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# ABO/Rh Blood Groups and Disease Associations in Northern Morocco: A Retrospective Study of 3000 Hospital Patients

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## Abstract

Introduction: ABO and Rh blood group rates differ between population groups and might be related to susceptibility to several diseases. This study aimed to investigate the distribution of ABO and Rh blood groups in a population from northern Morocco, as well as to assess their potential association with diverse pathological profiles, taking into consideration sex-related differences.

Patients and methods: This is a retrospective study involving 3000 subjects aged 0 to 85 years. ABO/Rh blood groups were determined using the agglutination method on opal plates. Medical records were used to establish the association between blood group and the major pathologies observed. Categorical variables were compared using the Pearson Chi-square test ($p < 0.05$ considered significant).

Results: Group O was predominant (N=1178, 39.27%), followed by groups A (N=1161, 38.70%), B (N=479, 15.97%), and AB (N=182, 6.07%). The majority of subjects were Rh+ (N=2795, 93.17%). The distribution of blood groups differed significantly between sexes ($\chi^2 = 25.71$, $p < 0.001$). Blood type O was associated with iron deficiency anemia and certain coagulation disorders, group A with cardiovascular and thromboembolic diseases, group B with type 2 diabetes and hypertension, and group AB with metabolic syndrome (all $p \leq 0.002$). Men had more cardiovascular and musculoskeletal pathologies, while women were more affected by iron deficiency anemia and dyslipidemia.

Conclusion: Blood types could be indicators of susceptibility to certain diseases. Taking them into account could contribute to a targeted preventive strategy.

**Categories:** Hematology, Pathology, Allergy/Immunology
**Keywords:** abo, blood groups, diseases, disorders, rhesus factor

## Introduction

The ABO blood group is the major system for transfusion compatibility. It is the most thoroughly studied genetic polymorphism in humans; however, certain functional details remain to be clarified [1]. Since its identification, many investigations have described strong associations between the expression of ABO antigens and the development or progression of diverse pathologies, including thrombotic, cardiovascular, metabolic, infectious, and neoplastic diseases [2]. ABO antigens are expressed not only on red blood cells but also on a wide range of tissues and on circulating proteins such as von Willebrand factor (vWF), which provides a biological rationale for these associations [2,3].

Our study aims to examine the distribution of ABO and Rh blood groups in patients admitted to the General University Hospital of Tangier, to assess the prevalence of these blood groups within the patient population, and to study the correlation between ABO and Rh blood groups and the health status of these patients [1,4].

## Materials And Methods

This is a retrospective, descriptive, cross-sectional study conducted at the Hematology and Immunohematology Laboratory of the Mohammed VI General University Hospital - Tangier-Tetouan-Al Hoceima Territorial Health Directorate (GST-TTA) over one year, from September 2023 to August 2024. The study was carried out on a sample of 3000 individuals admitted to the UGH. Blood groups were identified using the agglutination method on opal plates (red blood cell and serological tests). Medical records were used to establish the association between blood group and the major pathologies observed.

The data were collected from the hospital information system. Qualitative variables were expressed as numbers (N) and percentages (%), and quantitative variables as mean ± standard deviation (mean ± SD). Associations between categorical variables (blood group and sex; blood group and pathology; sex and pathology) were analyzed using the Pearson chi-square test of independence; the chi-square value ($\chi^2$), degrees of freedom (df), and p-value were reported for each comparison. A p-value < 0.05 was considered statistically significant, and $p < 0.001$ was highly significant.

## Results

### Distribution of ABO and Rh blood groups

The distribution of ABO blood groups showed a predominance of group O (N=1178, 39.27%), followed by group A (N=1161, 38.70%), group B (N=479, 15.97%), and group AB (N=182, 6.07%) (Table *1*, Figure *1*).

| Blood group | N | % |
|---|---|---|
| O | 1178 | 39.27 |
| A | 1161 | 38.7 |
| B | 479 | 15.97 |
| AB | 182 | 6.07 |
| Total | 3000 | 100 |

**TABLE 1: Distribution of ABO blood groups in the study population (N = 3000).**

Data are presented as number (N) and percentage (%) of the total study population. Descriptive data; no statistical test applied

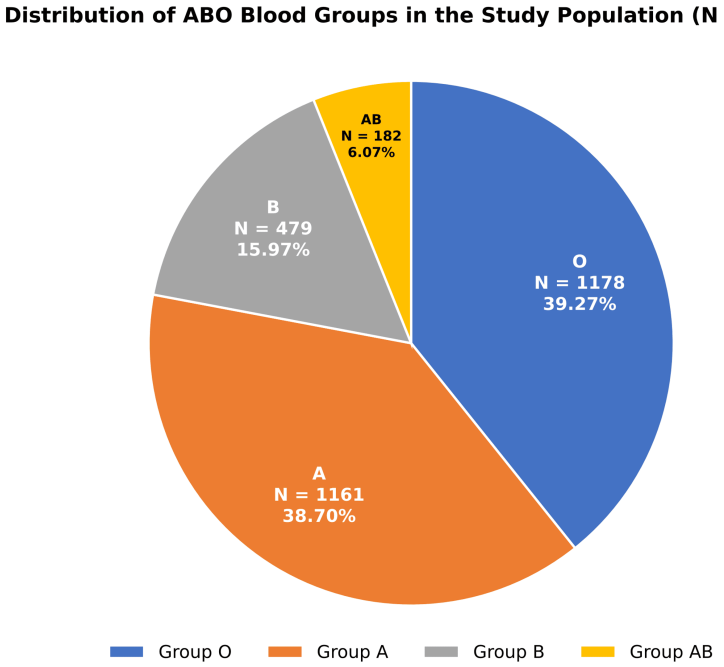



**FIGURE 1: Distribution of ABO blood groups in the study population (N = 3000).**

Data are presented as number (N) and percentage (%) of the total study population; decimals are shown with a point (.). Group O: N = 1178 (39.27%); group A: N = 1161 (38.70%); group B: N = 479 (15.97%); group AB: N = 182 (6.07%). Descriptive data; no statistical test applied.

Regarding the Rh factor, 2795 patients were Rh positive (93.17%), while 205 patients were Rh negative (6.83%) (Table *2*).

| Rh factor | N | % |
|---|---|---|
| Rh+ | 2795 | 93.17 |
| Rh− | 205 | 6.83 |
| Total | 3000 | 100 |

**TABLE 2: Distribution of the Rh (D) factor in the study population (N = 3000).**

Data are presented as number (N) and percentage (%). Descriptive data; no statistical test applied.

## Distribution of ABO blood groups according to sex

Blood group distribution differed according to sex. Among men, group O was the most frequent (N=761, 42.63%), whereas among women, group A predominated (N=504, 41.48%). Group AB was also more frequent in women (N=93, 7.65%) than in men (N=89, 4.99%) (Table *3*, Figure *2*). The chi-square test revealed a statistically significant association between blood group distribution and sex ($\chi^2 = 25.71$, df = 3, $p < 0.001$).

| Blood group | Men, N (%) | Women, N (%) | Total, N (%) |
|---|---|---|---|
| O | 761 (42.63) | 417 (34.32) | 1178 (39.27) |
| A | 657 (36.81) | 504 (41.48) | 1161 (38.70) |
| B | 278 (15.57) | 201 (16.54) | 479 (15.97) |
| AB | 89 (4.99) | 93 (7.65) | 182 (6.07) |
| Total | 1785 (100.00) | 1215 (100.00) | 3000 (100.00) |
| Chi-square test | $\chi^2 = 25.71$; df = 3; $p < 0.001$ | | |

**TABLE 3: Distribution of ABO blood groups according to sex.**

Values are expressed as N (%); percentages are calculated within each sex (column %). Comparison between sexes was performed using the Pearson chi-square test ($\chi^2 = 25.71$, df = 3, $p < 0.001$). Statistical significance is considered at $p < 0.05$.

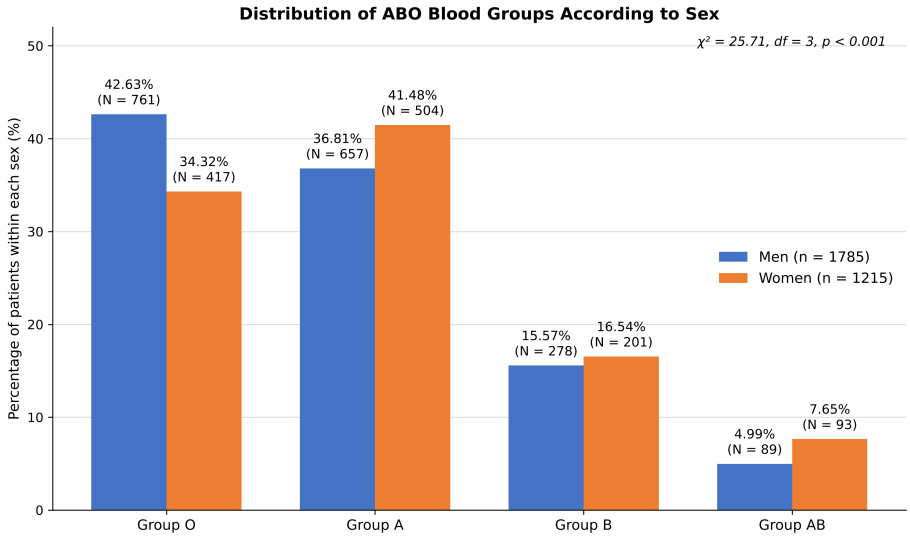



**FIGURE 2: Distribution of ABO blood groups according to sex.**

Bars represent the percentage (%) of patients within each sex, with the corresponding number (N) shown in parentheses; decimals are shown with a point (.). Men (n = 1785): group O, N = 761 (42.63%); group A, N = 657 (36.81%); group B, N = 278 (15.57%); group AB, N = 89 (4.99%). Women (n = 1215): group O, N = 417 (34.32%); group A, N = 504 (41.48%); group B, N = 201 (16.54%); group AB, N = 93 (7.65%). Comparison between sexes was performed using the Pearson chi-square test ($\chi^2 = 25.71$, df = 3, $p < 0.001$). Statistical significance is considered at $p < 0.05$.

## Correlation between blood groups and pathological profiles

The analysis showed associations between certain blood groups and specific pathological conditions (Table 4). Blood group O showed the highest frequency of iron deficiency anemia (N=312, 26.5%; $\chi^2 = 30.35$, df = 3, $p < 0.001$) and certain coagulopathies, while blood group A was most frequently associated with cardiovascular and thromboembolic diseases (N=342, 29.5%; $\chi^2 = 14.73$, df = 3, $p = 0.002$). Blood group B showed the highest prevalence of type 2 diabetes (N=128, 26.7%; $\chi^2 = 24.49$, df = 3, $p < 0.001$) and hypertension, and blood group AB was most often linked with metabolic syndrome (N=49, 26.9%; $\chi^2 = 14.44$, df = 3, $p = 0.002$) and recurrent infections. Overall, the chi-square test showed a significant association between ABO blood group and pathological profile ($\chi^2 = 64.84$, df = 9, $p < 0.001$).

| Pathology | O (n=1178), N (%) | A (n=1161), N (%) | B (n=479), N (%) | AB (n=182), N (%) | $\chi^2$ (df = 3) | p-value |
|---|---|---|---|---|---|---|
| Iron deficiency anemia | 312 (26.5) | 221 (19.0) | 82 (17.1) | 29 (15.9) | 30.35 | < 0.001 |
| Cardiovascular diseases | 268 (22.8) | 342 (29.5) | 116 (24.2) | 44 (24.2) | 14.73 | 0.002 |
| Type 2 diabetes | 201 (17.1) | 198 (17.1) | 128 (26.7) | 36 (19.8) | 24.49 | < 0.001 |
| Metabolic syndrome | 185 (15.7) | 216 (18.6) | 89 (18.6) | 49 (26.9) | 14.44 | 0.002 |
| Overall association | $\chi^2 = 64.84$; df = 9; $p < 0.001$ | | | | | |

**TABLE 4: Association between ABO blood groups and main pathologies.**

Values are expressed as N (%); percentages are calculated relative to the total number of patients in each blood group. For each pathology, the association with blood group was tested using the Pearson chi-square test (presence vs. absence of the pathology across the four groups, df = 3). The overall association between blood group and pathological profile was tested using the Pearson chi-square test on the 4 × 4 contingency table ($\chi^2 = 64.84$, df = 9, $p < 0.001$). Statistical significance is considered at $p < 0.05$.

## Sex-specific differences in pathological profiles

The analysis based on sex revealed notable differences in disease distribution (Table 5). Men presented a higher prevalence of cardiovascular diseases (N=624, 34.96%) than women (N=146, 12.02%) ($\chi^2 = 199.43$, df = 1, $p < 0.001$), as well as more musculoskeletal disorders, likely related to lifestyle factors such as smoking, occupational exposure, and physical workload. Conversely, women were more affected by iron deficiency

anemia (N=438, 36.05%) than men (N=206, 11.54%) ($\chi^2 = 257.58$, df = 1, $p < 0.001$), likely related to menstrual blood loss and pregnancy, as well as dyslipidemia influenced by hormonal and nutritional factors.

| Pathology | Men (n=1785), N (%) | Women (n=1215), N (%) | Total, N | $\chi^2$ (df = 1) | p-value |
|---|---|---|---|---|---|
| Cardiovascular diseases | 624 (34.96) | 146 (12.02) | 770 | 199.43 | < 0.001 |
| Iron deficiency anemia | 206 (11.54) | 438 (36.05) | 644 | 257.58 | < 0.001 |

**TABLE 5: Distribution of the main pathologies according to sex.**

Values are expressed as N (%); percentages are calculated within each sex. Comparisons between men and women were performed using the Pearson chi-square test (2 × 2 tables, df = 1). Statistical significance is considered at $p < 0.05$.

## Discussion

Our study highlights a predominance of blood group O (39.27%) and a high Rh+ rate (93.17%), consistent with Moroccan data. However, a study carried out in southern Morocco reports a more pronounced dominance of group O compared to group A [5], which suggests a North-South geographical variation. A study of 18,168 blood donations in the Meknès region reported a similar order of frequencies (O 48.50%, A 34.08%, B 14.18%, AB 3.24%), although group O was more predominant than in our series [6]. Compared to other populations, some Indian groups have a higher frequency of blood group B, while in many European countries, blood group A predominates, highlighting regional genetic and demographic influences [7,8]. The frequency of Rh-negative subjects in our series (6.83%) is slightly lower than that reported in Moroccan blood donors from Meknès (RhD+ 90.04%) [6] and lower than that usually reported in European populations [8].

### Correlations between blood groups and diseases

Our study highlights a notable correlation between ABO/Rh blood groups and different pathological profiles. Blood group O shows a significant association with iron deficiency anemia and certain coagulopathies, which may be explained by lower levels of von Willebrand factor and factor VIII, as demonstrated in recent studies [9]. Plasma vWF levels are approximately 25% lower in group O individuals than in non-O individuals, because the H antigen carried by vWF is associated with faster clearance of the protein [3]. This relative hypocoagulability may favor chronic occult bleeding, notably gastrointestinal, which has been linked to blood group O in a large Japanese multicenter cohort [10], and may thus contribute to iron deficiency.

Group A appears to be more exposed to cardiovascular diseases and thromboembolic events, due to a higher pro-coagulant activity. A large population-based study reported that non-O blood groups are associated with an increased risk of thromboembolic and arterial cardiovascular diseases, supporting the association observed in our results between blood group A and thrombotic complications [11]. These findings are in agreement with a systematic review and meta-analysis showing that non-O blood groups are associated with an increased risk of myocardial infarction, peripheral vascular disease, and venous thromboembolism [12], with two large prospective cohorts in which non-O blood groups were associated with a higher incidence of coronary heart disease [13], and with a meta-analysis identifying non-O blood type as the most common genetic risk factor for venous thromboembolism [14]. Similarly, a Danish phenome-wide cohort of 482,914 patients followed for 41 years found that non-O blood groups were associated with prothrombotic diseases of the circulatory system [15].

Group B had an increased frequency of type 2 diabetes and hypertension. This is consistent with the large French E3N cohort, in which blood group B carriers had the highest risk of type 2 diabetes compared with group O [16], with the Danish phenome-wide cohort in which blood group O was associated with a lower risk of type 2 diabetes [15], and with the retrospective Turkish study by Goktas, which reported associations between ABO groups and metabolic diseases [17]. Possible mechanisms include the influence of ABO antigens on circulating inflammatory and adhesion molecules and on the gut microbiota [2,16]. As for blood group AB, it combines metabolic and immune vulnerabilities, resulting in metabolic syndromes and recurrent infections [17].

Concerning sex, men exhibit more cardiovascular pathologies, likely linked to smoking, stress, and work-related factors, which is consistent with the well-documented sex and gender differences in cardiovascular risk [18]. Women are more affected by anemia and dyslipidemia, influenced by hormonal cycles, pregnancy, and diet; globally, iron deficiency remains the leading cause of anemia and disproportionately affects women of reproductive age [19]. These results suggest that blood groups are not merely transfusion markers, but also potential indicators of pathophysiological susceptibility (Table *6*).

| Blood group / profile | Our results | Results of the China study [9] | Results of the Turkey study [17] | Results of the Denmark study [15] |
|---|---|---|---|---|
| O | Iron deficiency anemia + coagulopathy | Decreased vWF → bleeding tendency | Non-specific | Lower thrombotic risk; later onset of phlebitis and thrombophlebitis |
| A | Thrombosis and cardiovascular diseases | Increased factor VIII → thrombosis | Non-specific | Non-O groups: increased prothrombotic circulatory diseases |
| B | Type 2 diabetes + hypertension | Weak association | Strong association with diabetes and hypertension | Non-O groups: higher type 2 diabetes risk than O; B associated with tuberculosis |
| AB | Metabolic syndromes + recurrent infections | Increased combined risk | Moderately increased metabolic risk | Non-O prothrombotic profile; no specific metabolic association |
| Male | Increased cardiovascular diseases | Confirmed | Confirmed | Not analyzed by sex |
| Female | Increased anemia + dyslipidemia | Confirmed (menstrual blood loss) | Confirmed | Not analyzed by sex |

**TABLE 6: Comparison of associations between ABO/Rh blood groups and pathological profiles according to different studies**

Qualitative comparison of the main findings of the present study with published data; no statistical test applied. vWF: von Willebrand factor

This study has several limitations. First, its retrospective design, based on hospital records, may lead to information and selection bias, and the study population consists of hospitalized patients rather than the general population, which limits the generalizability of the prevalence estimates. Second, potential confounding factors such as age, smoking, body mass index, diet, physical activity, socioeconomic status, and family history were not controlled for, and no multivariate analysis was performed; therefore, the associations observed cannot be interpreted as causal. Third, some patients may present several pathologies simultaneously, and biological parameters such as vWF and factor VIII levels, which could explain part of the associations, were not measured. Finally, the single-center design and the one-year study period may not reflect the entire population of northern Morocco. Larger prospective multicenter studies are needed to confirm these findings.

## Conclusions

Despite these regional particularities, the distribution of blood groups in the population of northern Morocco shows similarities with national and North African data. The predominance of group O and the Rh+ phenotype is confirmed, but variations according to sex and pathological profile give this population its own character. The links observed between blood groups and certain diseases, such as anemia, cardiovascular disease, and metabolic disorders, highlight the importance of considering the ABO-Rh phenotype in the assessment of clinical risk. However, larger and more mechanistic studies are still needed to further investigate these connections.

## Additional Information

### Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

**Concept and design:** Mouna Houari, Ammour Abdesselam, Bensaddik Mohammed, Idrissi Serhrouchni Karima

**Acquisition, analysis, or interpretation of data:** Mouna Houari, Bensaddik Mohammed, Arbai Salma

**Drafting of the manuscript:** Mouna Houari, Bensaddik Mohammed, Arbai Salma, Idrissi Serhrouchni Karima

**Critical review of the manuscript for important intellectual content:** Mouna Houari, Ammour Abdesselam, Bensaddik Mohammed

**Supervision:** Ammour Abdesselam, Idrissi Serhrouchni Karima

## Disclosures

**Human subjects:** Informed consent for treatment and open access publication was obtained or waived by all participants in this study. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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