutional review board approval; conflict of interest; lack of approval from third party; lack or withdrawn of informed consent by participants; false/forge authorship; false affiliation; concerns/issues about authorship e) Unreliable data/results: concerns/issues about images, data or results; unreliable data; unreliable image; unreliable results; g) Not specified: misconduct without specifying the type.

If a paper had been retracted for more than one type of scientific misconduct, to establish the main reason, an ad-hoc scale was created. The reasons for retraction were ranked in descending order of importance or relevance in terms of their potential impact on the scientific evidence. The ranking was adapted from a previously published study (10) and was as it follows: fabrication/falsification; plagiarism; duplication; ethical/legal issues; unreliable data/results. We then selected the reason of greatest importance identified for each article as the main reason for retraction.

Additionally, we accessed the full text of the included papers to collect information on the corresponding author's affiliation, the existence of a conflict-of-interest statement and declaration of conflicts of interests, the existence of a funding statement and declaration of funding. If a paper received funding, the source was categorized as public, private or both. In case the full text of a paper could not be located, it was requested to the authors through ResearchGate, email or both.

The total number of citations until 02/22/2023 received by the retracted papers were extracted manually from Google Scholar.

From Journal Citation Reports, the following data related to the journal of publication was collected: JCR category, Journal Impact Factor (JIF) and JCR quartile (i.e. the relative position of the journal in the JCR category, based on the IF). In journals indexed in more than one category, the most favorable one according to the JIF was chosen.

Statistical analysis

First, we assessed the frequency of retracted papers over time by calculating the annual proportion of retractions with respect to the total articles published with at least one Spanish author for each year, overall and by reason for retraction. The total number of papers by authors affiliated with Spanish institutions per year during the study period was obtained from Web of Science. Mann-Kendall test was used to evaluate trends in retractions during the study period.

A descriptive analysis was conducted to identify the characteristics and reasons for retraction of the papers included. Chi-square test was used to assess the differences between retracted papers due to error and those retracted due to scientific misconduct. Continuous variables were expressed as median and interquartile range (IQR) and categorical variables as proportions, overall and by cause for retraction. A detailed description of the reasons for retraction, and particularly those related to scientific misconduct, is

also presented, both overall and by field of knowledge. Chi-square test was used to assess differences between biomedical and non-biomedical papers. For each paper, the number of reasons for retraction was collected.

To analyse time to retraction, we performed a time-dependent analysis using the Kaplan-Meier method. A Cox proportional hazards model was also fitted, adjusted by reason for retraction and quartile of the journal of publication. Registries with missing data on date of publication or date of retraction were excluded from this analysis. In addition, the descriptive analysis of the citations received by the papers included is also shown, both overall and stratified by reason for retraction and journal quartile. To evaluate differences between these variables, we used the Kruskall-Wallis, and the Dunn's test was applied to determine between which groups differences existed.

The statistical significance was set in $p<0.05$. All statistical analyses were performed using the Stata v.17.0 computer software programme.

Ethical aspects

This study used publicly available materials and did not involve human subjects and therefore committee approval was not required.

Results

We identified 376 retracted papers through the Retraction Watch database published by authors affiliated with Spanish institutions. Of those, 374 met the pre-established selection criteria and were included. These retracted papers were published between 1998 and 2022 in 261 different scientific journals. Four papers were published in a preprint server.

In 2001, 1.0 paper out of 10,000 was retracted, while in 2022, there were 2.2 retracted papers per 10,000 publications, a statistically significant increase in the relative frequency of retractions (Kendall's Tau= 0.59; $p<0.001$) (figure 1). According to the reason for retraction, we observed a stronger upward trend for retractions due to scientific misconduct (Kendall's Tau= 0.58; p=0.001), than for retractions due to error (Kendall's Tau= 0.32; p=0.03), although both are significant. In the case of retractions without a specified reason, the trend was not significant (Kendall's Tau= 0.25, p=0.08).

The main characteristics of the papers, both overall and by reason for retraction, are described in Table 1. Of the included retracted papers, 79.9% were original articles, 77.0% were biomedical articles, in 82.7% an author affiliated with a Spanish institution was first, last or corresponding author, and 46.2% were affiliated with a university. Additionally, 58.1% of the papers did not have a conflicts of interest statement and of those declaring funding, 72.5% were funded by public bodies.

Reasons for Retraction

The main reason for retraction was error in 78 (20.9%) of the papers, scientific misconduct in 258 (69.0%) and the reason for retraction was not specified in 38 (10.2%). A total of 228 (63.9%) papers had registered one reason for retraction, 90 (25.2%) two different reasons and 18 (5.0%) three different reasons.

Table 2 shows the distribution of the reasons for retraction because of misconduct for the included papers both overall and by field of knowledge. Overall, the most common type of scientific misconduct was duplication (28.9%), followed by unreliable data/results (26.1%). The same results are found among biomedical papers. However, plagiarism accounts for almost half of the retracted non-biomedical papers (42.9%), followed by duplication (27.0%). Differences were observed in the reasons fabrication/falsification, plagiarism, unreliable data/results and ethical/legal issues between the samples ($p<0.001$).

Time from publication to retraction

A survival analysis was performed to analyze the period elapsed between publication and retraction (figure 2). Our results indicated that both the quartile of the journal of publication and the reason for retraction were significantly associated with the time to retraction. Specifically, articles published in the third and fourth quartile journals were retracted 1.7 times faster than those published in the first and second quartile (95%CI 1.3-2.6; p=0.001). Additionally, papers retracted due to errors had a risk of retraction 1.3 times as high as those retracted due to scientific misconduct (95%CI 1.1-1.7; p=0.018).

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Citation analysis

The median number of citations received by the included retracted papers was 10 (IQR 2-36.5). A total of 302 (81.2%) papers received at least 1 citation during the study period. Two papers (0.5%) received

more than 1,000 citations. There was a slightly higher median number of citations for papers retracted due to scientific misconduct compared to those retracted by error [11.5 (3-37.5) vs. 10 (1-23) citations], but this difference was not statistically significant (p=0.08). Figure 3 illustrates the distribution of citations by the quartile of the journal of publication. Papers published in first quartile journals received more citations than those in third and fourth quartile journals (p=0.02), but there was no significant difference when comparing first quartile with second quartile journal papers (p=0.07).

Discussion

In this cross-sectional study of all retracted articles authored by individuals affiliated with Spanish institutions we find that retractions have increased in the last decade, with duplication being the most frequent cause of retraction, although differences are observed between biomedical and non-biomedical articles. Notably, papers retracted due to scientific misconduct took more time to be retracted, as did papers published in first and second quartile journals. This study is, to our knowledge, the first to perform a formal analysis of all retractions with an author affiliated with a Spanish institution, regardless of the cause of retraction or discipline.

The trends in retractions continue to show an increase in Spain, even taking into account the exponential increase observed in the number of scientific publications (16). Other studies corroborate this trend (1), both in publications in general (2, 4, 17) and in those of a certain field of knowledge (18, 19), type of study (20) or country (8, 10). There are multiple reasons for the increasing of the retractions' frequency. Perhaps the most discussed is the pressure to publish (widely known as "publish or perish") (21), which emerges from the current system of evaluation and accreditation of researchers. However, other researchers conclude that pressure to publish does not influence retractions and scientific misconduct (12). In fact, Lacetera and Zirulia (22) established that pressure to publish can reduce scientific misconduct by increasing scrutiny. The main determinants for engaging in scientific misconduct varies between countries. A recent study comparing China and Flanders (Belgium) showed that the Flemish researchers pointed out the "publish or perish" axioma, while the Chinese blame the "bad apple" theory as the main determinant of committing scientific misconduct (23). The "bad apple" theory suggests that unethical conduct is caused by a few individuals ("bad apples") who are willing to violate scientific principles and ethics. In Spain, like in other countries, this evaluation system is mainly based on scientific production (24). Therefore, the number of publications, the impact factor of the journals where they publish, and the number of citations received are the main criteria used currently to evaluate a researcher. However, this may be changing. The Health Research Fund projects of the Carlos III Health Institute, one of the most important calls for project funding in Spain, has recently adopted the DORA declaration (San Francisco Declaration on Research Assessment) (25). Under this new evaluation system, Spanish researchers will have to select only 10 publications, which will be evaluated in a qualitative way. The objective of DORA is to shift the researcher evaluation system from quantitative to qualitative. Although it is necessary to change to a system of qualitative evaluation of research contributions, reducing pressure per se does seems not to lead to a reduction in misconduct.

Scientific misconduct, and more specifically duplication and plagiarism, have been identified as the main problems related to ethics in scientific publication among researchers carrying out their research activities in Spain. Our results are in line with previously conducted studies. Dal-Ré et al (14) found that the 35% of all biomedical retractions in Spain between 1970 and 2018 were due to duplication, a similar percentage to that calculated in our study, although our research extended the period of study through the beginning of 2023. Interestingly, Marco-Cuenca et al (15) identified fabrication and falsification as the main cause of retraction in Spain in biomedical articles during the same period of time. However, this difference may be attributed to how the authors categorized the reasons of retraction. Marco-Cuenca et al (15) divided duplication into two different reasons (duplication of images and duplication of text).

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Studies have shown that certain regions or countries have a higher frequency of duplication and plagiarism than others (8). In Europe, southern countries such as Portugal and Italy have been associated

with a high prevalence of plagiarism and duplication (10), while certain central and northern European countries and the United States have a lower prevalence (8). There are several factors that may contribute to these regional differences. Education systems and cultural factors may play a key role. In some countries, the emphasis on originality and critical thinking may be less pronounced (12), leading to a lower perception of duplication and plagiarism as types of misconduct (26), especially among less experienced researchers. Although a 68% of graduate and postgraduate European students perceived plagiarism as an illegal practice, 46% admitted they often copy and paste text without referencing (27). Inadequate supervision and oversight may also contribute to plagiarism by creating an environment where this practice is tolerated or even encouraged (19). In this context, training in research integrity is clearly needed (12). A variation of educational resources in research integrity has been observed across Europe. Northern and Western European countries provide more training on research integrity and have more advanced guidelines (28). The Nordic countries have even issued specific laws against scientific misconduct (29).

Although plagiarism and duplication are the main cause of scientific misconduct in non-biomedical articles and biomedical articles, respectively, we have observed considerable differences in the prevalence of other types of misconduct among fields of knowledge. The proportion of retracted biomedical articles for data fabrication and falsification is almost 20 times higher than the proportion of non-biomedical articles in which these practices were identified. Data fabrication and falsification of results or images could be considered the most serious type of scientific misconduct. The consequences of these practices can be enormous for science globally, especially in biomedical research. It should not be forgotten that the implementation of health policies, as well as clinical practice, is based on the results of research studies. Fabrication or falsification in biomedicine can lead for instance to incorrect policies or unsafe treatments or procedures for patients.

The characteristics of retractions, especially the main type of scientific misconduct, are different in Spain compared to those reported in other countries (8, 19). Fanelli et al (30) found that the country of affiliation of the author is a predictor of some types of scientific misconduct. The existing evidence makes it essential to analyze retractions at the national level, as the actions to be taken to prevent scientific misconduct will not be the same if the main reason for retraction is duplication compared to data fabrication, for example, Fanelli et al. even propose to design tailored interventions to specific institutions (30).

Knowing the context surrounding retractions of articles from authors of a particular country, and more specifically of scientific misconduct, will enable for the development of more effective preventive and corrective measures. In the case of Spain, there are different measures that can be implemented to curb duplication and plagiarism. Probably the most effective in the long term would be to improve training in ethics and research integrity for students and researchers, mainly in areas such as biomedicine, where the rates of scientific misconduct are higher. This type of training should be gradually implemented from high school, with the aim of promoting education and awareness of ethics at all educational levels. Abdi et al (28) observed that a 3-month training raised awareness about research integrity in most students. In contrast, other study showed that half of the students interviewed recently about scientific misconduct concluded that training had no effect on them (31). Because of that, in addition to increase ethics training in Spanish institutions, an easy way to make students to perceive plagiarism as a problem it would be to use plagiarism detection software at lower educational levels, as well as in universities. This would get students accustomed to avoiding plagiarism and duplication from basic educational levels. One study concluded that students knowing the use of this type of software had a deterrent effect on plagiarism (32).

Another interesting result of this study is that articles published in third and fourth quartile journals retract earlier than those published in first and second quartile journals. Previous studies found an inverse association between the impact factor of the publication journal and the time for retraction only in the case of fraud and not association was found for other types of scientific misconduct (33). One might think this should be the opposite, since first and second quartile publications usually undergo greater post-publication scrutiny, as they are generally highly read by the scientific community. This may favor the detection of errors and even fraud in such publications. However, it is also possible that publications that have undergone peer review in a high-impact journal do not contain easy-to-detect errors or fraud. Therefore, perhaps in these cases, more thorough investigation of possible fraud is needed, which may substantially

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prolong the time to retraction. Another possible explanation for this result could be that journals in the most favorable quartiles or authors are reluctant to retract for fear of losing their reputation, so they would take longer to make the decision. A previous qualitative study identified authors' reasons for not retracting an article and found that reputational fear was one of them. However, after the retraction, authors acknowledged that they did not see their reputation damaged but that the self-retraction process needs to be facilitated (34).

This study has limitations. On the one hand, some of the full texts of the articles could not be consulted, so variables such as corresponding author affiliation, conflicts of interest, or funding could not be collected in those cases. Despite attempting to contact the corresponding authors of these articles, we did not receive a response in some cases. However, the percentage of non-accessed studies was 9%, so we do not believe it has substantially influenced our results. On the other hand, the methodology used to assign a single reason for retraction to each paper may have underestimated the prevalence of certain types of misconduct. As an additional analysis, we compared methodology used in this study with treating each reason for retraction as a separate unit of analysis. However, this analysis did not change our overall results (data not shown). A further limitation would be including all studies in which at least one author was affiliated with a Spanish institution. However, in 82% of the included studies, a Spanish author was first, last or corresponding authors, being these the most important roles of authorship.

The main strength of this study is the inclusion of all retractions with at least one author affiliated with a Spanish institution, representing the sample universe. In addition, retractions were identified through the Retraction Watch database, the main source of information on retractions currently available, so we consider the number of lost studies to be minimal.

In conclusion, the frequency of retractions in Spain shows an upward trend. Moreover, scientific misconduct is the main reason for retraction, accounting for around 70% of all retractions, regardless of the field of knowledge. Duplication and plagiarism are the most common types of misconduct in biomedical and non-biomedical articles, respectively. However, other types of scientific misconduct are also a concern, such as fabrication and falsification among biomedical articles. It is essential to monitor and study retractions as a proxy for scientific misconduct at a country level. National organizations responsible for scientific integrity must rely on the available scientific evidence to develop, implement, and prioritize policies, mechanisms and strategies that prevent scientific misconduct.

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Table 1. Main characteristics of the retracted papers by authors affiliated with Spanish institutions, overall and by reason for retraction.

	Overall		Error		Scientific Misconduct		Not specified		p-value
	n	%	n	%	n	%	n	%	
OVERALL	374	100%	78	20.9%	258	69.0%	38	10.2%	
Type of publication									<0.001
Research Article	299	79.9%	60	76.9%	220	85.3%	19	50.0%	
Review/Metaanalysis	38	10.2%	6	7.7%	20	7.8%	12	31.6%	
Case report	12	3.2%	5	6.4%	5	1.9%	2	5.3%	
Conference abstract	6	1.6%	2	2.6%	2	0.8%	2	5.3%	
Other	19	5.1%	5	6.4%	11	4.3%	3	7.9%	
Field of knowledge									0.198
Biomedical papers	288	77.0%	56	71.8%	199	77.1%	33	86.8%	
Non-biomedical papers	86	23.0%	22	28.2%	59	22.9%	5	13.2%	
Number of authors									<0.001
1-5	194	51.9%	48	61.5%	125	48.4%	21	55.3%	
6-10	137	36.6%	14	17.9%	107	41.5%	16	42.1%	
More than 10	43	11.5%	16	20.5%	26	10.1%	1	2.6%	
Number of affiliation countries									0.080
1	207	55.3%	44	56.4%	144	55.8%	19	50.0%	
2	99	26.5%	14	17.9%	71	27.5%	14	36.8%	
3	34	9.1%	7	9.0%	23	8.9%	4	10.5%	
4 and more	34	9.1%	13	16.7%	20	7.8%	1	2.6%	
Main author's country*									0.286
Spanish first, last and/or corresponding author	297	82.7%	57	77.0%	211	84.7%	29	80.6%	
Other	62	17.3%	17	23.0%	38	15.3%	7	19.4%	
Type of affiliation**									0.003
University	169	46.4%	33	42.3%	125	49.6%	11	30.6%	
Hospital	52	14.3%	13	16.7%	28	11.2%	11	30.6%	
University and Research Center	44	12.1%	9	11.5%	35	14.0%		0.0%	
Research Center	55	15.1%	8	10.3%	39	15.6%	8	22.2%	
University and Hospital	20	5.5%	7	9.0%	9	3.6%	4	11.1%	
Other	25	6.9%	8	10.3%	15	6.0%	2	5.6%	
Declared conflicts of interest***									0.001
Had a statement	142	41.9%	33	44.6%	86	36.9%	23	71.9%	
Not had a statement	198	58.1%	41	55.4%	147	63.1%	10	28.1%	
Declared funding***									0.348
Received funding	198	87.2%	45	86.5%	135	88.8%	18	78.3%	
From public bodies	142	72.5%	34	75.6%	93	69.9%	15	83.3%	
From private bodies	8	4.1%	1	2.2%	6	4.5%	1	5.6%	
From both	46	23.5%	10	22.2%	34	35.6%	2	11.1%	
Not received funding	29	12.8%	7	13.5%	17	11.2%	5	21.7%	
JCR quartile									0.439
Not indexed in JCR	73	19.5%	17	21.8%	51	19.8%	5	13.2%	
Q1	183	48.9%	38	48.7%	125	48.4%	20	52.6%	
Q2	74	19.8%	12	15.4%	56	21.7%	6	15.8%	
Q3	29	7.8%	8	10.3%	15	5.8%	6	15.8%	

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Q4	15	4.0%	3	3.8%	11	4.3%	1	2.6%

*Missing values:15; **Missing values: 10.; ***Missing values: 34

Table 2. Description of the types of scientific misconduct, overall and by field of knowledge.

	Overall		**Biomedical papers**		**Non-biomedical papers**		**p-value**
Type of scientific misconduct	n	%	n	%	n	%	<0.001
Fabrication/falsification	42	16.3%	41	20.6%	1	1.7%	
Plagiarism	50	19.4%	23	11.6%	27	45.8%	
Duplication	86	33.3%	69	34.7%	17	28.8%	
Ethical/legal issues	30	11.6%	24	12.1%	6	10.2%	
Unreliable data/results	46	17.8%	39	19.6%	7	11.9%	
Not specified	4	1.6%	3	1.5%	1	1.7%	
Total	258	100%	199	100%	59	100%	



Figure 1. Number of retractions per 10,000 publications of Spanish authors between 2000 and 2023, overall and by reason

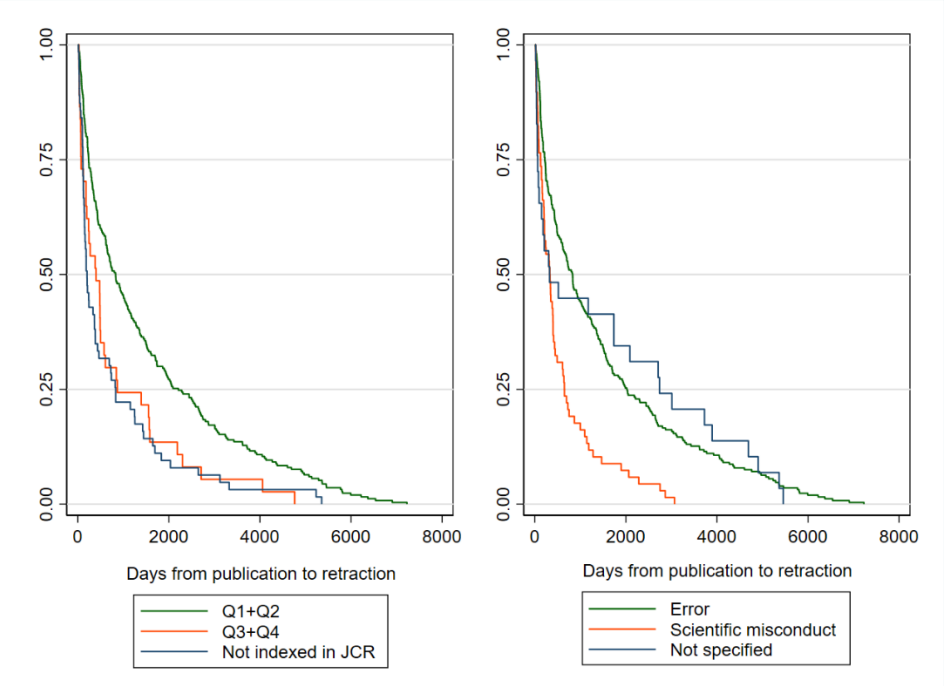


Figure 2. Survival analysis of the days from publication to retraction, by journal quartile and reason for retraction.

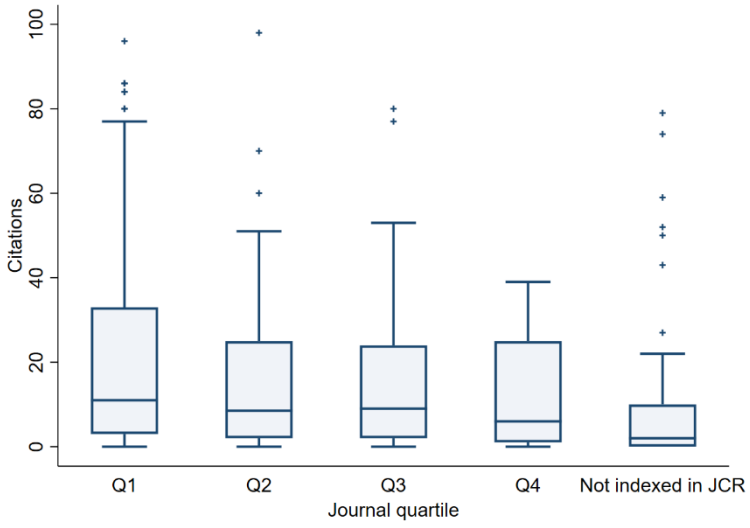


Figure 3.Distribution of received citations by the quartile of the journal of publication (The boxplot is restricted to <100 citations due to outlier

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Artículo 5. Candal-Pedreira C, Ghaddar A, Pérez-Ríos M, Varela-Lema L, Álvarez-Dardet C, Ruano-Ravina A. **Scientific Misconduct: Cross-Sectional Study of the Perceptions, Attitudes and Experiences of Spanish Researchers.**

Scientific Misconduct: a Cross-Sectional Study of the Perceptions, Attitudes and Experiences of Spanish Researchers.

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ABSTRACT

Introduction: Research misconduct has become an important problem for the scientific community. This study sought to identify the perceptions, attitudes and experiences of Spanish researchers regarding different aspects relating to scientific misconduct, both overall and differentiating by sex, years of research experience, and type of research institution.

Methods: Cross-sectional study based on an anonymous online survey, targeting researchers in the field of biomedicine. The survey comprised a first block (13 questions) covering sociodemographic data, and a second block (14 questions) covering researchers' perceptions, attitudes and experiences. A descriptive analysis was performed, and the chi-squared test was used to evaluate differences in responses by reference to the variables of interest.

Results: A total of 403 researchers answered the survey: 51.1% (n=205) women, median age 45 years. There was an observed frequency of scientific misconduct of 78.8%: 43.3% of researchers acknowledged having intentionally engaged at least once in some type of scientific misconduct (self-reported frequency). The most frequent type of scientific misconduct, both observed and self-reported, was false authorship. 14.2% of researchers were aware of the use of paper mills, and 1.0% acknowledged having used them intentionally. In general, the most frequent types of observed and self-reported scientific misconduct did not appear to differ by years of experience but did differ by sex and type of research institution.

Conclusions: There is a high frequency, both observed and self-reported, of scientific misconduct among Spanish biomedical science researchers. 4 of 10 researchers recognized that took part in any type of scientific miscronduct. There are differences between the most frequent types of misconduct according to different characteristics, mainly type of institution.

***Keywords*:** scientific integrity, scientific misconduct, Spain, survey, perception

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INTRODUCTION

In recent decades, research or scientific misconduct has become a global problem with a considerable impact on science, currently constituting the main cause of retraction of scientific papers (1, 2). According to the International Committee of Medical Journal Editors (3), scientific misconduct includes, but is not limited to, fabrication, falsification and plagiarism. Furthermore, the types of scientific misconduct have diversified and researchers who seek to engage in unethical practices have found new ways of doing so. An instance of this is the fake peer review, first identified in 2009 (4), or the phenomenon of paper mills, factories of scientific papers which have experienced a boom since 2020 (5), with a real frequency of use that is as yet unknown.

Scientific misconduct is a growing phenomenon, and is difficult to address due to its multifactorial nature. The main factors that contribute to this phenomenon (6) may be systemic, institutional, and personal (7, 8, 9, 10). Prominent among the institutional or systemic factors is increased competition among researchers to capture research resources (9), pressure to publish based on the axiom, "publish or perish", (8, 11) and the lack of a specific body that would manage scientific integrity in the author's country (7, 12). There are other personal causes, such as being a novel researcher, or cultural aspects, that appear to contribute to scientific misconduct (12). In addition to its multifactorial complexity, the problem of scientific misconduct is aggravated by a lack of knowledge about or training of members of the scientific community in good research practices. For instance, many researchers do not clearly differentiate between what does and does not constitute scientific misconduct (13). The lack of a precise and universally agreed definition of what is considered scientific misconduct (14) may contribute to this confusion.

In order to address scientific misconduct effectively, some exhaustive analyses of retractions of scientific papers have been performed at a national level (15, 16, 17, 18). These studies provide an overview of existing problems of scientific integrity, and serve as a basis for identifying the most frequent types of misconduct and drawing up preventive strategies, adapted to the context of each country. For a better understanding of the problem, however, it is crucial to complement these analyses with information drawn from the scientific community itself, since researchers are the protagonists and/or direct witnesses of the dynamics associated with day-to-day scientific misconduct. The scientific community's perceptions, attitudes and experiences regarding scientific misconduct have been studied for decades (19), and studies have been conducted in a number of countries, as well as at an international level, using both questionnaires and interviews (7, 8, 10, 13, 19, 20, 21, 22, 23). Yet there is a need of evidence in some contexts, and the data suggest an enormous variability among countries.

In Spain, as in other countries, notorious cases of scientific misconduct have been detected in different fields of research. Despite the fact that there are a number of quantitative analyses of the most frequent types of scientific misconduct (2, 16), to our knowledge, no study has analyzed the perceptions, attitudes and experiences of Spanish researchers with respect to this matter. The main aim of this study was therefore to identify Spanish researchers' perceptions, attitudes and experiences regarding different aspects linked to scientific misconduct, both overall and by gender, years of research experience, and type of research institution.

METHODS

We conducted a cross-sectional study based on an online survey, which was disseminated among researchers affiliated with a Spanish institution in the biomedical field, from 19/10/2022 to 13/06/2023. The survey was sent to the senior management of 6 Spanish scientific societies, 12 Health Research Institutes (HRI), and 13 Consortia for Biomedical Research, which were tasked with distributing it to their members by e-mail. The scientific societies that agreed to disseminate the survey among their members were: the Spanish Society of Epidemiology, Spanish Society of Pneumology and Thoracic Surgery, Spanish Society of Medical Oncology, Spanish Society of Public Health and Health Administration; the following Health Research Institutes: Santiago HRI and Fundación Jiménez Díaz HRI; and Biomedical Research Consortia, i.e., Consortium for Biomedical Research in Epidemiology and Public Health (*CIBER de Epidemiología y Salud Pública/CIBERESP*), Consortium for Biomedical Research in Mental Health (*CIBER en Salud Mental/CIBERSAM*) and Consortium for Biomedical Research in Physiopathology and Nutrition (*Centro de Investigación Biomédica en Red de la Fisiopatología de la Obesidad y Nutrición/CIBEROBN*).. In addition to distribution by these bodies, snowball sampling was carried out,

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with individuals who, though not affiliated with the institutions that disseminated the survey, were researchers in the biomedical field affiliated with a Spanish institution, being allowed to participate.

Survey and types of scientific misconduct included

The survey was completed online via the "Google Forms" platform and was completely anonymous. In order to design it, we took into account the Scientific Misconduct Questionnaire-Revised (SMQ-R) (24), previously used in research studies with similar objectives (8, 25). To select the types of scientific misconduct evaluated in the survey, we based ourselves on national and international documents pertaining to scientific integrity (3, 26, 27, 28) and the practices included in the SMQ-R. For study purposes, we considered both the practices included in the traditional definition of scientific misconduct (fabrication, falsification and plagiarism), as well as other practices commonly denominated unacceptable (problems with approval of a Clinical Research Ethics Committee, lack of informed consent, false authorship/affiliation, pressure of study sponsors, paper mills, and non-declaration of conflicts of interest). It is important to note that in this study no distinction was drawn between unacceptable practices and scientific misconduct, and that all the practices were included under the head of "scientific misconduct".

Before beginning the study, the survey was piloted in a sample of ten persons with characteristics similar to those of the population at which the study was targeted, and any questions that were difficult to understand or ambiguous were revised and amended.

The final survey was made up of 27 questions: the first block of 13 questions covered the sociodemographic data of the participants, along with information relating to their job and research activity; the second block of 14 questions covered the researchers' perceptions, attitudes and experiences regarding scientific misconduct. The complete survey can be consulted at the following link: https://forms.gle/WcJbm5dtenBqqNq29.

In the first block, data were gathered on gender (women, men, other (including the responses "non-binary" and "not considered relevant to answer")), age, educational level, job, type of institution (academic institution, hospital, research center, and others), years of experience in research, papers, and role in peer review processes. The second block gathered information on the selfperceived seriousness of different types of scientific misconduct, self-perceived frequency of misconduct by others in scientific journals, knowledge of participation in different types of misconduct (observed frequency), and participation (intentional or unintentional) in different types of misconduct (self-reported frequency). Observed frequency refers to practices in which other researchers have engaged, and of which the researcher completing the survey is aware. In contrast, self-reported frequency refers to practices in which the researcher completing the survey has participated.

Statistical analysis

We firstly performed a descriptive analysis of the sociodemographic variables, researcher's institution and research activity, and variables relating to perceptions, attitudes and experiences regarding scientific misconduct. Quantitative variables were expressed as median and interquartile range, and qualitative variables were expressed in absolute and relative frequencies.

Database processing and debugging was performed. With a view to presentation of the results of survey questions 17, 19 and 20, responses were categorized into "Never" (original category "Never") and "At least once" (pooling of the original categories "once", "2-5 times", "6-10 times", ">10 times"). The distribution of the original responses to these questions can be consulted in the supplementary material (Table S1 of Supplementary Material). The remaining questions were categorized in accordance with the possibilities of response to the survey.

The chi-squared test was used to evaluate differences in responses relating to self-perceived frequency in scientific journals, and observed and self-reported frequency (intentional or unintentional) of scientific misconduct by gender, years of research experience (≤15 and >15 years), and type of research institution (for analysis purposes, the category "others" was not taken into account, due to the limited number of respondents in this category (n=22)). Observed differences were deemed to be statistically significant at a p-value <0.05.

All statistical analyses were performed using the Stata v.17 and Excel software programs.

Ethical aspects

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Due to the delicate nature of some questions included in the survey, we ensured that the questionnaire was totally anonymous and that the responses would not enable identification of a given participant. The study was approved by the Bioethics Committee of the University of Santiago de Compostela (reference no. USC 37/2022) on 13/09/2022.

RESULTS

Characteristics of the participants

In all, 403 Spanish researchers in the field of biomedicine responded to the survey across the period 19/10/2022 through 13/06/2023. Table 1 shows the main sociodemographic characteristics and those relating to participants' research work and activity: 51.1% (n=205) were women and 47.9% (n=192) were men, median age 45 years (interquartile range 35-57); 74.1% (n=297) possessed doctoral degrees and 20.9% (n=84) Master's degrees; 32.1% (n=126) were researchers and 21.9% (n=86) were hospital physicians; 40.7% (n=162) of those surveyed worked at a health center (40.7%, n=162). In terms of research career, the median number of years devoted to research was 15, and while the majority had only participated as reviewers in the editorial process (49.9%; n=199), 20.8% (n=83) had participated as reviewers and editors. The median number of papers published in the last five years was 14 overall, and 7 in journals ranked in the first quartile.

Perception of the seriousness of the type of misconduct

The type of misconduct perceived as having the most negative consequences or considered most serious was fabrication of results (16.6%), followed by plagiarism (13.9%) and pressure of study sponsors (13.2%). False affiliation was identified by the participants as the type of scientific misconduct that had fewest negative consequences, with 19.8% of responses, followed by non-declaration of conflicts of interest (13.6%) and falsification of curriculum vitae (12.9%) (Figure 1).

Perception of the frequency of scientific misconduct

Figure 2 shows the frequency (self-perceived by the researchers surveyed) of the different types of misconduct in scientific journals indexed in Journal Citation Reports. The most frequent type of perceived misconduct was false authorship: 33.6% of researchers reported that they frequently encountered this in scientific journals and 39.0% that they encountered it very frequently. They also highlighted pressure by study sponsors (30.8% answered "frequently") and non-declaration of conflicts of interest (28.8% answered "frequently"). Fabrication and falsification were perceived as occasional practices by 56.8% to 62.5% of researchers. While no differences were observed in the perceived frequency of any type of scientific misconduct by gender or research institution, these were observed by reference to years of experience (Table S1 of Supplementary Material). Researchers with over 15 years of research experience perceived a lower frequency of lack of informed consent, fabrication, falsification, and false authorship, than did those who had been involved in research for 15 years or less ($p<0.05$).

Observed frequency of scientific misconduct

When it came to knowledge of cases of scientific misconduct (observed frequency), 78.8% of researchers knew of at least one case. The researchers surveyed stressed false authorship, with 63.2% reporting that they knew of at least one case, and falsification of data (36.0%) and results (36.4%) (Table 2). Responses did not differ by gender, and significant differences were not observed, with the exception of misconduct of the type "non-declaration of conflicts of interest", where 45.3% of men reported knowing of at least one case, as opposed to 30.7% of women ($p<0.05$). Differences were also found by years of experience and type of institution when it came to the specific types of misconduct reported, with non-declaration of conflicts of interest once again receiving special attention (Table 2).

The means whereby the researchers surveyed learned of cases of scientific misconduct were divided into the following 4 major groups: direct knowledge; via third parties; through generalist or specialized media; or through reviews (editorial, peer, ethics committee, individual). Almost half of those surveyed reported having direct knowledge of these cases (43.4%), whether because they themselves were involved or because they were told by the person involved.

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Self-reported frequency of scientific misconduct

Almost half the researchers surveyed reported that they had committed some type of scientific misconduct intentionally (43.3%); of these, 34.7% reported having participated in false authorship and

10.1% reported lack of informed consent, while 3.6% had participated at least once in falsification and/or manipulation of data. Of the researchers who reported participating in false authorship, 50.3% did not think it right but did nothing, whereas 18.4% considered it a routine practice. In terms of gender, differences were observed with respect to participation in misconduct associated with ethics committee approval, lack of informed consent, and non-declaration of conflicts of interest, with a higher percentage in men being observed in all cases ($p<0.05$) (Table 2). By type of research institution, differences were observed with respect to declaration of having falsified/manipulated data (higher proportion among subjects who worked at a research center ($p<0.01$)) and non-declaration of conflicts of interest (higher proportion among subjects who worked at a hospital center ($p=0.02$)).

When it came to engaging in scientific misconduct unintentionally, 47.6% had participated in false authorship and 19.7% in lack of informed consent. Eight people (2.1%) reported having unintentionally engaged the services of paper mills a minimum of once. By gender, a higher percentage of men reported having unintentionally participated in problems related with ethics committee approval, pressure from a study sponsor, and non-declaration of conflicts of interest ($p<0.05$). By reference to years of experience, those who had worked more than 15 years in research reported non-declaration of conflicts to a greater extent ($p=0.02$). In terms of type of institution, differences were observed in various items: participation in lack of informed consent and pressure of the industry was more frequent among subjects who worked at hospital centers, while participating in falsification of curriculum vitae and false authorship was more frequent among subjects who worked at academic institutions ($p<0.05$).

DISCUSSION

The results of this study highlight the high percentage of researchers from Spanish institutions who acknowledge having committed scientific misconduct intentionally or unintentionally. 4 of 10 of the surveyed researchers declared taking part intentionally in some type of scientific misconduct. Furthermore, a considerable percentage of those surveyed know of other cases of scientific misconduct, and in particular, of researchers who had engaged the services of paper mills, though no case in Spain has been formally identified to date. To our knowledge, this is the first survey to identify Spanish researchers' perceptions, attitudes and experiences regarding scientific misconduct.

In general, the results obtained agree with those of studies conducted in different countries. That said, the percentage of Spanish researchers surveyed who knew of one case of scientific misconduct is higher than that found in previous studies. This percentage, in our case, rises to 78.8%, but this may be due to the practices defined as scientific misconduct by the different studies undertaken. In one study conducted in the USA, only 11.9% of researchers reported knowing of practices classified as scientific misconduct, though they were referring to fabrication, falsification and plagiarism (22), and thus disregarding the other practices considered in our study. In an Italian study, this percentage was 21.2% and, as instances of misconduct, included the original items of the SMQ-R questionnaire (25). A study conducted in Nigeria, with a questionnaire similar to that of the Italian study, reported that 50.4% of researchers surveyed knew of at least one case of scientific misconduct in their workplace (29). Lastly, six studies conducted in China found that 30-60% of those surveyed knew of some case of scientific misconduct among their colleagues (13).

Similarly, in our study the percentage of participants who reported committing some type of misconduct was far higher than that of other studies: 43.3% of researchers acknowledged having intentionally participated at least once in some type of scientific misconduct. Previous systematic reviews, one that included studies undertaken in China until 2016 and another that included studies worldwide until 2008, observed a prevalence of self-reported misconduct of 2% to 33.7% (13, 30). This difference may also be due to the definition of scientific misconduct used in the respective studies and we have to acknowledge that the definition used by us was a broad one.

A systematic review of studies conducted in China concluded that while fabrication, falsification and plagiarism are commonly recognized as types of scientific misconduct, other types, such as duplication or problems of authorship, are less recognizable by researchers (13). This may be due to the fact that, while practically all definitions of scientific misconduct include fabrication, falsification and plagiarism, the other types of scientific misconduct are not explicitly specified, and are consequently relegated to a "gray area"

where they are commonly called unacceptable or questionable practices (31). This denomination, one that is different to "scientific misconduct", could lead researchers to perceive them as less serious, and thus even contribute to normalizing their use, despite being practices potentially prejudicial to scientific integrity. In our study, non-declaration of conflicts of interest and false authorship were types of scientific misconduct perceived as being less serious but which nonetheless registered a higher frequency, both observed and self-reported; in contrast, fabrication, falsification and plagiarism were practices perceived as being more serious. However, even those types of scientific misconduct which go unnoticed or which are perceived as being less serious may have important consequences (31). In view of these results, it is therefore essential to raise the awareness of the scientific community about the different types of misconduct, including those not perceived as such.

A total of 63.2% of the researchers surveyed knew of at least one case of false authorship, and 34.7% had intentionally participated in some type of scientific misconduct. These results agree with those reported by previous studies (23, 25, 32, 33) conducted in different countries, highlighting the persistence of this problem at a global level. Yet other studies conducted in China and in Nigeria have reported a lower frequency (observed and self-reported) of this problem (13, 29), which may mean that it is a context-dependent problem. In our study, false authorship refers to the practice known as “guest/gift authorship”, which is defined as the attribution of authorship to an individual who has not made a significant contribution to research. The main drawback of guest/gift authorship lies in the fact that it is considered a routine practice, totally accepted in the scientific community. In our study, 18.4% of researchers considered it normal and 50.3% did not think it right but did nothing to prevent it. It should be recalled here that guest/gift authorship violates the ethical principles and standards of scientific integrity (34).

Another worrying fact is that relating to the organizations known as “paper mills”: 14.2% of researchers surveyed were aware of the use of such organizations, and 12 persons acknowledged having participated in this type of scientific misconduct, intentionally or unintentionally. This result is alarming because there has been no news to date of any paper retracted for coming from a paper mill, which included an author affiliated with a Spanish institution among its list of authors. Paper mills devote themselves to producing scientific manuscripts, in great part fraudulent or plagiarized, for the purpose of then selling their authorship (35). These organizations are mainly associated with China, Russia and India, and the great majority of papers identified as coming from paper mills tend to feature authors from these countries (5), but their use has now spread worldwide. The fact that Spanish researchers acknowledge their participation in these practices, confirms this. Although no retracted paper linked to Spanish institutions has yet been identified, this in no way means that the problem does not exist in Spain: rather, it indicates the need for greater vigilance by scientific institutions and journals, with a view to its detection.

In some items, gender-based differences were observed in the survey responses, despite the fact that previous studies suggest that this variable is not associated with misconduct (10, 12, 21). Although previous studies (12) report a higher likelihood of scientific misconduct being committed by novel researchers, our study found no important differences by reference to years of research experience. Other studies (21) have observed differences according to the type of institution where the researcher works, a finding that coincides with our results. Hence, a higher percentage of subjects who work at research centers reported having participated intentionally in fabrication and/or falsification. At hospital centers, in contrast, non-declaration of conflicts of interest, lack of informed consent, and pressure of study sponsors seem to be more frequent: it is possible that more direct interaction between clinical researchers and the industry in the hospital setting may serve to increase the risk of influence and bias in research results. Indeed, Ziai et al. (36) previously reported that researchers in the clinical field are reluctant to declare conflicts of interest with the industry. In academic institutions, falsification of curriculum vitae and false authorship are the most frequent types of misconduct. These results are in line with those reported by Godecharle et al. (32), who identified an observed prevalence of false authorship of 76% in the academic sphere versus 50% in industry, with this same difference also being observed in self-reported prevalence. These behaviors could be accounted for by competition for funding, recognition, and research-career advancement opportunities, aspects based on the number of papers published by researchers. These findings highlight the importance of addressing scientific misconduct by considering the specific context of each institution. It is fundamental to implement

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preventive and educational measures that are targeted at the specific challenges faced by each research environment.

This study has a series of limitations. Firstly, it is likely that the researchers surveyed may not have reported information about their participation in practices regarded as scientific misconduct, despite the fact that the questionnaire was completely anonymous. Accordingly, it is possible that self-reported frequency of scientific misconduct may have been underestimated. Secondly, the range of practices defined as scientific misconduct in our study is broader than that used in other similar studies, thereby limiting the comparability of results and registering a higher frequency of scientific misconduct. Even so, we feel that restricting scientific misconduct to fabrication, falsification and plagiarism would not adequately represent the problem. Thirdly, the sample corresponds to researchers in the sphere of health sciences, with the result that our results are not generalizable to other disciplines. Furthermore, the sample is not completely representative of Spanish researchers in the biomedical field, due to the type of sampling conducted. Additionally, we do not know the total volume of persons who received the survey through research societies and institutions, and thus have no way of knowing the participation rate, though it could be expected to be low.

To conclude, our results indicate that scientific misconduct may well be common in Spanish research: 70% of Spanish researchers know of at least one case of scientific misconduct and 40% have engaged in scientific misconduct. Furthermore, our study identified unethical practices, such as false authorship, which have become completely normalized in the research world, as well as new forms of scientific misconduct that have spread to Spain, such as the use of paper mills. The results of this and previous studies suggest that a shift in research culture toward scientific integrity is essential, and highlight the need to set up control mechanisms and disciplinary sanctions for scientific misconduct, already previously proposed in the Spanish context (37) and similar to those already in force in other countries.

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Table 1. Main characteristics of study participants.

Sociodemographic and occupational characteristics	**N=403**	
	n	**%**
Gender		
Men	192	47.9%
Women	205	51.1%
Other	4	0.9%
Age		
Median (IQR)	45 (35-57)	
Educational level		
Doctorate	297	74.1%
Master's degree	84	20.9%
Degree/Diploma/Graduate	20	5.0%
Current job		
Researcher (includes pre- and postdoctoral) researchers	126	32.1%
Hospital physician	86	21.9%
Teaching and research staff	72	18.3%
Other	109	27.7%
Type of institution		
Health center	162	40.7%
Academic institution	125	31.4%
Research center	93	23.4%
Other	18	4.5%
Years of research career		
Median (IQR)	15 (6-25)	
Participation in the editorial process		
No	115	28.8%
Yes, only as reviewer	199	49.9%
Yes, only as editor	2	0.5%
Yes, only as editor and reviewer	83	20.8%
Papers in the last 5 years		
Median (IQR)	14 (6-30.5)	
In first quartile (median, IQR)	7 (3-18)	

IQR: interquartile range

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		Gender				Years of experience			Type of institution		
	Total	Men	Women	Other	p	15 or fewer	More than 15	p	Research center	Hospital center	Academic institution	p
	N=401	N=192	N=205	N=4		N=207	N=175		N=93	N=162	N=125	
Problems related with ethics committee approval					0.18			0.82				0.70
Never	255 (67.6%)	117 (63.9%)	136 (71.6%)	2 (50.0%)		131 (67.2%)	113 (68.5%)		63 (71.6%)	101 (66.4%)	79 (66.9%)	
At least once	122 (32.4%)	66 (36.1%)	54 (28.4%)	2 (50.0%)		64 (32.8%)	52 (31.5%)		25 (28.4%)	51 (33.6%)	39 (33.1%)	
Lack of informed consent					0.87			0.44				0.41
Never	248 (66.1%)	118 (64.8%)	127 (67.2%)	3 (75.0%)		125 (64.1%)	111 (68.1%)		60 (69.0%)	95 (62.1%)	80 (69.0%)	
At least once	127 (33.9%)	64 (35.2%)	62 (32.8%)	1 (25.0%)		70 (35.9%)	52 (31.9%)		27 (31.0%)	58 (37.9%)	36 (31.0%)	
Plagiarism					0.96			0.91				0.06
Never	254 (67.4%)	123 (67.6%)	128 (67.0%)	3 (75.0%)		132 (67.7%)	110 (66.7%)		62 (71.3%)	109 (71.7%)	70 (58.8%)	
At least once	123 (32.6%)	59 (32.4%)	63 (33.0%)	1 (25.0%)		63 (32.3%)	55 (33.3%)		25 (28.7%)	43 (28.3%)	49 (41.2%)	
Fabrication					0.70			0.23				1.00
Never	276 (73.6%)	130 (71.4%)	143 (75.7%)	3 (75.0%)		138 (70.4%)	124 (76.5%)		65 (73.9%)	112 (73.2%)	85 (73.9%)	
At least once	99 (26.4%)	52 (28.6%)	46 (24.3%)	1 (25.0%)		58 (29.6%)	38 (23.5%)		23 (26.1%)	41 (26.8%)	30 (26.1%)	
Falsification/manipulation of data					0.30			0.04				0.15
Never	240 (64.0%)	117 (64.3%)	122 (64.6%)	1 (25.0%)		114 (58.8%)	114 (69.5%)		48 (55.2%)	103 (67.8%)	76 (64.4%)	
At least once	135 (36.0%)	65 (35.7%)	67 (35.4%)	3 (75.0%)		80 (41.2%)	50 (30.5%)		39 (44.8%)	49 (32.2%)	42 (35.6%)	
Falsification/manipulation of images					1.00			0.39				0.49
Never	284 (75.9%)	137 (76.1%)	144 (75.8%)	3 (75.0%)		143 (73.3%)	126 (77.8%)		63 (71.6%)	118 (78.1%)	87 (74.4%)	
At least once	90 (24.1%)	43 (23.9%)	46 (24.2%)	1 (25.0%)		52 (26.7%)	36 (22.2%)		25 (28.4%)	33 (21.9%)	30 (25.6%)	
Falsification/manipulation of results					0.20			0.01				0.096
Never	239 (63.6%)	121 (65.8%)	117 (62.2%)	1 (25.0%)		110 (57.0%)	117 (70.5%)		47 (54.0%)	104 (68.0%)	75 (64.1%)	
At least once	137 (36.4%)	63 (34.2%)	71 (37.8%)	3 (75.0%)		83 (43.0%)	49 (29.5%)		40 (46.0%)	49 (32.0%)	42 (35.9%)	
Falsification of curriculum vitae					0.44			0.63				0.062
Never	280 (74.3%)	135 (73.8%)	143 (75.3%)	2 (50.0%)		142 (73.2%)	126 (75.9%)		64 (72.7%)	124 (80.5%)	79 (68.1%)	
At least once	97 (25.7%)	48 (26.2%)	47 (24.7%)	2 (50.0%)		52 (26.8%)	40 (24.1%)		24 (27.3%)	30 (19.5%)	37 (31.9%)	
False authorship					0.18			0.08				0.049
Never	139 (36.8%)	75 (40.8%)	62 (32.6%)	2 (50.0%)		63 (32.0%)	68 (41.5%)		29 (33.3%)	67 (43.8%)	36 (30.0%)	
At least once	239 (63.2%)	109 (59.2%)	128 (67.4%)	2 (50.0%)		134 (68.0%)	96 (58.5%)		58 (66.7%)	86 (56.2%)	84 (70.0%)	
False affiliation					0.19			0.14				0.23
Never	283 (75.7%)	131 (72.0%)	148 (78.7%)	4 (100.0%)		142 (72.4%)	129 (79.6%)		67 (76.1%)	122 (79.7%)	82 (70.7%)	
At least once	91 (24.3%)	51 (28.0%)	40 (21.3%)	0 (0.0%)		54 (27.6%)	33 (20.4%)		21 (23.9%)	31 (20.3%)	34 (29.3%)	
Pressure of study sponsor					0.15			0.47				0.56
Never	277 (74.1%)	127 (69.8%)	147 (78.2%)	3 (75.0%)		149 (76.4%)	119 (73.0%)		67 (76.1%)	111 (72.5%)	90 (78.3%)	
At least once	97 (25.9%)	55 (30.2%)	41 (21.8%)	1 (25.0%)		46 (23.6%)	44 (27.0%)		21 (23.9%)	42 (27.5%)	25 (21.7%)	
Paper mills					0.30			1.00				0.72
Never	319 (85.8%)	151 (83.9%)	165 (87.8%)	3 (75.0%)		167 (85.6%)	138 (85.7%)		78 (88.6%)	128 (84.8%)	98 (85.2%)	
At least once	53 (14.2%)	29 (16.1%)	23 (12.2%)	1 (25.0%)		28 (14.4%)	23 (14.3%)		10 (11.4%)	23 (15.2%)	17 (14.8%)	
Non-declaration of conflicts of interest					0.01			0.004				0.05
Never	232 (62.0%)	99 (54.7%)	131 (69.3%)	2 (50.0%)		135 (69.6%)	89 (54.6%)		63 (71.6%)	85 (55.9%)	75 (64.7%)	
At least once	142 (38.0%)	82 (45.3%)	58 (30.7%)	2 (50.0%)		59 (30.4%)	74 (45.4%)		25 (28.4%)	67 (44.1%)	41 (35.3%)	

Table 2. Frequency of first-hand knowledge of commission of the different types of scientific misconduct, overall and by gender, years of research experience, and type of academic institution.

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		Gender				Years of experience			Type of institution		
	Total	Men	Women	Other	p	15 or fewer	More than 15	p	Research center	Hospital center	Academic institution	p
INTENTIONAL PARTICIPATION												
Problems related with ethics committee approval					0.01			1.00				0.92
Never	365 (94.3%)	171 (91.4%)	191 (97.4%)	3 (75.0%)		188 (94.5%)	161 (94.2%)		84 (95.5%)	149 (94.3%)	115 (94.3%)	
At least once	22 (5.7%)	16 (8.6%)	5 (2.6%)	1 (25.0%)		11 (5.5%)	10 (5.8%)		4 (4.5%)	9 (5.7%)	7 (5.7%)	
Lack of informed consent					0.01			1.00				0.58
Never	346 (89.9%)	159 (85.9%)	184 (93.9%)	3 (75.0%)		178 (89.9%)	152 (89.4%)		79 (89.8%)	138 (87.9%)	111 (91.7%)	
At least once	39 (10.1%)	26 (14.1%)	12 (6.1%)	1 (25.0%)		20 (10.1%)	18 (10.6%)		9 (10.2%)	19 (12.1%)	10 (8.3%)	
Plagiarism					0.33			1.00				0.55
Never	380 (98.2%)	182 (97.3%)	194 (99.0%)	4 (100.0%)		195 (98.0%)	168 (98.2%)		85 (96.6%)	156 (98.7%)	120 (98.4%)	
At least once	7 (1.8%)	5 (2.7%)	2 (1.0%)	0 (0.0%)		4 (2.0%)	3 (1.8%)		3 (3.4%)	2 (1.3%)	2 (1.6%)	
Fabrication					1.00			1.00				0.18
Never	381 (99.0%)	183 (98.9%)	194 (99.0%)	4 (100.0%)		196 (99.0%)	169 (99.4%)		86 (97.7%)	155 (99.4%)	122 (100.0%)	
At least once	4 (1.0%)	2 (1.1%)	2 (1.0%)	0 (0.0%)		2 (1.0%)	1 (0.6%)		2 (2.3%)	1 (0.6%)	0 (0.0%)	
Falsification/manipulation of data					0.82			0.10				0.01
Never	373 (96.4%)	181 (96.8%)	188 (95.9%)	4 (100.0%)		189 (95.0%)	168 (98.2%)		80 (90.9%)	157 (99.4%)	118 (96.7%)	
At least once	14 (3.6%)	6 (3.2%)	8 (4.1%)	0 (0.0%)		10 (5.0%)	3 (1.8%)		8 (9.1%)	1 (0.6%)	4 (3.3%)	
Falsification/manipulation of images					1.00			0.13				1.00
Never	378 (97.9%)	182 (97.8%)	192 (98.0%)	4 (100.0%)		192 (97.0%)	170 (99.4%)		86 (97.7%)	154 (98.1%)	120 (98.4%)	
At least once	8 (2.1%)	4 (2.2%)	4 (2.0%)	0 (0.0%)		6 (3.0%)	1 (0.6%)		2 (2.3%)	3 (1.9%)	2 (1.6%)	
Falsification/manipulation of results					1.00			0.39				0.27
Never	375 (96.9%)	181 (96.8%)	190 (96.9%)	4 (100.0%)		190 (96.0%)	168 (97.7%)		83 (94.3%)	153 (96.8%)	120 (98.4%)	
At least once	12 (3.1%)	6 (3.2%)	6 (3.1%)	0 (0.0%)		8 (4.0%)	4 (2.3%)		5 (5.7%)	5 (3.2%)	2 (1.6%)	
Falsification de curriculum vitae					1.00			1.00				0.34
Never	382 (99.2%)	186 (99.5%)	192 (99.0%)	4 (100.0%)		195 (99.0%)	170 (99.4%)		86 (98.9%)	157 (100.0%)	120 (98.4%)	
At least once	3 (0.8%)	1 (0.5%)	2 (1.0%)	0 (0.0%)		2 (1.0%)	1 (0.6%)		1 (1.1%)	0 (0.0%)	2 (1.6%)	
False authorship					0.90			0.74				0.14
Never	252 (65.3%)	119 (64.3%)	130 (66.0%)	3 (75.0%)		128 (64.3%)	113 (66.5%)		65 (73.9%)	97 (61.8%)	78 (63.9%)	
At least once	134 (34.7%)	66 (35.7%)	67 (34.0%)	1 (25.0%)		71 (35.7%)	57 (33.5%)		23 (26.1%)	60 (38.2%)	44 (36.1%)	
False affiliation					0.18			0.73				0.38
Never	377 (97.7%)	180 (96.3%)	193 (99.0%)	4 (100.0%)		193 (97.5%)	168 (98.2%)		85 (96.6%)	153 (97.5%)	121 (99.2%)	
At least once	9 (2.3%)	7 (3.7%)	2 (1.0%)	0 (0.0%)		5 (2.5%)	3 (1.8%)		3 (3.4%)	4 (2.5%)	1 (0.8%)	
Pressure of study sponsor					0.48			1.00				0.18
Never	371 (96.6%)	177 (95.7%)	190 (97.4%)	4 (100.0%)		191 (96.5%)	163 (96.4%)		85 (97.7%)	148 (94.3%)	119 (98.3%)	
At least once	13 (3.4%)	8 (4.3%)	5 (2.6%)	0 (0.0%)		7 (3.5%)	6 (3.6%)		2 (2.3%)	9 (5.7%)	2 (1.7%)	
Paper mills					1.00			0.13				0.56
Never	383 (99.0%)	185 (98.9%)	194 (99.0%)	4 (100.0%)		195 (98.0%)	171 (100%)		88 (100.0%)	155 (98.1%)	121 (99.2%)	
At least once	4 (1.0%)	2 (1.1%)	2 (1.0%)	0 (0.0%)		4 (2.0%)	0 (0.0%)		0 (0.0%)	3 (1.9%)	1 (0.8%)	
Non-declaration of conflicts of interest					0.02			1.00				0.02
Never	348 (91.1%)	162 (87.6%)	183 (94.8%)	3 (75.0%)		178 (90.8%)	153 (90.5%)		82 (93.2%)	133 (85.8%)	115 (95.0%)	
At least once	34 (8.9%)	23 (12.4%)	10 (5.2%)	1 (25.0%)		18 (9.2%)	16 (9.5%)		6 (6.8%)	22 (14.2%)	6 (5.0%)	

Table 3. Intentional and unintentional participation in different types of scientific misconduct, overall and by gender, years of experience, and type of institution.

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Table 3 (cont.). Intentional and unintentional participation in different types of scientific misconduct, overall and by gender, years of experience, and type of institution.

		Gender				Years of experience			Type of institution			
	Total	Men	Women	Other	p	15 or fewer	More than 15	p	Research center	Hospital center	Academic institution	p
UNINTENTIONAL PARTICIPATION												
Problems related with ethics committee approval					0.01			0.89				0.32
Never	317 (83.4%)	143 (78.1%)	171 (88.6%)	3 (75.0%)		164 (83.7%)	139 (82.7%)		76 (86.4%)	121 (79.6%)	104 (85.2%)	
At least once	63 (16.6%)	40 (21.9%)	22 (11.4%)	1 (25.0%)		32 (16.3%)	29 (17.3%)		12 (13.6%)	31 (20.4%)	18 (14.8%)	
Lack of informed consent					0.60			0.69				0.02
Never	305 (80.3%)	143 (78.6%)	158 (81.4%)	4 (100.0%)		157 (79.7%)	136 (81.4%)		71 (81.6%)	112 (73.7%)	107 (87.0%)	
At least once	75 (19.7%)	39 (21.4%)	36 (18.6%)	0 (0.0%)		40 (20.3%)	31 (18.6%)		16 (18.4%)	40 (26.3%)	16 (13.0%)	
Plagiarism					1.00			0.84				1.00
Never	353 (93.4%)	170 (93.4%)	179 (93.2%)	4 (100.0%)		184 (93.4%)	153 (92.7%)		81 (93.1%)	140 (92.7%)	114 (93.4%)	
At least once	25 (6.6%)	12 (6.6%)	13 (6.8%)	0 (0.0%)		13 (6.6%)	12 (7.3%)		6 (6.9%)	11 (7.3%)	8 (6.6%)	
Fabrication					0.38			0.24				0.91
Never	360 (95.0%)	171 (93.4%)	185 (96.4%)	4 (100.0%)		184 (93.4%)	160 (96.4%)		83 (95.4%)	143 (94.1%)	116 (95.1%)	
At least once	19 (5.0%)	12 (6.6%)	7 (3.6%)	0 (0.0%)		13 (6.6%)	6 (3.6%)		4 (4.6%)	9 (5.9%)	6 (4.9%)	
Falsification/manipulation of data					0.05			0.13				0.83
Never	337 (88.9%)	160 (87.9%)	175 (90.7%)	2 (50.0%)		170 (86.3%)	152 (91.6%)		77 (87.5%)	133 (88.1%)	110 (90.2%)	
At least once	42 (11.1%)	22 (12.1%)	18 (9.3%)	2 (50.0%)		27 (13.7%)	14 (8.4%)		11 (12.5%)	18 (11.9%)	12 (9.8%)	
Falsification/manipulation of images					0.54			0.83				0.83
Never	356 (93.7%)	169 (92.3%)	183 (94.8%)	4 (100.0%)		183 (92.9%)	157 (94.0%)		81 (92.0%)	143 (94.1%)	114 (93.4%)	
At least once	24 (6.3%)	14 (7.7%)	10 (5.2%)	0 (0.0%)		14 (7.1%)	10 (6.0%)		7 (8.0%)	9 (5.9%)	8 (6.6%)	
Falsification/manipulation of results					0.11			0.86				0.74
Never	342 (90.0%)	160 (87.4%)	179 (92.7%)	3 (75.0%)		176 (89.3%)	151 (90.4%)		80 (90.9%)	134 (88.2%)	111 (91.0%)	
At least once	38 (10.0%)	23 (12.6%)	14 (7.3%)	1 (25.0%)		21 (10.7%)	16 (9.6%)		8 (9.1%)	18 (11.8%)	11 (9.0%)	
Falsification of curriculum vitae					0.20			0.62				0.03
Never	362 (95.5%)	170 (93.4%)	188 (97.4%)	4 (100.0%)		189 (95.9%)	157 (94.6%)		87 (98.9%)	146 (96.7%)	111 (91.0%)	
At least once	17 (4.5%)	12 (6.6%)	5 (2.6%)	0 (0.0%)		8 (4.1%)	9 (5.4%)		1 (1.1%)	5 (3.3%)	11 (9.0%)	
False authorship					0.97			0.67				0.04
Never	198 (52.4%)	94 (51.9%)	102 (52.8%)	2 (50.0%)		101 (51.8%)	91 (54.5%)		52 (59.1%)	87 (56.9%)	52 (43.7%)	
At least once	180 (47.6%)	87 (48.1%)	91 (47.2%)	2 (50.0%)		94 (48.2%)	76 (45.5%)		36 (40.9%)	66 (43.1%)	67 (56.3%)	
False affiliation					0.47			0.13				1.00
Never	353 (93.4%)	167 (91.8%)	182 (94.8%)	4 (100.0%)		179 (91.8%)	160 (95.8%)		82 (94.3%)	142 (93.4%)	113 (93.4%)	
At least once	25 (6.6%)	15 (8.2%)	10 (5.2%)	0 (0.0%)		16 (8.2%)	7 (4.2%)		5 (5.7%)	10 (6.6%)	8 (6.6%)	
Pressure of study sponsor					0.05			0.61				0.00
Never	341 (89.7%)	156 (85.7%)	181 (93.3%)	4 (100.0%)		179 (90.4%)	147 (88.6%)		82 (93.2%)	125 (82.2%)	117 (95.9%)	
At least once	39 (10.3%)	26 (14.3%)	13 (6.7%)	0 (0.0%)		19 (9.6%)	19 (11.4%)		6 (6.8%)	27 (17.8%)	5 (4.1%)	
Paper mills					0.23			0.30				0.12
Never	371 (97.9%)	177 (96.7%)	190 (99.0%)	4 (100.0%)		191 (97.0%)	165 (98.8%)		88 (100.0%)	146 (96.1%)	120 (98.4%)	
At least once	8 (2.1%)	6 (3.3%)	2 (1.0%)	0 (0.0%)		6 (3.0%)	2 (1.2%)		0 (0.0%)	6 (3.9%)	2 (1.6%)	
Non-declaration of conflicts of interest					0.04			0.02				0.10
Never	325 (86.0%)	148 (81.3%)	173 (90.1%)	4 (100.0%)		177 (90.8%)	137 (82.0%)		81 (92.0%)	124 (82.7%)	108 (88.5%)	
At least once	53 (14.0%)	34 (18.7%)	19 (9.9%)	0 (0.0%)		18 (9.2%)	30 (18.0%)		7 (8.0%)	26 (17.3%)	14 (11.5%)	

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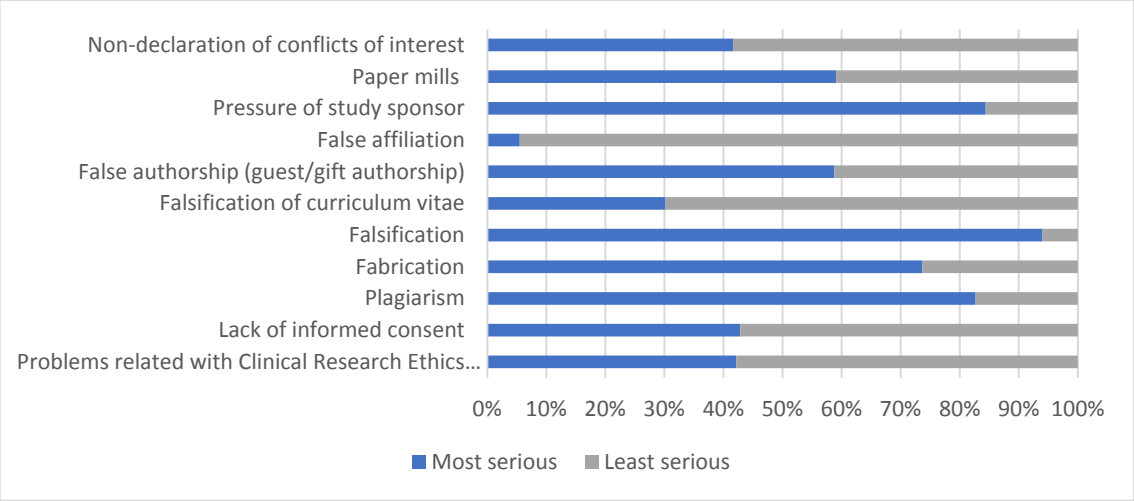


Figure 1. Perceived seriousness of different types of scientific misconduct.

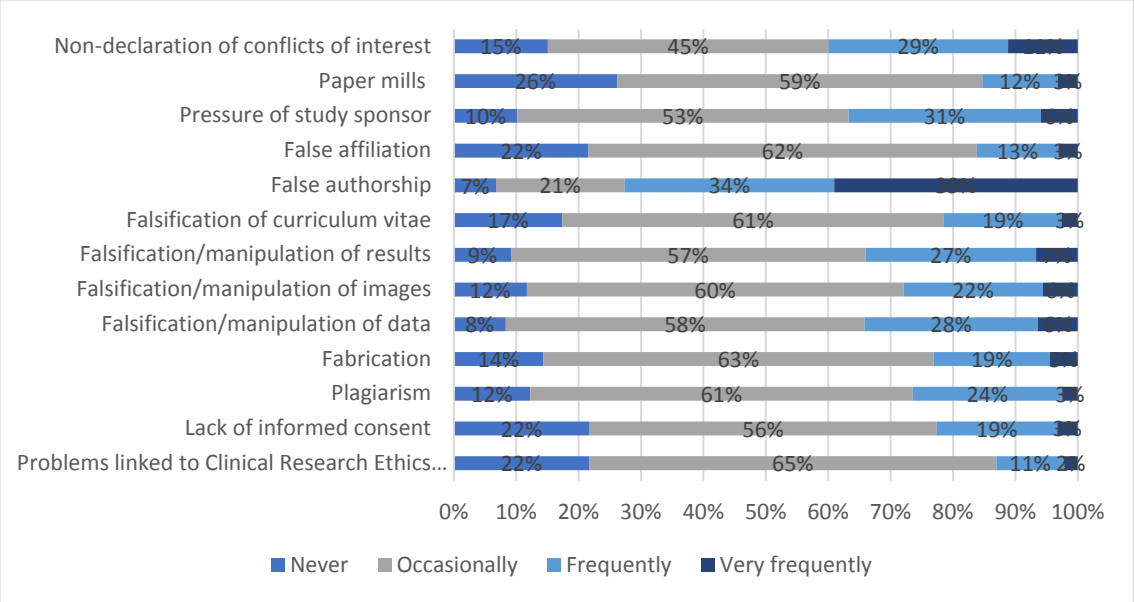


Figure 2. Perceived frequency of different types of scientific misconduct in journals indexed in Journal Citation Reports

Artículo 6. Candal-Pedreira C, Ghaddar A, Pérez-Ríos M, Varela-Lema L, Álvarez-Dardet C, Ruano-Ravina A. **Disciplinary Sanctions and Alert Signals of Scientific Misconduct from the Perspective of Spanish Researchers.**

Disciplinary Sanctions and Alert Signals of Scientific Misconduct from the Perspective of Spanish Researchers.

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Disciplinary Sanctions and Alert Signals of Scientific Misconduct from the Perspective of Spanish Researchers.

Abstract

Introduction: The aim of this study was to ascertain Spanish researchers' perceptions regarding the alert signals that might suggest scientific misconduct and the disciplinary sanctions that they would propose for different types of scientific misconduct.

Methods: We conducted a cross-sectional study using an anonymous online survey made up of 27 questions, targeting researchers in the biomedical field. A descriptive analysis was performed by reference to the variables of interest.

Results: A total of 403 researchers answered the survey; 51.1% (n=205) women, median age 45 years (interquartile range 35-57). The following alert signals were identified by half the researchers: not sharing the database; use of contradictory figures; publishing only positive results; and publishing very frequently. Special mention was made of warnings issued by research institutions, with dismissal from the institution being observed for some specific types of misconduct.

Conclusions: The alert signals identified by researchers are consistent with signals commonly associated with scientific misconduct. The most common disciplinary sanction proposed by the researchers was a warning from the research institution.

***Keywords*:** scientific integrity, scientific misconduct, Spain, survey, sanction

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Disciplinary Sanctions and Alert Signals of Scientific Misconduct from the Perspective of Spanish Researchers.

INTRODUCTION

Misconduct is the main cause of scientific retraction and there has been a rising trend in the frequency of this unethical practice over some decades (1, 2). When researchers engage in unethical practices, there is the hope that their institutions or pertinent bodies will take disciplinary actions or impose sanctions to address the problem.

The imposition of disciplinary sanctions for scientific misconduct has been the subject of controversy in the scientific community, and poses certain challenges (3, 4). Some authors argue that disciplinary sanctions are essential to preserve the integrity of science and discourage unethical practices among researchers. Others, however, contend that application of disciplinary sanctions could undermine trust in science (3). Furthermore, there is a clear limitation on the establishment of disciplinary sanctions, due to the fact that, apart from fabrication, falsification and plagiarism, there is no international consensus on which other types of unethical practices should be included under the head of "scientific misconduct" (4). This translates as the impossibility of establishing clear measures.

The aim of this study was therefore to ascertain: firstly, Spanish researchers' perceptions regarding which aspects that alert them to scientific misconduct in scientific papers; and, secondly, the disciplinary actions or sanctions that could be proposed for the various types of scientific misconduct.

METHODS

Cross-sectional study using an online, anonymous survey conducted from October 2022 through June 2023, targeting researchers affiliated with a Spanish institution in the biomedical field. The sample was obtained through contact with scientific societies, accredited Spanish health research institutes, and biomedical research centers such as the Consortium for Biomedical Research in Epidemiology and Public Health (*CIBER de Epidemiología y Salud Pública/CIBERESP*) and the Consortium for Biomedical Research in Physiopathology and Nutrition (*Centro de Investigación Biomédica en Red de la Fisiopatología de la Obesidad y Nutrición/CIBEROBN*). Purposeful sampling and snow-ball recruitment strategies were used.

The survey, which had previously been piloted, was based on the Scientific Misconduct Questionnaire-Revised (SMQ-R) developed by Broome et al. (5). In this study, we evaluated the following practices: fabrication, falsification and plagiarism; problems with Clinical Research Ethics Committee approval; lack of informed consent; false authorship/affiliation; pressure of study sponsors; paper mills; and non-declaration of conflicts of interest. The types of scientific misconduct evaluated were selected on the basis of national and international documents addressing scientific integrity, a number of practices deemed to amount to misconduct or be unacceptable (6, 7, 8, 9), and the practices included in the SMQ-R. In this study, no distinction was drawn between unacceptable practices and scientific misconduct, with all these practices being included under the head of "scientific misconduct".

The questionnaire consisted of 27 questions divided into two blocks: the first block covered sociodemographic information about those surveyed; and the second block asked the survey subjects about the disciplinary actions or sanctions that they would propose for each type of scientific misconduct. Additionally, subjects were asked about the alert signals that suggested scientific misconduct. A descriptive analysis of the data was performed using the Excel and Stata v.17.0 software programs.

The study was approved by the Bioethics Committee of the University of Santiago de Compostela (reference no.: USC 37/2022).

RESULTS

A total of 403 researchers answered the survey. The main characteristics of the sample are described in detail in a previous paper. In brief, 51.1% (n=205) were women, median age 45 years (interquartile range: 35-57), and 74.1% (n=297) had doctoral degrees. Researchers had a median of 15 years of research experience (interquartile range: 6-25).

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When it came to alert signals that suggested scientific misconduct (Table 1), half the researchers surveyed highlighted not sharing the database and use of contradictory figures (51.9% and 51.6% respectively), while 43.7% and 43.2% singled out publishing only positive results and publishing very frequently, respectively (multiple response question, the summation of the numbers for each category is higher than the total number).

Figure 1 shows the distribution of the disciplinary sanctions proposed by survey subjects for each type of scientific misconduct. Stress was laid on warnings issued by research institutions (ranging from 9.7% in the case of fabrication and falsification of data and results, to 64.6% in the case of problems linked to Clinical Research Ethics Committee approval). The disciplinary sanction proposed least frequently was that of receiving no promotion, which ranged from 0% (problems linked to Clinical Research Ethics Committee approval) to 5.7% (falsification of curriculum vitae), followed by dismissal from the institution, which was most frequently proposed in cases of falsification of results (8.2%) and data (7.5%).

DISCUSSION

The researchers participating in this study proposed different disciplinary sanctions for different types of scientific misconduct, with the most common being a warning from the research institution. Dismissal from the institution was most frequently proposed in specific cases, such as fabrication and falsification. This may be due to the perception of these practices as being more serious. As in our study, Hesselman et al. (10) observed that 90% of researchers were of the opinion that scientific misconduct should be punished, and that disciplinary sanctions should be in consonance with the seriousness of the practice. It is noteworthy that while more than 70% of those surveyed in Hesselman et al's study (10) proposed dismissal from the institution in certain cases, in our study the frequency was much lower. At all events, it can be said that the Spanish scientific community would be prepared for a disciplinary mechanism on the part of institutions in such cases of scientific misconduct.

Currently, the real imposition of disciplinary sanctions for scientific misconduct is not only anecdotal, but is, moreover, country-dependent. By way of exception, mention should be made of the USA, where the Office of Research Integrity (ORI) imposes disciplinary sanctions in line with the seriousness of the proven scientific misconduct. However, the ORI solely acts in the case of studies funded by the US Public Health Service, and is restricted to fabrication, falsification and plagiarism. In Europe, there are bodies that monitor scientific misconduct, though they do not have authority to levy sanctions (11). In our opinion, the imposition of disciplinary sanctions on subjects who have committed scientific misconduct could serve to dissuade the remaining researchers from engaging in such practices.

That said, it would be necessary to consider a distinction between disciplinary sanctions and warnings. Although these are both mechanisms for addressing problems of scientific integrity, they do not mean the same: disciplinary sanctions should be reserved for more serious situations, where there has been a clear and significant violation of ethical research norms, and may entail more severe consequences; warnings, on the other hand, could be reserved for less serious situations that do not put the integrity of science at risk.

Two of the situations most cited by Spanish researchers as alert signals suggesting scientific misconduct are: not sharing the database; and use of contradictory figures. This indicates the importance attributed by the scientific community to transparency and consistency in the presentation of data and results. The alert signals identified by the researchers surveyed are consistent with the signals commonly associated with scientific misconduct (12).

It can be concluded that Spanish researchers propose measures to address scientific misconduct, and that the severity of such measures should be in accordance with the seriousness of the misconduct. In this context, the implementation of solid and transparent policies that clearly define what comprises scientific misconduct and its consequences, is crucial. Furthermore, there is a need for greater collaboration and discussion in the scientific community, in order to arrive at a consensus about disciplinary sanctions and appropriate warnings for different types of misconduct. In addition, sanction and/or warning mechanisms should be uniform across institutions and countries, to ensure that ethically unscrupulous researchers know what to expect in such cases, and that there are no safe havens for scientific malpractice.

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Table 1. Alert signals for detecting scientific misconduct.

Alert signals for detecting scientific misconduct	**N**
Not sharing database	209
Use of contradictory figures	208
Only publishing positive results (favorable to the hypothesis postulated)	176
Publishing very frequently	174
Type of journal in which papers are published	152
The number of authors who appear in the paper is very high	144
False reviewers suggested	130
New authors added to the paper during the peer review process	110
Use of commercial e-mail accounts (e.g., @gmail.com or @yahoo.com)	30
Very sudden and radical changes to lines of research	2

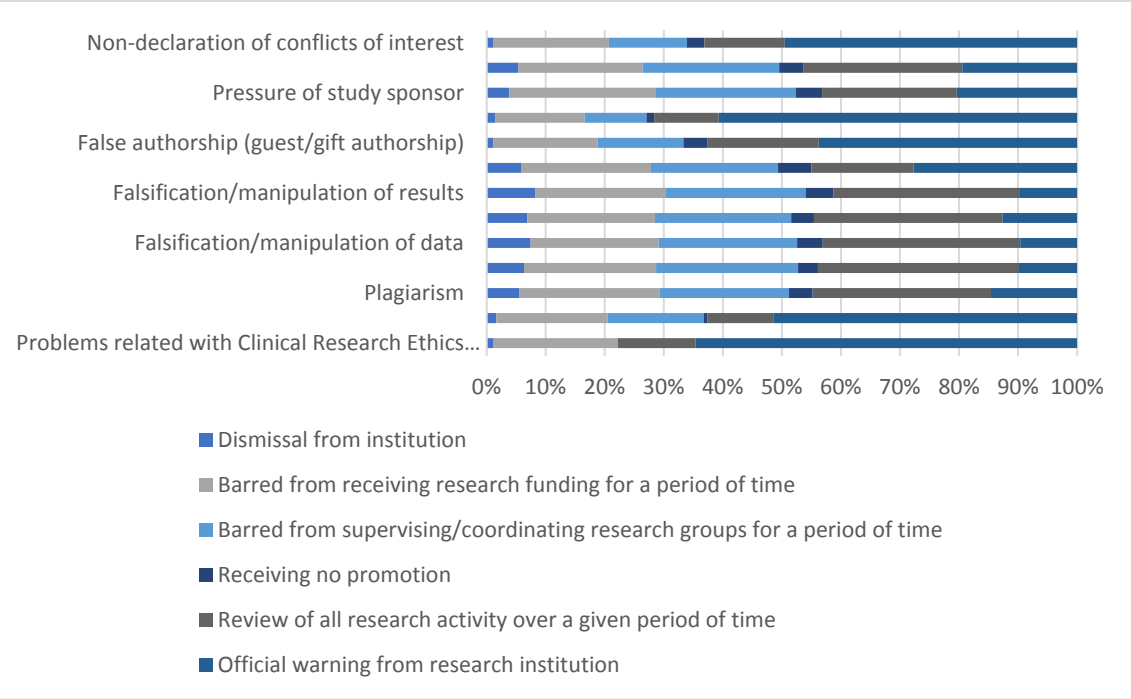


Figure 1. Disciplinary sanctions proposed for each type of scientific misconduct.

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Artículo 11. Candal-Pedreira C, Guerra-Tort C, Freijedo-Fariñas F, Rey-Brandariz J, Ruano-Ravina A, Pérez-Ríos M. **Retracted papers originating form paper mills: análisis of references and citations.**

RETRACTED PAPERS ORIGINATING FROM PAPER MILLS: ANALYSIS OF REFERENCES AND CITATIONS.

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Contributors:

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Data sharing: Part of the data that support the findings of this study are available from Retraction Watch. Restrictions apply to the availability of these data, which were used under contract license for this study.

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Transparency declaration: The lead author affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

Dissemination to participants and related patient and public communities: Not applicable.

ABSTRACT

Objectives: This study aimed to analyze the references and citations of retracted papers originated from paper mills.

Design: Cross-sectional study.

Setting: The Retraction Watch database was used to identify the retracted paper mill papers. We used Web of Science to identify the references and citations of the retracted paper mill papers. We collected information relating to the characteristics of the papers included and the journals involved.

Participants: All original papers that were retracted in 2022 for originated from paper mills and had been published at least 12 months before their retraction (hereinafter "primary articles"), and the references and citations of the primary articles.

Main outcome measures: A descriptive analysis was performed. Additionally, two networks of primary articles mutually interconnected via their citations and references were built: one with only retracted references and retracted citations; and the other with all references and citations (retracted or unretracted).

Results: 416 primary articles were identified, and 14,411 references and 8,479 citations were extracted. Of these, 473 references or citations had been retracted for being paper mill papers or suspected paper mill papers. A total of 55.3% of primary articles made reference to or were cited by at least one retracted paper mill paper or suspected paper mill paper. The network analysis, which included primary articles along with their retracted references and citations, found three clusters of 53, 48 and 44 retracted papers that were mutually interconnected. The second network analysis, with all references and citations (retracted or unretracted) identified a large cluster of 2,530 interconnected papers.

Conclusion: Retracted papers originated from paper mills display evident interrelationships through their references and citations. It is important to stress that a significant percentage of these papers are referenced or cited by other retracted papers associated or suspected to be association with paper mills.

***Keywords*: paper mills; research integrity; publication ethics.**

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RETRACTED PAPERS ORIGINATING FROM PAPER MILLS: ANALYSIS OF REFERENCES AND CITATIONS.

INTRODUCTION

In scientific publication, the term "paper mills" refers to organizations devoted to producing scientific manuscripts, for the most part fraudulent or plagiarized, with the aim of then selling the authorship to researchers or students (1). In addition, these organizations also increase the impact factor of a specific journal and manipulate the peer reviews of the manuscripts which they produce (2, 3). Despite being a relatively recent phenomenon, paper mills have experienced unprecedented growth (2, 4, 5, 6, 7). The estimated annual profit of these organizations has been put at 1,000 million euros (8). Furthermore, according to the findings of a recent study, it is estimated that, in 2020, 28.8% of all papers published may have come from paper mill organizations. This would mean that the number of paper mill papers published in 2020 would be in the order of 383,000 (2).

Far from declining, the number of papers originated from paper mills is expected to continue to rise. On the one hand, the main motivation of researchers who use paper mill services is probably that of increasing the number of their publications, fundamentally to improve their academic level (9). Researchers' own institutions sometimes put pressure on them to increase their scientific production, which leads some to take short-cuts to achieve the publication quotas expected by their organizations (10). Furthermore, universal accessibility to Artificial Intelligence generative-type tools, such as ChatGPT, is highly likely to increase the production of fraudulent scientific papers by paper mills. These tools make it possible for these organizations to generate text rapidly, intelligibly, and practically cost-free. The production of paper mills can thus easily be multiplied (11).

Available information on the *modus operandi* of paper mill organizations is very limited, and indeed may differ between organizations. Paper mills have been identified in China, India, Russia, USA and United Kingdom (2), and the great majority of papers identified as originating from these organizations pertain to specific fields of knowledge, particularly Pharmacy and Oncology (5). Recently, González-Márquez et al. plotted a map of retracted biomedical papers in PubMed by area of knowledge, from which it can be seen that retracted papers form groups or clusters of the same topic, suggesting the presence of paper-mill clusters (12). This would be in line with the findings of a previous systematic review (3).

To produce these manuscripts, paper mill organizations not only use Artificial Intelligence-based technology to manipulate and fabricate images, but also employ scientific writers and reviewers (2). Furthermore, part of their success seems to stem from establishing relationships and collaborations with national and international scientific journals, which guarantee, or at least facilitate, the publication of their papers (2, 13).

Some previous studies have analyzed the problem of paper mills and the papers originated from such organizations (2, 5, 14). A previous study described the trends in and characteristics of paper mill papers retracted until June 2022 (5). This study detected a possible fraudulent citation pattern: papers retracted for being generated by paper mills received a median of 11 citations, and most of these citations were concentrated in journals ranked in the third and fourth quartiles, something that is not common. As a key indicator for detecting paper mills, Sabel et al. (2) recently identified the practice of referencing other papers that were likewise generated by paper mills. Hence, the analysis of the references and citations of these papers can be a valuable tool for identifying papers originated from paper mill organizations (15), and even for identifying papers coming from the same paper mill organization.

Research in this field is crucial for developing effective strategies that would address the problem and safeguard the integrity of scientific publication. To date, no study has comprehensively analyzed either the references included in papers retracted for having been identified as generated from paper mills, or the citations received by these same papers. Accordingly, the aims of this study were as follows: (1) to analyze the references of retracted papers originated from paper mills; (2) to analyze the citations received by retracted papers originated from paper mills; and, (3) to analyze the potential relationships existing between paper mill papers, their references and their citations.

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METHODS

We conducted a cross-sectional study which included original articles which have been retracted for being paper mills. To be eligible, papers were required to have been retracted between 01/01/2022 and 31/12/2022, and published a minimum of 12 months before retraction. This criterion was established so that the papers included could have received citations for a minimum period before retraction (minimum citation window). Corrections, expressions of concern, and communications to conferences were excluded. To identify papers that met the pre-established selection criteria, we used the Retraction Watch Database (date last accessed 23/01/2023), selecting the Paper Mill option in the "Reason(s) for Retraction" field, and "Retracted" in the "Nature of Notice" field. The way in which Retraction Watch operates has been previously described (5).

In the case of retracted paper mill papers (hereinafter "primary articles"), the following data were retrieved from Retraction Watch: title; authors; number of authors; author affiliations; authors' country or countries; type of publication; date of publication; date of retraction; journal of publication; and reason for retraction. We used the variables, date of publication and date of retraction, to calculate the number of days elapsed between publication and retraction. Similarly, we recorded the corresponding author's affiliation and country, based on the full text of the primary article. From Web of Science, we retrieved the number of references and citations received by each of the primary articles. Insofar as citations were concerned, these could come from other papers or from the primary article's own retraction note. For analysis purposes, citations that came from other papers were retained, therefore eliminating the citations coming from the retraction note of the primary article itself. The following data were also collected from each of the references and citations identified and included: authors; number of authors; type and country of affiliation of corresponding author; title of paper; journal; journal's impact factor based on Journal Citation Reports (JCR); category and relative position (quartile) based on JCR; type of publication; and number of citations received. Additionally, we recorded whether some of the references or citations had been retracted and the reason for retraction, with the latter being retrieved from Retraction Watch. In any case where the reason for retraction was not shown in the Retraction Watch Database, the retraction note was accessed. Papers retracted for duplication/manipulation of images and/or impossibility of communicating with the author, or false peer review were categorized as "suspected paper mill", since these are all typical characteristics of these types of papers, as described by different sources (1, 3, 16).

Journal Citation Reports (JCR) 2021 was used to ascertain the impact factor of the journal of publication of the primary articles and of the references and citations, the category, and journal's relative position (quartile) in this category. In the case of journals included in different categories, data relating to the most favorable one were recorded. The publication modality was extracted from the journal's own website and classified as Open Access (OA) (universal and free access) or non-OA (publication by subscription, or hybrid).

Statistical analysis

We first performed a descriptive analysis of primary articles identified as being generated by paper mills, with quantitative variables expressed as median and interquartile range (IR), and qualitative variables as relative and absolute frequencies. The number of primary articles that referenced and were cited by other retracted papers was compared by quartile of journal of publication and publication modality (OA or non-OA), using the Wilcoxon signed-rank test.

Secondly, we performed a descriptive analysis of the references and citations of primary articles included in this study, by reference to the variables of interest. A bivariate analysis was also performed to assess differences in characteristics, according to whether the item was a reference or citation of the primary article. The Wilcoxon signed-rank test was used for quantitative variables and the Chi-squared test for qualitative variables. In a subsequent analysis, the sample of citations and references was restricted to those that had been retracted. The reasons for retracting references and citations were first analyzed descriptively and then compared using the Chi-squared test.

Two networks of primary articles (retracted for being generated by paper mills) interrelated by their citations and references were built. Each node in the network represented one paper (primary, reference or citation). The connections between nodes (ties) were established using the *edge betweenness* method.

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The first network was built with the aim of establishing groups or clusters of retracted papers that mutually referenced/cited one another. To this end, the network was restricted to analysis of primary articles and their retracted references and citations. This network shows clusters which include more than five interrelated elements (i.e., primary articles, retracted references and citations that comprise the cluster).

The second network was built by including primary articles and their references and citations, regardless of whether or not they had been retracted. In this network, references and citations were classified into three groups: unretracted; retracted for or being suspected of originating from a paper mill; and retracted for some other reason (authorship issues, plagiarism, error, ethical issues, fabrication/falsification, not specified). Due to the large amount of data, clusters made up of more than 45 elements (primary articles, citations retracted or unretracted, and references retracted or unretracted) are shown.

Statistical significance was set at $p<0.05$ for all tests conducted. All statistical analyses were performed using the Stata v.17 and R statistical software programs.

The networks in interactive format can be accessed at the following link: https://epideque.shinyapps.io/networks/.

Ethical aspects

Due to the nature of this study, ethics committee approval was not required.

RESULTS

Retracted papers originated from paper mills (primary articles)

We identified 416 original retracted papers originated from paper mills (primary articles), which had been published in 2022 and met the inclusion criteria. Table 1 describes their main characteristics. The primary articles included in the analysis were published in 85 different scientific journals and took a median time of 1,247 days to be retracted (IR: 907.75-1673.5). 39.7% of primary articles were published in journals ranked in the second quartile of their category and 22.1% in journals belonging to the Medicine, Research and Experimental category. Biomedicine & Pharmacotherapy and Molecular Medicine Reports were the journals which published the highest number of paper mill papers retracted in 2022, with 35 and 33 papers published and then retracted, respectively.

A total of 1,669 different authors were identified in the 416 primary articles included: two of these authors appeared in 14 of the papers, while another two were listed in 10 papers each. In 384 of the primary articles (92.3%), all the authors came from the same country (China), whereas in the remaining 32 papers (7.7%), the authors came from two to five different countries. The most frequent affiliation among all the authors identified was the University of Jilin in China, which featured in 77 different primary articles (18.5%). In terms of the corresponding author's affiliation, in 389 papers (92.8%) this was a Chinese institution and in four papers (1.0%) this was a Chinese institution and an institution from another country (Philippines, Russia, USA or Italy). In 213 of the primary articles (51.2%), corresponding authors were exclusively affiliated with a hospital, in 118 (28.4%) were affiliated with a hospital and a university, and in 69 (16.7%) were exclusively affiliated with a university. In 14 papers (3.4%), the corresponding author had provided an institutional e-mail.

References and citations of primary articles retracted for originating from paper mills

Based on the 416 primary articles included in this study, a total of 15,437 references and 8,689 citations were identified. We extracted metadata from 14,411 references and 8,479 citations, with the number of papers retrieved thus being 22,890 (94.9% of the total references and citations). The median number of references per primary article was 35 (IR: 29-40), and the median number of citations received was 16 (IR: 9-25).

Table 2 shows the main characteristics of the references and citations retrieved.

There was a median of six authors for both references and citations. Most of the corresponding authors of the references and citations were affiliated with an institution in China (54.0% of references and 78.3% of citations). Whereas 46.8% of the references had been published in first-quartile journals, 28.6% of the citations had been published in second-quartile journals. Journals in the Oncology category were those in which the majority of references and citations were published. While Oncotarget and Plos One were the journals most frequently referenced by primary articles (418 and 344 references in primary articles,

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respectively), the International Journal of Molecular Science and Frontiers in Oncology were the journals which most cited primary articles (206 and 187 citations of primary articles, respectively).

In the case of primary articles, 178 (42.8%) had received at least one citation from a paper retracted for any reason, and 169 (41.9%) had referenced a paper retracted for any reason. Of these, 145 (81.5%) and 156 (92.3%) referenced or were cited, respectively, by at least one paper retracted for originating from or being suspected of originating from paper mills. No differences were observed in the number of references or citations originating from or suspected of originating from paper mills, by publication modality or journal quartile of the primary article (data not shown).

The reasons for retraction of retracted references and citations (290 and 312, respectively) are shown in Table 3. Among the references and citations analyzed, we found 473 (2.1%) papers retracted for originating from or being suspected of originating from paper mills, amounting to 78.6% of all retractions found. Eight primary articles were identified with four or more references/citations to other paper mill papers or suspected paper mill papers, totaling 40 references/citations in all.

The link (https://epideque.shinyapps.io/networks/) shows the network of papers retracted for any reason, restricted to clusters made up of more than five elements interrelated via their citations and references. Shown in gray are primary articles, and in green and orange, references and citations, respectively (Figure 1). Note should be taken of the three major clusters formed by 53, 48 and 44 interrelated primary articles.

The additional analysis restricted to clusters made up of more than 45 elements, including all references and citations regardless of whether or not they had been retracted, yielded a large cluster of 2,530 interrelated papers. This cluster links 174 primary articles (41.8% of those included), 203 references and citations retracted for originating from or being suspected of originating from paper mills (42.9% of those identified) (Table 3), and 38 references and citations retracted for any other reason (27.3% of those identified).

DISCUSSION

The results of this study highlight the way in which original papers retracted in 2022 for originating from paper mills are interconnected through their references and citations. Furthermore, the most frequent cause of retraction among the references and citations of original paper mill papers retracted in 2022 is affiliation with such organizations, suggesting a possible manipulation of citations. To our knowledge, this is the first study to analyze the references and citations of retracted papers originated from paper mills.

The included in this study display the typical characteristics of these types of papers, previously described in other studies (2, 3, 5, 6, 14). Most of the authors are from China and are affiliated with hospitals. In addition, it has been observed that only 3.4% of email correspondence provided by the authors is associated with an institution (university, hospital or research center, or other). This characteristic has been previously identified as a "red flag" by the International Committee of Medical Journal Editors and the STM Integrity Hub (1), as well as by previous studies (2, 16). Identification of the typical characteristics of paper mill papers may be crucial for addressing the problem. Identifying these characteristics in papers submitted to a journal for publication can serve as an early warning signal for editors and reviewers and may therefore prevent their publication. Consequently, measures should be taken to conduct a more thorough review or potentially outright rejection of such papers. In addition to the characteristics already mentioned, others may include the detection of “tortured phrases” (i.e., an unexpected and strange turn of phrase that appears instead of a commonly used expression) (17), the inclusion of graphs (particularly western blot graphs) that are “too clean”, or the lack of study approval by a research ethics committee (1).

The results of this study appear to confirm the links among paper mill papers via their citations and references. According to our results, 41.9% of paper-mill papers referenced at least one retracted paper, while 42.8% received citations from retracted papers. This raises suspicion, as only about 2 out of every 10,000 published articles are retracted (18). Moreover, analysis of the reasons for retraction of these citations and references showed that approximately 77% came from organizations related with or suspected of being related with paper mills. These findings are in line with previous studies. Sabel et al. (2) fitted two models for detecting fraudulent publications generated by paper mills. In the first model, they included the

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variables, “non-institutional email” and “affiliation with a hospital”, though the percentage of false positives was too high. In the second model, they added the variable, “>10% of references to other paper-mill papers”, and the percentage of false positives fell from 44% to 37%, while sensitivity increased. Although the difference is small, this could suggest that the presence of references to other paper mill papers may improve algorithms designed to detect such papers.

The network analysis conducted with retracted articles (primary, references, and citations) revealed clusters of dozens of interconnected retracted articles. In the case of references and citations which have not been retracted, it is important to note that this does not necessarily mean that they do not originate from paper mills but rather that they may not yet have been identified as such. In view of this, and in order to obtain an overview, we built a second network which shows the primary articles and all their references and citations, highlighting those retracted for coming from or being suspected of coming from paper mills. This network contains a large cluster that encompasses 174 primary articles plus their references and citations, 203 of which were retracted for originating from or being suspected of originating from paper mills. This suggests the existence of a relationship between these primary articles and the references and citations retracted for originating from paper mills, with it being plausible that these may in fact come from the same paper mill organization. It is logical to think that papers coming from the same paper mill organization would tend to cite one another. One also has to consider the possibility that a number of organizations may be mutually collaborating to generate and cite papers fraudulently. This kind of collaboration might account for the large, dense cluster observed in the second network.

Based on the evidence generated, it might be prudent to consider the presence of a retracted reference originating from a "paper mill" or being cited by a paper mill paper as a "red flag”. These situations can be important indicators or warning signals for scientific journals, and must be borne in mind during the review process. Identification of such indicators may help prevent the publication of low-quality papers or papers that adopt ethically questionable practices, as well as help identify paper mill papers that have already been published.

Incorporating the identification of references originating from paper mills as an indicator into the peer review process of scientific journals could be integrated as a component of a checklist for assessing the integrity of papers before contemplating their publication. In addition to the above indicator, the checklist should include other typical characteristics associated with paper mills, which have been previously identified in the scientific literature. In the same way as there are checklists to verify whether or not a journal is potentially predatory, such as Think.Check.Submit (19), among others (20), this new checklist could help journals by improving the review procedures for scientific papers that are submitted to them for publication.

Another more automated and, hence, effective option could be the design of an algorithm that uses the above criteria to assign a percentage probability of an article being a paper mill paper. It should be stressed that a similar proposal was submitted by Sabel et al. (2), who fitted a model for the same purpose. As mentioned above, however, this model yielded a high number of false positives, so that its use would not be efficient for the prioritization and effective use of journal resources. In this respect, the STM Integrity Hub has been working on the development of a tool in recent years (21). In April 2023, a minimum viable product of this tool was launched (22), based on a scan of the manuscripts received by journals for publication, with the aim of finding evidence of paper mills. As far as we know, the specific details on the basis of which items are weighed and taken into account, are not public knowledge. Keeping this information confidential may prevent paper mill organizations from adapting their practices to avoid being detected. That being said, it appears that this tool will initially only be accessible to editors who are part of the STM Integrity Hub, and it remains uncertain whether its availability will be expanded to all other editors. We believe that the latter is desirable because, for this solution to be effective, it should be adopted by all scientific journals irrespective of their resources (23). Similarly, it remains uncertain whether the aforementioned tool has the capability to assign a percentage probability. However, this would be of great interest, as it would enable journals to establish "risk thresholds" and implement more efficient resource allocation. This way, journals could prioritize a more comprehensive review and analysis process for papers with the highest probability of being associated with paper mills.

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This study has some limitations. First, the networks analyzed were exclusively focused on references and citations of primary articles, without including the references and citations of "secondary papers" (i.e., the citations and references of primary articles). This could underestimate the relationship of the different papers included. In future studies, consideration should be given to the inclusion of both directions in the network of references and citations, so as to form a more complete picture. Second, while metadata were successfully extracted from approximately 95% of the citations and references of primary articles, there is a small percentage of missing data, though this is considered minimal. An additional limitation is the absence of a control group. Future studies should consider the inclusion of a control group of unretracted paper, with the aim of evaluating whether the results differ. Furthermore, to allow for minimum citation window, this study included primary articles having a minimum period of 12 months after retraction, but this period may possibly prove to be insufficient. Lastly, citations of the papers retracted during 2022 included in this study are likely to continue to increase with time.

This study has a number of advantages. The use of an exhaustive database such as Retraction Watch enabled all retractions that occurred in 2022 to be systematically included. To our knowledge, Retraction Watch is the most comprehensive retraction database, though the possibility of there being some missing data cannot be ruled out. A further important advantage is the longitudinal nature of the study, in the sense that the primary article (paper retracted for being generated by a paper mill) includes its references (previously published papers) as well as citations of the primary article (subsequently published papers), which allows for a better temporal approach to the cluster of papers generated by a single paper mill. Lastly, we feel that the visual representation system used is very useful for understanding the structures of references and citations, and may be of value for future studies on this topic.

In conclusion, the results of this study highlight the fact that papers originating from paper mills show evident interrelationships through their citations and references. It is pertinent to stress that a significant percentage of these papers cite or are cited by other studies which have been retracted due to links with paper mills or which are suspected of possibly originating from these organizations. The presence of these relationships in the citations and references may provide useful clues for identifying possible fraudulent publications. Early detection of paper mill papers is crucial for preserving the integrity of science. In the face of the proliferation of these types of papers, which will inevitably increase with time, editorial teams must put robust mechanisms in place for their detection, without in any way neglecting the supervision of papers which are suspected of originating from paper mills and have already been published.

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Table 1. Main characteristics of paper-mill papers retracted in 2022 (primary articles).

	Total (n=416)
Number of authors	
Median (interquartile range)	5 (4-7)
Number of affiliation countries (all authors)	
Median (interquartile range)	1 (1-1)
Affiliation institution of corresponding author	
Hospital	213 (51.2%)
Industry	1 (0.2%)
Research center	6 (1.4%)
Research center+Hospital	1 (0.2%)
University	69 (16.6%)
University+Hospital	118 (28.4%)
University+Hospital+Research center	2 (0.5%)
University+Research center	6 (1.4%)
Country of corresponding author	
China	386 (92.8%)
Russia	18 (4.3%)
Bangladesh	1 (0.2%)
Bulgaria	1 (0.2%)
China+Philippines	1 (0.2%)
China+Russia	1 (0.2%)
China+USA	1 (0.2%)
China+Germany	1 (0.2%)
China+Italy	1 (0.2%)
Iran	1 (0.2%)
India	1 (0.2%)
Kazakhstan	1 (0.2%)
Saudi Arabia	1 (0.2%)
USA	1 (0.2%)
Impact factor (IF)*	
Median (interquartile range)	3.38 (2.31-4.06)
Quartile	
No IF/Not indexed	66 (15.9%)
Q1	81 (19.5%)
Q2	165 (39.7%)
Q3	86 (20.7%)
Q4	18 (4.3%)
Category	
No IF/Not indexed	66 (15.9%)
Medicine, Research & Experimental	92 (22.1%)
Oncology	75 (18.0%)
Pharmacology & Pharmacy	27 (6.5%)
Biochemistry & Molecular Biology	25 (6.0%)
Pathology	22 (5.3%)
Multidisciplinary Sciences	16 (3.8%)
Physiology	13 (3.1%)
Endocrinology & Metabolism	12 (2.9%)
Neurosciences	11 (2.6%)
Cell biology	10 (2.4%)
Other	47 (11.4%)
Publishing model	

Open Access	270 (35.1%)
Non-Open Access	146 (64.9%)

*Data available for 350 papers, as 66 papers were published in non-indexed journals.

Table 2. Main characteristics of references and citations related with paper-mill papers retracted in 2022.

	References		**Citations**		
	n=14,411		n=8,479		p-value
Number of authors Median (interquartile range)	6.00	(3.0-8.0)	6.00	(4.0-8.0)	0.27
Country of corresponding author*					<0.001
China	5,834	(54.0%)	5,587	(78.3%)	
USA	3,111	(28.8%)	331	(4.6%)	
Japan	456	(4.2%)	88	(1.2%)	
Germany	365	(3.4%)	71	(1.0%)	
South Korea	300	(2.8%)	129	(1.8%)	
Italy	310	(2.9%)	141	(2.0%)	
Iran	113	(1.1%)	334	(4.7%)	
Other	307	(2.8%)	455	(6.4%)	
Impact factor (IF) Median (interquartile range)	3.9	(2.5-6.0)	2.9	(1.6-4.2)	<0.001
Journal Quartile based on Impact Factor (JCR)					<0.001
Q1	6,749	(46.8%)	2,149	(25.3%)	
Q2	3,757	(26.1%)	2,422	(28.6%)	
Q3	1,523	(10.6%)	1,589	(18.7%)	
Q4	674	(4.7%)	806	(9.5%)	
Not indexed	1,709	(11.9%)	1,513	(17.8%)	
Journal category (JCR)					<0.001
Biochemistry & Molecular Biology	1,001	(6.9%)	340	(4.0%)	
Medicine, Research & Experimental	935	(6.5%)	938	(11.1%)	
Multidisciplinary Sciences	803	(5.6%)	244	(2.9%)	
Oncology	2,803	(19.5%)	1,132	(13.4%)	
Pharmacology & Pharmacy	629	(4.4%)	679	(8.0%)	
Not indexed	1,709	(11.9%)	1,513	(17.5%)	
Other	6,531	(45.3%)	3,633	(42.8%)	

* 3,616 references and 1,343 citations without information.

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Table 3. Description of retracted references and citations of primary articles.

	References		Citations	
Retracted paper				
No	14,121	(98.0%)	8.167	(96.3%)
Yes	290	(2.0%)	312	(3.7%)
Reason for retraction				
Paper mill	167	(57.6%)	142	(45.5%)
Suspected paper mill	63	(21.7%)	101	(32.4%)
Concerns about data/images	13	(4.5%)	20	(6.4%)
Plagiarism	11	(3.8%)	2	(0.6%)
Error	8	(2.8%)	8	(2.6%)
Fabrication/falsification	3	(1.0%)	1	(0.3%)
Ethical issues	1	(0.3%)	0	(0.0%)
Authorship issues	0	(0.0%)	1	(0.3%)
Not specified	24	(8.3%)	37	(11.9%)

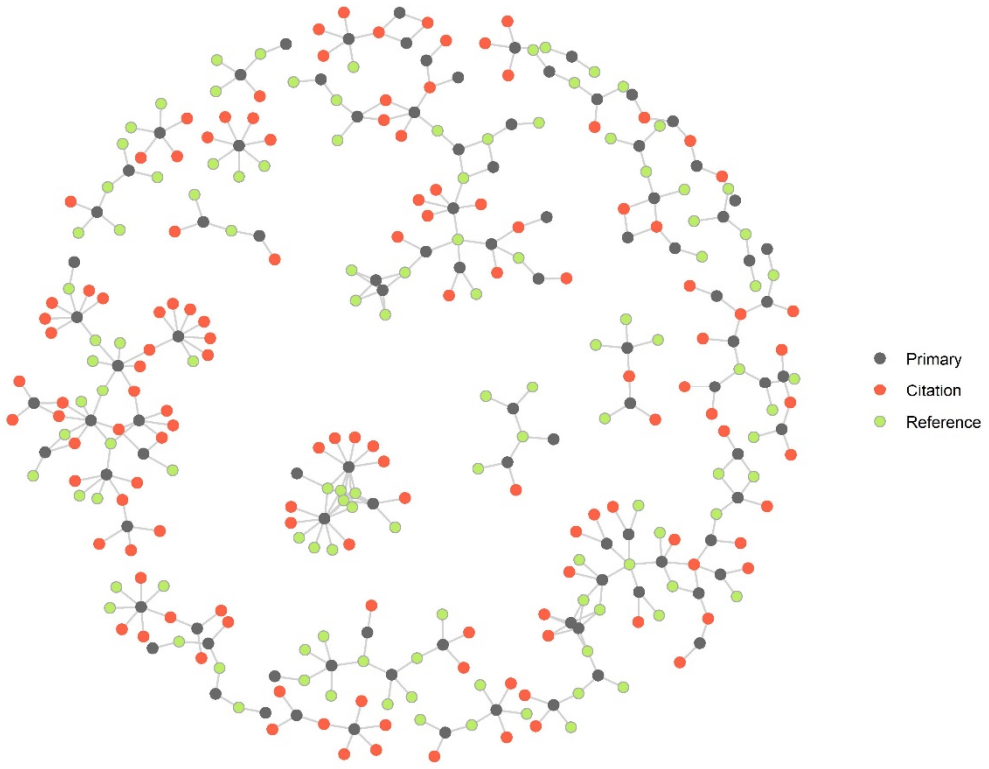


Figure 1. Network of primary articles interconnected through their retracted references and retracted citations.

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9.6. AUTORIZACIÓN DE LAS REVISTAS PARA LA INCLUSIÓN DE LOS ARTÍCULOS PUBLICADOS

Autorización de European Journal of Internal Medicine

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Publication Title	European journal of internal medicine	Rightsholder	Elsevier Science & Technology Journals
Article Title	Should the European Union have an office of research integrity?	Publication Type	Journal
		Start Page	1
Author/Editor	European Federation of Internal Medicine.	End Page	3
Date	01/01/1989	Volume	94
Language	English	URL	http://www.sciencedirect.com/science/jo...
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NEW WORK DETAILS

Title	Should the European Union have an office of research integrity?	Institution Name	University of Santiago de Compostela
		Expected Presentation Date	2023-12-01
Instructor Name	Dr. Alberto Ruano-Ravina		

ADDITIONAL DETAILS

Order Reference Number	N/A	The Requesting Person/Organization to Appear on the License	Cristina Candal Pedreira

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Title, Description or Numeric Reference of the Portion(s)	Full article	Title of the Article/Chapter the Portion Is From	Should the European Union have an office of research integrity?
Editor of Portion(s)	Candal-Pedreira, C; Ruano-Ravina, A; P?rez-R?os, M	Author of Portion(s)	Candal-Pedreira, C; Ruano-Ravina, A; P?rez-R?os, M
Volume / Edition	94	Issue, if Republishing an Article From a Serial	N/A
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Título de la revista
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2022

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Título del artículo
La Oficina de Integridad Científica en España. Una tarea pendiente [The Research Integrity Office in Spain. A pending issue]

Autor(es)
2. Candal-Pedreira C, Álvarez-Dardet C, Ruano-Ravina A, Pérez-Ríos M

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6

Título del artículo
Comparison of COVID-19 and non-COVID-19 papers.

Autor(es)
9. Candal-Pedreira C, Ruano-Ravina A, Pérez-Ríos M.

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Article Title	Research misconduct as a challenge for academic institutions and scientific journals	Rightsholder	BMJ Publishing Group Ltd
		Publication Type	e-Journal
Author/Editor	Society for Social Medicine (Great Britain and Ireland)	Start Page	jech-2023-220554
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Title	Research misconduct as a challenge for academic institutions and scientific journals	Institution Name	University of Santiago de Compostela
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Instructor Name	Dr. Alberto Ruano-Ravina		

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Title, Description or Numeric Reference of the Portion(s)	Full article	Title of the Article/Chapter the Portion Is From	Research misconduct as a challenge for academic institutions and scientific journals
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ISSN	0898-9621	Portion	Abstract

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Article Title	Evolution and Characterization of Health Sciences Paper Retractions in Brazil and Portugal.	Publication Type	Journal
		Start Page	1
Date	01/01/1989	End Page	18
Language	English	URL	http://www.tandfonline.com/loi/gacr20
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Title	Evolution and characterization of health sciences paper retractions in Brazil and Portugal	Institution Name	University of Santiago de Compostela
		Expected Presentation Date	2023-11-01
Instructor Name	Dr Alberto Ruano-Ravina		

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Editor of Portion(s)	Candal-Pedreira, Cristina; Ruano-Ravina, Alberto; Rey-Brandariz, Julia; Mourino, Nerea; Ravara, Sofia; Aguiar, Pedro; P?rez-R?os, M?nica	Author of Portion(s)	Candal-Pedreira, Cristina; Ruano-Ravina, Alberto; Rey-Brandariz, Julia; Mourino, Nerea; Ravara, Sofia; Aguiar, Pedro; P?rez-R?os, M?nica
Volume / Edition	N/A		
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ISSN	2059-7908	Portion	Abstract

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Publication Title	BMJ global health	Rightsholder	BMJ Publishing Group Ltd
Article Title	Does retraction after misconduct have an impact on citations? A pre–post study	Publication Type	Journal
		Start Page	e003719
Author/Editor	BMJ Publishing Group.	Issue	11
Date	01/01/2016	Volume	5
Language	English	URL	http://gh.bmj.com/
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		Expected Presentation Date	2023-11-01
Instructor Name	Mónica Pérez-Ríos		

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Editor of Portion(s)	Candal-Pedreira, Cristina; Ruano-Ravina, Alberto; Fernández, Esteve; Ramos, Jorge; Campos-Varela, Isabel; Pérez-Ríos, Mónica	Author of Portion(s)	Candal-Pedreira, Cristina; Ruano-Ravina, Alberto; Fernández, Esteve; Ramos, Jorge; Campos-Varela, Isabel; Pérez-Ríos, Mónica
Volume / Edition	5	Issue, if Republishing an Article From a Serial	11
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ISSN	1756-1833	Portion	Abstract

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Article Title	Retracted papers originating from paper mills: cross sectional study	Publication Type	e-Journal
		Start Page	e071517
Author/Editor	British Medical Association.	Volume	379
Date	01/01/2000	URL	http://www.bmj.com/
Language	English		
Country	United Kingdom of Great Britain and Northern Ireland		

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NEW WORK DETAILS

Title	Retracted papers originating from paper mills: cross sectional study.	Institution Name	University of Santiago de Compostela
		Expected Presentation Date	2023-11-01
Instructor Name	Dr Alberto Ruano-Ravina		

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Title, Description or Numeric Reference of the Portion(s)	Full article	Title of the Article/Chapter the Portion Is From	Retracted papers originating from paper mills: cross sectional study
Editor of Portion(s)	Candal-Pedreira, Cristina; Ross, Joseph S; Ruano-Ravina, Alberto; Egilman, David S; Fernández, Esteve; Pérez-Ríos, Mónica	Author of Portion(s)	Candal-Pedreira, Cristina; Ross, Joseph S; Ruano-Ravina, Alberto; Egilman, David S; Fernández, Esteve; Pérez-Ríos, Mónica
Volume / Edition	379	Issue, if Republishing an Article From a Serial	N/A
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9.7. ESTANCIAS DE INVESTIGACIÓN EN EL EXTRANJERO

Certificado de la Escola Nacional de Saúde Pública de Lisboa, Universidade Nova de Lisboa (Lisboa, Portugal).

Escola Nacional de Saúde Pública
UNIVERSIDADE NOVA DE LISBOA

To Whom It May Concern:

Cristina Candal Pedreira, PhD candidate from the University of Santiago de Compostela, Department of Preventive Medicine and Public Health, has done a research internship at the National School of Public Health (ENSP), NOVA University of Lisbon, from November 1st to 31st December 2021 and from 7th February to 21st February 2022. Cristina was supervised by Prof. Dr. Sofia Belo Ravara and Prof. Dr. Pedro Aguiar and worked on 1) COPD and other exposures than tobacco and 2) scientific misconduct in Brazil and Portugal. A scientific manuscript entitled *Evolution and characterization of retractions due to misconduct in Brazil and Portugal* has already been developed and is about to be submitted to a peer-review international journal.

Sincerely,

Lisbon, 16 th March 2022

Escola Nacional de Saúde Pública, Universidade NOVA de Lisboa

USC UNIVERSIDADE DE SANTIAGO DE COMPOSTELA

Certificado de Brown University Alpert Medical School, Brown University (Providence, Rhode Island, Estados Unidos) .

BROWN
Alpert Medical School

DAVID S. EGILMAN, MD, MPH
Clinical Professor
Department of Family Medicine

May 30, 2022

To whom it may concern:

This letter is to confirm that Cristina Candal Pedreira, PhD student from the University of Santiago de Compostela (Spain), has been with us for a research stay from April 1, 2022 to May 31, 2022. During this time, she worked with me, Dr. David Egilman, Clinical Professor of Family Medicine at Brown University Alpert Medical School (Brown University, Providence, Rhode Island, USA). During this period, Cristina Candal Pedreira has worked in research related to the analysis of selective publication and selective reporting of results of clinical trials on chronic obstructive pulmonary disease. In addition, we have identified potential areas of collaboration.

Sincerely,

David Egilman MD, MPH

David Egilman, MD, MPH
Clinical Professor of Family Medicine
Brown University
E-mail: David_Egilman_MD@brown.edu

USC
UNIVERSIDADE DE SANTIAGO DE COMPOSTELA

Certificado de Yale University School of Medicine, Yale University (New Haven, Connecticut, Estados Unidos).

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367 Cedar Street
New Haven, CT 06510

April 11, 2023

To whom it may concern:

This letter is to confirm that Cristina Candal Pedreira, PhD student from the University of Santiago de Compostela (Spain), has been with us for a research stay from February 1, 2023 to March 31, 2022. During this time, she worked with me, Dr. Joseph Ross, Professor of Medicine and Public Health at Yale University (New Haven, Connecticut, USA). During this period, Cristina Candal Pedreira has worked under my supervision in research related to the analysis of retracted publications and their characteristics and reasons. In addition, we have identified potential areas of collaboration.

Please contact me with any questions or concerns.

Sincerely,



Joseph S. Ross, MD, MHS
Professor of Medicine (General Internal Medicine)
Professor of Public Health (Health Policy and Management)

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La mala conducta científica es un problema transversal a todas las áreas de conocimiento y especialmente al área de la biomedicina. Su estudio ha sido históricamente limitado. Esta tesis contribuye a generar conocimiento sobre la regulación de la mala conducta científica en Europa y más específicamente en España, además de describir los tipos de mala conducta más frecuentes en España y en otros países. Adicionalmente, se han analizado nuevos tipos de fraude en ciencia y otras situaciones que pueden afectar negativamente a la publicación científica. Los resultados de esta tesis pueden contribuir al diseño y establecimiento de medidas para prevenir y detectar la mala conducta científica.