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衞生防護中心
Centre for Health Protection

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Department of Health

Thematic Report on Iron Status

Population Health Survey 2020–22

Thematic Report on Iron Status

(Population Health Survey 2020-22)

Non-Communicable Disease Branch
Centre for Health Protection
Department of Health

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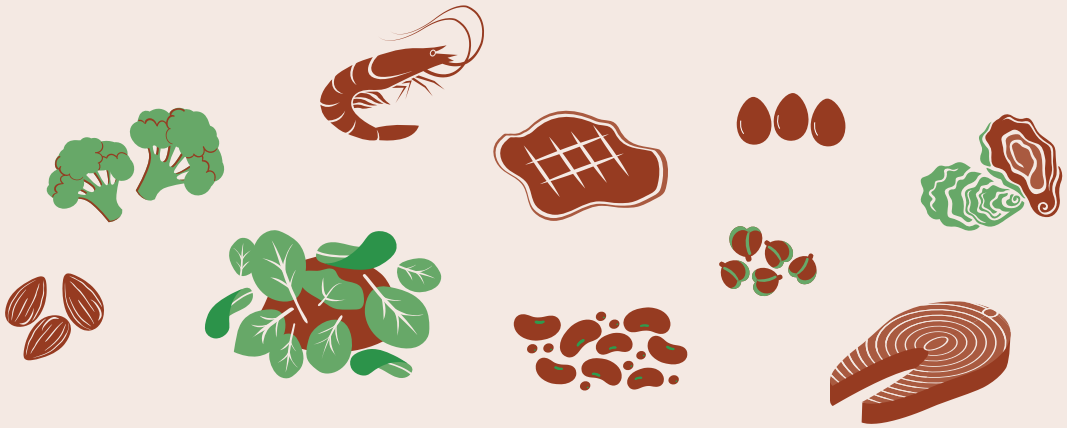
EXECUTIVE SUMMARY



Iron is vital for oxygen transport and cellular functions of human body. Inadequate iron intake or excess iron loss, for instance, menstruation in female, can lead to iron deficiency (ID). Prolonged deficiency may result in iron deficiency anaemia (IDA), causing fatigue and reduced exercise tolerance in adults and cognitive impairments in children. IDA in early pregnancy is associated with increased risks of preterm labour, low birthweight, and infant mortality.

Preventing ID requires sufficient intake of iron to replenish iron loss. Iron requirements vary by age and gender. Vulnerable groups such as children and women of reproductive age, who are menstruating, pregnant or lactating, need higher amounts of iron.

In light of a paucity of large-scale local population data on the iron status, assessment of the iron status of the Hong Kong was conducted as part of the Population Health Survey (PHS) 2020–22.

The Study

The fieldwork of PHS 2020–22 comprised two parts, namely (I) household survey; and (II) health examination. The fieldwork of the household survey was conducted between 2 November 2020 and 2 January 2022, with temporary suspension between 2 December 2020 and 22 February 2021 due to COVID-19 pandemic. It covered the land-based non-institutional population aged 15 or above in Hong Kong, excluding foreign domestic helpers and visitors. Health examination was conducted between 1 March 2021 and 19 February 2022. Age-gender stratified random subsample of respondents aged between 15 and 84, who were successfully enumerated in the household survey and had signed consent for health examination, were further invited to undergo health examination. A total of 16 655 individuals aged 15 or above were enumerated in the household interview (overall response rate: 73.3% at household level), 3 757 respondents out of 6 373 consented respondents were randomly selected and invited to make appointment for health examination, including 2 072 respondents who completed blood tests on iron status. These represented a participation rate of 55.2%. The survey data were adjusted for the differential participation rates by type of housing and grossed up to control for the age and gender profile of the study population for the second quarter (Q2) of 2021. Survey reports of PHS 2020–22 were released in batches from December 2022. The details of survey method and characteristics of the sample could be referred to Chapter 1 of the Part I Report.

Blood samples of the 2 072 respondents were tested for biochemical indicators of iron status and anaemia including serum ferritin (SF), soluble serum transferrin receptor (sTfR), serum iron and unsaturated iron-binding capacity (UIBC), C-reactive protein (CRP), haemoglobin (Hb) and mean corpuscular volume (MCV). Based on recommendations of the World Health Organization (WHO), SF is adopted as the indicator in PHS to assess prevalence of ID in local population, and a cut-off of <15 µg/L was used for apparently healthy individuals among adolescents and adults. For individuals with inflammation or infection (defined by CRP >5 mg/L), different adjustment methods were applied including 1) Excluding individuals with inflammation or infection; 2) Using a higher modified cut-off of SF <70 µg/L for those with inflammation or infection; and 3) Using a regression correction of SF level for individuals with inflammation or infection. In addition, sTfR was also used as an additional indicator to assess iron deficiency prevalence based on WHO's recommendations. Anaemia is defined as haemoglobin (Hb) levels <12.0 g/dL in women and <13.0 g/dL in men as recommended by the WHO. IDA was defined as individuals who were found to have both anaemia and ID. Prevalence of ID was analysed and interpreted according to WHO's interpretations of ID population prevalence:

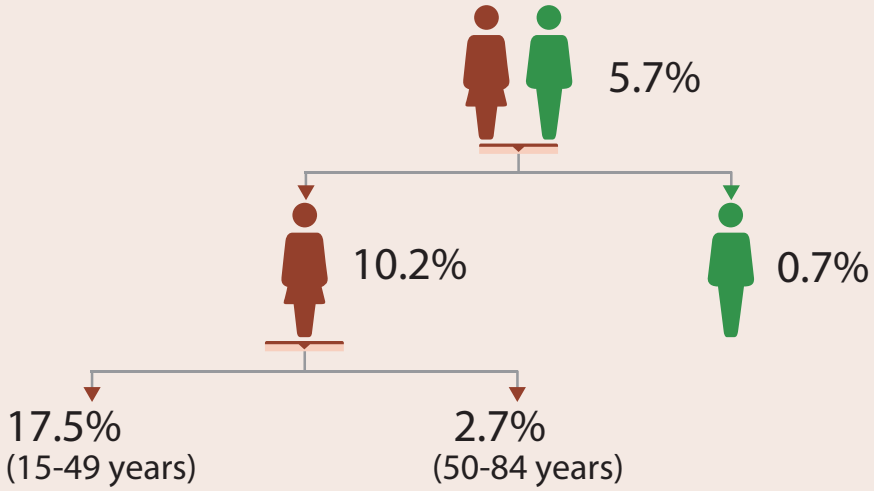
Table I: WHO's population prevalence ranges to define the magnitude of iron deficiency as a public health problem using ferritin concentration

Magnitude of the public health problem	Prevalence range (%)
High	≥ 40.0
Moderate	20.0–39.9
Mild	5.0–19.9
No public health problem	≤ 4.9

Source: WHO guideline on use of ferritin concentrations to assess iron status in individuals and populations (2020)

Key Findings

Among persons aged 15–84 (excluding those with inflammation or infection), the local prevalence of ID based on SF concentration was 5.7%. Remarkable difference in prevalence of ID between men (0.7%) and women of the reproductive age (aged 15–49) (17.5%) was observed while the prevalence of ID among women after menopausal (aged 50–84) remained low at 2.7%. The proportion of persons with raised CRP (higher than 5mg/L) was only 5.2% (95% CI [4.3%, 6.3%]) overall which indicated that the presence of infection or inflammation in local population was not a prevalent condition. The prevalence of ID estimated by using SF with different methods of adjustment and using sTfR were consistently found to be highest among women of reproductive age. Likewise, a remarkable difference in prevalence of adjusted IDA between men (0.3%) and women of reproductive age (10.6%) was found.



Approximately 1 in every 6 women aged 15–49 having ID

Conclusion of Findings

According to the WHO guidelines on use of ferritin concentrations to assess iron status published in 2020, the problem of ID in local adult population including women of reproductive age was in the range of "mild magnitude of public health problem" (5.0–19.9%), indicating universal iron supplementation is not necessary for the local population. The local findings of higher prevalence of ID and IDA among women of reproductive age are similar to that of relevant overseas studies in high income countries; and are likely due to their regular and heavy menstrual blood loss. Currently, there is no strong evidence in supporting population-based ID screening. Among high-income overseas countries with a comparable ID prevalence to Hong Kong, their strategy to prevent ID is comprehensive food strategy that suits their local situation. Taking these factors into consideration, public health measures on maintaining adequate iron intake in local population, in particularly to target reproductive-age females, are recommended.

Recommendations

The Working Group on Prevention of Iron Deficiency which has been set up by the Department of Health (DH) with representatives from the Centre for Food Safety (CFS), Food and Environmental Hygiene Department (FEHD), the Hospital Authority, the Hong Kong College of Community Medicine, the Hong Kong College of Family Physicians, the Hong Kong College of Obstetricians and Gynaecologists, the Hong Kong College of Pathologists, the Hong Kong College of Physicians, and the Hong Kong Red Cross Blood Transfusion Service, has reviewed the key findings of this study and the latest scientific evidence, and made the following recommendations on iron intake for members of public particularly for women of reproductive age:

In general, adequate iron intake can be achieved by a healthy balanced diet with iron-rich food. Women of reproductive age have a higher risk of iron loss during menstruation and hence a higher daily requirement for iron. They should pay particular attention to their diet to ensure adequate iron intake.

Consume iron-rich food

— Eat a moderate amount of meat, fish and seafood. Animal-based iron-rich food contains haem iron which can be absorbed easily.

— Eat more dark green vegetables and beans. Plant-based iron-rich food contains non-haem iron which is less readily absorbable and its absorption is affected by other foods and drinks in the diet.

— Iron-fortified cereals are also good sources of iron.

Consume adequate fruit and vegetables

— Consume vitamin C-rich fruit and vegetables to enhance absorption of iron from plant sources.

Reduce tea or coffee with meals

— Try to avoid drinking tea or coffee within 1 to 2 hours after meals as they can reduce iron absorption. Plain water or water added with lemon is a better choice as a beverage for meals.

Additional measures for those at higher risk of iron deficiency

— People at risk of iron deficiency (including women of reproductive age with heavy menstrual periods, pregnant women, persons on restrictive diets, persons with gastrointestinal disorders and/or having previous gastrointestinal surgery, frequent blood donors, etc.) may seek healthcare professionals' advice on management of their health conditions and their individual needs for taking iron supplement. Please note: iron supplement with too much iron can be harmful.

The joint recommendation will be promulgated to members of the public via various channels and shared with relevant stakeholders and healthcare professionals in Hong Kong. The DH will also conduct regular surveys to collect information on iron status among local population.

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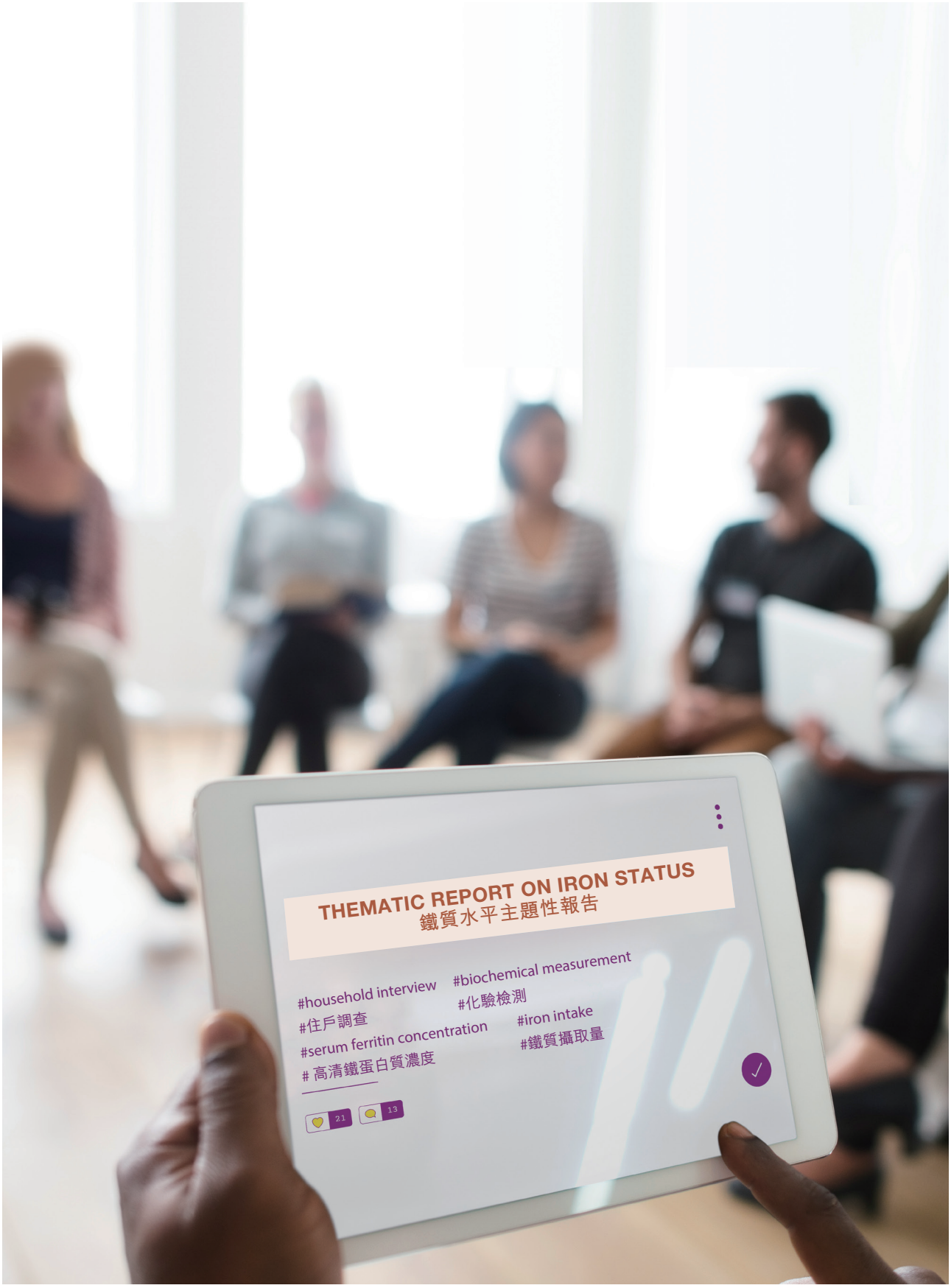
CHAPTER 1: INTRODUCTION



1.1 Background

Iron is an essential micronutrient for oxygen transport, DNA metabolism, and mitochondrial functions (i.e. generate the energy to power cells)[1]. While the majority of iron required by the human body is recycled from senescent red blood cells (RBC), approximately 1–2 milligrams of iron is lost daily through desquamation, with level varies during menstruation among women[2]. Iron deficiency (ID) occurs when body iron stores are inadequate to meet the needs for metabolism. Iron deficiency may be caused by inadequate iron intake or excess iron loss. Inadequate iron intake may result from diet with inadequate iron or impaired absorption due to gastrointestinal disorders, a history of gastrointestinal surgery or inflammation. The most common cause of excess iron loss is blood loss due to heavy menstrual bleeding among women of reproductive age, while blood loss may also be caused by other health problems such as gastrointestinal lesions. The requirements of iron increase for supporting growth and development during early childhood, adolescence and maternal and foetal growth during pregnancy. Progressive ID can eventually result in iron deficiency anaemia (IDA). The typical presentation of IDA in adults include fatigue and reduced exercise tolerance. Among children, IDA can impair cognition and motor activity and increase susceptibility to infections. IDA in early pregnancy is associated with higher risk of preterm labour, low birthweight and infant mortality. ID, even in the absence of anaemia, might be associated with symptoms such as fatigue, impaired physical performance, and suboptimal brain development[3].

To replace the iron loss and prevent ID, adequate dietary intake of iron is crucial. Dietary iron exists in two forms, namely haem and non-haem. Haem iron, the more bioavailable form, is abundant in animal-based food, while non-haem iron is found in plant-based food[2]. The daily iron requirement varies according to sex and age. Women of reproductive age, especially those who are pregnant or lactating, require more iron than men and postmenopausal women. Children and adolescents also need more iron than adults. The daily iron requirements for different groups are summarised in the table below[4]. (Table II)

Table II: Daily iron requirements for different age/stage and gender groups

Age/Stage	Male	Female
15–17 years old	16 mg	18 mg
18–49 years old	12 mg	18 mg
50 years old and older	12 mg	Pre-menopausal: 18 mg Post-menopausal: 10 mg
Pregnant women at 1st trimester	—	18 mg
Pregnant women at 2nd trimester	—	25 mg
Pregnant women at 3rd trimester	—	29 mg
Lactating mothers	—	24 mg

Source: Chinese Nutrition Society (2023)

Globally, ID is one of the commonest nutritional deficiencies, affecting 2 billion individuals worldwide, with dietary iron deficiency the leading cause of anaemia[5,6]. In 2021, the global prevalence of anaemia across all ages was 24.3%, corresponding to 1.92 billion cases. Males had a lower prevalence than females, and the differences were particularly large among persons aged 10–64. Also, large disparities in anaemia burden were noted between low-income and high-income countries, with the greatest prevalence (47.4%) in western sub-Saharan Africa and the lowest prevalence in Australasia (5.7%)[6]. The overall prevalence of ID ranged from 7.0% to 12.1% among high-income countries including the United States, Canada, the United Kingdom, Australia, and Korea[7,8,9,10,11]. The highest ID prevalence was found in women of reproductive age, which extended between 10.6% and 31.1%[7,8,11,12].

In the past, no large-scale study was conducted to assess the iron status of the local population. In 2012, a study of around 200 young adult blood donors in Hong Kong found low serum ferritin (SF) levels (<10 µg/L) in 7.2% of female donors[13]. A local study conducted in 2020–21 found that the overall prevalence of ID (defined by SF level <15 µg/L) among school-aged adolescents aged 16–20 was 11.1%. While neither ID nor IDA were found among male adolescents, the prevalence of ID and IDA among female adolescents was 17.1% and 10.9% respectively[14].

As part of the PHS 2020–22 targeting land-based non-institutional population aged 15–84 in Hong Kong, excluding foreign domestic helpers and visitors, assessment of iron status was conducted by the DH.

CHAPTER 2: SURVEY METHOD

2.1 Survey Method

The fieldwork of PHS 2020–22 comprised two parts, namely (I) household survey; and (II) health examination, including physical measurements and biochemical testing with indicators for assessing iron status. The DH commissioned a private research firm and a private healthcare organisation with laboratory service to conduct the fieldworks of household survey and health examination respectively. Data analysis and reporting of the PHS 2020–22 were commissioned to the Jockey Club School of Public Health and Primary Care, the Chinese University of Hong Kong. The DH was responsible for the overall planning of the survey including the study design and development of questionnaire as well as monitoring the quality of various parts of the survey.

2.1.1 Target Population Coverage

The household survey covered the land-based non-institutional population aged 15 or above in Hong Kong, excluding foreign domestic helpers and visitors of Hong Kong. The health examination covered persons aged between 15 and 84 (both ages inclusive) who had been enumerated in the household survey.

2.1.2 Sampling Frame and Sample Selection

The survey adopted the Frame of Quarters maintained by the Census and Statistics Department (C&SD) as the sampling frame. The Frame of Quarters consists of the Register of Quarters (RQ) and the Register of Segments (RS) which contain records of all addresses of permanent quarters in built-up areas and records of area segments in non-built-up areas respectively. Systematic replicated sampling was deployed for selecting a sample of replicates of living quarters in built-up areas from the RQ and a sample of area segments in non-built-up areas from the RS. Each replicate of living quarters is a representative sample of domestic households in Hong Kong.

2.1.3 Participants of Health Examination

All domestic households in the selected living quarters and all members aged 15 or above, excluding foreign domestic helpers and visitors, were enumerated individually. All enumerated persons aged between 15 and 84 were invited to sign consent for health examination. For respondents under 18 years of age, their consents were signed by parents or guardians. Based on age-sex stratified sampling, eligible and consented members of enumerated households, were invited to undergo a follow-up health examination.

2.1.4 Data Collection Method

Respondents who consented for health examination after completing the household interview were stratified into age and gender groups. For each group, the randomly selected respondents were contacted by telephone to make appointments at designated health examination centres. Appointment confirmation letters or SMS, a health examination pamphlet and instructions for biochemical test were sent to respondents who accepted the invitation. Another hotline was set up for enquiries and making appointments for health examination. Identities of respondents attending health examination were verified. Respondents were requested to complete a self-administered questionnaire on the day of the health examination. Blood taking for iron were performed by trained staff supervised by medical practitioner in four designated health examination centres, one each in Central, Causeway Bay, Mong Kok, and Tsuen Wan.

All laboratory reports were reviewed by registered medical laboratory technologists before passing to the DH. Medical staff of the DH further reviewed all laboratory results before sending to the respondents concerned. Health advice was provided to the respondents with results outside the reference range.

Procedures of biochemical tests followed the WHO STEPS Surveillance Manual[15]. Procedures for handling biochemical specimens followed the Safety Guidelines on Transport of Clinical Specimens and Infectious Substances for Courier Team and the relevant Infection Control Guidelines issued by the Centre for Health Protection of the DH.

2.1.5 Main Fieldwork

The fieldwork of health examination was conducted between 1 March 2021 and 19 February 2022. A total of 3 757 respondents out of 6 373 consented respondents were selected according to age-gender stratified sampling and invited to make appointment for health examination. Among these 3 757 invited respondents, 2 072 respondents completed physical measurements and blood tests (participation rate: 55.2%).

2.1.6 Biochemical Indicators and Their analyses

The biochemical tests relevant to iron status and anaemia performed in PHS 2020–22 were provided by laboratory that was accredited by the Hong Kong Accreditation Service under the Hong Kong Laboratory Accreditation Scheme (ISO 15189). Details of types of laboratory testing are as the following:

i. Serum ferritin (SF): Roche Cobas e602 system (Analytical measuring range: 0.500–2000 µg/L)

ii. Soluble serum transferrin receptor (sTfR): Roche Cobas c502 system (sTfR) assay (Analytical measuring range: 5.9–472 nmol/L)

iii. Serum iron and unsaturated iron-binding capacity (UIBC): Roche Cobas c502 system, (IRON2) assay and (UIBC) assay respectively (total iron-binding capacity (TIBC) was calculated by the formula TIBC = Serum iron + serum UIBC)

iv. C-Reactive protein (CRP): Roche Cobas c702 system (CRPL3) assay (analytical measuring range was 0.3–350 mg/L, with extended measuring range of 0.3–700 mg/L)

v. Haemoglobin (Hb): Sysmex XN-3000 automated system

vi. Mean corpuscular volume (MCV) would be reported if Hb <13.0 g/dL for male, or <12.0 g/dL for female

2.1.7 Grossing-up Method

The data collected from the study were adjusted by the differential participation rates for the three types of housing (i.e. public rental housing, subsidised sale flats and private housing), and grossed-up to control for the age and gender profile of the target population for the second quarter (Q2) of 2021. One set of statistical weights each was derived for (i) household survey and (ii) health examination. After these adjustments, the survey estimates can represent those of the study population during the survey period.

2.1.8 Statistical Analysis

The prevalence of inflammation, ID, IDA, and anaemia were presented as proportions with 95% Confidence Interval (CI). Some estimates were associated with a high (Coefficient of Variation (CV) ≥ 16.6% and < 33.3%) or extreme (CV ≥ 33.3%) sampling variability and they should be interpreted with special caution. Continuous data for SF, CRP and sTfR were highly skewed; therefore, geometric mean with 95% CIs were generated. The distribution of Hb was not deemed skewed, and the arithmetic mean with 95% CIs was reported.

2.1.9 Confidentiality

All questionnaires and data files were regarded as confidential documents, and the research team exercised due care in handling the records to avoid the leakage of information. At the beginning of the survey, all relevant staff of the private data collection firm commissioned for the survey were required to sign an undertaking not to disclose any confidential information related to the survey.

In accordance with the Personal Data (Privacy) Ordinance (Cap. 486) and the code of conduct of the research agency, all data collected from the survey were used only for research and statistical purposes. All worksheets filled with households' information would be destroyed within six months after completion of the survey.

2.1.10 Ethics Approval

The study was approved by the Ethics Committee of the DH.

CHAPTER 3: RESULTS

3.1 Demographic Characteristics

The proportion of male (47.4%) and female (52.6%) respondents were similar. 20.3% of the respondents were 55-64 years old, followed by 65-84 years old (19.8%). More than half of the respondents (51.7%) had attained secondary education level, followed by post-secondary or above (35.0%). 27.2% of the respondents had household income at $50,000 or above, followed by $20,000–$29,999 (19.9%). (Table 3.1)

Table 3.1: Demographic characteristics (weighted) among persons aged 15 to 84 participated in health examination

	%[#]
Gender	
Male	47.4%
Female	52.6%
Age Group	
15–24	9.7%
25–34	15.0%
35–44	17.0%
45–54	18.2%
55–64	20.3%
65–84	19.8%
Education level	
No schooling/Pre-primary	1.0%
Primary	12.3%
Secondary	51.7%
Post-secondary or above	35.0%
Monthly household income	
Below $5,000	5.6%
$5,000–$9,999	6.7%
$10,000–$19,999	14.6%
$20,000–$29,999	19.9%
$30,000–$39,999	14.6%
$40,000–$49,999	11.5%
$50,000 or above	27.2%
Total	100.0%

Notes: Figures may not add up to the total due to rounding.

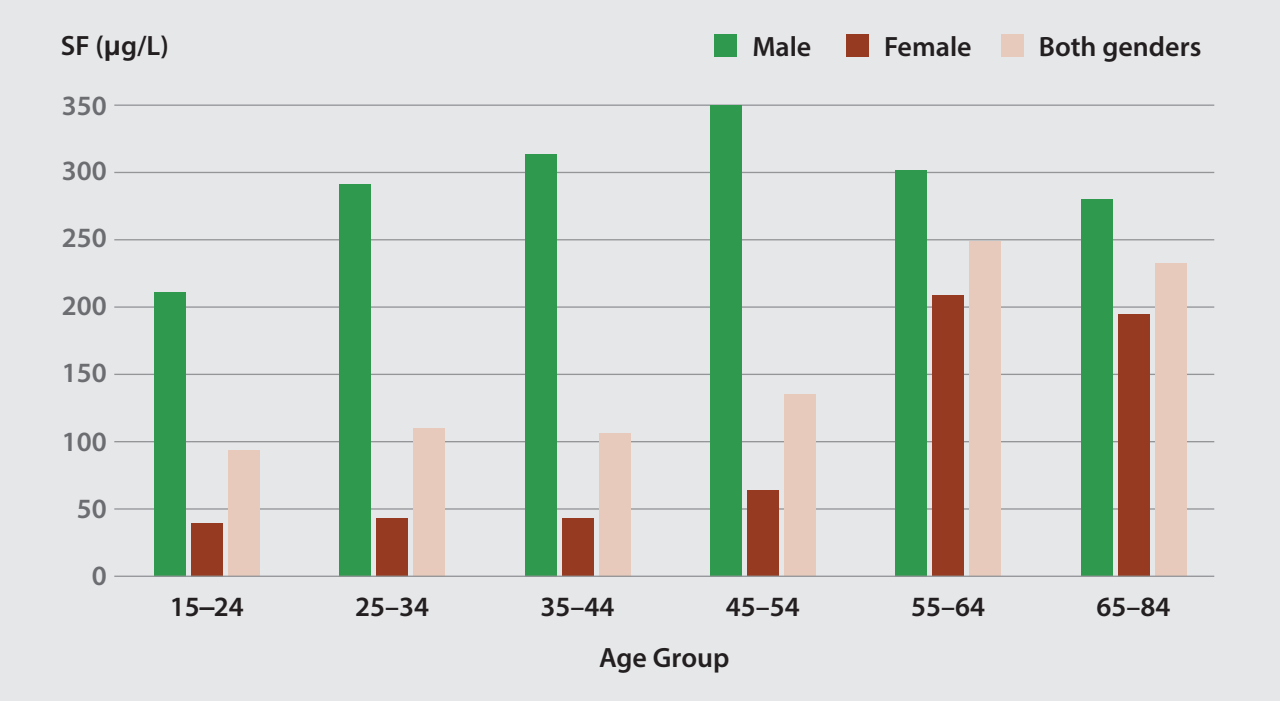
[#] It refers to weighted percentage among all participants who had participated in health examination.

3.2 Geometric Mean of Serum Ferritin (SF), Soluble Serum Transferrin Receptor (sTfR), C-reactive Protein (CRP), and Arithmetic Mean for Haemoglobin (Hb)

Among persons aged 15–84, their geometric mean level of serum ferritin (SF) was 153.0 µg/L, 95% CI [145.6, 160.5]. When analysed by age and gender group, males had higher mean SF concentrations compared to females (male: 293.9 µg/L, 95% CI [280.3, 307.4]; female: 85.0 µg/L, 95% CI [79.1, 90.9]), and the lower means of SF concentration were observed among groups of female aged 15-54. (Table 3.2)

Table 3.2: Geometric mean for SF (µg/L) by age group and gender

	Male			Female			Both genders		
Age group	Mean (µg/L)	95% CI (Lower limit)	95% CI (Upper limit)	Mean (µg/L)	95% CI (Lower limit)	95% CI (Upper limit)	Mean (µg/L)	95% CI (Lower limit)	95% CI (Upper limit)
15–24	211.2	192.7	229.8	39.7	33.2	46.2	93.4	80.5	106.3
25–34	291.5	264.9	318.2	43.3	36.6	50.0	110.0	95.8	124.3
35–44	313.7	277.9	349.5	42.8	36.6	48.9	106.4	92.9	120.0
45–54	350.3	317.9	382.7	63.6	52.9	74.3	135.1	117.7	152.6
55–64	302.0	263.9	340.0	208.6	190.9	226.3	248.7	229.8	267.5
65–84	279.8	249.0	310.6	194.8	174.0	215.6	232.3	213.7	251.0
15–84	**293.9**	**280.3**	**307.4**	**85.0**	**79.1**	**90.9**	**153.0**	**145.6**	**160.5**



The geometric mean concentration of C-reactive protein (CRP) among both genders, male and female aged 15-84 were 0.75 mg/L (95% CI [0.71, 0.80], 0.84 mg/L (95% CI [0.78, 0.90]) and 0.69 mg/L (95% CI [0.64, 0.74]) respectively, which were all far below cut off value of 5 mg/L (CRP value higher than 5 mg/L indicates the presence of inflammation or infection). When breakdown by age, the mean CRP concentration increased with increasing age and the highest mean CRP concentration (0.92 mg/L, 95% CI [0.82, 1.02]) was observed in those aged 55–64. (Annex, Table 1a)

Among persons aged 15–84, the geometric mean level of soluble serum transferrin receptor (sTfR) was 36.8 nmol/L, 95% CI [36.3, 37.3] (male: 35.3 nmol/L, 95% CI [34.7, 35.9]; female: 38.2 nmol/L, 95% CI [37.4, 39.0]). When analysed by age and gender group, the mean sTfR levels were higher among female than male and higher means were observed among groups of females aged 15–54. (Annex, Table 1b)

Among persons aged 15–84, the arithmetic mean concentration of haemoglobin (Hb) was 14.0 g/dL, 95% CI [13.9, 14.1]. When analysed by age and gender group, males had higher Hb concentration than female across all age groups (male: 15.0 g/dL, 95% CI [14.9, 15.1]; female: 13.1 g/dL, 95% CI [13.1, 13.2]), and the lowest mean Hb (12.9 g/dL) was observed among groups of female aged 45–54. (Annex, Table 1c)

3.3 Prevalence of Iron Deficiency (ID) Shown by Serum Ferritin (SF)

According to the WHO's recommendation, the threshold of SF <15 µg/L was used for apparently healthy individuals among children aged 5 or above, adolescents and adults to indicate ID[16,17]. However, as an acute phase protein, SF's concentration may be elevated during inflammation or infection. Therefore, the WHO's proposed adjustments were applied to assess the iron status in the presence of inflammation or infection. According to WHO, CRP concentration higher than 5 mg/L indicates the presence of inflammation or infection. Prevalence of ID was estimated based on SF level with adjustment for presence of inflammation or infection as reflected by CRP.

3.3.1 Prevalence of ID Shown by Low SF without Adjustment

Unadjusted prevalence of ID was estimated by SF <15 µg/L among population, regardless of inflammation or infection. The unadjusted prevalence of ID among persons aged 15-84 was 5.5%, 95% CI [4.6%, 6.5%]. Marked difference between male (0.7%, 95% CI [0.3%, 1.5%]) and female (9.8%, 95% CI [8.2%, 11.8%]) was observed. When analysed by age and gender group, ID was more prevalent among female of reproductive age (aged 15–49, 16.9%, 95% CI [14.0%, 20.3%]), while the prevalence decreased to 2.6%, 95% CI [1.5%, 4.5%] in female of 50–84 years old. (Table 3.3.1)

Table 3.3.1: Unadjusted prevalence of ID by low SF (<15 µg/L regardless of inflammation or infection) by age group and gender

	Male			Female			Both genders		
Age group	%	95% CI (Lower limit)	95% CI (Upper limit)	%	95% CI (Lower limit)	95% CI (Upper limit)	%	95% CI (Lower limit)	95% CI (Upper limit)
15–24	—	—	—	16.1%[H]	10.7%	23.4%	7.9%[H]	5.2%	11.8%
25–34	0.6%[E]	0.1%	4.0%	15.3%[H]	10.5%	21.9%	8.1%[H]	5.6%	11.7%
35–44	0.6%[E]	0.1%	4.1%	17.1%	12.3%	23.3%	9.5%	6.9%	13.1%
45–54	—	—	—	14.8%[H]	10.4%	20.6%	8.3%[H]	5.8%	11.7%
55–64	1.7%[E]	0.6%	5.2%	1.5%[E]	0.5%	4.5%	1.6%[E]	0.7%	3.5%
65–84	0.6%[E]	0.1%	4.0%	—	—	—	0.3%[E]	0.0%	2.0%
15–49				*16.9%*	*14.0%*	*20.3%*			
50–84				*2.6%[H]*	*1.5%*	*4.5%*			
15–84	**0.7%[E]**	**0.3%**	**1.5%**	**9.8%**	**8.2%**	**11.8%**	**5.5%**	**4.6%**	**6.5%**

Notes:

[H] High sampling variability (CV ≥ 16.6% and < 33.3%); estimates should be interpreted with caution.

[E] Extreme sampling variability (CV ≥ 33.3%); indicates a relatively high level of variability in relation to the central estimate or mean, which raises doubts about the reliability of the estimates and calls into question their validity.

"—" Estimates are unavailable due to absence of positive observations from the health examination.

3.3.2 Adjusted Prevalence of ID Shown by Low SF by Excluding Individuals with Inflammation or Infection

Excluding individuals with inflammation or infection (CRP >5 mg/L), and using SF <15 µg/L as cut-off for healthy individuals was adopted for estimating adjusted prevalence of ID. It was one of the adjustment approaches for assessing iron status among population as recommended by WHO[17].

Among persons aged 15–84, the proportion of persons with raised CRP (higher than 5 mg/L) was 5.2% (95% CI [4.3%, 6.3%]), which indicated that the overall presence of infection or inflammation in local population was not prevalent (male: 5.5%, 95% CI [4.2%, 7.1%]; female: 4.9%, 95% CI [3.7%, 6.6%]). (Annex, Table 2) Among persons with raised CRP, 84.0% were found to have self-reported chronic illness diagnosed by doctor or raised blood pressure / blood glucose / hypercholesterolemia found during the PHS.

By excluding individuals with inflammation or infection (CRP >5 mg/L) and using SF <15 µg/L as ID cut-off, the adjusted prevalence of ID was 5.7%, 95% CI [4.8%, 6.8%] among those aged 15-84. Similarly, marked difference between male (0.7%, 95% CI [0.3%, 1.5%]) and female (10.2%, 95% CI [8.5%, 12.3%]) was observed. When analysed by age and gender group, ID was more prevalent (17.5%, 95% CI [14.5%, 21.0%]) among female of reproductive age (aged 15 to 49), while the prevalence decreased to 2.7%, 95% CI [1.6%, 4.7%] in female 50–84 years old. (Table 3.3.2)

Table 3.3.2: Adjusted prevalence of ID by excluding individuals with inflammation or infection (CRP >5 mg/L) and using SF <15 µg/L as cut-off for healthy individuals by age group and gender

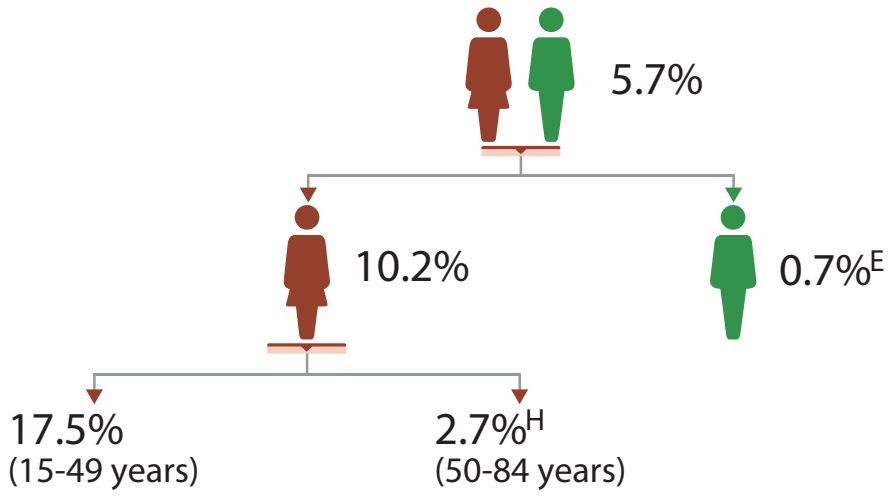
	Male			Female			Both genders		
Age group	%	95% CI (Lower limit)	95% CI (Upper limit)	%	95% CI (Lower limit)	95% CI (Upper limit)	%	95% CI (Lower limit)	95% CI (Upper limit)
15–24	—	—	—	16.4%[H]	11.0%	23.8%	8.2%[H]	5.4%	12.3%
25–34	0.6%[E]	0.1%	4.1%	16.4%[H]	11.2%	23.3%	8.5%[H]	5.8%	12.2%
35–44	0.6%[E]	0.1%	4.4%	17.4%	12.5%	23.8%	9.8%[H]	7.0%	13.5%
45–54	—	—	—	15.5%[H]	10.9%	21.5%	8.7%[H]	6.1%	12.3%
55–64	1.8%[E]	0.6%	5.4%	1.5%[E]	0.5%	4.7%	1.7%[E]	0.8%	3.6%
65–84	0.6%[E]	0.1%	4.3%	—	—	—	0.3%[E]	0.0%	2.1%
15–49				*17.5%*	*14.5%*	*21.0%*			
50–84				*2.7%[H]*	*1.6%*	*4.7%*			
15–84	**0.7%[E]**	**0.3%**	**1.5%**	**10.2%**	**8.5%**	**12.3%**	**5.7%**	**4.8%**	**6.8%**

Notes:

[H] High sampling variability (CV ≥ 16.6% and < 33.3%); estimates should be interpreted with caution.

[E] Extreme sampling variability (CV ≥ 33.3%); indicates a relatively high level of variability in relation to the central estimate or mean, which raises doubts about the reliability of the estimates and calls into question their validity.

"—" Estimates are unavailable due to absence of positive observations from the health examination.



3.3.3 Adjusted Prevalence of ID by SF Concentration with Alternative Approaches of Adjustment

Other adjustment approaches for assessing ID with concurrent infection or inflammation as recommended by WHO include[17]:

i. Adjusted prevalence of ID using SF <15 µg/L for healthy individuals and upper modified cut-off (SF <70 µg/L) for those with inflammation or infection

The adjusted prevalence of ID was 6.0%, 95% CI [5.0%, 7.1%]. Likewise, marked difference between male (0.7%, 95% CI [0.3%, 1.5%]) and female (10.8%, 95% CI [9.1%, 12.8%]) was observed. When analysed by age and gender group, ID was also more prevalent (18.1%, 95% CI [15.2%, 21.6%]) among female of reproductive age (aged 15 to 49). The prevalence decreased to 3.2%, 95% CI [2.0%, 5.3%] in female 50–84 years old. (Annex, Table 3)

ii. Adjusted prevalence of ID using SF <15 µg/L for healthy individuals and regression correction for individuals with inflammation or infection

The adjusted prevalence of ID was 5.6%, 95% CI [4.7%, 6.7%]. Similarly, marked difference between male (0.7%, 95% CI [0.3%, 1.5%]) and female (10.0%, 95% CI [8.4%, 12.0%]) was observed. When analysed by age and gender group, ID was more prevalent (17.3%, 95% CI [14.4%, 20.7%]) among female of reproductive age (aged 15 to 49). The prevalence decreased to 2.6%, 95% CI [1.5%, 4.5%] in female 50–84 years old. (Annex, Table 4)

3.4 Prevalence of ID as Indicated by Soluble Serum Transferrin Receptor (sTfR) Levels

As recommended by WHO, the level of sTfR above the cut-off value which was recommended by the manufacturer of the assay was classified as ID for the purpose of assessing ID in populations, in particularly in areas where chronic infection or inflammation is prevalent[18]. The reference range with the thresholds of sTfR >55.5 nmol/L (male) and sTfR >54.2 nmol (female) as recommended by the manufacturer of the assay were applied to define ID in this study. Prevalence of ID based on sTfR level was also estimated.

The prevalence of ID was 8.3%, 95% CI [7.1%, 9.6%]. Marked difference between male (4.7%, 95% CI [3.5%, 6.3%]) and female (11.5%, 95% CI [9.7%, 13.6%]) was again observed. With breakdown by age and gender group, ID was more prevalent (16.3%, 95% CI [13.4%, 19.7%]) among female of reproductive age (aged 15 to 49), the prevalence decreased to 6.6%, 95% CI [4.7%, 9.3%] in the female 50–84 years old. (Annex, Table 5)

3.5 Interpretations of SF and sTfR in Population Surveys

According to the WHO's latest guideline on the use of ferritin concentrations to assess iron status in individual and populations published in 2020, the prevalence of ID ranging from 5.0 to 19.9% is classified as mild magnitude of public health problem[17]. (Table III) The local prevalence of ID based on ferritin concentration was 5.7% by excluding individual with raised CRP, ranging from 5.6% to 6.0% with different adjusted approaches among the overall population aged 15–84. The prevalence of ID was consistently found to be highest among women of reproductive age (aged 15–49) at 17.5% by excluding individual with raised CRP, ranging from 17.3% to 18.1% with different adjusted approaches among the female population. The local prevalence of ID among the general population and women of reproductive age was found within the definition of mild magnitude of public health problem. On the other hand, the adjusted prevalence of ID by excluding individuals with inflammation or infection was as low as 0.7% (remained at 0.7% with different adjustment approaches for SF) and 2.7% (ranging from 2.6% to 3.2% with different adjustment approaches for SF) among male aged 15–84 and female aged 50–84 respectively which were consistently below 5% and were classified as no public health problem according to the WHO classification based on assessment of ferritin concentration.

Table III: WHO's population prevalence ranges to define the magnitude of iron deficiency as a public health problem using ferritin concentration

Magnitude of the public health problem	Prevalence range (%)
High	≥ 40.0
Moderate	20.0–39.9
Mild	5.0–19.9
No public health problem	≤ 4.9

Source: WHO guideline on use of ferritin concentrations to assess iron status in individuals and populations (2020)

According to the WHO's guideline published in 2014 on serum transferrin receptor levels for the assessment of iron status and iron deficiency, ID is interpreted as not prevalent with the percentage of SF concentrations below the threshold is less than 20% and the percentage of sTfR levels above the threshold is less than 10%[18]. (Table IV) Using SF <15 µg/L as the threshold by excluding individuals with raised CRP (CRP >5 mg/L), and the laboratory thresholds for sTfR, the overall prevalence of ID is 5.7% and 8.3% respectively. Therefore, ID is classified as not prevalent in the local population. (Annex, Table 6)

Table IV: WHO's interpretation of iron deficiency as a public health problem using percentage of serum ferritin and transferrin receptors values beyond thresholds

Percentage of serum ferritin values below threshold[a]	Percentage of transferrin receptor values above threshold[b]	Interpretation
< 20%[c]	< 10%	Iron deficiency is not prevalent
< 20%[c]	≥ 10%	Iron deficiency is prevalent; inflammation is prevalent
≥ 20%[d]	≥ 10%	Iron deficiency is prevalent
≥ 20%[d]	< 10%	Iron deficiency is prevalent

Notes:

[a] Apply threshold by age group given in WHO, UNICEF, UNU (1)

[b] Apply thresholds recommended by manufacturers of assay until an international reference standard is available.

[c] < 30% for pregnant women

[d] ≥ 30% for pregnant women

3.6 Prevalence of Anaemia

Based on the WHO's definition of anaemia (i.e. Hb <12.0 g/dL in women and <13.0 g/dL in men)[19], 9.3%, 95% CI [8.1%, 10.6%] of the local population had anaemia. Significant sex difference was observed, with 6.0%, 95% CI [4.6%, 7.7%] of male and 12.3%, 95% CI [10.4%, 14.4%] of female had anaemia respectively. When analysed by age and gender group, the prevalence of anaemia in male generally increased with age, reaching the highest (12.0%, 95% CI [7.9%, 17.7%]) in males aged 65–84. For female, the prevalence of anaemia was higher (16.8%, 95% CI [13.9%, 20.2%]) in the reproductive age group (15–49), compared to 7.6%, 95% CI [5.5%, 10.4%] among females aged 50–84. (Table 3.6)

Table 3.6: Prevalence of anaemia by age group and gender

	Male			Female			Both genders		
Age group	**%**	**95% CI (Lower limit)**	**95% CI (Upper limit)**	**%**	**95% CI (Lower limit)**	**95% CI (Upper limit)**	**%**	**95% CI (Lower limit)**	**95% CI (Upper limit)**
15–24	2.6%[E]	1.0%	6.7%	14.2%[H]	9.6%	20.5%	8.3%[H]	5.7%	11.8%
25–34	1.7%[E]	0.6%	5.2%	13.4%[H]	8.9%	19.7%	7.7%[H]	5.2%	11.2%
35–44	4.2%[E]	2.0%	8.5%	16.6%[H]	11.7%	22.9%	10.9%	8.0%	14.8%
45–54	4.6%[E]	2.3%	9.0%	18.5%	13.6%	24.8%	12.4%	9.4%	16.2%
55–64	7.4%[H]	4.3%	12.3%	3.9%[E]	2.0%	7.7%	5.6%[H]	3.7%	8.4%
65–84	12.0%[H]	7.9%	17.7%	9.1%[H]	5.5%	14.5%	10.5%	7.6%	14.2%
15–49				*16.8%*	*13.9%*	*20.2%*			
50–84				*7.6%*	*5.5%*	*10.4%*			
15–84	**6.0%**	**4.6%**	**7.7%**	**12.3%**	**10.4%**	**14.4%**	**9.3%**	**8.1%**	**10.6%**

Notes:

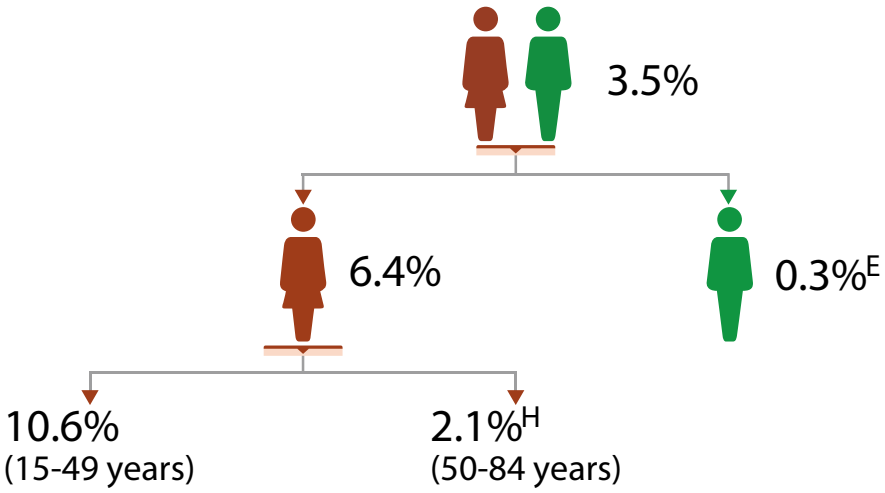
[H] High sampling variability (CV ≥ 16.6% and < 33.3%); estimates should be interpreted with caution.

[E] Extreme sampling variability (CV ≥ 33.3%); indicates a relatively high level of variability in relation to the central estimate or mean, which raises doubts about the reliability of the estimates and calls into question their validity.

3.7 Prevalence of Iron Deficiency Anaemia (IDA)

IDA was defined as individuals who were found to have both ID and anaemia. The unadjusted prevalence of ID among persons aged 15–84 was 5.5%, 95% CI [4.6%, 6.5%]. Among these individuals, 62.2% of them (male: 50.7%, female: 62.8%) were found to have IDA. The prevalence of IDA among the general population and women of reproductive age (aged 15–49) was 3.4%, 95% CI [2.7%, 4.3%] (0.3%, 95% CI [0.1%, 1.0%] in male and 6.2%, 95% CI [4.9%, 7.8%] in female) and 10.3%, 95% CI [8.0%, 13.2%] respectively. The adjusted prevalence of IDA by excluding individuals with inflammation or infection among the general population and women of reproductive age (aged 15–49) was 3.5%, 95% CI [2.8%, 4.5%] (0.3%, 95% CI [0.1%, 1.1%] in male and 6.4%, 95% CI [5.0%, 8.1%] in female) and 10.6%, 95% CI [8.2%, 13.5%] respectively. (Annex, Tables 7a, 7b, 7c and 7d)

Prevalence of IDA (excluding individuals with inflammation or infection)



3.8 Conclusion of Findings

In view of the presence of thalassaemia minor and low prevalence of inflammation or infection in the local situation, assessment of iron status based on SF concentration would be more relevant than the use of sTfR. Among the three adjustment methods for SF recommended by WHO, the method of excluding individuals with inflammation or infection is considered applicable to the local situation in view of the low prevalence of inflammation or infection, and the uncertainty of the SF cut-off values adopted for those with inflammation or infection in the other two adjustment methods. The prevalence of ID was consistently found to be highest among women of reproductive age (aged 15–49) at 17.5% by excluding individuals with raised CRP and was found within the definition of a mild magnitude of public health problem. On the other hand, adjusted prevalence of ID by excluding individuals with inflammation or infection was as low as 0.7% and 2.7% among male aged 15–84 and female aged 50-84 respectively, which were consistently below 5% and were classified as no public health problem according to the WHO classification based on assessment of ferritin concentration.

3.9 Key Findings

1. The prevalence of ID (by excluding individuals with inflammation) among girls and women of reproductive age (aged 15–49) (17.5%) was higher than males and women of post-menopausal age (aged 50–84).

2. The prevalence of ID among women after menopausal age was low at 2.7% by excluding individuals with inflammation.

3. Remarkable difference in prevalence of ID between men (0.7%) and women of the reproductive age (17.5%) was observed.

4. Remarkable difference in prevalence of IDA between men (0.3%) and women of reproductive age (10.6%) was also observed.

5. The local findings of higher prevalence of ID and IDA among women of reproductive age are similar to that of relevant overseas studies; and are likely due to their regular and heavy menstrual blood loss.

6. The local prevalence of ID among women of reproductive age is also comparable to those in high-income countries.

CHAPTER 4: DISCUSSION

4.1 Discussion

The PHS 2020–22 was the first territory-wide study on iron status in Hong Kong. The findings of this study provided valuable insights on iron status of the local population and served as a baseline for continuous monitoring and surveillance. Moreover, it offered supporting evidence to guide policies related to nutrition and healthcare in addressing iron deficiency, as well as evaluations of the relevant public health interventions in the future.

4.1.1 Prevalence of ID Using Different Adjustment Methods for SF

PHS 2020–22 adopted different adjustment methods recommended by WHO for the calculation of prevalence of ID. They include 1) Excluding individuals with inflammation of infection (defined by CRP >5 mg/L), and using SF <15 µg/L as cut-off for healthy individuals; 2) Using SF <15 µg/L as cut-off for healthy individuals, and a higher modified cut-off of SF <70 µg/L for those with inflammation or infection; and 3) Using SF <15 µg/L as cut-off for healthy individuals, and a regression correction for individuals with inflammation or infection. It is noted that the application of different adjustment approaches resulted in slight variability in estimated prevalence of ID. As only a minority of individuals was found to have raised CRP (5.2%), overall prevalence of ID only ranged from 5.5% to 6.0% (5.5% without adjustment; 5.7% with adjustment approach by excluding individual with raised CRP; 6.0% with adjustment approach by using higher cut-off value (SF <70 µg/L) among individual with raised CRP; 5.6% with adjustment approach by using regression correction among individual with raised CRP). With different adjustment approaches, the prevalence of ID was highest among women of reproductive age (aged 15 to 49) ranging from 16.9% to 18.1% (16.9% without adjustment; 17.5% with adjustment approach by excluding women with raised CRP; 18.1% with adjustment approach by using higher cut-off value among women with raised CRP; 17.3% with adjustment approach by using regression correction among individual with raised CRP). In general, findings were consistent with different approaches of adjustment.

4.1.2 Comparison of Prevalence of ID with Overseas Countries

The prevalence of ID ranged from 7.0% to 12.1% in developed countries[8,9,10,11]. In low-middle-income countries, the prevalence of ID could be as high as 41–63% in women and 13% in men, whilst IDA might be present in 20–39% of women and 4% of men[20]. For example, in India, the prevalence of ID and anaemia were 62% and 39% respectively. 95% of the women who had anaemia were suffering from iron deficiency[21]. Regarding anaemia, in general, males have a lower prevalence than females[22]. A study in the U.S. showed that the prevalence of anaemia was approximately 10% in young non-pregnant women due to losses from menstruation while the prevalence of anaemia was 1% in men under 50[22]. According to WHO, global prevalence of anaemia was 29.9% in women of reproductive age, 29.6% in non-pregnant women of reproductive age, and 36.5% in pregnant women in 2019[23].

The prevalence of ID in Hong Kong was comparable to overseas' developed countries and the higher ID prevalence among women of reproductive age in PHS 2020–22 was similar to relevant overseas' findings. The prevalence of ID in Hong Kong and some overseas countries are summarised in Table V.

Table V. ID prevalence in overseas countries in comparison to Hong Kong

		Prevalence of ID (%)		
Country/Region (year)	**Definition of ID**	**Overall age group (year)**	**Male age group (year)**	**Female age group (year)**
Hong Kong SAR, PRC (2024)	SF <15 µg/L, exclude those with inflammation	15–84: 5.7%	15–84: 0.7%	15–84: 10.2% 15–49: 17.5% 50–84: 2.7%
Canada (2022)[7]	SF <15 µg/L, exclude those with inflammation	3–79: 7.4%	3–79: 2.0%	3–79: 13.4% 14–18: 22.4% 19–50: 20.4%
US (2023)[54]	SF <15 µg/L	Not available	Not available	12–21: 17.0%
UK (2020)[9]	SF <15 µg/L	Not available	11–18: 6.0% 19–64: 1.0%	11–18: 17.0% 19–64: 15.0%
Australia (2022)[55]	SF <30 µg/L	18 or older: 19.0%*	Not available	Not available
South Korea (2014)[8]	SF <15 µg/L or Transferrin saturation <10%	10 or older: 12.1%	10 or older: 2.0%	10 or older: 22.4% 15–49: 31.4%

Note:
* Among adults with healthy weight, defined as BMI 18.5 to 25.0

4.2 Limitations

Some limitations should be noted. In particular, there are ongoing debates surrounding the optimal indicators and their cut-off values for assessing iron status in a population.

4.2.1 SF Concentration as the Indicator to Assess ID

While it is well established that neglecting to account for inflammation or infection when using SF to estimate iron status leads to underestimation, consensus has not been reached on the optimal adjustment methods for subpopulation with inflammation or infection, as they might have an impact on the magnitude of estimates; and different methods have their own strengths and limitations. The adjustment methods recommended by WHO include excluding people with evidence of inflammation or infection, adjusting for CRP and α-1 acid glycoprotein (AGP) levels using arithmetic or regression correction, and applying different cut-off values for healthy people and people with inflammation/infection[25,26]. Excluding individuals with evidence of inflammation or infection is the simplest method, but it may introduce selection bias by excluding a subgroup of the population. Applying different cut-off values for healthy individuals and those with inflammation or infection is also easy to implement given appropriate cut-off values have been accurately determined. However, the choice of cut-off values can impact the estimation of iron deficiency prevalence, potentially leading to over- or underestimation. Moreover, both methods do not consider the variability of degree of inflammation within the sample. Only by incorporating CRP and/or AGP levels using regression approach accounts for the influence of different degrees of inflammation on SF levels at individual level. The regression approach provides a more accurate estimation of iron deficiency prevalence provided that the underlying assumption of linear relationship between inflammation markers and SF levels is true. However, the regression approach requires additional measurements (CRP and AGP) which would be costly and time-consuming. On the other hand, excluding individuals with raised CRP concentration is the simplest adjustment and only resulted in a loss of 5.2% of the sample in this study.

Apart from the adjustment methods to account for the presence of inflammation or infection, there is also ongoing debate surrounding the population SF cut-offs for assessing the iron status of a population. The SF cut-off value below 15 µg/L for ID recommended by WHO was based on qualitative expert opinion and its guideline development was derived largely from the clinical literature, especially from studies examining the highest SF concentration among patients with microcytic iron deficiency anaemia who also either showed a therapeutic response to iron or iron depletion in their bone marrow[17]. In addition, selecting appropriate cut-off values for SF to indicate presence or absence of ID involves trade-offs between sensitivity and specificity. In general, the prevalence rate of ID is expected to increase if a higher cut-off value of SF is adopted for defining ID. While using SF <15 µg/L might underestimate the prevalence of ID in the local population, the potential implication from over-estimation of prevalence of ID which result in over diagnosis and treatment for asymptomatic populations who might not be able to have health benefit from treatment should also be taken into account.

Notwithstanding the above, SF is still widely accepted to be the most sensitive indicator of iron status and is a good marker of iron stores. PHS 2020–22 adopted WHO's recommended SF cut-off values which have been widely used in overseas population based surveys and cited. This can facilitate international comparison, enable us to adopt various SF adjustment approaches for infection/inflammation recommended by WHO, and consider the measures appropriate to the magnitude of ID as a public health problem classified by WHO.

4.2.2 sTfR Level as the Indicator to Assess ID

Besides SF, sTfR is another commonly used indicator of iron status in population studies and it reflects iron supply to the bone marrow. Level of sTfR reflects the intensity of erythropoiesis and demand for iron; and it rises after iron stores have been depleted[18]. sTfR has the advantage over SF as it is relatively not affected by inflammation. However, sTfR is influenced by the rate of erythropoiesis, as it is primarily produced by RBC precursors[28]. Thalassemia is a condition that result in ineffective erythropoiesis and raised sTfR level. Local study showed that prevalence of thalassaemia minor was estimated to be about 12.5% among local population[29]. Using sTfR as the indicator might lead to overestimation of prevalence of ID as compared to SF in regions, such as Hong Kong, where thalassaemia is common.

In PHS 2020–22, the use of both SF and sTfR as indicators of iron deficiency could compensate the limitations of each indicator to a certain extent, thus providing a more complete and reliable picture of ID prevalence in the local population.

4.2.3 CRP as the Indicator for Inflammation or Infection

In PHS 2020–22, only CRP was measured to reflect inflammation or infection. However, CRP alone may not capture all types of inflammation especially chronic inflammation. WHO, in its latest guideline published in 2020 and after PHS had been designed, recommends the use of both CRP and AGP in regression correction to adjust for inflammation or infection[17].

4.2.4 Hb as the Indicator to Determine the Burden of ID or IDA

Low Hb concentration or the presence of anaemia may not be a good indicator of ID because ID may not necessarily result in IDA. On the other hand, anaemia can be due to causes other than ID[3]. Moreover, Hb levels of normal and iron-deficient individuals can overlap. In PHS 2020–22, Hb level was measured mainly to estimate burden of IDA but misclassification of IDA versus other causes of anaemia might exist.

Furthermore, it is noted that the WHO's cut-off values for anaemia (Hb <12.0 g/dL for non-pregnant women aged 15 years of age and above and Hb <13.0 g/dL for male aged 15 years of age and above) were based on its study group on nutritional anaemias in 1968, which stated that more than 95% of normal individuals were shown to have Hb level higher than the cut-off[30]. Despite being unchanged since 1968, these values were additionally validated by findings among participants in the Second National health and Nutrition Examination Survey who were unlikely to have ID based on a number of additional biochemical tests[19]. Furthermore, these cut-offs were commonly applied in population-based ID prevalence studies in overseas countries. Moreover, it is important to note the normal Hb distribution is affected by altitude of residence, smoking habits, and ethnicity, in addition to age and gender.

Owing to the disparity of cut-off in the haemoglobin level between male and female, the optimal haemoglobin level of female is being questioned, especially when the likely cause of disparity is menstruation among female. Owing to scarcity of research on the optimal or standard value of haemoglobin for female, WHO's recommended cut-off on haemoglobin level for anaemia has been adopted in PHS 2020–22 in order to facilitate comparability with overseas countries and apply WHO's recommended measures in preventing ID in the local situation. Nevertheless, using Hb <12.0 g/dL in females might underestimate the prevalence of anaemia in the local population as a limitation.

4.2.5 Serum iron/TIBC/UIBC as the Indicators to Determine the Burden of ID or IDA

Serum iron and iron-binding capacity (TIBC/UIBC) were also measured in this study. Serum iron and TIBC/UIBC may not be sensitive indicators for assessing ID in a population but are commonly used in clinical settings[31]. In PHS 2020–22, these indicators mainly served to facilitate clinical referral and management of individual participants where necessary.

4.2.6 Sampling Variability and Prevalence of ID or IDA in Some Subgroups

In PHS 2020–22, high coefficients of variation (CV) were observed for certain items due to small sample sizes for specific conditions. This extreme sampling variability affected the reliability and generalisability of the results, requiring cautious interpretation. This Population Survey studies the iron status of the population of 15–84. Children and pregnant women have not been evaluated.

4.3 Conclusion

In view of the presence of thalassaemia minor and low prevalence of inflammation or infection in the local situation, assessment of iron status based on SF concentration would be more relevant than the use of sTfR. Among the three adjustment methods for SF recommended by WHO, the method of excluding individuals with inflammation or infection is considered applicable to the local situation in view of the low prevalence of inflammation or infection, and the uncertainty of the SF cut-off values adopted for those with inflammation or infection in the other two adjustment methods. The prevalence of ID was consistently found to be highest among women of reproductive age (aged 15–49) by various methods of adjustment, notably at 17.5% by excluding individuals with raised CRP and hence was found within the definition of a mild magnitude of public health problem for women of reproductive age. On the other hand, adjusted prevalence of ID by excluding individuals with inflammation or infection was as low as 0.7% and 2.7% among male aged 15–84 and female aged 50–84 respectively, which were consistently below 5% and were classified as no public health problem according to the WHO classification based on assessment of ferritin concentration. The adjusted prevalence of IDA among general population and women of reproductive age was 3.5% (0.3% in male and 6.4% in female) and 10.6% respectively.

Based on these findings, public health measures targeting reproductive-age females should be considered although population-wide iron fortification/supplementation is not warranted. While routine iron supplementation may not be warranted, public education, especially on a well-balanced diet and awareness of heavy menstrual bleeding targeted at reproductive-age female, should be strengthened to address ID in our locality.

4.4 Recommendations and Ways Forward

4.4.1 Evidences on Intervention and Recommendations made by WHO and Overseas Health Professional Bodies

Dietary change and diversification to increase iron intake

According to WHO, a diet containing adequate amount of micronutrients underpins all efforts for prevention and control of micronutrient malnutrition, which includes increasing diet diversification and bioavailability of iron[32,33]. To be absorbed, iron must be in the reduced state (ferrous iron, Fe^{2+}) or bound by a protein such as haem (i.e. haem iron)[34]. To improve dietary iron absorption, attention should be paid to the 'enhancers' and 'inhibitors' of iron absorption[35].

Enhancers of iron absorption include organic acids, such as citric acid, malic acid, and ascorbic acid (i.e. vitamin C), and animal tissues[35]. Vitamin C and other organic acids can improve absorption of non-haem iron by reducing it and forming a chelate that remains soluble at the alkaline pH of the proximal small intestine, where iron absorption takes place[36]. In addition, combining animal-based food which is rich in haem-iron will increase absorption of non-haem iron.

Vegetarians or persons on a restrictive diet should pay attention to their dietary source of iron or other micronutrients. A diet rich in wholegrains, nuts, green leafy vegetables, fruits, and legumes together with taking food rich vitamin C during meals can help to maintain healthy and regular body function.

On the other hand, phytate, polyphenols, and calcium can have inhibitory effects on iron absorption. As a natural antioxidant, phytate often occurs in plants. People who are at higher risk of iron deficiency can oppose the adverse effects of phytate in plant-based food by having a more varied and balanced diet. Polyphenols can be found abundant in tea, coffee, red wine, etc.[35]. According to WHO, consumption of tea or coffee 1 to 2 hours after a meal will not inhibit iron absorption[30]. People who are at higher risk of iron deficiency should avoid overconsuming these drinks as far as possible.

In general, overseas healthcare organisations (e.g. Canada and the UK) recommended a balanced diet with iron-rich food to prevent ID[22,37,38,39]. Common sources of dietary iron include meat, animal livers, egg yolk, seafood, cereals, green leafy vegetables, etc. Apart from regular meat and plant products, foods such as legumes, clam and shrimp are also proved to contain rich iron.

Universal iron supplementation in areas with high prevalence of anaemia

WHO recommends iron supplementation for women at reproductive age in regions where the prevalence of anaemia among non-pregnant women of reproductive age is 20% or higher. While mass iron supplementation is an interim measure for areas with a high prevalence of anaemia, the ultimate and long term measure is comprehensive food strategies, including public education on a balanced diet to prevent micronutrient deficiencies.

In areas with a lower prevalence of anaemia among non-pregnant women of reproductive age, studies and scientific evidence on health benefit and potential harms from routine provision of iron supplement for asymptomatic healthy women is limited. On the other hand, universal iron supplementation may also risk iron overload for those with thalassemia trait which is not uncommon in the local population.

Food fortification

Food fortification can also be part of the food-based strategy for combating micronutrient deficiencies. Food fortification is defined as the process of deliberately increasing the content of essential micronutrients in food in order to improve the nutritional quality of the food supply and to provide a public health benefits with minimal risk to health[30]. Based on experiences in other countries and places, food fortification with iron is challenging in terms of selecting a suitable food fortification vehicle, iron fortification compound and its relative stability and bioavailability, interaction with other nutrients, associated cost and consumer acceptability. Voluntary (in the US) or mandatory fortification (in Canada and the UK) of wheat and maize flour with iron has been practiced in some overseas countries for ID and IDA control. However, wheat or maize flour is not widely used in the traditional diet in Hong Kong and other Asian regions. Besides, there are also countries (e.g. Denmark, Sweden) which stopped their iron fortification programmes in food due to the uncertain health effects on some specific groups of patients (e.g. haemochromatosis)[40,41].

Routine screening of iron deficiency for asymptomatic non-pregnant women of reproductive age as secondary prevention

Principles of Screening by Wilson and Jungner should be taken into account when considering any screening programme. Notably, the overall health benefits of the population-based screening should outweigh potential harms for the asymptomatic population. There is currently limited data and scientific evidence on effectiveness in terms of measurable health outcome or cost-effectiveness to support routine ID screening for asymptomatic non-pregnant women of reproductive age. Similarly, there is also scarcity of research and scientific data to support the development of guidelines on screening and management protocols such as optimal screening tools and their cut-off values, screening interval and consensus on management of abnormal finding.

Equally important, the opportunity cost of any screening programme should be economically balanced in relation to the overall expenditure on medical care. Likewise, routine screening for an asymptomatic population might have implications for waiting time, referral, manpower and workups of other causes of ID on both private and public healthcare sectors. The society should be well-informed of the medical costs, opportunity costs and benefits before the question of adopting a population-based screening programme can be answered.

Table V showed the prevalence of ID among women of reproductive age in high-income overseas countries, ranging from 17.0% to 31.4% (all the countries with age group-specific data used the same SF cut-off of 15 µg/L), which was comparable to that of Hong Kong (17.5%). It is observed that population-based screening of iron deficiency among asymptomatic non-pregnant women of reproductive age has not been recommended by overseas health professional bodies in general and national ID screening programme for non-pregnant women of reproductive age has not been implemented in China[42], and other high income countries such as UK, Canada[43], Australia[44], and Singapore. Instead, overseas health authorities (e.g. US[45,46,47,48], UK[49], Australia[50,51,52] and Canada[53]) in general provide health education on a well-balanced diet to maintain adequate iron intake and promote awareness of heavy menstrual bleeding to prompt women to seek care from healthcare providers and further workup for anaemia in case of heavy menstrual bleeding. ID can recur, and the menstrual and dietary patterns can change across the life cycle. Educating women of reproductive age on seeking medical help for heavy menstrual bleeding would be one of the sustainable measures for preventing iron deficiency.

4.4.2 Joint Recommendation by the Working Group on Prevention of Iron Deficiency

The Working Group on Prevention of Iron Deficiency (the Working Group) which has been set up by the DH with representatives from the Centre for Food Safety (CFS), Food and Environmental Hygiene Department (FEHD), the Hospital Authority, the Hong Kong College of Community Medicine, the Hong Kong College of Family Physicians, the Hong Kong College of Obstetricians and Gynaecologists, the Hong Kong College of Pathologists, the Hong Kong College of Physicians, and the Hong Kong Red Cross Blood Transfusion Service, has reviewed the key findings of this study and the latest scientific evidence, and made the following recommendations on iron intake for members of public particularly for women of reproductive age:

In general, adequate iron intake can be achieved by a healthy balanced diet with iron-rich food. Women of reproductive age have a higher risk of iron loss during menstruation and hence a higher daily requirement for iron. They should pay particular attention to their diet to ensure adequate iron intake.

Consume iron-rich food

— Eat a moderate amount of meat, fish and seafood. Animal-based iron-rich food contains haem iron which can be absorbed easily.

— Eat more dark green vegetables and beans. Plant-based iron-rich food contains non-haem iron which is less readily absorbable and its absorption is affected by other foods and drinks in the diet.

— Iron-fortified cereals are also good sources of iron.

Consume adequate fruit and vegetables

— Consume vitamin C-rich fruit and vegetables to enhance absorption of iron from plant sources.

Reduce tea or coffee with meals

— Try to avoid drinking tea or coffee within 1 to 2 hours after meals as they can reduce iron absorption. Plain water or water added with lemon is a better choice as a beverage for meals.

Additional measures for those at higher risk of iron deficiency

— People at risk of iron deficiency (including women of reproductive age with heavy menstrual periods, pregnant women, persons on restrictive diets, persons with gastrointestinal disorders and/or having previous gastrointestinal surgery, frequent blood donors, etc.) may seek healthcare professionals' advice on management of their health conditions and their individual needs for taking iron supplement. Please note: iron supplement with too much iron can be harmful.

The joint recommendation endorsed by the Working Group will be promulgated to members of the public via various channels and shared with relevant stakeholders and healthcare professionals in Hong Kong.

4.4.3 Ways Forward

This Population Survey only studied the age group of 15–84. Children under 15 and pregnant women who are at risk groups due to increased iron requirements for supporting growth and development during early childhood, adolescence, maternal and foetal growth during pregnancy were not included in PHS 2020–22. Currently, there is no local study reporting the prevalence of iron deficiency or anaemia among young children and pregnant women. Studies assessing the prevalence of ID among these 2 groups would provide information to assist in formulating measures in preventing ID for them.

There are currently limited studies comparing ferritin concentrations and bone marrow content/other iron status indicators in healthy populations and studies that clarify optimal cut-off points for ID among a healthy population and population with inflammation, as well as effectiveness and cost-effectiveness on providing screening for ID. In view of the limited evidence, future studies in these areas might contribute to more accurate estimation of prevalence of ID and assessing effectiveness of intervention. The Working Group will keep in view of the latest scientific evidence in the future.

Also, the WHO guideline 2020 recommends to use both CRP and α-1 glycoprotein (AGP) as inflammation markers to indicate the presence of inflammation whereas only CRP was measured in the PHS 2020–22. The DH will conduct regular surveys to monitor the iron status among local population.

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ANNEX TABLES

Table 1a: Geometric mean for CRP (mg/L) by age group and gender

	Male			Female			Both genders		
Age group	Mean (mg/L)	95% CI (Lower limit)	95% CI (Upper limit)	Mean (mg/L)	95% CI (Lower limit)	95% CI (Upper limit)	Mean (mg/L)	95% CI (Lower limit)	95% CI (Upper limit)
15–24	0.56	0.46	0.67	0.42	0.36	0.49	0.49	0.43	0.55
25–34	0.67	0.57	0.78	0.51	0.41	0.61	0.58	0.50	0.66
35–44	0.98	0.80	1.17	0.67	0.56	0.78	0.80	0.69	0.90
45–54	0.96	0.81	1.11	0.66	0.56	0.77	0.78	0.69	0.87
55–64	0.92	0.77	1.06	0.92	0.78	1.07	0.92	0.82	1.02
65–84	0.87	0.70	1.03	0.84	0.70	0.98	0.85	0.75	0.96
15–84	**0.84**	**0.78**	**0.90**	**0.69**	**0.64**	**0.74**	**0.75**	**0.71**	**0.80**

Table 1b: Geometric mean for sTfR (nmol/L) by age group and gender

	Male			Female			Both genders		
Age group	Mean (nmol/L)	95% CI (Lower limit)	95% CI (Upper limit)	Mean (nmol/L)	95% CI (Lower limit)	95% CI (Upper limit)	Mean (nmol/L)	95% CI (Lower limit)	95% CI (Upper limit)
15–24	36.0	34.6	37.4	39.9	37.3	42.5	37.8	36.3	39.4
25–34	35.1	33.9	36.2	39.3	36.7	41.8	37.1	35.7	38.6
35–44	35.4	34.0	36.8	39.0	36.7	41.3	37.3	36.0	38.7
45–54	35.1	33.6	36.5	39.6	37.6	41.7	37.5	36.3	38.8
55–64	36.0	34.3	37.7	36.3	35.2	37.3	36.1	35.2	37.1
65–84	34.6	33.3	36.0	36.4	35.0	37.8	35.5	34.6	36.5
15–84	**35.3**	**34.7**	**35.9**	**38.2**	**37.4**	**39.0**	**36.8**	**36.3**	**37.3**

Table 1c: Arithmetic mean for Hb (g/dL) by age group and gender

	Male			Female			Both genders		
Age group	Mean (g/dL)	95% CI (Lower limit)	95% CI (Upper limit)	Mean (g/dL)	95% CI (Lower limit)	95% CI (Upper limit)	Mean (g/dL)	95% CI (Lower limit)	95% CI (Upper limit)
15–24	15.5	15.4	15.7	13.2	13.0	13.4	14.4	14.2	14.6
25–34	15.3	15.1	15.4	13.0	12.8	13.2	14.1	13.9	14.3
35–44	15.4	15.2	15.5	13.0	12.8	13.2	14.1	13.9	14.3
45–54	15.1	14.9	15.2	12.9	12.7	13.1	13.9	13.7	14.0
55–64	14.6	14.4	14.8	13.5	13.3	13.6	14.0	13.9	14.1
65–84	14.5	14.3	14.7	13.2	13.1	13.4	13.9	13.7	14.0
15–84	**15.0**	**14.9**	**15.1**	**13.1**	**13.1**	**13.2**	**14.0**	**13.9**	**14.1**

Table 2: Proportion of persons with raised CRP (higher than 5 mg/L) by age group and gender

	Male			Female			Both genders		
Age group	%	95% CI (Lower limit)	95% CI (Upper limit)	%	95% CI (Lower limit)	95% CI (Upper limit)	%	95% CI (Lower limit)	95% CI (Upper limit)
15–24	5.9%[H]	3.1%	11.0%	1.9%[E]	0.6%	5.5%	3.9%[H]	2.3%	6.8%
25–34	1.7%[E]	0.6%	5.3%	6.4%[H]	3.5%	11.4%	4.1%[H]	2.4%	6.9%
35–44	6.7%[H]	3.7%	11.6%	5.0%[H]	2.6%	9.3%	5.7%[H]	3.7%	8.7%
45–54	6.4%[H]	3.6%	11.2%	4.4%[E]	2.2%	8.5%	5.2%[H]	3.4%	8.1%
55–64	4.0%[E]	1.9%	8.1%	5.4%[H]	2.9%	9.9%	4.7%[H]	2.9%	7.6%
65–84	8.0%[H]	4.8%	12.9%	5.4%[H]	2.9%	10.1%	6.7%[H]	4.4%	10.0%
15–49				*4.5%[H]*	*3.0%*	*6.5%*			
50–84				*5.4%[H]*	*3.6%*	*8.0%*			
15–84	**5.5%**	**4.2%**	**7.1%**	**4.9%**	**3.7%**	**6.6%**	**5.2%**	**4.3%**	**6.3%**

Notes:

[H] High sampling variability (CV ≥ 16.6% and < 33.3%); estimates should be interpreted with caution.

[E] Extreme sampling variability (CV ≥ 33.3%); indicates a relatively high level of variability in relation to the central estimate or mean, which raises doubts about the reliability of the estimates and calls into question their validity.

Table 3: Adjusted prevalence of ID using SF <15 µg/L for healthy individuals and upper modified cut-off (SF <70 µg/L) for those with inflammation or infection by age group and gender

	Male			Female			Both genders		
Age group	%	95% CI (Lower limit)	95% CI (Upper limit)	%	95% CI (Lower limit)	95% CI (Upper limit)	%	95% CI (Lower limit)	95% CI (Upper limit)
15–24	—	—	—	16.7%[H]	11.3%	24.0%	8.2%[H]	5.4%	12.1%
25–34	0.6%[E]	0.1%	4.0%	17.9%[H]	12.7%	24.7%	9.4%[H]	6.7%	13.2%
35–44	0.6%[E]	0.1%	4.1%	18.2%	13.3%	24.5%	10.1%	7.4%	13.8%
45–54	—	—	—	15.9%[H]	11.4%	21.9%	8.9%[H]	6.3%	12.4%
55–64	1.7%[E]	0.6%	5.2%	2.0%[E]	0.7%	5.1%	1.8%[E]	0.9%	3.8%
65–84	0.6%[E]	0.1%	4.0%	—	—	—	0.3%[E]	0.0%	2.0%
15–49				*18.1%*	*15.2%*	*21.6%*			
50–84				*3.2%[H]*	*2.0%*	*5.3%*			
15–84	**0.7%[E]**	**0.3%**	**1.5%**	**10.8%**	**9.1%**	**12.8%**	**6.0%**	**5.0%**	**7.1%**

Notes:

[H] High sampling variability (CV ≥ 16.6% and < 33.3%); estimates should be interpreted with caution.

[E] Extreme sampling variability (CV ≥ 33.3%); indicates a relatively high level of variability in relation to the central estimate or mean, which raises doubts about the reliability of the estimates and calls into question their validity.

"—" Estimates are unavailable due to absence of positive observations from the health examination.

Table 4: Adjusted prevalence of ID using SF <15 µg/L for healthy individuals and regression correction for individuals with inflammation or infection by age group and gender

	Male			Female			Both genders		
Age group	%	95% CI (Lower limit)	95% CI (Upper limit)	%	95% CI (Lower limit)	95% CI (Upper limit)	%	95% CI (Lower limit)	95% CI (Upper limit)
15–24	—	—	—	16.1%[H]	10.7%	23.4%	7.9%[H]	5.2%	11.8%
25–34	0.6%[E]	0.1%	4.0%	16.6%[H]	11.5%	23.3%	8.8%[H]	6.1%	12.5%
35–44	0.6%[E]	0.1%	4.1%	17.1%	12.3%	23.3%	9.5%	6.9%	13.1%
45–54	—	—	—	14.8%[H]	10.4%	20.6%	8.3%[H]	5.8%	11.7%
55–64	1.7%[E]	0.6%	5.2%	1.5%[E]	0.5%	4.5%	1.6%[E]	0.7%	3.5%
65–84	0.6%[E]	0.1%	4.0%	—	—	—	0.3%[E]	0.0%	2.0%
15–49				*17.3%*	*14.4%*	*20.7%*			
50–84				*2.6%[H]*	*1.5%*	*4.5%*			
15–84	**0.7%[E]**	**0.3%**	**1.5%**	**10.0%**	**8.4%**	**12.0%**	**5.6%**	**4.7%**	**6.7%**

Notes:

[H] High sampling variability (CV ≥ 16.6% and < 33.3%); estimates should be interpreted with caution.

[E] Extreme sampling variability (CV ≥ 33.3%); indicates a relatively high level of variability in relation to the central estimate or mean, which raises doubts about the reliability of the estimates and calls into question their validity.

"—" Estimates are unavailable due to absence of positive observations from the health examination.

Table 5: Prevalence of ID as estimated by raised sTfR levels by age group and gender

	Male			Female			Both genders		
Age group	%	95% CI (Lower limit)	95% CI (Upper limit)	%	95% CI (Lower limit)	95% CI (Upper limit)	%	95% CI (Lower limit)	95% CI (Upper limit)
15–24	3.3%[E]	1.4%	7.6%	14.8%[H]	9.9%	21.6%	8.9%[H]	6.1%	12.9%
25–34	1.7%[E]	0.6%	5.3%	16.0%[H]	11.0%	22.6%	9.0%[H]	6.2%	12.9%
35–44	4.8%[E]	2.4%	9.4%	15.5%[H]	10.9%	21.4%	10.6%	7.8%	14.3%
45–54	5.8%[H]	3.1%	10.4%	14.8%[H]	10.5%	20.6%	10.8%	8.0%	14.5%
55–64	6.8%[H]	3.9%	11.7%	4.4%[H]	2.3%	8.2%	5.6%[H]	3.7%	8.3%
65–84	4.5%[E]	2.3%	8.8%	7.3%[H]	4.2%	12.4%	5.9%[H]	3.9%	9.0%
15–49				*16.3%*	*13.4%*	*19.7%*			
50–84				*6.6%[H]*	*4.7%*	*9.3%*			
15–84	**4.7%**	**3.5%**	**6.3%**	**11.5%**	**9.7%**	**13.6%**	**8.3%**	**7.1%**	**9.6%**

Notes:
ID cut-off for male: sTfR >55.5 nmol/L; for female sTfR >54.2 nmol/L.

[H] High sampling variability (CV ≥ 16.6% and < 33.3%); estimates should be interpreted with caution.

[E] Extreme sampling variability (CV ≥ 33.3%); indicates a relatively high level of variability in relation to the central estimate or mean, which raises doubts about the reliability of the estimates and calls into question their validity.

Table 6: Interpretation of SF and sTfR in PHS 2020–22

	SF threshold (<15 µg/L)	sTfR threshold (by manufacturer's cut-offs)	
Age group	Below threshold (%)	Above threshold (%)	Interpretation
15–84	5.7%[a] (< 20%)	8.3% (< 10%)	ID is not prevalent

Note:

[a] Adjusted prevalence rate by excluding individuals with raised CRP (CRP >5 mg/L)

Table 7a: Proportion of IDA among persons with ID (regardless of inflammation or infection) by age group and gender

	Male	Female	Both genders
Age group	**%**	**%**	**%**
15–24	—	53.8%	53.8%
25–34	0.0%*	50.1%	48.4%
35–44	100.0%*	64.5%	65.5%
45–54	—	75.2%	75.2%
55–64	33.5%*	67.1%*	49.9%*
65–84	100.0%*	—	100.0%*
15–49		*61.0%*	
50–84		*75.4%**	
15–84	**50.7%***	**62.8%**	**62.2%**

Notes:
* Small base (i.e. persons with ID regardless of inflammation or infection) and should be interpreted with cautions.
"—" Estimates are unavailable due to absence of positive observations from the health examination.

Table 7b: Proportion of IDA among local population (regardless of inflammation or infection) by age group and gender

	Male			Female			Both genders		
Age group	%	95% CI (Lower limit)	95% CI (Upper limit)	%	95% CI (Lower limit)	95% CI (Upper limit)	%	95% CI (Lower limit)	95% CI (Upper limit)
15–24	—	—	—	8.7%[H]	5.1%	14.4%	4.2%[H]	2.4%	7.2%
25–34	—	—	—	7.7%[H]	4.4%	13.1%	3.9%[H]	2.3%	6.8%
35–44	0.6%[E]	0.1%	4.1%	11.0%[H]	7.2%	16.5%	6.3%[H]	4.1%	9.4%
45–54	—	—	—	11.1%[H]	7.4%	16.5%	6.2%[H]	4.1%	9.3%
55–64	0.6%[E]	0.1%	4.0%	1.0%[E]	0.2%	3.9%	0.8%[E]	0.3%	2.4%
65–84	0.6%[E]	0.1%	4.0%	—	—	—	0.3%[E]	0.0%	2.0%
15–49				*10.3%*	*8.0%*	*13.2%*			
50–84				*1.9%[H]*	*1.0 %*	*3.7%*			
15–84	**0.3%[E]**	**0.1%**	**1.0%**	**6.2%**	**4.9%**	**7.8%**	**3.4%**	**2.7%**	**4.3%**

Notes:

[H] High sampling variability (CV ≥ 16.6% and < 33.3%); estimates should be interpreted with caution.

[E] Extreme sampling variability (CV ≥ 33.3%); indicates a relatively high level of variability in relation to the central estimate or mean, which raises doubts about the reliability of the estimates and calls into question their validity.

"—" Estimates are unavailable due to absence of positive observations from the health examination.

Table 7c: Proportion of IDA among persons with ID (excluding individuals with inflammation or infection) by age group and gender

	Male	Female	Both genders
Age group	**%**	**%**	**%**
15–24	—	53.8%	53.8%
25–34	0.0%*	50.1%	48.4%
35–44	100.0%*	63.3%	64.4%
45–54	—	75.2%	75.2%
55–64	33.5%*	67.1%*	49.9%*
65–84	100.0%*	—	100.0%*
15–49		*60.5%*	
50–84		*75.4%**	
15–84	**50.7%***	**62.5%**	**61.8%**

Notes:

* Small base (i.e. persons with ID excluding individuals with inflammation or infection) and should be interpreted with cautions.

"—" Estimates are unavailable due to absence of positive observations from the health examination.

Table 7d: Proportion of IDA among local population (excluding individuals with inflammation or infection) by age group and gender

	Male			Female			Both genders		
Age group	%	95% CI (Lower limit)	95% CI (Upper limit)	%	95% CI (Lower limit)	95% CI (Upper limit)	%	95% CI (Lower limit)	95% CI (Upper limit)
15–24	—	—	—	8.8%[H]	5.2%	14.7%	4.4%[H]	2.5%	7.5%
25–34	—	—	—	8.2%[H]	4.7%	13.9%	4.1%[H]	2.4%	7.0%
35–44	0.6%[E]	0.1%	4.4%	11.0%[H]	7.2%	16.6%	6.3%[H]	4.1%	9.5%
45–54	—	—	—	11.7%[H]	7.7%	17.2%	6.6%[H]	4.3%	9.8%
55–64	0.6%[E]	0.1%	4.1%	1.0%[E]	0.3%	4.1%	0.8%[E]	0.3%	2.5%
65–84	0.6%[E]	0.1%	4.3%	—	—	—	0.3%[E]	0.0%	2.1%
15–49				*10.6%*	*8.2%*	*13.5%*			
50–84				*2.1%[H]*	*1.1 %*	*3.9%*			
15–84	**0.3%[E]**	**0.1%**	**1.1%**	**6.4%**	**5.0%**	**8.1%**	**3.5%**	**2.8%**	**4.5%**

Notes:

[H] High sampling variability (CV ≥ 16.6% and < 33.3%); estimates should be interpreted with caution.

[E] Extreme sampling variability (CV ≥ 33.3%); indicates a relatively high level of variability in relation to the central estimate or mean, which raises doubts about the reliability of the estimates and calls into question their validity.

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