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The Profile Analysis of Prospective Elementary Teacher' Scientific Literacy as an Initial Strategy to Conduct Science Courses

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Abstract: Scientific literacy is one of the most important aspect students should have to help them in making decisions toward any problem and to understand all the changes that probably occurred in society. According to last PISA results, scientific literacy of Indonesian students categorized as low. Educational institutions and teachers have responsibilities to improve this scientific literacy. This research was conducted to analyze the scientific literacy of prospective elementary teachers. Descriptive qualitative method was used and involve research subjects as much as 120. The data taken by giving scientific literacy test. questionnaire, and interview to some research subjects. The data analysis was inductive technique, consisted of collecting, reducing, displaying, and verifying data. The result was was 47,5 and categorized as moderate. This result indicated that the lecturer may implement learning strategies where science process skill of students could be well-developed, integrate science and mathematics courses, and engage students in scientific reading.

Keywords: Prospective elementary teacher; Science course; Scientific literacy

Introduction

Scientific literacy is an ability to use scientific knowledge in identifying question, getting new knowledge, explaining scientific phenomenon, and constructing conclusions based on facts in reality (Jamilah et al., 2023). It implies concept mastery of scientific concepts and processes which enables people to interact with everyday scientific situations and helps them to participate in a society in which science and technology are of great importance (Kähler et al., 2020). Another definition about scientific literacy is stated by The National Research Council (NRC) and Programme for International Student Assessment (PISA). They defines scientific literacy as the ability to draw evidence and data-based conclusion in assessing and evaluating the quality of science information and arguments put forth by scientists and in the media in order to make some decision related to the world changes ((NRC) National Research Council, 1996; (OECD) Organisation for Economic Co-operation Development, 2003). Related to educational challenges of the 21st century, this literacy is actually needed to help students in making decision when they try to solve any problem in any field, understand all the context of changes that probably occurred in society. Even, scientific literacy is stated as one of sixteen skills analyzed by the World Economic Forum (2015) to be developed to face the challenge of 21st century. OECD 2018 stated that an early development of scientific literacy enables individuals not only to deal with daily problems but also to form the basic science competencies for highly individuals in the future (OECD, 2018).

Due to the rapid change of the world, scientific and technological progress are being a big deal to the improvement of scientific literacy (OECD, 2018). According to result of international study PISA in 2022, there was a decrement in score of students' scientific literacy globally. Indonesia's PISA results in the scientific literacy aspect decreased by 13 points. In 2018, Indonesia' score of scientific literacy was 396, while in

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2022, it was just 383. This decrement was actually greater than the average decrement globally which was just 12 points. Even so, Indonesia rose 6 places from the previous PISA ranking (Kemendikbudristek, 2023). Based on these results, it can be said that students have not been able to fulfill the indicators of scientific literacy. They are not yet fully able to identify scientific opinions, to search for a valid literature, to analyze impacts or findings, to create graphs based on data, to solve problems by interpreting data through basic statistics, and to make inferences, predictions, and draw conclusions based on data (Rahmadani et al., 2018).

The result of PISA 2022 is a challenge for education system in Indonesia. Educational institutions have a responsibility to improve the quality of education, including students' scientific literacy. Scientific literacy should start to be developed from an early age because of some considerations. According to the National Science Teachers Association, children have their own potential for engaging in scientific practices and develop science concept mastery at a conceptual stage (NSTA, 2009). They are actually in need of some opportunities to explore themselves in science discovery and exploration (Bosse et al., 2019). In order for children, like elementary students, to learn science, adults have a very important role (NSTA, 2009). Science learning, in which scientific literacy is increased expectedly is influenced by several factors, one of them is teacher who carrying out science learning in the classroom (Hidayah et al., 2019). Meaning that, elementary teacher, who accompany student during school time, also can help students to engage in such a science learning process and to prepare them the basis of scientific thinking and knowledge. It can be asking and answering questions session, giving scientific explanations, supporting an exploratory attempts, even arranging the difficulty levels of information (NSTA, 2009). To provide qualified-science learning to have students who are well-literate in science, elementary teachers are also expected to have good scientific literacy.

Universities, through PGSD (elementary teacher education) study program, are expected to make contribution in raising future teachers who is scientifically literate and well-understand in how elementary students' scientific literacy can be improved. The study program plays a role in seeking lecturing process that is able to facilitate the abilities of students with diverse backgrounds. Based on data, PGSD students of Perjuangan University come from various and different backgrounds. They come from any major, such as science major, social studies major, language major, and even vocational school which is not having any relation with science education at all. With the variety of human resource input in PGSD study program, there are certainly various levels of scientific literacy among students, which possibly can be some inhibiting factors in the process of lecturing. Based on the observation result in the last two years, there have been several obstacles experienced by both lecturers and students. It was about different prior knowledge in the field of science, learning strategies of lecturer, student difficulties in mastering science material independently, student views about the complexity of science which creates demotivation, and even a standard decrement in learning evaluation done by the lecturer. According to those factors, so it can be assumed that structured and systematic strategy in conducting science courses is needed to reduce some differences among students and bring them to the same level of scientific literacy and to create equal conditions in science teaching learning process (Kähler et al., 2020).

Based on the contexts above, the research about the profile analysis of prospective elementary teacher' scientific literacy in PGSD Perjuangan University was conducted to determine the possible strategies held by lecturers in science courses.

Method

This research is aimed at analyzing the scientific literacy of prospective elementary teachers. It went through six main steps starting by case study and problem identification and ending by drawing the conclusions. Figure 1 shows the whole steps of this research.

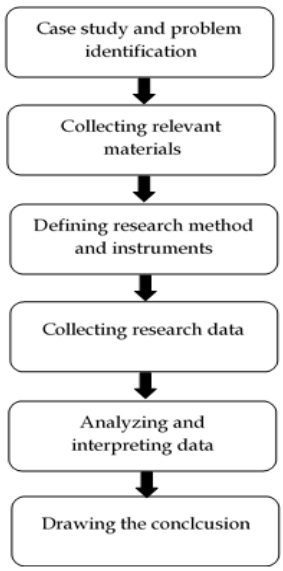

Figure 1. Research Step

Case study and problem identification had been done in the last two years as the science competencies of PGSD students were below expectation. It could be identified through some findings in science courses either student result of science final and middle

examination or student performance in science courses. Then, this research was finally conducted by using descriptive qualitative method which is an inquiry strategy that emphasize value, definition, concept, characteristic, symptom, symbol, and description of a phenomenon by using some different methods, focusing on the quality, in the natural and holistic way, presented narratively (Yusuf, 2014).

This research involves 120 first year students of PGSD Perjuangan University, called prospective elementary teachers, as research subjects. The data was taken by giving test of scientific literacy which refers to Test of Science Literacy Skills (TOSLS) by Gormally (Gormally et al., 2012), questionnaire of students' learning history, and interview to some research subjects related to their scientific literacy test' result. The scientific literacy test used in this research was developed based on eight indicators and they were made quite like the Gormally' example. This package of questions then was validated by expert before implemented to the research. The question distribution of scientific literacy test in this research instrument are presented below in Table 1.

Table 1. Question Distribution of Scientific Literacy Test

Indicator	Number of questions
A. *Understand methods of inquiry that lead to scientific knowledge*	
1. Identify a valid scientific argument	21, 22, 23, 24
2. Evaluate the validity of sources	25, 26, 27, 28
3. Evaluate the use and misuse of scientific information	29, 1, 2, 3
4. Understand elements of research design and how they impact scientific findings/conclusions	4, 5, 6
B. *Organize, analyze, and interpret quantitative data and scientific information*	
5. Create graphical representations of data	7, 30
6. Read and interpret graphical representation of data	8, 9, 10, 11
7. Understand & interpret basic statistics and solve problems using quantitative skills, including probability and statistics	12, 13, 14, 15, 16
8. Justify inferences, predictions, and conclusions based on quantitative data	17, 18, 19, 20

The scientific literacy test used in this research was 29 multiple choice questions in the field of science concept. The data obtained from the test are then converted into grades, using this formula below:

$$\text{Score} = \frac{\text{number of right answers}}{\text{number of questions}} \text{ x } 100 \quad (1)$$

The value of scientific literacy' score is then interpreted based on the criteria presented in Table 2.

Table 2. Scientific Literacy Category Based on Score

Range of Score	Category
67-100	High
33-66	Moderate
<33	Low

Another instrument which is the questionnaire of students' learning history was distributed to collect some information which possibly affect students' scientific literacy. As well as a questionnaire, interviews on some subjects was done to confirm what students have experienced thus far.

The after step was data analysis which is the main step lead to the research conclusion. This process was done before data collection, during data collection, and after data collection. Furthermore, the data analysis used in this research was inductive technique, applying Miles and Huberman Model. It actually compared the literature review and the specific factors appearing in this research to draw general conclusion (Umar, 2019). Figure 2. shows the scheme of data analysis of this research.

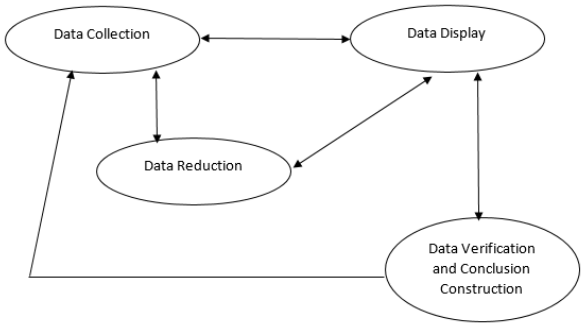

Figure 2. The Scheme of Data Analysis

Results and Discussion

Scientific literacy of prospective elementary teacher in PGSD Perjuangan University were obtained through a test consisted of multiple choice questions refers to eight indicators stated by Gormally. The average score gained in this test was 47,5 and categorized as moderate. The detailed score is displayed below in Table 3.

Table 3. Scientific Literacy' Score

Indicator	Average Score
A. Understand methods of inquiry that lead to scientific knowledge	
1. Identify a valid scientific argument	27.3
2. Evaluate the validity of sources	52.2
3. Evaluate the use and misuse of scientific information	55.2
4. Understand elements of research design and how they impact scientific findings/conclusions	39.2
B. Organize, analyze, and interpret quantitative data and scientific information	
5. Create graphical representations of data	59.0
6. Read and interpret graphical representation of data	46.7
7. Understand & interpret basic statistics and solve problems using quantitative skills, including probability and statistics	62.3
8. Justify inferences, predictions, and conclusions based on quantitative data	36.0

Based on the data result, none of indicators got 'high' category. These results indicated that the scientific literacy of prospective elementary teacher is quite far from it has to be. The result of their scientific literacy in each indicator is shown in Figure 3 and Figure 4.

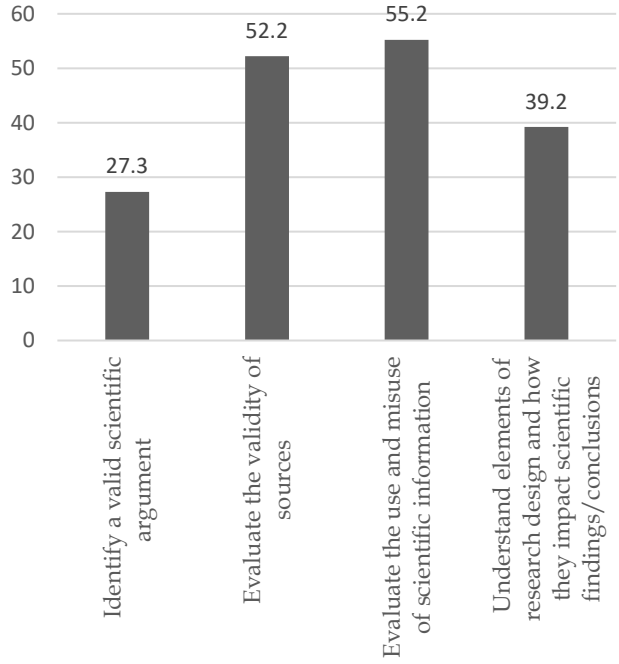

Figure 3. Average Score of Scientific Literacy in Indicator 1 until Indicator 4

Identify a valid scientific argument

Based on the graph above.it can be seen that the average score for this indicator is 27,3 and categorized as low. This score is the minimum score gained among all indicators. It is indicated that students are not used to be involved in scientific activities. The data result of questionnaire showed that the students were not often participated in laboratory works. Almost 50% of students confess that their school had no proper laboratory and teacher could not do some practicum to enhance their scientific argumentation. As result, it might hard for students to understand the phenomena that appeared and do reasoning. Involving students in scientific argumentation give some benefits such as stimulating students' motivation in learning, supporting cognitive abilities, enhancing student performance, and developing critical thinking (Faize et al., 2017). In a previous study, it is declared that the scientific reasoning of students could be enhanced through the process of scientific argumentation (Engelmann et al., 2016). Fortunately, regarding to the lack of abilities in scientific argument, a research in scientific reasoning claimed that it is more effective to improve students' scientific argumentation in higher education than other learning outcomes and other educational levels (Sari & El Islami, 2020). It means that lecturer in universities are able to engage students in teaching process and research that enable students reasoning and argumentation. Attracting students in an online argumentation model to get proficient in critiquing arguments, defending claims in reasoned discussions with peers, presenting high-quality argumentation, and linking science to the daily experiences are some examples lecturer could do in the courses to improve students ability in identifying scientific arguments (Fan et al., 2020).

Evaluate the validity of sources

According to the result in scientific literacy test, this indicator gained average score as much as 52,3 and categorized as moderate. This indicator related to their abilities in using sources, choosing one as valid resource that inform them some valid information. It is very important in term of conceptual construction is needed by students through the right way to avoid some misconception and invalid theory. A research claimed that students with a bit low knowledge are more likely to trust poor sites and fail to define the relevancy criteria when judging the trustworthiness of sources (Braten I, Stromso HI, 2011). The number that shown in the result indicates that students have not been able to differ which one is categorized as valid sources. They take

information anywhere without concern. Supporting the improvement of this ability, the first action that lecturer could do are introducing students how to look for valid information like scientific journal and pursuing them to read those resources as much as they can. The lecturer also may engage students through giving assignments or projects that possibly push students to read. The more students read, the more capable they are in evaluating the validity of sources. This exploration represents their curiosity and interest in new knowledge and experiences and also their intention to find out more about a topic for its own sake (Chen et al., 1999). Some reasons related to why students need to read is because it is a skill that needs to be nurtured over many years which suggest everyone scouring to the literature before making decisions or undertaking projects. Besides, reading also involves problem solving where someone can make sense from the words on the page as she/he relates new materials to pre-existing ideas, memories, and knowledge (Bradley & Wallace, 2008). Hence, it expected that in the future, with those ideas, memories, and knowledge they have, they are able to deal with daily problems confidently and to take well-considered decision as the solution of problem.

Evaluate the use and misuse of scientific information

This indicator gained an average score as much as 52,2 and it was moderate. This ability is related to how they deal with scientific information they have. Students with scientific literacy are able to explain natural phenomena, draw conclusions, and use theories, ideas, scientific information, as well as facts that occur in everyday life (Husna et al., 2022) The use and misuse of scientific information refers to recognizing a valid and ethical scientific action and identifying appropriate use of science to make societal decisions (Gormally et al., 2012). Scientific information processing actually could be implemented through some learning strategies such as approach, model, and method which involve students in some cases and problem (Amar et al., 2020). Case study, project, and problem-based learning may be way more effective and efficient to be applied by lecturer as new learning experiences and innovations to the students. Through this model, it is expected that students not only gain a new experience of learning model which increase their interest in science, but also they have their own ability to recognize, remember, explain, describe, and apply science knowledge. Regarding to the result of questionnaire, 43% of students have their own passion in science, 54% stated that they are not really into science, and just 3%of them having no passion at science at all. This kind of result could be a good input for lecturer conducting science courses due to their potential.

Understand elements of research design and how they impact scientific finding

This indicator states the ability of students to understand how a research could be designed and held. The average score of this indicator is 39,2 and categorized as moderate. This number might be affected by learning history of students. It is related to some learning experiences they have pass through during school for example when they experienced laboratory works and experiments. Based on data of questionnaire, students coming from science major is about 29%, it means that possibly they often had laboratory activities, while other students did not. This might be the reason why the score of this indicator was relatively low. In the laboratory activities, students are invited to learn and observe phenomena, identify variables, measure objects, use numbers, hypothesize the possibility, and conclude the result. (Kızılaslan, 2019; Kruea-In et al., 2015). When students have not been experienced this, they might be having difficulties in understanding element of research design and how to proceed it into findings. The lecturer could engage students in some laboratory works or any learning model or method that develop students' science process skill. According to Husna et al.(2022), science process skills is an investigative skill which allow and enhance students to design and carry out research.

The detailed results of scientific literacy indicators 5 to 8 are shown in Figure 4.

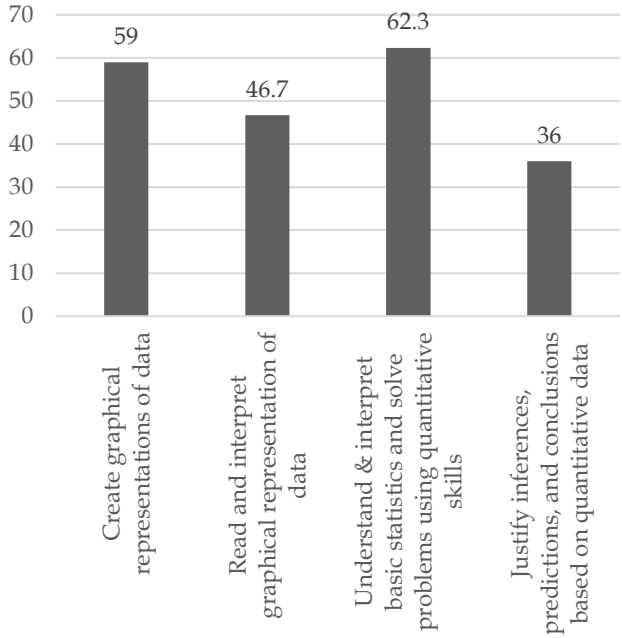

Figure 4. Average Score of Scientific Literacy in Indicator 5 until Indicator 8

Create graphical representation of data

Based on the graph above, the average score of this indicator is as much as 59,0. It is categorized as moderate. This indicator actually refer to students ability

in identifying the appropriate format for the graphical representation of data given (Gormally et al., 2012). Almost 50% of students still have consciousness when they have to create graph based on the data, though in this multiple choice test where students were given easiness as they have some options to be considered. In another session, the researcher try to dig more information about this ability by giving one case to be solved by the students. It was certainly asking students to create one graph of data given. Unfortunately, the result was just 10% of students were categorized enough in creating graphical representation of data and the rest of them even were not able to create graph. Analyzing this context, those students might be hard in reading data and understanding the content or information in the form of table which affect continuously to their abilities in transforming those data into the form of graph. Even, they seem don't have enough basic knowledge in how the graph could be executed. They didn't know what x and y axis could be. This kind of issue is also actually related with the presence of basic mathematic knowledge. The alternative of learning process that could be offered is the lecturer could create a learning with scientific process skill approach which is integrated with mathematic in context of science. The integration of science and mathematics may enrich students' experience in the courses which engage their learning process, and improve student attitude toward and achievement in both science and mathematics (Berlin & Lee, 2005).

Read and interpret graphical representation of data

The average score of this indicator according to the graph above is as much as 46,7. It is categorized as moderate. The goal of this indicator is students are able to make conclusion of a study findings through a graph (Gormally et al., 2012). According to the data, more than 50%of students haven't been skilled in reading and interpreting graphical representation of data. This problem could be one of focus that should be improved by lecturer through the courses. This condition may be occurred because their history in learning which affect students' lack of experience. As the result of interview stated that students rarely had experienced in reading and interpret graphical representation of data like the question given. They were not used to take some information through the graph and finally they were unskilled in this part of learning. They rarely either were involved in laboratory experiment where students can be involved in taking data, reading graph, and interpreting the conclusion of it, or got some kind of high order thinking skill (HOTS) questions, like PISA typical questions. Those things are actually describe the solution of these cases. Improving this kind of ability, the lecturer should be able to try giving some opportunities to students for example in manipulating data back and forth between different graphical representations. The students are able to note what changes and what information are revealed by the manipulations and to identify the changing role of axes and to plot elements from graph to graph (Bright, G. W., & Friel, 1998; Garfield & Ooms, 2015).

Understand & interpret basic statistics and solve problems using quantitative skills

According to the results of this research, which is presented on the graph above, the average score of this indicator reach the number of 62,3, categorized as moderate, and it is actually the highest number among all indicators. This ability is also related to the basic mathematic knowledge that students have. Improving this ability actually can be worked through integrated learning between science and mathematics where science and mathematics lecturer may have some project together to bring students experience mathematic in a context of science. As we know that mathematics is used in every field such as in science, social science, medicine, and of course in commerce. Science and mathematics is not only linked through the content between them but also through the process which is able to enactive an approach to solve problem in everyday life (National Council of Teachers of Mathematics, 2000). It also stated that integration of mathematics and science can facilitate students a good connection among concepts, processes and skills across the various subjects (Howes et al., 2013), bringing them to the more meaningful learning to understand the concept of subject (Czerniak & Johnson, 2014; Gresnigt et al., 2014). According to Burghardt et al. (2015), it is also beneficial to integrate mathematics and science in students learning where due to this kind of integrations, the deeper understanding of how to connect those disciplines could be well-supported (Baxter et al., 2014). The integration between science and mathematics will create a new atmosphere where collaboration between them could take place and develop shared meanings through questioning and negotiating process that may be occurred. Importantly, working in communities can help to overcome shortcomings in individual particular courses and support the transformation of better practicing in the courses (Rennie et al., 2012). Based on those considerations above, it is recommended for science and mathematics lecturer trying to update the curricula and collaborate in integration of both courses to facilitate students in developing this skill.

Justify inferences, predictions, and conclusion based on quantitative data

In context of this indicator, it can be seen on the graph that the average score reached by students is

about 36, which is the second lowest score among all indicators. This ability may help students in making logical hypothesis, taking decision of cases, recognizing flaws in arguments, and evaluating solution of problem (Gormally et al., 2012). Enhancing this indicator, the lecturer may involve students in learning that using science process skills approach. This kind of approach involve students in some activities, like observation, measurement, classification, taking data, that possibly enactive them to do inference, prediction, and defining conclusion. Some researcher stated that science process skill may support the science inquiry of students (Juhji, 2016; Kruea-In et al., 2015). Besides that, Komikesari (2016) and Nugraha, et. al. (2019) stated that science process skill is the foundation to form logical thinking abilities of someone which describe their ways of thinking through scientific investigation or experimentation. Then, it could be claimed that science process skills are one of the most important aspects to be improved in the science courses as it helps students to be able to produce concepts, theories, and principles as well as justify inferences, prediction, and conclusion based on quantitative data (Adriyawati et al., 2020; Pratono et al., 2018). Besides the role of lecturer facilitating students in a high-qualified learning process of science courses, the institutions is also expected to provide better learning facilities to supports all efforts done by the lecturer.

Conclusion

Based on the result of this research, it may concluded that the scientific literacy of prospective elementary teacher in PGSD Perjuangan University is still categorized as moderate, with the average score is equal to 47,5. Some aspects were considered as the reason why this number of scientific literacy attained, such as students' learning history and background, lack of experience in scientific laboratory activities or else which consider students' science process skill, teaching style of teacher, HOTS or PISA-typical question experience, students' interest in science, and even school facilities to support science learning. This result indicates that scientific literacy of PGSD students should be improved in term of the quality of graduates as elementary teacher in the future. Some efforts could be strategized by science lecturer to facilitate students in improving their scientific literacy. The initial strategy that may be conducted in science courses such as facilitating students in learning process that support their development in science process skill, include reasoning and argumentation skill, like having experiment, laboratory works, and application of modern teaching and learning model. These effort are expected to increase their interest of science. Other strategies such as the integration of science and mathematics course where both lecture could do some collaboration in update the curricula to achieve this goal, engaging students in more scientific reading for example through scientific journal, and even good maintenance in learning facilities.

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Author Contributions

Conceptualization, HM and RHZ.; methodology, HM.; validation, GSS.; formal analysis, HM.; investigation, HM.; resources, HM.; writing—review and editing, HM. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analysis, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

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