Phenotypic, Allelic and Genotypic Frequencies of ABO and Rhesus Blood Groups, Secretor Status, Phenylthiocarbamide Taste Perception and Haemoglobin Variants in Ore Community, Southwestern Nigeria

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Abstract: There is dearth of information on the gene frequencies of ABO and Rhesus blood groups, secretor status, PTC taste perception and haemoglobin variants in Osun State, Nigeria and previous studies have been based on heterogeneous population. We wanted to have information on the frequency distributions of these traits in Osun State and among a homogeneous population. A total of 555 individuals comprising 308 male and 247 female indigenes of Ore community participated in this study. Participants’ blood samples were typed for ABO, Rhesus blood groups and haemoglobin genotype, saliva samples were analysed for ABH secretory status and PTC taste perception was determined using PTC strips. The frequencies of O, A, B and AB individuals were 41.6%, 30.8%, 21.6% and 6.0% respectively, those of Rh positive and Rh negative were 89.9% and 10.1%, those of secretors and non-secretors were 69.2% and 30.8% respectively while those of tasters and non-tasters were 56.6% and 43.4% respectively. The observed ABO blood group, Rhesus factor, secretor status, PTC taste perception distributions did not differ significantly (p = 0.986, p = 0.943, p = 0.926, p = 0.864 respectively) from those expected under the Hardy-Weinberg equilibrium. The allelic frequencies for ABO were p(A) 0.205, p(B) 0.149 p(r) 0.645, those for Rhesus factor were D(0.682) and d(0.318), those for secretion and non-secretion were Se (0.445) and se(0.555) respectively while those of tasting and non-tasting were T(0.341) and t(0.659) respectively. Four haemoglobin genotypes in the order AA (68.6%) > AS (26.7%) > AC (3.8%) > SS (0.9%) were observed with allelic frequencies A(0.839), S(0.142) and C(0.019). This study has provided information on the frequency distributions of the studied genetic indices in Osun State. The information provided herein can be used to give medical and genetic counsel to the people of the State.

Keywords: ABO and Rhesus Blood groups; Secretor status; Phenylthiocarbamide; Haemoglobin variants; Gene frequencies.
rheumatic heart disease [16], thrombotic diseases [17], diabetes [18] while secretors have only been associated with some viral infections [19-22].

The Rhesus (Rh) blood group system is a complex consisting of several blood group antigens; the most important of which is antigen D commonly referred to as Rh factor. Like the ABO blood group, the Rhesus blood group has been associated with a number of diseases [23, 24] with Rh negative individuals being more susceptible than their Rh positive counterparts [23].

Haemoglobin is the oxygen carrying component of the red blood cell. In Southwestern Nigeria, in addition to normal haemoglobin A, haemoglobins S and C where valine and lysine are substituted respectively for glutamic acid in the 6th position of the beta chain exist, bringing about variants AA, AS, AC, SS, CC and SC among the people in the region [25, 26]. Many studies have associated HbAS and HbAC with resistance to severe and mild falciparum malaria [27-29]. Haemoglobinopathies especially sickle cell anaemia poses a lot of health challenges in Nigeria [30, 31]. Individuals with HbSS are easily susceptible to malaria [32] while HbCC variant is known to protect against malaria [27].

Phenylthiocarbamide (PTC) taste sensitivity has been used as a tool to trace family lineages and population migration patterns and it was previously used in paternity testing before the advent of DNA markers [33]. It has been correlated with a number of dietary preferences and human health [34, 35]. Also, it has been correlated with the ability to taste other naturally occurring bitter substances in cruciferous vegetables [36]. Tasters (TT or Tt) are those who taste PTC while non-tasters (tt) cannot taste it. Bitter taste perception occurs through bitter taste receptors located on the surface of taste cells of the tongue [37] and is thought to be an adaptive feature in mammals to avoid the ingestion of naturally toxic substances [38]. The ability to taste PTC or otherwise has been related to some diseases or disorders. Several studies have reported association or lack of association between PTC taste perception and different diseases/disorders [39-44].

In Nigeria, we are not aware of any study on the frequency distributions and gene frequencies of these genetic indices among the inhabitants of Osun State in Southwestern Nigeria. Also, previous studies carried out on this subject matter were largely based on heterogeneous populations. In this study, we examined the frequency distributions and gene frequencies of these genetic indices among some indigenes of Ore, a rural community in Osun State, Southwestern Nigeria.

MATERIALS AND METHODS

This study was carried out among the indigenes of Ore community, Southwestern Nigeria. A total of 555 individuals (308 males and 247 females) from about 2000 indigenes of Ore community between ages 5 years and 80 years old participated in this study. Questionnaires were administered to each participant to obtain relevant information. The consent of the parents and guardians of the children was obtained. The permission of the community leaders and school authority was obtained before the commencement of the study. Ethical approval for this study was obtained from the Ethical Committee of the Ministry of Health, Osogbo, Osun State.

Five (5) ml of venous blood was collected from each participant into ethylenediaminetetraacetic acid (EDTA) bottle. ABO and Rh blood group antigens tests were performed by standard tile techniques along with standard controls [45]. They were performed on saline washed red cells using commercially prepared monoclonal anti-A, anti-B and anti-D according to the manufacturer’s instructions (Biotech Laboratories, U.K). Haemoglobin genotype test was performed using the cellulose acetate electrophoresis technique [45]. In addition, 5 ml of saliva was collected from each participant for determination of secretor status. Secretor and non-secretor phenotypes were identified using the haemagglutination inhibition test as described elsewhere [46]. Phenylthiocarbamide (PTC) taste perception was determined using PTC strips (0.0143 mg of PTC /strip) (Carolina Biological Supply Company, North Carolina, USA). Briefly, each participant was given a PTC taste strip and a filter paper (as control) and was asked to put each on their tongue and allow to be soaked in their saliva before describing their perception to each strip. Taste description of each participant was recorded. Laboratory investigations were carried out in the Research Laboratory, Department of Biomedical Sciences, College of Health Sciences, Ladoke Akintola University of Technology, Osogbo, Nigeria.

Chi-square test was used to compare differences between percentages/proportions and to compare observed and expected frequencies. Allelic and genotypic frequencies were calculated using Hardy-Weinberg equation. A p-value of < 0.05 was considered to be significant.

RESULTS

The distributions of phenotypic, allelic and genotypic frequencies of ABO blood groups among the study population are given in Table 1. The overall frequencies of O, A, B and AB individuals were 41.6%, 30.8%, 21.6% and 6.0% respectively. There was no statistically significant difference in the distributions of ABO blood groups between the male and female participants ($\chi^2 = 0.355; df = 3; p = 0.949$). The allelic frequencies $p$ (A), $q$ (B), $r$ (O) for the males and
The allelic frequencies for Rh positive (D) and Rh negative (d) were 0.682 and 0.318 respectively. The overall genotypic frequencies were 0.465, 0.434 and 0.101 for DD, Dd and dd respectively.

The results of the secretor status of the study population are given in Table-3. The overall frequencies of secretors and non-secretors were 69.2% and 30.8% respectively. The frequencies of male (69.5%) and female (68.8%) secretors were not significantly different ($\chi^2 = 0.028; df = 1; p = 0.868$). The allelic frequencies for Rh negative males and females were 0.317 and 0.318 respectively while the overall allelic frequencies for Rh positive (D) and Rh negative (d) were 0.682 and 0.318 respectively. The overall genotypic frequencies were 0.465, 0.434 and 0.101 for DD, Dd and dd respectively.

The observed and expected frequencies for ABO and Rh blood groups, secretor status and PTC taste perception are given in Table 5. The observed and expected frequencies for the ABO blood group, O (41.6%, 42.2%), A (30.8%, 30.1%), B (21.6%, 21.8%) AB (33.0%, 33.0%) ($\chi^2 = 0.143; df = 3; p = 0.986$), Rh positive (89.9%, 90.0%) and Rh negative (10.1%, 10.0%) ($\chi^2 = 0.005; df = 1; p = 0.943$), secretors (69.2%, 69.0%) and non-secretor (30.8%, 31.0%) ($\chi^2 = 0.008; df = 1; p = 0.926$) and tasters (56.5%, 56.9%) and non-tasters (43.4%, 43.1%) ($\chi^2 = 0.005; df = 1; p = 0.943$) did not vary significantly under the Hardy-Weinberg equilibrium.

The allelic and genotypic frequencies of the haemoglobin types among the study population are given in Table 6. Three different haemoglobin variants: HbA, HbS and HbC were observed which occurred in 4 genotypic combinations in the order AA > AS > AC > SS (68.6% > 26.7% > 3.8% > 0.9%). The distribution of haemoglobin variants in male and female participants did not vary significantly ($\chi^2 = 1.469; df = 3; p = 0.689$). The overall allelic frequencies for A, S and C were 0.839, 0.142 and 0.019 respectively.

Table-1: Distribution of Phenotypic, Allelic and Genotypic Frequencies of ABO Blood Group among the Study Participants in Ore, Nigeria

<table>
<thead>
<tr>
<th>Sex</th>
<th>No Exam.</th>
<th>Phenotypic Frequency</th>
<th>Allelic frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>O(%)</td>
<td>A(%)</td>
</tr>
<tr>
<td>Male</td>
<td>308</td>
<td>129(41.9)</td>
<td>97(31.5)</td>
</tr>
<tr>
<td>Female</td>
<td>247</td>
<td>102(41.3)</td>
<td>74(30.0)</td>
</tr>
<tr>
<td>Total</td>
<td>555</td>
<td>231(41.6)</td>
<td>171(30.8)</td>
</tr>
</tbody>
</table>

Table-2: Distribution of Phenotypic, Allelic and Genotypic Frequencies of Rhesus Blood Group among the Study Participants in Ore, Nigeria

<table>
<thead>
<tr>
<th>Sex</th>
<th>No Exam.</th>
<th>Phenotypic Frequency (%)</th>
<th>Allelic Frequency</th>
<th>Genotypic Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Rh Positive</td>
<td>D</td>
<td>d</td>
</tr>
<tr>
<td>Male</td>
<td>308</td>
<td>277(89.9)</td>
<td>31(10.1)</td>
<td>0.683</td>
</tr>
<tr>
<td>Female</td>
<td>247</td>
<td>222(89.9)</td>
<td>25(10.1)</td>
<td>0.682</td>
</tr>
<tr>
<td>Total</td>
<td>555</td>
<td>499(89.9)</td>
<td>56(10.1)</td>
<td>0.682</td>
</tr>
</tbody>
</table>

$\chi^2 = 0.355; df = 3; p = 0.949$

$\chi^2 = 0.001; df = 3; p = 0.982$

Table-3: Distribution of Phenotypic, Allelic and Genotypic Frequencies of Secretors and Non-secretors among the Study Participants in Ore, Nigeria

<table>
<thead>
<tr>
<th>Sex</th>
<th>No Exam.</th>
<th>Secretor Phenotypic Frequency (%)</th>
<th>Non-secretor Phenotypic Frequency (%)</th>
<th>Secretor Allelic Frequency</th>
<th>Non-secretor Allelic Frequency</th>
<th>Genotypic Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>308</td>
<td>214(69.5)</td>
<td>94(30.5)</td>
<td>0.448</td>
<td>0.552</td>
<td>0.200 0.495 0.305</td>
</tr>
<tr>
<td>Female</td>
<td>247</td>
<td>170(68.8)</td>
<td>77(31.2)</td>
<td>0.442</td>
<td>0.558</td>
<td>0.195 0.493 0.312</td>
</tr>
<tr>
<td>Total</td>
<td>555</td>
<td>384(69.2)</td>
<td>171(30.8)</td>
<td>0.445</td>
<td>0.555</td>
<td>0.198 0.494 0.308</td>
</tr>
</tbody>
</table>

\( \chi^2 = 0.028; \text{df} = 1; p = 0.86 \)

Table-4: Distribution of Phenotypic, Allelic and Genotypic Frequencies of Phenylthiocarbamide Tasters and Non-tasters among the Study Participants in Ore, Nigeria

<table>
<thead>
<tr>
<th>Sex</th>
<th>No Exam.</th>
<th>Taster Phenotypic Frequency (%)</th>
<th>Non-taster Phenotypic Frequency (%)</th>
<th>Taster Allelic Frequency</th>
<th>Non-taster Allelic Frequency</th>
<th>Genotypic Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>308</td>
<td>165(53.6)</td>
<td>143(46.4)</td>
<td>0.319</td>
<td>0.681</td>
<td>0.102 0.434 0.464</td>
</tr>
<tr>
<td>Female</td>
<td>247</td>
<td>149(60.3)</td>
<td>98(39.7)</td>
<td>0.370</td>
<td>0.630</td>
<td>0.137 0.466 0.397</td>
</tr>
<tr>
<td>Total</td>
<td>555</td>
<td>314(56.6)</td>
<td>241(43.8)</td>
<td>0.341</td>
<td>0.659</td>
<td>0.116 0.450 0.434</td>
</tr>
</tbody>
</table>

\( \chi^2 = 2.544; \text{df} = 1; p = 0.11 \)

Table-5: Observed and Expected Frequencies of ABO and Rhesus Blood Groups, Secretor Status and Phenylthiocarbamide Taste Perception among the Study Participants in Ore, Nigeria

<table>
<thead>
<tr>
<th>Variable</th>
<th>Observed No</th>
<th>Observed Freq/%</th>
<th>Expected No</th>
<th>Expected Freq/%</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABO group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>231</td>
<td>41.6</td>
<td>234</td>
<td>42.2</td>
<td>0.986</td>
</tr>
<tr>
<td>A</td>
<td>171</td>
<td>30.8</td>
<td>167</td>
<td>30.1</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>120</td>
<td>21.6</td>
<td>121</td>
<td>21.8</td>
<td></td>
</tr>
<tr>
<td>AB</td>
<td>33</td>
<td>6.0</td>
<td>33</td>
<td>6.0</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>555</td>
<td>100.0</td>
<td>555</td>
<td>100.0</td>
<td></td>
</tr>
<tr>
<td>Rhesus group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rh Positive</td>
<td>499</td>
<td>89.9</td>
<td>500</td>
<td>90.0</td>
<td>0.943</td>
</tr>
<tr>
<td>Rh Negative</td>
<td>56</td>
<td>10.1</td>
<td>56</td>
<td>10.0</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>555</td>
<td>100.0</td>
<td>556</td>
<td>100.0</td>
<td></td>
</tr>
<tr>
<td>Secretor Status</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secretor</td>
<td>384</td>
<td>69.2</td>
<td>383</td>
<td>69.0</td>
<td>0.926</td>
</tr>
<tr>
<td>Non-secretor</td>
<td>171</td>
<td>30.8</td>
<td>172</td>
<td>31.0</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>555</td>
<td>100.0</td>
<td>555</td>
<td>100.0</td>
<td></td>
</tr>
<tr>
<td>PTC Tasting</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taster</td>
<td>314</td>
<td>56.6</td>
<td>316</td>
<td>56.9</td>
<td>0.864</td>
</tr>
<tr>
<td>Non-taster</td>
<td>241</td>
<td>43.4</td>
<td>239</td>
<td>43.1</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>555</td>
<td>100.0</td>
<td>555</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

Table-6: Distribution of Allelic and Genotypic Frequencies of Haemoglobin Variants among the Study Participants in Ore, Nigeria

<table>
<thead>
<tr>
<th>Sex</th>
<th>No Exam.</th>
<th>Genotypic Frequency (%)</th>
<th>Allelic Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>AA 82(26.6) AC 2(0.8)</td>
<td>A 0.484 S 0.143 C 0.015</td>
</tr>
<tr>
<td>Male</td>
<td>308</td>
<td>214(69.5)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>247</td>
<td>167(67.6)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>555</td>
<td>381(68.9)</td>
<td></td>
</tr>
</tbody>
</table>

\( \chi^2 = 1.469; \text{df} = 3; p = 0.689 \)

DISCUSSION

This study investigated the phenotypic, allelic and genotypic frequencies of ABO and Rh blood groups, secretor status, PTC taste perception and haemoglobin variants of indigenes of Ore community, Southwestern Nigeria. The distributions of genetic indices are known to vary from one race to another and from one geographical region to another. In this study, the phenotypic distribution of ABO blood group was in the order O > A > B > AB (41.6%, 30.8%, 21.6% and 6.0% respectively). This is in line with the reports of similar studies carried out across the country [4, 25, 47-50] and elsewhere in Africa [51-55], Asia [56], Middle East [9, 57-59], Europe [60, 61], North America [62, 63] with the exception of North-western Nigeria where the order O > B > A > AB has been reported [47, 50, 64, 65]. Generally, the O group is reported to be the most common in many given populations across the world.
world with the exception of some parts of India [66] and Pakistan [67] where group B is reported as the most frequent and in Nepal [62] and Jordan [68] where group A is the most common.

The ABO blood group allelic frequencies order of r(O) > p(A) > q(B) observed in this study is in agreement with the values observed in many previous studies in Nigeria [4, 47, 69] and this signifies that the r (O) allele is the most common in Nigeria followed by p (A) allele. The ABO blood group distribution in this study did not differ from the expected distribution under the Hardy-Weinberg equilibrium. This is not the case with some previous studies [4, 25, 49, 70] carried out among heterogeneous populations in Nigeria where the observed distributions differed significantly from those expected under the Hardy-Weinberg equilibrium. Nevertheless, the observation concurs with that of Alimba et al., [71] who reported no difference among a heterogeneous population in Lagos, Southwestern Nigeria. That group O is the most common in the present study which is in line with previous studies is an advantage considering its role in conferring resistance against some common infectious diseases. For instance, group O is known to protect against severe malaria [72], S. mansoni infections [73-75] and severe form of urogenital schistosomiasis [75, 76].

In this study, the frequencies of 89.9% (comprising 46.6% DD and 43.3% Dd) and 10.1% observed for Rh positive and Rh negative respectively were in agreement with the expected under the Hardy-Weinberg equilibrium. This is line with other previous studies in Nigeria which revealed that Rh positive individuals were more than Rh negative; nevertheless, the Rh negative value reported in this study was slightly higher than those of previous studies across the country where a range of 3% to 7.5% had been reported [4, 25, 47-49, 77]. This slight difference observed might be due to the homogenous nature of our study participants compared to the other studies which involved participants from different ethnic or racial groups. Elsewhere in Asia, Europe and North America, studies on Rh blood group have shown Rh negative range from 0 to 17% [58, 61, 78, 79]. Knowledge of Rh blood group system is used to prevent complications arising from Rh incompatibility between a mother and her foetus which is likely when a Rh negative (dd) mother marries a Rh positive (Dd) man. With 10.1% of the females examined being Rh negative, intending couples in this locality need to seek the advice of genetic counsellors so as to prevent cases of haemolytic disease of the Newborn.

Secretors were more than non-secretors in this study and this is in line with previous studies on prevalence of secretor status in Nigeria [46, 80]. But there was no significant difference between the frequencies of female and male secretors. The phenotypic frequency of non-secretors in this study was 31% and the allelic frequency was 0.56. In Osogbo, a city in Southwestern Nigeria, Igbenehegu et al., [23] reported a prevalence of 22% non-secretors. Elsewhere, Jaff [9] reported 24%, Akhter et al., [81] reported 40% and Saboor et al., [82] 36% and 20% reported among the Caucasians [45]. The low frequency of non-secretors in this study area is good for the population since non-secretors are known to be at a potential health disadvantage compared to secretors [46]. Also, previous studies carried out in the same region and elsewhere have shown that secretors varied significantly with ABO [9, 46, 80] with a higher proportion of group O secretors than any other group. Group O secretors have been associated with resistance to incidence and severity of chronic disorders such as tumours and malignancies including cancer of the stomach and colon [9, 83] and since a larger number of O individuals are secretors compared to the non-O groups, there would be low incidence and severity of such disorders in this locality.

Similarly, tasters were more than non-tasters which is in line with previous studies in Nigeria [71, 84, 85] and even across the world about 30% of the population is non-tasters [43, 44]. There was no significant difference between the frequencies of female and male tasters. The phenotypic and allelic frequencies of 43.4% and 0.66 observed for non-tasting in this study were higher than those of previous studies in the same region. Alimba et al., [71] reported 29.4% and 0.54 respectively and Bakare et al., [85] reported 25.6% and 0.49 respectively in Southwestern Nigeria. The differences observed could be associated with differences in the nature of the populations studied. These previous studies were carried out among mixed populations while the present study was among a homogenous population. Also, the different methods of the PTC tasting employed in these studies could partly be responsible for the differences observed. Elsewhere, phenotypic and allelic frequencies range from 24.5% to 71.5% and 0.09 to 0.89 respectively had been reported [35, 86]. Owing to the high frequency of non-tasting allele reported in this study, the population might likely be more prone to disorders/diseases that are associated with inability to taste PTC.

The data presented in this study showed that the four most common haemoglobin variants in Southwestern Nigeria were observed in the following order: AA (68.6%) > AS (26.7%) > AC (3.8%) > SS (0.9%). It is in agreement with the reports of a range of 55-75% AA for Africans and about 25% of the population of sub-Saharan Africa as sickle cell trait [87, 88], Three haemoglobins, Hb A, Hb S and Hb C with allelic frequencies 0.842, 0.143 and 0.015 respectively were observed. These allelic frequencies are similar to those previously reported by Bakare et al., [25] (0.81, 0.14 and 0.04) and Alimba et al., [71] (0.877, 0.111 and 0.012) in the same region. In view of the prevalence of sickle cell trait (26.7%) and sickle cell anaemia (0.9%)
reported in this study, premarital haemoglobin counselling would certainly play a vital role in the control of haemoglobinopathies in this community. Couples who are both HbAS have one-fourth chance of producing a baby with HbSS for every pregnancy. With four out of every five sickle-cell anaemia cases occurring in sub-Saharan Africa [30] and Nigeria harbouring the highest number of carriers and sufferers of the disorder with about 2% of newborns being affected by sickle cell anaemia annually and about 95% of the children with the disorder dying before the age of 10 years [30, 31] there is the need for the policy makers to take necessary measures without further delay to control this scourge.

CONCLUSION

This study presents the phenotypic, allelic and genotypic frequencies of ABO and Rh blood groups, secretor status, PTC taste perception and haemoglobin variants in a homogenous population in Southwestern Nigeria. Our result is a reflection of the general distribution of these genetic features in Southwestern Nigeria. The slight variations observed compared to the previous studies could be adduced to differences in the nature of population studied. Knowledge of the information regarding these genetic indices in each community is useful for medical diagnosis and genetic counselling.

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frequencies of ABO and Rh (D) blood group alleles in a healthy infant population in Ibadan, Nigeria. West African journal of medicine, 18(4), 294-297.


