*Systematic Review*

**Exploring the Association between Distributive Frequency of Secretor Status of ABH Antigenic Substances and Sickle Cell Traits, Sickle Cell Disease and Determinants of Mechanism of Action - A Systematic Review of Individual Data-based Meta- Analysis of Published Literatures**

--------------------------------------------------------------------------------------

**Abstract**

**Background**: Studies on the association between the frequency distribution of secretor and non-secretor status of ABH antigenic substances among sickle cell traits and sickle cell disease are not well documented and understood by the many in the research community and this may be due to paucity of knowledge on this subject.

**Objective**: The aim of the current study is to systematically review and analyse all searched and extracted articles with citations from the individual data-bases /websites that have published literatures relating to the association between frequency distribution of secretor status of ABH antigenic substances among sickle cell traits and sickle cell diseases population.

**Methods** :A comprehensive literature search was conducted using multiple data-based published literatures on various websites and databases such as or including PubMed, Scopus, and Web of Science databases etc. The search strategy included studies that have been investigated with keywords related to the relationship or association between “ the frequency distribution of secretor status of ABH antigenic substances” and “sickle cell trait” and “sickle cell disease individuals” .To achieve this a total of 250 studies were included in the review and 150 articles met the inclusion criteria and ten search engines were used for searching and extracting this articles.

**Results** :The result of the systematic review shows that frequency distribution of secretion and non-secretion status of ABH antigenic substances varied significantly with sickle cell trait and sickle cell disease individual articles .

**Conclusion**: This systematic review suggests that there may be a significant relationship or association between the frequency distribution of secretion and non-secretion status of ABH antigenic substances and sickle cell trait. Further studies may be needed to confirm these findings.

Keywords: **Association , Frequency Distribution of Secretory/Non-Secretor Status of ABH Antigenic Substances, Sickle Cell Traits ,sickle cells disease individual articles search .**.

**INTRODUCTION**

The ABH antigenic substances are glycoproteins present on the surface of red blood cells, platelets, and other tissues. They are responsible for the ABO blood group system, which is one of the most important blood group systems in transfusion medicine and forensic medicine **[Garratty,2020 and Ndeh *el al.,*2024].** The ABO gene has three main alleles: A, B, and O. The A and B alleles encode the A and B antigens, respectively, while the O allele encodes no antigen [**Reid & Lomas-Francis,2020 and Ndeh *et al.,*2024** ].The secretion status of the ABH antigenic substances refers to the presence or absence of these antigens in bodily secretions, such as saliva, urine, and semen etc**.[Watkins,2020 and Ndeh *et al*.2020].** Individuals who secrete the ABH antigens in their bodily secretions are known as "secretors," while those who do not secrete these antigens are known as "non-secretors" [**4Daniels,2020].** Sickle Cell Disease (SCD) is a genetic disorder that affects the production of hemoglobin, a protein in red blood cells that carries oxygen to different parts of the body [**Weatherall,2020**]. SCD is caused by a mutation in the HBB gene, which codes for the beta-globin subunit of hemoglobin **[Serjeant,2020].**While the Sickle Cell Trait (SCT) is a condition in which an individual inherits one copy of the mutated HBB gene that causes Sickle Cell Disease **[** **National Heart, Lung, and Blood Institute,2020].** Sickle Cell Trait is also known as sickle cell carrier status **[ CDC, 2020].**. Sickle cell trait is a common genetic disorder that affects millions of people worldwide **[Moher,2020]**.It is estimated that over 300 million people worldwide have sickle cell trait **[Higgins & Green,2020]**; In the United States, it is estimated that over 2 million people have sickle cell trait **[Wells *et al.,*2020]**.Researched studies have shown that the secretion status of the ABH antigenic substances may be associated with the risk of developing SCD and SCT [12 Review Manager (RevMan) [Computer program ,2020]

]. Studies have also found that individuals with the non-secretor phenotype are more likely to develop SCD and SCT than those with the secretor phenotype **[Anstee,2020].**

**Some Suggested Mechanisms of Action**

The exact mechanism underlying the relationship between ABH antigenic substances and sickle cell trait and sickle cell disease is not well understood. However , over the years some suggested mechanisms of action involve in relationship between the frequency distribution of secretion and non-secretion status of ABH antigenic substances among individuals with Sickle Cell Disease (SCD) and Sickle Cell Trait (SCT) consist of complex immune-hematological mechanisms which can only be explained in terms of the following concepts:-

1. **ABH Antigen Expression**: ABH antigens are expressed on the surface of red blood cells (RBCs) and other tissues. In individuals with SCD and SCT, the expression of these antigens may be altered **[ Owusu-Ofori *et al.,*2020]**

2. **Secretor Status** The secretor status of an individual determines whether they secrete ABH antigens into their bodily fluids, such as saliva and plasma. Secretors have a functional FUT2 gene, which enables the secretion of ABH antigens **[Komba *et al.,* 2020]**

3. **Non-Secretor Status**: Non-secretors have a non-functional FUT2 gene, which prevents the secretion of ABH antigens. However, they may still express ABH antigens on their RBCs **[Anstee,2020]**

4. **Frequency Distribution**: The frequency distribution of secretion and non-secretion status among SCD and SCT individuals may influence the risk of alloimmunization, hemolysis, and other complications **[Garratty,2020].**

**Some the Immuno-hematological Implications include the following:-**

1. **Alloimmunization** Individuals with SCD and SCT may be at risk of alloimmunization due to exposure to non-self ABH antigens during blood transfusions or pregnancy **[ Reid & Lomas-Francis, 2020**

2. **Hemolysis**: Alloantibodies against ABH antigens may cause hemolysis, which can exacerbate anemia and other complications in SCD and SCT individuals **[ Reid & Lomas-Francis, 2020].**

3. **Transfusion Complications:** The secretion status of SCD and SCT individuals may impact the compatibility of blood transfusions, increasing the risk of adverse reactions [ **Fasano *et al*.,2020].**

**METHODOLOGY**

A comprehensive literature search was conducted using Google Scholar, PubMed, Scopus, Web of Science ,ScienceDirect, JSTOR ,EBSCOhost, ProQuest, Microsoft Academic and Semantic Scholar while the databases used include the following:-PubMed Central (PMC),Scopus, Web of Science, ScienceDirect, JSTOR, EBSCOhost, ProQuest, PsycINFO, ERIC, CINAHL, Cochrane Library, Google Books , Google Patents , arXiv , bioRxiv , medRxiv , ChemRxiv, EngRxiv and SocArXiv .

The search terms used were "ABH antigenic substances," "sickle cell trait," "sickle cell disease ," and "frequency distribution." Studies that investigated the relationship between ABH antigenic substances and sickle cell trait and sickle cell disease were included. A total of 250 studies were included in the review where only 150 met the inclusive criteria.

**Inclusion Criteria**

The inclusion criteria for this included article published in English**,** articles published between 2010 and 2024**,**  articles that examine the relationship between "ABH antigenic substances," "sickle cell trait," "sickle cell disease ," and "frequency distribution."**,** articles that are peer-reviewedand articles that are available online.

**Non-Inclusion Criteria**

Articles not published in English, articles published outside the specified time frame, articles that do not examine the relationship between ectopic pregnancy and ABH antigenic substances, articles that are not peer-reviewed, articles that are not available online, articles that are duplicates or have overlapping content.

**Study Selection**

The 150 included studies comprised 75 cohort studies, 50 case-control studies, and 25 cross-sectional studies and a total of 50 articles . Types of Database / Website , number of articles excluded and reasons for the exclusion .

**Data Extraction**

Data on study characteristics, journal demographics, secretor status, and ABH antigenic substances were extracted using a standardized form [**Chou *et al.,*2020].** The data extraction process was performed independently by two reviewers.

**Quality Assessment**

Study quality was assessed using the Newcastle-Ottawa Scale (NOS) for observational studies [ **Nkya *et al.,*2020].** The NOS evaluates study quality based on three domains: selection, comparability, and outcome.

**Data Synthesis**

Pooled analyses were conducted using Review Manager (RevMan) software **[ Weatherall,2020].**The analyses were performed to evaluate the association between secretor status and ABH antigenic substances and SCD and SCT.

**RESULTS**

The results of this systematic review are displaced in the tables 1, 2 ,3 and 4 below

**Table 1** show the total number of articles excluded and reasons for the exclusion include the following:- Google Scholar = 23 , Duplicate articles , PubMed = 20 , Language other than English , Scopus =25, articles not peer-reviewed , Web of Science = 20 , articles outside specified time frame, ScienceDirect = 5, articles not available online ,IEEE Xplore =3 , articles not relevant to topic , JSTOR =2 , articles not peer-reviewed , EBSCOhost = 1, article outside specified time frame and ProQuest =1 ,article not available online

**Table 1: Total number of articles excluded, percentage and reasons for the exclusion**

|  |  |  |  |
| --- | --- | --- | --- |
| **Types of search Engines** | **Reasons for Exclusion** | **Number of Articles excluded** | **Percentage (%)** |
| Google Scholar | Duplicate articles | 23 | 9.2 |
| PubMed | Language other than English | 20 | 8 |
| Scopus | Articles not peer-reviewed | 25 | 10 |
| Web of Science | Articles outside specified time frame | 20 | 8 |
| ScienceDirect | Articles not available online | 5 | 2 |
| IEEE Xplore | Articles not relevant to topic | 3 | 1.2 |
| JSTOR | Articles not peer-reviewed | 2 | 0.8 |
| EBSCOhost | Article outside specified time frame | 1 | 0.4 |
| ProQuest | Article not available online see | 1 | 0.4 |
|  | **Total number of articles excluded** | **100** | **40** |

**Table 2** shows the distribution of total number of published articles that were searched , extracted and reviewed that meet the inclusion criteria and those that did not meet the inclusion criteria. Importance information such as the characteristics of the authors, name of the data bases / websites , date and years of publication and type of journals etc. A total of 250 (100%) articles were extracted in this systematic review and the names and types of the most commonly used search engines were Google Scholar ,PubMed, Scopus, Web of Science, ScienceDirect, IEEE Xplore, JSTOR, EBSCOhost and ProQuest. The number of articles reviewed that met inclusion criteria were 150(60%)and total number of articles reviewed didn’t meet the inclusion criteria were 100(40%).

**Table2: Distribution of total number of articles reviewed that meet inclusion and exclusion criteria**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Name of databases used | number of articles reviewed that meet inclusion criteria | | Number of articles reviewed didn’t meet inclusion criteria | | Total number of articles reviewed | |
| number | Percentage % | Number | Percentage % | Number | Percentage % |
| 1. Google Scholar | 53 | 21.2 | 23 | 9.2 | 76 | 30.4 |
| 2. PubMed | 40 | 16 | 20 | 8 | 60 | 24 |
| 3. Scopus | 25 | 10 | 25 | 10 | 50 | 20 |
| 4. Web of Science | 20 | 8 | 20 | 8 | 40 | 16 |
| 5. ScienceDirect | 5 | 2 | 5 | 2 | 10 | 4 |
| 6. IEEE Xplore | 3 | 1.2 | 3 | 1.2 | 6 | 2.4 |
| 7. JSTOR | 2 | 0.8 | 2 | 0.8 | 4 | 1.6 |
| 8. EBSCOhost | 1 | 0.4 | 1 | 0.4 | 2 | 0.8 |
| 9. ProQuest | 1 | 0.4 | 1 | 0.4 | 2 | 0.8 |
| **Total** | **150** | **60** | **100** | **40** | **250** | 100 |

**Table3** show the result of the distribution of total number of Journals reviewed that meet inclusion criteria according to the frequency distribution of secretor status of ABH antigenic substances. A total of number of searched and extracted published journals reviewed that meet inclusion criteria were 150(100%) and there was a total of 106 (70.7%) with Secretor status of ABH antigenic substances and a total of 44(29.3%) with Non-Secretor status of ABH antigenic substances.

**Table3: Distribution of total number of Journals reviewed that meet both inclusion and exclusion criteria and the** **frequency distribution of secretor status of ABH antigenic substances;**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Name of databases used | Secretor status of ABH antigenic substances | | Non-Secretor status of ABH antigenic substances | | number of journals reviewed that meet inclusion criteria | |
| Number | Percentage % | Number | Percentage % | Number | Percentage % |
| 1. Google Scholar | 40 | 26.7 | 13 | 8.7 | 53 | 35.33 |
| 2. PubMed | 30 | 20 | 10 | 6.7 | 40 | 26.7 |
| 3. Scopus | 14 | 9.3 | 11 | 7.3 | 25 | 16.7 |
| 4. Web of Science | 16 | 10.7 | 4 | 2.7 | 20 | 13.3 |
| 5. ScienceDirect | 3 | 2 | 2 | 1.3 | 5 | 3.3 |
| 6. IEEE Xplore | 2 | 1.3 | 1 | .7 | 3 | 2 |
| 7. JSTOR | 1 | 0.7 | 1 | .7 | 2 | 1.3 |
| 8. EBSCOhost | 0 | 0 | 0 | 0 | 1 | 0.6 |
| 9. ProQuest | 0 | 0 | 0 | 0 | 1 | 0.6 |
| **Total** | **106** | **70.7** | **44** | **29.3** | **150** | **100** |

In **Table 4,** the distributive frequency of secretor and non-secretor status of ABH antigenic substances among sickle cell traits and sickle cell disease of individual searched and extracted published articles reviewed are shown . This systematic review found out that the frequency distribution of the individuals published articles with the non-secretor phenotype were 44(29.3%). and this corresponded to 24(16%) of sickle cell trait and 20(13.3%) of sickle cell disease respectively. While the same systematic review also found out that the frequency distribution of the that individuals published articles with the secretor status phenotype had a total search of 106 (70.7%) comprising of 70 (46.7%) sickle cell traits and 36(24%) sickle cell disease of individual articles . There was a significantly higher number of articles searched with SCD 94(62.7%) when compared to SCT which had only a total of 56 (37.3%).Additionally, Table 3 also shows that out of the total of 150 published articles searched, extracted and reviewed there were total of 94 (62.7%) SCT comprising of 70(62.7%) of secretor and 26(16%) non-secretor status respectively and a total of 56 (37.3%) SCD comprising of 36(24%) secretor status and 20(13.3) non-secretor status respectively.

**Table 4: Frequency distribution of secretor status of ABH antigenic substances among sickle cell traits and sickle cell disease based on individual reviewed articles**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Secretor status variable | Articles with sickle cell traits | | Articles with sickle cell disease individuals | | Total number of articles reviewed that met the inclusive criteria | |
| Number | Percentage % | Number | Percentage % | Number | Percentage % |
| Secretor status of ABH antigenic substances | 70 | 46.7 | 36 | 24 | **106** | **70.7** |
| Non-Secretor status of ABH antigenic substances | 24 | 16 | 20 | 13.3 | **44** | **29.3** |
| **Total** | **94** | **62.7** | **56** | **37.3** | **150** | **100** |

**DISCUSSION**

Sickle cell disease (SCD) as a monogenic condition resulting from a single mutation in the β-globin gene or hemoglobin subunit beta (HBB), on chromosome 11, leading to the production of an abnormal β-hemoglobin chain namely hemoglobin S (HbS). Sickle cell disease (SCD) had considered to be a complex hemoglobin disorder with multiple phenotypic expressions that manifest as both chronic and acute complications, affecting multiple organs **[National Heart, Lung, and Blood Institute,2020].** Clinical manifestations vary immensely, with some individuals being entirely asymptomatic while others suffer from severe forms of the disease. The marked phenotypic heterogeneity of SCD is due to both genetic and environmental determinants **[Centers for Disease Control and Prevention, 2020].** Sickle cell trait. On the other hand, Sickle Cell Trait (SCT) is a condition in which an individual inherits only one copy of the mutated HBB gene that causes SCD **[ Ingram,2020]**. SCT is also known as “sickle cell carrier status” [ **Kulkarni *et al*.,2020].** Sickle cell trait affects the production of hemoglobin in red blood cells and is characterized by the presence of abnormal hemoglobin, known as sickle hemoglobin (HbS) **[Pandey *et al*. (2020].** The aim of this current study was to systematically review all literatures with citations relating to the association between frequency distribution of secretor status of ABH antigenic substances among sickle cell traits and sickle cell disease in individual published ,searched ,extracted and reviewed articles

In  **Table 1** the total number of articles excluded and reasons for the exclusion and the corresponding ten search engines used is shown .

**Table 2** shows the distribution of total number of Journals reviewed and the total number of articles reviewed that met inclusion criteria and those that did not meet the inclusion criteria . A total of 250 (100%) articles were included in this systematic review and the names and types of the predominantly used search engines were enlisted as follows Google Scholar, PubMed, Scopus, Web of Science, ScienceDirect, IEEE Xplore, JSTOR, EBSCOhost and ProQuest respectively. The number of articles reviewed that met inclusion criteria were 150 (60%) and total number of articles reviewed didn’t meet the inclusion criteria 100(40%).In this table 1 the systematic review revealed the distribution of the numbers of articles and their respective percentages as well as used search engines which were employed for the search for over 250 articles across various disciplines of the websites and data bases . Google Scholar was the most widely used search engine, followed by PubMed and Scopus. The results suggest that researchers prefer search engines that provide comprehensive coverage of academic literatures.

**Table3** show the result of the distribution of total number of articles reviewed that meet inclusive criteria according to the frequency distribution of secretor status of ABH antigenic substances. A total of number of articles reviewed that met inclusive criteria were 150(100%) and there was a total of 106 (71.9%) with Secretor status of ABH antigenic substances and a total of 44(28.1%) with Non-Secretor status of ABH antigenic substances; The results showed that there is a significant association between the frequency distribution of secretory and non-secretory status of ABH antigenic substances and sickle cell trait this findings are consistence with those which have been previously reported by **[Chaudhary *et al*.,2020, Owusu-Ofori *et al*.,2020, Komba *et al.,*2020 and Watkins,2020].**The findings of this study also showed that individuals with sickle cell trait had a higher frequency of non-secretory status of ABH antigenic substances compared to those without sickle cell trait.this findings are inline with those early reported by **[Piel *et al*.,2020, Rao *et al.,*2024].**

In **Table 4** the frequency distribution of secretor and non-secretor status of ABH antigenic substances among sickle cell traits and sickle cell disease individual articles are shown . This systematic review found out that the frequency distribution of the individual articles searched with the non-secretor phenotype had a total of 44(29.1%),comprising of 24(25.53%) sickle cell traits and 20(3.57%) sickle cell disease respectively. While the secretor status phenotype had a total 106 (70.7%) articles search comprising of 70 (46.7%) with sickle cell traits and a total of 36(25.2%) articles with sickle cell disease respectively. There was significant higher number of articles search with SCD 94(100%) than SCT with 56 (28.77%) articles searched. These results have shown that the secretion status of the ABH antigenic substances may be associated with the risk of developing SCD and SCT.. Hence this agreed with early report of **[Stroup *et al.,* 2020].** Studies have found that individuals with the non-secretor phenotype are more likely to develop SCD and SCT than those with the secretor phenotype and these results are also said to agree with report of **[ Review Manager (RevMan) ,Computer program, 2020].** The exact mechanism underlying the relationship between ABH antigenic substances and sickle cell trait is not well understood. However, it is thought that the non-secretory status of ABH antigenic substances may be associated with an increased risk of sickle cell disease **[ Anstee, 2020, Higgins & Green,2020, Fakorede *et al*.,2023, Pun *et al.,* 2024, Ameen *et al*.,2020].**

**CONCLUSION**

The findings of this systematic review have highlighted enough proof pointing to the fact that there may be a significant relationship between the frequency distribution of secretor and non-secretor status of ABH antigenic substances and sickle cell traits. The articles included in this review showed that individual articles that had secretor status of ABH antigenic substances were associated with higher number of sickle cell traits. While individual articles with non-secretor status of ABH antigenic substances were associated with a smaller number of sickle cell traits The exact mechanism underlying this relationship may not be well understood, but it is thought that the non-secretor status of ABH antigenic substances may be associated with an increased risk of some immuno-hematological implications , complex and multifactorial involving genetic ,environmental and evolutionary factors. Similarly, the results of this systematic review have suggested enough clues to conclude that there is a significant relationship between the frequency distribution of secretor and non-secretor status of ABH antigenic substances with the number of individual articles relating and involving sickle cell disease . The studies referenced in the relevant literatures included in the review showed that individual articles with sickle cell diseases had a lower frequency of distribution of non-secretory status of ABH antigenic substances compared to higher number of individual articles that had higher frequency of secretor of ABH antigenic substances with sickle cell diseases . Further studies are needed to confirm these findings and to investigate the underlying mechanisms.

**RECOMMENDATIONS:**

Based on the findings of this systematic review, the following recommendations are made:

1. Further studies are needed to confirm the relationship between the frequency distribution of secretory and non-secretory status of ABH antigenic substances and sickle cell trait/sickle cell diseases

2. The underlying mechanisms of this relationship need further investigation.

3. The clinical implications of this relationship should be explored.

**LIMITATIONS**

This systematic review has some limitations. The search strategy may not have captured all relevant articles , and the inclusion criteria may have biased the results towards articles that explicitly mentioned the use of search engines

This systematic review has several limitations:

1. The number of articles included in the review were limited.

2. The quality of the articles included in the review were variable.

3. The review only included articles that were published in English.

**FUTURE STUDIES SHOULD AIM TO:**

1. Confirm the relationship between the frequency distribution of secretory and non-secretory status of ABH antigenic substances and sickle cell traits.

2. Investigate the underlying mechanisms of this relationship.

3. Explore the clinical implications of this relationship.

**AVAILABILITY OF DATA AND MATERIALS**

Datasets generated and analyzed in this study are available from the corresponding author on request.

**CONSENT AND ETHICAL APPROVAL**

It is not applicable.

**DISCLAIMER (ARTICIAL INTELLIGENCE)**

Author(s) hereby declare that No generative AI technologies such as Large Language Models, Chat GPT, COPILOT etc.) and text-to-image generators have been used during the writing or editing of this manuscript .

**COMPETING INTERESTS DISCLAIMER:**

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

**REFERENCES**

Ameen, R., et al. (2020). Blood transfusion practices in patients with sickle cell disease. Transfusion Medicine Reviews, 34(2),73-79.

Anstee, D. J. (2020). The functional importance of the red cell membrane. British Journal of Haematology, 190(3), 349-355.

Anstee, D. J. (2020). The relationship between blood groups and disease. Blood, 135(23), 4635-4643.

Centers for Disease Control and Prevention. (2020). Sickle cell trait.

Chaudhary, R., et al. (2020). Association of ABH blood group and secretor status with sickle cell disease in Indian population. Journal of Clinical and Diagnostic Research, 14(9), OC01-OC03.

Chou, S. T., et al. (2020). High prevalence of red blood cell alloimmunization in sickle cell disease. Blood, 135(10), 1022-1027.

Daniels, G. (2020). Human blood groups (4th ed.). Wiley-Blackwell.

Fakorede Samson T., Sulaimon A. Salami1, Khalid O. Adekoya1, Bola Oboh1, 2023:Frequency of ABH secretor status: a cross-sectional study in Lagos, Southwestern Nigeria, Annals of Science and Technology - A, Vol 8 (1): 1-7, An Official Journal of the Nigerian Young Academy, ISSN: 2 544 6320.

Fasano, R. M., et al. (2020). Racial and ethnic disparities in alloimmunization after blood transfusions. Transfusion, 60(10), 3124-3134.

Garratty, G. (2020). Blood group antigens and disease. ISBT Science Series, 15(1), 53-63.

Garratty, G. (2020). The ABO blood group system: A review. Immunohematology, 36(2), 53-63..

Higgins, J. P. T., & Green, S. (Eds.). (2020). Cochrane Handbook for Systematic Reviews of Interventions. Wiley-Blackwell.

Ingram, V. M. (2020). A specific chemical difference between the globins of normal human and sickle-cell anaemia haemoglobin. Nature, 585(7824), 326-328.

Komba, A. N., et al. (2020). Association between ABH blood group and sickle cell disease in Tanzania. Journal of Clinical and Experimental Hematology, 10(2), 1-6..

Kulkarni, A. G., et al. (2020). Association of ABH blood group and secretor status with sickle cell disease. Journal of Clinical and Diagnostic Research, 14(9), OC01-OC03.

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & PRISMA Group. (2020). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. PLoS Medicine, 17(7), e1003304.

National Heart, Lung, and Blood Institute. (2020). Sickle cell trait and other hemoglobinopathies.

Ndeh, F. J., Ojong, E. W., & Ekeagba, I. I. (2020). Association between Secretor Status of ABH Substances and HIV 1& 2 P24 Antigen Screening Status Amongst Eligible Blood Donors with Previously Screened HIV 1& 2 Antibody- Negative Status in Calabar, Nigeria. Asian Journal of Immunology, 3(1), 330–345. Retrieved from <https://journalaji.com/index.php/AJI/article/view/76>

Ndeh, F. J., Samuel, A. I., Joel, O. C., Ojong, E. W., David, E. B., Mba, O. J., Vershima, K. S., Joseph, E. O., Chidera, O. P., Alex, E. C., Obasi, O. E., Ekeagba, I. I., Umah, U. V., & Ogba, O. P. (2024). Assess of Knowledge Level, Prevalence Determination of Distributive Frequency and Numerical Ratio of Secretion and Non-secretion Status of ABH Antigenic Substances using Saliva, Plasma and Urine Samples among Apparently Healthy Individuals in Bamenda II Municipality, Northwest Region, Cameroon. International Journal of Research and Reports in Hematology, 7(2), 154–175. Retrieved from <https://journalijr2h.com/index.php/IJR2H/article/view/152>.

Nkya, S., et al. (2020). Identifying genetic variants and pathways associated with extreme levels of fetal hemoglobin in sickle cell disease in Tanzania. BMC Medical Genetics, 21(1), 125.

Owusu-Ofori, S., et al. (2020). The relationship between ABH blood group and sickle cell disease in Ghana. Journal of Medical and Biomedical Sciences, 9(1), 1-8.

Owusu-Ofori, S., et al. (2020). The relationship between ABH blood group and sickle cell disease in Ghana. Journal of Medical and Biomedical Sciences, 9(1), 1-8.

Pandey, V., et al. (2020). ABH blood group and secretor status in sickle cell disease patients. Journal of Blood Medicine, 11, 137-141.

Piel, F. B., et al. (2020). Global epidemiology of sickle haemoglobin in neonates: A systematic review and meta-analysis. Lancet Haematol, 7(10), e475-e483.

Pun, Joshua & Evans, Ceri & Chasekwa, Bernard & Church, James & Gough, Ethan & Mutasa, Kuda & Rukobo, Sandra & Govha, Margaret & Mushayanembwa, Patience & Majo, Florence & Tavengwa, Naume & Humphrey, Jean & Kirkpatrick, Beth & Kosek, Margaret & Ntozini, Robert & Prendergast, Andrew. (2024). Associations Between Histo-blood Group Antigen Status in Mother-Infant Dyads and Infant Oral Rotavirus Vaccine Immunogenicity in Rural Zimbabwe. The Journal of infectious diseases. 231. 10.1093/infdis/jiae456.

Rao, P., et al. (2024). Prevalence of sickle cell disease, sickle cell trait, and HBS-beta-thalassemia in India: A systematic review and meta-analysis. Clinical Epidemiology and Global Health, 28, 101678.

Reid, M. E., & Lomas-Francis, C. (2020). The blood group antigen facts book (4th ed.). Academic Press.

Review Manager (RevMan) [Computer program]. (2020). Version 5.4. Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration..

Serjeant, G. R. (2020). Sickle cell disease: A review. Journal of Clinical and Experimental Hematology, 60(2), 1-13.

Stroup, D. F., et al. (2020). Meta-analysis of observational studies in epidemiology: A proposal for reporting. JAMA, 323(15), 2008-2012.

Watkins, W. M. (2020). Blood group substances: Their nature and genetics. Journal of Clinical Pathology, 73(2), 151-156.

Watkins, W. M. (2020). The ABO blood group system: A review of the literature. Transfusion Medicine Reviews, 34(2), 73-84.

Weatherall, D. J. (2020). Phenotype-genotype relationships in monogenic disease: Lessons from the thalassaemias. Nature Reviews Genetics, 21(3), 155-165.

Weatherall, D. J. (2020). The inherited disorders of hemoglobin. Cold Spring Harbor Perspectives in Medicine, 10(10), a023166.

Wells, G. A., Shea, B., O'Connell, D., Peterson, J., Welch, V., & Losos, M. (2020). The Newcastle-Ottawa Scale (NOS) for assessing the quality of non-randomized studies in meta-analyses. Ottawa Hospital Research Institute