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Iron-Deficiency Anaemia (IDA): Socio-Economic Inequality and Spatial Patterns in its Prevalence in Women of Reproductive Age in Pakistan

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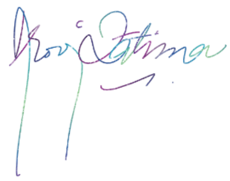
Declaration

I, Arooj Fatima, hereby declare that this Masters Thesis titled “Iron-Deficiency Anaemia (IDA): Socio-Economic Inequality and Spatial Patterns in its Prevalence in Women of Reproductive Age in Pakistan“, submitted to GLODEP Consortium, is my original work completed under the supervision of Professor Dr. Jaromír Harmáček from the Palacky University and of Professor Sebastian Vollmer from the University of Gottingen. I confirm that the work is my own effort for the successful completion of Erasmus Mundus Joint Master Degree in International Development Studies –GLODEP. The theoretical and empirical literature, datasets and methodology adopted from other studies have been duly cited and referenced. I have adhered to academic honesty and integrity in creating this study and have not misrepresented any idea, fact, or result.



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Zásady pro vypracování

The World Health Organization has stated that malnutrition is the single most dangerous threat to global public health. It affects health of infants at birth, cognitive development in early years and productivity in later age. While the causes can be attributed to poor quality of diet, poor maternal health and socioeconomic status, severe deficiencies in protein, iron, iodine, vitamin A and zinc are main manifestations of malnutrition in developing countries. Based on a conservative scenario by UNICEF, it is projected that an additional 22 million children in low- and middle-income countries will be stunted, an additional 40 million will be wasted between 2020 and 2030 due to the pandemic. Comprehensive and urgent efforts are required to address the detrimental effects of the pandemic and achieve the 2030 global targets.

This research aims to study the incidence of malnutrition in poor communities of developing countries and perform a thorough exploratory analysis in a selected region. Considering possible constraints, it may also carry out comparative analyses and present policy recommendations.

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UNICEF / WHO / World Bank Group. *Levels and Trends in Child Malnutrition. Joint Child Malnutrition Estimates.* Key findings of the 2021 edition
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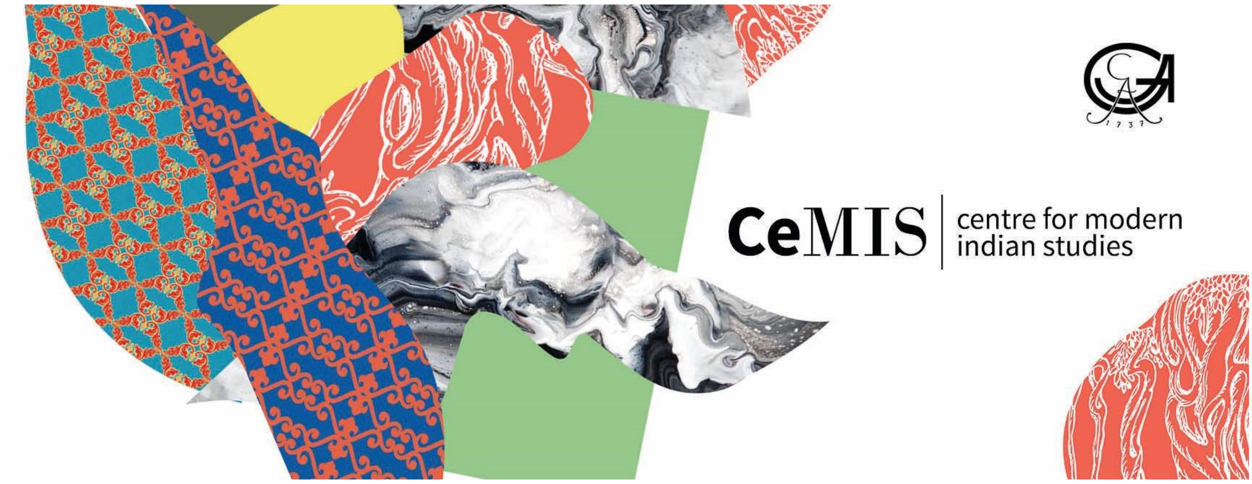

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Abstract

Prevalence of iron deficiency anaemia (IDA) in women of reproductive age is a major malnutrition concern in developing countries. IDA is associated with complex interactions between its causes and socioeconomic determinants, varying across regions at sub-national levels. Dearth of academic and clinical literature on this association and lack of nationally representative data on the relevant indicators for Pakistan are major roadblocks to treat the national burden. Relevant literature is available for India but almost no studies are done on other countries in South Asia and Sub-Saharan Africa. This study presents the prevalence of anaemia in women of reproductive age, a vulnerable group that is disadvantaged in Pakistan in terms of access to and outcomes related to health. The study explores the socio-economic determinants of IDA in women, the extent of socio-economic inequality in IDA and district-wise spatial patterns in its prevalence. By using data from the recent Pakistan National Nutrition Survey 2018 and employing sophisticated empirical techniques of bivariate analysis, multivariate logistic regression, concentration index and choropleth maps, the study elucidate how multifactorial socio-economic determinants affect the prevalence of IDA in Pakistan. There is also a significant inequality in the incidence of IDA across the districts. Hence, multi-sectoral and integrated interventions targeting specific groups and geographical areas need to be designed, developed and implemented.

Keywords: iron deficiency anaemia, women of reproductive age, Pakistan, prevalence, socio-economic determinants, socio-economic inequality, spatial pattern

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List of Abbreviations

AJK	Azad Jammu and Kashmir
AKU	Aga Khan University
ANC	Antenatal Care
BMI	Body Mass Index
CDC	Centers for Disease Control and Prevention
CI	Concentration Index
DFID	Department for International Development
DHS	Demographic and Health Survey
FAO	Food and Agriculture Organization
GB	Gilgit-Baltistan
GBD	Global Burden of Disease
ICT	Islamabad Capital Territory
IDA	Iron Deficiency Anaemia
KP	Khyber Pakhtunkhwa
KP-NMD	Khyber Pakhtunkhwa Newly Merged Districts
MICS	Multiple Indicator Cluster Survey
MNHRC	Ministry of National Health Services, Regulations and Coordination
OR	Odds Ratio
PBS	Pakistan Bureau of Statistics
PNNS	Pakistan National Nutrition Survey
SDG	Sustainable Development Goals
SDI	Socio Demographic Index
UN	United Nations
UNICEF	United Nations Children's Fund
WFP	World Food Program
WHO	World Health Organisation
WRA	Women of Reproductive Age

INTRODUCTION

Malnutrition, in all its forms, is a global concern today. Sustainable Development Goal (SDG) 2 gives particular attention to the access of nutritious food to all to end hunger while Target 2.2 specifically focuses on addressing the nutritional needs of children, adolescents, women and older persons (UN, 2015). Anaemia is a nutritional deficiency that affects around 32.9% of the world's population (Kassebaum, 2010), and iron-deficiency anaemia (IDA) constitutes about half of those cases (SR Pasricha, 2021). IDA is a health concern all over the world but this malnutrition is more prevalent in women of low and middle-income countries because of a combination of casual and correlated socioeconomic, nutritional and health factors.

Iron-deficiency anaemia (IDA) is the leading cause of years lost in disability (YLD) for women (GBD, 2017). According to the World Health Organization (WHO), one-third of women of reproductive age, 15-49 years, are anaemic (2020). With adverse maternal outcomes and lifelong cognitive and development problems in children, IDA has more detrimental health effects on women than of any other vulnerable group. This nutritional deficiency is interlinked with other global nutrition targets related to stunting, wasting, low birth weight, childhood overweight, and exclusive breastfeeding (WHO, 2020). Thus, reducing anaemia in women of reproductive age is one of World Health Assembly Global Nutrition Targets for 2025[1] and an Indicator for the Sustainable Development Goals (SDG 2.2.3)[2] (WHO, 2012; UN 2015).

Prevalence of iron deficiency anaemia, in 2019, among women in developing countries was estimated to range from 35% to 62% (WHO, 2020). The World Health Organization classifies anaemia prevalence percentages into four categories: severe (≥40%), moderate (20-39.9%), mild (5-19.9%) and normal (≤5%) (2011). The region of South Asia has the highest anaemia cases (Kassebaum et al., 2014), with Pakistan having an anemia incidence of 41.3% among women of reproductive age (WHO, 2020) putting the country into the severe category. According to the Global Health Observatory, 44% of pregnant and 41.1% of non-pregnant women in Pakistan suffer from anaemia (2019). Among many other low and middle-income countries, Pakistan is on the forefront of this global health emergency.

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[1] WHO, 2012. Global nutrition targets 2025: policy brief series: ''*achieve a 50% reduction of anaemia in women of reproductive age by 2025*''

[2] UN, 2015. Target 2.2: By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons

Indicator 2.2.3: Prevalence of anaemia in women aged 15 to 49 years, by pregnancy status (percentage)

Anaemia is an indicator of both poor nutrition and poor health. With low socioeconomic status in most districts, poor dietary intake, substandard living conditions, low levels of education and a large share of the population lacking knowledge about nutritional anaemia, the issue in Pakistan is acute, and presses for urgent interventions. A lack of relevant data and a dearth of academic and clinical literature due to the complex interaction of its determinants are major roadblocks to explore the national burden, further hampering the overall progress. Nutrition crosses multiple sectors, so success requires cross-sectoral actions (WHO, 2020). The burden of iron-deficiency anaemia is a consequence of complex interactions between its causes and determinants; hence, a multi-sectoral and coordinated analysis is critical to design interventions. Moreover, Pakistan has a modified Palma ratio of 4.7 signifying that the richest quintile has 4.7 times the income of the poorest quintile (Human Development Report, 2020). Since Pakistan is one of the lower-middle income countries with unequitable access to health, this economic and social inequality also translates to health inequality in the country by limiting people's access to better nutrition and healthcare services.

The objective of this study is to present the prevalence of anaemia in women of reproductive age that is already a marginalized group in terms of access to and outcomes related to health. The study will focus on this group and analyze the differential outcomes on anaemia by socioeconomic determinants,-shed light on the issue of inequality in nutrition to prevent and treat the national health burden and formulate policy recommendations in regions/districts with a high prevalence of anaemia. The study aims to answer three research questions:

RQ1: What are the effects of socio-economic predictors on the prevalence of iron deficiency anaemia?

RQ2: Is there a socio-economic inequality in the prevalence of iron deficiency anaemia in women of reproductive age across the districts of Pakistan and if yes, what is its extent?

RQ3: Are there any spatial differences in pattern of iron deficiency anaemia in women of reproductive age across various districts in Pakistan?

This study aims to understand the complex socioeconomic predictors of undernutrition and anaemia together with its other biochemical deficiencies and also, more importantly, understand the spatial variation in the prevalence of anaemia among different districts of Pakistan. It focuses on analyzing the extent of socio-economic inequalities and spatial patterns in anaemia among women of reproductive age using data from the recent National Nutrition

Survey 2018 in Pakistan. It uses bivariate analysis and multivariate logistic regressions to elucidate the socio-economic determinants of anaemia using three different measures of iron deficiency anaemia. Concentration index, a measure to quantify the degree of socio-economic-related inequality in a specific health variable, is calculated to check for the extent of inequality in anaemia prevalence across various districts. The spatial variation in anaemia prevalence incidence across the country is presented by using district-level statistics and choropleth maps.

The remainder of this thesis is organized as follows: the first chapter reviews the literature that establishes the theoretical context of global anaemia prevalence, use of explanatory variables and relevant methodologies in related studies. The second chapter presents the anaemia landscape of Pakistan. The third chapter states information on data, including the source, description and summary statistics of the variables used in the analysis. The fourth chapter explains the methodology adopted to carry out the quantitative analysis while the fifth chapter presents the empirical results. The final two chapters discuss results from the previous section and simultaneously provide policy implications to reduce the burden of anaemia for the country. The chapter on Discussion also highlights the importance of studying socio-economic inequality in health outcomes and using spatial patterns to formulate geographically targeted interventions, followed by the Conclusion.

CHAPTER 1 LITERATURE REVIEW

This chapter is subdivided into seven parts. The first part precisely states the definition and causes of iron deficiency anaemia (IDA). The second part presents the global, regional, and national burden of IDA. The third section sheds light on the manifestations of IDA with a focus on our target group. The fourth section reviews the interventions to treat IDA and why they have not been very effective. It further presents a qualitative analysis on what lessons have been learnt to design interventions for anaemia reduction around the world. The fifth section reviews literature on the choice of variables used by earlier studies while the sixth section provides an overview of the studies which have used logistic regression, concentration index and spatial patterns to conduct various types of analysis on anaemia landscape. Finally, the last section briefly identifies the gaps in the literature.

1.1 Definition and Causes of Iron-Deficiency Anaemia

Anaemia is a condition in which the number of red blood cells or the concentration of oxygen-carrying protein called haemoglobin within them is lower than normal (WHO, 2020). It affects 33% of the world's population, and iron-deficiency anaemia (IDA) constitutes about half of those cases (SR Pasricha, 2021). Iron deficiency as the most common cause of anaemia globally may result from prolonged negative iron balance, caused by inadequate dietary iron intake or absorption, increased iron needs during pregnancy or growth periods, and increased iron losses as a result of menstruation or helminth (intestinal worms) infestation (WHO, 2014). Other important causes of anaemia worldwide include various nutritional deficiencies (including folate, vitamin B12, vitamin A and zinc), acute and chronic inflammation, parasitic infections, and inherited or acquired disorders that affect haemoglobin synthesis, red blood cell production or red blood cell survival.

1.2 Burden and Prevalence of IDA

According to a comparative study carried out by Safiri et al. (2019), *globally*, there were 1.8 billion prevalent cases in 2019, but the incidence was 13.4% lower as compared to that in 1990. The global absolute number of prevalent cases of anaemia, however, has increased from 1.4 billion in 1990 to 1.8 billion in 2019 (Safiri et al., 2020). This increase is primarily due to population growth and population ageing and better survival chances in patients with conditions like long-term kidney disease and others that cause anaemia. According to a study carried out for *Current Developments in Nutrition* by Gardner and Kassebaum (2020), global prevalence in 2019 was highest among children under five years (39.7%). According to WHO estimates, 42% of children under five and 40% of pregnant women suffer from anaemia (2020). Out of all the cases of anaemia worldwide, 54.1% were mild, 42.5% were moderate, and 3.4% were severe (Gardner and Kassebaum, 2020). Anaemia was responsible for 58.6 million years lived with disability in 2019 (Gardner, Kassebaum, 2020). In women of reproductive age, iron deficiency anaemia globally affects 29% of non-pregnant (Stevens et al., 2013) and 38% of pregnant women (Kassebaum et al., 2014). The incidence of anaemia in non-pregnant women of reproductive age (15-49 years) changed little between 2000 and 2019, from 31% to 30%, while in pregnant women of reproductive age (15–49 years), it decreased from 41% to 36% (Stevens et al., 2022).

Regionally, the rates are highest in low-resource countries of South-Asia and Sub-Saharan Africa. as these regions are associated with a complex combination of poverty, insufficient dietary intakes, and high burden of disease (Balarajan et al., 2011). All Global Burden of Disease (GBD) regions have witnessed reduction in the age-standardized point prevalence[3] of anaemia in twenty years from 1990 to 2019. The rates improved significantly in East Asia (-59.3%), Andean Latin America (-38.3%) and high-income Asia Pacific (-37.5%) (Safiri et al., 2019). The same study presents that South Asia, East Asia and Southeast Asia experienced the largest number of prevalent cases in 1990, while the highest in 2019 were found in South Asia, Western and Eastern Sub-Saharan Africa. Looking at *national* statistics, anaemia is prevalent highest in Zambia, Mali and Burkina Faso & lowest in France, Iceland and Belgium (Safiri et al., 2019).

1.3 Manifestations of IDA

Iron deficiency anaemia (IDA) is among the leading five causes of years lived with disability in the general population, and the leading one for women (GBD, 2017). IDA has significant detrimental effects on cognitive and motor development in children and it causes exhaustion and low productivity in adults. For women of reproductive age, it is linked to poor reproductive outcomes. In pregnancy, IDA may be linked to low birth weight of the child, decreased iron stores causing impaired development and increased risk of maternal and perinatal mortality (WHO, 2014). Annually, an estimated 22% of maternal deaths and 24% of perinatal deaths around the world are due to IDA (Murray, 2019). Menstrual loss, pregnancy and abnormal uterine bleeding put women at a higher risk of developing an iron deficiency that can result in severe fatigue, reduced exercise capacity and poor work performance (Benson et al., 2021). Anaemia is an outcome and indicator of both poor nutrition and poor health. It is itself an issue, but it is linked to other global nutritional concerns as well including stunting, wasting and low

[3] In epidemiology and demography, it is a technique used to allow statistical populations to be compared when the age profiles of the populations are quite different (*Epidemiological Bulletin, Vol. 23 No. 3, September 2002*)

birth weight. Poor academic performance in children and reduced work productivity in adults have further social and economic consequences for the individual and family (WHO, 2020).

1.4 Interventions to treat IDA and why they fail to improve the situation

Evidence indicates that anaemia due to iron deficiency varies by population group, geographical environment, the prevalence of infectious diseases, and by the presence of other causes of anaemia as well (Chaparro and Suchdev, 2019). Because of these multifactorial causes and complex interactions between the determinants, an integrated and multisectoral approach is needed to design, develop, and implement interventions to reduce the global burden.

Anaemia prevention and control strategies to address nutritional causes of anaemia have been described in various literature. All of them majorly include: improved dietary intake and increased food diversity with increased iron bioavailability; targeted fortification of foods for vulnerable groups (e.g., in infant formula and staple flours); and iron (and folic acid) supplementation for high-risk groups, such as children and women. (Safiri, S et al., 2019; WHO, 2020). The most effective interventions are micronutrient supplementation programs, specifically iron or iron plus folic acid supplements provided to target adolescent girls and women of reproductive age. For example, in Gujarat, India, the prevalence of anaemia reduced from 74.2% to 53.3% only within a year, by providing intermittent (weekly) iron–folic acid supplementation to over 1.2 million adolescent girls (WHO, 2014). Also, fortification of commonly consumed products like iron-fortified wheat flour, with or without other micronutrients, reduced the risk of anaemia by 27% (Field, Mithra and Peña-Rosas, 2021). However, supplementation programmes, specifically, need to address further challenges associated with healthcare services that have limited their effectiveness. These include poor attendance at antenatal clinics, insufficient intake of supplements, or insufficient emphasis on behavioural aspects of taking supplements regularly (WHO, 2020). Moreover, insufficient uptake, little priority and low adherence by the target population are other problems associated with interventions directed to treat iron-deficiency (Safiri S et al., 2019).

As established earlier, efforts to reduce anaemia must target a wide range of predictors and causes. Efforts should not only focus on treating anaemia that is attributed to iron deficiency (WHO, 2020). Recent research points out that as the overall incidence of infection burden increased, overall anaemia incidence also increased but the proportion of women with iron deficiency anaemia in the sample decreased (Wirth et al., 2017). In countries with a high prevalence of infections and inflammation, the proportion of anaemia caused by iron deficiency among women of reproductive age is lower as compared to the anaemia caused by other factors majorly infections. Hence, the non-nutritional causes of anaemia should also be addressed to reduce the overall burden. Interventions may include periodic deworming, malaria control preventative measures and treatments, HIV/tuberculosis programmes, programmes that address genetic blood disorders, and as importantly programmes for basic hygiene, water and sanitation that reduce risk of infections. Control for Malaria in regions of Sub-Saharan Africa lowered the risk of mild and severe anaemia by 27% and 60%, respectively (WHO, 2015). According to context-specific conditions, the measures must therefore, be paired to achieve synergistic benefits in reducing the burden of anaemia. In parts of African, Eastern Mediterranean and South-East Asia regions for instance, sickle cell traits and thalassemia play a more important role (Piel et al., 2010). Also, in rural tropical regions of Asia and Africa, poor sanitation facilities call for an increased need for improved water and sanitation situation as well as periodic deworming for hookworms and schistosomiasis (Smith and Brooker, 2010).

A mix of socioeconomic and environmental determinants must also be factored when evaluating the quality, scope and comprehensive nature of anaemia reduction efforts. Safiri et al. (2021) while reporting the burden of anaemia and its underlying causes, studied its association with a socio-demographic index (SDI) observing a negative relationship. The SDI is an important indicator for a range of socio demographic predictors, including nutritional status, access to health services, level of education and gender equality (Safiri et al., 2021). Research suggests that illiterate women have an 8% higher chance of anaemia and their children are 9% more at risk to develop anaemia, as compared to those having secondary or higher education (Balarajan et al., 2011). Gender inequality is another crucial determinant of anaemia as it is intricately linked to women's empowerment, lifestyle and nutrition intake. Societies with higher incidence of gender inequality have worse social and health outcomes for women including reduced access to education, insufficient nutritional literacy, restricted household income, also higher chances of early marriages, increased fertility and frequency of pregnancies and having children during adolescence (WHO, 2017). This makes women a largely marginalized segment of society as they bear the direct and indirect consequences of lower anaemia levels. Therefore, an integrated strategy to control and manage anaemia must include advocacy, behaviour change communications and raising awareness. For example, an ongoing study in India, RANI (Reduction in Anaemia through Normative Innovations) was designed on the premise that proper awareness and counselling can achieve better and faster results in anaemia reduction (Sedlander et al., 2018).

Global efforts headed by development institutions as well as country-led policies are aimed at controlling and reducing the anaemia incidence worldwide. However, there are significant barriers to for the dissemination and uptake of these aforementioned programs. These include insufficient priority to interventions for anaemia reduction, lack of awareness and education on anaemia and its prevention, and the difficulty in policy formulation and implementation in focusing on the needs of high-risk groups at specific times in their lives. Moreover, provider capacity, integrating services, community-based programmes, and various dimensions of governance are other important domains that affect the policies aimed at reducing anaemia in general (WHO, 2020). Therefore, anaemia among girls and women of reproductive age remains a worrying issue: the reduction needed to meet the targets by 2025 are not satisfying. On the contrary, the increased incidence reported over recent years will lead to an incidence that is more than double the agreed target (31.2% instead of 14.3%) (Global Nutrition Report, 2021).

1.4.1 Qualitative Analysis: General lessons learnt for anaemia reduction

Multisectoral approach

In the study carried out by the World Health Organization (2020), broad dimensions for interventions to reduce anaemia were realized as a result of extensive qualitative research. This qualitative analysis was especially carried out to complement it with country-level performances and efforts. The countries that reported a significant decrease in anaemia prevalence, had undertaken a *multisectoral approach* in designing and implementing the relevant programmes. Within the country, education, finance, health and nutrition, agriculture, and gender affairs were important sectors while local and international nongovernmental organizations, United Nations agencies (e.g., United Nations Children's Fund, WHO, World Food Programme, Food and Agriculture Organization of the United Nations) played a key role as well (WHO, 2020).

Integration of anaemia activities in existing programmes

Policies to reduce anaemia can be designed either in the form of specific interventions: nutrition-specific or nutrition-sensitive or they can be formulated to leverage on existing health, education, and food-production systems as a delivery platform. It emerged from the same study by WHO (2020) that almost all countries design their anaemia reduction interventions around existing programmes. The Ministry of Health, the Ministry of Nutrition or other ministries such as the Ministry of Agriculture and Ministry of Education play a crucial role for disseminating knowledge, awareness and relevant services thereby producing positive results. On the contrary, countries that demonstrated slow progress in anaemia reduction had less integration within existing programmes and with related ministries. (WHO, 2020).

Others

The lack of relevant data remains a roadblock to assess progress, while the lack of explicit targeting on diets makes it impossible to fully address the problems associated with malnutrition (Global Nutrition Report, 2021). It is absolutely crucial to bring awareness about nutrition-related behaviours, and relevant communication strategies should be designed and implemented. There should be interventions to treat basic causes of anaemia such as those related to disease control, quality of water, sanitation and hygiene, maternal reproductive health while policies should also focus on addressing the root causes such as poverty, lack of education and gender norms (WHO, 2020).

1.5 Socioeconomic predictors of IDA

1.5.1 Measures of outcome variables

Haemoglobin concentration is one globally acknowledged indicator used to measure and assess the severity of anaemia or iron-deficiency anaemia (WHO, 2011). This concentration alone is not sufficient to diagnose iron deficiency or anaemia both, because not all anaemia is caused by iron deficiency. However, an estimated 56.8% of anaemia in women of reproductive age worldwide is a result of iron deficiency (Safiri et al., 2019). Serum ferritin concentration is also recommended by WHO as a biomarker to assess iron status as it is very sensitive and can detect low levels of iron deficiency and early stages of iron deficiency anaemia (Garcia-Casal et al. 2018). The sensitivity of a ferritin test is 89% to assess iron depletion compared with that of haemoglobin, which is only 26% (AAFP, 2022). However, the only problem with ferritin diagnosis is that its levels are elevated in inflammation and infection as it is an acute-phase protein. Hence, a combination of both, serum ferritin and haemoglobin concentration are also used to better diagnose IDA. Habib et al. (2019) has used IDA status as the main outcome variable for non-pregnant women of reproductive age; it was a combination of haemoglobin levels of <120 g/L and ferritin levels of < 12 μg/L. A similar combination for the outcome variable was used to study anaemia in children under five years of age in Pakistan by Habib et al. (2016).

1.5.2 Explanatory Factors

Various socio-economic factors affecting anaemia and iron-deficiency anaemia have been identified. Safiri et al. (2021) has studied the burden of anaemia and its association with socio-demographic index (SDI). They observed a negative relationship between anaemia and the degree of development, at both regional and national levels (Safiri et al., 2021). A low SDI signifies poor outcomes for a range of socio demographic and lifestyle indicators, including substandard nutritional status, inadequate access to health services, illiteracy and gender imbalance in the society. Individuals with lower socioeconomic status do not have proper access to prenatal care and are hence, at a higher risk for developing obstetric complications due to iron deficiency anaemia (Shams et al., 2017).

Education level is a widely studied variable that influences women's attitude to her health and hence influences haemoglobin deficiency leading to anaemia. Women with higher levels of education are less frequently anaemic than women with no education or women with primary or secondary completed education ((Khan et al., 2020; Bharati et al., 2019; Morsy & Alhady, 2014). Also, having any formal education as compared to no education at all was corelated to a significant 4% point reduction in anaemia probability (Sagalova et al., 2021). Family income is another significant predictor of anaemia levels as it is linked to improvement in other related predictors such as education, nutrition, awareness, and hygienic living conditions (Morsy & Alhady, 2014). Sagalova et al. (2021) found out that belonging to the wealthiest quintile was linked to 7% decreased risk of anaemia. Similarly, Mbule et al., (2013) discovered that women from the three lowest wealth quintiles were 2.15 times more likely to be diagnosed with anaemia than those belonging to higher wealth quintiles.

Whether women are based in urban or rural setting also has significant correlation with the prevalence of anaemia (Habib et al, 2019; Sharma, Singh & Srivastava, 2020). Some studies report more prevalence in rural areas (Habib et al, 2019) while others show contrasting results with higher burden in urban settings (Sagalova et al., 2021). Anaemia inequality also varies with regions and states; the trend, however, is mixed with respect to socio-economic inequality. In India, a study done by Kumar, Sharma & Sinha (2021) found that men from the poorest wealth quintile in less developed states experience highest inequality in prevalence of anaemia and this is consistent the findings of another study by Jose (2011). However, another nationally representative cross-sectional study done in India showed that GDP per capita accounts for little of the cross-country variability in the burden of anaemia among states (Didzun et al., 2021).

Anaemia is also importantly explained by the Body Mass Index (BMI) with the outcome prevalence demonstrating a decreasing trend with increasing BMI. Women with lower BMI or belonging to underweight categories are more prone to developing anaemia as compared to women with a normal BMI (Kamruzzaman, 2021; Qin et al., 2013). Nutritional status and daily dietary of women is another dimension that is shown to have differentials in anaemia rates ((Khan et al., 2020; Morsy & Alhady, 2014). As anaemia is usually associated with nutritional deficiency, it is vital to have a nutritious and balanced diet comprising green leafy vegetables, animal proteins, beans, seafood, and dried fruits. Food security status gives a composite score of the condition of affordability, availability, quality, and safety of food for a household (FAO, 2020). For the purpose of various studies, this index is developed at local levels by nationally representative surveys (PNNS, 2018; PNNS 2011). In food insecure households, all the vulnerable groups (infants, toddlers and women of reproductive age) have shown to be at a greater risk of anaemia (Khan et al., 2020; Habib et al., 2019; Moradi et al., 2018). Both BMI and food security are better determinants of socio-economic status than individual-level characteristics.

A number of other women-related characteristics are also dominant predictors of IDA. Severe maternal anaemia is linked to higher risks of poor maternal, foetal, and neonatal outcomes (Parks et al., 2019). Age is shown to be substantially linked to anaemia levels; with older women being slightly more likely than younger women to develop mild or severe anaemia (Morsy & Alhady, 2014; Rasool et al., 2015). Marital status and pregnancy status along with number of deliveries also lead to specifically higher anaemia rates among women of reproductive age (Habib et al, 2019; Parks et al., 2019; Saydam et al., 2017). According to Habib et al. (2019), a history of four or more pregnancies would result in around 30% more chances of having mild or severe anaemia. Pregnancy status is another complex variable linked to other related factors like nutrition, history of pregnancies and deliveries and also the level of antenatal care during both.

IDA is a direct result of iron-deficiency, the most common cause and type of anaemia globally. However, there are other causes of other types of anaemia as well that are associated with IDA (WHO, 2020). These include various nutrient deficiencies namely vitamin A, vitamin D and zinc. Both vitamin A and vitamin D have been linked to the development of anaemia, various studies implying that they are involved in the iron mobilization metabolic pathway (Bacchetta et al., 2014; da Cunha et al., 2018). According to epidemiological knowledge, the prevalence of anaemia is significant among populations with vitamin A deficiency (Semba & Bloem, 2002; Habib et al., 2019), and improvements in the levels of vitamin A have been found to reduce anaemia (Semba & Bloem 2002). Also, serum haemoglobin and ferritin levels, both outcomes that represent iron-deficiency anaemia were reported lower in the vitamin D deficient group than in the non-deficient group (Nur-Eke & Özen, 2020). Zinc, on the other hand, is considered a direct predictor of iron-deficiency anaemia because of its structure as an enzyme that coordinates and catalyzes iron metabolism (Abdelhaleim, 2019). A decrease in zinc levels has a strong association with impaired iron absorption and observed iron-deficiency anaemia (Atasoy & Bugdayci, 2018).

The above evidence from the literature and the availability of the data informed the choice of socio-economic predictors of anaemia used in this thesis.

1.6 Methods to study prevalence of IDA and other health outcomes

1.6.1 Logistic Regression

In recent times, clinical investigations that assess the relative contribution of various factors or patient characteristics to a single binary outcome, like that of the presence or absence of a condition or a disease, most commonly use the logistic regression method (Anderson, Jin, & Grunkemeier, 2003; Tolles & Meurer, 2016). Having the ability to "adjust" for confounding factors, i.e., factors that are associated with both, other explanatory variables and the outcome, logistic regression can be employed to evaluate epidemiological associations that do not represent cause and effect (Tolles & Meurer, 2016). Ahmad et al. (2014) employed logistic regression while studying the association of hypertension with risk factors affecting significantly the execution of hypertension. Another study by AbdulQader (2016) used logistic regression analysis with discriminant analysis on data for natural and caesarean births to study the choice and performance of these methods. Other studies have used a similar methodology to examine associations in health. A few include: related to oral health infirmities (Javali and Pandit, 2012), stammer (Reeda and Wub, 2013), and effect of estrogen on the rate of reverse pregnancy results (Junguk et al., 2017).

For evaluating the factors affecting anaemia in vulnerable groups specifically women of reproductive age, various studies on Bangladesh, Thailand, Jordan, Sudan, Pakistan and India have used univariate, bivariate and multivariate logistic regressions (Yusuf et al., 2019; Jamnok et al., 2020; Arabyat et al., 2019; Elmardi et al., 2020; Habib et al., 2019; Habib et al., 2016; Sharma Singh & Srivastava, 2020; Kumar, Sharma & Sinha, 2021). One of the studies on India has used bivariate and multivariate logistic regressions to analyze the prevalence of anaemia in children by various background characteristics, maternal factors and child characteristics (Sharma, Singh &

Srivastava, 2020). Habib et al. (2019) used the same methodology to describe the determinants and prevalence of IDA among non-pregnant Pakistani women by presenting unadjusted and adjusted odd ratios. A similar methodology was employed by the same authors to study prevalence of iron deficiency anaemia in children under five years of age in Pakistan (Habib et al., 2016). Both studies carried out a secondary analysis of the National Nutrition Survey Data from the years 2011-12. Another study was conducted to assess socio-economic inequality in anaemia among men in India (Kumar, Sharma & Sinha, 2021) and they have also employed logistic regression techniques. In more advanced studies, such as one on Ethiopia, multilevel ordinal logistic regression analysis was used to study individual, household and community level factors associated with anaemia among women of reproductive age (Tirore et al. 2020).

1.6.2 Concentration Index & Poor-rich ratios

The concentration index (CI) quantifies the degree of socio-economic-related inequality in a specific health variable (Kakwani, Wagstaff, and van Doorslaer 1997; O'donnell et al., 2007). It has been used widely to investigate the extent of socioeconomic-related inequality in health care utilization (van Doorslaer et al. 2006), in child mortality (Wagstaff 2000), in child malnutrition (Wagstaff et al., 2003), and in health subsidies (O'Donnell et al. 2007). With respect to prevalence of anaemia, socio-economic inequality exists based on several socio-economic factors (Sharma et al., 2020). Sharma et al. (2020) employed a CI to study the extent of inequity in anaemia in children under five years of age across all states of India (2020). Another study on India used wealth quintile as the critical variable, for a decomposition analysis and the calculation of a Concentration Index (CI) to measure the socioeconomic inequality in anaemia among men in India (Kumar, Sharma & Sinha, 2021). This study also illustrated the concentration curve among men in India by regions. Similarly, in the analysis by Sharma et al. (2020), the poorest and richest wealth quintiles were used to compute the poor-rich ratios. As the wealth quintile was arranged from the lowest to highest, a negative value indicated the concentration of anaemia in the lowest wealth quintiles and vice versa for the positive value of +1.

1.6.3 Spatial analysis to study Patterns in Demography and Health

Spatial patterns are widely used to study prevalence of a phenomenon that is expected to vary geographically, with a non-random pattern. Since global average statistics do not capture accurate situation of the local conditions, more sophisticated techniques are needed to study context-specific patterns (Fotheringham et al., 2002). This may include complex methods and simpler ones as well for the experts and for the layman respectively. Integration of geographical data with clinical outcomes has recently found its use in the fields of demography and health as they may reveal interesting hidden associations (Guzzi et al., 2017).

For the prevalence of anaemia across districts in India, Sharma et al. (2021) used choropleth maps to illustrate the various determinants including poorest wealth quintile, underweight children, illiterate women and antenatal (ANC) visits. Kumar et al. (2021) illustrated spatial pattern in anaemia prevalence in Empowered Action Group (EAG) states while Challa and Amirapu (2016) also used choropleth maps to identify high risk territories with respect to anaemia. Geographical variation coupled with regression models gives powerful information about prevalence of anaemia in target groups (Yadav and Nilima, 2021). This type of mapping is also used as an effective tool of advocacy for policymaking in health care (Challa et al., 2017). Cromley and Cromley, (2007) have explained how choropleth maps may be used to visualize geographical distribution and disparities in health outcomes linked to social characteristics of the population.

1.7 Gap in the literature

Based on the literature reviewed for this study, I discovered gaps in the literature of studying prevalence of anaemia. First, data is very limited in developing countries that have high prevalence of anaemia. None of the publicly accessible nationally representative surveys, for example in Pakistan, have the relevant indicators to measure or demonstrate incidence of anaemia. Secondly, there is a dearth of literature on multifactorial causes and complex interaction between the socioeconomic determinants on the incidence of anaemia in Pakistan. The existing studies explore the prevalence of anaemia with respect to only a limited set of explanatory variables. Hence, the integrated interventions are very rarely designed, developed and implemented to reduce the global burden.

Thirdly, women of reproductive age remain a marginalized and vulnerable group that need to be studied more in depth to be able to progress towards the 2025 Global Nutrition Target of reducing anaemia levels by half. Fourthly, there is a need to study the extent of socio-economic inequality in the prevalence of anaemia. Almost all the relevant studies are based on India while the literature on other countries in South Asia and Africa is very limited. Finally, there is no evidence on the spatial pattern of the district-wise prevalence of anaemia in Pakistan.

CHAPTER 2 ANAEMIA LANDSCAPE OF PAKISTAN

Pakistan, in the region of South Asia, is among the countries that suffer from severe anaemia prevalence (41.3%) for women of reproductive age (WHO, 2020). According to the same data source, the prevalence of overall anaemia in Pakistan was 42.2% in 2014 and 42.6% in 2009. Hence, the progress to reduce the malnutrition burden has rather been 'anaemic' as well.

The reported prevalence of iron deficiency anaemia (IDA) in women in Pakistan is between 18-45% (PNNS 2018; Habib et al., 2019; Khan et al., 2020). The country has a high maternal (186 per 100,000 live births) and perinatal mortality (42 per 1000 pregnancies) (DHS Special 2019; DHS 2017-18). 41% of the maternal deaths in Pakistan are due to obstetric haemorrhage; there is a strong correlation of IDA and the risk of excessive postpartum bleeding (DHS Special, 2019; KA Frass, 2015; Lao et al. 2021). Both maternal and perinatal mortality, in most cases, is a consequence of acute blood loss in situations of chronic IDA (Lone et al., 2004). A high number of preterm deliveries (860,000 per year), small for gestational age (SGA) births (19.3%) and low birthweight babies (32%) in Pakistan are also associated with IDA in mothers. (DHS 2012-13; USAID 2015; Scholl 2011). IDA in women of reproductive age is thus linked to adverse maternal and foetal outcomes as well as poor health of infants and children in early years.

Despite that malnutrition is endemic in Pakistan, and little progress is observed as measured by WHO, the health data available for Pakistan, such as the Demographic and Health Survey (DHS) or the Multiple Indicator Cluster Survey (MICS), do not include any measures of anaemia or iron-deficiency anaemia in mothers or women of reproductive age. This lack of data translates into an expected inadequate literature on the subject. Nevertheless, there have been studies that explore the association of iron-deficiency anaemia on outcomes in women. The majority of them, however, are based on old or small, non-representative samples, are limited to sub-groups, or are based only on haemoglobin concentrations (Habib et al., 2019). Also, most of them are grounded on clinical research from primary data collected from non-random target groups. Depending on the circumstances, sub-groups of either pregnant or non-pregnant women have been selected for the scope of specific investigations.

As reported by Awan et al., the incidence of anaemia among pregnant women living in urban areas in Pakistan ranges from 29% to 50% (2004). A descriptive cross-sectional study conducted by Khan et al. (2020) found a 33.39% prevalence of IDA in pregnant women. However, it was not a uniform community-based study and patients were interviewed in a tertiary care hospital. Other studies have traversed through regional and city-wise investigations with IDA in pregnant women varying with 76.6% in Mardan, 55.7% in Karak, 66.6% in Kohat, 73% in Lahore, and 64% in Karachi (Shams et al., 2017; Irfan et al., 2013; Riaz et al., 2013). According to the study by Riaz et al. (2013), 66.6% of pregnant women, 55.87% of non-pregnant married women, and 48.4% of married young girls were diagnosed with iron-deficiency anaemia. However, the sample size of this study was quite insufficient to produce reliable results.

There is, however, one national survey, Pakistan National Nutrition Survey (PNNS) that particularly assesses the nutritional status of vulnerable populations including children, adolescents and women of reproductive age. It should be noted that the data from this only national-level nutrition survey is not publicly accessible; a comprehensive report of the findings is available only. The most recent available population-based report on Pakistan is from the PNNS conducted in 2017-18 that is used for the scope of this study. The last round of the Survey was in 2010-2011 and more previous of that one was in 2001 which was already more than ten years old. In 2011, it was the first time that the fourth round of Survey provided provincial specificity with representative population-based samples (PNNS, 2011). Nonetheless, this survey presents critical information on the country's actual scale and magnitude of malnutrition. It offers the federal and provincial governments with essential information on determinants, differentials, and policy guidance to reduce the national burden.

Unfortunately, there are not many studies conducted on the PNNS over the years, primarily because of the issues of data availability. It is imperative to explore the various socio-economic, environmental and biochemical determinants of different nutritional deficiencies. Habib et al. have conducted secondary data analysis of the Pakistan National Nutrition Survey (PNNS) 2011-2012 that is already a decade old. In 2016, they explored the prevalence and predictors of IDA in children under five years of age, and in 2019, they studied the prevalence and determinants of IDA among non-pregnant Pakistani women. The analysis on the IDA incidence in non-pregnant women was, though, thorough to check for three groups of explanatory factors (sociodemographic, women-related and biochemical). The outcome of IDA was a combination of both, low serum ferritin and less than normal haemoglobin levels and it was reported to be 18.1% among non-pregnant women of Pakistan (Habib et al., 2019). The study further presented cross-investigations of increased odds of IDA with various characteristics: significant results were obtained with not using iron folic acid supplementation during the last pregnancy (1.31), a history of four or more pregnancies (1.30), birth interval of <24 months (1.27), presence of clinical anaemia (5.82) and household food insecurity (1.42), while obesity was found to be associated with decreased odds of IDA (0.60) (Habib et al., 2019). Owing to these results, the authors suggested a multifaceted approach that integrates iron supplementation, food fortification, effective family planning services and initiatives to alleviate food insecurity.

Anaemia is caused by a wide range of risk factors acting through interwoven mechanisms that vary by context (Balarajan 2013; SPRING 2015). In Pakistan there is a dearth of up-to-date data and knowledge on the prevalence and determinants of iron-deficiency anaemia. The dataset used for this study was the first survey to have included district-specific sampling. It is critical that the anaemia situation in the specific socioeconomic context is understood and analyzed, and interventions should be designed based on the evidence. The approach to reduce anaemia in girls and women of reproductive age in Pakistan requires more integrated efforts. Thus, combining socio-economic determinants with spatial clustering to identify areas or districts where anaemia is more prevalent may be a significant milestone along the path toward measurable anaemia reduction.

CHAPTER 3 DATA

3.1 Data Source

In this nationally representative cross-sectional study, secondary analysis was conducted on Pakistan's fifth round of the National Nutrition Survey (NNS) 2018. The survey was carried out from April 2018 to January 2019 by a collaborated effort of The Ministry of National Health Services, Regulations and Coordination (MNHSRC), Pakistan, and Aga Khan University (AKU), with the technical support of United Nations Children's Fund (UNICEF) Pakistan and funding from Department for International Development (DFID). The Pakistan Bureau of Statistics (PBS) prepared the overall sampling frame and the list of enumeration blocks based on the Population and Housing Census 2017. It was the largest national nutrition survey of Pakistan, providing estimates on key micronutrient indicators for the nutrition landscape on national, provincial, regional and district level. PNNS 2018 was designed and implemented to assess the current nutritional status of different target groups (children, adolescents and women), to establish trends comparable to previous surveys conducted in 2011 and 2001, to evaluate progress in nutrition interventions and to guide evidence-based policy making to prioritize action in the context of Sustainable Development Goal 2. All the variables used in the study were requested exclusively from the relevant authorities and were accessed as a subset of the PNNS 2018 data.

Pakistan National Nutrition Survey 2018 was the first survey to yield a district representative sample to produce district-level estimates at the national level. The sample had data for urban and rural localities, and by gender for all provinces (Punjab, Sindh, Balochistan and Khyber Pakhtunkhwa, KP) and key regions (Azad Jammu and Kashmir, AJK, Gilgit-Baltistan, GB, Khyber Pakhtunkhwa Newly Merged Districts, KP-NMD and Islamabad Capital Territory, ICT). The survey was conducted at the household level, with a two-stage stratified sampling technique. It used a mixed-method data collection integrating both quantitative and qualitative approaches. A total of 100,304 households (5,507 Primary Sample Units - PSUs) were successfully interviewed; there were 29,858 urban and 70,446 rural households with an overall response rate of 94.9%. The sample included data on 68,493 children (0-59 months), 64,829 adolescents (10-19 years), and 123,092 women of reproductive age (15-45 years). For the biochemical assessment, blood samples were taken from 31,828 women and children.

Responses were collected on a unique set of nutrition-related factors including environmental, anthropometric, and biochemical indicators. There was also data on socio-economic status, maternal reproductive history and food security using a pre-structured and pre-tested instrument. Blood and urine samples were obtained from the target groups for micronutrient assessment. As for anthropometric measurements, body mass index (BMI) was calculated from women's height and weight as per WHO guidelines. For haemoglobin levels, testing was done in the field; for biochemical assays of ferritin, vitamin A, vitamin D, zinc and others, process was carried out at the Nutritional Research Laboratory of the Aga Khan University in Karachi. Standard methods and procedures were adopted for collection and transportation of the specimens.

3.2 Description of Variables

3.2.1 Measurement of Iron Deficiency Anaemia

The dependent variable for this thesis is the IDA status of women of reproductive age. The outcome is dichotomous having 0 as "non-deficient" and 1 as "deficient". "Deficient" is defined as the combination of haemoglobin levels of <120 g/L and ferritin levels of < 12 µg/L (Habib et al., 2019; Paricha et al., 2010). Both variables, haemoglobin, and ferritin levels, were measured by PNNS 2018 with categories as Severe deficiency <7 gm/dL, Moderate deficiency 7 - 11.99 gm/dL, Normal >= 12 gm/dL, and as Low Ferritin <12 ng/mL, Normal >=12 ng/mL respectively. Haemoglobin testing was done during the surveys in the field using blood samples using a dual wavelength HemoCue photometer. The concentration was adjusted for altitude of greater than 1000 meters using the CDC criteria (Nestel, 2002). Analyses of serum ferritin were carried out in labs. Ferritin concentration has about three times more sensitivity and specificity than haemoglobin for the detection of iron deficiency (AAFP, 2022; Gordon, 1992), but it also must be adjusted as it is raised in cases of inflammation. (Thurnham, 2010). Hence, for the first part of the analysis in this study, the three measures of anaemia, haemoglobin levels, ferritin concentration and a combination of both as IDA, are used to present and compare results.

3.2.2 Independent Variables

All explanatory variables, as described in Table 3.2.1, are informed by the pertinent literature. For the scope of the analysis on the prevalence of anaemia in women of reproductive age, a list of 13 socioeconomic determinants were considered: education, wealth index quintile, area of residence, province, BMI and food insecurity status, age, marital status, pregnancy status, number of deliveries, deficiency of vitamin A,vitamin D and zinc. All independent variables are categorical.

Education is the highest level of schooling attained categorized as none for illiterate and then increasing in order of primary, middle, secondary and higher. Wealth index quintiles were computed using the Standard Demographic and Health Survey and were categorized into five from being poorest to richest. Area of residence is simply categorization into urban or rural living place. Province describes the all four provinces and four main regions of the country (Punjab, Sindh, KP, Baluchistan, ICT, KP-NMD, AJK and GB). Body Mass Index gives an idea of the nutritional status of the women and is calculated on the basis of height and weight as per the guidelines of the WHO. BMI is categorized as <18.5 underweight, 18.5-24.9 normal, 25-34.9 overweight and ≥35 obese. For food insecurity status, a total of 96,307 people were assessed in households using the Food and Agriculture Organization's Food Insecurity Experience Scale (FIES). FIES tracks self-reported food-related behaviours and experiences in the context of increasing difficulties in accessing food due to resource constraints (PNNS 2018). By incorporating these variables, the study ascertains the socioeconomic status of households and individuals and analyzes the inter-linked effects of these determinants on the prevalence of anaemia.

Age is a categorical variable grouped into 4 categories of 15-19, 20-29, 30-39 and 40-49 years. Marital status and pregnancy status are self-explanatory while the number of deliveries is the number of previous births the women has given and is categorized as 0,1,2,3,4,5 and >=6. There are three variables explaining the biochemical factors that may contribute to anaemia in women. Deficiency of serum vitamin A is categorized as (Severe <0.35 μmol/L, Mild 0.35 - 0.70 μmol/L and Non deficient >0.70 μmol/L). Deficiency of serum vitamin D is categorized as (Severe Deficiency <8.0 ng/mL, Deficiency 8.0 - 20.0 ng/mL, Desirable >20.0 - 30.0 ng/mL and Sufficient >30.0 ng/mL) while deficiency of the ion Zinc is categorized as (Deficient <60 μg/dL and Non-Deficient >=60 μg/dL). These cutt offs are guided by pertinent literature.

Table 3.2.1 Description of Explanatory Variables used in the analysis

Variables	Description
Socioeconomic factors	
Education	Level of education categorized as (None, Primary, Middle, Secondary, Higher)
Wealth Index Quintile	Wealth quintiles computed using the Standard Demographic and Health Survey categorized as (Poorest, Second, Middle, Fourth and Richest)
Area	Urban and Rural
Region	All four Provinces and main regions as (Punjab, Sindh, KP, Baluchistan, ICT, KP-NMD, AJK and GB)
BMI	Body Mass Index calculated on the basis of height and weight and categorized as (Normal 18.5-24.9, Underweight <18.5, Overweight 25-29.9 and Obese >30)
Food Insecurity Status	Food insecurity status was measured by using the Food and Agriculture Organization's Food Insecurity Experience Scale (FIES) and categorized as (Food Secure, Mild Food Insecure, Moderate Food Insecure and Severe Food Insecure)
Age	Categorized as (15-19 years, 20-29 years, 30-39 years and 40-49 years)
Marital Status	Categorized as (Currently Married, Ever Married, Unmarried)
Pregnancy Status	If the woman is currently pregnant
Number of Deliveries	Number of previous births categorized as (0,1,2,3,4,5,>=6)
Vitamin A Deficiency	Deficiency of serum vitamin A categorized as (Non deficient >0.70 μmol/L, Mild 0.35 - 0.70 μmol/L and Severe <0.35 μmol/L)
Vitamin D Deficiency	Deficiency of serum vitamin D categorized as (Sufficient >30.0 ng/mL, Desirable >20.0 - 30.0 ng/mL, Deficiency 8.0 - 20.0 ng/mL, and Severe Deficiency <8.0 ng/mL)
Zinc Deficiency	Deficiency of ion Zinc categorized as (non-Deficient >=60 μg/dL and Deficient <60 μg/dL)

KP: Khyber Pakhtunkhwa; ICT: Islamabad Capital Territory; KP-NMD: Khyber Pakhtunkhwa Newly Merged Districts, AJK: Azad Jammu and Kashmir; and GB: Gilgit-Baltistan

Source: Author's elaboration

3.2.3 District codes

PNNS 2018 is the first national survey to incorporate district-wise sample for district-level analysis on nutrition indicators for the target groups. The data has district codes for a total of 156 districts of Pakistan that will be used to perform analysis on the prevalence of anaemia among the women of reproductive age in these districts.

3.3 Descriptive Statistics

From the 33,328 women of reproductive age in our sample who tested for haemoglobin, 45.33% have less than normal levels (< 12 gm/dL). 1.66% of these women had severe deficiency with levels less than 7 gm/dL while the remaining 43.67% had moderate deficiency with levels between 7 - 11.99 gm/dL. A total of 25,368 women were additionally tested for serum ferritin and 33.38% were found to be deficient with levels less than 12 ng/mL. Hence, a total of 25,368 women of reproductive age were included in the analysis for iron deficiency anaemia (IDA). The overall prevalence of IDA for women of reprodutive age is 17.96% and Table 3.3.1 presents the descriptive findings of our sample. Among those who were ferritin deficient, 4,557 (54%) had low haemoglobin and 3,912 (46%) had normal haemoglobin levels (Table 3.3.2). Descriptive statistics of all explanatory variables used in the analysis are presented in the Appendix (A1).

Table 3.3.1 Descriptive Statistics of the Sample from National Nutrition Survey Pakistan

Variables	N	%
Iron deficiency Anaemia		
Deficient (Anaemia & Low Ferritin)	4,557	17.96
Non-Deficient	20,811	82.04
Total	*25,368*	*100*
Haemoglobin		
Severe deficiency (<7 gm/dL)	553	1.66
Moderate deficiency (7 - 11.99 gm/dL)	14,553	43.67
Normal (>= 12 gm/dL)	18,222	54.67
Total	*33,328*	*100*
Ferritin		
Low Ferritin (<12 ng/mL)	8,469	33.38
Normal (>=12 ng/mL)	16,899	66.62
Total	*25,368*	*100*

Source: Author's elaboration

Table 3.3.2 Cross tabulation of Ferritin and Haemoglobin

	Haemoglobin			
Ferritin	**Severe**	**Moderate**	**Normal**	**Total**
Low Ferritin	196	4,361	3,912	*8,469*
Normal	253	5,956	10,690	*16,899*
Total	*449*	*10,317*	*14,602*	25,368

Source: Author's elaboration

CHAPTER 4 METHODOLOGY

The study employs different statistical analysis tools to present and explain the prevalence of iron-deficiency anaemia in women of reproductive age in Pakistan. The chapter is divided into three main sections directly corresponding to the three research questions of the study. The first section presents the effects of socio-economic and women-related demographic determinants of anaemia. The second section explains the socio-economic inequality in anaemia prevalence and the third section illustrates its district-wise disparity. Stata for the statistical analysis and Tableau for the graphical illustrations, were used to carry out the study.

4.1 Socioeconomic and Demographic Predictors on Prevalence of IDA

The prevalence of anaemia with respect to its socioeconomic and demographic predictors is presented and explained through univariate, bivariate and multvariate analysis. All of the analysis in this sub-section is carried out for three different outcome variables as measures of iron-deficieny anaemia.

4.1.1 Bivariate % prevalence

For each of the three measures of iron deficiency anaemia: haemoglobin deficiency, ferritin deficiency and IDA, percentage prevalence is calculated for each category of the independent variables in the population. Population weights are assigned to the samples to obtain nationally representative figures. The analysis also includes 95% confidence intervals for the prevalance.

4.1.2 Multivariate Logistic Regression

Logistic regression is used to analyze the relationship between one or more explanatory variables and a single binary response variable that is dichotomous in nature (takes two values only) representing presence or absence of a characteristic or outcome. To test for the prevalence of anaemia in women of reproductive age in our sample, logistic regression is employed and IDA, ferritin deficiency and haemoglobin deficiency are used as single outcome variables in each of the bi- and multiple logistic regressions.

Logistic regression models estimate probabilities of events as functions of explanatory variables. Taking the case of one binary outcome variable Y, and one explanatory variable X, the logistic model predicts the logit of Y from X, that equals the natural logarithm of odds of Y. To begin with, a simple formula can be used to explain this (Abdulqader, 2017; Peng et al., 2002; James et al., 2013) :

$$\ln\left(\frac{\pi}{1-\pi}\right) = \alpha + \beta x. \quad (1)$$

where π is the the probability that the outcome Y occurs, X is the predictor variable, β is its corresponding coefficient and α is simply the intercept.

The left-hand side is called the log-odds or logit and logistic regression estimates the log odds as a linear combination of all the independent variables and can thus be written as:

$$\mathbf{logit(\pi) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots + \beta_k X_k}$$

For our study, a basic equation of the logistic model will be as follows:

logit(IDA_i) = $\beta_0 + \beta_1$Woman Education$_i$ + β_2Wealth Index$_i$ + β_3Area$_i$ + β_4Region$_i$ + β_5BMI$_i$ + β_6Food Insecurity Status$_i$ + β_7Age of Woman$_i$ + β_8Marital Status$_i$ + β_9Pregnancy Status$_i$ + β_{10}Number of Previous Deliveries$_i$ + β_{11}Vitamin A Deficiency$_i$ + β_{12}Vitamin D Deficiency$_i$ + β_{13}Zinc Deficiency$_i$ + ε_i

In logistic regression, instead of the coefficients of explanatory variables, odds ratios (OR) are more important as a measure of association between a variable of interest and the occurance of the outcome. They represent the *constant* effect of a predictor X on the likelihood that one outcome will occur (Grace-Martin, 2020). It is to be noted that odds are not probabilities, and the odds ratio is simply the ratio of two odds. For the categorical predictors in our data set, the OR compares the odds of being anaemia deficient at different levels of the socioeconomic predictor. OR greater than 1 indicates that the chances of anaemia are higher as compared to the reference category while OR less than 1 indicates that chances of anaemia are lower as compared to the reference category of the predictor.

The analysis further yields 95% confidence intervals for the odds ratios. These are the range of values between which the true value of OR lies 95% of the times. A large confidence interval reflects low level of precision of the OR while a small confidence interval reflects a higher precision of the OR. Since the calculation of confidence interval uses normal distribution, a large sample size is an important assumption of using logistic regression. According to Hair et al. (2010) and Kleinbaum & Klein (2010), fifty cases minimum are needed for each explanatory variable. The sample size for our study is fairly large (N=33, 328 for haemoglobin testing and

N=25,368 for ferritin testing). In interpreting OR, the p-value must be considered as well following the standard cutoffs of significance levels (*P < 0.05, **P < 0.01 and ***P<0.001).

4.2 Socioeconomic Inequality in the Prevalence of IDA

For measuring socio-economic inequality in a specific health variable, existing literature uses information on an individual's income levels and healthcare status. This study adopts a widely used standard tool, i.e. the concentration index, to examine the magnitude of this type of inequality in the prevalence of anaemia by using wealth quintile as a rank variable. The methodology is further supported by the computation of poor-rich ratios to analyze the district-level anaemia landscape of the country.

4.2.1 Concentration Index

The concentration index is used as one of the widely acknowledged standard methods to quantify income-related inequalities in health economics (Wagstaff and van Doorslaer, 2000). In this study, the concentration index (CI) is employed to analyze the extent of inequity in anaemia across all 156 districts of Pakistan. The calculation uses weights to compute population representative figures.

The subset of data from the PNNS 2018 has five categories of wealth index quintiles (poorest to richest) of 20% each. This variable is the critical variable to ascertain the socioeconomic status of a household. The study calculates concentration index and uses wealth index as a rank to measure the socioeconomic inequality in anaemia among women of reproductive age in Pakistan. The value of concentration index ranges from −1 to +1. The magnitude of the concentration index indicates the relationship between the health outcome and the position in the wealth distribution as well as the degree of variability in the evaluated health outcome (O'Donnell et al., 2007). The sign reflects the direction of the stated relationship. The absolute value quantifies the extent of socio-economic inequality: a larger absolute value indicates more disproportionate concentration of health outcome among one group. A negative value means disproportional concentration of inequality among the poor. If the outcome variable of health is "bad", for example, being anaemia deficient in this study, the negative value will mean that ill health is higher among the poor. Conversely, a positive value of concentration index will imply disproportionate inequality among the rich. A concentration index of zero indicates an absence of socioeconomic inequality.

For computation, a simpler form of the formula for the concentration index reflects it as a relationship of the covariance between the health variable and the fractional rank of wealth distribution (O'donnell et al., 2007, Jenkins 1988; Kakwani 1980; Lerman and Yitzhaki 1989):

$$C = \frac{2}{\mu} cov\left(y_i, R_i\right)$$

where C is the concentration index; y_i is the outcome variable index; R_i is the fractional rank of individual i in the distribution of socioeconomic position; μ is the mean of the outcome variable of the sample, and *cov* denotes the covariance (O'donnell et al., 2007).

It is to be noted, however, that the CI depends only on the relationship between the health variable and the wealth distribution of the variable used as rank in this case and not on the changes in the wealth level itself (O'donnell et al., 2007). Any variation in income inequality does not necessarily affect the concentration index measure of income-related health inequality.

4.2.2 Poor rich ratios

In the analysis, poor-rich ratios are also calculated to comprehensively grasp the level of inequality across the districts of Pakistan. Only the two categories of wealth index quintile: poorest (bottom 20%) and richest (top 20%) have been considered for the computation. These ratios for each of the 156 districts of Pakistan, have been tabulated with concentration index in terms of anaemia prevalence to illustrate the gap in women malnutrition. The larger the ratio, the larger the wealth inequality exists among the two extreme groups that translates into worse inequalities in health outcomes. For further analysis, poor-rich ratios are also computed for the eight main regions and urban-rural areas.

4.3 Spatial Pattern in Prevalence of Anaemia

The percentage prevalence of haemoglobin deficiency, ferritin deficiency and IDA are separately calculated for each of the 156 districts. Using district codes from the data, and the country shape file, choropleth maps are created. They give powerful information on the spatial pattern of anaemia among women of reproductive age across districts of Pakistan. Since anaemia is common health concern, it is useful to illustrate its prevalence graphically without using overly technical language and complicated statistical measures. In the study, shades of blue are used to create thematic maps for the districts of Pakistan. The intensity of the colors reflect the deficiency of iron deficiency anaemia.

CHAPTER 5 RESULTS

5.1 RQ1: Socioeconomic Predictors & Prevalence of IDA in Women in Pakistan

5.1.1 Prevalence of Haemoglobin Deficiency, Ferritin Deficiency, and Iron Deficiency Anaemia (IDA)

The overall percentage prevalence of women in Pakistan with haemoglobin levels less than normal is 42.65%, ferritin levels less than normal is 34.4%, and both, diagnosed as IDA is 18.19% as weighted for the population. The percentage prevalence along with the 95% confidence intervals is calculated for each category of the population as presented in the Table 5.1.1 for education and wealth. Women with no education had the highest prevalence of haemoglobin deficiency 45.3% while those belonging to poorest household also had the highest prevalence of 52.1% among the wealth index group. The pattern was similar for the other two outcome variables as well. 35.8% of illiterate women and 38.4% of those belonging to poorest households have ferritin levels less than normal. The prevalence of IDA is also the greatest in women with no education (20.5%) and lowest economic background (24.4%).

Table 5.1.1 (Weighted) Percentage Prevalence of Haemoglobin Deficiency, Ferritin Deficiency and IDA in WRA according to Education and Wealth Index

	Haemoglobin Levels less than Normal (<12 gm/dL)				Ferritin levels less than Normal (< 12 ng/mL)				Iron Deficiency Anaemia (Low HB & Low Ferritin)			
Variables	Total	% Prev.	95% CI		Total	% Prev.	95% CI		Total	% Prev.	95% CI	
	33,328	**42.65**			25,368	**34.40**			25,368	**18.19**		
Education												
None	17436	**45.33**	45.29	45.37	14756	**35.74**	35.70	35.77	14756	**20.51**	20.47	20.54
Primary	3674	**42.44**	42.37	42.52	2724	**34.47**	34.38	34.55	2724	**17.05**	16.99	17.12
Middle	3532	**40.99**	40.91	41.07	2281	**34.42**	34.32	34.51	2281	**17.52**	17.44	17.59
Secondary	4693	**40.78**	40.71	40.85	2889	**30.86**	30.78	30.94	2889	**14.45**	14.39	14.51
Higher	3993	**36.42**	36.35	36.49	2718	**31.96**	31.88	32.04	2718	**13.20**	13.14	13.26
Wealth Index												
Poorest	7952	**52.08**	52.02	52.15	6303	**38.47**	38.40	38.54	6303	**24.39**	24.33	24.45
Second	7681	**45.75**	45.70	45.81	5803	**34.88**	34.82	34.95	5803	**19.21**	19.15	19.26
Middle	7020	**41.76**	41.70	41.82	5214	**33.65**	33.59	33.71	5214	**16.62**	16.57	16.67
Fourth	6051	**38.07**	38.01	38.12	4576	**33.20**	33.14	33.26	4576	**15.99**	15.94	16.04
Richest	4624	**37.09**	37.04	37.15	3472	**32.22**	32.16	32.28	3472	**15.45**	15.40	15.49

Source: Author's elaboration

As presented in Table 5.1.2, the prevalence of haemoglobin deficiency (44.3%), ferritin deficiency (34.4%) and IDA (18.7%) are all higher in rural areas. The prevalence of anaemia among women varied widely between regions and the variation was important with respect to the three different kinds of measures of anaemia (Table 5.1.2). The haemoglobin deficiency was highest the province of Balochistan (61.3%) and the in Azad Jammu and Kashmir region

(55.9%) followed by KP-NMD (52.2%) and Sindh (45.3%). The low ferritin levels were diagnosed among the women of Sindh (36.9%) and Punjab (36.3%) followed by Gilgit Baltistan (34.2%) and Balochistan (29.7%). For IDA, the highest prevalence was found in Sindh (22.8%), Balochistan (18.6%), Punjab (18.0%) and Gilgit Baltistan (17.6%). The lowest values were reported in Islamabad Capital Territory, ICT for HB (28.4%), in Khyber Pakhtunkhwa Newly Merged Districts, KP-NMD for ferritin (21.5%,) and in the province of Khyber Pakhtunkhwa, KP for IDA (8.5%). The variability among the regions was also large: 32.9% points for haemoglobin, 15.3% points for ferritin levels and 14.3% points for the prevalence of IDA.

Table 5.1.2 (Weighted) Percentage Prevalence of Haemoglobin Deficiency, Ferritin Deficiency and IDA in WRA according to Area and Province

	Haemoglobin Levels less than Normal (<12 gm/dL)				Ferritin levels less than Normal (< 12 ng/mL)				Iron Deficiency Anaemia (Low HB & Low Ferritin)			
Variables	**Total**	**% Prev.**	**95% CI**		**Total**	**% Prev.**	**95% CI**		**Total**	**% Prev.**	**95% CI**	
Area												
Urban	10452	**40.17**	40.13	40.21	7980	**34.23**	34.18	34.27	7980	**17.44**	17.40	17.47
Rural	22876	**44.26**	44.23	44.29	17388	**34.51**	34.48	34.55	17388	**18.68**	18.65	18.71
Province												
Punjab	13092	**41.13**	41.10	41.17	9564	**36.25**	36.21	36.29	9564	**17.95**	17.92	17.98
Sindh	6049	**45.30**	45.25	45.35	4870	**36.87**	36.81	36.93	4870	**22.82**	22.77	22.87
KP	3977	**32.98**	32.90	33.06	3092	**24.23**	24.15	24.32	3092	**8.50**	8.45	8.56
Balochistan	4933	**61.30**	61.19	61.42	3900	**29.72**	29.60	29.84	3900	**18.64**	18.54	18.74
ICT	431	**28.46**	28.23	28.70	298	**26.44**	26.17	26.72	298	**11.46**	11.26	11.66
KP-NMD	639	**52.21**	51.96	52.47	523	**21.54**	21.31	21.77	523	**13.22**	13.03	13.41
AJK	2404	**55.86**	55.66	56.05	1791	**27.31**	27.11	27.51	1791	**17.05**	16.88	17.22
GB	1803	**37.88**	37.53	38.23	1330	**34.23**	33.84	34.63	1330	**17.62**	17.30	17.94

Source: Author's elaboration

Table 5.1.3 presents prevalence of anaemia for women according to the Body Mass Index (BMI), food insecurity status and age. The prevalence for any type of anaemia was substantially higher in women with lower BMI of <18.5 (underweight). Haemoglobin deficiency was diagnosed among 53.5% of underweight women as compared to 45.0% in women with normal BMI. Ferritin deficiency was present in 39.3% of underweight women as opposed to 37.0% of women with normal BMI, while IDA was diagnosed in 24.1% of women of lowest BMI as opposed to 20.4% of those with normal BMI. Women with higher BMI as being overweight (25.0 – 29.9) and obese (>=30) show less prevalence of anaemia as indicated by all three measures. Households with severe food insecurity had the greatest number of women suffering from haemoglobin deficiency (49.0%), ferritin deficiency (37.0%) and IDA (22.2%)

among the food insecurity status categories in the population. The prevalence of IDA is highest in early (15-19 years) age (21.3%); it then decreases to 17.9 % among women of 20-29 years and 30-39 years until it is increased again to 19.2% at the later years of life among women aged 40-49 years. A similar pattern is observed in deficiency of haemoglobin while the prevalence of ferritin deficiency shows a decreasing trend through the years.

Table 5.1.3 (Weighted) Percentage Prevalence of Haemoglobin Deficiency, Ferritin Deficiency and IDA in WRA according to BMI, Food Insecurity Status and Age

	Haemoglobin Levels less than Normal (<12 gm/dL)				Ferritin levels less than Normal (< 12 ng/mL)				Iron Deficiency Anaemia (Low HB & Low Ferritin)			
Variables	**Total**	**% Prev.**	**95% CI**		**Total**	**% Prev.**	**95% CI**		**Total**	**% Prev.**	**95% CI**	
BMI												
Normal	15716	**45.04**	45.00	45.08	11533	**36.99**	36.94	37.03	11533	**20.35**	20.31	20.38
Underweight	4699	**53.50**	53.43	53.57	2557	**39.30**	39.20	39.39	2557	**24.10**	24.02	24.18
Overweight	7140	**36.11**	36.05	36.16	6336	**32.64**	32.59	32.70	6336	**15.26**	15.22	15.31
Obese	3888	**33.96**	33.89	34.03	3535	**28.79**	28.72	28.86	3535	**14.08**	14.03	14.13
Food Insecurity Status												
Food Secure	19359	**39.51**	39.48	39.54	14622	**33.12**	33.09	33.16	14622	**16.26**	16.23	16.29
Mild food insecure	3771	**45.21**	45.13	45.29	2849	**36.32**	36.23	36.41	2849	**20.16**	20.09	20.24
Moderate food insecure	2490	**46.17**	46.07	46.26	1901	**34.56**	34.46	34.66	1901	**20.31**	20.22	20.39
Severe food insecure	6536	**49.03**	48.97	49.10	5100	**37.03**	36.96	37.10	5100	**22.20**	22.14	22.26
Age												
15-19 Years	7464	**52.77**	52.71	52.82	942	**38.14**	37.98	38.29	942	**21.25**	21.11	21.38
20-29 Years	10508	**39.54**	39.49	39.58	9934	**35.51**	35.47	35.56	9934	**17.88**	17.85	17.92
30-39 Years	10820	**38.89**	38.85	38.94	10232	**33.55**	33.51	33.60	10232	**17.87**	17.83	17.91
40-49 Years	4536	**42.19**	42.11	42.26	4260	**32.79**	32.72	32.87	4260	**19.20**	19.14	19.26

Source: Author's elaboration

Women who are currently married showed the highest prevalence of 51.7% of those with haemoglobin deficiency and 35.6% of those with ferritin deficiency. For IDA, women who were ever married (divorced, widowed, separated) showed the highest prevalence of 19.7%. For pregnancy status, however, haemoglobin deficiency is more prevalent among non-pregnant women with 43.2% incidence, while ferritin deficiency and IDA reported a higher value of 46.5% and 21.0% respectively among pregnant women. The IDA incidence increased as the number of previous deliveries by the woman increase. It went from a low of 14.0% for zero births to a high of 20.1% in the population from a sample size of 3075 women who gave six or more than six births. On the contrary, ferritin deficiency is prevalent in the group of women with zero deliveries; a high value of 37.2% with a relatively large 95% confidence interval of 36.8% - 37.6% is reported for this group. Haemoglobin deficiency shows a similar pattern to IDA with a low value of 26.4% in women with zero births to the higher values of 44.2% and 42.0% among women with 5 and 6 or more than 6 births respectively. Table 5.1.4 presents these results with respective confidence intervals.

Table 5.1.4 (Weighted) Percentage Prevalence of Haemoglobin Deficiency, Ferritin Deficiency and IDA in WRA according to Marital Status, Pregnancy Status and No. of Deliveries

	Haemoglobin Levels less than Normal (<12 gm/dL)				Ferritin levels less than Normal (< 12 ng/mL)				Iron Deficiency Anaemia (Low HB & Low Ferritin)			
Variables	**Total**	**% Prev.**	**95% CI**		**Total**	**% Prev.**	**95% CI**		**Total**	**% Prev.**	**95% CI**	
Marital Status												
Currently Married	8073	**51.68**	51.63	51.73	1466	**35.58**	35.45	35.71	23539	**17.78**	17.68	17.88
Ever Married	380	**40.41**	40.18	40.65	363	**33.42**	33.19	33.65	363	**19.73**	19.54	19.92
Un-Married	24875	**39.55**	39.52	39.58	23539	**34.35**	34.32	34.38	1466	**18.19**	18.16	18.21
Pregnancy Status												
Not Pregnant	31841	**43.15**	43.12	43.17	23972	**33.67**	33.64	33.70	23972	**18.02**	18.00	18.04
Pregnant	1487	**35.18**	35.06	35.30	1396	**46.45**	46.32	46.57	1396	**20.98**	20.88	21.08
No. of Deliveries												
0	185	**26.44**	26.12	26.75	174	**37.24**	36.89	37.58	174	**13.98**	13.73	14.23
1	3868	**37.34**	37.26	37.41	3673	**33.62**	33.54	33.69	3673	**16.74**	16.68	16.80
2	5238	**38.23**	38.17	38.30	4944	**34.81**	34.75	34.88	4944	**17.45**	17.40	17.51
3	4840	**39.07**	39.00	39.14	4561	**35.58**	35.51	35.65	4561	**18.24**	18.19	18.30
4	3789	**39.29**	39.22	39.37	3590	**34.08**	34.01	34.16	3590	**18.80**	18.74	18.86
5	2444	**44.23**	44.13	44.33	2328	**33.32**	33.23	33.42	2328	**19.01**	18.93	19.09
6 and 6+	3203	**42.03**	41.94	42.12	3075	**34.26**	34.17	34.34	3075	**20.10**	20.03	20.17

Source: Author's elaboration

Deficiencies of other micronutrients were also associated with IDA as shown in Table 5.1.5. A mild deficiency in Vitamin A resulted in the highest prevalence of 22.3% of the population suffering from IDA. For deficiency in Vitamin D, there was no observable pattern in the association with any type of anaemia. Being deficient in zinc was significantly associated with higher prevalence of anaemia: 43.2% of the 5,501 zinc deficient women in the sample were also haemoglobin deficient. Also, out of the 5,447 women deficient in zinc, 39.6% were deficient in ferritin and 22.9% of women were diagnosed with IDA.

Table 5.1.5 (Weighted) Percentage Prevalence of Haemoglobin Deficiency, Ferritin Deficiency and IDA in WRA according to Micronutrient Deficiencies

	Haemoglobin Levels less than Normal (<12 gm/dL)				Ferritin levels less than Normal (< 12 ng/mL)				Iron Deficiency Anaemia (Low HB & Low Ferritin)			
Variables	Total	% Prev.	95% CI		Total	% Prev.	95% CI		Total	% Prev.	95% CI	
Vitamin A												
Non deficient	17859	**37.22**	37.18	37.25	17725	**33.15**	33.12	33.19	17725	**16.82**	16.79	16.85
Mild deficiency	5812	**44.90**	44.84	44.97	5745	**38.78**	38.72	38.84	5745	**22.39**	22.33	22.44
Severe deficiency	1284	**45.87**	45.73	46.01	1270	**36.13**	36.00	36.26	1270	**21.35**	21.23	21.46
Vitamin D												
Sufficient	2429	**39.38**	39.28	39.48	2400	**31.22**	31.13	31.32	2400	**16.83**	16.76	16.91
Deficiency	2628	**41.31**	41.22	41.39	2614	**36.60**	36.52	36.69	13052	**21.00**	20.93	21.08
Desirable	13153	**39.88**	39.84	39.92	13052	**34.98**	34.94	35.02	2614	**18.66**	18.63	18.69
Severe Deficiency	6943	**37.65**	37.59	37.70	6895	**33.40**	33.35	33.46	6895	**16.34**	16.29	16.38
Zinc												
Non-Deficient	19714	**38.17**	38.14	38.20	19567	**33.02**	32.99	33.05	19567	**16.85**	16.82	16.87
Deficient	5501	**43.20**	43.13	43.26	5447	**39.56**	39.49	39.62	5447	**22.85**	22.80	22.91

Source: Author's elaboration

5.1.2 Effects of Socioeconomic Determinants on Anaemia

Multivariate Logistic Regression with OR for Haemoglobin Deficiency, Ferritin Deficiency, and Iron Deficiency Anaemia

Table 5.1.6 presents results of multiple logistic regression models, portraying odds ratio of various socio-economic factors on prevalence of anaemia among women of reproductive age in Pakistan. Model (1) and Model (2) shows the effects on haemoglobin deficiency and ferritin deficiency respectively and Model (3) measures results for IDA. Each model looks at the effect of all the socioeconomic variables, however, each variable in the multivariate logistic regression compares odds ratio with the reference category of that variable, keeping the other variables constant. The analysis incorporates population weights.

The odds of developing iron deficiency anaemia significantly decreased as the level of education of the women increased. Women who had middle [OR: 0.86; CI: 0.73,0.99], secondary [OR: 0.72; CI: 0.61,0.87] and higher [OR 0.68; CI: 0.55,0.84] education had 14%, 28% and 32% lower probabilities of IDA, respectively, as compared to those who had no education. A similar pattern was observed with odds of haemoglobin deficiency and ferritin deficiency with respect to the level of women's education; odds were 14% [OR: 0.86; CI: 0.75,1.00] and 19% [OR: 0.81; CI: 0.70;0.93] lower in women with secondary level of education as compared to illiterate women. Women with higher education had 26% significantly lower chances [OR: 0.74; CI: 0.63,0.86] of developing haemoglobin deficiency.

Household wealth had a negative relationship with anaemia among women of reproductive age. The odds of IDA decreased with an increase in the wealth index. With reference to women from poorest households, the likelihood of haemoglobin deficiency was 11%, 25%, 28% and 21% less likely among women who belonged to second [OR: 0.89; 0.799,0.99], middle [OR: 0.75; CI: 0.66,0.86], fourth [OR: 0.72; CI: 0.63,0.84] and richest [OR: 0.79; CI: 0.66,0.94] quintile households. Women who belonged to middle [OR: 0.86; CI: 0.75,0.98] and fourth [OR: 0.83; CI: 0.72,0.97] wealth quintile were 14% and 19% less likely to have ferritin deficiency respectively as compared to women in the poorest wealth quintile. The odds of having IDA also significantly decreased by 23% each if the women belong to households with middle [OR: 0.77; CI: 0.66,0.91] and fourth [OR: 0.77; CI: 0.64,0.92] wealth quintile.

For urban and rural area of living, there are no significant differences in the odds ratio for all three models. The likelihood of IDA was 18% more likely among women who belonged to the province of Sindh [OR: 1.18; CI: 1.05,1.33] and 57%, 41% and 22% less likely among those belonging to Khyber Pakhtunkhwa (KP) [OR: 0.43; CI: 0.36,0.52], Khyber Pakhtunkhwa Newly Merged Districts (KP-NMD) [OR: 0.59; CI: 0.37,0.94] and Balochistan [OR: 0.78; CI: 0.66,0.92] respectively as compared to those women who belonged to Punjab. The ferritin levels of women in all regions tend to decrease significantly as compared to those in Punjab. For haemoglobin deficiency, the odds of anaemia were 101% and 50% significantly more likely among women in Azad Jammu & Kashmir (AJK) [OR: 2.01; CI: 1.71,2.37] and Balochistan [OR: 1.50; CI: 1.31,1.71] as compared to women in Punjab. In the similar analysis, Khyber Pakhtunkhwa (KP) [OR: 0.69; CI: 0.61,0.78], Islamabad Capital Territory (ICT) [OR 0.53; CI: 0.38,0.75] and Gilgit Baltistan (GB) [OR: 0.65; CI: 0.54,0.77] had 31%, 47% and 35% lower chances of developing haemoglobin deficiency, respectively.

The odds of haemoglobin deficiency were significant and higher among women who were underweight [OR: 1.18; CI: 1.03,1.33] and lower among the overweight [OR: 0.81; CI: 0.74,0.89] and obese [OR: 0.79; CI: 0.71,0.89] women as compared to women with normal body mass index (BMI). The likelihood of ferritin deficiency was lower among women who had BMI higher than normal: 14% and 26% less chances for the overweight [OR: 0.86; CI: 0.78,0.94] and obese [OR: 0.74; CI: 0.66,0.83] women. For IDA as well, the odds of deficiency were 23% and 26% lower in overweight [OR: 0.78; CI: 0.69,0.87] and obese [OR: 0.74; CI: 0.63,0.85] women as compared to women with normal weight and BMI.

Women who belonged to food secure households were at a significantly lower risk of haemoglobin deficiency and of IDA. Severe food insecurity exposed women to 18% more chances of having haemoglobin deficiency [OR: 1.18; CI: 1.07,1.31] and 16% more chances of developing IDA [OR: 1.16; CI: 1.02,1.31] as compared to being food secure. Also, mild food insecurity exposed women to 21% and 23% more chances of being haemoglobin deficient [OR: 1.21; CI: 1.08,1.36] and developing IDA [OR: 1.23; CI: 1.06,1.43] respectively as compared to being in households with food security.

As compared to non-pregnant women, pregnant women had 21% lower odds of developing haemoglobin deficiency [OR: 0.79; CI: 0.67,0.93] while 68% higher odds of having ferritin deficiency [OR: 1.68; CI: 1.44,2.00]. With respect to micronutrient deficiencies, mild [OR: 1.35; CI: 1.23,1.47] and severe [OR: 1.34; CI: 1.15,1.58] deficiency of vitamin A increased the risk of haemoglobin deficiency by 35% and 34% respectively. Mild deficiency of vitamin A corresponded to 24% more chances of ferritin deficiency [OR: 1.24; CI: 1.14,1.36] while mild [OR: 1.37; CI: 1.23, 1.52] and severe [OR: 1.24; CI: 1.02, 1.51] deficiency of vitamin A was associated with 37% and 24% greater chances of developing IDA respectively as compared to the non-deficient group. Being severely deficient in Vitamin D had 18% [OR: 1.18; CI: 1.01, 1.37] more chances of developing ferritin deficiency. Moreover, being deficient in zinc increases the odds of haemoglobin deficiency by 21% [OR: 1.21; CI: 1.11,1.32], ferritin deficiency by 27% [OR: 1.27; CI: 1.16,1.39] and IDA by 43% [OR: 1.43; CI: 1.29,1.59] as compared to those with no zinc deficiency.

Table 5.1.6 Multivariate Logistic Regression with Odds Ratios for Haemoglobin Deficiency, Ferritin Deficiency and Iron Deficiency Anaemia

	(1) HB Deficiency		(2) Ferritin Deficiency		(3) Iron deficiency Anemia	
Woman Education						
None	1	[1,1]	1	[1,1]	1	[1,1]
Primary	0.920	[0.814,1.041]	0.919	[0.811,1.042]	0.856*	[0.733,0.999]
Middle	0.884	[0.766,1.019]	1.001	[0.867,1.155]	0.988	[0.825,1.182]
Secondary	0.862*	[0.749,0.993]	0.809**	[0.701,0.933]	0.727***	[0.606,0.873]
Higher	0.735***	[0.627,0.860]	0.867	[0.743,1.012]	0.680***	[0.553,0.837]
Wealth Index						
Poorest	1	[1,1]	1	[1,1]	1	[1,1]
Second	0.886*	[0.789,0.996]	0.908	[0.805,1.025]	0.895	[0.775,1.033]
Middle	0.754***	[0.662,0.858]	0.861*	[0.754,0.984]	0.774**	[0.659,0.910]
Fourth	0.723***	[0.625,0.836]	0.831*	[0.715,0.967]	0.766**	[0.639,0.918]
Richest	0.788**	[0.664,0.935]	0.867	[0.728,1.032]	0.867	[0.698,1.077]
Area						
Urban	1	[1,1]	1	[1,1]	1	[1,1]
Rural	1.019	[0.927,1.121]	0.977	[0.887,1.076]	1.023	[0.909,1.151]
Region						
Punjab	1	[1,1]	1	[1,1]	1	[1,1]
Sindh	1.022	[0.924,1.131]	0.945	[0.852,1.047]	1.180**	[1.046,1.331]
KP	0.687***	[0.607,0.777]	0.556***	[0.490,0.631]	0.431***	[0.358,0.517]
Balochistan	1.498***	[1.314,1.709]	0.649***	[0.564,0.747]	0.779**	[0.663,0.916]
ICT	0.533***	[0.380,0.749]	0.693*	[0.499,0.961]	0.719	[0.464,1.114]
KP-NMD	1.139	[0.860,1.509]	0.529***	[0.373,0.750]	0.591*	[0.371,0.942]
AJK	2.014***	[1.711,2.371]	0.629***	[0.525,0.755]	0.953	[0.768,1.182]
GB	0.648***	[0.543,0.772]	0.880	[0.742,1.045]	0.926	[0.745,1.151]
BMI						
Normal 18.5-24.9	1	[1,1]	1	[1,1]	1	[1,1]
Underweight <18.5	1.175*	[1.034,1.334]	1.059	[0.928,1.207]	1.078	[0.927,1.254]
Overweight 25-29.9	0.814***	[0.742,0.892]	0.860**	[0.784,0.943]	0.777***	[0.691,0.873]
Obese >=30	0.794***	[0.710,0.888]	0.739***	[0.658,0.829]	0.735***	[0.634,0.851]
Food Insecurity Status						
Food Secure	1	[1,1]	1	[1,1]	1	[1,1]
Mild food insecure	1.212**	[1.079,1.362]	1.052	[0.933,1.185]	1.232**	[1.063,1.428]
Moderate food insecure	1.155*	[1.001,1.333]	0.975	[0.843,1.127]	1.097	[0.921,1.307]
Severe food insecure	1.183**	[1.067,1.311]	1.037	[0.931,1.154]	1.155*	[1.019,1.310]
Age of Woman						
15-19 Years	1	[1,1]	1	[1,1]	1	[1,1]
20-29 Years	0.948	[0.687,1.309]	0.957	[0.685,1.337]	0.862	[0.589,1.261]
30-39 Years	0.891	[0.642,1.237]	0.883	[0.629,1.241]	0.812	[0.551,1.197]
40-49 Years	1.021	[0.727,1.433]	0.877	[0.617,1.247]	0.920	[0.616,1.376]
Marital Status						
Currently Married	1	[1,1]	1	[1,1]	1	[1,1]
Ever Married	1.106	[0.814,1.503]	1.156	[0.843,1.585]	1.296	[0.875,1.919]
Pregnancy Status						
Not Pregnant	1	[1,1]	1	[1,1]	1	[1,1]
Pregnant	0.791**	[0.672,0.932]	1.680***	[1.436,1.964]	1.127	[0.924,1.374]

No. of Previous Deliveries						
0	1	[1,1]	1	[1,1]	1	[1,1]
1	1.367	[0.854,2.188]	0.955	[0.624,1.462]	1.272	[0.692,2.340]
2	1.448	[0.904,2.317]	1.032	[0.674,1.579]	1.363	[0.741,2.506]
3	1.495	[0.933,2.396]	1.101	[0.718,1.687]	1.435	[0.780,2.641]
4	1.491	[0.927,2.398]	1.063	[0.691,1.636]	1.472	[0.797,2.721]
5	1.751*	[1.082,2.834]	0.965	[0.623,1.497]	1.375	[0.739,2.559]
6 or 6+	1.453	[0.899,2.350]	1.040	[0.672,1.611]	1.388	[0.746,2.582]
Vitamin A Deficiency						
Non deficient (>0.70 Ã‚Âµmol/L)	1	[1,1]	1	[1,1]	1	[1,1]
Mild (0.35 - 0.70 Ã‚Âµmol/L)	1.347***	[1.233,1.472]	1.241***	[1.135,1.358]	1.366***	[1.228,1.519]
Severe (<0.35 Ã‚Âµmol/L)	1.343***	[1.145,1.575]	1.091	[0.922,1.291]	1.242*	[1.021,1.512]
Vitamin D Deficiency						
Sufficient (>30.0 ng/mL)	1	[1,1]	1	[1,1]	1	[1,1]
Desirable (>20.0 - 30.0 ng/mL)	0.991	[0.841,1.167]	1.091	[0.922,1.292]	1.050	[0.857,1.288]
Deficiency (8.0 - 20.0 ng/mL)	1.024	[0.898,1.168]	1.116	[0.974,1.279]	1.070	[0.903,1.269]
Severe Deficiency (<8.0 ng/mL)	1.026	[0.888,1.185]	1.176*	[1.013,1.366]	1.069	[0.886,1.290]
Zinc Deficiency						
Non-Deficient (>=60 Ã‚Âµg/dL)	1	[1,1]	1	[1,1]	1	[1,1]
Deficient (<60 Ã‚Âµg/dL)	1.207***	[1.105,1.319]	1.273***	[1.164,1.393]	1.434***	[1.291,1.593]
Ll	-5472858.5		-5308239.5		-3859222.3	
chi2	587.0		346.6		399.7	
P	5.93e-99		5.86e-51		2.38e-61	

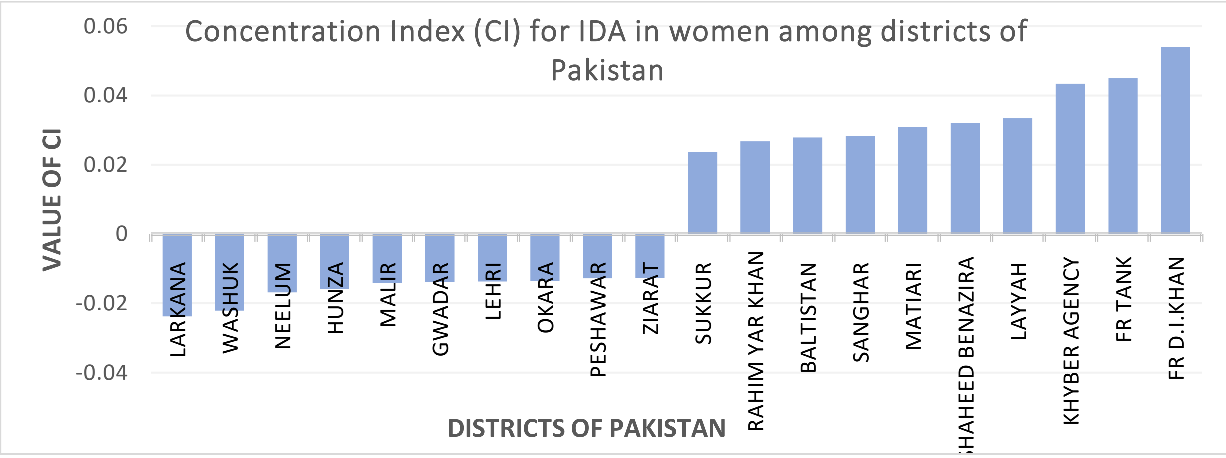
Exponentiated coefficients; 95% confidence intervals in brackets
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: Author's elaboration

5.2 RQ2: Socioeconomic Inequality in the Prevalence of IDA across districts in Pakistan

Figure 5.2.1 illustrates the lowest and the highest 10 values of the concentration index for IDA among the districts of Pakistan. The bar chart shows the districts that have the highest and the lowest inequality in the prevalence of IDA among women. A negative value of concentration index shows that IDA is concentrated among the poor; this inequality depicts pro-rich bias of IDA among women in these districts. The highest inequality was observed in the districts of Larkana (-0.0238), Washuk (-0.0221), Neelam (-0.0168) and Hunza (-0.0159), while the lowest were witnessed in Frontier Region Dera Ismail Khan (FR D.I Khan) (0.054), Frontier Region Tank (FR Tank) (0.045), Khyber Agency (0.0434) and Layyah (0.0334).

Figure 5.2.1 Lowest and Highest Concentration Index for IDA in Women of Reproductive Age among Districts of Pakistan



Rank (lowest CI)	District	Rank (highest CI)	District
1	LARKANA	147	SUKKUR
2	WASHUK	148	RAHIM YAR KHAN
3	NEELUM	149	BALTISTAN
4	HUNZA	150	SANGHAR
5	MALIR	151	MATIARI
6	GWADAR	152	SHAHEED BENAZIRA
7	LEHRI	153	LAYYAH
8	OKARA	154	KHYBER AGENCY
9	PESHAWAR	155	FR TANK
10	ZIARAT	156	FR D.I.KHAN

Source: Author's elaboration

Table 5.2.2 presents the values of the Concentration Index for women of reproductive age with IDA in districts of Pakistan with a spectrum of region, also including poor-rich ratios. Poor-rich ratios for each district reflects a condition with poor as compared to rich, being marginalized in terms of health and nutrition. With the highest negative value of concentration index, Larkana (-0.0238) in Sindh region, has a high poor-rich ratio of 2.82 (95% CI 1.26-4.39) significant at 5%. This depicts that the poorest households share the highest burden of IDA in the district. Hunza in Gilgit Baltistan also has a very high poor-rich ratio of 8.00 (95% CI -3.79-9.79), with a negative value of concentration index (-0.0159). Gawadar in Balochistan has the highest poor-rich ratio of 11 (95% CI 1.78-20.22) in the region while having a negative but non-significant negative value for the concentration index. From the districts that have the highest positive value of concentration index in the data, Baltistan (38.00, 95% CI 15.49-91.49) has a significantly high poor-rich ratio. For the districts that were majorly poor and had no women in the rich category gave no poor rich ratio.

Table 5.2.1 Concentration Index and Poor-Rich ratio depicting socio-economic inequality in Anaemia in Women across Pakistani districts, PNNS 2018

District	Region	No. of obs.	CI Index	Robust Std. Error	Poor Rich Ratio	Linearized Std. Err.	[95% CI]	
Larkana	Sindh	146	**-0.0238****	0.011556 0	2.82	0.799	1.26	4.39
Washuk	Balochistan	100	**-0.0221*****	0.00734851 0	.	(denominator estimate equals zero)		
Neelum	AJK	133	**-0.0168***	0.00918751 0	.	(denominator estimate equals zero)		
Hunza	GB	138	**-0.0159****	0.00749277 0	8.00	6.017	-3.79	19.79
Malir	Sindh	326	**-0.0141***	0.00763631 0	0.17	0.048	0.08	0.26
Gwadar	Balochistan	137	**-0.0139**	0.0119365 0	11.00	4.705	1.78	20.22
Lehri	Balochistan	130	**-0.0137**	0.011264 0	.	(denominator estimate equals zero)		
Okara	Punjab	289	**-0.0136****	0.00663909 0	1.04	0.298	0.46	1.63
Peshawar	KP	257	**-0.0128****	0.00537086 0	0.44	0.097	0.25	0.63
Ziarat	Balochistan	58	**-0.0127**	0.01380741 0	.	(denominator estimate equals zero)		
Sukkur	Sindh	144	**0.0236****	0.01097695 0	1.96	0.493	0.99	2.92
Rahim Yar Khan	Punjab	270	**0.0268****	0.01008771 0	1.96	0.332	1.31	2.61
Baltistan	GB	150	**0.0279*****	0.00854465 0	38.00	27.290	-15.49	91.49
Sanghar	Sindh	151	**0.0283****	0.01221873 0	3.43	0.816	1.84	5.03
Matiari	Sindh	117	**0.0309***	0.01509321 0	5.82	1.906	2.08	9.55
Shaheed Benazira	Sindh	147	**0.0321****	0.01275756 0	11.43	4.516	2.58	20.28
Layyah	Punjab	256	**0.0334******	0.00883817 0	2.18	0.422	1.35	3.01
Khyber Agency	KP NMD	40	**0.0434***	0.0242421 0	.	(denominator estimate equals zero)		
FR Tank	KP NMD	15	**0.045***	0.01264819 0	.	(denominator estimate equals zero)		
FR D I Khan	KP NMD	25	**0.054****	0.0149652 0	.	(denominator estimate equals zero)		

P < 0.10 *,P < 0.05**,P < 0.01***P<0.001****

*Concentration Index for only the least 10 and highest 10 values for Concentration Index shown here

Source: Author's elaboration

As poor-rich ratios are used here to measure the gap in women nutrition, Table 5.2.2 presents calculated ratio for regions (all four provinces and four main regions) and areas of residence (urban and rural). Balochistan has the highest poor-rich ratio of 22.46, (95% CI 18.47-

26.46) followed by Gilgit Baltistan. GB (26.00, 95% CI 14.93-37.07) and Kyber Pakhtunkhwa Newly Merged Districts, KP-NMD (13.10, 95% CI 7.14-19.06). The lowest value of poor-rich ratio was observed in Islamabad Capital Territory, ICT (0.03, 95% CI 0.01-0.06), implying that the anaemia is equally shared by both sections of the society in this region. Considering area of residance, rural area has a substantially high poor-rich ratio (4.98, 95% CI 4.70-5.27), depicting huge disparity within and among areas as well compared to urban (0.23, 95% CI 0.21-0.24).

Table 5.2.2 Poor-Rich Ratios for the Major Regions and Areas of Pakistan

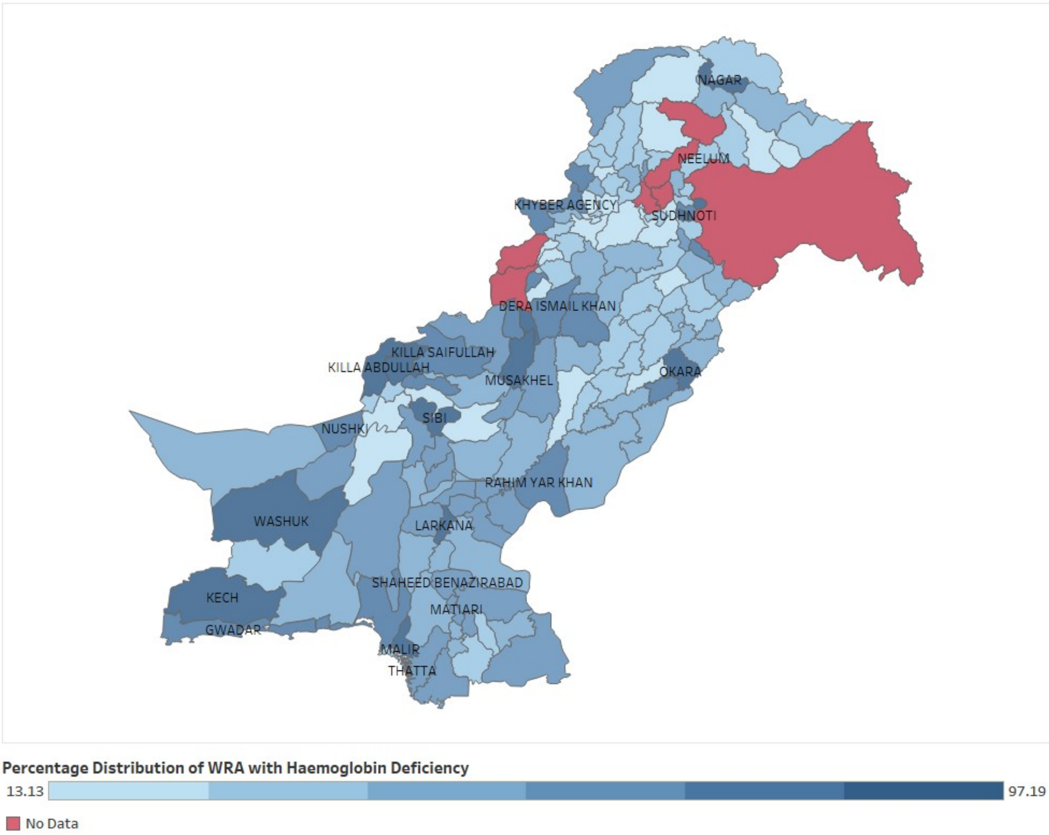
	Poor-Rich Ratio	Linearized St. Error	95% Conf. Interval	
Region				
Punjab	0.48	0.02	0.45	0.52
Sindh	1.77	0.07	1.64	1.90
KP	2.50	0.16	2.19	2.81
Balochistan	22.46	2.04	18.47	26.46
ICT	0.03	0.01	0.01	0.06
KP-NMD	13.10	3.04	7.14	19.06
AJK	1.02	0.10	0.82	1.22
GB	26.00	5.65	14.93	37.07
Area				
Urban	0.23	0.01	0.21	0.24
Rural	4.98	0.14	4.70	5.27

Source: Author's elaboration

5.3 RQ 3: Spatial Pattern in Prevalence of IDA in Women across Districts of Pakistan

Haemoglobin is the most common measure of iron deficieny anaemia. The range of percentage prevalence in the population varied from 13.13% to 97.19% with districts in Sindh and Balochistan showing more prevalence of haemoglobin deficiency (Figure 5.3.1). Districts in the province of Sindh (Thatta, Malir, Larkana, Shaheed Benazirabad, Larkana), Balochistan (Kech, Washuk, Sibi, Nushk, Musakhel, Killa Saifullah, Killa Abdullah, Gawadar), Punjab (Dera Ismail Khan, Okara, Rahim Yar Khan), and in the regions of Khyber Pakhtunkhwa Newly Merged Districts, KPNMD (Khyber Agency), Azad Jammu & Kashmir, AJK (Neelam, Sudhnoti) and Giligit Baltistan, GB (Nagar) show the highest concentration of women deficient in haemoglobin.

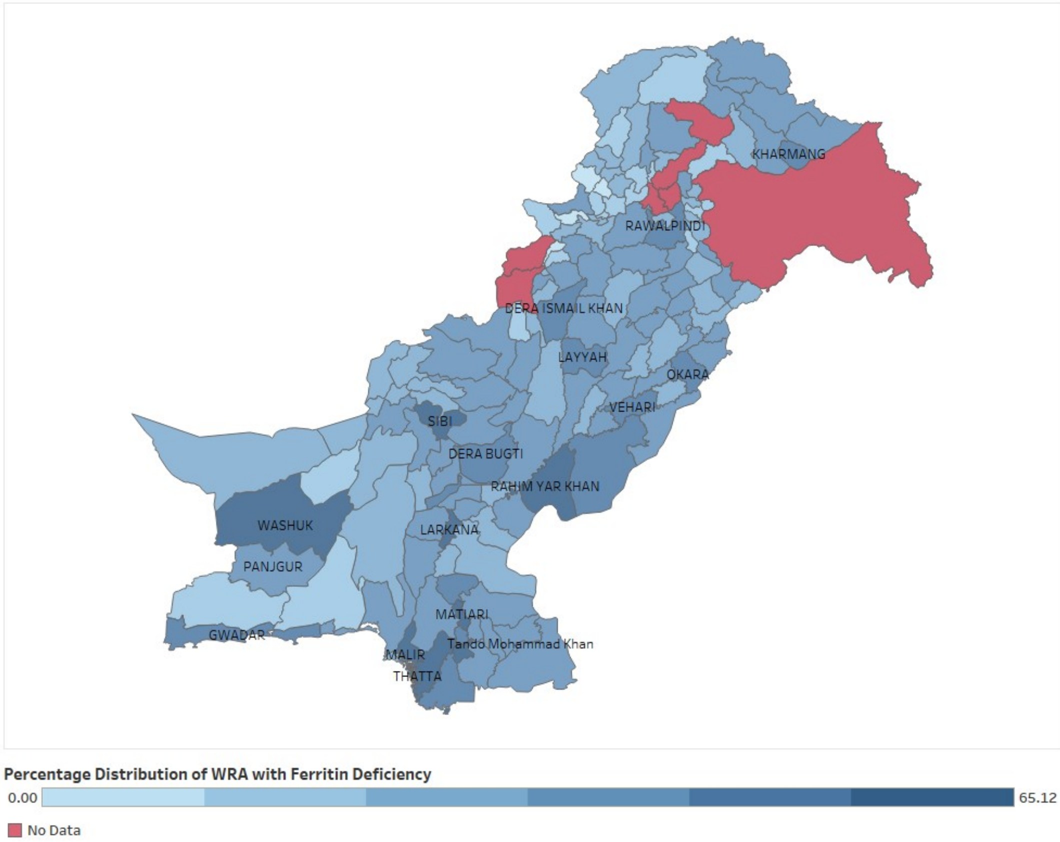
Figure 5.3.1 Prevalence of Haemoglobin Deficiency in Women across Districts of Pakistan



Source: Author's elaboration

Ferritin deficiency in women of reproductive age in Pakistan ranges from 0% to 65.12% across the districts (Figure 5.3.2). The value of zero is observed in the district of Frontie Region Bannu (FR Bannu) which had a very low sample size comprising only six women. Districts of Malir, Thatta, Matiari and Larkana in Sindh, Washuk, Gawadar, Sibi and Panjgur in Balochistan, Rahim Yar Khan, Vehari, Layyah, Rawalpindi and Okara in Punjab while Kharming in Gilgit Baltistan show the highest prevalence of women with ferritin deficiency.

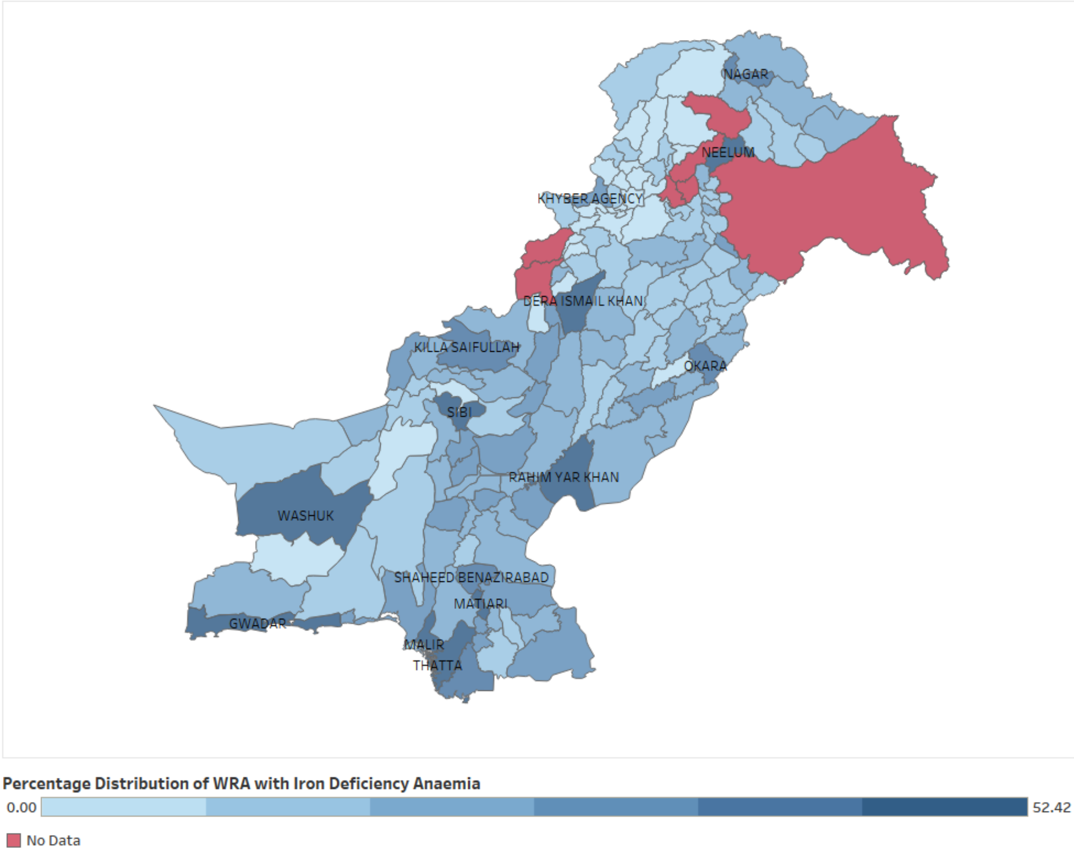
Figure 5.3.2 Prevalence of Ferritin Deficiency in Women across Districts of Pakistan



Source: Author's elaboration

Since IDA is a combination of both, haemoglobin and ferritin deficiency, the overall range of IDA is narrower than each of the other two. The prevalence of IDA varries from a low of 0% in Frontier Region Bannu (FR Bannu) and Mohmand Agency (both with very small sample size) to a high of 52.42% in Thatta (Figure 5.3.3). Women in the districts of Malir, Matiari and Saheed Behanizarabad in Sindh, Washuk, Gawadar, Sibi and Killa Saifulla in Balochistan, Okara and Dera Ismail Khan in Punjab, Neelam in Azad Jammu and Kahsmir and Nagar in Gilgit Baltistan experience the highest incidence of IDA.

Figure 5.3.3 Prevalence of IDA in Women across Districts of Pakistan



Source: Author's elaboration

The three measures of iron deficiency anaemia show more or less a similar pattern across Pakistan. However, the geographical disparity in concentration across provinces and regions reflect the inequality in anaemia prevalance across the country.

CHAPTER 6 DISCUSSION

The percentage prevalence of anaemia in the population of women caused by iron deficiency is found to be 42.7% as measured by Haemoglobin deficiency, 34.4% as measured by serum Ferritin concentration and 18.2% when taken as a combination of both, low haemoglobin and low ferritin levels. National Nutrition Survey of Pakistan measures IDA as a combination of the two measures, hence most part of the analysis used the same variable to be able to be consistent with the earlier studies done in Pakistan. In addition to that, two separate measures of IDA are also used for comparisons with other studies. Given that the previous two PNNS conducted in 2001 and 2011 reported the prevalence of IDA as 25.5% (PNNS, 2004) and 18.1% (PNNS 2011) respectively, the current findings reflect a 28.6% decrease in the rate of IDA over the eighteen-year period between PNNS 2001 and PNNS 2018. The overall reduction looks satisfying; however, it is also evident that the progress in the recent years from 2011 to 2018 has been declined by (0.1%) indicating very little change or worse outcomes in core nutrition indicators for women of reproductive age in Pakistan. This presents more complex challenges and policy implications to design context-specific interventions to treat the national burden.

From the logistic regression analysis, it was concluded that the odds of IDA increased for women with low levels of education, belonging to lower wealth quintiles, having less than normal BMI and having lesser food security. This indicates how a combination of determinants that reflect low socioeconomic status are corelated with higher chances of developing iron deficiency anaemia. This is consistent with the study done by Safiri et al. (2021) on the burden of anaemia in 204 countries over the period 1990-2019. They reported a negative relationship between the prevalence of anaemia and sociodemographic index (SDI) where SDI was an important measure for various socio demographic variables, including nutrition status, access to health services, education and gender equality (Safiri et al., 2021). Being pregnant increased odds of developing serum ferritin deficiency while being deficient in other micronutrients like Vitamin A (severe) and Zinc had greater incidence for haemoglobin deficiency, ferritin deficiency and IDA. Thus, in addition to food security, the results highlight the need for better nutrition to address the combination of dietary deficiency, poor maternal health and a high burden of morbidity for women in Pakistan.

For all three measures of IDA, the odds significantly decreased as women belonged to households with higher incomes as measured by wealth quintiles. Studies in other countries comprehensively elucidate the inter-relationship between poverty and malnutrition. Siddiqui et al. (2020) suggests that in India, malnutrition leads to poverty by limiting the economic potential of the population and that poverty exacerbates malnutrition by increasing the intensity of food insecurity. Similar studies have been done that confirm the closely linked interaction of malnutrition and poverty. While this widespread perception cannot be denied, the poverty-nutrition linkage is complex and is greatly affected by a range of other socio-economic indicators as well. In addition to the studied variables, the form and extent of female subjugation is a significant predictor affecting nutrition and health for women in Pakistan. Thus, addressing issues of women education and empowerment coupled with mass campaign for public awareness on the importance and impact of women malnutrition on nation's health is imperative.

The socioeconomic inequality in the prevalence of IDA among women of reproductive age is reflected by the values of concentration index. The study using district level data of wealth status and population weights for 156 districts of Pakistan, presented population representative results. Significant negative values for the districts of Larkana, Washuk, Neelum, Hunza and Malir reflect that women from poor households bear a disproportionate burden of anaemia. Spatial analysis on mapping the districts illustrates the geographically disadvanteged location of these regions. The analysis is complemented with poor-rich ratios that measure the gap in women nutrition, adding to the increase in the prevalence of IDA. The high ratios for the province of Balochistan, Gilgit Baltistan and Sindh reflect the role of underlying factors of underdevelopment, lower incomes and inadequate access to healthcare for anaemia prevalence in these regions. Results from logistic regression also reported Sindh, Balochistan and AJK to have higher prevalence of haemoglobin deficiency thus supporting that inequality within and among regions can significantly impact the incidence of IDA.

While the results report a worse prevalence of IDA among women of the lowest socioeconomic status, the lowest poor-rich ratio in Islamabad Capital Territory reveal that women belonging to well-off households have access to better nutrition and thus also had lower odds of suffering from any form of iron deficiency resulting in IDA as suggested by the regression analysis. Among rural and urban areas, there was no significant variation in IDA prevalence as yielded by the logistic regression. It is noteworthy, however, that the poor-rich ratio was substantially higher for women in rural areas thus emphasizing the need to additionally study socioeconomic inequality in health outcomes. These findings are consistent with the situation in the neighbouring country India where inherent socioeconomic inequality exists in anaemia among children under five years of age (Kanjilal, 2017). Also, Sharma et al. (2020) makes the point that socioeconomic status is an important determinant of distribution of anaemia among children across different states of India.

The findings from the choropleth maps illustrate the spatial patterns in IDA prevalance across the districts as measured by the three outcome variables. The diparity in areas with high pervalence is prominent, depicting how geographical differences can contribute to inherent inequalities in health outcomes. This spatial pattern must be analyzed coupled with the socioeconomic determinants of anaemia prevalence to get a full picture of the context. It is a very challenging task to coordinate and/or integrate the programs of various health units and sectors, perhaps the most challenging task of the anaemia control approach (USAID, 2014; SPRING, 2017). However, based on the findings of this study, it is crucial to formulate appropriate and context-sensitive policy interventions. One of the possible future works that will be a significant milestone in reducing anaemia in Pakistan might be conducting an *Anaemia Landscape Analysis*[4] using the tool developed by SPRING[5]. Such landscape analyses aid policy makers identify the combination of probable causes of anaemia, which related interventions are already implemented, and which interventions are likely to be added or improved along the path toward measurable anaemia reduction (WHO, 2020). This tool has been used and anaemia landscape analysis is available on three countries: Ghana (2016), Sierra Leone (2015) and Uganda (2015). Thorough analysis of the situation is needed for other countries like Pakistan where anaemia is prevalent as a severe health crisis.

All the explanatory variables included in the analysis were exclusively requested from the relevant authorities and thus the subset of the data may be limited to capture all determinants related to women nutrition and health. There are some other limitations of the study as well. The range of concentration index was narrow, as the data on wealth had only five categories. Population representative weights could not be added to the poor-rich ratios as the absence of rich in some districts would otherwise skew the results. The nature of the study is cross-sectional hence, temporality between IDA and its related factors cannot be confirmed. Also, as haemoglobin testing was done in fields with capillary blood sample by using HemoCue device rather than in laboratories with venous blood sample, the deficiency and anaemia prevalence might be slightly underestimated (Shamah Levy et al., 2017). Nonetheless, the major achievement of this study is that this is the first secondary analysis performed on the data from National Nutrition Survey 2018. Other strengths include the use of serum ferritin concentration to diagnose IDA and the use of three different outcome measures of IDA in total. A large nationally representative sample and analysis will make this study useful for experts and

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[4] https://www.spring-nutrition.org/publications/tools/anemia-landscape-analysis-tool

[5] *Four-Step process: 1. Characterize anaemia prevalence 2. Establish causes of anaemia 3. Review anaemia policies 4. Assess status of anaemia interventions*

policymakers. This study jointly employs statistical analysis and graphical representation to present socioeconomic inequality and regional disparities in anaemia linked to spatial patterns. Contrary to numerous studies done on its immidiate neighbour India, there was no such analysis done on Pakistan.

CONCLUSION

IDA is an important public health issue in Pakistan. It is an interweaving outcome of several socioeconomic factors associated with malnutrition in women of reproductive age in the country. The findings of the study are reflective of an insufficient priority to the nutrition situation, inadequate awareness on women nutrition and health, and lack of a coordinated and interlinked approach to design and implement a coherent strategy to address malnutrition. The almost zero reduction in the IDA prevalence over the years from 2011 and 2018 point to the fact that concern for nutrition has been absent in designing current social safety nets and income support programs. Limited availability of nationally representative data including samples from targeted groups is a major roadblock in assessing the anaemia landscape of the country. It is imperative to conduct academic and clinical research on IDA, assimilating and disseminating useful information on women nutrition and IDA. Developing and studying spatial patterns in anaemia prevalence and employing socioeconomic inequality is critical to address the root causes. As quoted by World Bank, nutrition is an area that necessitates a multi-sectoral approach for interventions (2020). Thus efforts to reduce IDA in women of reproductive age in Pakistan requires more integrated efforts and geographically targeted interventions.

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Appendix

Table A1. Descriptive Statistics of the Explanatory Variables from Sample in Pakistan National Nutrition Survey 2018

Variables	N	%
Education		
None	17436	52.32
Primary	3674	11.02
Middle	3532	10.60
Secondary	4693	14.08
High	3993	11.98
Wealth Index		
Poorest	7952	23.86
Second	7681	23.05
Middle	7020	21.06
Fourth	6051	18.16
Richest	4624	13.87
Area		
Urban	10452	31.36
Rural	22876	68.64
Province		
Punjab	13092	39.28
Sindh	6049	18.15
KP	3977	11.93
Balochistan	4933	14.80
ICT	431	1.29
KP-NMD	639	1.92
AJK	2404	7.21
GB	1803	5.41
BMI		

Underweight(<18.5)	4699	14.94
Normal(18.5-24.9)	15716	49.98
Overweight(25.0-29.9)	7140	22.71
Obese(>=30)	3888	12.37
Food Insecurity Status		
Food Secure	19359	60.20
Mild food insecure	3771	11.73
Moderate food insecure	2490	7.74
Severe food insecure	6536	20.33
Age of the Woman		
15-19 Years	7464	22.40
20-29 Years	10508	31.53
30-39 Years	10820	32.47
40-49 Years	4536	13.61
Marital Status of the Woman		
Currently Married	24875	74.64
Ever Married	380	1.14
Un-Married	8073	24.22
Pregnancy Status		
Not Pregnant	31841	95.54
Pregnant	1487	4.46
Number of Deliveries		
0	185	0.78
1	3868	16.41
2	5238	22.23
3	4840	20.54
4	3789	16.08
5	2444	10.37
6 or 6+	3203	13.59
Vitamin A Deficiency		
Severe (<0.35 Ã,Âµmol/L)	17859	71.56

Mild (0.35 - 0.70 Ã,Âµmol/L)	5812	23.29
Non deficient (>0.70 Ã,Âµmol/L)	1284	5.15
Vitamin D Deficiency		
Severe Deficiency (<8.0 ng/mL)	6943	27.60
Deficiency (8.0 - 20.0 ng/mL)	13153	52.29
Desirable (>20.0 - 30.0 ng/mL)	2628	10.45
Sufficient (>30.0 ng/mL)	2429	9.66
Zinc Deficiency		
Non-Deficient (>=60 Ã,Âµg/dL)	19714	78.18
Deficient (<60 Ã,Âµg/dL)	5501	21.82

Source: Author's elaboration