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The final published version is available online here:

<https://doi.org/10.1177/10105395241248545>

Ab Aziz, M., Ai Kah, N., Ismail, M., & Majid, H. A. (2024). The prevalence and determinants of anemia among indigenous (Orang Asli) children in Peninsular Malaysia: A systematic review. *Asia Pacific Journal of Public Health*. © 2024 APJPH

Available online: <https://doi.org/10.1177/10105395241248545>

THE PREVALENCE AND DETERMINANTS OF ANAEMIA AMONG CHILDREN OF INDIGENOUS (ORANG ASLI) IN PENINSULAR MALAYSIA: A SYSTEMATIC REVIEW

ABSTRACT

Low- and lower-middle income countries bear the greatest burden of anaemia, particularly those living in rural settings like indigenous community. The objective of this systematic review is to recognise the prevalence of anaemia and its determinants among the Orang Asli children in Peninsular Malaysia. A web-based search of PubMed, Web of Science, Scopus, Medline, and ProQuest from January 2000 to June 2022 using specified search/MESH terms and keywords was conducted. The search identified studies that reported children of Orang Asli anaemia prevalence and its causes. Eight studies were included in the final analysis. The prevalence of anaemia among Orang Asli children was high (61.6%). Most research has focused primarily on iron-deficiency anaemia and soil-transmitted helminths infections. Other causes include female gender, mothers with low education levels, and low household incomes. Despite being a public health concern, this study found no studies associating Orang Asli children with hereditary anaemia and malaria, which is a limitation. In conclusion, the Orang Asli children are more likely to have anaemia compared to the general Malaysian population. To overcome this, a comprehensive examination of the determinants of anaemia in this community is required. Thus, interventions can be personalised.

Keywords: Anaemia, iron-deficiency anaemia (IDA), soil-transmitted helminths (STH), Orang Asli, children, Malaysia

What We Already Know

- Anaemia is one of the most frequent and challenging nutritional problems of today, affecting people of all ages, and it can affect anyone at any point in their lives.
- Anaemia is prevalent among the Orang Asli population regardless of age group.
- To date, the majority of research on anaemia has concentrated on iron-deficiency anaemia, particularly in females and young children. But only a few small-scale studies have been done on the marginalised indigenous group (Orang Asli).

What This Article Adds

- The prevalence of anaemia among Orang Asli is significantly greater (61.1%) than the national data (21.3%). However, the prevalence of anaemia varies significantly between studies.
- Anaemia is primarily attributed to iron-deficiency anaemia and soil-transmitted helminths. Nevertheless, it is crucial not to overlook the social factors influencing the health of this marginalised demographic, including female gender, maternal education level, and household income.
- Potential gaps were identified where there was a none of research on hereditary anaemia and malaria as a possible risk factor for anaemia among Orang Asli children.

1.0 INTRODUCTION

Anaemia is defined as a condition in which the number of red blood cells or the concentration of haemoglobin inside them is lower than expected.¹ According to the World Health Organisation (WHO), anaemia affects two billion people worldwide.² The higher prevalence is particularly affecting children, adolescent girls, women of reproductive age, and pregnant mothers.¹⁻³ This burden on human health, as well as on social and economic development, is enormous, and it affects both developing and developed countries.¹⁻³

Globally, iron deficiency is by far the most prominent cause of anaemia, which is why the terms "iron deficiency anaemia" (IDA) and "anaemia" are frequently used interchangeably, and the incidence of anaemia is commonly used as a proxy for IDA.² WHO mentioned that iron deficiency (ID) is associated with up to 50% of all instances of anaemia.² But ID is rarely observed in isolation. It is more frequently associated with a number of additional factors, such as parasite and malaria infection, dietary deficiencies, significant blood loss as a result of menstruation, and haemoglobinopathies.^{1,3-5} Socioeconomic factors such as illiteracy, gender norms, and poverty have also been identified as contributory factors to anaemia.⁵

According to the most recent National Health and Morbidity Survey (NHMS) for 2019, over 4.6 million Malaysians or 21.3% of the population were anaemic. Females were more likely to be affected than males (30.4% vs 12.6%).⁶ This was also demonstrated by a recent Orang Asli Health Survey 2022 (OAHS) conducted among Orang Asli women of reproductive age where the prevalence of anaemia was similar to NHMS 2019.⁷ Meanwhile, among the Orang Asli children, the most recent study conducted in 2021 revealed that up to 61% of this group were anaemic.⁸

Peninsular Malaysia is home to a tribe of indigenous Malaysians known as the Orang Asli. There are 18 ethnic groupings generally classified under the terms Negrito, Senoi, and Proto-Malay based on their physical characteristics, language preferences, and cultural practices.⁹ Orang Asli are a minority in Malaysia and are marginalised in socioeconomics, education, and health.¹⁰ Because of poor nutrition, social-emotional stress, early pregnancy, and parasite infections, they were more prone to anaemia than the general population.^{11,12}

Given the importance of anaemia to public health, it is notable that Malaysia has no centralised source that consistently reports the prevalence of anaemia among indigenous people, particularly Orang Asli. Simultaneously, a number of studies that concentrated on this population only looked at a single cause of anaemia at a time.^{6,12} They either examine nutritional issues, parasitic infections, or blood disorders exclusively rather than analysing the problem in its entirety, which is understandable given the complicated nature of the aetiology of anaemia.^{11,13} The objective of this systematic review is to synthesise and evaluate what is currently known in the peer-reviewed scientific literature about the prevalence of anaemia and its determinants among the indigenous (Orang Asli) children in Peninsular Malaysia.

2.0 METHODS

This review on the determinants of anaemia among Orang Asli was registered with PROSPERO, the International Prospective Register of Systematic Reviews (ID: CRD42022341971). In addition, this review was carried out in compliance with the guidelines

established by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020).

2.1 Eligibility criteria

PICOS (Participant, Intervention, Comparison, Outcomes, and Study Design) criteria were applied to the design of a systematic review:

- Participant: Children of Indigenous (Orang Asli) of Peninsular Malaysia
- Intervention/ exposure: Anaemia
- Comparison: Non-indigenous of Malaysia
- Outcomes: Prevalence of anaemia among the Orang Asli and its aetiology
- Study design: Randomised controlled trial (RCT), non-RCT, cohort, and cross-sectional studies

A systematic literature search was carried out to identify studies that reported on the estimated prevalence of anaemia among the Orang Asli people as a primary or secondary outcome. It focused on all possible causes of anaemia, including IDA, soil-transmitted helminths (STH), malaria, thalassemia, hemoglobinopathies, and others. Only peer-reviewed literature in the English and Malay languages were explored for this review.

This review excluded studies that did not report any outcome of interest, aged more than 12 years old, those conducted on the indigenous people of Sabah and Sarawak, studies that examined individuals according to specific disease groups (such as diabetes, rheumatoid arthritis, renal disease, etc.), and studies that examined indigenous plants, animals, molecular or specific genes. Studies deemed to be of poor (< 4 stars) or fair (4-6 stars) quality based on the Newcastle-Ottawa Quality assessment scale were also omitted.

2.2 Information source

A web-based search was carried out in PubMed, Web of Science, Scopus, Medline, and ProQuest. Searches of databases were complemented with grey literature, internet searches (e.g., Google Scholar), reference lists of articles included in the systematic review, and manual searches. The final search was undertaken on October 31, 2022.

2.3 Search strategy

Studies reporting on the prevalence of anaemia in free-living healthy populations and cohorts were identified using structured searches in PubMed, Web of Science, Scopus, Medline and ProQuest from January 2000 to June 2022. Cross-referencing pertinent article reference lists aided in rounding out the research.

The search procedure involved searching for terms that are found in the title, abstract, or keywords. The following keywords and MESH terms were used: "Anaemia" or "IDA" or "Thalassaemia" AND "Orang Asli" or "OA" or "Bumiputra" or "Aborigine" or "Indigenous" or "Tribe" or "Native" or "Senoi" or "Negrito" or "Proto-Malay" AND "Malaysia" or "Peninsular" or "Pahang" or "Perak" or "Kelantan" or "Terengganu" or "Johor" or "Malacca" or "Negeri Sembilan" or "Selangor" or "Kedah". All these words were utilised and combined with the search using Boolean terms such as "AND" and "OR".

2.4 Selection process

The screening of articles takes place in two stages. The first stage involved screening the titles and abstracts of all papers found through electronic searches. A second stage was then used to look at the full text of each article for screening. Bibliographic information such as author, publication year, title, study design, setting, inclusion and exclusion criteria, subject recruitment, age, gender, and the study duration and dates were all acquired. Any Malay-language papers were translated by one of the reviewers (M.A.A).

2.5 Data collection process

All the data gathered was uploaded into the Covidence Systematic Review software to manage and streamline the literature.

Using an inclusion form in the software, two investigators (M.A.A, V.R.S.) independently studied the abstracts of potentially suitable studies and evaluated the entire content of potentially eligible research. Disagreements from the first stage of screening were revisited later in the second stage of screening. Any disparities discovered during the second step of screening were resolved through discussions with the third reviewer (H.A.M) . Both reviewers had to extract data directly into tables of the software, or if one of the reviewers had already extracted the data, the second reviewer needed to review it for completeness and accuracy.

If there was insufficient information regarding research outcomes or other details, the original authors of the studies were contacted to obtain the missing information.

2.6 Data items

The following descriptive information was retrieved for each study: state, type of study design, study period, sampling frame, sampling method, response rate, participant age, and description of the indigenous community examined. The following data were included in the study findings: study location, age group, ethnicity, sample size, anaemia definition criteria, instruments used for diagnosing anaemia prevalence, anaemia prevalence comparisons between indigenous and non-indigenous populations, gender and age, public health significance and anaemia aetiologies.

2.7 Study risk of bias assessment

Adapted for cross-sectional, case-control, and cohort studies, the modified Newcastle-Ottawa quality assessment scale was used to evaluate observational studies. This method permits the incorporation of more efficient, objective, and reproducible assessments into systematic reviews. It evaluates selection, comparability, and outcomes, which are graded as "Good," "Fair," or "Poor" quality, respectively. Two reviewers separately assessed the risk of bias in each article, and any discrepancies were discussed with the third author. The results of the biased assessments were included in the tabulation.

2.8 Outcome measures

Effective measurements such as percentage, mean, mean difference, and odds ratios were utilised to synthesise and present results based on binary and continuous outcomes. Other calculations and statistics, such as quartiles, were also included in the evaluation.

2.9 Data synthesis

During the data synthesis, studies were grouped by indigeneity, gender and age in reporting on the prevalence of anaemia, the severity of public health significance, and the aetiology of anaemia, where data was available. The results were put together in a tabulation and visual display of methods.

The following are the WHO classifications that were used to gather the data needed and identify the prevalence of anaemia among indigenous populations in Peninsular Malaysia based on their public health significance:⁴

- i. no public health significance (anaemia prevalence < 4.9%)
- ii. mild public health significance (anaemia prevalence 5.0–19.9%)
- iii. moderate public health significance (anaemia prevalence 20.0–39.9%)
- iv. severe public health significance (anaemia prevalence > 40%)

3.0 RESULTS

3.1 Search results

The search of the databases PubMed, Web of Science, Scopus, Medline, and ProQuest yielded 133 possibly relevant studies, from which 80 duplicates were eliminated. After excluding 29 publications based on their titles and abstracts, 53 full-text articles remained to be evaluated for eligibility. Subsequently, 18 full-text papers that did not report the prevalence of anaemia, aged more than 12 years old, review or opinion articles, and duplicate material with different titles or authors were removed. Simultaneously, two eligible publications were found in the reference lists of articles included in the review. Finally, a total of 8 articles were considered for inclusion. There was good agreement between the two reviewers about the selection of full-text articles. None of the articles were found to have poor quality after quality evaluation. Thus, all 8 research were included in the synthesis. Figure 1 displays the screening procedure outcomes in detail using the PRISMA flow diagram.

“INSERT FIGURE 1 HERE”

3.2 Study characteristics

Table 1 provides a summary of the results of this systematic review. This evaluation took into account a total of 8 research studies that were all cross-sectional in design. The studies were conducted in Pahang (n = 3), Terengganu (n = 1), Negeri Sembilan (n = 1), Peninsular Malaysia (n = 1), and Malaysia (n = 2). The majority of the participants in this study (n = 5) were children aged between 7 to 12 years old who volunteered after receiving parental consent.^{8,11,12,14,15} Most of the studies (n = 6) were conducted in Orang Asli communities,^{8,11,13,14,16,17} which can be further subdivided into subethnic groups, with one study conducted on Negritos⁸ and one on Proto-Malay.¹⁶ Other studies (n = 2) were conducted among the general population of Malaysia,^{12,15} which included Orang Asli individuals. Only three studies differentiated the population sample by the gender of the participants.^{11,13,17} Equal number of studies used either haemoglobinometer^{8,11,13,14} or full blood count^{12,15-17} to measure haemoglobin level in order to diagnose. It is important to note that only four studies used the 2011 WHO anaemia guideline

cut-off value as a reference, accounting for age.^{12,15-17} The remaining studies either employed alternative cut-off values (n = 3)^{11,13,14} or did not report the value at all (n = 1).⁸

“INSERT TABLE 1 HERE”

3.3 Quality assessment

All (n = 8) of the studies were regarded as being of good quality.^{8,11-17} None were deemed as fair or poor quality. It is important to highlight that all studies included in this systematic review were cross-sectional studies only, and the results are summarised in Table 2.

“INSERT TABLE 2 HERE”

3.4 Prevalence of anaemia among Orang Asli and its public health significance

The prevalence of anaemia among Orang Asli varied from 4% to 61.6% overall. A local study conducted among the Negrito subethnic group revealed the greatest frequency of anaemia (61.6%).⁸ The lowest prevalence was seen among Malaysian primary school children (4%); however, the prevalence of anaemia among the indigenous population was substantially greater in this study (9.9%) than among their counterparts (3.3%).¹² Three studies reported their gender comparison results. Two research concluded that males have a higher prevalence of anaemia than females,^{11,13} while the other investigation concluded otherwise.¹⁷

Using a classification that WHO proposed for the public health significance of anaemia, this review discovered that four of the studies (50.0%) had severe public health significance,^{8,11,14,18} three of the studies were classified as moderate,¹⁵⁻¹⁷ and only one study stated mild health significance.¹²

3.5 Determinants of anaemia among Orang Asli

There are a number of potential causes of anaemia, some of which might be considered independent contributors. But the vast majority are interconnected. In order to find the determinants of anaemia, the results of this review were separated into nutritional causes, infectious causes, genetic causes, and others. The outcomes are summarised in Table 1.

Only four of the eight studies examined nutritional factors as a cause of anaemia.^{11,14,15,17} These investigations have all implicated IDA as one of the causes of anaemia. Among the Orang Asli, the prevalence of IDA ranged between 9.1% and 34.0%. Orang Asli children in Pos Betau, Pahang exhibited the highest prevalence of IDA (34.0%).¹¹ Meanwhile, Tan et al. (2022) found the lowest prevalence of anaemia among Orang Asli (9.1%) in a survey of Malaysian children.¹⁵ In addition, two of the studies also compared IDA prevalence with gender^{11,17} and determined that females have a higher incidence of IDA than males.

Two studies looked at other nutritional deficiencies.^{11,15} A study done among Orang Asli in Pahang, found the total percentage of children with low serum ferritin (< 10 g/l), serum iron (< 10.6 mol/l), and percentage of total serum (< 16%) concentrations was 26.1%, 49.4%, and 52.7%, respectively, and high TIBC (> 75 mol/l) was reported in 63.9% of the children.¹¹ Meanwhile, another study found that there were significantly lower concentrations of retinol, retinol binding protein (RBP), α -carotene, and haemoglobin (Hb). Simultaneously, these Orang Asli schoolchildren had significantly higher levels of α -tocopherol, β -carotene and high sensitive C-reactive protein (hs-CRP).¹⁵

The infection that cause anaemia from soil-transmitted helminths was investigated in two separate studies.^{13,17} Infection with either *T. trichiasis*, *A. lumbricoides* or STH polyparasitism was identified as a risk factor for anaemia among the Orang Asli children in both of the studies included in this analysis.^{13,17} The probability of having anaemia was as high as 8-fold compared to those non-infected with STH.

Few additional causes of anaemia merited a mention in this systematic review. Current findings discovered that females are more likely than males to suffer from anaemia.¹¹ Age has been investigated in two studies as a factor in anaemia, which all showed children have an increased likelihood of anaemia.^{11,13} Two studies indicated that low-educated mothers are more likely to have children with anaemia.^{11,17} Moreover, non-working mothers are twice as likely to have a child with anaemia in one of the studies.¹⁷ Two studies examined the association between household income and anaemia, where having a low household income increases the probability of having children with anaemia twofold.^{11,17} In one of the papers that were reviewed, anthropometric measurements were used as an indicator of anaemia risk among Orang Asli children. It concluded that anaemia is associated with a greater risk of stunting than normal height.¹⁶ Fascinatingly, this review did find one study examining the relationship between IDA and cognitive function and academic achievement in Orang Asli schoolchildren, where children with IDA had significantly lower intelligence quotient (IQ) scores and total education scores than children without anaemia.¹⁴

No research has been discovered regarding the genetic factor, and the rationale for the lack of findings will be elucidated in the discussion segment.

4.0 DISCUSSION

This is the first systematic review of the prevalence, severity, and determinants of anaemia in the Orang Asli children in Malaysia. This review found that there has been few national-level research on anaemia in this population over the last two decades.^{12,15} In this review, only eight studies were identified to have primary or secondary objectives of examining anaemia as a cause.

Almost all research (n = 6) on anaemia among Orang Asli children focused on primary schoolchildren with greater emphasized on IDA (n = 4)^{11,14,15,17} and STH (n = 2)^{13,17} as aetiologies of anaemia. In recent years, there has been a greater emphasis on child-related concerns and enhancing their health. The growing body of evidence demonstrated that childhood health lays the groundwork for adult health.¹⁹ Another probable explanation is that it is difficult and expensive to obtain statistics on indigenous populations. Indigenous communities are typically located in rural and isolated areas and constitute a small percentage of the total population of a nation.²⁰ It is therefore much easier for the researcher to catch these Orang Asli children and have them undergo screening and intervention during school sessions.

On the basis of this analysis, the prevalence of anaemia among Orang Asli children is significantly greater (61.6%)⁸ than the national data (21.3%).⁶ However, the prevalence of anaemia varies significantly between studies. The Negrito tribes, the smallest of the three primary tribes of the Orang Asli group, were the focus of a study by Yee et al.,⁸ who had displayed the highest prevalence. This tribe has unique characteristics as a nomadic forager and is the most economically backwards among the other Orang Asli ethnic groups, which

contributes to the higher prevalence of anaemia.⁹ When comparing indigenous populations around the world to their own general population, the prevalence of anaemia is constantly higher, independent of the income level of the country.^{20,21} Although Malaysia as a whole has made substantial advances in population health since their independence in 1957, the Orang Asli have a marginalised health condition compared to other ethnic groups in Malaysia.^{22,23} Over the past 50 years, the Malaysian government has assisted the Orang Asli population by enhancing their educational quality, upgrading their basic facilities, enhancing the quality of their medical services and health status, and involving them in a resettlement programme.²³ Despite these efforts, the prevalence of anaemia among the Orang Asli people has not changed significantly and has deteriorated in the past year, particularly during the COVID-19 pandemic.²⁴

This review includes only four studies^{11,14,15,17} investigated nutritional components as a possible cause of anaemia. All of the research focused primarily on IDA as a cause of anaemia, where IDA prevalence reached 34.0%.¹¹ This was slightly lower to WHO data, where 50% of anaemia cases are caused by iron deficiency.² However, nutritional deficiency is not only caused by inadequate iron intake. It also includes inadequate intake of other dietary supplements (e.g., Vitamins A, B12, B6, C, D, and E, folate, riboflavin, copper, and zinc), altered nutrient metabolism (e.g., Vitamin A or riboflavin deficiency affecting mobilisation of iron stores), increased nutrient losses (e.g., blood loss from parasites, haemorrhage associated with childbirth, or heavy menstrual losses).^{25,26} Being an Orang Asli children, which is a group that is well-known for being marginalised, will magnify the effect of this and lead to a higher prevalence of IDA.

STH was the focus of two^{13,17} of papers for this review as an aetiology of anaemia. In all of these studies, infection with *T. trichiasis*, *A. lumbricoides*, or mixed worms was found to have a substantial correlation with anaemia. This was consistent with indigenous group research conducted either locally or internationally.²⁷⁻³⁰ STH causes anaemia in multiple ways among those it infects. Worms could consume host tissues, such as blood, resulting in a loss of iron, Vitamin A and protein, leading to anaemia.^{27,30} In addition, STH can also cause appetite loss, which leads to a reduction in nutrient intake and physical fitness. Even though effective interventions, such as the Health Education Learning Package (HELP), have been employed to reduce the prevalence of STH among the Orang Asli children, the disease is still exceedingly prevalent in this group. This may be the result of a severe lack of personal hygiene, an unimproved source of drinking water, and inadequate WASH facilities.^{31,32}

In areas where malaria is endemic, malaria control can reduce anaemia (25%) and severe anaemia (60%).³³ Malaysia is one of the 21 WHO E2020 nations designated as malaria-free by the year 2020.³⁴ Over the course of the last two decades, research carried out in Malaysia has revealed that the indigenous community is prone to suffering from malaria.^{35,36} However, no studies has been done among children of Orang Asli. Majority of the investigations on malaria were conducted in Borneo, Malaysia, which place restrictions on this research.³⁷ Yet, studies conducted in Sabah do indicated that anaemia was prevalent among children, and *P. knowlesi* infection was associated with moderately severe anaemia.^{38,39}

Although IDA is the most common cause of anaemia worldwide, hereditary anaemias such as thalassemia, G6PD deficiency, and sickle cell disease are also significant causes.⁴ Their incurable nature and high incidence of psychological and physical disabilities account for a

disproportionate share of morbidity and mortality, placing a substantial strain on healthcare systems.^{40,41} Despite being a public health concern, this review was unable to identify any studies associating anaemia among Orang Asli children with hereditary anaemia. This will be considered the most significant shortcoming of this systematic review. Orang Asli, like many other indigenous groups worldwide, have a high rate of consanguineous marriages at an early age and large average family size.^{42,43} Consequently, the recessive gene associated with inherited diseases will likely manifest itself in these populations over the centuries.

Other potential intermediate causes of anaemia identified by this review include female gender,¹¹ having a mother with low education level,^{11,17} and having a low household income of less than RM500 per month.^{11,17} Due to a lack of income and other resources that prohibit them from consuming a diet with sufficient, well-absorbed iron, the Orang Asli children are at a greater risk of developing anaemia. Iron is a micronutrient with high income elasticity. As family finances increase, families tend to purchase more meat, which contains iron that is more readily absorbed than the iron found in the majority of plant foods.⁴⁴ Additionally, poverty may impede the poor from using health facilities.⁴⁵ The inability to pay for mother and child health services, iron supplements, malaria and deworming drugs, and other preventive measures increase the risk of anaemia. In addition, many Orang Asli have a low level of education, and a lack of understanding regarding anaemia will contribute to its increased prevalence.³ They may not realise that it is a significant contributor to ill health, nor may they be aware of preventive behaviours. Orang Asli cultural prejudices and taboos (such as those limiting particular meals or requiring women to eat after others have done so) also contribute to anaemia risk, as do noncompliance with iron and folic acid (IFA) supplements and malaria or STH treatments.¹⁰

5.0 STRENGTHS AND LIMITATIONS

This is the first study of its kind to comprehensively evaluate and discuss the prevalence of anaemia and its determinants among the Orang Asli children of Peninsular Malaysia. In order to reduce the possibility of bias, grey literature was also incorporated into the evaluation of the study quality.

However, one of the limitations of this systematic review is that it only includes material published after the year 2000, despite the fact that the issues regarding Orang Asli have been a concern since the Malaysian Independence Day in 1957 and have remained stagnant since then. In addition, the cross-sectional form of all the articles included in this evaluation makes it difficult to establish a causal relationship between the associated factors and the outcomes. This review also highlighted the asymmetry of the selected articles, where half of them are either on nutrition or worm infestation.

6.0 CONCLUSION

In conclusion, the Orang Asli children have a greater prevalence of anaemia than the general Malaysian population, notably due to nutritional deficiency and STH. A comprehensive study into the specific aetiology of anaemia within this Orang Asli children is necessary in order to address this anaemia issue. Consolidated efforts among stakeholders, including the Ministry of Health, Ministry of Education, JAKOA, Department of Social Welfare, and community partners, are crucial in improving the health results of the Orang Asli community compared to

previous years. The priority is to address the disparities in healthcare access, implement targeted nutritional interventions, and develop customised educational approaches to tackle anaemia among the Orang Asli community effectively. This not only improves health outcomes within this Orang Asli children but also helps in reducing health disparities among these marginalised populations, improving equitable healthcare strategies in Malaysia.

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TABLES

Table 1: Prevalence, public health significance and determinants of anaemia among indigenous (Orang Asli) in Peninsular Malaysia

Study	Study location	Age group (years)	Ethnic	Sample size	Definition anaemia (Hb)	Instruments	Prevalence of anaemia	Public health significance	Determinants			
									Nutritional	Infection	Genetic	Others
Ahmed A et al., 2012 ¹³	Pahang	6-12	OA	N: 289 M: 140 F: 149	<12g/dL	Haemoglobinometer	O: 41% M: 45.1% F: 37.1%	Severe	NR	Moderate-to-heavy ascariasis: OR 2.05 (95%CI= 1.12, 3.76; p= 0.021)	NR	Age <10 years: OR 2.11 (95%CI= 1.23, 3.63; p= 0.007)
Al-Mekhlafi et al., 2011 ¹⁴	Pahang	7-12	OA	N: 241	<12.0g/dL	Haemoglobinometer	48.5%	Severe	IDA (n=82): 34%	NR	NR	Children suffering IDA had significantly lower IQ scores than non-anaemic children (t= 2.140; P=0.033) Children suffering from IDA (t= 2.460; P= 0.007) had significantly lower TS scores than children without IDA

Al-Mekhlafi et al., 2008 ¹¹	Pahang	7-12	OA	N: 241 M: 120 F: 121	<12.0g/dl	Haemoglobinometer	O: 48.5% M: 53.3% F: 43.8%	Severe	IDA (n=82): O: 34.0% M: 27.5% F: 40.5%	NR	NR	Age ≤10 years (76.8%): OR 1.7 (95% CI: 1.0, 3.2; p= 0.049) Female (59.8%): OR 3.6 (95% CI: 1.7, 8.4; p= 0.033) Low mothers' education (<6 years) (91.5%): OR 3.7 (95% CI: 1.6, 8.7; p= 0.001) Low household income (<RM450) (89.0%): OR 2.5 (95% CI: 1.2, 5.6; p= 0.016)
Fatihah et al., 2018 ¹⁶	Negeri Sembilan	2-6	Proto-Malay	N: 264	<11g/dL (<5y) <11.5g/dL (≥5y)	Full Blood Count	O: 21.6%	Moderate	NR	NR	NR	Anaemic children were 2.742 times (95% CI= 1.265, 5.945; p=0.011) more likely to become stunted

Ngui et al., 2012 ¹⁷	Peninsular Malaysia	1-12	OA	N: 550 M: 254 F: 296 1-6: 30 7-12: 520	<11g/dL (6-59m) <11.5g/dL (5-11y) <12.0g/dL (≥12y)	Full Blood Count	O: 26.2% M: 24.0% F: 28.0% 1-6: 36.7% 7-12: 25.6%	Moderate	ID (n=302): O: 54.9% M: 50% F: 59.1% 1-6: 26.7% 7-12: 16.3% IDA (n=93): O: 16.9% M: 15.7% F: 17.9% 1-6: 26.7% 7-12: 16.3%	T. trichiura: OR 2.15 (95%CI= 1.21, 3.81; p= 0.008) A. lumbricoides infections: OR 1.63 (95%CI= 1.04, 2.55; p= 0.032)	NR	Low level of mother's education: OR 2.52 (95%CI= 1.38, 4.60; p = 0.002) Non-working parents: OR 2.18 (95%CI= 2.06, 2.31; p= 0.013) Low household income: OR 2.02 (95%CI= 1.14, 3.59; p= 0.015)
Nik Shanita et al., 2018 ¹²	Malaysia	7-12	General	N: 544 I: 59 NI: 485	<11.5g/dL (5-11y) <12.0g/dL (12-14y)	Full Blood Count	O: 4% I: 9.9% NI: 3.3%	In terms of overall prevalence, it has no public health significance but it does have a mild public health significance for indigenous groups.	NR	NR	NR	NR

Tan et al., 2022 ¹⁵	Malaysia	7-12	General	N: 776	<11.5 g/dL	Full Blood Count	O: 14.9%	In terms of overall prevalence, it has mild public health significance but it does have a moderate public health significance for indigenous groups.	ID: O: 12.8% I: 17.9% NI: 3.6% IDA: O: 6.1% I: 9.1% NI: 0.7% Low retinol: 0.83 µmol/l (P25:0.69, P75:0.97) Low RBP: 0.70 µmol/l (P25:0.58, P75:0.82) Low α-carotene: 0.06 µmol/l (P25:0.04, P75:0.08) Low Hb: 124.0 g/l (P25:117.0, P75:129.0) Low ferritin: 35.0 µg/l (P25:19.5, P75:62.5) High α-tocopherol: 8.03 µmol/l (P25:6.94, P75:9.25) High β-carotene: 0.30 µmol/l (P25:0.20, P75:0.43) High hs-CRP: 0.2 mg/l (P25:0.2, P75:1.2)	NR	NR	NR
Yee et al., 2021 ⁸	Terengganu	7-12	Negrito	N: 77	NR	Haemoglobinometer	O: 61.6%	Severe	NR	NR	NR	NR

Abbreviations: Hb, haemoglobin; OA, Orang Asli; N, number; M, male; F, female; I, indigenous; NI, non-indigenous; YO, years old; NR, not reported; O, overall; ID, iron deficiency; IDA, iron-deficiency anaemia; SF, serum ferritin; SI, serum iron; TIBC, total iron binding capacity; RBP, retinol binding protein; hs-CRP, high sensitivity C-reactive protein; STH, soil-transmitted helminth; IQ, intelligence quotient; IJV, inland jungle village; RPS, resettlement plan scheme; OR, odd ratio; CI, confidence interval

Table 2. Summary of Quality Assessment of the included studies using the Newcastle-Ottawa Quality Assessment Scale (adapted for cross-sectional studies)

Studies	Selection			Ascertainment of the Exposure (Risk Factor)	Comparability		Outcome		Score Quality
	Representativeness of the Sample	Sample Size	Non-Respondents		Comparability	Assessment of the Outcome	Statistical Test		
Ahmed A et al., 2012	*	*	*	*	**	**	*	Good (4+2+3)	
Al-Mekhlafi et al., 2011	*	*	*	*	**	**	*	Good (4+2+3)	
Al-Mekhlafi et al., 2008	*	*	*	*	**	**	*	Good (4+2+3)	
Murtaza et al., 2018	*	*	*	*	**	**	*	Good (4+2+3)	
Ngui et al., 2012	*	*	*	*	**	**	*	Good (4+2+3)	
NikShanita et l., 2018		*	*	*	**	**	*	Good (3+2+3)	
Tan et al., 2022	*	*		*	**	**	*	Good (3+2+3)	
Yee et al., 2021	*	*		*	*	*	*	Good (3+1+2)	

Quality score: Overall scores were given (good, fair, and poor).

Good quality: 3 or 4 stars (*) in the selection domain AND 1 or 2 stars in the comparability domain and 2 or 3 stars in the outcome domain;

Fair quality: 2 stars in the selection domain and 1 or 2 stars in the comparability domain and 2 or 3 stars in the outcome/exposure domain;

Poor quality: 0 or 1 star in the selection domain OR 0 stars in the comparability domain OR 0 or 1 stars in the outcome/exposure domain.

FIGURES

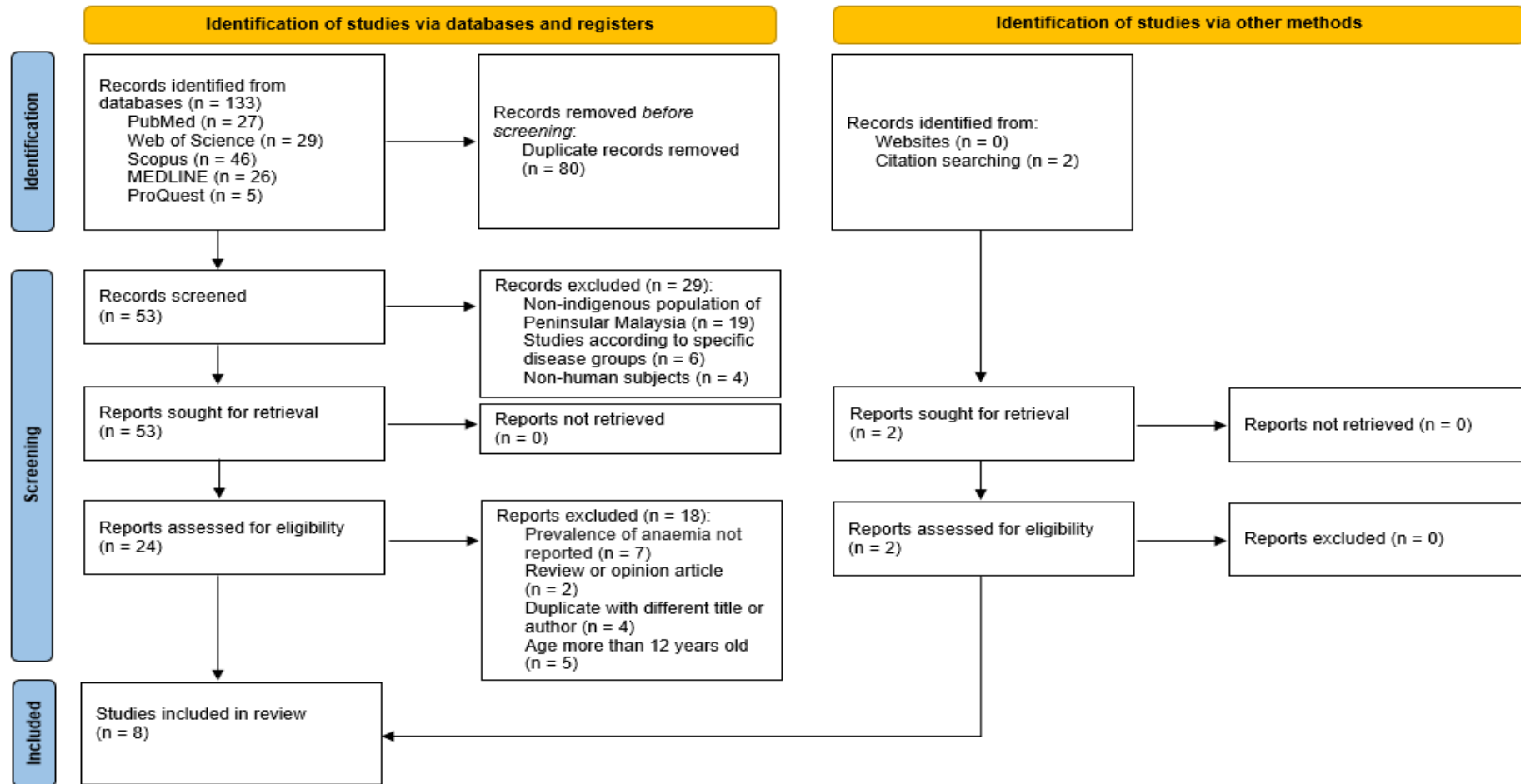


Figure 1: The Preferred Reporting Items for Systematic reviews and Meta-Analysis (PRISMA) flow diagram for searching, screening, and selection process