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Correspondence

Response to a letter to the editor, "Impact of smartphone radiation on pregnancy: A systematic review"

1. Introduction

I would like to thank the editor for having the chance to respond to the letter of Mate et al. (2022) regarding the published paper by Eljarrah and Rababa (2022) titled "Impact of smartphone radiation on pregnancy: A systematic review." This paper offers responses to each comment for that letter.

The main aim of Eljarrah and Rababa's (2022) paper is to systematically review published studies on the "direct effects" of mobile phones' electromagnetic field (EMF) radiation on pregnancy, birth, and infant outcomes, focusing on "smartphones." The conclusion showed inconclusive evidence to assess the specific impacts of EMF radiation exposure on pregnancy, birth, and infant outcomes. The reviewed studies included complex contextual factors associated with EMF. Eljarrah and Rababa (2022) explicitly showed these contextual factors under the Result subheading in Tables 2 and 3 (i.e., duration of EMF, intensity of EMF, frequency of EMF, type of device, or source of EMF; Eljarrah and Rababa, 2022, p. 4–5). These tables also have 1) Country, 2) Study Limitations, and 3) Rating subheadings, presenting the location, limitations, and critical appraisal results for each study, respectively (Eljarrah and Rababa, 2022, p. 4–5). Under these tables' Design and Sample subheading, the design and characteristics of the samples (i.e., age, gender, gestational age) are described (Eljarrah and Rababa, 2022, p. 4–5).

According to the reviewed studies in their paper, Eljarrah and Rababa (2022) reported that exposure to EMF may be linked to health outcomes in adults and pregnancy. However, Eljarrah and Rababa stand up by the conclusion of "limited and unclear evidence of harmful outcomes" of EMF on adults and pregnancy. In their review, Eljarrah and Rababa (2022) focused on presenting the main aim of reviewing the available evidence on the impacts of EMF radiation exposure on physiological and pregnancy outcomes. The physiological changes of adults, in general, are so huge. Thus, to address the main aim of Eljarrah and Rababa's (2022) review, physiological changes related to pregnancy were the main focus, including maternal 1) temperature, 2) headache (triggered by increased temperature), 3) heart rate variability, and 4) estrogen, progesterone, and thyroid hormones. Eljarrah and Rababa (2022, p.6, lines 21–26) explicitly stated that they included studies of adults regarding physiological outcomes since they faced challenges in finding sufficient publications, especially concerning pregnancy. In the last three lines of the discussion, the authors recommended filling this gap in future research (Eljarrah and Rababa, 2022, p.7).

Eljarrah and Rababa's (2022) review concluded that it is difficult to draw a conclusion based on the findings in the results, discussion, conclusion, and tables. Eljarrah and Rababa (2022) included studies of diverse designs, contextual factors, and conflicting evidence regardless of quality or EMF exposure levels. However, this heterogeneity makes it difficult to reach a firm conclusion. Given that, having studies of strict quality or a single design will not completely accomplish the main aim of Eljarrah and Rababa (2022) 's review. Thus, there is a need for more research to be conducted in this area. Nevertheless, according to the authors' knowledge, this is the first review that has integrated the literature to assess the EMF outcomes on pregnancy and physiology, considering contextual factors. Future studies could benefit from this review to set a framework to understand this area deeply. Given those factors, alongside each study's limitations and sample characteristics, researchers should be cautious while interpreting the result. The pregnancy and physiological outcomes may reflect the effect of other confounding variables rather than the direct effect of EMF. In future, researchers could use the "life course theory" approach to study various factors that pregnant mothers could experience early in their life and how they may impact their pregnancy outcomes later. Examples of these factors may be related to preconception or intrauterine life, such as maternal nutrition, stress, and gestational diabetes (Halfon et al., 2018).

2. Response to each comment

2.1. Finding high-quality evidence

Eljarrah and Rababa (2022) focused on presenting the main aim of the review. At the first attempt, quantitative studies that assessed smartphone radiation on pregnancy were systematically searched and assessed. However, it was noted that including a single design and a strict quality level was not enough to accomplish the review aim. Later, the cohort with metanalysis and case studies were included, and a further in-depth search for physiological outcomes was conducted. The final documents include 18 studies with diverse designs and quality levels. Tables 2 and 3 of Eljarrah and Rababa's (2022, p.4-5) paper explicitly display each study's characteristics and appraisal results.

During the search process, Eljarrah and Rababa (2022) faced challenges in finding high-quality evidence in the literature involving experimental studies or using randomized sampling, especially since the literature is unsure whether exposure of pregnant mothers to radiation might result in harm. Eljarrah and Rababa's (2022) paper explicitly acknowledged this limitation in the discussion's seventh paragraph

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(Lines 5–9). **To overcome this issue,** Eljarrah and Rababa's (2022) paper included an experimental study published by Yüksel et al. (2016) and conducted on rates.

2.2. Omitting evidence

It is possible for all reviews to exclude evidence since researchers have different eligibility criteria and diverse ways of researching. Also, each database has complex concepts to describe the phenomena. Further, the exclusion criteria were predetermined in Eljarrah and Rababa's (2022) paper. According to these criteria, reports and reviews were not included. The International Commission on Non-Ionizing Radiation Protection (2020) and the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) (2015) meet that exclusion criterion. Eljarrah and Rababa (2022) explicitly stated that they aimed to have the most recent references in the study since their main focus was assessing the impact of smartphone radiation on pregnancy. "Smartphone" is a modern concept, and it has been introduced to the literature recently, replacing old terms such as cellphone, feature phone, basic phone, or cordless phone in the published research. Eljarrah and Rababa (2022) did not find sufficient evidence in the outdated literature on the health impact of "smartphone" radiation on pregnancy. The recent rapid evolution of the smartphone growth rate may explain the likelihood of introducing "smartphone" more in the recent literature rather than the outdated one, suggesting that "smartphone" was not widely ubiquitous before 2015, with a lack of data regarding its ownership rate in 2016. Further, in recent years, the Corona Virus Disease (COVID-19) pandemic has opened the world to even greater use of online devices, including smartphones.

According to the latest report published by the Pew Research Center, surveying technology use across 34 countries worldwide during the COVID-19 pandemic, the median of smartphone ownership reached 70% (Schumacher and Kent, 2020). However, in emerging and advanced economies, 97% of people in South Korea and 88% in Lebanon claim to own a smartphone, compared to only 36% of people in Kenya and 32% of Indians (Schumacher and Kent, 2020). Although, in advanced economies, there was an age gap in smartphone ownership, with most people aged <35 years owning a smartphone, this age gap in smartphone ownership has been closed since 2015 (Silver, 2019a).

The Pew Research Center reported that the majority of people own "smartphones" combined with "mobile phones" (Silver, 2019b). However, this was not the case in emerging economies; the median "smartphone" ownership increased from 18% in 2013 to only 27% in 2015, while the median "mobile phone" ownership increased from 78% in 2013 to 80% in 2015 (Silver, 2019b). Compared with 2013–2015, the median "mobile phone" ownership remained slightly constant, from 78% in 2017 to 80% in 2018 (Silver, 2019b). However, the median "smartphone" ownership exhibited a larger increase over the same time period; it increased from 37% in 2017 to reach about one-half (47%) in 2018 (Silver, 2019b). According to this report, these percentages did not represent all emerging countries, and no data was available for the year "2016". It would be helpful to future research to provide more data about that year, differentiate between "mobile phone" and "smartphone" concepts, and assess whether people use mobile phones combined with a smartphone or other mobile devices.

Upon this sudden surge in "smartphone" use, the "smartphone" has been introduced to the literature recently and has replaced old concepts such as a cellphone, or cordless phone in published research. However, Eljarrah and Rababa's (2022) search did not find sufficient evidence that introduced the impact of the "smartphone" radiation on maternal health, especially during pregnancy. Therefore, studies that included other recent mobile devices were included. This research gap is well observed in the literature. For example, no outdated nor updated studies in Ashrafinia et al.'s (2022) systematic review on the same topic included the "smartphone" concept in their work. Smartphone features may mimic computers, such as having cameras, Global Position system (GPS) location, internet access, flight mode, Light Emitting Diode (LED) screen, touchscreen, and downloadable applications, making it varied from other mobile devices. For example, "basic phone" features may be limited to Short Message Service (SMS) texting and calling. The Pew Research Center classified mobile devices into three categories: 1) smartphones, 2) feature phones, and 3) basic phones, surveying the prevalence for each separately (Silver et al., 2019). It would be helpful in future investigations to differentiate between outdated and updated mobile devices and compare any potential health outcomes for each.

It is common to see articles in literature that do not offer a detailed search strategy in some parts. Eljarrah and Rababa (2022) offer a full Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) chart, including detailed explanations about the reasons for excluding articles. The minor flaw in calculations in the PRISMA chart of Eljarrah and Rababa's (2022) review is checked and considered in future updates.

Eljarrah and Rababa's searches did not retrieve study records for the three studies of Papadopoulou et al. (2017), Choi et al. (2017), and Sudan et al. (2016) that were included in Ashrafinia et al.'s (2022) paper; despite using diverse keywords and academic and grey literature databases in their search. Each review has a varied and sensitive search, making it challenging to have a "one size" search strategy that fits all review types. This point could leave heterogeneity in the type and number of studies included in each review's final result.

For future updates, Papadopoulou et al. (2017), Choi et al. (2017), and Sudan et al. (2016) 'studies will be screened against the inclusion criteria of Eljarrah and Rababa's (2022) review to determine if these studies will be eligible for inclusion in any future updates.

2.3. Methodological issues and risk of bias

It is common to see papers subject to methodological strengths and weaknesses; this is why research is a cycle. Eljarrah and Rababa's (2022) performed arduous tasks in analyzing and presenting each study's characteristics, limitations, and critical appraisals, which are explicitly reflected in the result and discussion parts. The critical appraisal for Lu et al.'s (2017) study in Eljarrah and Rababa's (2022) paper is checked and considered in future updates.

It is difficult to present a biased work of Eljarrah and Rababa's (2022) paper for many reasons. **First**, Eljarrah and Rababa's (2022) paper explicitly reported that there is inadequate evidence, and it is difficult to draw a conclusion. **Second**, to meet this review aim, the authors considered diverse contextual factors/themes that are associated with exposure to smartphone radiation, which hints to readers to be cautious while interpreting the result. These factors included the intensity of EMF, duration of EMF, the number of mobile devices of EMF, calling time, and how this device is far away from human bodies. The authors embedded these factors in Tables 2 and 3 under the result subheadings (Eljarrah and Rababa, 2022, pp.4-5). Eljarrah and Rababa's (2022) paper included studies that presented non-association results or their association results depending on the above **contextual factors.** Elsayed and Jastaniah (2016) and **Heo et al. (2017) studies had nonsignificant findings.** Rubik (2017) reported mild relaxation after exposure, which may be a positive or not harmful health outcome. Also, the reviewed literature itself contains conflicting evidence. For example, Tables 2 and 3 of Eljarrah and Rababa's (2022) paper showed that **Ekici et al. (2016) and Rubik (2017) had conflicting results based on the HRV.** Bauer et al. (2018) reported conflicting results in auricle temperatures based on flight and calling mode. Karuserci et al. (2019) showed that the presence of base stations close to the home had no impact on birth weight, but it might have an effect on head circumference. **Also,** Saadia (2018) showed that changes in fetal heart rate variability (FHRV) in mobile phone users versus none depend on the Body Mass Index (BMI), and there is no information about if changes in FHRV could be harmful or not.

Furthermore, the authors explicitly stated that each of these studies had a diverse source of EMF, such as smartphones, mobile phones, smartphone applications, and cell phones (Eljarrah and Rababa,

2022), making it difficult **to compare and reach conclusive evidence.** It could increase the redundancy if the authors repeat them in the text; presenting them in a table reflects the detailed picture and saves more page space. The authors explicitly acknowledge biases for each study in the results, discussion, and conclusion parts (Eljarrah and Rababa, 2022). Also, the authors explicitly stated, "A thorough review of each of the selected studies revealed that further research is needed to find conclusive evidence." (Eljarrah and Rababa, 2022, p.7).

Eljarrah and Rababa (2022) spent long months conducting this review. The authors encountered several difficulties in addressing the research aim 1) there was a lack of enough evidence that uses only one design, 2) the literature was rare in finding such kind of study, 3) the contextual factors that were associated with the impact of EMF radiation on pregnancy were complex, and 4) the literature was unsure whether an experimental study on this kind of radiation exposure may be harmful to human bodies, so the authors included studies conducted on animals. The results were then presented in narrative form without any meta-analysis. The author's perspective was to increase understanding of the topic, so only a single method might provide insufficient information. When researchers address a complex research question, they could consider different factors that are affected by this question (Oermann and Hays, 2019). In Eljarrah and Rababa's (2022) review, the authors considered each study's characteristics and the contextual factors associated with smartphone radiation. This aspect is common to happen in the literature. For example, Theodoratou et al. (2014) faced large heterogeneity and added metanalysis of randomized controlled trials and observational studies to have an umbrella systematic review and metanalysis to accomplish the main aim of their study. It is also true that researchers could spend long years to accomplish the study's aim of a complex type.

The integrative review tends to be a broad description and understanding of a topic (Oermann and Hays, 2019). One type of systematic review is a systematic mixed studies review (Pluye and Hong, 2014). I acknowledge that Eljarrah and Rababa's (2022) paper offers a systematic integrative review. Eljarrah and Rababa's (2022) paper faced overlap in conceptualizing systematic reviews of mixed study designs. The terms "mixed methods review" and "mixed studies review" are frequently interchanged in the literature. However, for mixed method-systematic reviews, Pluye and Hong (2014) suggested that the phrase "mixed studies review" should be chosen over "mixed methods review" because a review that includes a mixture of studies with diverse designs is referred to as "mixed studies review," and a review that included only studies of mixed methods refer to "mixed methods review." Camilli Trujillo et al. (2021) used the concept of "Integrative Systematic Review." for titling their study, which included mixed study designs. The integrative review can include diverse designs, such as experimental and nonexperimental (Whittemore and Knafl, 2005).

2.4. Formal synthesis of the result

Eljarrah and Rababa (2022) identified and presented in detail what they found and showed the findings in table and text formats. They used Oermann and Hays's (2019) textbook to guide the process of synthesizing the result. The result section followed the PRISMA guidelines and included three parts: 1) characteristics of the eligible papers, 2) data quality, and 3) study design, tools, and measures (Eljarrah and Rababa, 2022). Having complex contextual factors, diverse concepts to define smartphones, and several health outcomes makes it difficult to formally synthesize the result. It is possible for all reviews that have such diversity and complexity to have no formal synthesis of the result.

2.5. Concluding remarks

I would like to thank you for the opportunity to read Eljarrah and Rababa's (2022) study and for offering insightful comments. Each research study may face limitations that could be overcomed in future studies, which is why research is a cyclic process. Honestly, when the reality is talking, efforts that were made to conduct Eljarrah and Rababa's (2022) paper were much more than what was written here or in their original paper. Eljarrah and Rababa's (2022) study is large and complex and consequently may face more limitations than simpler or more straightforward studies.

Eljarrah and Rababa (2022) included 18 studies that could offer a broad understanding of this topic by considering diverse contextual factors involving diverse study designs. Eljarrah and Rababa's (2022) main motivation was to accomplish their review aim; years were spent conducting this review. To my knowledge, this is the first review of integrating diverse designs that has been conducted in this area. I believe that the strengths of Eljarrah and Rababa's (2022) study far exceed the weaknesses to accomplish the main aim. Discussing each study's characteristics and appraisal levels by the two authors could offer a broad understanding of the topic and the nature of the available evidence. Another strength of this paper is including the contextual factors associated with smartphone radiation, as well as diverse sources of EMF that the reader can consider while interpreting the findings and drawing a conclusion. The limitations of each study were explicitly presented in the text and tables of Eljarrah and Rababa's (2022) paper. The decision to combine diverse designs represents a major strength of this review since they increase the understanding of such a rare and complex topic to accomplish the main aim of this review. Eljarrah and Rababa's (2022) paper included studies of diverse designs and followed the strategies of systematic reviews, but Eljarrah and Rababa's (2022) paper has an overlap in how to conceptualize the title in terms of systematic reviews of mixed study designs. I acknowledge that Eljarrah and Rababa's (2022) paper offers an integrative review of the final work. To remove any overlap and complexities, in the future update, the title will be updated to "Integrative Review." In the conclusion part, this sentence will be added "Overall, findings of this review should be taken cautiously and cannot be used to formulate policy at this point in time, highlighting a need to more thoroughly assess smartphone radiation and its impact on pregnancy. Because of including studies of 1) diverse designs, 2) diverse contextual factors, 3) conflicting evidence, and 4) low exposure assessment, it is difficult to draw a firm conclusion." Future researchers could use studies in Eljarrah and Rababa's (2022) paper to prepare more than one systematic review or a separate systematic review involving a meta-analysis, taking into account a wide variety of contextual factors for each review. They could also add more studies to those reviews. Future studies could differentiate between the smartphone and other mobile device concepts. Given that the COVID-19 pandemic has increased the prevalence of technology use, it is noteworthy to assess new challenges that studies face in terms of EMF exposure assessment. While Eljarrah and Rababa's (2022) paper recognizes that smartphone exposure might be an environmental risk factor, it stands by its reported and explicit conclusion of "inadequate evidence" in the area and presents evidence that encourages the reader to take contextual factors and each study characteristics into account while interpreting the findings.

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Additional information

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