

BMJ Open

BMJ Open is committed to open peer review. As part of this commitment we make the peer review history of every article we publish publicly available.

When an article is published we post the peer reviewers' comments and the authors' responses online. We also post the versions of the paper that were used during peer review. These are the versions that the peer review comments apply to.

The versions of the paper that follow are the versions that were submitted during the peer review process. They are not the versions of record or the final published versions. They should not be cited or distributed as the published version of this manuscript.

BMJ Open is an open access journal and the full, final, typeset and author-corrected version of record of the manuscript is available on our site with no access controls, subscription charges or pay-per-view fees (<http://bmjopen.bmj.com>).

If you have any questions on BMJ Open's open peer review process please email info.bmjopen@bmj.com

BMJ Open

Anemia and associated factors among the elderly in an urban district in China: a large-scale cross-sectional study

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2021-056100
Article Type:	Original research
Date Submitted by the Author:	03-Aug-2021
Complete List of Authors:	Ni, Wenqing; Shenzhen Center for Chronic Disease Control Yuan, Xueli; Shenzhen Center for Chronic Disease Control Sun, Yuanying Zhang, Hong Zhang, Yan Xu, Jian; Shenzhen Nanshan Center for Chronic Disease Control
Keywords:	NUTRITION & DIETETICS, Anaemia < HAEMATOLOGY, EPIDEMIOLOGY

SCHOLARONE™
Manuscripts



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our [licence](#).

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which [Creative Commons](#) licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

1
2
3
4 1 **Anemia and associated factors among the elderly in an urban**
5
6 2 **district in China: a large-scale cross-sectional study**
7
8
9 3

10
11 4 Wenqing Ni^{1#}, Xueli Yuan^{1#}, Yuanying Sun¹, Hongmin Zhang¹,
12
13
14 5 Yan Zhang¹, Jian Xu¹
15

16
17 6 ¹Department of Elderly Health Management, Shenzhen Center for Chronic Disease
18
19 7 Control, Shenzhen, Guangdong, 518020, China

20
21 8 # These authors contributed equally to this work.
22

23 9
24 10 *Corresponding author :

25 11 Jian Xu, Ph.D.

26 12 Shenzhen Center for Chronic Disease Control

27 13 No.2021, Buxin Rd. Shenzhen, Guangdong 518020, P.R. China
28
29 14

30 15 Tel: 86-755-25506942

31 16 Fax: 86-755-25506942

32 17 E-mail: anniexu73@126.com
33
34 18
35 19

36 20 Tel: 86-755-25506942

37 21 Fax: 86-755-25506942

38 22 E-mail: 1498384005@qq.com
39
40 23
41 24
42 25
43 26
44 27
45 28
46 29
47 30
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 **Abstract**

2 **Objective:** Anemia leads to poor health outcomes in the elderly; however, most
3 current research in China has focused on younger adults. The present study aimed to
4 investigate the prevalence of anemia and its associated risk factors in elderly
5 individuals in an urban district in China.

6 **Design:** A cross-sectional study.

7 **Setting:** A urbanization region, Shenzhen of China.

8 **Participants:** A total of 121,981 participants aged ≥ 65 years were recruited at local
9 community health service centers in Shenzhen from January to December 2018.

10 **Primary outcomes:** Their hemoglobin (Hb) levels and the prevalence of anemia were
11 analyzed and potential associated factors were evaluated.

12 **Results:** The mean Hb level was 13.64 ± 1.67 g/dL and the prevalence of anemia was
13 15.43%. Anemia was positively associated with older age, being underweight (odds
14 ratio (*OR*): 2.06, 95% confidence interval (*CI*): 1.93–2.20), diabetes (*OR*: 1.23, 95%
15 *CI*: 1.19–1.28), and chronic kidney disease (*OR*: 1.41, 95% *CI*: 1.36–1.46), and
16 inversely with higher education level, current-smoker (*OR*: 0.84, 95% *CI*: 0.78–0.89),
17 non-habitual drinker (*OR*: 0.86, 95% *CI*: 0.81–0.92), habitual drinker (*OR*: 0.81, 95%
18 *CI*: 0.75–0.87), overweight (*OR*: 0.67, 95% *CI*: 0.64–0.70), obesity (*OR*: 0.57, 95%
19 *CI*: 0.53–0.61), central obesity (*OR*: 0.86, 95% *CI*: 0.82–0.89), hypertension (*OR*:
20 0.86, 95% *CI*: 0.83–0.89), and dyslipidemia (*OR*: 0.81, 95% *CI*: 0.78–0.84).

21 **Conclusion:** Anemia is prevalent among people aged 65 years and older in China.
22 Prevention, screening of key populations, and treatment of senile anemia should be a
23 top priority in Shenzhen, and should be listed as important public health intervention
24 measures for implementation.

25 **Keywords:** elderly, anemia, epidemiologic study, risk factor

1
2
3
4 1 **Strengths and limitations of this study**

5 2 ■ This is the first large-scale cross-sectional study to assess the prevalence of anemia
6 and its factors in an urban district in China.

7 3
8 4 ■ This study had a sufficient sample size to detect statistical significance in the
9 prevalence of anemia among elderly.

10 5
11 6 ■ Convenience sampling was used to enroll the population sample.

12 7 ■ The data set used in this study did not provide information on dietary behaviour of
13 the participants.
14

15 9

16
17
18 10

19
20
21 11

22
23 12

24
25
26 13

27
28 14

29
30
31 15

32
33 16

34
35
36 17

37
38 18

39
40
41 19

42
43
44 20

45
46 21

47
48
49 22

50
51 23

52
53
54 24

55
56
57 25

58
59 26
60

1. Introduction

Anemia, characterized by decreased hemoglobin (Hb) levels, occurs when low numbers of red blood cells reduce the ability of the blood to carry oxygen to meet the body's physiological needs. Although anemia may occur at any stage of life, older people are particularly vulnerable,^{1, 2} and anemia in the elderly is a risk factor for a variety of adverse health outcomes, such as hospitalization, disability, and death.^{1, 3-5} Anemia is also an independent risk factor for declining physical performance, and has a negative impact on quality of life, physical function, and muscle strength in older people.⁶⁻⁸

Globally, 11.0% of men and 10.2% of women aged ≥ 65 years are anemic⁹. Ruan et al. revealed that the prevalence of anemia among middle-aged and elderly residents in China was 31.0%,¹⁰ while Qin et al. reported a prevalence of 12.86% among similar populations from 2011 to 2012.¹¹ Although China has seen a significant reduction in anemia among middle-aged and elderly residents in the past decade, its occurrence among the elderly cannot be neglected.

A total of 150 million Chinese were aged 65 years or above in 2016, accounting for 10.8% of the population.¹² Improving anemia in the elderly thus has important public health implications. Previous studies have investigated the prevalence of anemia in middle-aged and elderly people, but there is a lack of large-scale studies on anemia in the urban elderly population.^{10, 11, 13} The current study therefore aimed to assess the prevalence of anemia and associated factors among elderly people in an urban district in China.

2. Materials and methods

a) Study population

We used convenience sampling to select our population sample by recruiting people aged 65 years and older from the lists of all residents registered at local community health centers in Shenzhen, China, from January 2018 through December 2018. Recruitment activities include pasting posters or placing foldings in local community health centers and other public places. Electronic posters also be distributed via all the open WeChat groups of local community health centers' staff, to make the survey available to the close contacts easily. Moreover, the staff of the local community health centers recruited the elderly adults in their service community to participate in the survey by telephone. The eligibility criteria were as follows: (1) having lived in Shenzhen for more than 6 months; and (2) able to participate in the study and give informed consent. A total of 141,684 individuals were recruited in this study, accounting for 36.9% (141,684/383,700) of the resident elderly population in Shenzhen according to the 2015 population census. Data were collected at examination centers in local community health centers in the participants' residential areas. Participants were asked to complete a questionnaire, provide a fasting blood sample, and undergo physical examinations. A total of 19,703 respondents were excluded because of failure to fulfil one or all of these requirements. Finally, 121,981 participants (86.09%) were included in the final data analysis.

2.2 Questionnaire survey

Prior to the study, all investigators completed a training course to understand the methodology and process of the study. Working manuals containing questionnaire techniques, blood pressure measurement, anthropometric measurements, biological sample collection, and processing information were distributed to all the investigators.

Data were recorded by face-to-face interview 1 hour after blood collection. All participants completed a standardized questionnaire including questions on sociodemographic status (e.g., date of birth, sex, education level, marital status), past medical history (e.g., history of previous disease, operation history, history of trauma), family health history (e.g., hypertension, diabetes, coronary heart disease, malignant tumor, stroke), lifestyle (e.g., smoking, physical activity, alcohol consumption), and medication use, under the supervision of trained general practitioners and nurses. Educational level was categorized into three groups according to the number of years of education: illiterate, no education; primary education, 1–6 years of education; and junior high school education and above, seven or more years of education. Regarding drinking habits, participants were classified as habitual drinkers (drink at least once a day), non-habitual drinkers (six times a week to once a month), or non-drinker (almost never).¹⁴ Based on a previous study, we divided participants into current smokers, ex-smokers, and never-smokers.¹⁵

2.3 Physical examination

Anthropometric examinations were carried out in the morning after overnight fasting, and body measurements were taken by trained examiners based on a standardized protocol. The physical examination methods were described as previous study.¹² Height and weight were measured with the participants wearing light clothing without shoes, using analogue scales. Waist circumference (WC) was measured at the end of normal expiration at the midpoint level of the mid-axillary line between the 12th rib head and the superior anterior iliac spine. Body mass index (BMI) was calculated by dividing body weight (in kilograms) by height squared (in meters). Blood pressure were measured in both arms and recorded the higher one. Calibrated electronic sphygmomanometers were used to measure blood pressure on the arm supported at heart level with sitting position, carried out twice. The average of the two measurements was used for the statistical analysis. To obtain accurate readings, the participants were asked to rest for at least 5 min before the measurement, or, if having engaged in excessive exercise prior to the visit, for at least 30 min before the measurement.

2.4 Blood sample collection and biochemical analyses

Venous blood samples were taken after overnight fasting for at least 8 hours. All blood samples were analyzed in clinical laboratories at the grade 2 hospitals to which the community health centers were directly affiliated. All the laboratories had successfully completed a standardization and competency program. Fasting venous blood was used to measure levels of Hb, plasma glucose, creatinine, total cholesterol (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-C), and high-density lipoprotein cholesterol (HDL-C) using an automatic biochemistry analyzer. Biochemical analysis of fresh blood samples was completed within 4 hours.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 Serum creatinine was used to calculate the estimated glomerular filtration rate (eGFR)
2 using the full age spectrum equation.¹⁶

3 **2.5 Definitions**

4 Anemia was defined as a Hb concentration < 13 g/dL in men and < 12 g/dL in
5 women, according to World Health Organization standards.¹⁷ Chronic kidney disease
6 (CKD) was defined as eGFR < 60 mL/min/1.73 m².¹⁸ A diagnosis of hypertension
7 was considered when three consecutive high readings (≥ 140 systolic and/or ≥ 90
8 mm Hg diastolic) with 2-week intervals were registered or treatment with
9 antihypertensive medication within the previous 2 weeks was self-reported.^{19, 20}
10 Participants who met one of the following three criteria were diagnosed with diabetes:
11 (1) previously diagnosed by professional doctors, (2) fasting plasma glucose (FBG) \geq
12 7.0 mmol/L, and (3) 2-hour plasma glucose level ≥ 11.1 mmol/L.²¹ High TC, high TG,
13 high LDL-C, and low HDL-C were diagnosed according to the 2016 Chinese
14 Guidelines for the Management of Dyslipidemia in Adults.²² In this study, we defined
15 dyslipidemia as an abnormal concentration of one or more lipid components or the
16 use of anti-dyslipidemia medications in the past 2 weeks.

17 Participants were divided into four groups based on the adult weight criteria
18 published by the Ministry of Health of China (WS/T 428-2013): BMI < 18.5 kg/m²
19 (low weight), BMI ≥ 18.5 kg/m² and < 24.0 kg/m² (normal weight), BMI ≥ 24.0 kg/m²
20 and < 28.0 kg/m² (overweight), and BMI ≥ 28.0 kg/m² (obesity). A WC ≥ 90 cm for
21 men and ≥ 85 cm for women was defined as central obesity.

22 **2.6 Statistical analyses**

23 Descriptive statistics, including means and standard deviations, were used to
24 compute continuous variables. Numerical data were expressed as percentages and
25 compared by χ^2 tests. Multivariate logistic regression analysis was performed to
26 explore the association between prevalence of anemia and associated risk factors. In
27 the multivariate logistic regression model, the prevalence of anemia was defined as
28 the dependent variable, and gender, education level, age group, smoking status,
29 drinking habit, BMI, central obesity, diabetes, hypertension, dyslipidemia and CKD
30 were defined as the independent variables. Data analysis was carried out using SAS
31 9.4 (Institute, Cary, NC, USA). A two-sided value of $P < 0.05$ was considered to be
32 statistically significant.

33 **2.7 Participants and public involvement**

34 Neither the study participants nor the public were involved in the design,
35 recruitment or conduct of the study. All the participants had the option of receiving a
36 health check and biochemical results when they visited the local community health
37 centers.

38 **2.8 Ethical Approval Statement**

39 The study received ethnicity approval from the Center for Chronic Disease
40 Control in Shenzhen (Grant No: SZCCC-201802, SZCCC-2020-018-01-PJ). The study
41 complies with the guidelines of the Declaration of Helsinki. Written informed consent
42 was received by all participants before the collection of data and conducting of the
43 research. Where participants were illiterate, we obtained written informed consent
44 from their proxies.

3. Results

3.1 Characteristics of participants

The characteristics of the study participants are shown in Table 1. The mean age was 71.28 ± 5.58 years (range 65–103 years). There were 54,649 men and 69,358 women, and > 50% of participants had a minimum of a junior school education. Among the study population, 8.22% were current smokers and 6.35% were habitual drinkers. The mean Hb, BMI, SBP, DBP, WC, FBG, TC, TG, LDL-C, HDL-C, and eGFR values among all 121,981 participants were 13.64 ± 1.67 g/dL, 23.83 ± 3.17 kg/m², 134.71 ± 17.69 mmHg, 77.23 ± 10.31 mmHg, 85.10 ± 8.82 cm, 5.96 ± 1.90 mmol/L, 5.21 ± 2.00 mmol/L, 1.57 ± 1.14 mmol/L, 3.09 ± 1.05 mmol/L, 1.39 ± 1.05 mmol/L, and 68.74 ± 16.70 mL/min/1.73m², respectively. A total of 100,762 participants (82.60%) had at least one chronic disease, with hypertension (55.61%), dyslipidemia (44.73%), CKD (31.09%), and diabetes (22.31%) being the most prevalent (data not shown).

3.2 Prevalence of anemia in different subgroups

The overall prevalence anemia was 15.43%. The prevalence of anemia among subpopulations is shown in Table 2. Anemia was significantly more prevalent in women than in men and generally increased with age. The prevalence was lower among individuals with at least primary-level education, and lower in current smokers and habitual drinkers compared with their counterparts. The prevalence of anemia was higher in participants with low weight and lower in those with overweight, obesity, central obesity, hypertension, or dyslipidemia. Individuals with diabetes or CKD had a higher prevalence of anemia than those without these conditions.

3.3 Association between anemia and related variables

Binary logistic regression analysis was carried out with presence or absence of anemia as the dependent variable, and factors in univariate analysis as independent variables to determine the factors influencing anemia. Higher education level, current-smoker, drinker, overweight, obesity, central obesity, hypertension, and dyslipidemia were independently associated with lower odds for the presence of anemia (Fig. 1), while older age, underweight, diabetes, and CKD were independently associated with greater odds (Fig. 1). However, there was no significant difference in the risk of anemia in relation to sex.

4. Discussion

In this study, the prevalence of anemia among elderly individuals in an urban district in China was 15.43%. This was higher than the 12.86% reported in previous national studies in China,¹¹ but lower than the 18.90% prevalence reported in the 2009 national survey in China.²³ The difference in prevalence rates among these studies may have been caused by differences in study design, sample size, and/or the age of the study participants.

The current study found a significant negative correlation between anemia prevalence and educational level. This was consistent with studies conducted in Nepal

1 and Pakistan, which confirmed that a low educational level was a risk factor for
2 anemia.²⁴ This relationship probably occurs because higher levels of education enable
3 people to earn more and thus escape from the poverty trap. Multivariate analysis also
4 identified older age as an independent risk factor for anemia, consistent with the
5 findings of other related studies.^{9, 25} The prevalence of anemia increased with age,
6 with a two-to-three-fold increase (26.89% vs. 12.72%) in people aged > 80 years,
7 suggesting the need for routine screening for anemia in this high-risk subgroup.

8 Current smokers had a lower risk of anemia than never smokers, and habitual
9 drinking was also associated with a decreased risk of anemia (odds ratio: 0.81).
10 However, these findings were not consistent with an Indian study.²⁶ Considering the
11 potential risks to human health from alcohol or tobacco use, we do not recommend
12 that alcohol or tobacco should be used as protective factors against anemia.

13 We also found a negative association between increased BMI and anemia
14 prevalence, in accord with other studies conducted in China, the United States, Nepal,
15 and Pakistan.^{24, 27} The reasons for being underweight may include poor distribution of
16 inadequate food within the family, food insecurity, poverty, and micronutrient
17 deficiencies, which tend to coexist with other macronutrient deficiencies. The
18 underlying mechanism accounting for the significant negative association between
19 overweight or obesity and anemia risk is unclear; however there are several possible
20 explanations. First, obese participants are less likely to be malnourished, because
21 excess calorie intake leads to obesity,²⁸ and overnutrition in obese participants may
22 thus be associated with a significant reduction in anemia risk. Second, obese
23 participants may have a variety of other diseases that could increase Hb levels, such
24 as obstructive sleep apnea and other obesity-related breathing disorders, which lead to
25 chronic tissue hypoxia and increased red blood cells.²⁹

26 We found that older people with diabetes had higher rates of anemia than
27 non-diabetics, consistent with previous studies.³⁰ Evidence indicates that the
28 incidence and prevalence of anemia in diabetic patients is often associated with
29 erythropoietin deficiency caused by diabetic kidney damage.³¹ Other researchers have
30 also shown a link between anemia and hypertension, as shown in our current study.¹⁸

31 This study showed that the prevalence of anemia was low among individuals with
32 dyslipidemia. A study by Zaribaf et al. found a significant positive correlation
33 between Hb levels and dyslipidemia.³² However, this study differed from our study in
34 that it assessed the relationship between anemia and lipids in premenopausal women,
35 whereas our study focused on older adults (aged 65–113 years).³² In contrast, a study
36 conducted by other researchers in women of childbearing age found no significant
37 association between serum LDL and anemia.³² The reasons for the different results in
38 terms of the relationship between dyslipidemia and anemia deserve further
39 investigation. Patients with CKD have defects in renal endocrine function, resulting in
40 decreased erythropoietin secretion by the kidney, leading to nephrogenic anemia.³³
41 Nearly half of all patients with CKD have anemia.³³ The current study found the
42 similar results.

43 This study had some limitations. First, it was a cross-sectional study and could only
44 infer correlation, not causation. Second, we adopted a convenient sampling method to

1 recruit elderly participants. This is a major factor preventing true extrapolation of the
2 results to the general population. Finally, renal disease was assessed based on a
3 one-time GFR measurement, possibly leading to overestimation of the actual
4 prevalence of CKD. However, these limitations do not affect the significance of the
5 results, which provide the first evidence of the prevalence and risk factors of anemia
6 among elderly individuals in urban China.

7 **5. Conclusion**

8 In conclusion, anemia is prevalent among the elderly population in China, with
9 older age, underweight, diabetes, CKD, and anemia being positively associated with
10 anemia, and higher education level, current-smoker, drinker, overweight, obesity,
11 central obesity, hypertension, and dyslipidemia being negatively associated. The
12 prevention, screening of key populations, and treatment of senile anemia should be a
13 top priority in Shenzhen, and should be listed as important public health intervention
14 measures for implementation.

18 **Acknowledgments**

19 We are grateful to all the volunteers for participating in the present study, and to
20 all the investigators for their support and hard work during this survey.

22 **Author Contributions**

23 WN, XY, and JX: study conception and design. WN, XY, JZ, PL, HZ, YZ, and JX:
24 performance of research. XY and JZ: data analysis and interpretation. WN and XY:
25 writing the original draft. WN and JX: Writing the review and editing. All authors
26 have read and agreed to the published version of the manuscript.

28 **Funding**

29 This study was supported by the Science and Technology Planning Project of
30 Shenzhen City, Guangdong Province, China (Grant No. JCYJ20180703145202065);
31 Shenzhen medical key discipline construction fund, and Sanming Project of Medicine
32 in Shenzhen (Grant No. SZSM201811093).

34 **Conflicts of Interest**

35 The authors declare no conflict of interest.

37 **Patient consent for publication**

38 Not required.

40 **Ethics approval**

41 This study was approved by the ethical review committee of the Center for
42 Chronic Disease Control of Shenzhen.

Data sharing statement

All data generated or analysed during this study are included in this published article. No additional data are available.

References

1. Working Group on "Expert Consensus on nutrition Prevention and Treatment of Iron deficiency Anemia" of Chinese Nutrition Society. Expert consensus on nutrition prevention and treatment of iron deficiency anemia. *Acta Nutrimenta Sinica* **2019**; 41,417-426.
2. Stevens GA, Finucane MM, De-Regil LM, *et al.* Global, regional, and national trends in haemoglobin concentration and prevalence of total and severe anaemia in children and pregnant and non-pregnant women for 1995-2011: a systematic analysis of population-representative data. *Lancet Glob Health* **2013**; 1, e16-25.
3. Wu WC, Rathore SS, Wang Y, *et al.* Blood transfusion in elderly patients with acute myocardial infarction. *N Engl J Med* **2001**; 345, 1230-1236.
4. Groenveld HF, Januzzi JL, Damman K, *et al.* Anemia and mortality in heart failure patients a systematic review and meta-analysis. *J Am Coll Cardiol* **2008**, 52, 818-827.
5. Ezekowitz JA MF, Armstrong PW. Anemia is common in heart failure and is associated with poor outcomes: insights from a cohort of 12065 patients with new-onset heart failure. *Circulation* **2003**; 107, 223-225.
6. Penninx BW, Guralnik JM, Onder G, *et al.* Anemia and decline in physical performance among older persons. *Am J Med* **2003**; 115, 104-110.
7. Penninx BW, Pahor M, Cesari M, *et al.* Anemia is associated with disability and decreased physical performance and muscle strength in the elderly. *J Am Geriatrics Soc* **2004**; 52, 719-724.
8. Cesari M, Penninx BW, Lauretani F, *et al.* Hemoglobin levels and skeletal muscle: results from the InCHIANTI study. *J Gerontol A Biol Sci Med Sci* **2004**;59(3):249-254.
9. Bianchi VE. Role of nutrition on anemia in elderly. *Clin Nutr ESPEN* **2016**; 11, e1-e11.
10. Ruan Y, Guo Y, Kowal P, *et al.* Association between anemia and frailty in 13,175 community-dwelling adults aged 50 years and older in China. *BMC Geriatr* **2019**; 19, 327.
11. Qin T, Yan M, Fu Z, *et al.* Association between anemia and cognitive decline among Chinese middle-aged and elderly: evidence from the China health and retirement longitudinal study. *BMC Geriatr* **2019**; 19, 305.
12. Ni W, Weng R, Yuan X, *et al.* Clustering of cardiovascular disease biological risk factors among older adults in Shenzhen City, China: a cross-sectional study. *BMJ Open* **2019**; 9, e024336.
13. Zhang Q, Qin G, Liu Z, *et al.* Dietary Balance Index-07 and the Risk of

- 1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
- 1 Anemia in Middle Aged and Elderly People in Southwest China: A Cross
2 Sectional Study. *Nutrients* **2018**; 10, 162.
- 3 14. Zhang L, Wang F, Wang L, *et al.* Prevalence of chronic kidney disease in
4 China: a cross-sectional survey. *Lancet* **2012**; 379, 815-822.
- 5 15. Zhang M, Liu S, Yang L, *et al.* Prevalence of smoking and knowledge about
6 the smoking hazards among 170,000 Chinese adults: a nationally
7 representative survey in 2013-2014. *Nicotine Tob Res* **2019**; 21, 1644-1651.
- 8 16. Pottel H, Hoste L, Dubourg L, Ebert N, *et al.* An estimated glomerular
9 filtration rate equation for the full age spectrum. *Nephrol Dial Transplant*
10 **2016**; 31,798-806.
- 11 17. World Health Organization. Haemoglobin Concentrations for the Diagnosis of
12 Anaemia and Assessment of Severity.
13 https://apps.who.int/iris/bitstream/handle/10665/85839/WHO_NMH_NHD_M
14 [NM_11.1_eng.pdf?ua=1](https://apps.who.int/iris/bitstream/handle/10665/85839/WHO_NMH_NHD_M). Accessed July 21 **2021**.
- 15 18. Lee YG, Chang Y, Kang J, *et al.* Risk factors for incident anemia of chronic
16 diseases: A cohort study. *PLoS One* **2019**; 14, e0216062.
- 17 19. Writing Group of 2018 Chinese Guidelines for the Management of
18 Hypertension, Chinese Hypertension League, Chinese Society of Cardiology,
19 Chinese Medical Doctor Association Hypertension Committee, Hypertension
20 Branch of China International Exchange and Promotive Association for
21 Medical and Health Care, Hypertension Branch of Chinese Geriatric
22 Medical Association. 2018 Chinese guidelines for the management of
23 hypertension. *Chin J Cardiovasc Med* **2019**; 24, 24-56.
- 24 20. Qaseem A, Wilt TJ, Rich R, *et al.* Pharmacologic Treatment of Hypertension
25 in Adults Aged 60 Years or Older to Higher Versus Lower Blood Pressure
26 Targets: A Clinical Practice Guideline From the American College of
27 Physicians and the American Academy of Family Physicians. *Ann Intern Med*
28 **2017**; 166, 430-437.
- 29 21. Wang Q, Zhang X, Fang L, *et al.* Prevalence, awareness, treatment and control
30 of diabetes mellitus among middle-aged and elderly people in a rural Chinese
31 population: A cross-sectional study. *PLoS One* **2018**; 13, e0198343.
- 32 22. Joint committee for guideline revision. 2016 Chinese guidelines for the
33 management of dyslipidemia in adults. *J Geriatr Cardiol* **2018**; 15, 1-29.
- 34 23. Xu X, Hall J, Byles J, *et al.* Dietary pattern, serum magnesium, ferritin,
35 C-reactive protein and anaemia among older people. *Clin Nutr* **2017**; 36,
36 444-451.
- 37 24. Harding KL, Aguayo VM, Namirembe G, *et al.* Determinants of anemia
38 among women and children in Nepal and Pakistan: An analysis of recent
39 national survey data. *Matern Child Nutr* **2018**; Suppl 4, e12478.
- 40 25. Fiseha T, Adamu A, Tesfaye M, *et al.* Prevalence of anemia in diabetic adult
41 outpatients in Northeast Ethiopia. *PLoS One* **2019**; 14, e0222111.
- 42 26. Didzun O, De Neve JW, Awasthi A, *et al.* Anaemia among men in India: a
43 nationally representative cross-sectional study. *Lancet Glob Health* **2019**; 7,
44 e1685-e1694.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

- 1 27. Qin Y, Melse-Boonstra A, Pan X, *et al.* Anemia in relation to body mass index
2 and waist circumference among Chinese women. *Nutr J* **2013**. doi:
3 10.1186/1475-2891-1112-1110.
- 4 28. Dandona P, Aljada A, Chaudhuri A, *et al.* Metabolic syndrome: a
5 comprehensive perspective based on interactions between obesity, diabetes,
6 and inflammation. *Circulation* **2005**;111,1448-1454.
- 7 29. Schwartz AR, Patil SP, Laffan AM, *et al.* Obesity and obstructive sleep apnea:
8 pathogenic mechanisms and therapeutic approaches. *Proc Am Thorac Soc*
9 **2008**; 5, 185-192.
- 10 30. Gauci R, Hunter M, Bruce DG, *et al.* Anemia complicating type 2 diabetes:
11 Prevalence, risk factors and prognosis. *J Diabetes Complications* **2017**; 31,
12 1169-1174.
- 13 31. Thomas MC. The High Prevalence of Anemia in Diabetes Is Linked to
14 Functional Erythropoietin Deficiency. *Semin Nephrol* **2006**; 26, 275-282.
- 15 32. Zaribaf F, Entezari MH, Hassanzadeh A, *et al.* Association between dietary
16 iron, iron stores, and serum lipid profile in reproductive age women. *J Educ*
17 *Health Promot* **2014**; 3: DOI: 10.4103/2277-9531.127586.
- 18 33. Ryu SR, Park SK, Jung JY, *et al.* The Prevalence and Management of Anemia
19 in Chronic Kidney Disease Patients: Result from the KoreaN Cohort Study for
20 Outcomes in Patients With Chronic Kidney Disease (KNOW-CKD). *J Korean*
21 *Med Sci* **2017**; 32, 249-256.

1
2
3
4 **1 Tables**

5
6 **2 Table 1** Sociodemographic and other characteristics of older adults living in
7 Shenzhen community ($N=121981$)
8

Characteristics	General
Age (years)	71.28 ± 5.58
Hb(g/dL)	13.64 ± 1.67
BMI (Kg/m ²)	23.83 ± 3.17
SBP (mm Hg)	134.71 ± 17.69
DBP (mm Hg)	77.23 ± 10.31
WC (cm)	85.1 ± 8.82
FBG (mmol/L)	5.96 ± 1.9
TC(mmol/L)	5.21 ± 2
TG(mmol/L)	1.57 ± 1.14
LDL-C(mmol/L)	3.09 ± 1.05
HDL-C(mmol/L)	1.39 ± 0.51
eGFR	68.74 ± 16.7
Gender, n(%)	
Male	54649 (44.07%)
Female	69358 (55.93%)
Education level, n(%)	
Illiterate	9888 (8.11%)
Primary education	43441 (35.61%)
Junior school education and above	68652 (56.28%)
Smoking status, n (%)	
Current smoker	10023 (8.22%)
Ex-smoker	7546 (6.19%)
Never-smoker	104412 (85.6%)
Drinking habit, n (%)	
Non-drinker	101661 (83.34%)
Non-habitual drinker	12571 (10.31%)
Habitual drinker	7749 (6.35%)

9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

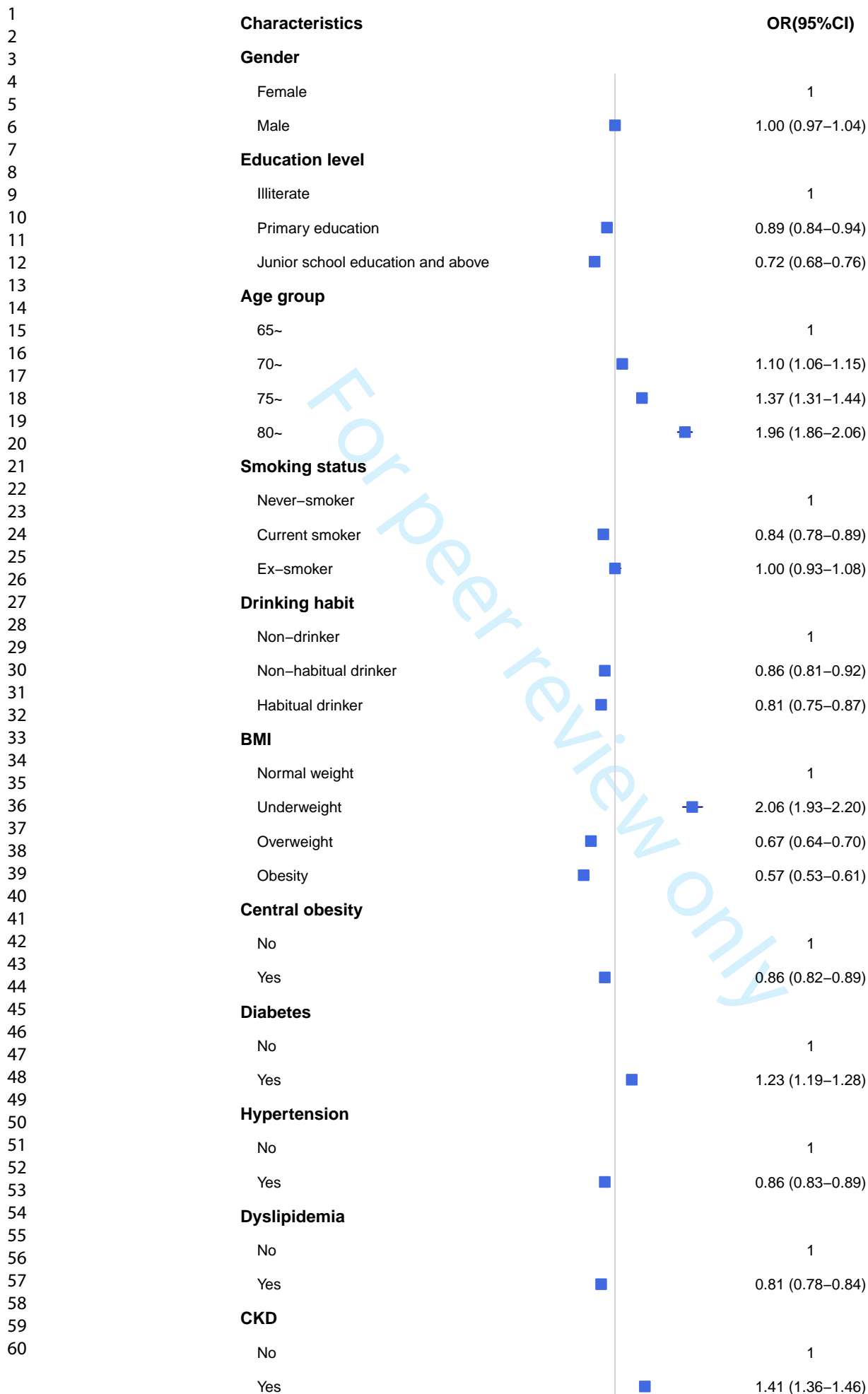
1
2
3 **Table 2** Prevalence of anemia in older adults living in Shenzhen community,
4 according to sociodemographic and other characteristics
5

Characteristics	Total	N	%	χ^2 Value	<i>P</i> Value
Total	121981	18820	15.43		
Gender				22.36	<0.001
Male	53743	7946	14.79		
Female	68238	10874	15.94		
Education level				263.21	<0.001
Illiterate	9888	2027	20.50		
Primary education	43441	7240	16.67		
Junior school education and above	68652	9553	13.92		
Age group				1201.99	<0.001
65~	60043	7635	12.72		
70~	32750	4730	14.44		
75~	16599	3070	18.50		
80~	12589	3385	26.89		
Smoking status				68.89	<0.001
Current smoker	10023	1253	12.50		
Ex-smoker	7546	1047	13.87		
Never-smoker	104412	16520	15.82		
Drinking habit				130.24	<0.001
Non-drinker	101661	16302	16.04		
Non-habitual drinker	12571	1589	12.64		
Habitual drinker	7749	929	11.99		
BMI				1522.11	<0.001
Low weight	4496	1504	33.45		
Normal weight	61532	11041	17.94		
Overweight	44644	5175	11.59		
Obesity	11309	1100	9.73		
Central obesity				540.10	<0.001
Yes	49051	5897	12.02		
No	72930	12923	17.72		
Diabetes				27.05	<0.001
Yes	27220	4520	16.61		
No	94761	14300	15.09		
Hypertension				63.27	<0.001
Yes	67835	9883	14.57		
No	54146	8937	16.51		
Dyslipidemia				211.72	<0.001
Yes	54564	7354	13.48		
No	67417	11466	17.01		
CKD				624.34	<0.001
Yes	37927	7574	19.97		
No	84054	11246	13.38		

1
2
3
4 **1 Figure legends**

- 5
6 2 Fig 1 Risk factors analyses on the prevalence of anemia in older adults living in
7 3 Shenzhen community
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

For peer review only



STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	Page 1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	Page 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 4
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 4
Methods			
Study design	4	Present key elements of study design early in the paper	Page 4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 4
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	Page 4
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 5-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page 5-6
Bias	9	Describe any efforts to address potential sources of bias	Page 6
Study size	10	Explain how the study size was arrived at	Page 4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Not applicable
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	Page 6
		(b) Describe any methods used to examine subgroups and interactions	Not applicable
		(c) Explain how missing data were addressed	Not applicable
		(d) If applicable, describe analytical methods taking account of sampling strategy	Not applicable
		(e) Describe any sensitivity analyses	Not applicable
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Page 4
		(b) Give reasons for non-participation at each stage	Not applicable
		(c) Consider use of a flow diagram	Not applicable
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page 7
		(b) Indicate number of participants with missing data for each variable of interest	Not applicable
Outcome data	15*	Report numbers of outcome events or summary measures	Page 7
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Page 7
		(b) Report category boundaries when continuous variables were categorized	Page 7
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Page 7
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Not applicable
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page 7-8
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page 8-9
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 7-9
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 9
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 9

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Anemia and associated factors among older adults in an urban district in China: a large-scale cross-sectional study

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2021-056100.R1
Article Type:	Original research
Date Submitted by the Author:	02-Oct-2021
Complete List of Authors:	Ni, Wenqing; Shenzhen Center for Chronic Disease Control, Department of Elderly Health Management Yuan, Xueli; Shenzhen Center for Chronic Disease Control, Department of Elderly Health Management Sun, Yuanying; Shenzhen Center for Chronic Disease Control, Department of Elderly Health Management Zhang, Hong; Shenzhen Center for Chronic Disease Control, Department of Elderly Health Management Zhang, Yan; Shenzhen Center for Chronic Disease Control, Department of Elderly Health Management Xu, Jian; Shenzhen Nanshan Center for Chronic Disease Control, Department of Elderly Health Management
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Epidemiology, Public health
Keywords:	Anaemia < HAEMATOLOGY, EPIDEMIOLOGY, Risk management < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

SCHOLARONE™
Manuscripts



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our [licence](#).

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which [Creative Commons](#) licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

1
2
3
4 1 **Anemia and associated factors among older adults in an urban**
5
6 2 **district in China: a large-scale cross-sectional study**
7
8
9 3

10
11 4 Wenqing Ni^{1#}, Xueli Yuan^{1#}, Yuanying Sun¹, Hongmin Zhang¹,
12
13
14 5 Yan Zhang¹, Jian Xu¹
15

16
17 6 ¹Department of Elderly Health Management, Shenzhen Center for Chronic Disease
18
19 7 Control, Shenzhen, Guangdong, 518020, China

20
21 8 # These authors contributed equally to this work.
22

23
24 9
25 10 *Corresponding author :

26 11 Jian Xu, Ph.D.

27 12 Shenzhen Center for Chronic Disease Control

28 13 No.2021, Buxin Rd. Shenzhen, Guangdong 518020, P.R. China
29

30 14
31 15 Tel: 86-755-25506942

32 16 Fax: 86-755-25506942

33 17 E-mail: anniexu73@126.com
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Abstract

Objective: Anemia leads to poor health outcomes in older adults; however, most current research in China has focused on younger adults. The present study aimed to investigate the prevalence of anemia and its associated factors in older adults in an urban district in China.

Design: A cross-sectional study.

Setting: A urbanized region, Shenzhen, China.

Participants: A total of 121,981 participants aged ≥ 65 years were recruited at local community health service centers in Shenzhen from January to December 2018.

Primary outcomes: The prevalence of anemia was analyzed and potential associated factors were evaluated.

Results: The mean Hemoglobin level was 13.64 ± 1.67 g/dL and the prevalence of anemia was 15.43%. Prevalence of mild, moderate and severe anemia were 12.24%, 2.94% and 0.25% respectively. Anemia was positively associated with older age, being underweight (adjusted odds ratio (*AOR*): 2.06, 95% confidence interval (*CI*): 1.93–2.20), diabetes (*AOR*: 1.23, 95% *CI*: 1.19–1.28), and chronic kidney disease (*AOR*: 1.41, 95% *CI*: 1.36–1.46), and inversely with higher education level, current-smoker (*AOR*: 0.84, 95% *CI*: 0.78–0.89), non-habitual drinker (*AOR*: 0.86, 95% *CI*: 0.81–0.92), habitual drinker (*AOR*: 0.81, 95% *CI*: 0.75–0.87), overweight (*AOR*: 0.67, 95% *CI*: 0.64–0.70), obesity (*AOR*: 0.57, 95% *CI*: 0.53–0.61), central obesity (*AOR*: 0.86, 95% *CI*: 0.82–0.89), hypertension (*AOR*: 0.86, 95% *CI*: 0.83–0.89), and dyslipidemia (*AOR*: 0.81, 95% *CI*: 0.78–0.84).

Conclusion: Anemia is prevalent among people aged 65 years and older in China. Screening of high-risk populations, and treatment of senile anemia should be a top priority in Shenzhen, and should be listed as important public health intervention measures for implementation.

Keywords: older adults, anemia, epidemiologic study, risk factor

1
2
3
4 1 **Strengths and limitations of this study**

5 2 ■ This was the first large-scale cross-sectional study to assess the prevalence of
6 3 anemia and its factors in an urban district in China.

7 4 ■ This study had a sufficiently large sample size to detect significant differences in
8 5 the prevalence of anemia among older adults.

9 6 ■ Convenience sampling was used to enroll the population sample.

10 7 ■ The dataset used in this study did not provide information on the dietary behavior
11 8 of the participants.
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

For peer review only

1. Introduction

Anemia results from an inadequate number of erythrocytes which leads to a decreased ability to carry oxygen to meet the body's physiological demands. It is characterized by reduced levels of hemoglobin (Hb) in the blood in affected individuals. Anemia may occur at all stages of life, however, older people are among the most vulnerable.^{1,2} Globally, 11.0% of men and 10.2% of women aged 65 years and older are anemic.³ Anemia is a risk factor for a variety of adverse outcomes in the older population, including hospitalization, disability and mortality.¹ Previous studies found higher mortality rates in people aged 65 years and older hospitalized for myocardial infarction, patients with systolic and diastolic chronic heart failure (CHF), and in older CHF patients with anemia.⁴⁻⁶ Anemia is also an independent risk factor for decline in physical performance and has a negative impact on quality of life, physical functioning, and muscle strength in older individuals.⁷⁻⁹ Early identification and treatment of anemia is therefore an important strategy to improve the quality of life of older adults with anemia.

In China, 13.5% of the total population (approximately 190.64 million people) were aged 65 years or older in 2020,¹⁰ and increasing life expectancy and declining fertility rates mean that China is experiencing an ongoing aging process. In line with the aging of the population, anemia has become an important public health problem in China. The China Health and Retirement Longitudinal Study showed a prevalence of anemia in middle-aged and older Chinese residents of 12.86% from 2011 to 2012,¹¹ and the 2010–2012 China National Nutrition and Health Survey found a prevalence of anemia in older Chinese people of 12.6%.¹² Preventing anemia and improving the health of older adults in China are thus urgent issues. However, the only previous trial for preventing anemia examined the use of iron-fortified soy sauce in some cities in China, which aimed to reduce the prevalence of iron-deficiency anemia among women of reproductive age.¹³ The prevention of anemia in older adults thus still presents a challenge, and limited measures have been taken to address this public health problem.

Identifying the factors affecting the occurrence of anemia would help to determine effective interventional targets. Economic development and living standards are important factors affecting anemia.¹⁴ Most previous studies focused on the prevalence of anemia among middle-aged and older adults in urban and rural districts of China, but there is a lack of large-sample studies of anemia among older adults in urban districts.^{11,12,15,16} This study therefore aimed to examine the prevalence of anemia and its related factors among people aged 65 or older in an urban district of China, to help develop strategies for future interventions and the prevention of anemia in older adults living in urban districts in China.

2. Materials and methods

2.1 Study population

We used convenience sampling to select our study population by recruiting people aged 65 years and older from the lists of all residents registered at local community

1 health centers in Shenzhen, China, from January 2018 to December 2018.
2 Recruitment activities include pasting posters or placing leaflets in local community
3 health centers and other public places. Electronic posters were also distributed via all
4 the open WeChat groups of local community health center staff, to make the survey
5 easily available to close contacts. The staff of the local community health centers also
6 recruited older adults in their community to participate in the survey by
7 telephone. The eligibility criteria were as follows: (1) lived in Shenzhen for more than
8 6 months; (2) able to participate in the study and give informed consent; and (3)
9 conscious and able to cooperate to complete the face-to-face interview, medical
10 examinations and biomedical tests. We excluded residents living in prisons. A total of
11 141,684 individuals were recruited in this study, accounting for 36.9%
12 (141,684/383,700) of the resident older adult population in Shenzhen according to the
13 2015 population census. Data were collected at examination centers in local
14 community health centers in the participants' residential areas. Participants were
15 asked to complete a questionnaire, provide a fasting blood sample, and undergo
16 physical examinations. A total of 19,703 respondents were excluded because of
17 failure to fulfil one or all of these requirements. Finally, 121,981 participants
18 (86.09%) were included in the final data analysis.

19 **2.2 Questionnaire survey**

20 Prior to the study, all investigators completed a training course to understand the
21 methodology and process of the study. Working manuals containing questionnaire
22 techniques, blood pressure measurement, anthropometric measurements, biological
23 sample collection, and processing information were distributed to all the investigators.

24 Data were recorded by face-to-face interview 1 hour after blood collection. All
25 participants completed a standardized questionnaire including questions on
26 sociodemographic status (e.g., date of birth, sex, education level, marital status), past
27 medical history (e.g., history of previous disease, operation history, history of
28 trauma), family health history (e.g., hypertension, diabetes, coronary heart disease,
29 malignant tumor, stroke), lifestyle (e.g., smoking, physical activity, alcohol
30 consumption), and medication use, under the supervision of trained general
31 practitioners and nurses. Educational level was categorized into three groups
32 according to the number of years of education: not educated; primary education (1–6
33 years of education); and junior high school education and above (≥ 7 years of education).
34 Regarding drinking habits, participants were classified as habitual drinkers (drink at
35 least once a day), non-habitual drinkers (six times a week to once a month), or
36 non-drinker (almost never).¹⁷ Based on a previous study, we divided participants into
37 current smokers, ex-smokers, and never-smokers.¹⁸

38 **2.3 Physical examination**

39 Anthropometric examinations were carried out in the morning after overnight
40 fasting, and body measurements were taken by trained examiners based on a
41 standardized protocol. Height and weight were measured with the participants
42 wearing light clothing without shoes, using analogue scales. Waist circumference
43 (WC) was measured at the end of normal expiration at the midpoint level of the
44 mid-axillary line between the 12th rib head and the superior anterior iliac spine. Body

1 mass index (BMI) was calculated by dividing body weight (in kilograms) by height
2 squared (in meters). Blood pressure was measured twice in both arms supported at
3 heart level with the participants in a sitting position, using a calibrated electronic
4 sphygmomanometer and the higher level was recorded and used for statistical
5 analysis. To obtain accurate readings, the participants were asked to rest for at least 5
6 min before the measurement, or if they had engaged in excessive exercise prior to the
7 visit, to rest for at least 30 min before the measurement.

8 **2.4 Blood sample collection and biochemical analyses**

9 Venous blood samples were taken after overnight fasting for at least 8 hours. All
10 blood samples were analyzed in clinical laboratories at the grade 2 hospitals to which
11 the community health centers were directly affiliated. All the laboratories had
12 successfully completed a standardization and competency program. Fasting venous
13 blood was used to measure levels of Hb, plasma glucose, creatinine, total cholesterol
14 (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-C), and
15 high-density lipoprotein cholesterol (HDL-C) using an automatic biochemistry
16 analyzer. Biochemical analysis of fresh blood samples was completed within 4 hours.
17 Serum creatinine was used to calculate the estimated glomerular filtration rate (eGFR)
18 using the full age spectrum equation.¹⁹

19 **2.5 Operational definitions/measurements**

20 Anemia was defined as a Hb concentration < 13 g/dL in men and < 12 g/dL in
21 women, according to World Health Organization standards.²⁰ The severity of anemia
22 was classified as mild (11–11.9 g/dL (women), 11–12.9 g/dL (men)), moderate (8–
23 10.9 g/dL), and severe (<8 g/dL).²⁰ Chronic kidney disease (CKD) was defined as
24 eGFR < 60 mL/min/1.73 m².²¹ A diagnosis of hypertension was considered in
25 participants with three consecutive high readings (≥ 140 systolic and/or ≥ 90 mm
26 Hg diastolic) with 2-week intervals or treatment with antihypertensive medication
27 within the previous 2 weeks was self-reported.^{22, 23} Participants who met one of the
28 following three criteria were diagnosed with diabetes: (1) previously diagnosed by
29 professional doctors, (2) fasting plasma glucose (FBG) ≥ 7.0 mmol/L, and (3) 2-hour
30 plasma glucose level ≥ 11.1 mmol/L.²⁴ High TC, high TG, high LDL-C, and low
31 HDL-C were diagnosed according to the 2016 Chinese Guidelines for the
32 Management of Dyslipidemia in Adults.²⁵ In this study, we defined dyslipidemia as an
33 abnormal concentration of one or more lipid components or the use of
34 anti-dyslipidemia medications in the past 2 weeks.

35 Participants were divided into four groups based on the adult weight criteria
36 published by the Ministry of Health of China (WS/T 428-2013): BMI < 18.5 kg/m²
37 (low weight), BMI ≥ 18.5 kg/m² and <24.0 kg/m² (normal weight), BMI ≥ 24.0 kg/m²
38 and < 28.0 kg/m² (overweight), and BMI ≥ 28.0 kg/m² (obesity). A WC ≥ 90 cm for
39 men and ≥ 85 cm for women was defined as central obesity.²⁶

40 **2.6 Statistical analyses**

41 Descriptive statistics, including means and standard deviations, were used to
42 compute continuous variables. Numerical data were expressed as percentages and
43 compared by χ^2 tests. Multivariate logistic regression analysis was performed to
44 explore the associations between the prevalence of anemia and associated risk factors.

1 In the multivariate logistic regression model, the prevalence of anemia was defined as
2 the dependent variable, and sex, education level, age group, smoking status, drinking
3 habit, BMI, central obesity, diabetes, hypertension, dyslipidemia and CKD were
4 defined as the independent variables. Data analysis was carried out using SAS 9.4
5 (Institute, Cary, NC, USA). A two-sided value of $P < 0.05$ was considered to be
6 statistically significant.

7 **2.7 Participants and public involvement**

8 Neither the study participants nor the public were involved in the design,
9 recruitment or conduct of the study. All the participants had the option of receiving a
10 health check and biochemical results when they visited the local community health
11 centers.

12 **2.8 Ethical Approval Statement**

13 The study received ethical approval from the Center for Chronic Disease Control
14 in Shenzhen (Grant No: SZCCC-201802, SZCCC-2020-018-01-PJ). The study
15 complied with the guidelines of the Declaration of Helsinki. Written informed consent
16 was obtained from all participants before the collection of data and conducting of the
17 research. If the participants were not educated, we obtained written informed consent
18 from their proxies (son, daughter, daughter-in-law, son-in-law, etc).

19 **3. Results**

20 **3.1 Characteristics of participants**

21 The characteristics of the study participants are shown in Table 1. The mean age
22 was 71.28 ± 5.58 years (range 65–103 years). There were 54,649 men and 69,358
23 women, and $> 50\%$ of participants had a minimum of a junior school education.
24 Among the study population, 8.22% were current smokers and 6.35% were habitual
25 drinkers. The mean Hb, BMI, SBP, DBP, WC, FBG, TC, TG, LDL-C, HDL-C, and
26 eGFR values among all 121,981 participants were 13.64 ± 1.67 g/dL, 23.83 ± 3.17
27 kg/m^2 , 134.71 ± 17.69 mmHg, 77.23 ± 10.31 mmHg, 85.10 ± 8.82 cm, 5.96 ± 1.90
28 mmol/L, 5.21 ± 2.00 mmol/L, 1.57 ± 1.14 mmol/L, 3.09 ± 1.05 mmol/L, 1.39 ± 1.05
29 mmol/L, and 68.74 ± 16.70 mL/min/1.73m², respectively. A total of 100,762
30 participants (82.60%) had at least one chronic disease, with hypertension (55.61%),
31 dyslipidemia (44.73%), CKD (31.09%), and diabetes (22.31%) being the most
32 prevalent (data not shown).

33 **3.2 Prevalence of anemia in different subgroups**

34 The overall prevalence anemia was 15.43% and the prevalence (95% confidence
35 intervals(CI)) of mild, moderate and severe anemia were 12.24% (12.05-12.42),
36 2.94% (2.84-3.03) and 0.25% (0.23-0.28) respectively. The prevalence of anemia
37 among subpopulations is shown in Table 2. Anemia was significantly more prevalent
38 in women than in men and generally increased with age. The prevalence was lower
39 among individuals with at least primary-level education, and lower in current smokers
40 and habitual drinkers compared with their counterparts. The prevalence of anemia was
41 higher in participants with low weight and lower in those with overweight, obesity,
42 central obesity, hypertension, or dyslipidemia. Individuals with diabetes or CKD had a
43 higher prevalence of anemia than those without these conditions.

3.3 Association between anemia and related variables

Binary logistic regression analysis was carried out with presence or absence of anemia as the dependent variable, and factors in univariate analysis as independent variables to determine the factors influencing anemia. Primary education (adjusted odds ratio (AOR)=0.89, 95%CI:0.84-0.94), junior school education and above (AOR=0.72, 95%CI:0.68-0.76) current-smoker (AOR=0.84, 95%CI:0.78-0.89), non-habitual drinker (AOR=0.86, 95%CI:0.81-0.92), habitual drinker (AOR=0.81, 95%CI:0.75-0.87), overweight (AOR=0.67, 95%CI:0.64-0.70), obesity (AOR=0.57, 95%CI:0.53-0.61), central obesity (AOR=0.86, 95%CI:0.82-0.89), hypertension (AOR=0.86, 95%CI:0.83-0.89), and dyslipidemia (AOR=0.81, 95%CI:0.78-0.84) were independently associated with lower odds for the presence of anemia (Fig. 1), while age 70-74 years (AOR=1.10, 95%CI:1.06-1.15), age 75-79 years (AOR=1.37, 95%CI:1.31-1.44), age \geq 80 years (AOR=1.96, 95%CI:1.86-2.06), underweight (AOR=2.06, 95%CI:1.93-2.20), diabetes (AOR=1.23, 95%CI:1.19-1.28), and CKD (AOR=1.41, 95%CI:1.36-1.46) were independently associated with greater odds (Fig. 1). However, there was no significant difference in the risk of anemia in relation to sex.

4. Discussion

This was the first large-scale cross-sectional survey to report the prevalence of anemia in older adults (aged 65 years or older) living in an urban district of China. This study demonstrated that the prevalence of anemia was relatively high, representing a public health problem in Shenzhen. After controlling for the confounding factors we found that the prevalence of anemia varied with education level, age group, smoking status, drinking habit, BMI, central obesity, and some non-communicable diseases. The prevalence of anemia among older adults in an urban district in China in current study was 15.43%, which was higher than the 12.86% reported in previous national studies in China,¹¹ but lower than the 18.90% reported in the 2009 national survey in China.¹³ The difference in prevalence rates among these studies may have been caused by differences in study design, sample size, and/or the age of the study participants.

The current study found a significant negative correlation between anemia prevalence and educational level. This was consistent with studies conducted in Nepal and Pakistan, which confirmed that a low educational level was a risk factor for anemia.²⁷ This relationship probably occurs because higher levels of education enable people to earn more and thus escape from the poverty trap. Multivariate analysis also identified older age as an independent risk factor for anemia, consistent with the findings of other related studies.^{3, 28} The prevalence of anemia increased with age, with a two-to-three-fold increase (26.89% vs. 12.72%) in people aged > 80 years, suggesting the need for routine screening for anemia in this high-risk subgroup.

Current smokers had a lower risk of anemia than never smokers. Similarly, previous studies showed that smoking was negatively correlated with the risk of anemia.^{29,30} A multiple logistic regression analysis of the health check-up database of

1 St. Luke's International Hospital in Tokyo between April 2016 and March 2017
2 revealed that Japanese women (35–49 years) who were current smokers had a 25%
3 lower risk of anemia compared with non-smokers, after adjusting for the covariates.³⁰
4 Increased Hb levels in smokers were associated with elevated carboxyhemoglobin
5 (HbCO), a stable complex of Hb and carbon monoxide (CO), because of the exposure
6 to excess CO caused by smoking.³¹ The form of HbCO decreases oxygen delivery,
7 and smokers had compensatory elevated Hb to increase erythropoiesis and maintain
8 oxygen transportation.³² This might explain why adaptation to excess CO during
9 smoking was reflected by increases in Hb and RBC mass.³³ Habitual drinking was
10 also associated with a decreased risk of anemia, with a corresponding OR of 0.81,
11 consistent with a Korean study.²⁹ However, the direct causality of this negative
12 correlation between alcohol drinking and anemia is still unclear.²⁹ Given the potential
13 risks of alcohol and tobacco consumption to human health, we do not recommend
14 increasing alcohol consumption or smoking to protect against anemia.

15 We also found a negative association between increased BMI and anemia
16 prevalence, in accord with other studies conducted in China, the United States, Nepal,
17 and Pakistan.^{27, 34} The reasons for being underweight may include poor distribution of
18 inadequate food within the family, food insecurity, poverty, and micronutrient
19 deficiencies, which tend to coexist with other macronutrient deficiencies. The
20 underlying mechanism accounting for the significant negative association between
21 overweight or obesity and anemia risk is unclear; however there are several possible
22 explanations. First, obese participants are less likely to be malnourished, because
23 excess calorie intake leads to obesity,³⁵ and overnutrition in obese participants may
24 thus be associated with a significant reduction in anemia risk. Second, obese
25 participants may have a variety of other diseases that could increase Hb levels, such
26 as obstructive sleep apnea and other obesity-related breathing disorders, which lead to
27 chronic tissue hypoxia and increased red blood cells.³⁶

28 We found that older people with diabetes had higher rates of anemia than
29 non-diabetics, consistent with previous studies.³⁷ Evidence indicates that the
30 incidence and prevalence of anemia in diabetic patients is often associated with
31 erythropoietin deficiency caused by diabetic kidney damage.³⁸ Other researchers have
32 also shown a link between anemia and hypertension, as shown in our current study.²¹

33 This study showed that the prevalence of anemia was low among individuals with
34 dyslipidemia. A study by Zaribaf et al. found a significant positive correlation
35 between Hb levels and dyslipidemia.³⁹ However, this study differed from our study in
36 that it assessed the relationship between anemia and lipids in premenopausal women,
37 whereas our study focused on older adults (aged 65–113 years).³⁹ In contrast, a study
38 conducted by other researchers in women of childbearing age found no significant
39 association between serum LDL and anemia.³⁹ The reasons for the different results in
40 terms of the relationship between dyslipidemia and anemia deserve further
41 investigation. Patients with CKD have defects in renal endocrine function, resulting in
42 decreased erythropoietin secretion by the kidney, leading to nephrogenic anemia.⁴⁰
43 Nearly half of all patients with CKD have anemia.⁴⁰ The current study found the
44 similar results.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 This study had some limitations. First, it was a cross-sectional study and could only
2 infer correlation, not causation. Second, randomized sampling would represent the
3 best design for testing the prevalence of anemia and its associated factors among older
4 adults; however, large random sampling was not practically feasible and we therefore
5 adopted a convenient sampling method to recruit older adult participants. This was a
6 major factor preventing the extrapolation of the results to the general population.
7 Finally, renal disease was assessed based on a one-time GFR measurement, possibly
8 leading to overestimation of the actual prevalence of CKD. However, these
9 limitations do not affect the significance of the results, which provide the first
10 evidence of the prevalence and risk factors of anemia among older adults in urban
11 China.

12 **5. Conclusion**

13 In conclusion, anemia is prevalent among the older adult population in China,
14 with older age, underweight, diabetes, CKD, and anemia being positively associated
15 with anemia, and higher education level, current-smoker, drinker, overweight,
16 obesity, central obesity, hypertension, and dyslipidemia being negatively associated.
17 Screening of high risk populations, and treatment of senile anemia should be top
18 priorities in Shenzhen, and should be listed as important public health intervention
19 measures for implementation.

23 **Acknowledgments**

24 We are grateful to all the volunteers for their participation in the present study,
25 and to all the investigators for their support and hard work during this survey.

27 **Author Contributions**

28 WN, XY, and JX: study conception and design. WN, XY, YS, HZ, YZ, and JX:
29 performance of research. XY and YS: data analysis and interpretation. WN and XY:
30 writing the original draft. WN and JX: Writing the review and editing. All authors
31 have read and agreed to the published version of the manuscript.

33 **Funding**

34 This study was supported by the Science and Technology Planning Project of
35 Shenzhen City, Guangdong Province, China (Grant No. JCYJ20180703145202065),
36 the Science and Technology Planning Project of Shenzhen City, Guangdong Province,
37 China(Grant No. KCXFZ20201221173600001) Shenzhen medical key discipline
38 construction fund, and Sanming Project of Medicine in Shenzhen (Grant No.
39 SZSM201811093).

41 **Conflicts of Interest**

42 The authors declare no conflict of interest.

1 Patient consent for publication

2 Not required.

4 Ethics approval

5 This study was approved by the ethical review committee of the Center for
6 Chronic Disease Control of Shenzhen.

8 Data sharing statement

9 All data generated or analyzed during this study are included in this published
10 article. No additional data are available.

13 References

- 15 1. Working Group on "Expert Consensus on nutrition Prevention and Treatment
16 of Iron deficiency Anemia" of Chinese Nutrition Society. Expert consensus on
17 nutrition prevention and treatment of iron deficiency anemia. *Acta Nutrimenta*
18 *Sinica* **2019**; 41,417-426.
- 19 2. Stevens GA, Finucane MM, De-Regil LM, *et al.* Global, regional, and national
20 trends in haemoglobin concentration and prevalence of total and severe
21 anaemia in children and pregnant and non-pregnant women for 1995-2011: a
22 systematic analysis of population-representative data. *Lancet Glob Health*
23 **2013**; 1, e16-25.
- 24 3. Bianchi VE. Role of nutrition on anemia in elderly. *Clin Nutr ESPEN* **2016**;
25 11, e1-e11.
- 26 4. Wu WC, Rathore SS, Wang Y, *et al.* Blood transfusion in elderly patients with
27 acute myocardial infarction. *N Engl J Med* **2001**; 345, 1230-1236.
- 28 5. Groenveld HF, Januzzi JL, Damman K, *et al.* Anemia and mortality in heart
29 failure patients a systematic review and meta-analysis. *J Am Coll Cardiol*
30 **2008**, 52, 818-827.
- 31 6. Ezekowitz JA MF, Armstrong PW. Anemia is common in heart failure and is
32 associated with poor outcomes: insights from a cohort of 12065 patients with
33 new-onset heart failure. *Circulation* **2003**; 107, 223-225.
- 34 7. Penninx BW, Guralnik JM, Onder G, *et al.* Anemia and decline in physical
35 performance among older persons. *Am J Med* **2003**; 115, 104-110.
- 36 8. Penninx BW, Pahor M, Cesari M, *et al.* Anemia is associated with disability
37 and decreased physical performance and muscle strength in the elderly. *J Am*
38 *Geriatrics Soc* **2004**; 52, 719-724.
- 39 9. Cesari M, Penninx BW, Lauretani F, *et al.* Hemoglobin levels and skeletal
40 muscle: results from the InCHIANTI study. *J Gerontol A Biol Sci Med Sci*
41 **2004**;59:249-254.
- 42 10. National Bureau of Statistics. Bulletin of the Seventh National Population
43 Census (No. 5).
44 http://www.stats.gov.cn/tjsj/tjgb/rkpcgb/qgrkpcgb/202106/t20210628_181882

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

- [4.html](#). Accessed September 26 2021
11. Qin T, Yan M, Fu Z, *et al*. Association between anemia and cognitive decline among Chinese middle-aged and elderly: evidence from the China health and retirement longitudinal study. *BMC Geriatr* **2019**; 19, 305.
 10. Ruan Y, Guo Y, Kowal P, *et al*. Association between anemia and frailty in 13,175 community-dwelling adults aged 50 years and older in China. *BMC Geriatr* **2019**; 19, 327.
 12. Chang J, Wang Y. Reports of China Nutrition and Health Survey (2010–2013). Peking University Medical Press Co. LTD, Beijing, **2016**.
 13. Xu X, Hall J, Byles J, *et al*. Dietary pattern, serum magnesium, ferritin, C-reactive protein and anaemia among older people. *Clin Nutr* **2017**; 36, 444-451.
 14. Wu Y, Ye H, Liu J, *et al*. Prevalence of anemia and sociodemographic characteristics among pregnant and non-pregnant women in southwest China: a longitudinal observational study. *BMC Pregnancy Childbirth* **2020**; 20, 535.
 15. Ruan Y, Guo Y, Kowal P, *et al*. Association between anemia and frailty in 13,175 community-dwelling adults aged 50 years and older in China. *BMC Geriatr* **2019**; 19:327.
 16. Zhang Q, Qin G, Liu Z, *et al*. Dietary Balance Index-07 and the Risk of Anemia in Middle Aged and Elderly People in Southwest China: A Cross Sectional Study. *Nutrients* **2018**; 10, 162.
 17. Zhang L, Wang F, Wang L, *et al*. Prevalence of chronic kidney disease in China: a cross-sectional survey. *Lancet* **2012**; 379, 815-822.
 18. Zhang M, Liu S, Yang L, *et al*. Prevalence of smoking and knowledge about the smoking hazards among 170,000 Chinese adults: a nationally representative survey in 2013-2014. *Nicotine Tob Res* **2019**; 21, 1644-1651.
 19. Pottel H, Hoste L, Dubourg L, Ebert N, *et al*. An estimated glomerular filtration rate equation for the full age spectrum. *Nephrol Dial Transplant* **2016**; 31,798-806.
 20. World Health Organization. Haemoglobin Concentrations for the Diagnosis of Anaemia and Assessment of Severity. https://apps.who.int/iris/bitstream/handle/10665/85839/WHO_NMH_NHD_MNM_11.1_eng.pdf?ua=1. Accessed July 21 2021.
 21. Lee YG, Chang Y, Kang J, *et al*. Risk factors for incident anemia of chronic diseases: A cohort study. *PLoS One* **2019**; 14, e0216062.
 22. Writing Group of 2018 Chinese Guidelines for the Management of Hypertension, Chinese Hypertension League, Chinese Society of Cardiology, Chinese Medical Doctor Association Hypertension Committee, Hypertension Branch of China International Exchange and Promotive Association for Medical and Health Care, Hypertension Branch of Chinese Geriatric Medical Association. 2018 Chinese guidelines for the management of hypertension. *Chin J Cardiovasc Med* **2019**; 24, 24-56.
 23. Qaseem A, Wilt TJ, Rich R, *et al*. Pharmacologic Treatment of Hypertension

- 1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
- 1 in Adults Aged 60 Years or Older to Higher Versus Lower Blood Pressure
2 Targets: A Clinical Practice Guideline From the American College of
3 Physicians and the American Academy of Family Physicians. *Ann Intern Med*
4 **2017**; 166, 430-437.
- 5 24. Wang Q, Zhang X, Fang L, *et al.* Prevalence, awareness, treatment and control
6 of diabetes mellitus among middle-aged and elderly people in a rural Chinese
7 population: A cross-sectional study. *PLoS One* **2018**; 13, e0198343.
- 8 25. Joint committee for guideline revision. 2016 Chinese guidelines for the
9 management of dyslipidemia in adults. *J Geriatr Cardiol* **2018**; 15, 1-29.
- 10 26. National Health Commission of the People's Republic of China. Criteria of
11 Weight for Adults.
12 [http://www.nhc.gov.cn/ewebeditor/uploadfile/2013/08/20130808135715967.p](http://www.nhc.gov.cn/ewebeditor/uploadfile/2013/08/20130808135715967.pdf)
13 [df](http://www.nhc.gov.cn/ewebeditor/uploadfile/2013/08/20130808135715967.pdf). Accessed September 26 **2021**
- 14 27. Harding KL, Aguayo VM, Namirembe G, *et al.* Determinants of anemia
15 among women and children in Nepal and Pakistan: An analysis of recent
16 national survey data. *Matern Child Nutr* **2018**; Suppl 4, e12478.
- 17 28. Fiseha T, Adamu A, Tesfaye M, *et al.* Prevalence of anemia in diabetic adult
18 outpatients in Northeast Ethiopia. *PLoS One* **2019**; 14, e0222111.
- 19 29. Chun MY, Kim JH, Kang JS. Relationship between Self-Reported Sleep
20 Duration and Risk of Anemia: Data from the Korea National Health and
21 Nutrition Examination Survey 2016-2017. *Int J Environ Res Public Health*
22 **2021**; 18:4721.
- 23 30. Hisa K, Haruna M, Hikita N, *et al.* Prevalence of and factors related to anemia
24 among Japanese adult women: Secondary data analysis using health check-up
25 database. *Sci Rep* **2019**;9:17048.
- 26 31. Nordenberg D, Yip R, Binkin NJ. The effect of cigarette smoking on
27 hemoglobin levels and anemia screening. *JAMA* **1990**;264:1556-1559.
- 28 32. Sharma AJ, Addo OY, Mei Z, *et al.* Reexamination of hemoglobin adjustments
29 to define anemia: altitude and smoking. *Ann N Y Acad Sci* **2019**;1450:190-203.
- 30 33. Pollini G, Maugeri U, Bernardo A, *et al.* Erythrocytes parameters due to aging,
31 smoking, alcohol consumption and occupational activity in a working
32 population of petrochemical industry. The Pavia Study. *G Ital Med Lav*
33 **1989**;11:237-240.
- 34 34. Qin Y, Melse-Boonstra A, Pan X, *et al.* Anemia in relation to body mass index
35 and waist circumference among Chinese women. *Nutr J* **2013**. doi:
36 10.1186/1475-2891-1112-1110.
- 37 35. Dandona P, Aljada A, Chaudhuri A, *et al.* Metabolic syndrome: a
38 comprehensive perspective based on interactions between obesity, diabetes,
39 and inflammation. *Circulation* **2005**;111,1448-1454.
- 40 36. Schwartz AR, Patil SP, Laffan AM, *et al.* Obesity and obstructive sleep apnea:
41 pathogenic mechanisms and therapeutic approaches. *Proc Am Thorac Soc*
42 **2008**; 5, 185-192.
- 43 37. Gauci R, Hunter M, Bruce DG, *et al.* Anemia complicating type 2 diabetes:
44 Prevalence, risk factors and prognosis. *J Diabetes Complications* **2017**; 31,

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1169-1174.

38. Thomas MC. The High Prevalence of Anemia in Diabetes Is Linked to Functional Erythropoietin Deficiency. *Semin Nephrol* **2006**; 26, 275-282.
39. Zaribaf F, Entezari MH, Hassanzadeh A, *et al.* Association between dietary iron, iron stores, and serum lipid profile in reproductive age women. *J Educ Health Promot* **2014**; 3: DOI: 10.4103/2277-9531.127586.
40. Ryu SR, Park SK, Jung JY, *et al.* The Prevalence and Management of Anemia in Chronic Kidney Disease Patients: Result from the KoreaN Cohort Study for Outcomes in Patients With Chronic Kidney Disease (KNOW-CKD). *J Korean Med Sci* **2017**; 32, 249-256.

For peer review only

Tables

Table 1 Sociodemographic and other characteristics of older adults living in Shenzhen community ($N=121,981$)

Characteristics	Total	95%CI
Age (years)	71.28 ± 5.58	71.25-71.31
Hb(g/dL)	13.64 ± 1.67	13.63-13.65
BMI (Kg/m ²)	23.83 ± 3.17	23.81-23.85
SBP (mm Hg)	134.71 ± 17.69	134.61-134.81
DBP (mm Hg)	77.23 ± 10.31	77.18-77.29
WC (cm)	85.1 ± 8.82	85.05-85.15
FBG (mmol/L)	5.96 ± 1.9	5.95-5.97
TC(mmol/L)	5.21 ± 2	5.20-5.23
TG(mmol/L)	1.57 ± 1.14	1.57-1.58
LDL-C(mmol/L)	3.09 ± 1.05	3.08-3.09
HDL-C(mmol/L)	1.39 ± 0.51	1.39-1.39
eGFR	68.74 ± 16.7	68.65-68.83
Sex, n(%)		
Male	54649 (44.07%)	43.78-44.34
Female	69358 (55.93%)	55.66-56.22
Education level, n(%)		
Not educated	9888 (8.11%)	7.95-8.26
Primary education	43441 (35.61%)	35.34-35.88
Junior school education and above	68652 (56.28%)	56.00-56.56
Smoking status, n (%)		
Current smoker	10023 (8.22%)	8.06-8.37
Ex-smoker	7546 (6.19%)	6.05-6.32
Never-smoker	104412 (85.59%)	85.40-85.79
Drinking habit, n (%)		
Non-drinker	101661 (83.34%)	83.13-83.55
Non-habitual drinker	12571 (10.31%)	10.14-10.48
Habitual drinker	7749 (6.35%)	6.22-6.49

1
2
3 1
4 2
5 2
6 3 **Table 2** Prevalence of anemia in older adults living in Shenzhen community,
7 4 according to sociodemographic and other characteristics
8

Characteristics	Total	N	%	95%CI	χ^2 Value	P Value
Total	121981	18820	15.43	15.23-15.63		
Sex					22.36	<0.001
Male	53743	7946	14.79	14.49-15.09		
Female	68238	10874	15.94	15.66-16.21		
Education level					263.21	<0.001
Not educated	9888	2027	20.50	19.70-21.30		
Primary education	43441	7240	16.67	16.32-17.02		
Junior school education and above	68652	9553	13.92	13.66-14.17		
Age group					1201.99	<0.001
65~69	60043	7635	12.72	12.45-12.98		
70~74	32750	4730	14.44	14.06-14.82		
75~79	16599	3070	18.50	17.90-19.09		
80~	12589	3385	26.89	26.11-27.66		
Smoking status					68.89	<0.001
Current smoker	10023	1253	12.50	11.85-13.15		
Ex-smoker	7546	1047	13.87	13.09-14.65		
Never-smoker	104412	16520	15.82	15.60-16.04		
Drinking habit					130.24	<0.001
Non-drinker	101661	16302	16.04	15.81-16.26		
Non-habitual drinker	12571	1589	12.64	12.06-13.22		
Habitual drinker	7749	929	11.99	11.27-12.71		
BMI					1522.11	<0.001
Low weight	4496	1504	33.45	32.07-34.83		
Normal weight	61532	11041	17.94	17.64-18.25		
Overweight	44644	5175	11.59	11.29-11.89		
Obesity	11309	1100	9.73	9.18-10.27		
Central obesity					540.10	<0.001
Yes	49051	5897	12.02	11.73-12.31		
No	72930	12923	17.72	17.44-18.00		
Diabetes					27.05	<0.001
Yes	27220	4520	16.61	16.16-17.05		
No	94761	14300	15.09	14.86-15.32		
Hypertension					63.27	<0.001
Yes	67835	9883	14.57	14.30-14.83		
No	54146	8937	16.51	16.19-16.82		
Dyslipidemia					211.72	<0.001
Yes	54564	7354	13.48	13.19-13.76		
No	67417	11466	17.01	16.72-17.29		
CKD					624.34	<0.001

Yes	37927	7574	19.97	19.57-20.37
No	84054	11246	13.38	13.15-13.61

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 A two-sided value of $P < 0.05$ was considered to be statistically significant.

2

3

4

5

6

7

8

9

10

11

12

13

14

15

16

17

18

19

20

21

22

For peer review only

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1

2 **Figure legends**

3 Fig 1 Risk factor analyses of the prevalence of anemia in older adults living in
4 Shenzhen community

For peer review only

Characteristics	AOR(95%CI)
Gender	
Female	1
Male	1.00 (0.97–1.04)
Education level	
Not educated	1
Primary education	0.89 (0.84–0.94)
Junior school education and above	0.72 (0.68–0.76)
Age group	
65~69	1
70~74	1.10 (1.06–1.15)
75~79	1.37 (1.31–1.44)
80~	1.96 (1.86–2.06)
Smoking status	
Never-smoker	1
Current smoker	0.84 (0.78–0.89)
Ex-smoker	1.00 (0.93–1.08)
Drinking habit	
Non-drinker	1
Non-habitual drinker	0.86 (0.81–0.92)
Habitual drinker	0.81 (0.75–0.87)
BMI	
Normal weight	1
Underweight	2.06 (1.93–2.20)
Overweight	0.67 (0.64–0.70)
Obesity	0.57 (0.53–0.61)
Central obesity	
No	1
Yes	0.86 (0.82–0.89)
Diabetes	
No	1
Yes	1.23 (1.19–1.28)
Hypertension	
No	1
Yes	0.86 (0.83–0.89)
Dyslipidemia	
No	1
Yes	0.81 (0.78–0.84)
CKD	
No	1
Yes	1.41 (1.36–1.46)

For peer review only

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study’s design with a commonly used term in the title or the abstract	Page 1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	Page 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 4
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 4
Methods			
Study design	4	Present key elements of study design early in the paper	Page 4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 4
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	Page 4
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 5-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page 5-6
Bias	9	Describe any efforts to address potential sources of bias	Page 6
Study size	10	Explain how the study size was arrived at	Page 4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Not applicable
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	Page 6
		(b) Describe any methods used to examine subgroups and interactions	Not applicable
		(c) Explain how missing data were addressed	Not applicable
		(d) If applicable, describe analytical methods taking account of sampling strategy	Not applicable
		(e) Describe any sensitivity analyses	Not applicable
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Page 4
		(b) Give reasons for non-participation at each stage	Not applicable
		(c) Consider use of a flow diagram	Not applicable
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page 7
		(b) Indicate number of participants with missing data for each variable of interest	Not applicable
Outcome data	15*	Report numbers of outcome events or summary measures	Page 7
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Page 7
		(b) Report category boundaries when continuous variables were categorized	Page 7
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Page 7
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Not applicable
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page 7-8
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page 8-9
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 7-9
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 9
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 9

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Anemia and associated factors among older adults in an urban district in China: a large-scale cross-sectional study

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2021-056100.R2
Article Type:	Original research
Date Submitted by the Author:	30-Nov-2021
Complete List of Authors:	Ni, Wenqing; Shenzhen Center for Chronic Disease Control, Department of Elderly Health Management Yuan, Xueli; Shenzhen Center for Chronic Disease Control, Department of Elderly Health Management Sun, Yuanying; Shenzhen Center for Chronic Disease Control, Department of Elderly Health Management Zhang, Hong; Shenzhen Center for Chronic Disease Control, Department of Elderly Health Management Zhang, Yan; Shenzhen Center for Chronic Disease Control, Department of Elderly Health Management Xu, Jian; Shenzhen Nanshan Center for Chronic Disease Control, Department of Elderly Health Management
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Epidemiology, Public health
Keywords:	Anaemia < HAEMATOLOGY, EPIDEMIOLOGY, Risk management < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

SCHOLARONE™
Manuscripts



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our [licence](#).

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which [Creative Commons](#) licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

1
2
3
4 1 **Anemia and associated factors among older adults in an urban**
5
6 2 **district in China: a large-scale cross-sectional study**
7
8
9 3

10
11 4 Wenqing Ni^{1#}, Xueli Yuan^{1#}, Yuanying Sun¹, Hongmin Zhang¹,
12
13
14 5 Yan Zhang¹, Jian Xu¹
15

16
17 6 ¹Department of Elderly Health Management, Shenzhen Center for Chronic Disease
18
19 7 Control, Shenzhen, Guangdong, 518020, China

20
21 8 # These authors contributed equally to this work.
22

23
24 9
25 10 *Corresponding author :

26 11 Jian Xu, Ph.D.

27 12 Shenzhen Center for Chronic Disease Control

28 13 No.2021, Buxin Rd. Shenzhen, Guangdong 518020, P.R. China
29

30 14
31 15 Tel: 86-755-25506942

32 16 Fax: 86-755-25506942

33 17 E-mail: anniexu73@126.com
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Abstract

Objective: Anemia leads to poor health outcomes in older adults; however, most current research in China has focused on younger adults. The present study aimed to investigate the prevalence of anemia and its associated factors in older adults in an urban district in China.

Design: A cross-sectional study.

Setting: An urbanized region, Shenzhen, China.

Participants: A total of 121,981 participants aged ≥ 65 years were recruited at local community health service centers in Shenzhen from January to December 2018.

Primary outcomes: The prevalence of anemia was analyzed and potential associated factors were evaluated.

Results: The mean hemoglobin level was 13.64 ± 1.67 g/dL and the prevalence of anemia was 15.43%. The prevalences of mild, moderate, and severe anemia were 12.24%, 2.94%, and 0.25% respectively. Anemia was positively associated with older age, being underweight (adjusted odds ratio (AOR): 2.06, 95% confidence interval (CI): 1.93–2.20), diabetes (AOR: 1.23, 95% CI: 1.19–1.28), and chronic kidney disease (AOR: 1.41, 95% CI: 1.36–1.46), and inversely with higher education level, current-smoker (AOR: 0.84, 95% CI: 0.78–0.89), non-habitual drinker (AOR: 0.86, 95% CI: 0.81–0.92), habitual drinker (AOR: 0.81, 95% CI: 0.75–0.87), overweight (AOR: 0.67, 95% CI: 0.64–0.70), obesity (AOR: 0.57, 95% CI: 0.53–0.61), central obesity (AOR: 0.86, 95% CI: 0.82–0.89), hypertension (AOR: 0.86, 95% CI: 0.83–0.89), and dyslipidemia (AOR: 0.81, 95% CI: 0.78–0.84).

Conclusion: Anemia is prevalent among people aged 65 years and older in China. Screening of high-risk populations and treatment of senile anemia should be a top priority in Shenzhen, and should be listed as important public health intervention measures for implementation.

Keywords: older adults, anemia, epidemiologic study, risk factor

Strengths and limitations of this study

■ This was the first large-scale cross-sectional study to assess the prevalence of anemia and its factors in an urban district in China.

■ This study had a sufficiently large sample size to detect significant differences in the prevalence of anemia among older adults.

■ Convenience sampling was used to enroll the population sample.

■ The dataset used in this study did not provide information on the dietary behavior of the participants.

For peer review only

1. Introduction

Anemia results from an inadequate number of erythrocytes which leads to a decreased ability to carry oxygen to meet the body's physiological demands. It is characterized by reduced levels of hemoglobin (Hb) in the blood in affected individuals. Anemia may occur at all stages of life, however, older people are among the most vulnerable.^{1,2} Globally, 11.0% of men and 10.2% of women aged 65 years and older are anemic.³ Anemia is a risk factor for a variety of adverse outcomes in the older population, including hospitalization, disability and mortality.¹ Previous studies found higher mortality rates in people aged 65 years and older hospitalized for myocardial infarction, patients with systolic and diastolic chronic heart failure (CHF), and in older CHF patients with anemia.⁴⁻⁶ Anemia is also an independent risk factor for decline in physical performance and has a negative impact on quality of life, physical functioning, and muscle strength in older individuals.⁷⁻⁹ Early identification and treatment of anemia is therefore an important strategy to improve the quality of life of older adults with anemia.

In China, 13.5% of the total population (approximately 190.64 million people) were aged 65 years or older in 2020,¹⁰ and increasing life expectancy and declining fertility rates mean that China is experiencing an ongoing aging process. In line with the aging of the population, anemia has become an important public health problem in China. The China Health and Retirement Longitudinal Study showed a prevalence of anemia in middle-aged and older Chinese residents of 12.86% from 2011 to 2012,¹¹ and the 2010–2012 China National Nutrition and Health Survey found a prevalence of anemia in older Chinese people of 12.6%.¹² Preventing anemia and improving the health of older adults in China are thus urgent issues. However, the only previous trial for preventing anemia examined the use of iron-fortified soy sauce in some cities in China, which aimed to reduce the prevalence of iron-deficiency anemia among women of reproductive age.¹³ The prevention of anemia in older adults thus still presents a challenge, and limited measures have been taken to address this public health problem.

Clarifying the risk factors of anemia in the older adults will help to identify the population at risk of anemia, and promote the development of targeted screening and intervention measures. Economic development and living standards are important factors affecting anemia.¹⁴ Most previous studies focused on the prevalence of anemia among middle-aged and older adults in urban and rural districts of China, but there is a lack of large-sample studies of anemia among older adults in urban districts.^{11,12,15,16} This study therefore aimed to examine the prevalence of anemia and its related factors among people aged 65 or older in an urban district of China, to help develop strategies for future interventions and the prevention of anemia in older adults living in urban districts in China.

2. Materials and methods

2.1 Study population

We used convenience sampling to select our study population by recruiting people

aged 65 years and older from the lists of all residents registered at local community health centers in Shenzhen, China, from January 2018 to December 2018. Recruitment activities include pasting posters or placing leaflets in local community health centers and other public places. Electronic posters were also distributed via all the open WeChat groups of local community health center staff, to make the survey easily available to close contacts. The staff of the local community health centers also recruited older adults in their community to participate in the survey by telephone. The eligibility criteria were as follows: (1) lived in Shenzhen for more than 6 months; (2) able to participate in the study and give informed consent; and (3) conscious and able to cooperate to complete the face-to-face interview, medical examinations and biomedical tests. Prisoners are not free to visit community health centres, and we excluded residents living in prisons. A total of 141,684 individuals were recruited in this study, accounting for 36.9% (141,684/383,700) of the resident older adult population in Shenzhen according to the 2015 population census. Data were collected at examination centers in local community health centers in the participants' residential areas. Participants were asked to complete a questionnaire, provide a fasting blood sample, and undergo physical examinations. A total of 19,703 respondents were excluded because of failure to fulfil one or all of these requirements. Finally, 121,981 participants (86.09%) were included in the final data analysis.

2.2 Questionnaire survey

Prior to the study, all investigators completed a training course to understand the methodology and process of the study. Working manuals containing questionnaire techniques, blood pressure measurement, anthropometric measurements, biological sample collection, and processing information were distributed to all the investigators.

Data were recorded by face-to-face interview 1 hour after blood collection. All participants completed a standardized questionnaire including questions on sociodemographic status (e.g., date of birth, sex, education level, marital status), past medical history (e.g., history of previous disease, operation history, history of trauma), family health history (e.g., hypertension, diabetes, coronary heart disease, malignant tumor, stroke), lifestyle (e.g., smoking, physical activity, alcohol consumption), and medication use, under the supervision of trained general practitioners and nurses. Educational level was categorized into three groups according to the number of years of education: not educated; primary education (1–6 years of education); and junior high school education and above (≥ 7 years of education). Regarding drinking habits, participants were classified as habitual drinkers (drink at least once a day), non-habitual drinkers (six times a week to once a month), or non-drinker (almost never).¹⁷ Based on a previous study, we divided participants into current smokers, ex-smokers, and never-smokers.¹⁸

2.3 Physical examination

Anthropometric examinations were carried out in the morning after overnight fasting, and body measurements were taken by trained examiners based on a standardized protocol. Height and weight were measured with the participants wearing light clothing without shoes, using analogue scales. Waist circumference (WC) was measured at the end of normal expiration at the midpoint level of the

1 mid-axillary line between the 12th rib head and the superior anterior iliac spine. Body
2 mass index (BMI) was calculated by dividing body weight (in kilograms) by height
3 squared (in meters). Blood pressure was measured twice in both arms supported at
4 heart level with the participants in a sitting position, using a calibrated electronic
5 sphygmomanometer and the higher level was recorded and used for statistical
6 analysis. To obtain accurate readings, the participants were asked to rest for at least 5
7 min before the measurement, or if they had engaged in excessive exercise prior to the
8 visit, to rest for at least 30 min before the measurement.

9 **2.4 Blood sample collection and biochemical analyses**

10 Venous blood samples were taken after overnight fasting for at least 8 hours. All
11 blood samples were analyzed in clinical laboratories at the grade 2 hospitals to which
12 the community health centers were directly affiliated. All the laboratories had
13 successfully completed a standardization and competency program. Fasting venous
14 blood was used to measure levels of Hb, plasma glucose, creatinine, total cholesterol
15 (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-C), and
16 high-density lipoprotein cholesterol (HDL-C) using an automatic biochemistry
17 analyzer. Biochemical analysis of fresh blood samples was completed within 4 hours.
18 Serum creatinine was used to calculate the estimated glomerular filtration rate (eGFR)
19 using the full age spectrum equation.¹⁹

20 **2.5 Operational definitions/measurements**

21 Anemia was defined as a Hb concentration < 13 g/dL in men and < 12 g/dL in
22 women, according to World Health Organization standards.²⁰ The severity of anemia
23 was classified as mild (11–11.9 g/dL (women), 11–12.9 g/dL (men)), moderate (8–
24 10.9 g/dL), and severe (<8 g/dL).²⁰ Chronic kidney disease (CKD) was defined as
25 eGFR < 60 mL/min/1.73 m².²¹ A diagnosis of hypertension was considered in
26 participants with three consecutive high readings (≥ 140 systolic and/or ≥ 90 mm
27 Hg diastolic) with 2-week intervals or self-reported treatment with antihypertensive
28 medication within the previous 2 weeks.^{22, 23} Participants who met one of the
29 following three criteria were diagnosed with diabetes: (1) previously diagnosed by
30 professional doctors, (2) fasting plasma glucose (FBG) ≥ 7.0 mmol/L, and (3) 2-hour
31 plasma glucose level ≥ 11.1 mmol/L.²⁴ High TC, high TG, high LDL-C, and low
32 HDL-C were diagnosed according to the 2016 Chinese Guidelines for the
33 Management of Dyslipidemia in Adults.²⁵ In this study, we defined dyslipidemia as an
34 abnormal concentration of one or more lipid components or the use of
35 anti-dyslipidemia medications in the past 2 weeks.

36 Participants were divided into four groups based on the adult weight criteria
37 published by the Ministry of Health of China (WS/T 428-2013): BMI < 18.5 kg/m²
38 (low weight), BMI ≥ 18.5 kg/m² and <24.0 kg/m² (normal weight), BMI ≥ 24.0 kg/m²
39 and < 28.0 kg/m² (overweight), and BMI ≥ 28.0 kg/m² (obesity). A WC ≥ 90 cm for
40 men and ≥ 85 cm for women was defined as central obesity.²⁶

41 **2.6 Statistical analyses**

42 Descriptive statistics, including means and standard deviations, were used to
43 compute continuous variables. Numerical data were expressed as percentages and
44 compared by χ^2 tests. Multivariate logistic regression analysis was performed to

1 explore the associations between the prevalence of anemia and associated risk factors.
2 In the multivariate logistic regression model, the prevalence of anemia was defined as
3 the dependent variable, and sex, education level, age group, smoking status, drinking
4 habit, BMI, central obesity, diabetes, hypertension, dyslipidemia and CKD were
5 defined as the independent variables. Data analysis was carried out using SAS 9.4
6 (Institute, Cary, NC, USA). A two-sided value of $P < 0.05$ was considered to be
7 statistically significant.

8 **2.7 Participants and public involvement**

9 Neither the study participants nor the public were involved in the design,
10 recruitment or conduct of the study. All the participants had the option of receiving a
11 health check and biochemical results when they visited the local community health
12 centers.

13 **2.8 Ethical Approval Statement**

14 The study received ethical approval from the Center for Chronic Disease Control
15 in Shenzhen (Grant No: SZCCC-201802, SZCCC-2020-018-01-PJ). The study
16 complied with the guidelines of the Declaration of Helsinki. Written informed consent
17 was obtained from uneducated participants before the collection of data and
18 conducting of the study. For participants who were not educated, the participants and
19 a proxy (family member) who accompanied the participant in the survey were
20 informed orally (participant) and in writing (proxy) about the purpose, process, methods,
21 benefits, and health risks of the study. During the informed consent process, uneducated
22 older adults and their proxies were able to consult the investigators with questions at any
23 time. After explaining the concept of informed consent, uneducated older adults provided
24 verbal agreement, and written informed consent to participate in the study was provided
25 by their proxy. The consent processes were approved by the committee of the Center for
26 Chronic Disease Control of Shenzhen.

27 **3. Results**

28 **3.1 Characteristics of participants**

29 The characteristics of the study participants are shown in Table 1. The mean age
30 was 71.28 ± 5.58 years (range 65–103 years). There were 54,649 men and 69,358
31 women, and $> 50\%$ of participants had a minimum of a junior school education.
32 Among the study population, 8.22% were current smokers and 6.35% were habitual
33 drinkers. The mean Hb, BMI, SBP, DBP, WC, FBG, TC, TG, LDL-C, HDL-C, and
34 eGFR values among all 121,981 participants were 13.64 ± 1.67 g/dL, 23.83 ± 3.17
35 kg/m^2 , 134.71 ± 17.69 mmHg, 77.23 ± 10.31 mmHg, 85.10 ± 8.82 cm, 5.96 ± 1.90
36 mmol/L, 5.21 ± 2.00 mmol/L, 1.57 ± 1.14 mmol/L, 3.09 ± 1.05 mmol/L, 1.39 ± 1.05
37 mmol/L, and 68.74 ± 16.70 mL/min/1.73m², respectively. A total of 100,762
38 participants (82.60%) had at least one chronic disease, with hypertension (55.61%),
39 dyslipidemia (44.73%), CKD (31.09%), and diabetes (22.31%) being the most
40 prevalent (data not shown).

41 **3.2 Prevalence of anemia in different subgroups**

42 The overall prevalence anemia was 15.43% and the prevalences (95% confidence
43 intervals(CI)) of mild, moderate and severe anemia were 12.24% (12.05-12.42),
44

2.94% (2.84-3.03) and 0.25% (0.23-0.28) respectively. The prevalence of anemia among subpopulations is shown in Table 2. Anemia was significantly more prevalent in women than in men and generally increased with age. The prevalence was lower among individuals with at least primary-level education, and lower in current smokers and habitual drinkers compared with their counterparts. The prevalence of anemia was higher in participants with low weight and lower in those with overweight, obesity, central obesity, hypertension, or dyslipidemia. Individuals with diabetes or CKD had a higher prevalence of anemia than those without these conditions.

3.3 Association between anemia and related variables

Binary logistic regression analysis was carried out with presence or absence of anemia as the dependent variable, and factors in univariate analysis as independent variables to determine the factors influencing anemia. Primary education (adjusted odds ratio (AOR)=0.89, 95%CI:0.84-0.94), junior school education and above (AOR=0.72, 95%CI:0.68-0.76) current-smoker (AOR=0.84, 95%CI:0.78-0.89), non-habitual drinker (AOR=0.86, 95%CI:0.81-0.92), habitual drinker (AOR=0.81, 95%CI:0.75-0.87), overweight (AOR=0.67, 95%CI:0.64-0.70), obesity (AOR=0.57, 95%CI:0.53-0.61), central obesity (AOR=0.86, 95%CI:0.82-0.89), hypertension (AOR=0.86, 95%CI:0.83-0.89), and dyslipidemia (AOR=0.81, 95%CI:0.78-0.84) were independently associated with lower odds for the presence of anemia (Fig. 1), while age 70-74 years (AOR=1.10, 95%CI:1.06-1.15), age 75-79 years (AOR=1.37, 95%CI:1.31-1.44), age \geq 80 years (AOR=1.96, 95%CI:1.86-2.06), underweight (AOR=2.06, 95%CI:1.93-2.20), diabetes (AOR=1.23, 95%CI:1.19-1.28), and CKD (AOR=1.41, 95%CI:1.36-1.46) were independently associated with greater odds (Fig. 1). However, there was no significant difference in the risk of anemia in relation to sex.

4. Discussion

This was the first large-scale cross-sectional survey to report the prevalence of anemia in older adults (aged 65 years or older) living in an urban district of China. This study demonstrated that the prevalence of anemia was relatively high, representing a public health problem in Shenzhen. After controlling for the confounding factors we found that the prevalence of anemia varied with education level, age group, smoking status, drinking habit, BMI, central obesity, and some non-communicable diseases. The prevalence of anemia among older adults in an urban district in China in the current study was 15.43%, which was higher than the 12.86% reported in previous national studies in China,¹¹ but lower than the 18.90% reported in the 2009 national survey in China.¹³ The difference in prevalence rates among these studies may have been caused by differences in study design, sample size, and/or the age of the study participants.

The current study found a significant negative correlation between anemia prevalence and educational level. This was consistent with studies conducted in Nepal and Pakistan, which confirmed that a low educational level was a risk factor for anemia.²⁷ This relationship probably occurs because higher levels of education enable

1 people to earn more and thus escape from the poverty trap. Multivariate analysis also
2 identified older age as an independent risk factor for anemia, consistent with the
3 findings of other related studies.^{3, 28} The prevalence of anemia increased with age,
4 with a two-to-three-fold increase (26.89% vs. 12.72%) in people aged > 80 years,
5 suggesting the need for routine screening for anemia in this high-risk subgroup.

6 Current smokers had a lower risk of anemia than never smokers. Similarly,
7 previous studies showed that smoking was negatively correlated with the risk of
8 anemia.^{29,30} A multiple logistic regression analysis of the health check-up database of
9 St. Luke's International Hospital in Tokyo between April 2016 and March 2017
10 revealed that Japanese women (35–49 years) who were current smokers had a 25%
11 lower risk of anemia compared with non-smokers, after adjusting for the covariates.³⁰
12 Increased Hb levels in smokers were associated with elevated carboxyhemoglobin
13 (HbCO), a stable complex of Hb and carbon monoxide (CO), because of the exposure
14 to excess CO caused by smoking.³¹ The form of HbCO decreases oxygen delivery,
15 and smokers had compensatory elevated Hb to increase erythropoiesis and maintain
16 oxygen transportation.³² This might explain why adaptation to excess CO during
17 smoking was reflected by increases in Hb and RBC mass.³³ Habitual drinking was
18 also associated with a decreased risk of anemia, with a corresponding OR of 0.81,
19 consistent with a Korean study.²⁹ However, the direct causality of this negative
20 correlation between alcohol drinking and anemia is still unclear.²⁹ Given the potential
21 risks of alcohol and tobacco consumption to human health, we do not recommend
22 increasing alcohol consumption or smoking to protect against anemia.

23 We also found a negative association between increased BMI and anemia
24 prevalence, in accord with other studies conducted in China, the United States, Nepal,
25 and Pakistan.^{27, 34} The reasons for being underweight may include poor distribution of
26 inadequate food within the family, food insecurity, poverty, and micronutrient
27 deficiencies, which tend to coexist with other macronutrient deficiencies. The
28 underlying mechanism accounting for the significant negative association between
29 overweight or obesity and anemia risk is unclear; however there are several possible
30 explanations. First, obese participants are less likely to be malnourished, because
31 excess calorie intake leads to obesity,³⁵ and overnutrition in obese participants may
32 thus be associated with a significant reduction in anemia risk. Second, obese
33 participants may have a variety of other diseases that could increase Hb levels, such
34 as obstructive sleep apnea and other obesity-related breathing disorders, which lead to
35 chronic tissue hypoxia and increased red blood cells.³⁶

36 We found that older people with diabetes had higher rates of anemia than
37 non-diabetics, consistent with previous studies.³⁷ Evidence indicates that the
38 incidence and prevalence of anemia in diabetic patients is often associated with
39 erythropoietin deficiency caused by diabetic kidney damage.³⁸ Other researchers have
40 also shown a link between anemia and hypertension, as shown in our current study.²¹

41 This study showed that the prevalence of anemia was low among individuals with
42 dyslipidemia. A study by Zaribaf et al. found a significant positive correlation
43 between Hb levels and dyslipidemia.³⁹ However, this study differed from our study in
44 that it assessed the relationship between anemia and lipids in premenopausal women,

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 whereas our study focused on older adults (aged 65–113 years).³⁹ In contrast, a study
2 conducted by other researchers in women of childbearing age found no significant
3 association between serum LDL and anemia.³⁹ The reasons for the different results in
4 terms of the relationship between dyslipidemia and anemia deserve further
5 investigation. Patients with CKD have defects in renal endocrine function, resulting in
6 decreased erythropoietin secretion by the kidney, leading to nephrogenic anemia.⁴⁰
7 Nearly half of all patients with CKD have anemia.⁴⁰ The current study found the
8 similar results.

9 This study had some limitations. First, it was a cross-sectional study and could only
10 infer correlation, not causation. Second, randomized sampling would represent the
11 best design for testing the prevalence of anemia and its associated factors among older
12 adults; however, large random sampling was not practically feasible and we therefore
13 adopted a convenient sampling method to recruit older adult participants. This was a
14 major factor preventing the extrapolation of the results to the general population.
15 Finally, renal disease was assessed based on a one-time GFR measurement, possibly
16 leading to overestimation of the actual prevalence of CKD. However, these
17 limitations do not affect the significance of the results, which provide the first
18 evidence of the prevalence and risk factors of anemia among older adults in urban
19 China.

20 **5. Conclusion**

21 In conclusion, anemia is prevalent among the older adult population in China,
22 with older age, underweight, diabetes, CKD, and anemia being positively associated
23 with anemia, and higher education level, current-smoker, drinker, overweight,
24 obesity, central obesity, hypertension, and dyslipidemia being negatively associated.
25 Screening of high-risk populations, and treatment of senile anemia should be top
26 priorities in Shenzhen, and should be listed as important public health intervention
27 measures for implementation.

31 **Acknowledgments**

32 We are grateful to all the volunteers for their participation in the present study,
33 and to all the investigators for their support and hard work during this survey.

35 **Author Contributions**

36 WN, XY, and JX: study conception and design. WN, XY, YS, HZ, YZ, and JX:
37 performance of research. XY and YS: data analysis and interpretation. WN and XY:
38 writing the original draft. WN and JX: Writing the review and editing. All authors
39 have read and agreed to the published version of the manuscript.

41 **Funding**

42 This study was supported by the Science and Technology Planning Project of
43 Shenzhen City, Guangdong Province, China (Grant No. JCYJ20180703145202065),

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 the Science and Technology Planning Project of Shenzhen City, Guangdong Province,
2 China(Grant No. KCXFZ20201221173600001) Shenzhen Medical Key Discipline
3 Construction Fund, and Sanming Project of Medicine in Shenzhen (Grant No.
4 SZSM201811093).

5 6 **Conflicts of Interest**

7 The authors declare no conflict of interest.

8 9 **Patient consent for publication**

10 Not required.

11 12 **Ethics approval**

13 This study was approved by the ethical review committee of the Center for
14 Chronic Disease Control of Shenzhen.

15 16 **Data sharing statement**

17 All data generated or analyzed during this study are included in this published
18 article. No additional data are available.

19 20 21 **References**

- 22
23 1. Working Group on "Expert Consensus on nutrition Prevention and Treatment
24 of Iron deficiency Anemia" of Chinese Nutrition Society. Expert consensus on
25 nutrition prevention and treatment of iron deficiency anemia. *Acta Nutrimenta*
26 *Sinica* **2019**; 41,417-426.
- 27 2. Stevens GA, Finucane MM, De-Regil LM, *et al.* Global, regional, and national
28 trends in haemoglobin concentration and prevalence of total and severe
29 anaemia in children and pregnant and non-pregnant women for 1995-2011: a
30 systematic analysis of population-representative data. *Lancet Glob Health*
31 **2013**; 1, e16-25.
- 32 3. Bianchi VE. Role of nutrition on anemia in elderly. *Clin Nutr ESPEN* **2016**;
33 11, e1-e11.
- 34 4. Wu WC, Rathore SS, Wang Y, *et al.* Blood transfusion in elderly patients with
35 acute myocardial infarction. *N Engl J Med* **2001**; 345, 1230-1236.
- 36 5. Groenveld HF, Januzzi JL, Damman K, *et al.* Anemia and mortality in heart
37 failure patients a systematic review and meta-analysis. *J Am Coll Cardiol*
38 **2008**, 52, 818-827.
- 39 6. Ezekowitz JA MF, Armstrong PW. Anemia is common in heart failure and is
40 associated with poor outcomes: insights from a cohort of 12065 patients with
41 new-onset heart failure. *Circulation* **2003**; 107, 223-225.
- 42 7. Penninx BW, Guralnik JM, Onder G, *et al.* Anemia and decline in physical
43 performance among older persons. *Am J Med* **2003**; 115, 104-110.
- 44 8. Penninx BW, Pahor M, Cesari M, *et al.* Anemia is associated with disability

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

- and decreased physical performance and muscle strength in the elderly. *J Am Geriatrics Soc* **2004**; 52, 719-724.
9. Cesari M, Penninx BW, Lauretani F, *et al.* Hemoglobin levels and skeletal muscle: results from the InCHIANTI study. *J Gerontol A Biol Sci Med Sci* **2004**;59:249-254.
10. National Bureau of Statistics. Bulletin of the Seventh National Population Census (No. 5). http://www.stats.gov.cn/tjsj/tjgb/rkpcgb/qgrkpcgb/202106/t20210628_1818824.html. Accessed September 26 **2021**
11. Qin T, Yan M, Fu Z, *et al.* Association between anemia and cognitive decline among Chinese middle-aged and elderly: evidence from the China health and retirement longitudinal study. *BMC Geriatr* **2019**; 19, 305.
12. Chang J, Wang Y. Reports of China Nutrition and Health Survey (2010–2013). Peking University Medical Press Co. LTD, Beijing, **2016**.
13. Xu X, Hall J, Byles J, *et al.* Dietary pattern, serum magnesium, ferritin, C-reactive protein and anaemia among older people. *Clin Nutr* **2017**; 36, 444-451.
14. Wu Y, Ye H, Liu J, *et al.* Prevalence of anemia and sociodemographic characteristics among pregnant and non-pregnant women in southwest China: a longitudinal observational study. *BMC Pregnancy Childbirth* **2020**; 20, 535.
15. Ruan Y, Guo Y, Kowal P, *et al.* Association between anemia and frailty in 13,175 community-dwelling adults aged 50 years and older in China. *BMC Geriatr* **2019**; 19:327.
16. Zhang Q, Qin G, Liu Z, *et al.* Dietary Balance Index-07 and the Risk of Anemia in Middle Aged and Elderly People in Southwest China: A Cross Sectional Study. *Nutrients* **2018**; 10, 162.
17. Zhang L, Wang F, Wang L, *et al.* Prevalence of chronic kidney disease in China: a cross-sectional survey. *Lancet* **2012**; 379, 815-822.
18. Zhang M, Liu S, Yang L, *et al.* Prevalence of smoking and knowledge about the smoking hazards among 170,000 Chinese adults: a nationally representative survey in 2013-2014. *Nicotine Tob Res* **2019**; 21, 1644-1651.
19. Pottel H, Hoste L, Dubourg L, Ebert N, *et al.* An estimated glomerular filtration rate equation for the full age spectrum. *Nephrol Dial Transplant* **2016**; 31,798-806.
20. World Health Organization. Haemoglobin Concentrations for the Diagnosis of Anaemia and Assessment of Severity. https://apps.who.int/iris/bitstream/handle/10665/85839/WHO_NMH_NHD_MNM_11.1_eng.pdf?ua=1. Accessed July 21 **2021**.
21. Lee YG, Chang Y, Kang J, *et al.* Risk factors for incident anemia of chronic diseases: A cohort study. *PLoS One* **2019**; 14, e0216062.
22. Writing Group of 2018 Chinese Guidelines for the Management of Hypertension, Chinese Hypertension League, Chinese Society of Cardiology, Chinese Medical Doctor Association Hypertension Committee, Hypertension

- 1
2
3
4 1 Branch of China International Exchange and Promotive Association for
5 2 Medical and Health Care, Hypertension Branch of Chinese Geriatric
6 3 Medical Association. 2018 Chinese guidelines for the management of
7 4 hypertension. *Chin J Cardiovasc Med* **2019**; 24, 24-56.
- 8
9 23. Qaseem A, Wilt TJ, Rich R, *et al.* Pharmacologic Treatment of Hypertension
10 6 in Adults Aged 60 Years or Older to Higher Versus Lower Blood Pressure
11 7 Targets: A Clinical Practice Guideline From the American College of
12 8 Physicians and the American Academy of Family Physicians. *Ann Intern Med*
13 9 **2017**; 166, 430-437.
- 14
15 24. Wang Q, Zhang X, Fang L, *et al.* Prevalence, awareness, treatment and control
16 11 of diabetes mellitus among middle-aged and elderly people in a rural Chinese
17 12 population: A cross-sectional study. *PLoS One* **2018**; 13, e0198343.
- 18
19 25. Joint committee for guideline revision. 2016 Chinese guidelines for the
20 14 management of dyslipidemia in adults. *J Geriatr Cardiol* **2018**; 15, 1-29.
- 21
22 26. National Health Commission of the People's Republic of China. Criteria of
23 16 Weight for Adults.
24 17 [http://www.nhc.gov.cn/ewebeditor/uploadfile/2013/08/20130808135715967.p](http://www.nhc.gov.cn/ewebeditor/uploadfile/2013/08/20130808135715967.pdf)
25 18 [df](http://www.nhc.gov.cn/ewebeditor/uploadfile/2013/08/20130808135715967.pdf). Accessed September 26 **2021**
- 26
27 27. Harding KL, Aguayo VM, Namirembe G, *et al.* Determinants of anemia
28 20 among women and children in Nepal and Pakistan: An analysis of recent
29 21 national survey data. *Matern Child Nutr* **2018**; Suppl 4, e12478.
- 30
31 28. Fiseha T, Adamu A, Tesfaye M, *et al.* Prevalence of anemia in diabetic adult
32 23 outpatients in Northeast Ethiopia. *PLoS One* **2019**; 14, e0222111.
- 33
34 29. Chun MY, Kim JH, Kang JS. Relationship between Self-Reported Sleep
35 25 Duration and Risk of Anemia: Data from the Korea National Health and
36 26 Nutrition Examination Survey 2016-2017. *Int J Environ Res Public Health*
37 27 **2021**; 18:4721.
- 38
39 30. Hisa K, Haruna M, Hikita N, *et al.* Prevalence of and factors related to anemia
40 29 among Japanese adult women: Secondary data analysis using health check-up
41 30 database. *Sci Rep* **2019**;9:17048.
- 42
43 31. Nordenberg D, Yip R, Binkin NJ. The effect of cigarette smoking on
44 32 hemoglobin levels and anemia screening. *JAMA* **1990**;264:1556-1559.
- 45
46 32. Sharma AJ, Addo OY, Mei Z, *et al.* Reexamination of hemoglobin adjustments
47 34 to define anemia: altitude and smoking. *Ann N Y Acad Sci* **2019**;1450:190-203.
- 48
49 33. Pollini G, Maugeri U, Bernardo A, *et al.* Erythrocytes parameters due to aging,
50 36 smoking, alcohol consumption and occupational activity in a working
51 37 population of petrochemical industry. The Pavia Study. *G Ital Med Lav*
52 38 **1989**;11:237-240.
- 53
54 34. Qin Y, Melse-Boonstra A, Pan X, *et al.* Anemia in relation to body mass index
55 40 and waist circumference among Chinese women. *Nutr J* **2013**. doi:
56 41 10.1186/1475-2891-1112-1110.
- 57
58 35. Dandona P, Aljada A, Chaudhuri A, *et al.* Metabolic syndrome: a
59 43 comprehensive perspective based on interactions between obesity, diabetes,
60 44 and inflammation. *Circulation* **2005**;111,1448-1454.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

- 1 36. Schwartz AR, Patil SP, Laffan AM, *et al.* Obesity and obstructive sleep apnea:
2 pathogenic mechanisms and therapeutic approaches. *Proc Am Thorac Soc*
3 **2008**; 5, 185-192.
- 4 37. Gauci R, Hunter M, Bruce DG, *et al.* Anemia complicating type 2 diabetes:
5 Prevalence, risk factors and prognosis. *J Diabetes Complications* **2017**; 31,
6 1169-1174.
- 7 38. Thomas MC. The High Prevalence of Anemia in Diabetes Is Linked to
8 Functional Erythropoietin Deficiency. *Semin Nephrol* **2006**; 26, 275-282.
- 9 39. Zaribaf F, Entezari MH, Hassanzadeh A, *et al.* Association between dietary
10 iron, iron stores, and serum lipid profile in reproductive age women. *J Educ*
11 *Health Promot* **2014**; 3: DOI: 10.4103/2277-9531.127586.
- 12 40. Ryu SR, Park SK, Jung JY, *et al.* The Prevalence and Management of Anemia
13 in Chronic Kidney Disease Patients: Result from the KoreaN Cohort Study for
14 Outcomes in Patients With Chronic Kidney Disease (KNOW-CKD). *J Korean*
15 *Med Sci* **2017**; 32, 249-256.

Tables

Table 1 Sociodemographic and other characteristics of older adults living in Shenzhen community ($N=121,981$)

Characteristics	Total	95%CI
Age (years)	71.28 ± 5.58	71.25-71.31
Hb(g/dL)	13.64 ± 1.67	13.63-13.65
BMI (Kg/m ²)	23.83 ± 3.17	23.81-23.85
SBP (mm Hg)	134.71 ± 17.69	134.61-134.81
DBP (mm Hg)	77.23 ± 10.31	77.18-77.29
WC (cm)	85.1 ± 8.82	85.05-85.15
FBG (mmol/L)	5.96 ± 1.9	5.95-5.97
TC(mmol/L)	5.21 ± 2	5.20-5.23
TG(mmol/L)	1.57 ± 1.14	1.57-1.58
LDL-C(mmol/L)	3.09 ± 1.05	3.08-3.09
HDL-C(mmol/L)	1.39 ± 0.51	1.39-1.39
eGFR	68.74 ± 16.7	68.65-68.83
Sex, n(%)		
Male	54649 (44.07%)	43.78-44.34
Female	69358 (55.93%)	55.66-56.22
Education level, n(%)		
Not educated	9888 (8.11%)	7.95-8.26
Primary education	43441 (35.61%)	35.34-35.88
Junior school education and above	68652 (56.28%)	56.00-56.56
Smoking status, n (%)		
Current smoker	10023 (8.22%)	8.06-8.37
Ex-smoker	7546 (6.19%)	6.05-6.32
Never-smoker	104412 (85.59%)	85.40-85.79
Drinking habit, n (%)		
Non-drinker	101661 (83.34%)	83.13-83.55
Non-habitual drinker	12571 (10.31%)	10.14-10.48
Habitual drinker	7749 (6.35%)	6.22-6.49

1
2
3 1
4
5 2
6 3 **Table 2** Prevalence of anemia in older adults living in Shenzhen community,
7 4 according to sociodemographic and other characteristics

Characteristics	Total	Number of anemia	Prevalence of anemia(%)	95%CI	χ^2 Value	P Value
Total	121981	18820	15.43	15.23-15.63		
Sex					22.36	<0.001
Male	53743	7946	14.79	14.49-15.09		
Female	68238	10874	15.94	15.66-16.21		
Education level					263.21	<0.001
Not educated	9888	2027	20.50	19.70-21.30		
Primary education	43441	7240	16.67	16.32-17.02		
Junior school education and above	68652	9553	13.92	13.66-14.17		
Age group					1201.99	<0.001
65~69	60043	7635	12.72	12.45-12.98		
70~74	32750	4730	14.44	14.06-14.82		
75~79	16599	3070	18.50	17.90-19.09		
80~	12589	3385	26.89	26.11-27.66		
Smoking status					68.89	<0.001
Current smoker	10023	1253	12.50	11.85-13.15		
Ex-smoker	7546	1047	13.87	13.09-14.65		
Never-smoker	104412	16520	15.82	15.60-16.04		
Drinking habit					130.24	<0.001
Non-drinker	101661	16302	16.04	15.81-16.26		
Non-habitual drinker	12571	1589	12.64	12.06-13.22		
Habitual drinker	7749	929	11.99	11.27-12.71		
BMI					1522.11	<0.001
Low weight	4496	1504	33.45	32.07-34.83		
Normal weight	61532	11041	17.94	17.64-18.25		
Overweight	44644	5175	11.59	11.29-11.89		
Obesity	11309	1100	9.73	9.18-10.27		
Central obesity					540.10	<0.001
Yes	49051	5897	12.02	11.73-12.31		
No	72930	12923	17.72	17.44-18.00		
Diabetes					27.05	<0.001
Yes	27220	4520	16.61	16.16-17.05		
No	94761	14300	15.09	14.86-15.32		
Hypertension					63.27	<0.001
Yes	67835	9883	14.57	14.30-14.83		

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

No	54146	8937	16.51	16.19-16.82		
Dyslipidemia					211.72	<0.001
Yes	54564	7354	13.48	13.19-13.76		
No	67417	11466	17.01	16.72-17.29		
CKD					624.34	<0.001
Yes	37927	7574	19.97	19.57-20.37		
No	84054	11246	13.38	13.15-13.61		

1 A two-sided value of $P < 0.05$ was considered to be statistically significant.

2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

For peer review only

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1

2 **Figure legends**

3 Fig 1 Risk factor analyses of the prevalence of anemia in older adults living in
4 Shenzhen community

For peer review only

Characteristics	AOR(95%CI)
Gender	
Female	1
Male	1.00 (0.97–1.04)
Education level	
Not educated	1
Primary education	0.89 (0.84–0.94)
Junior school education and above	0.72 (0.68–0.76)
Age group	
65~69	1
70~74	1.10 (1.06–1.15)
75~79	1.37 (1.31–1.44)
80~	1.96 (1.86–2.06)
Smoking status	
Never-smoker	1
Current smoker	0.84 (0.78–0.89)
Ex-smoker	1.00 (0.93–1.08)
Drinking habit	
Non-drinker	1
Non-habitual drinker	0.86 (0.81–0.92)
Habitual drinker	0.81 (0.75–0.87)
BMI	
Normal weight	1
Underweight	2.06 (1.93–2.20)
Overweight	0.67 (0.64–0.70)
Obesity	0.57 (0.53–0.61)
Central obesity	
No	1
Yes	0.86 (0.82–0.89)
Diabetes	
No	1
Yes	1.23 (1.19–1.28)
Hypertension	
No	1
Yes	0.86 (0.83–0.89)
Dyslipidemia	
No	1
Yes	0.81 (0.78–0.84)
CKD	
No	1
Yes	1.41 (1.36–1.46)

For peer review only

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	Page 1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	Page 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 4
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 4
Methods			
Study design	4	Present key elements of study design early in the paper	Page 4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 4
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	Page 4
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 5-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page 5-6
Bias	9	Describe any efforts to address potential sources of bias	Page 6
Study size	10	Explain how the study size was arrived at	Page 4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Not applicable
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	Page 6
		(b) Describe any methods used to examine subgroups and interactions	Not applicable
		(c) Explain how missing data were addressed	Not applicable
		(d) If applicable, describe analytical methods taking account of sampling strategy	Not applicable
		(e) Describe any sensitivity analyses	Not applicable
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Page 4
		(b) Give reasons for non-participation at each stage	Not applicable
		(c) Consider use of a flow diagram	Not applicable
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page 7
		(b) Indicate number of participants with missing data for each variable of interest	Not applicable
Outcome data	15*	Report numbers of outcome events or summary measures	Page 7
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Page 7
		(b) Report category boundaries when continuous variables were categorized	Page 7
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Page 7
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Not applicable
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page 7-8
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page 8-9
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 7-9
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 9
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 9

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Anemia and associated factors among older adults in an urban district in China: a large-scale cross-sectional study

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2021-056100.R3
Article Type:	Original research
Date Submitted by the Author:	30-Jan-2022
Complete List of Authors:	Ni, Wenqing; Shenzhen Center for Chronic Disease Control, Department of Elderly Health Management Yuan, Xueli; Shenzhen Center for Chronic Disease Control, Department of Elderly Health Management Sun, Yuanying; Shenzhen Center for Chronic Disease Control, Department of Elderly Health Management Zhang, Hong; Shenzhen Center for Chronic Disease Control, Department of Elderly Health Management Zhang, Yan; Shenzhen Center for Chronic Disease Control, Department of Elderly Health Management Xu, Jian; Shenzhen Nanshan Center for Chronic Disease Control, Department of Elderly Health Management
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Epidemiology, Public health
Keywords:	Anaemia < HAEMATOLOGY, EPIDEMIOLOGY, Risk management < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

SCHOLARONE™
Manuscripts



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our [licence](#).

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which [Creative Commons](#) licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

1
2
3
4 1 **Anemia and associated factors among older adults in an urban**
5
6 2 **district in China: a large-scale cross-sectional study**
7
8
9 3

10
11 4 Wenqing Ni^{1#}, Xueli Yuan^{1#}, Yuanying Sun¹, Hongmin Zhang¹,
12
13
14 5 Yan Zhang¹, Jian Xu¹
15

16
17 6 ¹Department of Elderly Health Management, Shenzhen Center for Chronic Disease
18
19 7 Control, Shenzhen, Guangdong, 518020, China

20
21 8 # These authors contributed equally to this work.
22

23
24 9
25 10 *Corresponding author :

26 11 Jian Xu, Ph.D.

27 12 Shenzhen Center for Chronic Disease Control

28 13 No.2021, Buxin Rd. Shenzhen, Guangdong 518020, P.R. China
29

30 14
31 15 Tel: 86-755-25506942

32 16 Fax: 86-755-25506942

33 17 E-mail: anniexu73@126.com
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Abstract

Objective: Anemia leads to poor health outcomes in older adults; however, most current research in China has focused on younger adults. The present study aimed to investigate the prevalence of anemia and its associated factors in older adults in an urban district in China.

Design: A cross-sectional study.

Setting: An urbanized region, Shenzhen, China.

Participants: A total of 121,981 participants aged ≥ 65 years were recruited at local community health service centers in Shenzhen from January to December 2018.

Primary outcomes: The prevalence of anemia was analyzed and potential associated factors were evaluated.

Results: The mean hemoglobin level was 13.64 ± 1.67 g/dL and the prevalence of anemia was 15.43%. The prevalences of mild, moderate, and severe anemia were 12.24%, 2.94%, and 0.25%, respectively. Anemia was positively associated with older age, being underweight (adjusted odds ratio (AOR): 2.06, 95% confidence interval (CI): 1.93–2.20), diabetes (AOR: 1.23, 95% CI: 1.19–1.28), and chronic kidney disease (AOR: 1.41, 95% CI: 1.36–1.46), and inversely with higher education level, current-smoker (AOR: 0.84, 95% CI: 0.78–0.89), non-habitual drinker (AOR: 0.86, 95% CI: 0.81–0.92), habitual drinker (AOR: 0.81, 95% CI: 0.75–0.87), overweight (AOR: 0.67, 95% CI: 0.64–0.70), obesity (AOR: 0.57, 95% CI: 0.53–0.61), central obesity (AOR: 0.86, 95% CI: 0.82–0.89), hypertension (AOR: 0.86, 95% CI: 0.83–0.89), and dyslipidemia (AOR: 0.81, 95% CI: 0.78–0.84).

Conclusion: Anemia is prevalent among people aged 65 years and older in China. Screening of high-risk populations and treatment of senile anemia should be a top priority in Shenzhen, and should be listed as important public health intervention measures for implementation.

Keywords: older adults, anemia, epidemiologic study, risk factor

Strengths and limitations of this study

■ This was the first large-scale cross-sectional study to assess the prevalence of anemia and its factors in an urban district in China.

■ This study had a sufficiently large sample size to detect significant differences in the prevalence of anemia among older adults.

■ Convenience sampling was used to enroll the population sample.

■ The dataset used in this study did not provide information on the dietary behavior of the participants.

For peer review only

1. Introduction

Anemia results from an inadequate number of erythrocytes which leads to a decreased ability to carry oxygen to meet the body's physiological demands. It is characterized by reduced levels of hemoglobin (Hb) in the blood in affected individuals. Anemia may occur at all stages of life, however, older people are among the most vulnerable.^{1,2} Globally, 11.0% of men and 10.2% of women aged 65 years and older are anemic.³ Anemia is a risk factor for a variety of adverse outcomes in the older population, including hospitalization, disability and mortality.¹ Previous studies found higher mortality rates in people aged 65 years and older hospitalized for myocardial infarction, patients with systolic and diastolic chronic heart failure (CHF), and in older CHF patients with anemia.⁴⁻⁶ Anemia is also an independent risk factor for decline in physical performance and has a negative impact on quality of life, physical functioning, and muscle strength in older individuals.⁷⁻⁹ Early identification and treatment of anemia is therefore an important strategy to improve the quality of life of older adults with anemia.

In China, 13.5% of the total population (approximately 190.64 million people) were aged 65 years or older in 2020,¹⁰ and increasing life expectancy and declining fertility rates mean that China is experiencing an ongoing aging process. In line with the aging of the population, anemia has become an important public health problem in China. The China Health and Retirement Longitudinal Study showed a prevalence of anemia in middle-aged and older Chinese residents of 12.86% from 2011 to 2012,¹¹ and the 2010–2012 China National Nutrition and Health Survey found a prevalence of anemia in older Chinese people of 12.6%.¹² Preventing anemia and improving the health of older adults in China are thus urgent issues. However, the only previous trial for preventing anemia examined the use of iron-fortified soy sauce in some cities in China, which aimed to reduce the prevalence of iron-deficiency anemia among women of reproductive age.¹³ The prevention of anemia in older adults thus still presents a challenge, and limited measures have been taken to address this public health problem.

Clarifying the risk factors of anemia in the older adults will help to identify the population at risk of anemia, and promote the development of targeted screening and intervention measures. Economic development, living standards, body mass index (BMI), chronic disease and specific risk factors, chronic kidney disease (CKD), older age are important factors affecting anemia.^{1,3,14,15} Most previous studies focused on the prevalence of anemia among middle-aged and older adults in urban and rural districts of China, but there is a lack of large-sample studies of anemia among older adults in urban districts.^{11,12,16,17} This study therefore aimed to examine the prevalence of anemia and its related factors among people aged 65 or older in an urban district of China, to help develop strategies for future interventions and the prevention of anemia in older adults living in urban districts in China.

2. Materials and methods

2.1 Study population

1 We recruited participants aged 65 years and older from the lists of all residents
2 registered at local community health centers in Shenzhen by convenient sampling
3 method, from January 2018 to December 2018. The staff of the local community
4 health centers recruited older adults in their community to participate in the survey by
5 pasting posters, placing leaflets, telephone, distributed electronic posters via Wechat.
6 The eligibility criteria were as follows: (1) lived in Shenzhen for more than 6 months;
7 (2) able to participate in the study and give informed consent; and (3) conscious and
8 able to cooperate to complete the face-to-face interview, medical examinations and
9 biomedical tests. Prisoners are not free to visit community health centres, and we
10 excluded residents living in prisons. A total of 141,684 individuals were recruited in
11 this study, accounting for 36.9% (141,684/383,700) of the resident older adult
12 population in Shenzhen according to the 2015 population census. Data were collected
13 at examination centers in local community health centers in the participants'
14 residential areas. Participants were asked to complete a questionnaire, provide a
15 fasting blood sample, and undergo physical examinations. A total of 19,703
16 respondents were excluded because of failure to fulfil one or all of these requirements.
17 Finally, 121,981 participants (86.09%) were included in the final data analysis.

18 **2.2 Questionnaire survey**

19 Prior to the study, all investigators completed a training course to understand the
20 methodology and process of the study. Working manuals containing questionnaire
21 techniques, blood pressure measurement, anthropometric measurements, biological
22 sample collection, and processing information were distributed to all the investigators.

23 Data were recorded by face-to-face interview 1 hour after blood collection.
24 Detailed sociodemographic characteristics and health parameters were collected by a
25 standardized questionnaire including age, sex, education level, marital status, past
26 medical history, family health history, lifestyle behaviors, and medication use.
27 Participants were categorized according to the level of education into three categories:
28 not educated; primary education; and junior high school education and above.
29 Regarding drinking habits, participants were classified as habitual drinkers (drink at
30 least once a day), non-habitual drinkers (six times a week to once a month), or
31 non-drinker (almost never).¹⁸ Based on a previous study, we divided participants into
32 current smokers, ex-smokers, and never-smokers.¹⁹

33 **2.3 Physical examination**

34 Anthropometric examinations were carried out in the morning after overnight
35 fasting by standard methods. Body height, weight and waist circumference (WC) of
36 the participants were measured, and BMI was calculated. Blood pressure was
37 measured twice in both arms supported at heart level with the participants in a sitting
38 position, using a calibrated electronic sphygmomanometer and the higher level was
39 recorded and used for statistical analysis. To obtain accurate readings, the participants
40 were asked to rest for at least 5 min before the measurement, or if they had engaged in
41 excessive exercise prior to the visit, to rest for at least 30 min before the
42 measurement.

43 **2.4 Blood sample collection and biochemical analyses**

44 Venous blood samples were taken after overnight fasting for at least 8 hours. All

1 blood samples were analyzed in clinical laboratories at the grade 2 hospitals to which
2 the community health centers were directly affiliated. All the laboratories had
3 successfully completed a standardization and competency program. Fasting venous
4 blood was used to measure levels of Hb, plasma glucose, creatinine, total cholesterol
5 (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-C), and
6 high-density lipoprotein cholesterol (HDL-C) using an automatic biochemistry
7 analyzer. Biochemical analysis of fresh blood samples was completed within 4 hours.
8 Serum creatinine was used to calculate the estimated glomerular filtration rate (eGFR)
9 using the full age spectrum equation.²⁰

10 **2.5 Operational definitions/measurements**

11 Anemia was defined as a Hb concentration < 13 g/dL in men and < 12 g/dL in
12 women, according to World Health Organization standards.²¹ The severity of anemia
13 was classified as mild (11–11.9 g/dL (women), 11–12.9 g/dL (men)), moderate (8–
14 10.9 g/dL), and severe (<8 g/dL).²¹ CKD was defined as eGFR < 60 mL/min/1.73
15 m².²² A diagnosis of hypertension was considered in participants with three
16 consecutive high readings (\geq 140 mm Hg systolic blood pressure and/or \geq 90 mm
17 Hg diastolic blood pressure) with 2-week intervals or self-reported treatment with
18 antihypertensive medication within the previous 2 weeks.^{23, 24} Participants who met
19 one of the following three criteria were diagnosed with diabetes: (1) previously
20 diagnosed by professional doctors, (2) fasting plasma glucose (FBG) \geq 7.0 mmol/L,
21 and (3) 2-hour plasma glucose level \geq 11.1 mmol/L.²⁵ High TC, high TG, high
22 LDL-C, and low HDL-C were diagnosed according to the 2016 Chinese Guidelines
23 for the Management of Dyslipidemia in Adults.²⁶ In this study, we defined
24 dyslipidemia as an abnormal concentration of one or more lipid components or the
25 use of anti-dyslipidemia medications in the past 2 weeks.

26 Participants were divided into four groups based on the adult weight criteria
27 published by the Ministry of Health of China (WS/T 428-2013): BMI < 18.5 kg/m²
28 (low weight), BMI \geq 18.5 kg/m² and <24.0 kg/m² (normal weight), BMI \geq 24.0 kg/m²
29 and < 28.0 kg/m² (overweight), and BMI \geq 28.0 kg/m² (obesity). A WC \geq 90 cm for
30 men and \geq 85 cm for women was defined as central obesity.²⁷

31 **2.6 Statistical analyses**

32 Descriptive statistics, including means and standard deviations, were used to
33 compute continuous variables. Numerical data were expressed as percentages and
34 compared by χ^2 tests. Multivariate logistic regression analysis was performed to
35 explore the associations between the prevalence of anemia and associated risk factors.
36 In the multivariate logistic regression model, the prevalence of anemia was defined as
37 the dependent variable, and sex, education level, age group, smoking status, drinking
38 habit, BMI, central obesity, diabetes, hypertension, dyslipidemia and CKD were
39 defined as the independent variables. Data analysis was carried out using SAS 9.4
40 (Institute, Cary, NC, USA). A two-sided value of $P < 0.05$ was considered to be
41 statistically significant.

42 **2.7 Participants and public involvement**

43 Neither the study participants nor the public were involved in the design,
44 recruitment or conduct of the study. All the participants had the option of receiving a

1 health check and biochemical results when they visited the local community health
2 centers.

3 **2.8 Ethical Approval Statement**

4 The study received ethical approval from the Center for Chronic Disease Control
5 in Shenzhen(Grant No: SZCCC-201802, SZCCC-2020-018-01-PJ). The study
6 complied with the guidelines of the Declaration of Helsinki. Written informed consent
7 was obtained from all participants before the collection of data and conducting the
8 study. For participants who were not educated, the participants and a proxy (family
9 member) who accompanied the participant in the survey were informed orally
10 (participant) and in writing (proxy) about the purpose, process, methods, benefits, and
11 health risks of the study. During the informed consent process, uneducated older adults
12 and their proxies were able to consult the investigators with questions at any time. After
13 explaining the concept of informed consent, uneducated older adults provided verbal
14 agreement, and written informed consent to participate in the study was provided by their
15 proxy. The consent processes were approved by the committee of the Center for Chronic
16 Disease Control of Shenzhen.

17 **3. Results**

18 **3.1 Characteristics of participants**

19 The characteristics of the study participants are shown in Table 1. The mean age
20 was 71.28 ± 5.58 years (range 65–103 years). There were 54,649 men and 69,358
21 women, and > 50% of participants had a minimum of a junior school education.
22 Among the study population, 8.22% were current smokers and 6.35% were habitual
23 drinkers. The mean Hb, BMI, SBP, DBP, WC, FBG, TC, TG, LDL-C, HDL-C, and
24 eGFR values among all 121,981 participants were 13.64 ± 1.67 g/dL, 23.83 ± 3.17
25 kg/m^2 , 134.71 ± 17.69 mmHg, 77.23 ± 10.31 mmHg, 85.10 ± 8.82 cm, 5.96 ± 1.90
26 mmol/L, 5.21 ± 2.00 mmol/L, 1.57 ± 1.14 mmol/L, 3.09 ± 1.05 mmol/L, 1.39 ± 1.05
27 mmol/L, and 68.74 ± 16.70 mL/min/1.73m², respectively. A total of 100,762
28 participants (82.60%) had at least one chronic disease, with hypertension (55.61%),
29 dyslipidemia (44.73%), CKD (31.09%), and diabetes (22.31%) being the most
30 prevalent (data not shown).

31 **3.2 Prevalence of anemia in different subgroups**

32 The overall prevalence anemia was 15.43% and the prevalences (95% confidence
33 intervals(CI)) of mild, moderate and severe anemia were 12.24% (12.05-12.42),
34 2.94% (2.84-3.03) and 0.25% (0.23-0.28), respectively. The prevalence of anemia
35 among subpopulations is shown in Table 2. Anemia was significantly more prevalent
36 in women than in men and generally increased with age. The prevalence was lower
37 among individuals with at least primary-level education, and lower in current smokers
38 and habitual drinkers compared with their counterparts. The prevalence of anemia was
39 higher in participants with low weight and lower in those with overweight, obesity,
40 central obesity, hypertension, or dyslipidemia. Individuals with diabetes or CKD had a
41 higher prevalence of anemia than those without these conditions.

42 **3.3 Association between anemia and related variables**

43 Binary logistic regression analysis was carried out with presence or absence of

1 anemia as the dependent variable, and factors in univariate analysis as independent
2 variables to determine the factors influencing anemia. Primary education(adjusted
3 odds ratio (*AOR*)=0.89, 95%*CI*:0.84-0.94), junior school education and above
4 (*AOR*=0.72, 95%*CI*:0.68-0.76) current-smoker (*AOR*=0.84, 95%*CI*:0.78-0.89),
5 non-habitual drinker (*AOR*=0.86, 95%*CI*:0.81-0.92), habitual drinker (*AOR*=0.81,
6 95%*CI*:0.75-0.87), overweight (*AOR*=0.67, 95%*CI*:0.64-0.70), obesity(*AOR*=0.57,
7 95%*CI*:0.53-0.61), central obesity (*AOR*=0.86, 95%*CI*:0.82-0.89), hypertension
8 (*AOR*=0.86, 95%*CI*:0.83-0.89), and dyslipidemia (*AOR*=0.81, 95%*CI*:0.78-0.84) were
9 independently associated with lower odds for the presence of anemia (Fig. 1), while
10 age 70-74 years (*AOR*=1.10, 95%*CI*:1.06-1.15) , age 75-79 years (*AOR*=1.37,
11 95%*CI*:1.31-1.44), age \geq 80 years (*AOR*=1.96, 95%*CI*:1.86-2.06), underweight
12 (*AOR*=2.06, 95%*CI*:1.93-2.20), diabetes (*AOR*=1.23, 95%*CI*:1.19-1.28), and CKD
13 (*AOR*=1.41, 95%*CI*:1.36-1.46) were independently associated with greater odds (Fig.
14 1). However, there was no significant difference in the risk of anemia in relation to
15 sex.

16 4. Discussion

17 This was the first large-scale cross-sectional survey to report the prevalence of
18 anemia in older adults (aged 65 years or older) living in an urban district of China.
19 This study demonstrated that the prevalence of anemia was relatively high,
20 representing a public health problem in Shenzhen. After controlling for the
21 confounding factors we found that the prevalence of anemia varied with education
22 level, age group, smoking status, drinking habit, BMI, central obesity, and some
23 non-communicable diseases.
24 The prevalence of anemia among older adults in an urban district in China in the
25 current study was 15.43%, which was higher than the 12.86% reported in previous
26 national studies in China,¹¹ but lower than the 18.90% reported in the 2009 national
27 survey in China.¹³ The difference in prevalence rates among these studies may have
28 been caused by differences in study design, sample size, and/or the age of the study
29 participants.

30 The current study found a significant negative correlation between anemia
31 prevalence and educational level. This was consistent with studies conducted in Nepal
32 and Pakistan, which confirmed that a low educational level was a risk factor for
33 anemia.²⁸ This relationship probably occurs because higher levels of education enable
34 people to earn more and thus escape from the poverty trap. Multivariate analysis also
35 identified older age as an independent risk factor for anemia, consistent with the
36 findings of other related studies.^{3, 29} The prevalence of anemia increased with age,
37 with a two-to-three-fold increase (26.89% vs. 12.72%) in people aged > 80 years,
38 suggesting the need for routine screening for anemia in this high-risk subgroup.

39 Current smokers had a lower risk of anemia than never smokers. Similarly,
40 previous researches revealed that smoking was decrease the risk of anemia.^{15,30}
41 Sharma and co-researchers found that women aged 35-49 years who were current
42 smokers had a 25% lower risk of anemia compared with non-smokers, after adjusting
43 for the covariates.³⁰ Elevated Hb levels in smokers were associated with elevated

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 carboxyhemoglobin (HbCO), a stable compound of Hb and carbon monoxide (CO),
2 due to exposure to excess CO as a result of smoking.³¹ The form of HbCO reduces
3 oxygen delivery, and smokers had compensatory elevated Hb to increase
4 erythropoiesis and maintain oxygen transportation.³² This might explain why
5 adaptation to excess CO during smoking was shown by increase in Hb and red blood
6 cell mass.³³ Habitual drinking was also associated with a decreased risk of anemia,
7 with a corresponding *OR* of 0.81, consistent with a Korean study.¹⁵ However, the
8 direct causality of this negative correlation between alcohol drinking and anemia is
9 still unclear.¹⁵ Given the potential risks of alcohol and tobacco consumption to human
10 health, we do not recommend increasing alcohol consumption or smoking to protect
11 against anemia.

12 We also found a negative association between increased BMI and anemia
13 prevalence, in accord with other studies conducted in China, the United States, Nepal,
14 and Pakistan.^{28, 34} The reasons for being underweight may include poor distribution of
15 inadequate food within the family, food insecurity, poverty, and micronutrient
16 deficiencies, which tend to coexist with other macronutrient deficiencies. The
17 underlying mechanism accounting for the significant negative association between
18 overweight or obesity and anemia risk is unclear; however there are several possible
19 explanations. First, obese participants are less likely to be malnourished, because
20 excess calorie intake leads to obesity,³⁵ and overnutrition in obese participants may
21 thus be associated with a significant reduction in anemia risk. Second, obese
22 participants may have a variety of other diseases that could increase Hb levels, such
23 as obstructive sleep apnea and other obesity-related breathing disorders, which lead to
24 chronic tissue hypoxia and increased red blood cells.³⁶

25 We found that older people with diabetes had higher rates of anemia than
26 non-diabetics, consistent with previous studies.³⁷ Evidence indicates that the
27 incidence and prevalence of anemia in diabetic patients is often associated with
28 erythropoietin deficiency caused by diabetic kidney damage.³⁸ Other researchers have
29 also shown a link between anemia and hypertension, as shown in our current study.²²

30 This study showed that the prevalence of anemia was low among individuals with
31 dyslipidemia. A study by Zaribaf et al. found a significant positive correlation
32 between Hb levels and dyslipidemia.³⁹ However, this study differed from our study in
33 that it assessed the relationship between anemia and lipids in premenopausal women,
34 whereas our study focused on older adults (aged 65–113 years).³⁹ In contrast, a study
35 conducted by other researchers in women of childbearing age found no significant
36 association between serum LDL and anemia.³⁹ The reasons for the different results in
37 terms of the relationship between dyslipidemia and anemia deserve further
38 investigation. Patients with CKD have defects in renal endocrine function, resulting in
39 decreased erythropoietin secretion by the kidney, leading to nephrogenic anemia.⁴⁰
40 Nearly half of all patients with CKD have anemia.⁴⁰ The current study found the
41 similar results.

42 This study had some limitations. First, it was a cross-sectional study and could only
43 infer correlation, not causation. Second, randomized sampling would represent the
44 best design for testing the prevalence of anemia and its associated factors among older

1 adults; however, large random sampling was not practically feasible and we therefore
2 adopted a convenient sampling method to recruit older adult participants. This was a
3 major factor preventing the extrapolation of the results to the general population.
4 Finally, renal disease was assessed based on a one-time GFR measurement, possibly
5 leading to overestimation of the actual prevalence of CKD. However, these
6 limitations do not affect the significance of the results, which provide the first
7 evidence of the prevalence and risk factors of anemia among older adults in urban
8 China.

9 **5. Conclusion**

10 In conclusion, anemia is prevalent among the older adult population in China,
11 with older age, underweight, diabetes, and CKD being positively associated with
12 anemia, and higher education level, current-smoker, drinker, overweight, obesity,
13 central obesity, hypertension, and dyslipidemia being negatively associated.
14 Screening of high-risk populations, and treatment of senile anemia should be top
15 priorities in Shenzhen, and should be listed as important public health intervention
16 measures for implementation.

20 **Acknowledgments**

21 We are grateful to all the volunteers for their participation in the present study,
22 and to all the investigators for their support and hard work during this survey.

24 **Author Contributions**

25 WN, XY, and JX: study conception and design. WN, XY, YS, HZ, YZ, and JX:
26 performance of research. XY and YS: data analysis and interpretation. WN and XY:
27 writing the original draft. WN and JX: Writing the review and editing. All authors
28 have read and agreed to the published version of the manuscript.

30 **Funding**

31 This study was supported by the Science and Technology Planning Project of
32 Shenzhen City, Guangdong Province, China (Grant No. JCYJ20180703145202065),
33 the Science and Technology Planning Project of Shenzhen City, Guangdong Province,
34 China (Grant No. KCXFZ20201221173600001), Shenzhen Medical Key Discipline
35 Construction Fund, and Sanming Project of Medicine in Shenzhen (Grant No.
36 SZSM201811093).

38 **Conflicts of Interest**

39 The authors declare no conflict of interest.

41 **Patient consent for publication**

42 Not required.

1 Ethics approval

2 This study was approved by the ethical review committee of the Center for
3 Chronic Disease Control of Shenzhen.

4 Data sharing statement

5 All data generated or analyzed during this study are included in this published
6 article. No additional data are available.

7 References

- 8 1. Working Group on "Expert Consensus on nutrition Prevention and Treatment
9 of Iron deficiency Anemia" of Chinese Nutrition Society. Expert consensus on
10 nutrition prevention and treatment of iron deficiency anemia. *Acta Nutrimenta
11 Sinica* **2019**; 41,417-426.
- 12 2. Stevens GA, Finucane MM, De-Regil LM, *et al.* Global, regional, and national
13 trends in haemoglobin concentration and prevalence of total and severe
14 anaemia in children and pregnant and non-pregnant women for 1995-2011: a
15 systematic analysis of population-representative data. *Lancet Glob Health*
16 **2013**; 1, e16-25.
- 17 3. Bianchi VE. Role of nutrition on anemia in elderly. *Clin Nutr ESPEN* **2016**;
18 11, e1-e11.
- 19 4. Wu WC, Rathore SS, Wang Y, *et al.* Blood transfusion in elderly patients with
20 acute myocardial infarction. *N Engl J Med* **2001**; 345, 1230-1236.
- 21 5. Groenveld HF, Januzzi JL, Damman K, *et al.* Anemia and mortality in heart
22 failure patients a systematic review and meta-analysis. *J Am Coll Cardiol*
23 **2008**, 52, 818-827.
- 24 6. Ezekowitz JA MF, Armstrong PW. Anemia is common in heart failure and is
25 associated with poor outcomes: insights from a cohort of 12065 patients with
26 new-onset heart failure. *Circulation* **2003**; 107, 223-225.
- 27 7. Penninx BW, Guralnik JM, Onder G, *et al.* Anemia and decline in physical
28 performance among older persons. *Am J Med* **2003**; 115, 104-110.
- 29 8. Penninx BW, Pahor M, Cesari M, *et al.* Anemia is associated with disability
30 and decreased physical performance and muscle strength in the elderly. *J Am
31 Geriatrics Soc* **2004**; 52, 719-724.
- 32 9. Cesari M, Penninx BW, Lauretani F, *et al.* Hemoglobin levels and skeletal
33 muscle: results from the InCHIANTI study. *J Gerontol A Biol Sci Med Sci*
34 **2004**;59:249-254.
- 35 10. National Bureau of Statistics. Bulletin of the Seventh National Population
36 Census (No. 5).
37 [http://www.stats.gov.cn/tjsj/tjgb/rkpcgb/qgrkpcgb/202106/t20210628_181882](http://www.stats.gov.cn/tjsj/tjgb/rkpcgb/qgrkpcgb/202106/t20210628_1818824.html)
38 [4.html](http://www.stats.gov.cn/tjsj/tjgb/rkpcgb/qgrkpcgb/202106/t20210628_1818824.html). Accessed September 26 **2021**
- 39 11. Qin T, Yan M, Fu Z, *et al.* Association between anemia and cognitive decline
40 among Chinese middle-aged and elderly: evidence from the China health and
41
42
43
44

- 1 retirement longitudinal study. *BMC Geriatr* **2019**; 19, 305.
- 2
3
4 12. Chang J, Wang Y. Reports of China Nutrition and Health Survey (2010–2013).
5 Peking University Medical Press Co. LTD, Beijing, **2016**.
- 6
7 13. Xu X, Hall J, Byles J, *et al*. Dietary pattern, serum magnesium, ferritin,
8 C-reactive protein and anaemia among older people. *Clin Nutr* **2017**; 36,
9 444-451.
- 10
11 14. Wu Y, Ye H, Liu J, *et al*. Prevalence of anemia and sociodemographic
12 characteristics among pregnant and non-pregnant women in southwest
13 China: a longitudinal observational study. *BMC Pregnancy Childbirth* **2020**;
14 20, 535.
- 15
16 15. Chun MY, Kim JH, Kang JS. Relationship between Self-Reported Sleep
17 Duration and Risk of Anemia: Data from the Korea National Health and
18 Nutrition Examination Survey 2016-2017. *Int J Environ Res Public Health*
19 **2021**; 18:4721.
- 20
21 16. Ruan Y, Guo Y, Kowal P, *et al*. Association between anemia and frailty in
22 13,175 community-dwelling adults aged 50 years and older in China. *BMC*
23 *Geriatr* **2019**; 19:327.
- 24
25 17. Zhang Q, Qin G, Liu Z, *et al*. Dietary Balance Index-07 and the Risk of
26 Anemia in Middle Aged and Elderly People in Southwest China: A Cross
27 Sectional Study. *Nutrients* **2018**; 10, 162.
- 28
29 18. Zhang L, Wang F, Wang L, *et al*. Prevalence of chronic kidney disease in
30 China: a cross-sectional survey. *Lancet* **2012**; 379, 815-822.
- 31
32 19. Zhang M, Liu S, Yang L, *et al*. Prevalence of smoking and knowledge about
33 the smoking hazards among 170,000 Chinese adults: a nationally
34 representative survey in 2013-2014. *Nicotine Tob Res* **2019**; 21, 1644-1651.
- 35
36 20. Pottel H, Hoste L, Dubourg L, Ebert N, *et al*. An estimated glomerular
37 filtration rate equation for the full age spectrum. *Nephrol Dial Transplant*
38 **2016**; 31,798-806.
- 39
40 21. World Health Organization. Haemoglobin Concentrations for the Diagnosis of
41 Anaemia and Assessment of Severity.
42 https://apps.who.int/iris/bitstream/handle/10665/85839/WHO_NMH_NHD_M
43 [NM_11.1_eng.pdf?ua=1](https://apps.who.int/iris/bitstream/handle/10665/85839/WHO_NMH_NHD_M). Accessed July 21 **2021**.
- 44
45 22. Lee YG, Chang Y, Kang J, *et al*. Risk factors for incident anemia of chronic
46 diseases: A cohort study. *PLoS One* **2019**; 14, e0216062.
- 47
48 23. Writing Group of 2018 Chinese Guidelines for the Management of
49 Hypertension, Chinese Hypertension League, Chinese Society of Cardiology,
50 Chinese Medical Doctor Association Hypertension Committee, Hypertension
51 Branch of China International Exchange and Promotive Association for
52 Medical and Health Care, Hypertension Branch of Chinese Geriatric
53 Medical Association. 2018 Chinese guidelines for the management of
54 hypertension. *Chin J Cardiovasc Med* **2019**; 24, 24-56.
- 55
56 24. Qaseem A, Wilt TJ, Rich R, *et al*. Pharmacologic Treatment of Hypertension
57 in Adults Aged 60 Years or Older to Higher Versus Lower Blood Pressure
58 Targets: A Clinical Practice Guideline From the American College of
59
60

- 1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
- 1 Physicians and the American Academy of Family Physicians. *Ann Intern Med* **2017**; 166, 430-437.
25. Wang Q, Zhang X, Fang L, *et al.* Prevalence, awareness, treatment and control of diabetes mellitus among middle-aged and elderly people in a rural Chinese population: A cross-sectional study. *PLoS One* **2018**; 13, e0198343.
26. Joint committee for guideline revision. 2016 Chinese guidelines for the management of dyslipidemia in adults. *J Geriatr Cardiol* **2018**; 15, 1-29.
27. National Health Commission of the People's Republic of China. Criteria of Weight for Adults. <http://www.nhc.gov.cn/ewebeditor/uploadfile/2013/08/20130808135715967.pdf>. Accessed September 26 **2021**
28. Harding KL, Aguayo VM, Namirembe G, *et al.* Determinants of anemia among women and children in Nepal and Pakistan: An analysis of recent national survey data. *Matern Child Nutr* **2018**; Suppl 4, e12478.
29. Fiseha T, Adamu A, Tesfaye M, *et al.* Prevalence of anemia in diabetic adult outpatients in Northeast Ethiopia. *PLoS One* **2019**; 14, e0222111.
30. Hisa K, Haruna M, Hikita N, *et al.* Prevalence of and factors related to anemia among Japanese adult women: Secondary data analysis using health check-up database. *Sci Rep* **2019**;9:17048.
31. Nordenberg D, Yip R, Binkin NJ. The effect of cigarette smoking on hemoglobin levels and anemia screening. *JAMA* **1990**;264:1556-1559.
32. Sharma AJ, Addo OY, Mei Z, *et al.* Reexamination of hemoglobin adjustments to define anemia: altitude and smoking. *Ann N Y Acad Sci* **2019**;1450:190-203.
33. Pollini G, Maugeri U, Bernardo A, *et al.* Erythrocytes parameters due to aging, smoking, alcohol consumption and occupational activity in a working population of petrochemical industry. The Pavia Study. *G Ital Med Lav* **1989**;11:237-240.
34. Qin Y, Melse-Boonstra A, Pan X, *et al.* Anemia in relation to body mass index and waist circumference among Chinese women. *Nutr J* **2013**. doi: 10.1186/1475-2891-1112-1110.
35. Dandona P, Aljada A, Chaudhuri A, *et al.* Metabolic syndrome: a comprehensive perspective based on interactions between obesity, diabetes, and inflammation. *Circulation* **2005**;111,1448-1454.
36. Schwartz AR, Patil SP, Laffan AM, *et al.* Obesity and obstructive sleep apnea: pathogenic mechanisms and therapeutic approaches. *Proc Am Thorac Soc* **2008**; 5, 185-192.
37. Gauci R, Hunter M, Bruce DG, *et al.* Anemia complicating type 2 diabetes: Prevalence, risk factors and prognosis. *J Diabetes Complications* **2017**; 31, 1169-1174.
38. Thomas MC. The High Prevalence of Anemia in Diabetes Is Linked to Functional Erythropoietin Deficiency. *Semin Nephrol* **2006**; 26, 275-282.
39. Zaribaf F, Entezari MH, Hassanzadeh A, *et al.* Association between dietary iron, iron stores, and serum lipid profile in reproductive age women. *J Educ Health Promot* **2014**; 3: DOI: 10.4103/2277-9531.127586.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

40. Ryu SR, Park SK, Jung JY, *et al.* The Prevalence and Management of Anemia in Chronic Kidney Disease Patients: Result from the KoreaN Cohort Study for Outcomes in Patients With Chronic Kidney Disease (KNOW-CKD). *J Korean Med Sci* **2017**; 32, 249-256.

For peer review only

Tables

Table 1 Sociodemographic and other characteristics of older adults living in Shenzhen community ($N=121,981$)

Characteristics	Total	95%CI
Age (years)	71.28 ± 5.58	71.25-71.31
Hb(g/dL)	13.64 ± 1.67	13.63-13.65
BMI (Kg/m ²)	23.83 ± 3.17	23.81-23.85
SBP (mm Hg)	134.71 ± 17.69	134.61-134.81
DBP (mm Hg)	77.23 ± 10.31	77.18-77.29
WC (cm)	85.1 ± 8.82	85.05-85.15
FBG (mmol/L)	5.96 ± 1.9	5.95-5.97
TC(mmol/L)	5.21 ± 2	5.20-5.23
TG(mmol/L)	1.57 ± 1.14	1.57-1.58
LDL-C(mmol/L)	3.09 ± 1.05	3.08-3.09
HDL-C(mmol/L)	1.39 ± 0.51	1.39-1.39
eGFR	68.74 ± 16.7	68.65-68.83
Sex, n(%)		
Male	54649 (44.07%)	43.78-44.34
Female	69358 (55.93%)	55.66-56.22
Education level, n(%)		
Not educated	9888 (8.11%)	7.95-8.26
Primary education	43441 (35.61%)	35.34-35.88
Junior school education and above	68652 (56.28%)	56.00-56.56
Smoking status, n (%)		
Current smoker	10023 (8.22%)	8.06-8.37
Ex-smoker	7546 (6.19%)	6.05-6.32
Never-smoker	104412 (85.59%)	85.40-85.79
Drinking habit, n (%)		
Non-drinker	101661 (83.34%)	83.13-83.55
Non-habitual drinker	12571 (10.31%)	10.14-10.48
Habitual drinker	7749 (6.35%)	6.22-6.49

1
2
3 1
4
5 2
6 3 **Table 2** Prevalence of anemia in older adults living in Shenzhen community,
7 4 according to sociodemographic and other characteristics

Characteristics	Total	Number of anemia	Prevalence of anemia(%)	95%CI	χ^2 Value	P Value
Total	121981	18820	15.43	15.23-15.63		
Sex					22.36	<0.001
Male	53743	7946	14.79	14.49-15.09		
Female	68238	10874	15.94	15.66-16.21		
Education level					263.21	<0.001
Not educated	9888	2027	20.50	19.70-21.30		
Primary education	43441	7240	16.67	16.32-17.02		
Junior school education and above	68652	9553	13.92	13.66-14.17		
Age group					1201.99	<0.001
65~69	60043	7635	12.72	12.45-12.98		
70~74	32750	4730	14.44	14.06-14.82		
75~79	16599	3070	18.50	17.90-19.09		
80~	12589	3385	26.89	26.11-27.66		
Smoking status					68.89	<0.001
Current smoker	10023	1253	12.50	11.85-13.15		
Ex-smoker	7546	1047	13.87	13.09-14.65		
Never-smoker	104412	16520	15.82	15.60-16.04		
Drinking habit					130.24	<0.001
Non-drinker	101661	16302	16.04	15.81-16.26		
Non-habitual drinker	12571	1589	12.64	12.06-13.22		
Habitual drinker	7749	929	11.99	11.27-12.71		
BMI					1522.11	<0.001
Low weight	4496	1504	33.45	32.07-34.83		
Normal weight	61532	11041	17.94	17.64-18.25		
Overweight	44644	5175	11.59	11.29-11.89		
Obesity	11309	1100	9.73	9.18-10.27		
Central obesity					540.10	<0.001
Yes	49051	5897	12.02	11.73-12.31		
No	72930	12923	17.72	17.44-18.00		
Diabetes					27.05	<0.001
Yes	27220	4520	16.61	16.16-17.05		
No	94761	14300	15.09	14.86-15.32		
Hypertension					63.27	<0.001
Yes	67835	9883	14.57	14.30-14.83		

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

No	54146	8937	16.51	16.19-16.82		
Dyslipidemia					211.72	<0.001
Yes	54564	7354	13.48	13.19-13.76		
No	67417	11466	17.01	16.72-17.29		
CKD					624.34	<0.001
Yes	37927	7574	19.97	19.57-20.37		
No	84054	11246	13.38	13.15-13.61		

1 A two-sided value of $P < 0.05$ was considered to be statistically significant.

2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

For peer review only

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1

2 **Figure legends**

3 Fig 1 Risk factor analyses of the prevalence of anemia in older adults living in
4 Shenzhen community

For peer review only

Characteristics	AOR(95%CI)
Gender	
Female	1
Male	1.00 (0.97–1.04)
Education level	
Not educated	1
Primary education	0.89 (0.84–0.94)
Junior school education and above	0.72 (0.68–0.76)
Age group	
65~69	1
70~74	1.10 (1.06–1.15)
75~79	1.37 (1.31–1.44)
80~	1.96 (1.86–2.06)
Smoking status	
Never-smoker	1
Current smoker	0.84 (0.78–0.89)
Ex-smoker	1.00 (0.93–1.08)
Drinking habit	
Non-drinker	1
Non-habitual drinker	0.86 (0.81–0.92)
Habitual drinker	0.81 (0.75–0.87)
BMI	
Normal weight	1
Underweight	2.06 (1.93–2.20)
Overweight	0.67 (0.64–0.70)
Obesity	0.57 (0.53–0.61)
Central obesity	
No	1
Yes	0.86 (0.82–0.89)
Diabetes	
No	1
Yes	1.23 (1.19–1.28)
Hypertension	
No	1
Yes	0.86 (0.83–0.89)
Dyslipidemia	
No	1
Yes	0.81 (0.78–0.84)
CKD	
No	1
Yes	1.41 (1.36–1.46)

For peer review only

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study’s design with a commonly used term in the title or the abstract	Page 1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	Page 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 4
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 4
Methods			
Study design	4	Present key elements of study design early in the paper	Page 4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 4
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	Page 4
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 5-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page 5-6
Bias	9	Describe any efforts to address potential sources of bias	Page 6
Study size	10	Explain how the study size was arrived at	Page 4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Not applicable
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	Page 6
		(b) Describe any methods used to examine subgroups and interactions	Not applicable
		(c) Explain how missing data were addressed	Not applicable
		(d) If applicable, describe analytical methods taking account of sampling strategy	Not applicable
		(e) Describe any sensitivity analyses	Not applicable
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Page 4
		(b) Give reasons for non-participation at each stage	Not applicable
		(c) Consider use of a flow diagram	Not applicable
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page 7
		(b) Indicate number of participants with missing data for each variable of interest	Not applicable
Outcome data	15*	Report numbers of outcome events or summary measures	Page 7
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Page 7
		(b) Report category boundaries when continuous variables were categorized	Page 7
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Page 7
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Not applicable
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page 7-8
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page 8-9
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 7-9
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 9
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 9

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.