Association of ABO blood groups with allergic diseases: a scoping review

Nur Hidayah Dahalan, Sharifah Azdiana Tuan Din, Siti Mardhiana Binti Mohamad

ABSTRACT

Objective The objective of this study was to map evidence of the association of ABO blood groups with allergic diseases such as allergic rhinitis (AR), atopic dermatitis (AD) and asthma.

Design A scoping review.

Data sources PubMed, Scopus, Direct Open Access Journal, Medline, Cumulative Index to Nursing and Allied Health Literature, ScienceDirect and SpringerLink were searched from October 2017 until May 2018.

Eligibility criteria for selecting studies We selected all types of studies including case-control studies, prospective or retrospective cohort studies, cross-sectional studies and experimental studies, and we included reviews such as literature reviews, systematic reviews with or without meta-analysis and scoping reviews that were published in English and associated the ABO blood group with the three allergic diseases (asthma, AR and AD) in humans of all age groups.

Data extraction and synthesis Two reviewers independently screened the titles and abstracts and assessed the full-text articles of the abstracts that met the eligibility requirements. Data from the included studies were extracted, evaluated and reported in the form of narrative synthesis.

Results Of the 10246 retrieved titles, only 14 articles were selected for a scoping review based on the eligibility criteria. The majority of the studies demonstrated a significant association between ABO blood groups and allergic diseases. We found that blood group O is prominent in patients with AR and asthma, while a non-O blood group is common in patients with AD.

Conclusion This scoping review serves as preliminary evidence for the association of ABO blood groups with allergic diseases. Further studies need to be conducted so that the relationship between ABO blood groups and allergic diseases can be fully established. This could be helpful for clinicians and health professionals in consulting and managing patients who suffer from allergic diseases in the future.

INTRODUCTION

Allergic diseases are common in human populations and can lead to morbidity and mortality among individuals who suffer from allergic diseases. The incidence of people suffering from allergic diseases continues to rise worldwide, especially in countries with low and intermediate socioeconomic status. Allergic diseases develop from abnormal reactivity of the immune system, whereby the immune system becomes hyper-responsive to allergens that are not harmful to the body. Allergic diseases include anaphylaxis, food allergies, asthma, rhinitis, conjunctivitis, angioedema, urticaria, eczema, eosinophilic disorders (including eosinophilic oesophagitis) and drug and insect allergies. Therefore, allergic diseases are of great concern to governments and communities because they can cause serious health problems if they remain unrecognised and underestimated.

The antigen of the ABO blood group system is a complex carbohydrate molecule that acts as a surface marker on the membrane of red blood cells, and it is also highly expressed in body fluids and several cell and tissue types, such as epithelial cells of the gastrointestinal tract, salivary glands and the skin. Although the biological function of blood groups is not fully understood, Chigira reported that most blood group antigens play crucial roles in cell-cell recognition and in self-declaration mechanisms by functioning as receptors or surface markers. Therefore, these antigens may behave as potential receptors for microorganisms or substances such as toxins or...
allergens that could influence the susceptibility of individuals to diseases.8

Certain genetic and environmental factors have been identified as risk factors for developing allergic diseases. The most important risk factor is family history. If a parent has allergies, the risk of their children developing allergies is approximately 15%–20%.9 Moreover, the risk is doubled when both parents have allergies.10 Indoor and outdoor pollutants are also significantly correlated with the development of allergic diseases.11 Examples of indoor pollutants include house dust mites, animal dander, cockroaches and moulds, while examples of outdoor pollutants include tobacco smoke, transportation smoke, factories and plant pollen.11–13 To date, ABO blood type has not been considered a risk factor for developing allergies.

However, numerous associations between particular ABO blood groups and an increased susceptibility to diseases such as cardiovascular disease, cancer and parasite infection have been reported. For example, blood group O was reported to be protective against pancreatic cancer (OR=0.53).14, 15 whereas blood group A, which is relative to other blood types, is more commonly observed in gastric cancer (OR=1.20, 95% CI 1.02 to 1.42).16, 17 Furthermore, people with non-O blood types have a higher risk of developing cardiovascular disease (OR=1.79, 95% CI 1.41 to 2.26) compared with those with type O blood.

In the 1960s, an observational study suggested that the ABO agglutinins that are present in a wide variety of pollens from grasses, flowers and trees might interact with cells containing blood group antigens in the respiratory epithelium.3 This may raise the possibility of a relationship between ABO blood groups and allergic diseases. To date, only a few studies have reported a relationship between ABO blood groups and susceptibility to allergic diseases such as AR,3 AD,18 asthma19, 20 and food allergies.21, 22 However, the association of specific ABO blood types with AR, AD and asthma is poorly understood, and the susceptibility of people with specific blood types to these diseases has not been comprehensively explored. Therefore, we conducted a scoping review to explore and map evidence for the association of ABO blood type with susceptibility to AR, AD and asthma. This review may act as a precursor for a full systematic review and help improve doctors’ consultations and management of treatment for patients who suffer from allergic diseases in the future.

METHOD

This study was conducted using the scoping review framework and followed the guidelines outlined by Arksey and O’Malley.23 The five stages included in this framework are (1) identification of research questions, (2) identification of related studies, (3) selection of studies, (4) charting of data and (5) collating, summarising, and reporting the results. The International Prospective Register of Systematic Reviews (PROSPERO) registration is not required for scoping reviews. The protocol followed for the scoping review in this study is as follows:

Stage 1: identification of research questions

The following research questions were developed based on the objective of the study:

i. Is there any association between ABO blood groups and AR, AD and asthma?
ii. Which ABO blood type is susceptible to AR, AD and asthma?

Stage 2: identification of related studies

One reviewer performed the search for related studies based on eligibility criteria, electronic databases and search strategies.

Eligibility criteria

In this study, the inclusion criteria were articles that (1) were originally published in English or had been translated into an English version, (2) included all age groups, (3) included human subjects, (4) involved three specific allergic diseases (asthma, AR and AD), (5) were limited to developed and developing countries and (6) had a publication period from January 1970 to May 2018.

Types of studies

All types of studies, such as case-control studies, prospective or retrospective cohort studies, cross-sectional studies and experimental studies, were included. Reviews such as literature reviews, systematic reviews with or without meta-analysis and scoping reviews were also included. The references from the relevant studies that were related to the study were also included.

Databases

Studies corresponding to the aim of this research were found by searching the following electronic databases: PubMed, Scopus and Direct Open Access Journal were searched from October 2017 until January 2018, followed by Cumulative Index to Nursing and Allied Health Literature, ScienceDirect and SpringerLink, which were searched from February 2018 until May 2018. The reference lists of the included studies were searched to identify other potentially relevant studies.

Search strategy

The searches were guided using the Boolean operators ‘AND’ and ‘OR’. The results from each search were documented, and all references from the search were imported into the Endnote X8 reference management software programme. Duplicate articles were removed. Table 1 lists the keywords used to construct the search strategy. The full search strategy for one database is provided (refer to online supplementary file 1).

Stage 3: selection of studies

The selection of relevant studies was based on the research questions and the eligibility criteria. The studies

Dahalan NH, et al. BMJ Open 2020;10:e029559. doi:10.1136/bmjopen-2019-029559
Table 1  Keywords used in the study

| ABO Blood Groups | Asthma | Allergic Rhinitis | Atopic Dermatitis |
|-----------------|--------|-------------------|-------------------|
| A Blood Group   | Asthma Attack | Rhinitis | Dermatitis |
| B Blood Group   | Bronchial Asthma | Hypersensitivity | Atopic Eczema |
| AB Blood Group  | Respiratory Diseases | Hay Fever | Eczema |
| O Blood Group   | Lung Diseases | Allergen Induced Hypersensitivity | Inflamed Skin |

Table 2  Description of data extracted from each included study

| Type of data               | Study characteristics | Sample characteristics | Findings/results |
|----------------------------|-----------------------|------------------------|------------------|
|                            | Year of publication   | Age                    | Association of ABO blood groups |
|                            | Authors               | Gender                 |                  |
|                            | Country of study      |                        |                  |
|                            | Sample size           |                        |                  |
|                            | Objectives            |                        |                  |
|                            |                      |                        |                  |

were selected and recorded following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram for the scoping review process. At this stage, two levels of article screening were used. In the first screening process, two reviewers independently screened the title and abstract of the retrieved articles; they both read and analysed the abstracts to determine the eligibility of the selected studies. The abstracts that did not match the scope of the study were excluded. Discrepancies between the two reviewers at the abstract stage were resolved by a third reviewer. In the second screening process, the full-text articles were assessed independently by the two reviewers to determine whether they met the inclusion criteria and whether the research questions were answered. Non-relevant articles and those that did not consider the association of ABO blood groups with the three allergic diseases were excluded.

Stage 4: data charting
Data from the selected articles were extracted independently by two of the same reviewers. These data included standard information such as author, year of publication, objective of the study, study location, subject characteristics, sample size and study design (refer to table 2). The extracted data were compared between the two reviewers to ensure consistency, and any disagreement that arose between the two reviewers was discussed. The data charting process provided a summary of the articles that corresponded to the research questions and the objectives of the study.

Stage 5: collating, summarising and reporting the results
The PRISMA flow diagram of the scoping review framework was used so that the review search results could be reported accurately. The findings of the selected articles were summarised in a table format and analysed to elucidate the relationship between blood groups and the selected diseases.

Patient and public involvement
No patients and public were involved in the planning, design and conception of this study.

RESULTS
Characteristics of the selected studies
The first screening of the databases and other resources produced 10246 records (figure 1). After removing the duplicate records, 8415 records were left. Only 78 records were included after the removal of abstracts and titles that did not meet the eligibility criteria. After the second...
| No | Author (year) | Study design | Types of allergy | Purpose | Sample size and group comparison | Subjects characteristics | Association with ABO blood groups |
|----|---------------|--------------|------------------|---------|----------------------------------|------------------------|---------------------------------|
| 1  | Falsarella et al.26  
Country: Brazil  
Year: 2011 | Case control | Allergic rhinitis | To determine if ABO phenotypes are associated with allergic rhinitis. | 168 patients and 168 controls | Age: 18–85 years, patients matched by age and gender with controls | The O phenotype was associated with susceptibility to allergic rhinitis for men but not for women (p=0.016; OR= 1.735; 95% CI 1.127 to 2.673). |
| 2  | Hamad 26  
Country: Iraq  
Year: 2016 | Cross sectional | Allergic rhinitis | To determine the prevalence of ABO blood groups and to investigate their association with allergic rhinitis and relate this association with genetics. | 109 | Age: 18–60 years (female and male) | Group O is the most common and has a high level of risk for developing allergic rhinitis (p=0.049). |
| 3  | Topno et al.27  
Country: India  
Year: 2017 | Case control | Allergic rhinitis | To study the correlation of ABO phenotypes in patients with allergic rhinitis. | 100 patients and 100 controls | Outpatient department Ear, Nose and Throat (ENT) Age: 11–70 years, patients matched by age and gender with controls | The O blood group phenotype is associated with allergic rhinitis (OR 3.63, p=0.006). |
| 4  | Kauffmann et al.19  
Country: France  
Year: 1996 | Cross sectional | Asthma | To assess the role of all three systems—Lewis, secretor and ABO—in lung function, wheezing and asthma. | 228 males | Age: 34–50 years, coal miners | Non-secretor subjects of blood group O have significantly lower lung function and higher prevalence of wheezing and asthma (p<0.01). |
| 5  | Ronchetti et al.20  
Country: Italy  
Year: 2001 | Case control | Asthma | To analyse the joint phenotype ABO/secretor in a cohort of asthmatic children in an attempt to confirm the association observed in adult subjects. | 165 children (109 males and 56 females) 362 newborn infants as controls | Outpatients of a paediatric pulmonary clinic or patients who were admitted to a ward of the same clinic for acute respiratory episodes. Age: 1 month–15 years | O/non-secretor in asthmatic male children was higher than the controls (p<0.025). |
| 6  | Chen et al.28  
Country: Taiwan  
Year: 2005 | Case control | Asthma | To analyse the histo-blood groups of ABO, Lewis and secretor in a cohort of asthmatic children in Taiwan. | 136 asthmatic children and 161 aged-matched controls | Age: 6–13 years | Blood group O/secretors were associated with childhood asthma (OR=2.7, 95% CI 1.126 to 6.033, p<0.02) |
| 7  | Saini and Yadav29  
Country: India  
Year: 2014 | Case control | Asthma | To investigate the association of ABO and Rh (D) allele frequency in patients with asthma. | 180 subjects (120 asthmatics and 60 controls) | Patients matched by age, sex and socioeconomic status with controls | A possible association between blood group O and asthma prevalence was noted (p<0.05). |
| No | Author (year) | Study design | Types of allergy | Purpose | Sample size and group comparison | Subjects characteristics | Association with ABO blood groups |
|----|---------------|--------------|-----------------|---------|----------------------------------|-------------------------|-------------------------------|
| 8  | Yaro et al[30] | Case control | Asthma          | To explore the relationship of blood group type and susceptibility to asthma in Sokoto Metropolis, Nigeria. | 200 asthmatic patients and 100 adults (control group) | Individuals attending the Pulmonary Unit of Usmanu Danfodiyo University Teaching Hospital, Specialist Hospital and Maryam Abacha Women and Children Hospital, all in Sokoto metropolis, Nigeria | A possible association between blood group A and asthma susceptibility was noted (p<0.05). |
| 9  | Gangopadhyay et al[36] | Cross sectional | Atopic dermatitis | To evaluate the relationship between atopic dermatitis and the ABO blood group. | 30 patients with atopic dermatitis | Patients attending the Dermatology Outpatient Department (OPD) of NRS Medical College, Kolkata, over a period of 1 year Age: 6 month–65 years | Blood group O with atopic dermatitis among patients is less prevalent than among controls (p<0.05). Blood group B is the most prevalent in patients with atopic dermatitis, followed by blood group A. |
| 10 | Abid[33]       | Cross sectional | Atopic dermatitis | To determine the prevalence of ABO blood groups and to investigate their association with dust, pollen and skin allergy. | 123 young adults (males and females) Age: 18–21 years | Blood group B is most common and has a high risk level for developing allergies (p=0.0007774). |
| 11 | Brachtel et al[34] | Case control | Atopy           | To assess the association of atopic disease with blood group with reference to a new population sample and to include polymorphic systems. | 239 patients 151 controls | Outpatients of the Dermatological Clinic of the University of Mainz | Higher susceptibility of individuals with blood groups A and B to atopic diseases such as rhinitis, bronchial asthma, dermatitis and many more. |
screening, 14 final full-text articles remained, and these articles were subdivided into the following three categories: four studies for AR, three studies for AD and seven studies for asthma.

### Association of ABO blood groups with allergic diseases

**Allergic rhinitis**

Of the four studies related to AR, three studies reported that blood group O is correlated with AR.\(^25\)\(^{-}\)\(^27\) (refer table 3A). No association was found in the fourth study\(^3\) (refer to table 3B).

**Asthma**

Four of the seven studies reported that patients with blood group O had greater susceptibility to asthma\(^19\)\(^\)\(^20\)\(^28\)\(^\)\(^29\) than patients with other blood groups (refer table 3). Additionally, one study found that blood group A was the predominant type in asthma patients versus controls.\(^30\) Two studies did not show any association between ABO blood groups and asthma\(^31\)\(^\)\(^32\) (refer to table 3B).

**Atopic dermatitis**

All three studies related to AD reported that people with non-O blood groups (A and B blood groups) were at high risk of developing AD\(^18\)\(^33\)\(^34\) (refer to table 3A).

### DISCUSSION

The purpose of a scoping review is to map the evidence provided in the literature to specific areas of interest,\(^23\) and this method can be used when the field or topic has not yet been reviewed extensively.\(^35\) A scoping review can also be used to identify the gaps present in the existing research about a topic of interest.\(^25\) The aim of the scoping review conducted in this study was to provide evidence for the association of ABO blood groups with AR, AD and asthma and to help determine which blood type is predominant in each of the diseases. Most of the evidence presented in the selected studies pointed to an association of allergic diseases with ABO blood groups. However, the mechanism by which the blood type can affect the development of allergic disease remains unknown.

In this review, several important insights were gained. First, in the selected studies, participants with blood group O were more susceptible than those with non-O blood groups to allergic diseases, especially AR and asthma.\(^19\)\(^\)\(^20\)\(^25\)\(^\)\(^26\)\(^\)\(^28\)\(^\)\(^29\) In contrast, those with non-O blood groups were more susceptible to AD.\(^18\)\(^33\)\(^34\) Gangopadhyay et al.\(^18\) found that blood group B was the most prominent type in patients with AD, followed by blood group A, and this finding was consistent with the results reported by Abid\(^33\) and Brachtel et al.\(^34\) These results suggest that certain ABO blood groups may act as a risk factor for developing allergic diseases in the future. ABO blood groups have been established as a risk factor for cardiovascular diseases\(^36\) such as venous thromboembolism\(^37\) and coronary artery disease.\(^38\)

Second, out of all the selected studies, only three studies focused on AD, and four studies focused on AR, whereas seven studies focused on asthma. This finding demonstrates that most studies focused on a disease that can cause mortality and is recognised as a serious global health problem. In contrast, AD and AR are not life-threatening diseases and can be controlled by medicines. Therefore, these diseases are less compelling as research topics and in clinical practice.\(^39\) Overall, the search for studies regarding a relationship between ABO blood

### Table 3B Summary of studies with no association

| No | Author (Year) | Study design | Types of allergy | Purpose | Sample size and group comparison | Subjects' characteristics | Association with ABO blood groups |
|----|---------------|--------------|------------------|---------|---------------------------------|--------------------------|---------------------------------|
| 1  | Carpeggiani Country: Italy Year: 2011\(^3\) | Literature review | Allergic rhinitis | Not stated. | Not stated. | Not stated. | Association of blood group O with allergic rhinitis remains unknown due to limitations in some studies. |
| 2  | Dhiman et al Country: India Year: 1990\(^31\) | Case control | Asthma | To determine whether an association exists between ABO, Rh, and MN blood groups and asthma. | 125 patients (70 males and 55 females) 6204 controls | Indoor and outdoor patients Age: 16–70 years | Non-significant differences between ABO phenotypes and asthma (0.7>p >0.5). |
| 3  | Bijanzadeh et al Country: India Year: 2009\(^32\) | Case control | Asthma | To evaluate the relationship between asthma and the ABO blood group in the population of Mysore, Karnataka State, South India. | 200 (adults and children) 2000 controls | Asthmatic cases from university hospitals and allergy centre controls from blood donors at the hospital Age: Children: younger than 18 years Adults: older than 19 years | ABO blood group status has a non-significant association with asthma among the population of Mysore, Karnataka, South India. (p=0.931) |

**ENT, Ear, Nose and Throat; OPD, Outpatient Department.**
groups and allergic diseases produced few results after the unwanted search results were eliminated.

Third, no evidence was found for the association between ABO blood groups and allergic diseases in South-east Asia, including Malaysia. Thus, this review highlights an important gap in geographic data for the link between allergic diseases and ABO blood groups. In the future, researchers should assess the relationships by conducting similar studies in Asian populations. Finally, the results of this review showed that males are significantly more predisposed to allergic diseases than females. This finding is supported by other studies that have reported that the male gender poses a significant and independent risk factor for asthma and AR.

This study has some limitations. First, the quality appraisal assessment was excluded; thus, the quality of some articles may have been poor. Second, we included only English language articles and excluded grey literature; thus, some relevant articles may have been overlooked. Finally, the number of studies selected was low and may have been affected by lack of availability of full-text articles (particularly old articles), coverage of databases and language barriers.

CONCLUSION

This scoping review has helped highlight the relationship between ABO blood groups and allergic diseases, although the specific role of ABO blood groups in the pathophysiology of allergic diseases remains unknown. In addition, this review also identified the gap in geographic data for the link between allergic diseases and ABO blood groups. Hence, further studies focusing on different populations and mechanisms need to be conducted so that more evidence and better knowledge on the relationship between ABO blood groups and allergic diseases can be fully established and understood. Later, these findings may help to improve the consultation and management of patients suffering from allergic diseases.

Contributors SMM and NHD carried out the literature search and the screening of the articles. NHD drafted the manuscript. SMM and SATD assisted in interpreting the data and checking the manuscript. All authors read and approved the final manuscript.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent for publication Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement All data relevant to the study are included in the article or uploaded as supplementary information.

Open access This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: http://creativecommons.org/licenses/by-nc/4.0/.

ORCID iD Nur Hidayah Dahalan http://orcid.org/0000-0002-5547-8867

REFERENCES

1. Douglass JA, O’Hehir RE. 1. diagnosis, treatment and prevention of allergic disease: the basics. Med J Aust 2006;185:228–33.
2. Pawankar R. Allergic diseases and asthma: a global public health concern and a call to action. World Allergy Organ J 2014;7:12–13.
3. Carpeggiani C. Allergic rhinitis and association with the O blood group. Rev Bras Hematol Hemoter 2011;33:406–7.
4. Pawankar R, Canonica G, Holgate S, et al. The WAO white book on allergy (update 2013). World Allergy Organization, 2015.
5. Hosoi E. Biological and clinical aspects of ABO blood group system. J Med Invest 2008;55:174–92.
6. Storry JR, Olsson ML. The ABO blood group system revisited: a review and update. Immunohematology 2009;25:48–59.
7. Chigira M. Origin of blood-group antigens: a self-declaration mechanism in somatic cell Society. Med Hypotheses 1996;46:290–4.
8. Cooling L. Blood groups in infection and host susceptibility. Clin Microbiol Rev 2015;28:801–70.
9. Paaso EMS, Jaakkola MS, Rantala AK, et al. Allergic diseases and asthma in the family predict the presence and onset-age of asthma: a prospective cohort study. Respir Res 2014;15:152.
10. Kausman F, Frentzas C, Clarke M, et al. Epidemiology and risk factors of allergic diseases in adolescents. J Allergy Clin Immunol 2018;141:AB223.
11. Jenerowicz D, Silny W, Daiczk-Pazdrowska A, et al. Environmental factors and allergic diseases. Ann Agric Environ Med 2012;19:475–81.
12. Wang D-Y. Risk factors of allergic rhinitis: genetic or environmental? Ther Clin Risk Manag 2005;1:115–23.
13. Yadav A, Naidu R. Indoor environmental and demographic factors of Malaysian allergic children. Journal of Allergy and Clinical Immunology 2013;131:AB163.
14. Iodice S, Maisonneuve P, Botteri E, et al. ABO blood group and cancer. Eur J Cancer 2010;46:3345–50.
15. Risch HA, Yu H, Lu L, et al. ABO blood group, Helicobacter pylori seropositivity, and risk of pancreatic cancer: a case-control study. J Natl Cancer Inst 2010;102:502–5.
16. Edgren G, Hjalgrim H, Rostgaard K, et al. Risk of gastric cancer and peptic ulcers in relation to ABO blood type: a cohort study. Am J Epidemiol 2010;172:1280–5.
17. Wang Z, Liu L, Ji J, et al. ABO blood group system and gastric cancer: a case-control study and meta-analysis. Int J Mol Sci 2012;13:13308–21.
18. Gangopadhyay D, Naskar B, Roy AK. Atopic dermatitis and ABO blood group. Indian J Dermatol 2006;51:33–5.
19. Kastenmann F, Frentzas C, Clarke M, et al. Associations of blood group related antigens to FEV1, wheezing, and asthma. Am J Respir Crit Care Med 1996;153:76–82.
20. Ronchetti F, Villa MP, Ronchetti R, et al. ABO/Secretor genetic complex and susceptibility to asthma in childhood. Eur Respir J 2001;17:1236–41.
21. Hamsten C, Tran TAT, Starkhammer M, et al. Red meat allergy in Sweden: association with tick sensitization and B-negative blood groups. J Allergy Clin Immunol 2013;132:1431–4.
22. Leite ICR, dos Santos Júnior JC, de Sousa CCS, et al. Recognition of phenylthiocarbamide (PTO) in taste test is related to blood group A phenotype, females, and risk of developing food allergy: a cross-sectional Brazilian-based study. Nutrition Research 2018;52:22–38.
23. Arksy H, O’Malley L. Scoping studies: towards a methodological framework. Int J Soc Res Methodol 2005;8:19–32.
24. Moher D, Shamseer L, Clarke M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. Syst Rev 2015;4:1.
25. Falsarella A, Ferreira Aldac, Nakashima F, et al. Evidence of an association between the O blood group and allergic rhinitis. Rev Bras Hematol Hemoter 2011;33:444–8.
26. Hamad ON. A relationship between allergic rhinitis and ABO blood group and related it with genetics in population based cohort study in Kut. Int J Med Res Prot 2016;2:71–4.
27. Topno N, Narvey VP, Jain AK. The correlation of allergic rhinitis with ABO phenotype. Indian Journal of Otolaryngology and Head & Neck Surgery 2017.
28. Chen Y-L, Chen J-C, Lin TM, et al. ABO/secretor genetic complex is associated with the susceptibility of childhood asthma in Taiwan. Clin Exp Allergy 2005;35:926–32.
29. Saini M, Yadav A. Distribution of ABO & Rh (D) allele frequency among asthmatic patients. IMPACT Int J Res Appl Nat Sci Soc 2014;2:217–22.
30. Yaro SA, Jubril B, Nwanoke NN. Relationship between ABO and rhesus blood groups and susceptibility to asthma within Sokoto Metropolis, Nigeria. International Journal of Immunology 2015;3:37–41.
31 Dhiman SR, Kaur M, Bansal US. ABO, Rh & MN Blood Groups in Relation to Asthma. *Indian Anthropologist* 1990;20:73–9.

32 Bijanzadeh M, Ramachandra NB, Mahesh PA, et al. Lack of association between asthma and ABO blood group. *Lung* 2009;187:389–92.

33 Abid K. Prevalence of ABO blood groups and their association with dust, pollen and skin allergy in young adults. *Ann Pak Inst Med Sci* 2015;11:12–15.

34 Brachtel R, Walter H, Beck W, et al. Associations between atopic diseases and the polymorphic systems ABO, Kidd, inv and red cell acid phosphatase. *Hum Genet* 1979;49:337–48.

35 Mays N, Roberts E, Popay J. Synthesising research evidence. In: *Studying the organisation and delivery of health services: research methods*, 2001: 188–220.

36 Etemadi A, Kamangar F, Islami F, et al. Mortality and cancer in relation to ABO blood group phenotypes in the Golestan cohort study. *BMC Med* 2015;13:8.

37 Streiff MB, Segal J, Grossman SA, et al. ABO blood group is a potent risk factor for venous thromboembolism in patients with malignant gliomas. *Cancer* 2004;100:1717–23.

38 Zhou B, Wu N, Zhu C, et al. ABO blood group is a risk factor for coronary artery disease in patients with poor blood pressure control. *Clin Exp Hypertens* 2017;39:366–70.

39 Deepak D, Shah A. Allergic rhinitis: a neglected disease. *Indian J Allergy Appl Immunol* 2000;14:6.

40 Kurukullaaratchy RJ, Karmaus W, Razza A, et al. The influence of gender and atopy on the natural history of rhinitis in the first 18 years of life. *Clin Exp Allergy* 2011;41:851–9.

41 Al Ghobain MO, Al-Hajjaj MS, Al Moamary MS. Asthma prevalence among 16- to 18-year-old adolescents in Saudi Arabia using the Isaac questionnaire. *BMC Public Health* 2012;12:239.