INTERNAL MEDICINE JOURNAL

Prevalence of anaemia and iron deficiency in Portugal: the EMPIRE study

C. Fonseca,[1,2,3] F. Marques,[1,2,3] A. Robalo Nunes,[1,4] A. Belo,[1,5] D. Brilhante[1,6] and J. Cortez[1,7,8]

[1]Anemia Working Group Portugal, [2]Internal Medicine Department, S. Francisco Xavier Hospital/Centro Hospitalar Lisboa Ocidental, [3]NOVA Medical School/Faculdade de Ciências Médicas, Universidade Nova de Lisboa, [4]Immunohemotherapy (Transfusion Medicine) Department, Centro Hospitalar Lisboa Norte, [5]OM Pharma, [6]Hematology Department, Cancer Portuguese Institute, Francisco Gentil - Lisbon, [7]Laboratory Medicine Unit, Nova Medical School/Faculdade de Ciências Médicas, Universidade Nova de Lisboa, and [8]Clinical Pathology (Haematology Laboratory), Cancer Portuguese Institute, Francisco Gentil - Lisbon, Lisbon, Portugal

Key words
anaemia, iron deficiency, epidemiology, prevalence, portugal.

Correspondence
Cândida Fonseca, S. Francisco Xavier Hospital/CHLO, Estrada Forte do Alto do Duque, 1449-005, Lisboa, Portugal.
Email: mcandidafonseca@gmail.com

Received 16 July 2015; accepted 13 December 2015.

doi:10.1111/imj.13020

Abstract

Background: Anaemia and iron deficiency are major public health problems with great implications on quality of life.
Aims: To establish the general prevalence of anaemia and iron deficiency in the adult Portuguese population and the prevalence by age, gender and region.
Methods: This was a population-based, cross-sectional study (EMPIRE study) based on a representative sample of 7980 adults residing in mainland Portugal, which were selected using a random route sampling method. Levels of haemoglobin, ferritin, creatinine and C-reactive protein were measured by Point-of-Care assays; participants also completed a questionnaire about demography and medical history.
Results: The measured prevalence of anaemia was 19.9% (95% confidence interval: 19.0–20.8%); 84% of cases were previously undiagnosed. Anaemia was more prevalent among women (20.8%), young adults (18–34 years) (22.8–30.5%), older adults (21.0%), and pregnant women (54.2%). Anaemia varied across regions: from 15.5% in the Center region to 24.9% in the South. Iron deficiency was also highly prevalent: 16.7% (ferritin <15 ng/mL), 31.9% (<30 ng/mL), 53.3% (<50 ng/mL) and 84.3% (<100 ng/mL). Iron deficiency anaemia represented most anaemia cases: 29.0% (ferritin <15 ng/mL), 54.8% (<30 ng/mL), 75.4% (<50 ng/mL) and 92.5% (<100 ng/mL).
Conclusion: Anaemia and iron deficiency are highly prevalent in Portugal and largely undiagnosed. Women, young adults and older individuals are more prone to present these conditions and there are marked regional asymmetries. Nationwide strategies for prevention, diagnosis and treatment of these conditions should be implemented.

Introduction

Anaemia, a major public health problem affecting nearly 25% of the world population, has great implications on quality of life.[1–8] It can occur during all ages, but it particularly affects young children (≤5 years) and women, especially during pregnancy.[1,9–12] The prevalence, being ≥20% in developing countries (most of Africa, Asia and South America), represents a significant public health problem.[1]

Anaemia, characterised by reduced red blood cell count, leads to impaired oxygen delivery to tissues.[13,14] This is mainly due to one (or more) of three causes: increased or decreased red blood cell production or blood loss. There are many causes of these processes: nutritional deficiencies (e.g. iron, vitamin B12 and folate)[13,15] and genetic disorders (e.g. thalassaemia)[13,16] as well as many medical conditions (e.g. infections, cancer and autoimmune disorders).[13,17,18]

Iron deficiency, the leading aetiology of anaemia, is generally assumed to account for more than half of the cases worldwide.[19,20] In fact, iron deficiency is by itself the most common nutritional disorder, being prevalent even in industrialised nations.[19,20] In developed countries, iron deficiency is normally caused by insufficient dietary iron intake or by conditions that cause either iron loss or decreased iron absorption.[21,22] It also occurs in

Funding: OM Pharma Portugal provided financial support to the Anemia Working Group Portugal (AWGP) to conduct this study. Nonetheless, the AWGP had full autonomy in the design, conduct, analysis, interpretation and publication of the study results.
Conflict of interest: C. Fonseca, F. Marques, A. Robalo Nunes, D. Brilhante and J. Cortez received speaker honoraria from OM Pharma Portugal.

© 2016 Royal Australasian College of Physicians

northern Europe[23,24] mainly due to the low intake of meat and vegetables and the high intake of dairy products, which reduces iron absorption.[22] In countries using Mediterranean diets (includes a high intake of meat, fruits and vegetables), iron deficiency is thought to be less prevalent.[22] In developing countries where iron deficiency is very common due to malnutrition and poor dietary iron intake,[25,26] infections/infestations contribute to make the issue a major public health problem.[19]

Iron deficiency is more likely to occur when requirements are increased, such as during periods of rapid growth (children and adolescents). Female adolescents are even more prone because of menstrual bleeding and reduced dietary iron intake.[20,22,27–31] Additionally, women of reproductive age and particularly pregnant women have a high risk of iron deficiency.[20,22,27] Even without anaemia, iron deficiency can cause deleterious effects: impairment of cognitive development and performance, reduced working capacity (especially physical labour) and increased maternal mortality.[19]

In Portugal, there are no data regarding the prevalence of anaemia and iron efficiency, although the World Health Organization (WHO) estimates the prevalence of anaemia in the general population to be approximately 15%.[1] Hence, this study aims to establish the extent of the problem in the Portuguese adult population and the prevalence by age, gender and region. An additional aim is to raise public awareness in this country.

Methods

Study design and setting

This epidemiological, cross-sectional, population-based study (the EMPIRE study) was conducted in mainland Portugal from March to July 2013. All efforts were made to ensure the representativeness of the study population, including the sample size calculation and sampling method (fully described in the following sections).

Participants were interviewed at their residencies during week days from 10:00 am to 9:30 pm. During the interview, levels of relevant biomarkers were measured, and the participants completed a questionnaire about demography and medical history.

All members of the independent team conducting the interviews were healthcare professionals (mainly nurses), with training on inquiry techniques and on the study materials.

The study received favourable opinion by the Ethics Committee of the NOVA Medical School/Faculdade de Ciências Médicas, Universidade Nova de Lisboa, Lisbon, Portugal. The study protocol and data collection forms received approval from the Portuguese National Data Protection Committee (CNPD, Lisbon, Portugal). Participants provided their oral informed consent before any study procedure was conducted.

Study sample and selection of subjects

The study enrolled adults (≥18 years old) residing in mainland Portugal who were willing and consented to participate. The autonomous regions of Madeira and Azores were not included in the study due to logistic constraints (i.e. difficulties in conducting the study on the several islands that constitute these regions).

To obtain a representative sample of the Portuguese population, an area-random route-sampling method consisting of two steps was employed.[32] First, the Portuguese population was stratified into four regions: North, Center, Lisbon and Tagus Valley and South, which represent the current distribution of the mainland Portuguese population. Within each region, municipalities representative of the geographic and demographic characteristics were selected based on data from the 2011 Portuguese National census, made available by the National Institute of Statistics (INE). The study was conducted in a total of 45 representative municipalities; the number of interviews conducted within each municipality was calculated based on data from the 2011 Portuguese National census.[33]

Second, in each municipality, a random route with turns to the right and left from a starting point (city hall, church, etc.) was defined. At the first street, the interviewer went to the first house on the right. In the case of apartment buildings, the interviewer went to the right ground-floor apartment, then the left first floor apartment and so on up to the last floor of the building. Then, the interviewer went to the second house on the left. In the case of apartment buildings, the interviewer went to the left ground-floor apartment, then the right first floor apartment and so on up to the last floor of the building. This process was repeated up to the turning points defined by the route and then was repeated at each new street.

Once the households were selected, all members ≥18 years old were invited to participate. Once participants provided their oral informed consent, they were asked to complete the study questionnaire, and the study-related measurements were undertaken.

Assessments

Demographics and medical history

Study participants were asked to complete a questionnaire about demographic and anthropometric characteristics, dietary habits, medical history (with

© 2016 Royal Australasian College of Physicians

emphasis on surgeries and cancer diagnosis), known lifestyle risk factors, diagnosis and symptoms of anaemia and current therapies. Research staff assisted subjects with low literacy skills.

Biomarkers: haemoglobin, ferritin, creatinine, C-reactive protein

Relevant biomarkers were measured through capillary puncture using point-of-care testing devices. Haemoglobin levels were measured using CERA CHEK Hb Plus (Ceragem Medisys, Chungnam, South Korea). Ferritin and C-reactive protein levels were determined using VEDALAB EASY READER (Veda Lab, Alençon, France). Creatinine levels were measured using CardioCheck PA (Polymer Technology Systems, Inc, Indianapolis, IN, USA). All tests have been properly validated by the manufacturer.

Definition of anaemia

The WHO haemoglobin thresholds were used to identify anaemic participants: haemoglobin levels <13 g/dL for men, <12 g/dL for non-pregnant women and <11 g/dL for pregnant women in the first and third trimesters and <10.5 g/dL in the second trimester. Corrections for altitude were not implemented as no interviews were conducted at altitudes higher than 1000 meters, reflecting the population distribution in mainland Portugal.

Definition of iron deficiency

Iron deficiency was classified according to different cut-off levels of ferritin: <15 ng/mL, <30 ng/mL, <50 ng/mL and <100 ng/mL, considering the different cut-offs of ferritin proposed overtime.[19,34–38] All iron deficiency analyses were conducted for these four different levels.

Statistical methods

This study was designed to obtain representative estimates of the prevalence of anaemia and iron deficiency in the adult Portuguese population. A sample size of 7890 subjects was calculated, assuming an estimated prevalence of anaemia of 15% (WHO estimates)[1] and considering a significance level of 5%, an error margin lower than 2.5% in each of the four regions of the country and an error margin lower than 1% for the country.

Descriptive statistics were employed for all variables. Relative frequency distributions for categorical variables were expressed as percents; distribution indicators for quantitative variables were expressed as mean, median, standard deviation, minimum and maximum. Demographic, anthropometric and clinical variables underwent bivariate analysis. An independent sample *t*-test and chi-square test were used as appropriate. For each estimated prevalence, the respective 95% confidence interval (CI) was also calculated. Statistical analyses were performed at a 5% significance level.

Analyses were conducted using SPSS for Windows, version 16.0 (SPSS Inc., Chicago, IL, USA); 95% CI for the estimated prevalence was calculated using OpenEpi, version 3.01.[39]

Results

Study population

A total of 10 572 adult Portuguese residents was invited to participate in the study. Of those, 7890 agreed to participate, representing a 75% acceptance rate.

The study population comprised 3731 men (47%). The mean (SD) age was 47.4 (18.7) years; most participants were aged 18–64 years (79.5%).

Approximately, one third of participants (34.4%) reported having 12 years of schooling; 19.0% had a college degree and 21.8% had 4 or fewer years of formal education. About half the study population was professionally active (53.7%); 15.3% were unemployed; 9.1% were students and 21.9% were retired.

A few participants reported having a restricted diet: 2.4% were vegetarian; 0.1% were ovolactovegetarian and 0.1% were vegan. The vast majority had an unrestricted diet (97.5%). One per cent of participants reported a surgical procedure within 3 months of enrollment in the study. The percentage of participants with an infectious or inflammatory disorder at the time of the study was 4%.

Prevalence of anaemia

The overall measured prevalence of anaemia was 19.9% (95% CI: 19.0–20.8%), but 84% of anaemic participants reported never having had a diagnosis of anaemia. When considering those participants under treatment with iron, folate or vitamin B12 as anaemic independent of their haemoglobin level, the 'actual' prevalence of anaemia was raised to 20.6% (95% CI: 19.7–21.5%).

Table 1 shows the prevalence of anaemia in specific groups of the study population. Anaemia was significantly more prevalent among women (20.8% vs 18.9%; $P < 0.034$), especially pregnant women (54.2%). The elderly also tended to a have a higher prevalence of anaemia (21.0% vs 19.6%; $P = 0.198$).

Figure 1A depicts the prevalence of anaemia according to gender and age groups. Women presented higher prevalence of anaemia up to the age of 65, but in the elderly (≥65 years,) anaemia was more prevalent among men. It is noteworthy that anaemia was more prevalent

© 2016 Royal Australasian College of Physicians

Table 1 Measured prevalence of anaemia in the study population

Population groups	Prevalence of anaemia, % (95% CI)
Total population (*n* = 7890)	19.9 (19.0–20.8)
Men (*n* = 3731)	18.9 (17.6–20.1)
Women (*n* = 4159)	20.8 (19.6–22.0)
Pregnant women (*n* = 59)	54.2 (41.5–66.6)
Non-pregnant fertile women (*n* = 2445)	20.7 (19.2–22.4)
Elderly ≥65 years old (*n* = 1617)	21.0 (19.1–23.1)

in young adults (<35 years), the numbers being particularly striking in younger women: 30.5% in women aged 18–24 years and 27.6% in women aged 25–34 years.

The estimated prevalence of anaemia varied significantly ($P < 0.001$) between the different regions of the country (Fig. 2A). Anaemia was more prevalent in the South (24.9%) and in Lisbon and Tagus Valley (23.9%) than in the Center (15.5%) and in the North (17.9%).

Table 2 shows the measured prevalence of anaemia according to participants' characteristics. Anaemia was more prevalent among participants with body mass index (BMI) <18.5 kg/m^2. It varied between the different education levels, with higher prevalence among those with no formal qualifications (25.8%) and those with a 12-year scholarship (23.5%).

Participants with an unrestricted diet had a prevalence of anaemia compatible with general population estimates. Vegetarians had, however, a considerably higher prevalence of anaemia (26.5%). Ovolactovegetarians

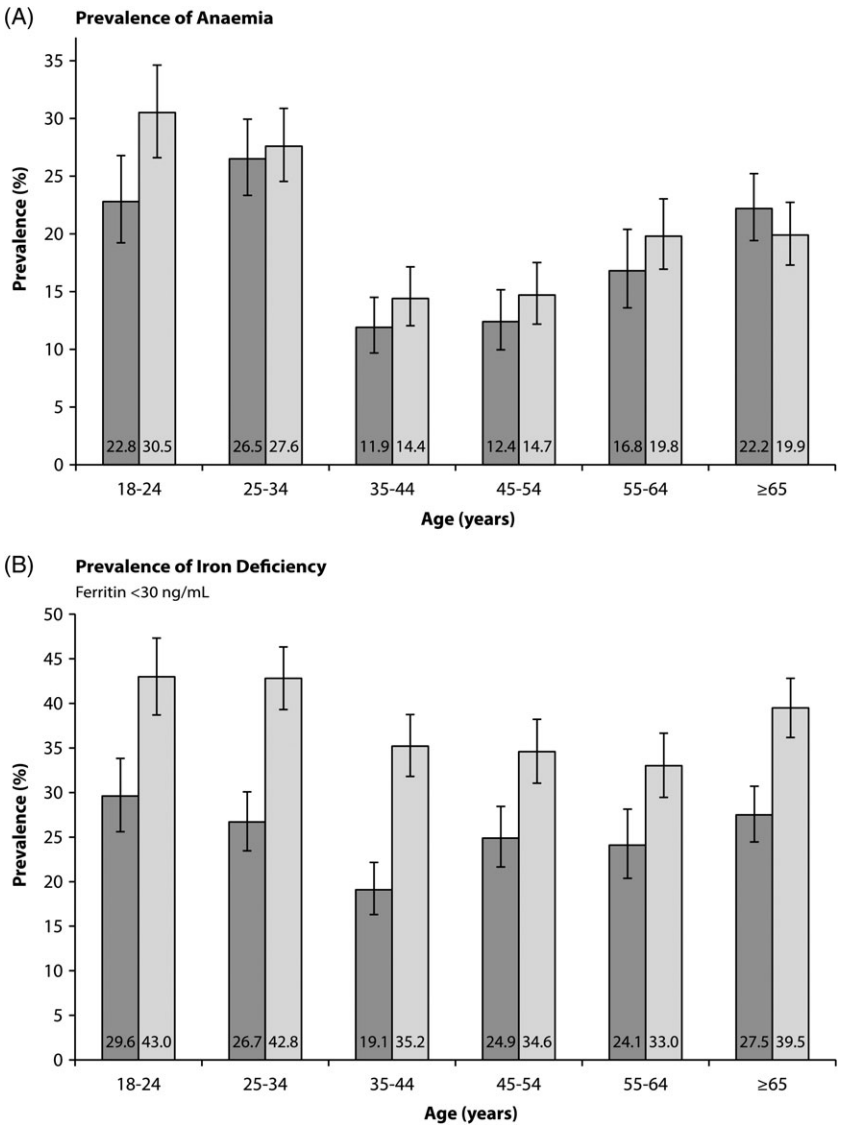

Figure 1 Measured prevalence of anaemia (A) and iron deficiency (B) in the study population by age and gender. Error bars represent 95% confidence intervals.

© 2016 Royal Australasian College of Physicians

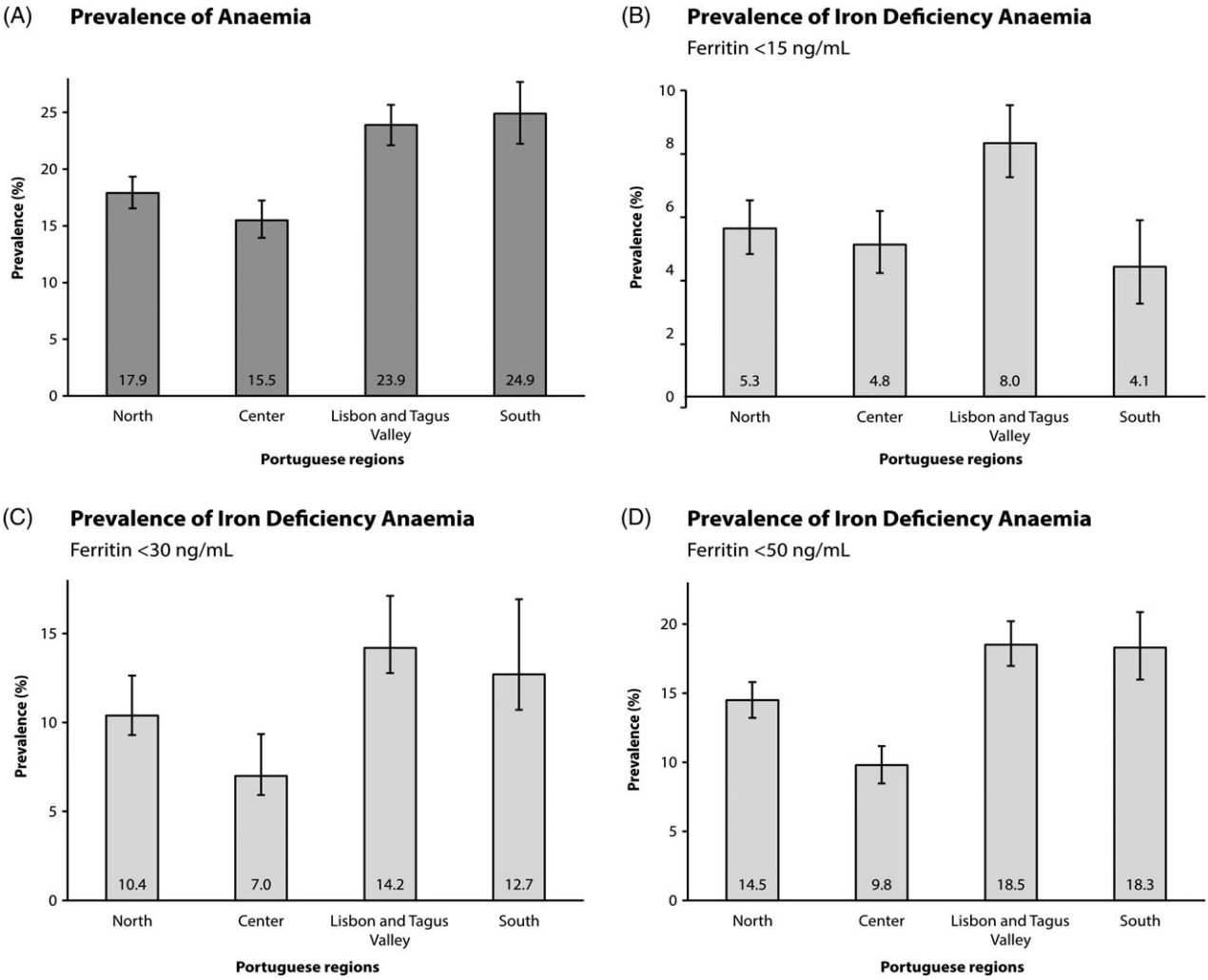

Figure 2 Measured prevalence of anaemia (A) and iron deficiency anaemia (B–D) in the study population by region of the country. Error bars represent 95% confidence intervals.

and vegans also displayed a high prevalence of anaemia; however, only a few participated in the study (n = 10 and n = 2 respectively).

Prevalence of iron deficiency

Iron deficiency (as measured by ferritin levels) was present in considerable portions of the study population. The overall measured prevalence of iron deficiency was 16.7% (95% CI: 15.7–17.4%) for ferritin <15 ng/mL, 31.9% (95% CI: 30.8–32.9%) for ferritin <30 ng/mL, 53.3% (95% CI: 52.2–54.4%) for ferritin <50 ng/mL and 84.3% (95% CI: 83.5–58.1%) for ferritin <100 ng/mL.

Table 3 shows the measured prevalence of iron deficiency in specific groups of the study population, and Figure 1B depicts the prevalence of anaemia according to gender and age groups. Similar to anaemia, iron deficiency was more common among women for all ferritin cut-off levels, reaching a striking prevalence of 40.7% among pregnant women at a ferritin cut-off of 15 ng/mL. The elderly also presented a consistently higher prevalence of iron deficiency.

The measured prevalence of iron deficiency according to participants' characteristics is also shown in Table 2. Generally, for all ferritin cut-off levels previously defined, iron deficiency followed similar patterns to those of anaemia. Participants with BMI <18.5 or ≥40 kg/m^2 showed a higher prevalence of iron deficiency. Vegetarians were more prone to present iron deficiency in comparison to individuals with unrestricted diets.

© 2016 Royal Australasian College of Physicians

Table 2 Measured prevalence of anaemia and iron deficiency according to demographic and clinical characteristics of participants

Characteristic	Prevalence of anaemia, % (95% CI)	Prevalence of iron deficiency, % (95% CI)		
		Ferritin <15 ng/mL	Ferritin <30 ng/mL	Ferritin <50 ng/mL
Age				
18–64 years (*n* = 6267)	19.6 (18.6–20.6)	16.5 (15.6–17.4)	31.5 (30.3–32.6)	52.7 (51.5–53.9)
≥65 years (*n* = 1617)	21.0 (19.1–23.1)	17.0 (15.2–18.9)	33.5 (31.3–35.9)	55.7 (53.3–58.1)
Race/ethnicity				
Caucasian (*n* = 7661)	19.8 (18.9–20.7)	16.4 (15.6–17.3)	31.7 (30.7–32.8)	53.2 (52.1–54.3)
Black (*n* = 195)	22.6 (17.1–28.8)	21.5 (16.2–27.7)	38.5 (31.8–45.4)	57.4 (50.4–64.2)
Indian (*n* = 17)	23.5 (8.0–47.5)	23.5 (8.0–47.5)	35.3 (15.7–59.5)	64.7 (40.5–84.3)
Asian (*n* = 17)	23.5 (8.0–47.5)	17.7 (4.7–40.9)	23.5 (8.0–47.5)	58.8 (35.0–79.9)
Body mass index (kg/m^2)				
<18.5 (*n* = 90)	30.0 (21.2–40.1)	24.4 (16.4–34.1)	60.0 (49.6–69.7)	77.8 (68.3–85.5)
18.5–24.9 (*n* = 3856)	20.4 (19.1–21.7)	20.2 (18.9–21.4)	35.1 (33.6–36.7)	56.0 (54.4–57.5)
25.0–29.9 (*n* = 3096)	18.3 (17.0–19.7)	12.5 (11.4–13.7)	26.7 (25.2–28.3)	48.3 (46.6–50.1)
30.0–39.9 (*n* = 564)	21.6 (18.4–25.2)	13.5 (10.8–16.5)	32.3 (28.5–36.2)	57.3 (53.2–61.3)
≥40 (*n* = 14)	21.4 (5.80–48.0)	14.3 (2.5–39.7)	42.9 (19.6–68.9)	64.3 (37.60–96.0)
Education				
No formal qualification (*n* = 349)	25.8 (21.4–30.6)	9.7 (7.0–13.2)	32.1 (27.4–37.1)	63.6 (58.5–68.5)
4 years of schooling (*n* = 1339)	16.6 (14.7–18.6)	15.9 (14.0–17.9)	28.4 (26.0–30.8)	51.2 (48.6–53.9)
6 years of schooling (*n* = 648)	14.7 (12.1–17.5)	9.3 (7.2–11.7)	20.4 (17.4–23.6)	44.0 (40.2–47.8)
9 years of schooling (*n* = 1264)	15.3 (13.4–17.3)	11.8 (10.1–13.7)	23.4 (21.1–25.8)	46.2 (43.5–49.0)
12 years of schooling (*n* = 2654)	23.5 (21.9–25.2)	19.9 (18.4–21.5)	38.2 (36.3–40.0)	57.1 (55.2–59.0)
College degree (*n* = 1466)	19.9 (17.9–22.0)	19.4 (17.4–21.5)	35.5 (33.1–38.0)	56.2 (53.7–58.7)
Diet				
Unrestricted (*n* = 7689)	19.7 (18.8–20.6)	16.2 (15.4–17.1)	31.3 (30.3–32.4)	52.8 (51.7–53.9)
Ovolactovegetarian (*n* = 10)	30.0 (8.3–62.0)	40.0 (14.2–70.9)	60.0 (29.1–85.8)	70.0 (38.0–91.7)
Vegetarian (*n* = 189)	26.5 (20.5–33.1)	29.1 (23.0–35.9)	51.3 (44.2–58.4)	73.0 (66.4–79.0)
Vegan (*n* = 2)	50.0 (2.5–97.5)	0.0 (0.0–77.64)	50.0 (2.5–97.5)	100 (22.4–100.0)

Table 3 Measured prevalence of iron deficiency in the study population

Population groups	Prevalence of iron deficiency, % (95% CI)		
	Ferritin <15 ng/mL	Ferritin <30 ng/mL	Ferritin <50 ng/mL
Total population (*n* = 7890)	16.7 (15.7–17.4)	31.9 (30.8–32.9)	53.3 (52.2–54.4)
Men (*n* = 3731)	12.9 (11.9–14.0)	25.1 (23.8–26.6)	41.7 (40.1–43.2)
Women (*n* = 4159)	19.8 (18.7–21.1)	37.9 (36.4–39.4)	63.8 (62.3–65.2)
Pregnant women (*n* = 59)	40.7 (28.7–53.5)	62.7 (49.9–74.3)	83.1 (71.9–91.1)
Non-pregnant fertile women (*n* = 2445)	20.0 (18.4–21.6)	38.0 (36.1–40.0)	64.4 (62.5–66.3)
Elderly ≥65 years old (*n* = 1617)	17.0 (15.2–18.9)	33.5 (31.3–35.9)	55.7 (53.3–58.1)

Prevalence of iron deficiency anaemia

The prevalence of anaemia attributable to iron deficiency identified in this study (i.e. participants with both anaemia and iron deficiency) is considerably high for all ferritin cut-off levels. The overall estimated prevalence of iron deficiency anaemia was 5.8% (95% CI: 5.3–6.3%) for ferritin <15 ng/mL, 10.9% (95% CI: 10.3–11.6%) for ferritin <30 ng/mL, 15.0% (95% CI: 14.2–15.8%) for ferritin <50 ng/mL and 18.4% (95% CI: 17.40–19.4%) for ferritin <100 ng/mL.

Table 4 shows the measured prevalence of iron deficiency anaemia in specific groups of the study population. For all ferritin levels, women presented a higher prevalence of iron deficiency anaemia; pregnant women presented a remarkably high prevalence of iron deficiency anaemia, with all anaemic pregnant women in the study presenting ferritin <100 ng/mL. It is also noteworthy that iron deficiency anaemia was not particularly prevalent among the elderly in contrast to anaemia and iron deficiency alone.

Iron deficiency anaemia varied between the different regions of the country (as depicted in Figure 2B–D) and in this case, followed somewhat different patterns than all-cause anaemia. In the Center and South regions, the

© 2016 Royal Australasian College of Physicians

Table 4 Measured prevalence of iron deficiency anaemia in the study population

Population groups	Prevalence of iron deficiency anaemia, % (95% CI)		
	Ferritin <15 ng/mL	Ferritin <30 ng/mL	Ferritin <50 ng/mL
Total population (*n* = 7890)	5.8 (5.3–6.3)	10.9 (10.3–11.6)	15.0 (14.2–15.8)
Men (*n* = 3731)	5.1 (4.4–5.8)	9.4 (8.5–10.9)	13.4 (12.3–14.5)
Women (*n* = 4159)	6.4 (5.7–7.2)	12.3 (11.3–13.3)	16.4 (15.3–17.6)
Pregnant women (*n* = 59)	27.1 (17.0–39.5)	40.7 (28.7–53.5)	49.2 (36.6–61.8)
Non-pregnant fertile women (*n* = 2445)	6.7 (5.7–7.7)	12.4 (11.1–13.7)	16.7 (15.3–18.3)
Elderly ≥65 years old (*n* = 1617)	5.4 (4.4–6.6)	10.6 (9.2–12.2)	14.9 (13.2–16.7)

extent of anaemia explained by iron deficiency is considerably lower than in other regions.

Overall, 29.0% of anaemic participants had ferritin <15 ng/mL, 54.8% had ferritin <30 ng/mL, 75.4% had ferritin <50 ng/mL and 92.5% had <100 ng/mL.

Discussion

Anaemia is highly prevalent in the adult Portuguese population. About a fifth of the population is afflicted by the condition, but 84% of those affected do not have a diagnosis of anaemia and therefore are left untreated. Iron deficiency anaemia accounts for a major proportion of anaemia cases, which, depending on the ferritin cut-off used, can range from 29.0% to 92.5% of all anaemia cases.

The estimates for the prevalence of anaemia from our study (19.9%) are above WHO estimates for Portugal (15.0%).[1] The WHO estimates were based on a regression model developed using prevalence data from other countries and the classification on the United Nations Human Development Index. According to these regression-based estimates, anaemia in Portugal was classified as a 'mild public health problem' for all population groups (prevalence from 5.0% to 19.9%).[1] However, according to the results of our study, a measured prevalence of anaemia of 19.9% and an 'actual' prevalence of 20.6% is, in fact, already classified as a 'moderate public health problem' (prevalence from 20.0% to 39.9%). For pregnant women (53.8%), it is even considered a 'severe public health problem' (prevalence ≥40.0%). The prevalence of anaemia estimated in this study is also higher than WHO estimates for southern European countries with similar socioeconomic development, such as Spain, Italy or Greece. Nevertheless, for these countries, there are no prevalence data; estimates are all regression-based, and therefore, a similar underestimating phenomenon might be present.

In this study, iron deficiency was also found to be highly prevalent. At a widely accepted ferritin cut-off of 15 ng/mL,[36] about a sixth of the population was affected by iron deficiency. Considering that ferritin <30 ng/mL[25,38,40] and even <50 ng/mL can already indicate some degree of iron depletion,[37,38] about half the population might be currently affected by this 'silent' condition. These results are somewhat in line with studies from other European countries. However, remarkably, the patterns of prevalence measured in this study were similar to those usually observed in northern Europe.[20] In fact, iron deficiency was higher than what would generally be expected for a southern European country.

The differences observed between the regions of the country might be due to the socioeconomic characteristics of each region but are most probably associated with nutritional differences. In a population-based nutritional survey conducted in Portugal,[41] more residents in the North and Center regions reported maintaining a healthy diet. Unpublished data from this study also show an increased consumption of meat, fish and dairy products in these regions. This may help explain the regional differences observed.

Some groups were more prone to have anaemia and iron deficiency, namely, lower weight participants and participants following restricted diets, probably due to poor dietary iron intake. Participants with no formal qualifications and 12 years of schooling also had a higher prevalence of anaemia and iron deficiency, but the results cannot be dissociated from age and gender distributions in these groups; most individuals with no formal qualifications are aged ≥65 years, whereas among participants with 12 years of schooling, there is a remarkably high proportion (approximately one third) of young women. Black participants showed higher prevalence of anaemia, as would be expected from epidemiological data. However, the difference to Caucasian participants is small compared to other studies due to the overall higher prevalence of anaemia in the Caucasian population identified in this study.[42]

This study had some limitations. First, as with all population surveys, it depends on the individuals who are willing to participate. Still, the acceptance rate was fairly high (75%), and the demographic characteristics of the study population closely followed the estimates obtained in the 2011 Portuguese census, with an exception of a trend for

© 2016 Royal Australasian College of Physicians

under-representation of individuals with less years of schooling in the study, which would be expected for a epidemiological study with this type of methodology.[33] Second, although the main study outcomes are related to objective measurements based on blood biomarkers, the study also included a questionnaire, which might be subject to recall bias. Third, the study was designed to be conducted in the adult population; children were not included (mainly) due to ethical issues, but given the known relevance of anaemia and iron deficiency in this population group, further clarification is warranted.

Nevertheless, this study demonstrates that there is a public health issue that needs to be addressed. Nationwide strategies for the prevention, diagnosis and treatment of these conditions need to be implemented, and proper resource allocation is warranted. These strategies should be targeted for at-risk population groups (women, particularly pregnant women; young adults and the elderly) and should also consider the regional asymmetries observed. Given the relevance of iron deficiency for the Portuguese population confirmed by this study, nutrition education should have a crucial role among the implemented strategies. Special consideration should be given to pregnant women, who, according to these results, are at a high risk to develop these conditions. As iron supplementation is only started during the second trimester in Portugal, early intervention approaches must be considered. Given the benefits of iron supplementation in pregnancy,[43] other European countries, such as the United Kingdom, have already adopted iron supplementation throughout the entire pregnancy for women with ferritin <30 ng/mL or at a high risk of developing iron deficiency.[44] Such an early intervention approach might be warranted among pregnant Portuguese women.

Conclusion

Both anaemia and iron deficiency are relevant public health problems in Portugal. Women, young adults and older individuals are more prone to present these conditions, and there are some interesting regional asymmetries that call for targeted intervention. Nationwide strategies for the prevention, diagnosis and treatment of these conditions will have to be implemented to target this public health problem.

References

1 World Health Organization. *Worldwide Prevalence of Anemia 1993–2005*. Geneva, Switzerland: WHO Global Database on Anaemia; 2008.

2 Bailey RA, Reardon G, Wasserman MR, McKenzie RS, Hord RS. Association of anemia with worsened activities of daily living and health-related quality of life scores derived from the minimum data set in long-term care residents. *Health Qual Life Outcomes* 2012; **10**: 129.

3 Cella D. Factors influencing quality of life in cancer patients: anemia and fatigue. *Semin Oncol* 1998; **25**: 43–6.

4 Cella D. The effects of anemia and anemia treatment on the quality of life of people with cancer. *Oncology (Williston Park)* 2002; **16**: 125–32.

5 Gregory N. Effect of higher hemoglobin levels on health-related quality of life parameters. *Nephrol Nurs J* 2003; **30**: 75–8.

6 Kraai IH, Luttik ML, Johansson P, De Jong RM, Van Veldhuisen DJ, Hillege HL *et al.* Health-related quality of life and anemia in hospitalized patients with heart failure. *Int J Cardiol* 2012; **161**: 151–5.

7 Sabbatini P. The relationship between anemia and quality of life in cancer patients. *Oncologist* 2000; **5**: 19–23.

8 Valderrabano F. Quality of life benefits of early anaemia treatment. *Nephrol Dial Transplant* 2000; **15**(Suppl 3): 23–8.

9 Villalpando S, Shamah-Levy T, Ramirez-Silva CI, Mejia-Rodriguez F, Rivera JA. Prevalence of anemia in children 1 to 12 years of age. Results from a nationwide probabilistic survey in Mexico. *Salud Publica Mex* 2003; **45** (Suppl 4): S490–8.

10 Bentley ME, Griffiths PL. The burden of anemia among women in India. *Eur J Clin Nutr* 2003; **57**: 52–60.

11 Kalaivani K. Prevalence & consequences of anaemia in pregnancy. *Indian J Med Res* 2009; **130**: 627–33.

12 Cornet M, Le Hesran JY, Fievet N, Cot M, Personne P, Gounoue R *et al.* Prevalence of and risk factors for anemia in young children in southern Cameroon. *Am J Trop Med Hyg* 1998; **58**: 606–11.

13 Balarajan Y, Ramakrishnan U, Ozaltin E, Shankar AH, Subramanian SV. Anaemia in low-income and middle-income countries. *Lancet* 2011; **378**: 2123–35.

14 Milman N. Anemia--still a major health problem in many parts of the world!. *Ann Hematol* 2011; **90**: 369–77.

15 Carmel R. Nutritional anemias and the elderly. *Semin Hematol* 2008; **45**: 225–34.

16 Steinberg MH. Genetic etiologies for phenotypic diversity in sickle cell anemia. *Scientific World Journal* 2009; **9**: 46–67.

17 Davis SL, Littlewood TJ. The investigation and treatment of secondary anaemia. *Blood Rev* 2012; **26**: 65–71.

18 Weiss G, Goodnough LT. Anemia of chronic disease. *N Engl J Med* 2005; **352**: 1011–23.

19 World Health Organization. *Iron deficiency anaemia: assessment, prevention and control. A guide for programme managers*. Geneva, Switzerland: World Health Organization; 2001.

20 Hercberg S, Preziosi P, Galan P. Iron deficiency in Europe. *Public Health Nutr* 2001; **4**: 537–45.

21 Johnson-Wimbley TD, Graham DY. Diagnosis and management of iron deficiency anemia in the 21st century. *Therap Adv Gastroenterol* 2011; **4**: 177–84.

22 Hallberg L. Results of surveys to assess iron status in Europe. *Nutr Rev* 1995; **53**: 314–22.

© 2016 Royal Australasian College of Physicians

23 Lahti-Koski M, Valsta LM, Alfthan G, Tapanainen H, Aro A. Iron status of adults in the capital area of Finland. *Eur J Nutr* 2003; **42**: 287–92.
24 Milman N, Clausen JO, Jordal R. Iron status in young Danish men and women: a population survey comprising 548 individuals. *Ann Hematol* 1995; **70**: 215–21.
25 Aspuru K, Villa C, Bermejo F, Herrero P, Lopez SG. Optimal management of iron deficiency anemia due to poor dietary intake. *Int J Gen Med* 2011; **4**: 741–50.
26 Tolentino K, Friedman JF. An update on anemia in less developed countries. *Am J Trop Med Hyg* 2007; **77**: 44–51.
27 Centers for Disease C, Prevention. Iron deficiency--United States, 1999–2000. *MMWR Morb Mortal Wkly Rep* 2002; **51**: 897–9.
28 Armstrong PL. Iron deficiency in adolescents. *BMJ* 1989; **298**: 499.
29 Hallberg L, Hulten L, Lindstedt G, Lundberg PA, Mark A, Purens J *et al.* Prevalence of iron deficiency in Swedish adolescents. *Pediatr Res* 1993; **34**: 680–7.
30 Milman N, Ulrik CS, Graudal N, Jordal R. Iron status in young Danes. Evaluation by serum ferritin and haemoglobin in a population survey of 634 individuals aged 14–23 yr. *Eur J Haematol* 1997; **58**: 160–6.
31 Eskeland B, Hunskaar S. Anaemia and iron deficiency screening in adolescence: a pilot study of iron stores and haemoglobin response to iron treatment in a population of 14-15-year-olds in Norway. *Acta Paediatr* 1999; **88**: 815–21.
32 Hoffmeyer-Zlotnik JHP. New sampling designs and the quality of data. *Dev Appl Stat* 2003; **19**: 205–17.
33 Instituto Nacional de Estatística. *Censos 2011 Resultados Definitivos*. Lisbon, Portugal: Instituto Nacional de Estatística; 2012.
34 Jankowska EA, Rozentryt P, Witkowska A, Nowak J, Hartmann O, Ponikowska B *et al.* Iron deficiency: an ominous sign in patients with systolic chronic heart failure. *Eur Heart J* 2010; **31**: 1872–80.
35 Anker SD, Comin Colet J, Filippatos G, Willenheimer R, Dickstein K, Drexler H *et al*. Ferric carboxymaltose in patients with heart failure and iron deficiency. *N Engl J Med* 2009; **361**: 2436–48.
36 World Health Organization. *Serum Ferritin Concentrations for the Assessment of Iron Status and Iron Deficiency in Populations*. Geneva, Switzerland: Vitamin and Mineral Nutrition Information System; 2011.
37 Koulaouzidis A, Cottier R, Bhat S, Said E, Linaker BD, Saeed AA. A ferritin level >50 microg/L is frequently consistent with iron deficiency. *Eur J Intern Med* 2009; **20**: 168–70.
38 Suominen P, Punnonen K, Rajamaki A, Irjala K. Serum transferrin receptor and transferrin receptor-ferritin index identify healthy subjects with subclinical iron deficits. *Blood* 1998; **92**: 2934–9.
39 Sullivan KM, Dean A, Soe MM. OpenEpi: a web-based epidemiologic and statistical calculator for public health. *Public Health Rep* 2009; **124**: 471–4.
40 van den Broek NR, Letsky EA, White SA, Shenkin A. Iron status in pregnant women: which measurements are valid? *Br J Haematol* 1998; **103**: 817–24.
41 Poínhos R, Franchini B, Afonso C, Correia F, Teixeira V, Moreira P *et al*. Alimentação e estilos de vida da população portuguesa: metodologia e resultados preliminares. *Alimentação Humana* 2009; **15**: 43–60.
42 Zakai NA, McClure LA, Prineas R, Howard G, McClellan W, Holmes CE *et al.* Correlates of anemia in American blacks and whites: the REGARDS Renal Ancillary Study. *Am J Epidemiol* 2009; **169**: 355–64.
43 Haider BA, Olofin I, Wang M, Spiegelman D, Ezzati M, Fawzi WW *et al.* Anaemia, prenatal iron use, and risk of adverse pregnancy outcomes: systematic review and meta-analysis. *BMJ* 2013; **346**: f3443.
44 Pavord S, Myers B, Robinson S, Allard S, Strong J, Oppenheimer C *et al*. UK guidelines on the management of iron deficiency in pregnancy. *Br J Haematol* 2012; **156**: 588–600.

© 2016 Royal Australasian College of Physicians