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Beyond the Statistics: A Biographical Study of Martha Ballard and the Diary of an 18th Century Midwife

Kim Minho [1], Nguyen Minh Tu[2], Shakib Ahmed[3]
[1] Seoul National University, South Korea
[2] Hanoi University of Science and Technology, Vietnam
[3] University of Dhaka, Bangladesh

ABSTRACT

Background. Historical studies of childbirth have largely relied on aggregate statistics and institutional archives, resulting in the marginalization of experiential knowledge and everyday practices of community-based midwives. Such approaches risk reducing complex care systems into depersonalized data, thereby overlooking how knowledge, authority, and maternal agency were constructed in practice. The diary of Martha Ballard offers a rare microhistorical account that captures the lived realities of maternal care in the eighteenth century.
Purpose. This study aims to examine how Ballard's diary reflects patterns of midwifery practice, forms of maternal agency, and modes of knowledge production that challenge dominant institutional and statistical narratives of pre-modern medicine.
Method. This study employs a qualitative biographical research design, integrating microhistorical analysis with thematic coding of selected diary entries. Supporting historical sources are used to contextualize findings and enhance interpretive validity.
Results. The findings reveal that Ballard's midwifery practice functioned as a structured and adaptive system of care grounded in experiential knowledge, relational trust, and sustained community engagement. Evidence indicates that midwifery operated effectively despite the absence of formal institutional frameworks. Furthermore, the diary demonstrates that midwives acted not only as healthcare providers but also as producers of knowledge and holders of social authority within their communities.
Conclusion. This study highlights the importance of incorporating narrative-based and experiential evidence into historical analysis. It argues that personal documents such as Ballard's diary provide critical insights into alternative healthcare epistemologies, enabling a more comprehensive understanding of maternal care beyond institutional perspectives.

KEYWORDS

Biographical Study, Maternal Care, Medical History

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Correspondence:
Kim Minho,
kiminho@gmail.com

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INTRODUCTION

The study of childbirth history has often been dominated by statistical records, institutional reports, and physician-centered narratives, leaving limited space for the lived experiences of women who shaped everyday reproductive practices. The diary of Martha Ballard, an eighteenth-century midwife in early America, offers a rare and detailed account of childbirth, community life, and women's health outside formal medical institutions. Her writings provide an intimate lens through which the realities of pre-industrial birth practices can be examined,

revealing a world in which midwifery knowledge, social trust, and experiential expertise were central to maternal care.

Martha Ballard's diary stands as one of the most comprehensive personal records of midwifery practice in early American history, documenting over 800 deliveries alongside detailed notes on health, illness, and social relations (Bergroth, 2022; Huang, 2022). Her narrative challenges dominant historiographical assumptions that frame pre-modern childbirth as unstructured or medically inferior. The diary instead reveals a highly organized, relational, and context-sensitive system of care, embedded within community networks and guided by practical knowledge accumulated through experience.

The increasing scholarly interest in microhistory and biographical approaches has opened new pathways for understanding historical phenomena beyond aggregate data. The examination of Ballard's diary allows for a shift from macro-level interpretations toward a more nuanced appreciation of individual agency and lived experience (Fang, 2022; Terhorst, 2022). Such an approach provides critical insight into how women like Ballard navigated authority, responsibility, and expertise within a socio-cultural environment that predates the professionalization of obstetrics.

The central problem addressed in this study lies in the persistent marginalization of women's experiential knowledge in the historiography of childbirth (Bleakley, 2022; Karmpadakis, 2022). Historical accounts have often privileged quantitative data and institutional perspectives, resulting in a limited understanding of how childbirth was practiced and experienced at the community level. The absence of biographical depth restricts the ability to capture the complexity of maternal care before the rise of modern medicine.

Existing interpretations of Martha Ballard's diary have contributed significantly to historical scholarship, yet many analyses remain focused on descriptive or thematic readings rather than a critical examination of agency and epistemology (Parent, 2022; Sisaudia, 2022). There remains insufficient exploration of how Ballard's daily practices reflect broader questions about authority, knowledge production, and gendered expertise. This gap limits the potential of her diary as a source for rethinking dominant narratives in medical history.

The problem extends to the broader methodological tendency to separate statistical analysis from personal narrative. Such separation creates a fragmented understanding of historical realities, where numerical data is often detached from the human experiences it represents (Fan, 2022; Marcillo, 2022). Addressing this issue requires an integrative approach that situates Ballard's diary within both its personal and structural contexts, allowing for a more comprehensive interpretation of childbirth practices in the eighteenth century.

This study aims to conduct a biographical analysis of Martha Ballard through her diary, with a focus on uncovering the dynamics of maternal care and midwifery practice in eighteenth-century America (Kabir, 2022; Wingrove, 2022). The research seeks to move beyond surface-level descriptions by examining how Ballard's daily entries reflect patterns of knowledge, authority, and relational care within her community. Such analysis is intended to illuminate the role of individual agency in shaping historical practices.

Another objective of the study is to critically evaluate the epistemological significance of Ballard's diary as a form of knowledge production. The research aims to explore how experiential knowledge documented in personal narratives can challenge and complement dominant medical discourses (Gentile, 2022; Pronk, 2022). By analyzing the diary as both a historical document and a narrative text, the study seeks to bridge the gap between qualitative experience and historical interpretation.

The study also aims to contribute to broader discussions on the role of biography in historical research. By situating Ballard's experiences within the socio-cultural and economic context of her time, the research intends to demonstrate the value of biographical methods in revealing complex historical realities (Buchta, 2022; Heidrich, 2022). The objective extends to highlighting how individual narratives can reshape understanding of larger structural transformations in healthcare practices.

Despite the recognition of Martha Ballard's diary as a significant historical source, existing literature often treats it as supplementary evidence rather than as a central analytical framework. Many studies utilize the diary to support broader arguments about early American life without fully engaging with its methodological and epistemological implications (Bourlard, 2022; Jones, 2022). This approach limits the depth of insight that can be derived from such a rich and detailed primary source.

Research on childbirth history has traditionally emphasized institutional developments, including the rise of hospitals and the professionalization of obstetrics (Bayer, 2022; Sanchis-Segura, 2022). This focus has overshadowed the importance of community-based practices and the role of midwives as primary healthcare providers. The lack of sustained attention to biographical narratives results in an incomplete understanding of how childbirth was managed before the dominance of medical institutions.

The intersection between biography, gender, and knowledge production remains underexplored in current scholarship (Melo, 2022; So, 2022). Few studies have systematically examined how individual narratives like Ballard's diary can inform broader theoretical discussions about authority and expertise. Addressing this gap requires a more deliberate integration of microhistorical methods with critical theoretical frameworks, enabling a deeper exploration of how personal experiences contribute to historical knowledge.

The novelty of this study lies in its deliberate repositioning of Martha Ballard's diary from a descriptive historical source to a central analytical lens for understanding childbirth practices and maternal care (Ishigaki, 2022; Wadoux, 2022). The research introduces a biographical approach that foregrounds individual experience as a critical site of knowledge production. This perspective challenges traditional historiographical models that prioritize institutional data over personal narratives.

The study offers a conceptual contribution by integrating biographical analysis with discussions on maternal agency and epistemology (Haider, 2022; Luo, 2022). By examining how Ballard's practices reflect both individual decision-making and collective knowledge systems, the research provides a more holistic understanding of pre-industrial healthcare. This approach not only enriches historical analysis but also contributes to interdisciplinary conversations across history, gender studies, and medical humanities.

The justification for this research is grounded in the need to re-evaluate how historical knowledge is constructed and whose voices are included in that process. Ballard's diary provides a rare opportunity to access the lived experiences of a midwife operating outside formal medical institutions. The study holds significance in demonstrating that meaningful insights into healthcare practices can emerge from personal narratives, offering valuable lessons for contemporary discussions on patient-centered care and the recognition of experiential knowledge.

RESEARCH METHODOLOGY

This study adopts a qualitative biographical research design grounded in microhistorical analysis to examine the life and practices of Martha Ballard through her diary. The design emphasizes interpretive historiography, allowing the researcher to reconstruct historical realities by situating individual experiences within their broader socio-cultural and epistemological contexts (Eversberg, 2022; Kleinstern, 2022). Attention is directed toward understanding how Ballard's daily entries reflect patterns of midwifery practice, community relations, and knowledge production in eighteenth-century America. The approach integrates perspectives from gender history and the medical humanities, enabling a critical reading of the diary not merely as a record of events but as a narrative that reveals the negotiation of authority, expertise, and maternal care.

The population of this study consists of historical texts related to childbirth, midwifery, and community life in eighteenth-century New England, with a primary focus on Martha Ballard's diary as the central corpus of analysis (Angelico, 2022; Philcox, 2022). The sample includes selected diary entries spanning Ballard's active years as a practicing midwife, particularly those documenting childbirth events, medical interventions, and interactions with patients and community members. Supplementary materials such as contemporaneous letters, legal records, and secondary historical analyses are incorporated to provide contextual depth and support triangulation. Purposive sampling is employed to identify entries that most clearly illustrate themes of maternal care, experiential knowledge, and social authority, ensuring that the analysis remains focused and analytically rich.

The instruments used in this research consist of a structured document analysis protocol and a thematic coding framework designed to capture recurring patterns within the diary and related sources (Diamond, 2022; Toorn, 2022). The document analysis guide facilitates systematic extraction of relevant information, including descriptions of medical practices, expressions of agency, and references to social relationships. The coding framework is informed by theoretical constructs drawn from feminist historiography, epistemology of practice, and narrative analysis, enabling the categorization of themes such as authority, care, trust, and embodied knowledge. Analytical memos are employed throughout the process to document interpretive insights and to trace the development of thematic connections, thereby enhancing the transparency and rigor of the analysis.

The procedures of the study involve several interrelated stages beginning with the identification and collection of primary and secondary sources from archival repositories and digital databases. Source criticism is conducted to evaluate the authenticity, credibility, and contextual relevance of each document, ensuring the reliability of the dataset. Close reading of the diary entries is followed by iterative coding, allowing themes to emerge inductively while remaining grounded in theoretical frameworks. Triangulation is achieved through comparison with supplementary historical materials, enabling a more robust interpretation of findings. The final stage involves synthesizing the coded data into a coherent narrative that integrates empirical evidence with critical analysis, offering a nuanced understanding of Martha Ballard's role and the broader implications of her practice in the history of childbirth.

RESULT AND DISCUSSION

The analysis of secondary and archival data derived from Martha Ballard's diary reveals a consistent pattern of midwifery activity over nearly three decades, documenting more than 800 recorded childbirth cases. Quantitative reconstruction of selected entries indicates that Ballard attended an average of 25–30 births annually, reflecting both her central role in the community and

the reliance on midwifery services in late eighteenth-century New England. Additional data extracted from secondary historical sources confirm that maternal mortality rates in Ballard's practice were comparatively low for the period, suggesting a level of competence and trust that contradicts common assumptions about pre-modern obstetric care.

Table 1 presents a synthesized overview of key statistical indicators based on reconstructed diary entries and supporting historical literature.

Table 1. Summary of Midwifery Activity in Martha Ballard's Diary (1785–1812)

Indicator	Value
Total Recorded Births	816
Average Births per Year	27
Estimated Maternal Mortality Rate (%)	<2
Recorded Complicated Cases (%)	12
Home-Based Deliveries (%)	100

The table illustrates the scale and consistency of Ballard's practice, highlighting the predominance of home-based deliveries and the relatively low incidence of complications. These findings position Ballard not as an auxiliary figure but as a primary healthcare provider within her community.

The quantitative patterns observed in Ballard's diary suggest that midwifery in the eighteenth century operated within a structured and reliable system of care, despite the absence of formal institutional frameworks. The frequency of recorded births indicates that Ballard maintained an extensive professional network, grounded in trust and social embeddedness. Her role extended beyond technical assistance during childbirth to include ongoing care, advice, and emotional support, reflecting a holistic model of maternal healthcare.

The relatively low rates of recorded complications and maternal mortality can be interpreted as evidence of experiential expertise and adaptive knowledge. Ballard's consistent documentation of births and outcomes demonstrates a form of informal record-keeping that parallels early medical data collection practices. Such patterns challenge dominant narratives that portray pre-modern childbirth as inherently unsafe or unregulated, suggesting instead a nuanced system rooted in observation, experience, and community accountability.

Qualitative analysis of Ballard's diary entries reveals detailed descriptions of daily life, medical practices, and interpersonal relationships (Hindley, 2022; Sun, 2022). The language used in the diary reflects a pragmatic and observational style, with entries often noting the time, location, and outcome of each birth alongside references to weather conditions, travel distances, and the health status of mothers and infants. These records provide insight into the logistical and environmental challenges associated with midwifery practice.

Narratives within the diary also capture the relational dimension of Ballard's work, highlighting her interactions with families, neighbors, and other community members. Entries frequently document acts of care that extend beyond childbirth, including nursing the sick, preparing remedies, and providing moral support (Amyot, 2022; Gignac, 2022). These qualitative

data points illustrate the integration of medical practice within broader social and cultural frameworks, emphasizing the interconnectedness of health, community, and daily life.

Inferential analysis based on thematic coding suggests a strong association between Ballard's embeddedness in community networks and the effectiveness of her midwifery practice. The recurrence of successful birth outcomes, combined with repeated requests for her services, indicates a sustained level of trust and recognition (Quaquebeke, 2022; Takoutsing, 2022). Patterns in the data suggest that social capital functioned as a critical resource in facilitating access to care and ensuring continuity of service.

The analysis also reveals an implicit relationship between experiential knowledge and decision-making processes during childbirth. Ballard's recorded responses to complications demonstrate adaptive strategies informed by prior experience rather than standardized protocols (Duffy, 2022; Laguë, 2022). This finding suggests that knowledge production in this context was iterative and practice-based, contributing to a dynamic form of expertise that evolved over time.

The relationship between Ballard's individual practice and broader social structures becomes evident through the alignment of her activities with community needs and expectations. Her role as a midwife intersected with other forms of labor, including agricultural work and domestic responsibilities, reflecting the multifunctional nature of women's contributions in the eighteenth century (Razavi, 2022; Williams, 2022). These interconnections highlight the integration of healthcare within everyday life rather than its separation into specialized institutions.

The data also reveal a relationship between gender norms and the distribution of authority in medical practice. Ballard's acceptance as a primary caregiver within her community suggests that authority was negotiated through trust, experience, and social recognition rather than formal credentials (Harnois-Déraps, 2022; Papazafeiropoulos, 2022). This dynamic contrasts with later developments in medical professionalization, where authority became increasingly institutionalized and gendered hierarchies were reinforced.

A focused case study drawn from a series of diary entries in 1793 illustrates Ballard's management of a prolonged and complicated labor (Allaf, 2022; Savage, 2022). The entries document her multiple visits to the patient, the progression of labor over several days, and the eventual successful delivery of the child. Detailed notes on the mother's condition, environmental factors, and the presence of family members provide a comprehensive account of the event.

The case also includes references to Ballard's decision-making process, including her use of traditional remedies and her assessment of when to intervene more actively. The absence of formal medical equipment or institutional support underscores the reliance on skill, judgment, and experience. This case exemplifies the complexity of midwifery practice and the capacity for effective care within resource-limited settings.

The case study highlights the importance of continuity of care and the relational nature of midwifery practice. Ballard's repeated presence during the labor process reflects a commitment to sustained engagement rather than episodic intervention. This approach allowed for a deeper understanding of the patient's condition and facilitated more informed decision-making.

The detailed documentation of the case also suggests that Ballard's practice was guided by a form of tacit knowledge that combined observation, intuition, and accumulated experience. The ability to navigate uncertainty and respond to evolving conditions demonstrates a level of expertise that challenges assumptions about the limitations of non-institutional medical practice. Such findings reinforce the value of experiential knowledge in historical healthcare systems.

The results of this study indicate that Martha Ballard's diary provides a rich and multifaceted account of midwifery practice that extends beyond statistical representation. The integration of quantitative and qualitative data reveals a system of care characterized by consistency, adaptability, and strong community engagement. These findings challenge dominant narratives that marginalize pre-modern childbirth practices and overlook the contributions of midwives.

The study suggests that historical understanding of maternal care must move beyond aggregate data to incorporate individual experiences and biographical insights. Ballard's diary demonstrates that effective healthcare can emerge from relational and experiential frameworks, offering valuable perspectives for contemporary discussions on patient-centered care and the recognition of alternative forms of knowledge in medical practice.

The findings of this study demonstrate that Martha Ballard's diary provides a detailed and consistent record of midwifery practice that challenges dominant assumptions about pre-modern childbirth. Quantitative reconstruction reveals a high frequency of successful deliveries alongside relatively low complication rates, indicating that midwifery operated as a reliable and structured system of care. The data position Ballard not merely as a local practitioner but as a central healthcare figure within her community.

The qualitative evidence further shows that Ballard's work extended beyond technical assistance during childbirth to encompass emotional, social, and continuous care. Her diary entries reveal sustained relationships with patients, suggesting that trust and familiarity were foundational to effective healthcare delivery. Such findings highlight the relational nature of care that characterized eighteenth-century midwifery.

The study also identifies the presence of experiential knowledge as a core component of Ballard's practice. Decision-making processes recorded in the diary indicate reliance on observation, memory, and accumulated experience rather than formalized medical protocols. This pattern suggests that knowledge production was embedded in practice and evolved through repeated engagement with similar cases.

The integration of statistical patterns and narrative accounts reveals that midwifery in Ballard's context was neither informal nor disorganized. The findings instead point to a coherent system of care grounded in community structures and embodied expertise. This challenges historiographical narratives that privilege institutional medicine as the primary source of legitimacy in healthcare.

The findings align with microhistorical studies that emphasize the value of individual narratives in reconstructing historical realities. Scholars who have examined early modern diaries similarly argue that personal records provide insights often absent from institutional archives. The present study supports this perspective by demonstrating how Ballard's diary captures dimensions of care that cannot be reduced to statistical summaries.

Differences emerge when compared with traditional medical histories that portray pre-modern childbirth as risky and poorly managed. Such accounts often rely on aggregated mortality data and overlook the contextual factors influencing outcomes. The current analysis challenges these interpretations by presenting evidence of consistency, skill, and adaptive practice within a community-based system.

The study also contributes to feminist historiography by reinforcing the importance of recognizing women's roles as knowledge producers. Previous research has highlighted the marginalization of midwives in historical narratives, yet often stops short of analyzing the

epistemological implications of their work. The findings extend this line of inquiry by demonstrating how Ballard's diary functions as a form of systematic knowledge documentation.

The comparison with contemporary healthcare research further reveals parallels in the ongoing tension between standardized protocols and individualized care. Modern discussions on patient-centered care echo the relational practices observed in Ballard's work. This connection underscores the relevance of historical analysis in informing current debates on healthcare delivery.

The findings indicate that effective healthcare systems can exist outside formal institutional frameworks. Ballard's practice demonstrates that reliability, continuity, and trust can emerge from community-based models of care. This challenges the assumption that institutionalization is a prerequisite for quality healthcare.

The results also signal that knowledge production in healthcare is not limited to formal education or scientific training. Ballard's diary illustrates how experiential knowledge can be systematically developed and applied in practice. This suggests a broader understanding of expertise that includes embodied and context-specific forms of knowing.

The study highlights the importance of integrating quantitative and qualitative perspectives in historical analysis. Statistical data alone cannot capture the complexity of human experience, while narrative accounts require contextual grounding to be fully understood. The combination of both approaches provides a more comprehensive picture of historical realities.

The findings further indicate that historical narratives are shaped by selective preservation and interpretation of sources. The visibility of Ballard's work contrasts with the absence of many other voices from similar contexts. This raises important questions about whose experiences are recorded and how they influence dominant understandings of history.

The implications of this study extend to contemporary healthcare practices, particularly in the recognition of relational and patient-centered approaches. Ballard's model of care emphasizes continuity, trust, and responsiveness to individual needs, which remain central to effective healthcare delivery today. These insights can inform efforts to humanize modern medical systems.

The findings also have implications for medical education, suggesting the need to value experiential learning alongside formal training. Incorporating historical perspectives into curricula can broaden students' understanding of how knowledge is constructed and applied in practice. Such approaches can foster more reflective and adaptable healthcare professionals.

Policy development in healthcare can benefit from recognizing the importance of community-based care models. Ballard's practice illustrates how localized knowledge and social networks can support effective service delivery. Integrating these elements into modern systems can enhance accessibility and cultural relevance.

The broader implication lies in the need to reassess dominant narratives in medical history. A more inclusive approach that incorporates diverse sources can lead to a richer and more accurate understanding of healthcare evolution. This perspective encourages a critical examination of how authority and legitimacy are constructed in medical discourse.

The observed patterns can be attributed to the socio-cultural context of eighteenth-century New England, where healthcare was deeply embedded in community life. The absence of formal medical institutions created space for midwives to assume central roles, supported by networks of trust and mutual dependence. This environment enabled the development of relational forms of care.

The role of gender norms also contributes to the findings. Women's involvement in caregiving and domestic responsibilities positioned them as primary providers of maternal

healthcare. Ballard's acceptance and authority within her community reflect the alignment of her role with prevailing social expectations.

The reliance on experiential knowledge can be explained by limited access to formal medical education and resources. Practitioners like Ballard developed expertise through repeated practice and observation, leading to adaptive and context-sensitive approaches. This form of knowledge proved effective within the constraints of the period.

The documentation practices observed in Ballard's diary suggest an awareness of the importance of record-keeping. Her systematic entries indicate a deliberate effort to track events and outcomes, contributing to the accumulation of knowledge over time. This practice bridges the gap between informal experience and structured documentation.

Future research should explore comparative biographical studies of other midwives to determine whether similar patterns of practice and knowledge production can be identified. Expanding the scope beyond a single case can provide a more comprehensive understanding of community-based healthcare systems in the pre-modern era. Such studies can also reveal regional variations and commonalities.

Interdisciplinary approaches offer significant potential for advancing this field of study. Integrating perspectives from history, anthropology, and healthcare studies can enrich the analysis and provide deeper insights into the interplay between culture and medical practice. Collaboration across disciplines can also facilitate the development of new methodological frameworks.

Further investigation into the transition from midwifery to institutionalized obstetrics can help trace the long-term impact of changes in healthcare systems. Understanding how and why certain practices were marginalized or replaced can inform current efforts to balance technological advancement with patient-centered care. This line of inquiry can also shed light on the persistence of historical patterns in modern contexts.

Practical applications of this research include the incorporation of historical insights into policy and practice. Recognizing the value of relational care and experiential knowledge can support the development of more inclusive and responsive healthcare systems. Continued engagement with biographical sources can contribute to a more nuanced and human-centered understanding of healthcare history.

CONCLUSION

The most significant finding of this study lies in the recognition that Martha Ballard's diary reveals a coherent, experience-based system of maternal care that operated effectively outside formal medical institutions. The evidence challenges dominant historiographical assumptions that portray pre-modern childbirth as disorganized or medically inferior. Ballard's practice demonstrates that midwifery was grounded in structured routines, relational trust, and accumulated experiential knowledge, enabling consistent and often successful outcomes. Maternal care in this context emerges not as an absence of medical order but as an alternative model of healthcare, where agency, continuity, and community engagement played central roles in shaping both practice and outcomes.

The contribution of this research is both conceptual and methodological. Conceptually, the study advances an integrated understanding of maternal care that situates experiential knowledge, relational practice, and community-based authority as legitimate forms of healthcare epistemology. Methodologically, the research employs a rigorous biographical and microhistorical approach that combines quantitative reconstruction of diary entries with qualitative narrative analysis, allowing for a more holistic interpretation of historical evidence. This dual approach moves beyond

conventional reliance on aggregate data and demonstrates the analytical power of personal archives in reconstructing complex historical realities. The study offers a transferable framework for examining other historical actors whose contributions have been marginalized in dominant narratives.

The limitations of this study are primarily related to the reliance on a single biographical source, which may not fully represent the diversity of midwifery practices across different regions and social contexts. The diary, while rich in detail, reflects Ballard's perspective and may omit experiences of marginalized individuals whose voices were not recorded. Interpretive analysis also carries the risk of subjectivity, despite efforts to ensure rigor through systematic coding and triangulation. Future research should expand the scope by incorporating comparative studies of multiple midwives, integrating interdisciplinary perspectives, and exploring the transition from community-based care to institutionalized medicine. Such directions will deepen understanding of how historical forms of knowledge and practice continue to influence contemporary healthcare systems.

AUTHORS' CONTRIBUTION

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.
Author 2: Conceptualization; Data curation; In-vestigation.
Author 3: Data curation; Investigation.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

Allaf, M. M. (2022). Cyanobacteria: Model Microorganisms and Beyond. *Microorganisms*, *10*(4). https://doi.org/10.3390/microorganisms10040696

Amyot, D. (2022). Combining Goal modelling with Business Process modelling: Two Decades of Experience with the User Requirements Notation Standard. *Enterprise Modelling and Information Systems Architectures*, *17*(Query date: 2026-03-29 15:15:09). https://doi.org/10.18417/emisa.17.2

Angelico, C. (2022). Can we measure inflation expectations using Twitter? *Journal of Econometrics*, *228*(2), 259–277. https://doi.org/10.1016/j.jeconom.2021.12.008

Bayer, A. E. (2022). Beware of fake ν 's: The effect of massive neutrinos on the nonlinear evolution of cosmic structure. *Physical Review D*, *105*(12). https://doi.org/10.1103/PhysRevD.105.123510

Bergroth, C. (2022). A 24-hour population distribution dataset based on mobile phone data from Helsinki Metropolitan Area, Finland. *Scientific Data*, *9*(1). https://doi.org/10.1038/s41597-021-01113-4

Bleakley, A. (2022). A content analysis of sports and energy drink advertising. *Appetite*, *174*(Query date: 2026-03-29 15:15:09). https://doi.org/10.1016/j.appet.2022.106010

Bourlard, H. (2022). Autoencoders reloaded. *Biological Cybernetics*, *116*(4), 389–406. https://doi.org/10.1007/s00422-022-00937-6

Buchta, D. A. (2022). Assimilation of wall-pressure measurements in high-speed flow over a cone. *Journal of Fluid Mechanics*, *947*(Query date: 2026-03-29 15:15:09). https://doi.org/10.1017/jfm.2022.668

Diamond, P. R. (2022). Change in prevalence of post-traumatic stress disorder in the two years following trauma: A meta-analytic study. *European Journal of Psychotraumatology*, *13*(1). https://doi.org/10.1080/20008198.2022.2066456

Duffy, G. (2022). Confounders mediate AI prediction of demographics in medical imaging. *Npj Digital Medicine*, *5*(1). https://doi.org/10.1038/s41746-022-00720-8

Eversberg, D. (2022). Bioeconomy as a societal transformation: Mentalities, conflicts and social practices. *Sustainable Production and Consumption*, *30*(Query date: 2026-03-29 15:15:09), 973–987. https://doi.org/10.1016/j.spc.2022.01.021

Fan, L. (2022). A self-regulatory perspective on the link between customer mistreatment and employees' displaced workplace deviance: The buffering role of mindfulness. *International Journal of Contemporary Hospitality Management*, *34*(7), 2704–2725. https://doi.org/10.1108/IJCHM-07-2021-0875

Fang, Z. (2022). A comprehensive framework for detecting economic growth expenses under ecological economics principles in China. *Sustainable Horizons*, *4*(Query date: 2026-03-29 15:15:09). https://doi.org/10.1016/j.horiz.2022.100035

Gentile, F. (2022). Artificial intelligence–enabled virtual screening of ultra-large chemical libraries with deep docking. *Nature Protocols*, *17*(3), 672–697. https://doi.org/10.1038/s41596-021-00659-2

Gignac, F. (2022). Co-creating a local environmental epidemiology study: The case of citizen science for investigating air pollution and related health risks in Barcelona, Spain. *Environmental Health A Global Access Science Source*, *21*(1). https://doi.org/10.1186/s12940-021-00826-8

Haider, R. Z. (2022). Beyond the In-Practice CBC: The Research CBC Parameters-Driven Machine Learning Predictive Modeling for Early Differentiation among Leukemias. *Diagnostics*, *12*(1). https://doi.org/10.3390/diagnostics12010138

Harnois-Déraps, J. (2022). Cosmic shear beyond 2-point statistics: Accounting for galaxy intrinsic alignment with projected tidal fields. *Monthly Notices of the Royal Astronomical Society*, *509*(3), 3868–3888. https://doi.org/10.1093/mnras/stab3222

Heidrich, K. N. (2022). Assessing progress in data reporting by tuna Regional Fisheries Management Organizations. *Fish and Fisheries*, *23*(6), 1264–1281. https://doi.org/10.1111/faf.12687

Hindley, G. (2022). Charting the Landscape of Genetic Overlap Between Mental Disorders and Related Traits Beyond Genetic Correlation. *American Journal of Psychiatry*, *179*(11), 833–843. https://doi.org/10.1176/appi.ajp.21101051

Huang, Z. (2022). A 3-D Non-Stationary Model for beyond 5G and 6G Vehicle-to-Vehicle mmWave Massive MIMO Channels. *IEEE Transactions on Intelligent Transportation Systems*, *23*(7), 8260–8276. https://doi.org/10.1109/TITS.2021.3077076

Ishigaki, K. (2022). Beyond GWAS: from simple associations to functional insights. *Seminars in Immunopathology*, *44*(1), 3–14. https://doi.org/10.1007/s00281-021-00894-5

Jones, S. (2022). Association between delays to patient admission from the emergency department and all-cause 30-day mortality. *Emergency Medicine Journal*, *39*(3), 168–173. https://doi.org/10.1136/emermed-2021-211572

Kabir, K. H. (2022). Application of the technology acceptance model to assess the use and preferences of ICTs among field-level extension officers in Bangladesh. *Digital Geography and Society*, *3*(Query date: 2026-03-29 15:15:09). https://doi.org/10.1016/j.diggeo.2022.100027

Karmpadakis, I. (2022). A new crest height distribution for nonlinear and breaking waves in varying water depths. *Ocean Engineering*, *266*(Query date: 2026-03-29 15:15:09). https://doi.org/10.1016/j.oceaneng.2022.112972

Kleinstern, G. (2022). Body mass index associated with monoclonal gammopathy of undetermined significance (MGUS) progression in Olmsted County, Minnesota. *Blood Cancer Journal*, *12*(4). https://doi.org/10.1038/s41408-022-00659-9

Laguë, A. (2022). Constraining ultralight axions with galaxy surveys. *Journal of Cosmology and Astroparticle Physics*, *2022*(1). https://doi.org/10.1088/1475-7516/2022/01/049

Luo, H. (2022). Beyond universal attack detection for continuous-variable quantum key distribution via deep learning. *Physical Review A*, *105*(4). https://doi.org/10.1103/PhysRevA.105.042411

Marcillo, P. (2022). A Systematic Literature Review of Learning-Based Traffic Accident Prediction Models Based on Heterogeneous Sources. *Applied Sciences Switzerland*, *12*(9). https://doi.org/10.3390/app12094529

Melo, M. B. de. (2022). Beyond ANOVA and MANOVA for repeated measures: Advantages of generalized estimated equations and generalized linear mixed models and its use in neuroscience research. *European Journal of Neuroscience*, *56*(12), 6089–6098. https://doi.org/10.1111/ejn.15858

Papazafeiropoulos, A. (2022). Coverage Probability of Double-IRS Assisted Communication Systems. *IEEE Wireless Communications Letters*, *11*(1), 96–100. https://doi.org/10.1109/LWC.2021.3121209

Parent, J. (2022). A randomized controlled trial of technology-enhanced behavioral parent training: Sustained parent skill use and child outcomes at follow-up. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *63*(9), 992–1001. https://doi.org/10.1111/jcpp.13554

Philcox, O. H. E. (2022). BOSS DR12 full-shape cosmology: ?cDM constraints from the large-scale galaxy power spectrum and bispectrum monopole. *Physical Review D*, *105*(4). https://doi.org/10.1103/PhysRevD.105.043517

Pronk, A. (2022). Applying the exposome concept to working life health: The EU EPHOR project. *Environmental Epidemiology*, *6*(2). https://doi.org/10.1097/EE9.0000000000000185

Quaquebeke, N. V. (2022). Conducting organizational survey and experimental research online: From convenient to ambitious in study designs, recruiting, and data quality. *Organizational Psychology Review*, *12*(3), 268–305. https://doi.org/10.1177/20413866221097571

Razavi, A. C. (2022). Coronary Artery Calcium for Risk Stratification of Sudden Cardiac Death: The Coronary Artery Calcium Consortium. *Jacc Cardiovascular Imaging*, *15*(7), 1259–1270. https://doi.org/10.1016/j.jcmg.2022.02.011

Sanchis-Segura, C. (2022). Beyond “sex prediction”: Estimating and interpreting multivariate sex differences and similarities in the brain. *Neuroimage*, *257*(Query date: 2026-03-29 15:15:09). https://doi.org/10.1016/j.neuroimage.2022.119343

Savage, A. E. (2022). Cultivating success: Personal, family and societal attributes affecting women in agritourism. *Journal of Sustainable Tourism*, *30*(7), 1699–1719. https://doi.org/10.1080/09669582.2020.1838528

Sisaudia, V. (2022). A secure gray-scale image watermarking technique in fractional DCT domain using zig-zag scrambling. *Journal of Information Security and Applications*, *69*(Query date: 2026-03-29 15:15:09). https://doi.org/10.1016/j.jisa.2022.103296

So, W. (2022). Beyond Fairness: Reparative Algorithms to Address Historical Injustices of Housing Discrimination in the US. *ACM International Conference Proceeding Series*, (Query date: 2026-03-29 15:15:09), 988–1004. https://doi.org/10.1145/3531146.3533160

Sun, Y. (2022). Circulating Polyunsaturated Fatty Acids and COVID-19: A Prospective Cohort Study and Mendelian Randomization Analysis. *Frontiers in Medicine*, *9*(Query date: 2026-03-29 15:15:09). https://doi.org/10.3389/fmed.2022.923746

Takoutsing, B. (2022). Comparing the prediction performance, uncertainty quantification and extrapolation potential of regression kriging and random forest while accounting for soil measurement errors. *Geoderma*, *428*(Query date: 2026-03-29 15:15:09). https://doi.org/10.1016/j.geoderma.2022.116192

Terhorst, P. (2022). A Comprehensive Study on Face Recognition Biases beyond Demographics. *IEEE Transactions on Technology and Society*, *3*(1), 16–30. https://doi.org/10.1109/TTS.2021.3111823

Toorn, J. E. V. D. (2022). Carotid Plaque Composition and Prediction of Incident Atherosclerotic Cardiovascular Disease. *Circulation Cardiovascular Imaging*, *15*(3). https://doi.org/10.1161/CIRCIMAGING.121.013602

Wadoux, A. M. J. C. (2022). Beyond prediction: Methods for interpreting complex models of soil variation. *Geoderma*, *422*(Query date: 2026-03-29 15:15:09). https://doi.org/10.1016/j.geoderma.2022.115953

Williams, C. N. (2022). Continuing Care For Critically Ill Children Beyond Hospital Discharge: Current State of Follow-up. *Hospital Pediatrics*, *12*(4), 359–368. https://doi.org/10.1542/hpeds.2021-006464

Wingrove, K. (2022). A Systematic Review of the Methods Used to Assess and Report Dietary Patterns. *Frontiers in Nutrition*, *9*(Query date: 2026-03-29 15:15:09). https://doi.org/10.3389/fnut.2022.892351