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Research

Associations between Maternal Nutritional Status, Carbohydrate, Fat, and Protein Intakes, and Low Birth Weight in Jember, East Java

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ABSTRACT

Background: Pregnancy can cause several bodily changes, both anatomically, physiologically, and biochemically. Mothers' metabolism and food intake will change during pregnancy. Food intake of pregnant women will increase every trimester, so it must be considered because it is not only for herself, but for the foetus she is carrying. Excessive carbohydrate intake has an adverse effect on babies born, lack of excessive intake is also not good. This study aims to analyze the association between nutritional status, carbohydrate, fat, and protein intakes of pregnant women with birth weight (BBL).

Subjects and Method: This was a cohort study conducted at community health center in Jember, East Java, from April to June 2019. The sample was randomly selected as many as 120 study subjects. The dependent variable was birth weight (LBW). The independent variables were carbohydrate, fat, protein intakes and maternal nutritional status. The data collection technique used was questionnaires and analyzed by path analysis.

Results: Birth weight directly increased with the maternal nutritional status (b= 38.65; 95% CI= 24.96 to 53.33; p<0.001) and carbohydrate intake of pregnant women with birth weight (b= 0.53; 95% CI= -0.48 to 1.54; p= 0.149). Birth weight directly decreased with protein intake (b= -0.53; 95% CI= -3.09 to 2.98; p= 0.729) (b= -0.75; 95% CI= -3.11 to 1.60; p= 0.010). Maternal carbohydrate and protein intake had an indirect association and birth weight.

Conclusion: There is a direct association between fat intake and maternal nutritional status with birth weight. Nutritional status has a positive effect on birth weight. While fat intake has a negative effect on birth weight. Maternal carbohydrate and protein intake has an indirect effect on birth weight.

Keywords: birth weight, macronutrient intake, nutritional status

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BACKGROUND

Since 2012, the government of Indonesia through the Ministry of Health has promoted the first 1000 days of life (HPK) program. Human quality begins from the womb of the mother. The first 1000 days of life starts from fetus in the womb until the child is two years old. At this time the fulfillment of nutrients is very necessary, because the nutritional needs affect the physical and cognitive development. Pregnant mother's nutrition has a strong influence on the development of the fetus. Pregnant mothers, in fulfilling her nutrition, does not only meet the needs for herself but, for her fetus as well. All nutrients from macronutrients and micronutrient are needed by the mother and fetus. Deficiency or excess macro and micro nutrients have a bad impact for both. Lack of macro nutrients such as protein, can result in stunting babies. Lack of micronutrients such as iron (Fe) has an impact on mothers becoming anemic or can give birth to low birth weight babies (LBW). Excess macro nutrients such as carbohydrates can risk degenerative diseases (RI Ministry of Health, 2012). Mothers with poor dietary habits have a risk of getting less nutritional intake compared to mothers who have a good dietary habit (Sinawangwulan et al., 2018).

Aside from the fulfillment of nutrients, the nutritional status of pregnant women determines the health condition of the fetus. Determination of nutritional status can be determined based on mid-upper arm circumference (MUAC) or body mass index (BMI). Pregnant women are at risk of experiencing chronic energy deficiency (CED) if they have MUAC <23.5 cm and for the category of obesity if they have MUAC> 25 gr/m². The normal limit value for BMI measurement is based on body weight according to height. Related to the target determine weight gain during pregnancy the nutritional status before pregnancy is adjusted. The normal limit of first trimester weight gain 1-2 kg per week, second and third trimesters 0.5 kg per week. Total weight gain from the first to third trimester by 8.8 kg to 13.6 kg (Arisman, 2010). Birth weight is a description of the nutritional status of children under two years of early life. Babies born with a weight of less than 2,500 g or also called a low birth weight, have experienced nutritional deficiencies during the pregnancy period (Kusuma et al., 2017).

Pregnant women who have poor nutriational status will have the risk of giving birth to babies with low birth weight (LBW) or big babies (macrosomia). LBW is the impact of pregnant women with chronic lack of nutritional status or premature born babies. Low birth babies (LBW) have low weight or less than 2,500 grams. LBW can affect the growth and development of children and health complications that can cause death in the end. Premature babies are babies born less than 9 months of gestational age. Moreover, the negative impact of LBW is infant's mortality.

Meanwhile, macrosomia for infants is the impact of pregnant women with overweight or obese nutritional status. Macrosomia infant weight is >4,000 g. Obesity can also cause babies to be at risk for obesity later in life, or other degenerative diseases. In addition, the nutritional status of the mother also has a negative impact on the mother. Pregnant women with CED can indirectly cause maternal death. The nutritional status of obese pregnant women can also put women at risk of developing gestational diabetes mellitus.

The results of the Jember Regency Regional Medium-Term Development Plan (RPJMD) (2016), Maternal Mortality Rate (MMR) and Infant Mortality Rate (IMR) are still relatively high despite a decline from 2013 to 2016. Maternal Mortality Rate (MMR) for every 1,000 live births in 2013 was 101.20 %, in 2014 it decreased to 86.13%. In 2015 to 2016, it increased from 87.73% to 93.77%, while the target for indicators free from maternal mortality was 100%. These results indicate that mothers who give birth will also have health effects on the fetus that will be born as a result of the high MMR, the local government has more concentration on maternal health during pregnancy.

For every integrated health service post for pregnant women who do not come to the integrated health service post, health workers, ie cadres, will pick up. This was done to reduce MMR (Jember District Health Office, 2017).

SUBJECTS AND METHOD

1. Study Design

This study used an observational analytic design with a cohort design. The location of the study was carried out in the Integrated Health Service Post (Posyandu) Community Health Center (Puskesmas) in the working area of the Jember District Health Office namely Sukorambi and Panti Sub-District. The study was conducted from April 2019 to July 2019.

2. Population and Sample

The population who participated in the study were 120 pregnant women who came to Integrated Health Service Post. The technique used for sample selection was random sampling. The inclusion criteria in this study were pregnant women in the third trimester of pregnancy who were willing to sign informed consent and pregnant women who routinely visited Integrated Health Service Post. While the exclusion criteria in this study are pregnant women who do not have KMS and use insulin drugs. Nutritional status data was needed for the calculation of the level of consumption of pregnant women, the results of measurements of body weight and height that had been listed in the Health towards Card (KMS) book.

3. Study Variables

The dependent variable was birth weight. The independent variables were carbohydrate, fat, protein intakes, and nutritional status.

4. Operational Definition of Variables

Birth weight was a measurement of birth weight that was weighed after birth. Weighing the baby's weight was done by a midwife who helped the mother's birth process. Data collection conducted by researchers was to record the results of weighing that had been done by midwives. Weighing the baby's weight was done after 2 hours after birth. Measuring instruments used were baby scale scales. Baby scale had a level of accuracy of 0.05 kg. The measurement results were said to be normal if the baby weighed 2,500 grams to 3,900 grams. Infants who have birth weight <2,500 grams are classified as low birth weight (LBW), while for babies born 3,900 grams are classified as macrosomia babies. The measurement scale used was continuous data.

Nutritional status was a measurement of body mass index by knowing the body weight in kilograms and height in meters squared of pregnant women. Data collection was carried out by recording the results of measurements by Integrated Health Service Post officers that were available in the Health towards Card (KMS) book. The results of the measurement of nutritional status can be used to determine weight gain during pregnancy. Measuring instruments used for body weight were a scale (bathroom weight scale) and height using a microtoise. Stepping scales had a level of accuracy of 0.1 kg and microtoise had a level of accuracy of 0.1 cm. The measurement results were said to be normal if you have a body mass index of 18.5 kg/m2. The measurement scale used was continuous data.

Macronutrient intake was the calculation of the amount of carbohydrate, protein, and fat intake consumed for 24 hours by pregnant women. Data collection was done by keeping in mind the amount and type of food consummed during 24 hours starting with the initial researcher asking the study subjects. The measuring instrument used was 24-hour food recall. Researchers recorded the menu of cooking and how to cook it and asked about the size of the meal with a household size. The size of the household was converted into units of weight, namely grams. Food intake that had been converted in grams, then the nutritional value was calculated using the nutritional application that was Nutri Survey. The measurement of macronutrient intake that had been in Nutri Survey would be calculated its consumption level to find out its adequacy, namely the formula for the amount of macronutrient intake in units of grams over the need for macronutrients multiplied by 100 %.

Total needs were based on weight, height, age of the mother, and maternal activities. The results of the calculation of the level of normal consumption if it had a value of 90-119%. The measurement scale used was continuous data.

5. Study Instruments

Weight and height data of pregnant women using medical records in the Health towards Card book. Medical record books such as Health towards Card of pregnant women were also used to record weight gain at each visit and to determine the gestational age of pregnant women.

The instrument used to measure body weight was a bathroom weights scale and to measure height was a microtoise. Form for study instruments 24-hour food recall was a form that is used to determine and calculate carbohydrate intake and the amount of food consumed in the past 24 hours.

Authors used the Nutri Survey application to calculate the nutritional value consumed during pregnancy. The baby's birth weight sees the Integrated Health Service Post birth record weighed by the village midwife. The tool used to weigh was the baby scale.

6. Data Analysis

Univariate data analysis was used to see the frequency distribution and characteristics of study subjects. Characteristics of study subjects (continuous data) were described in Mean, SD, minimum, and maximum. To see the association of all study variables the study was analyzed by path analysis.

7. Research Ethic

This study was conducted based on research ethics, including informed consent, anonymity, confidentiality, and research ethics. This study was approved by the Health Research Ethics Commission of the Faculty of Medicine, Universitas Sebelas Maret No.72/ UN27.06 / KEPK / 2019.

RESULTS

1. Univariate analysis

Univariate analysis is used to explain the frequency distribution of study subject characteristics. The results of the analysis can be seen in Table 1.

Table 1 shows the results of a univariate analysis that the study subjects that followed the average study of pregnant women aged 25 years with the youngest age of 17 years and the oldest age was 35 years. The gestational age of mothers who took part in the study averaged 27 weeks' gestation with the youngest gestational age of 24 weeks and the oldest gestational age was 37 weeks.

The birth weight variable had a mean value of 2,879 g with a minimum value of 2,200 g and a maximum value of 3,900 g. Maternal nutritional status had a mean value of 21.62 grams with a minimum value of 15.77 g and a maximum value of 29.14 g. Maternal carbohydrate intake had a mean value of 255.09 g with a minimum value of 160.6 g and a maximum value of 426.25 g. Mother protein intake had a mean value of 70.02 g with a minimum value of 38.25 g and a maximum value of 113 g. Maternal fat intake had a mean value of 73.65 g with a minimum value of 30 g and a maximum value of 129.9 g. The results of the analysis can be seen in Table 2.

Table 1. Univariate analysis

Variables	n	Mean	SD	Min.	Max.
Maternal age (years)	120	25.43	4.82	17	35
Gestational age (weeks)	120	27.31	3.25	24	37
Birth weight (g)	120	2,870	253.58	2,200	3,900
Nutritional Status (g)	120	21.62	2.97	15.77	29.14
Maternal carbohydrate intake (g)	120	255.09	45.40	160.6	426.25
Maternal protein intake (g)	120	70.02	13.85	38.25	113
Maternal fat intake (g)	120	73.65	20.13	30	129.9

2. The result of multivariate analysis

Multivariate analysis used linear regression method. Multivariate explained the association between carbohydrate intake, fat intake, protein intake, maternal nutritional status, and birth weight. The results of the analysis can be seen in Table 2.

The results of the analysis can be seen in Table 2 showing that there was a statistically significant association between maternal nutritional status and fat intake with birth weight (LBW). The analysis shows that there was a positive association between the nutritional status of pregnant women and the birth weight. Pregnant women with more nutritional status can increase 40.14 units of birth weight (LBW) (b= 33.25; 95% CI= 19.03 to 47.47; p <0.001). There is an indirect association between carbohydrate intake of pregnant women and birth weight, but it is not statistically significant (b= 0.64; 95% CI= -0.26 to 1.54; p= 0.160). Pregnant mothers who have a higher carbohydrate intake will increase 0.64 weight units of babies born.

Protein and fat intake had a negative association birth weight. Protein intake showed no statistically significant results. The higher the protein intake, the lower the weight of the baby being born. Meanwhile, fat intake was statistically significant. Higher fat intake would reduce -9.63 weight units of babies born (b = -9.63; 95% CI -17.21 to -2.05; p = 0.013). R squared values indicated the contribution of nutritional status, maternal carbohydrate, protein, and fat intake 27.62% of on birth weight and as many as 25.10% were influenced by other factors outside the independent variable.

Table 2 Multivariate analysis of the dependent variable of birth weight

Independent Variable	b	95% CI		p
		Lower limit	Upper limit	
Maternal nutritional status (kg/m2)	33.25	19.03	47.47	<0.001
Carbohydrate intake (grams)	0.64	-0.26	1.54	0.160
Protein intake (grams)	-0.49	-3.39	2.39	0.735
Fat intake (grams)	-9.63	-17.21	-2.05	0.013
n observations = 120				
R squared = 27.62%				

3. Path Analysis

Figure 1 illustrates a factor path analysis model of the independent variables (carbohydrate, fat, protein intake, and maternal nutritional status) on the dependent variable is the birth weight of the baby. The path analysis model built by researchers in accordance with the theory is examined and tested against sample data. The picture can be seen in Figure 1. The results of the factor path analysis show that there was a direct association between nutritional status and fat intake and birth weight. Pregnant women with nutritional status have a tendency to give birth to babies with a low weight of 38.65 units higher than the nutritional status of overweight (b= 38.65; 95% CI= 24.96 to 53.33; p<0.001). Pregnant women with high fat intake have a tendency to give birth to low-weight babies -0.75 units more than fat deficit intake (b= -0.75; 95% CI= -3.11 to 1.60; p= 0.010).

In addition there was a direct association between carbohydrate intake and birth weight. However, the association was not statistically significant.

Pregnant women whose carbohydrate intake was more likely to give birth to a normal infant body weight were 0.53 units higher than the deficit intake (b= 0.53; 95% CI= -0.48 to 1.54; p= 0.149).

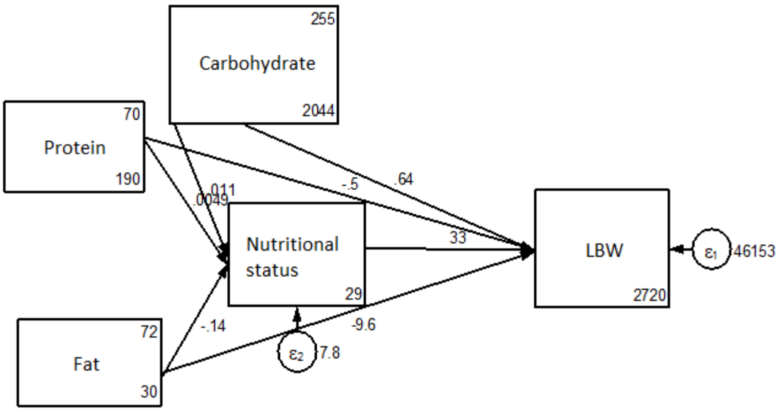

Figure 1. Path analysis model with estimation

There was a direct association between protein intake and birth weight, but the association was not statistically significant. Pregnant women whose protein deficit intake had a tendency to give birth to more than -0.53 units of infant weight compared with more protein intake (b= -0.53; 95% CI= -3.09 to 2.98; p= 0.729). Carbohydrate intake was directly associated to the nutritional status of the mother. Women whose carbohydrate intake are deficits have 0.02 less nutritional status compared to overweight nutritional status.

Table 3. Results of the path analysis of the association between nutritional status, intake of carbohydrates, fats, and proteins of pregnant women with birth weight.

Dependent Variables	Independent Variables	b	95% CI		p
			Lower limit	Upper limit	
Direct effect					
Birth weight	Nutritional status	38.65	24.96	53.33	<0.001
	Carbohydrate intake	0.53	-0.48	1.54	0.149
	Protein intake	-0.53	-3.09	2.98	0.729
	Fat intake	-0.75	-3.11	1.60	0.010
Indirect effect					
Nutritional status	Carbohydrate intake	0.02	0.01	0.03	0.047
	Protein intake	-0.00	-0.04	0.04	0.790
	Fat intake	0.02	-0.01	0.05	0.002
n observation = 120					
Log likelihood = -2593.94%					

DISCUSSION

1. The association between the nutritional status of pregnant women and infants birth weight

Pregnant women who are in weight monitoring is something that is important to consider during pregnancy, because this is an indicator of fetal growth and development and is also important for the process of preparation for breastfeeding. In the third trimester of pregnancy the fetus experiences very rapid growth and development. At this time mothers are encouraged to avoid overeating so that the weight gain does not exceed normal limits. Weight gain depends on body weight before pregnancy because it can affect the nutritional status. Weight gain during pregnancy varies depending on the culture and diet of the mother. The recommended increase of 7-13.5 kg of total pregnancy (Arisman, 2010).

Determination of the nutritional status of the mother is done by weighing weight and height from early pregnancy to the last weighing. Weighing must be routine to do, because it is useful to find out the weight gain of the mother during pregnancy. Weight gain is adjusted to the nutritional status of the mother before becoming pregnant. Mothers should routinely at least once a month during a visit (parity) to the integrated health service post, because to find out the condition of the womb such as the position of the baby, the baby's pulse, and the blood pressure of the mother in use to prevent preeclampsia. A study by Paramitasari et al. (2018) showed that parity in mothers is closely related to LBW events. Parity 1 or >3 is risk parity for pregnancy and child birth. Parity 1 can cause LBW because of lack of information and experience so that the mother's knowledge to meet nutrition and poor pregnancy care.

The results of this study indicate that there was an association between the nutritional status of pregnant women and birth weight. Pregnant women with more nutritional status can increase 38.65 units of birth weight (b= 38.65; 95% CI= 24.96 to 53.33; p<0.001). This is in line with a study by Khayati et al. (2016) which showed that the nutritional status of mothers during pregnancy had an effect on the incidence of LBW. Women with insufficient nutritional status had a 5.5 times greater risk than women with adequate nutritional status.

Maternal nutritional status before pregnancy and during pregnancy will affect the weight of the baby born. Pregnant women who have overweight nutritional status will have a risk for suffering from pregnancy diseases, such as gestational diabetes mellitus or giving birth to macrosomia compared to the group of pregnant women with normal weight (Catalano, 2012; Stuart and Amer-Wåhlin, 2017).

There is also another study that found that pregnant women who had more weight were significantly more at risk of giving birth to LGA (Large for Gestational Age) compared to pregnant women who had normal nutriational status (Poon et al., 2013). Metabolic conditions of the mother can affect the health of the mother for the future and will also affect the health condition of the baby in the future (Nielsen et al., 2016; Tumurbaatar et al., 2017).

2. The association between carbohydrate intake of pregnant women and birth weight

The results of the analysis showed that there was a direct association between carbohydrate intake of pregnant women and birth weight. However, the association is not statistically significant. Carbohydrate intake is increasingly more likely to give birth to infants with high weight compared with a deficit intake. The results of the recall carried out showed carbohydrate intake in pregnant women is quite high, but the association has a low significance. Food sources of carbohydrates that are often consumed are rice. Besides rice also consumes tubers, which are a source of complex carbohydrates. Complex carbohydrates take a long time to be converted into energy, so they don't get hungry fast.

This is not in accordance with the theory which stated that high consumption of carbohydrate intake will increase the amount of energy. A high amount of energy intake can increase the birth weight of a baby compared to the amount of a deficit carbohydrate intake (Santana et al., 2015). Besides consuming foods with low micronutrient content, such as vitamins and minerals can cause weight gain (obesity) in mothers, degenerative diseases, and baby born macrosomia. The content of vitamins and minerals can reduce the need for simple carbohydrates, because they have complex carbohydrate content which can cause a long feeling of fullness (Santana et al., 2015).

The main role of carbohydrates in the body is to provide glucose for body cells which are then converted into energy. High carbohydrate consumption, has a poor impact on pregnant women, because it can result in mothers becoming obese, suffering from diabetes mellitus pregnancy. Simple carbohydrates are more easily absorbed by the body, so it can increase the body to produce insulin (Malik et al., 2010). Conversely, pregnant women who are lacking in fulfilling carbohydrate intake and other nutrients can also result in low birth weight (LBW) (Mistry et al., 2012).

3. The association between fat intake of pregnant women and birth weight

Fat is the densest source of energy producing 9 kcal for each gram. Fat is the body's biggest energy reserve that comes from excessive consumption of food sources of fat (Almatsier, 2009). Changes in diet can affect the health conditions of the mother and fetus during pregnancy. Food intake, especially macronutrients, needs to be considered because if excess or lack of it has a negative impact on the mother and baby. A study by Josefson et al. (2014), showed the results of blood lipid concentrations significantly increased during pregnancy. Triglyceride concentration is related to birth weight and leptin concentration is related to birth weight. Leptin can significantly increase body fat percentage.

Fat is very important for pregnant women, which is unsaturated fat. The composition of unsaturated fatty acids, especially DHA and EPA fatty acids. Omega 3 fatty acids are beneficial for brain development and retinal health of the fetus. DHA serves to prevent the formation of pro-inflammatory arachidonic acid products (Rogers et al, 2013).

High intake of MUFA fat during pregnancy and trans fat can increase adipocytes and will be more susceptible to disease exposure. MUFA levels in pregnant women have an association with waist circumference being higher, high cholesterol levels, and insulin resistance (Maslova et al., 2017). The results showed there was no direct association between fat intake and birth weight and was not statistically significant. Increased fat intake will reduce 0.75 birth weight units. The results of the recall showed that the consumption of maternal fat is quite high, but babies born have a normal weight. The results showed that pregnant women often consume fat source foods such as meatballs.

As many as 4% of pregnant women in Tennessee have a healthy diet. The types of nutrient intake that are often consumed are high energy, higher saturated fatty acids, high consumption of simple sugars, high sodium, iron, zinc, meat, and low in consuming grains. The healthy menu available is from the nutritional menu of grains, nuts, and processed milk (Colón-Ramos et al., 2015). Babies born to pregnant women with unbalanced food intake have a fat mass of 24.9 grams more than pregnant women with a balanced diet (Bunney et al., 2017).

4. The association between protein intake of pregnant women and the weight of babies born

Protein requirements during pregnancy are almost the same as the amount of energy needs. Pregnant women's need for protein during pregnancy is about 68% increase compared to non-pregnant conditions. The amount of protein must be available and fulfilled until the end of pregnancy which is estimated at 925 grams. This amount is spread in maternal, placental, and fetal tissue (Arisman, 2010). Protein acts to stimulate insulin secretion. The main function of protein is for growth, but if the body lacks energy substances the function of proteins to produce energy or form glucose will take precedence. When glucose in the body is limited, protein will be used to form glucose and energy. The process of digesting protein is slower compared to carbohydrates. Starch grains have amylose and amylopectin chains arranged in a semi-crystalline form, so they can cause water-insoluble and can slow the digestion by the pancreas (Almatsier, 2009).

Consumption of high protein in a long time can cause an increase in fasting glucose levels, increased gluconeogenesis's (Pang et al., 2017). Gluconeogenesis is the synthesis or formation of glucose from precursors, such as amino acids, pyruvate, propionate, glycerol, galactose, lactate, and fructose. Gluconeogenesis occurs because glucose decreases in cells, so proteins and fats form new glucose which results in a buildup of glucose in the blood (Mary Greece, 2008). Protein and amino acids are modulators of metabolism and insulin sensitivity (Zhou et al., 2018).

The results showed there was no direct association between protein intake and birth weight and not statistically significant. Increased protein intake will decrease 0.53 units of birth weight. The recall result shows that pregnant women who consume food sources of protein are quite low. This is affected by food taboo still in the home environment. Sources of protein available from the sea or fresh fish, such as skipjack, boiled or other types of fish are not consumed. They believe if eating fish will make children become scaly, difficult to get out, even when born will smell fishy. So eating a source of protein consumed every day knows tempeh.

This study is not in line with the study of Danielewicz et al. (2017) conducted on a mouse sample showed that mice that experienced a lack of protein intake during pregnancy would result in weight loss of birth babies or low birth weight (LBW), decrease in heart weight, increase in heart rate, and in systolic blood pressure.

AUTHOR CONTRIBUTION

Brillia Firsti Winasandis was responsible for all scientific content of the article, conducting analysis, data interpretation and discussion, preparing manuscript drafts and making revisions. Didik Gunawan Tamtomo provided guidance starting from the concept of study to analyze data, make corrections start from data, results, discussion, and providing advice and motivation. Sapja Anantanyu provided guidance starting with concepts of the study to data analysis, correcting data, results, discussions, and providing advice and motivation.

CONFLICT OF INTEREST

The authors declare that there was no conflict of interests regarding the publication of this article.

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