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Prevalence and Predictors of Anemia in a Population-Based Study of Octogenarians and Centenarians in Georgia

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Background. Anemia has been associated with increased physical and financial costs and occurs more frequently in older individuals. Therefore, the primary objectives of this study were to examine the prevalence and possible predictors of anemia in the very old.

Methods. Hemoglobin was used to identify those with anemia in a group of centenarians and near centenarians (98+, $n = 185$) and octogenarians ($n = 69$), who were recruited as part of the population-based multidisciplinary Georgia Centenarian Study. Blood markers, including ferritin, vitamin B12, red blood cell folate, methylmalonic acid, creatinine, and C-reactive protein, demographic variables, and medication and/or supplement usage were used to determine possible predictors of anemia.

Results. The prevalence of anemia was 26.2% in octogenarians and 52.1% in centenarians. Low serum albumin (<3.6 g/dL) and decreased estimated glomerular filtration rate (<45 mL/min/m^2) were predictors of anemia in centenarians.

Conclusions. Anemia is a major health issue, particularly as people age. Because of the high prevalence of anemia in older individuals, awareness of the predictors associated with anemia becomes increasingly important so as to reduce the negative consequences associated with it and allow for the identification of steps that can be taken to correct anemia, including managing chronic disease.

Key Words: Anemia—Centenarians—Renal function.

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THE over 85 segment of the population is projected to be the fastest growing segment in the United States this next century (1). With a growing number of older individuals comes an increase in chronic health conditions (2), one of which is anemia. Anemia both causes symptoms and is a signal of other underlying serious health conditions (3–7). In addition to the physical costs, the health care costs of anemia have been estimated to be an additional $7,000–$30,000 more than those incurred with similar health conditions but not anemia (8).

Previous studies on anemia have focused on the entire group of older adults, often combining individuals in their sixties with those who are in their one hundreds (9–11). Considering that the fastest growing segment of the population is those over 85 years and the relatively rapid growth in number of individuals reaching their one hundreds (12), there could potentially be differences in anemia status between those in their sixties and those in their eighties or one hundreds. Consequently, there is a need for better understanding of anemia in older adults, particularly the very old.

Therefore, the purpose of this study was to determine differences, if any, in the prevalence of anemia in a population-based study of octogenarians and centenarians and to determine possible predictors of anemia in the older age group. Based on previous studies (3,9,10,13), it was hypothesized that (a) the prevalence of anemia is higher in centenarians than in octogenarians and (b) that being African American, being male, having decreased estimated glomerular filtration rate (eGFR), and low serum albumin concentrations are possible predictors of anemia in this population. The findings of this study will help identify potential predictors of anemia in the very old, which can then aid in the development of prevention and treatment programs for anemia.

Methods

Study Participants

Data for the secondary analysis came from the population-based multidisciplinary Georgia Centenarian Study (2002–2005), comprised 244 centenarians and near centenarians (98 years and older) and 80 octogenarians (80–89 years) residing in 44 counties of northern Georgia. The recruitment and sampling procedures have been detailed elsewhere (14, 15). Briefly, recruitment of participants from skilled nursing facilities was based on estimates of the institutionalized population of the area according to the 2000 U.S. Census tabulations. Community-dwelling participants, residing in private residences and personal care homes, were recruited from voter registration roles. Participants were also recruited to approximate census figures for gender and race/ethnicity (white or black, all were non-Hispanic), and there was reasonable agreement between the 2000 Census data and the final Georgia Centenarian Study sample, with a slight underrepresentation of African Americans (15). Participants were interviewed in their place of residence by trained personnel, and all questionnaires and procedures were approved by the University of Georgia Institutional Review Board for human subject research.

Blood Values

Non-fasting blood samples were obtained, processed, and stored as previously described (14). Vitamin B12 and red blood cell folate concentrations were determined by radioimmunoassay (Quantaphase II Vitamin B12/Folate Radioassay; Bio-Rad, Richmond, CA) and serum methylmalonic acid and 2-methylcitrate values by capillary gas chromatography–mass spectrometry (16). Complete blood count, ferritin, C-reactive protein (CRP), creatinine, albumin, and other laboratory values were obtained through an independent clinical laboratory (LabCorp, Inc, Burlington, NC). The eGFR was determined using the Modification of Diet in Renal Disease equation (17): $175 \times \text{standardized Scr}^{-1.154} \times \text{age}^{-0.203} \times 1.212$ [if black] $\times$ 0.742 [if female].

Additional Measurements

Height and weight were measured using a stadiometer (58.9% of participants) and scale (57.7% of participants), obtained from the participant's chart (height: 29.6%; weight: 32.4%) or from self-report (height: 11.5%; weight: 9.9%). Body mass index was calculated using the standard formula of weight in kilograms divided by height in meters squared. Information regarding medication and supplement usage was obtained through interview with the participant, a proxy or recorded from the participants' chart (skilled nursing facility). Supplement use was a dichotomous variable (yes or no) and included any supplement containing vitamin B12, folate, and/or iron. Disease sum was based on self-report of osteoporosis, chronic kidney disease, diabetes, chronic airway obstruction, cancers (present), hypertension, Parkinson's disease, or peripheral vascular disease, calculated using a formula described previously (18) and used as a predictor for anemia.

Definition of Anemia and Other Laboratory Values

Participants were categorized as anemic as defined by the World Health Organization [<12 g hemoglobin/dL for females and <13 g hemoglobin/dL for males (19)]. Other laboratory cut-offs were identified, based on previous studies (20–28). Serum ferritin less than 50 ng/mL (20), red blood cell folate less than 317 nmol/L (21), and CRP greater than 5.0 mg/L (22) were considered abnormal, whereas vitamin B12 deficiency was defined as serum B12 less than 258 pmol/L, serum methylmalonic acid (MMA) greater than 271 nmol/L (23), and serum 2-methylcitric acid less than MMA (24). An eGFR, based on the Modification of Diet in Renal Disease equation, of less than 45 mL/min/1.73 m^2 was used as a cut-off point for renal function, as several studies have shown a much greater risk of negative health outcomes in individuals below this cut-off (25–28).

Exclusions From Data Analysis

Of the original centenarian cohort of 244, blood could not be drawn or sufficient sample was not available for hemoglobin analysis for 10 centenarians, thus the overall prevalence of anemia was determined for 80 octogenarians and 234 centenarians. Ultimately, data from 69 octogenarians and 185 centenarians were included in the analysis of baseline characteristics and possible predictors of anemia in the study, as participants missing key blood values (ie, ferritin, CRP) or body mass index information ($n = 11$ octogenarians; $n = 59$ centenarians) were excluded from the final analysis. The included and excluded octogenarians did not differ in mean hemoglobin level, age, gender, race/ethnicity, place of residence, or prevalence of low ferritin, vitamin B12 deficiency, or low eGFR. Compared with the included centenarians, the excluded centenarians were older (101.2 vs 100.4 years) and more likely to have low ferritin (60.3% vs 37.1%) and low eGFR (44.8% vs 26.3%). However, the two groups did not differ in mean hemoglobin level, gender, race/ethnicity, place of residence, or prevalence of vitamin B12 deficiency.

Statistics

Descriptive statistics were performed and included mean, median, standard deviation, and range, or percentage. Chi square tests and Wilcoxon rank sum tests were used to determine differences in baseline characteristics and the prevalence of anemia between octogenarians and centenarians. Multivariate logistic regression analysis was used to identify predictors of anemia for centenarians. The initial model included the 234 centenarians that could be classified

Table 1. Selected Characteristics of Georgia Centenarian Study Participants in the Total Sample and Subsample, Stratified by Age Group[†]

	Total Sample[‡], n = 314		Subsample[§], n = 254	
	Octogenarians	Centenarians	Octogenarians	Centenarians
	Median, Range, M (SD), or % (n)	Median, Range, M (SD), or % (n)	Median, Range, M (SD), or % (n)	Median, Range, M (SD), or % (n)
Age (y)	83.4, 80.5–90.1, 84.3 (2.78)	100.2, 98.1–108.6, 100.6 (2.0)**	84.0, 80.5–90.1, 84.5 (2.8)	100.1, 98.1–108.6, 100.4 (1.9)**
Gender				
Female	66.2 (53)	84.2 (197)	66.7 (46)	84.7 (157)
Male	33.8 (27)	15.8 (37)*	33.3 (23)	15.1 (28)**
Race				
White	82.5 (66)	79.5 (186)	82.6 (57)	80.5 (149)
African American	17.5 (14)	20.5 (48)	17.4 (12)	19.5 (36)
Living arrangement				
Community/personal care	85.0 (68)	57.7 (135)	82.6 (57)	57.8 (107)
Skilled nursing facility	15.0 (12)	42.3 (99)**	17.4 (12)	42.2 (78)**
Anemia	26.2 (21)	52.1 (122)**	27.5 (19)	50.3 (93)**

Notes: [†]Differences between octogenarians and centenarians in the total sample and subsample that were statistically significant are noted as follows: *$p < .01$, **$p < .001$.

[‡]Total sample included all participants except those missing hemoglobin values.

[§]Subsample included participants with complete demographic, biochemical, and anthropometric data.

as anemic or non-anemic based on available hemoglobin data and the demographic variables of race/ethnicity, gender, and type of residence. A subsequent series of regression analyses was conducted for centenarians with complete demographic, biochemical, and anthropometric data (n = 185). Model 1 included race/ethnicity, gender, and type of residence. Model 2 included Model 1 + low B12 and/or folate, low ferritin, low eGFR, low albumin, and high CRP. Model 3 included Model 2 + low body mass index, number of medications, and nutritional supplements. Due to the low sample size, similar regression analysis was not conducted for the octogenarians. Statistical analysis was performed using SAS software (version 9.1; SAS Institute, Carey, NC). The $p < .05$ was considered statistically significant.

Results

In this study, the prevalence of anemia was 26.2 among octogenarians and 52.1 among centenarians in the total sample (n = 314) and 27.5% among octogenarians and 50.3% among centenarians in the subset with complete data for all variables of interest (n = 254). In the total sample, centenarians were more likely than octogenarians to be female, reside in a skilled nursing home, and have anemia (Table 1). Among those with complete demographic, biochemical, and anthropometric data, centenarians were more likely than octogenarians to be female, reside in a skilled nursing facility, and have anemia (Table 1), and have a lower body mass index, a lower eGFR, and lower albumin and folate concentrations, and higher CRP and MMA concentrations (data not shown). In contrast, there were no differences between centenarians and octogenarians with regard to being African American in either sample group.

As shown in Table 2, octogenarians with anemia were more likely to be female, African American, and have lower albumin concentrations and lower eGFR as compared with octogenarians without anemia. Centenarians with anemia were more likely than those without anemia to have lower albumin concentrations, have an eGFR less than 45 mL/min/m^2, and have higher creatinine concentrations. The two groups did not differ by race/ethnicity.

Multivariate regression analyses were subsequently performed to determine possible predictors of anemia in centenarians. When all centenarians with available hemoglobin data were included in the analysis (n = 234), males were more than twice as likely to have anemia than females (odds ratio = 2.32, 95% confidence interval: 1.09–4.94, p = .03) and there was a trend for African Americans to be about twice as likely to have anemia than whites (odds ratio = 1.93, 95% confidence interval: 0.99–3.76, p = .05); however, the probability of having anemia was not related to place of residence (odds ratio = 1.36, 95% confidence interval: 0.80–2.32, p = .26). Among the subset of centenarians with a complete set of data for key demographic, biochemical, and anthropometric parameters (Table 3), the odds of having anemia were about 2.3 and 2.4 times higher in those with a low albumin concentration (<3.6 g/dL) and/or a decreased eGFR (<45 mL/min/1.73 m^2), respectively, as compared with those with normal albumin levels and/or higher kidney function. In these analyses having low ferritin, B12/folate, and high CRP were not predictors of anemia.

Discussion

The objectives of this study were to examine the difference in overall prevalence of anemia between centenarians and octogenarians and to determine possible predictors of anemia in centenarians. The results of this study support the hypothesis that centenarians have a much higher prevalence of anemia than octogenarians. This is consistent with other

Table 2. Selected Characteristics of Georgia Centenarian Study Participants With and Without Anemia, Stratified by Age Group[†]

	Octogenarians, $n = 69$		Centenarians, $n = 185$	
	With Anemia	Without Anemia	With Anemia	Without Anemia
	Median, Range, *M* (*SD*), or % (*n*)	Median, Range, *M* (*SD*), or % (*n*)	Median, Range, *M* (*SD*), or % (*n*)	Median, Range, *M* (*SD*), or % (*n*)
Age (y)	83.2, 80.5–90.1, 84.2 (3.1)	85.4, 80.5–90.0, 84.7 (2.8)	99.6, 98.1–105.0, 100.2 (1.7)	100.2, 98.1–108.6, 100.6 (1.9)
Gender				
Male	13.0 (3)	87.0 (20)*	64.3 (18)	35.7 (10)
Female	34.8 (16)	65.2 (30)	47.8 (75)	52.2 (82)
Race				
White	19.3 (11)	80.7 (46)**	47.6 (71)	52.4 (78)
African American	66.7 (8)	33.3 (4)	61.1 (22)	38.9 (14)
Living arrangement				
Skilled nursing facility	33.3 (4)	66.7 (8)	51.3 (40)	48.7 (38)
Community/personal care	26.3 (15)	73.7 (42)	49.5 (53)	50.5 (54)
Hemoglobin (g/dL)	11.2, 9.7–12.8, 11.2 (0.8)	13.8, 12.0–16.5, 13.9 (1.1)***	11.1, 7.5–12.6, 10.9 (1.0)	12.9, 12.0–16.7, 13.1 (0.9)***
Albumin (g/dL)	3.9, 3.0–4.3, 3.8 (0.3)	4.1, 2.3–4.8, 4.0 (0.4)**	3.6, 2.6–4.4, 3.6 (0.4)	3.8, 2.9–4.7, 3.7 (0.3)**
CRP (mg/dL)	4.4, 0.4–20.5, 5.4 (4.8)	2.0, 0.4–33.4, 4.1 (5.8)	3.2, 0.4–106.0, 10.0 (20.4)	3.6, 0.3–149.9, 7.8 (16.4)
High CRP (>5.0 mg/dL)	36.84 (7)	24.0 (12)	37.6 (35)	41.3 (38)
Creatinine (mg/dL)	1.0, 0.7–2.1, 1.1 (0.3)	0.9, 0.6–1.9, 0.9 (0.2)	1.1, 0.5–2.5, 1.1 (0.4)	1.0, 0.5–5.5, 1.0 (0.6)*
High creatinine (>1.4 mg/dL)	10.5 (2)	6.0 (3)	23.7 (22)	10.9 (10)*
eGFR (mL/min/1.73 m^2)[‡]	59.4, 27.2–112, 60.0 (20.9)	67.9, 32.6–111, 69.8 (18.6)*	51.1. 22.8–114, 56.9 (22.9)	57.5, 9.6–147, 60.4 (22.3)
Low eGFR (<45 mL/min/1.73 m^2)	21.0 (4)	10.0 (5)	34.4 (32)	18.5 (17)*
Ferritin (ng/mL)	59.0, 8.0–1257, 166 (284)	70.5, 11.0–280, 86.0 (65.3)	80.0, 1.6–1955, 139 (231)	76.5, 10.0–409, 101 (90.7)
Low ferritin (<50 ng/mL)	47.4 (9)	36.0 (18)	39.8 (37)	34.8 (32)
Vitamin B12 or folate deficiency[§]	21.0 (4)	26.0 (13)	33.3 (31)	38.0 (35)
Body mass index categories				
Underweight (<18.5 kg/m^2)	5.3 (1)	2.0 (1)	22.6 (21)	14.1 (13)
Normal (18.5–24.9 kg/m^2)	31.7 (6)	42.0 (21)	53.8 (50)	58.7 (54)
Overweight (25.0–29.9 kg/m^2)	47.4 (9)	46.0 (23)	20.4 (19)	19.6 (18)
Obesity (≥30 kg/m^2)	15.8 (3)	10.0 (5)	3.2 (3)	7.6 (7)
Total number of medications	8, 2–12, 7 (3)	6, 0–13, 6 (3)	7, 0–15, 7 (4)	7, 0–15, 7 (4)
Supplement use[‖]				
Yes	42.1 (8)	42.0 (21)	46.2 (43)	50.0 (46)
No	57.9 (11)	58.0 (29)	53.8 (50)	50.0 (46)
Disease score[¶]	1.0, 0.0–5.0, 1.8 (1.4)	1.0, 0.0–5.0, 1.2 (1.1)	1.0, 0.0–5.0, 1.3 (1.0)	1.0, 0.0–4.0, 1.3 (1.1)

Notes: CRP = C-reactive protein; eGFR = estimated glomerular filtration rate.

[†]Listed characteristics are for the subset of octogenarians and centenarians with complete demographic, biochemical, and anthropometric data. Differences between octogenarians and centenarians that were statistically significant are noted as follows: *$p < .05$, **$p < .01$, ***$p < .001$.

[‡]eGFR formula: 175 × standardized $Scr^{-1.154}$ × $age^{-0.203}$ × 1.212 [if black] × 0.742 [if female] (16).

[§]Vitamin B12 deficiency: serum B12 < 258 pmol/L, MMA > 271 nmol/L, and 2-methylcitric acid level less than MMA. Folate deficiency: red blood cell folate levels < 317 nmol/L.

[‖]Supplements: B vitamin, B vitamins + omega-3 fatty acids, herbals + vitamins, iron, minerals, multivitamin, multivitamin + calcium, multivitamin + iron, multivitamin + minerals, multivitamin + zinc, vitamin, vitamins + minerals, vitamins + zinc, vitamins; b complex + c.

[¶]Disease score: one point for a self-report of osteoporosis, chronic kidney disease, diabetes chronic airway obstruction, present cancer, hypertension, Parkinson's disease, and peripheral vascular disease. Points were then summed for a score.

studies (10,29) that have shown that the prevalence of anemia generally increases with age and sharply increases after the age of 85 years.

Previous studies have successfully classified anemia into distinct classifications in order to determine potential etiologies (nutritional, inflammatory, renal insufficiency, or unexplained) but have also focused on a generally "younger" older adult population (9–11,30). Unfortunately, anemia could not be readily classified in this uniquely aged population due to a limited battery of laboratory assessments and lack of clinical diagnoses. Nonetheless, it seems likely that there may be a greater prevalence of "explained" anemia among the centenarians than has previously been reported in other studies of older adults (9–11,30) due to the increased prevalence of chronic disease that often accompanies advanced age (2,31,32), which may affect a person's hemoglobin status. Accordingly, Wieczorowska-Tobis and colleagues (33) found that most cases of anemia in a small study of Polish centenarians appeared to be accompanied by another pathological condition, such as low serum iron, low albumin, increased CRP, and/or increased activity of liver enzymes, that could have contributed to the individual having anemia.

Results of regression analysis may provide some insight into the high prevalence of anemia in centenarians. The results of multiple regression analysis indicate that having decreased renal function (eGFR < 45 mL/min/1.73 m^2) and low albumin concentration (<3.6 g/dL) are the two greatest predictors of anemia in centenarians, whereas having increased

Table 3. Multivariate Regression Analyses Exploring Predictors of Anemia in Centenarians*

Dependent Variable	Model 1, Odds Ratio (95% CI)†	*p*	Model 2, Odds Ratio (95% CI)‡	*p*	Model 3, Odds Ratio (95% CI)§	*p*
Male	2.01 (0.87–4.66)	.103	1.98 (0.82–4.78)	.127	2.25 (0.92–5.51)	.077
African American	1.75 (0.82–3.70)	.146	1.74 (0.80–3.79)	.162	1.94 (0.87–4.33)	.106
Skilled nursing facility	1.06 (0.58–1.91)	.860	1.00 (0.53–1.89)	.991	0.83 (0.41–1.69)	.612
Ferritin (<50 ng/mL)			1.32 (0.70–2.50)	.395	1.34 (0.70–2.56)	.383
B12 and/or folate deficiency			0.79 (0.42–1.50)	.478	0.84 (0.44–1.61)	.592
eGFR (<45 mL/min/1.73 m^2)			2.27 (1.13–4.59)	.022	2.38 (1.16–4.89)	.018
High CRP (>5 mg/L)			0.68 (0.36–1.32)	.256	0.62 (0.32–1.22)	.170
Low albumin (<3.6 g/dL)			2.41 (1.22–4.78)	.012	2.30 (1.14–4.65)	.020
Low BMI (<18.5 kg/m^2)					2.14 (0.93–4.94)	.074
Number of supplements					0.73 (0.37–1.42)	.355
Number of medications					1.06 (0.96–1.16)	.241

Notes: BMI = body mass index; CI = confidence interval; CRP = C-reactive protein; eGFR = estimated glomerular filtration rate.

*A series of regression analysis was conducted on the subset of centenarians with complete demographic, biochemical, and anthropometric data (n = 185).

†Model 1: sex, race, and residence.

‡Model 2: Model 1 + low ferritin (<50 ng/mL), vitamin B12 or folate deficiency (Vitamin B12 deficiency: serum B12 < 258 pmol/L, MMA > 271 nmol/L, and 2-methylcitric acid < MMA, folate deficiency: red blood cell folate levels < 317 nmol/L), eGFR < 45 mL/min/1.73 m^2 [175 × standardized $Scr^{-1.154}$ × $age^{-0.203}$ × 1.212 [if black] × 0.742 [if female] (16)] and albumin (< 3.6 g/dL).

§Model 3: Model 2 + low BMI (<18.5 kg/m^2), number of supplements (B vitamin, B vitamins + omega-3 fatty acids, herbals + vitamins, iron, minerals, multivitamins, multivitamin + calcium, multivitamin + iron, multivitamin + minerals, multivitamin + zinc, vitamin, vitamins + minerals, vitamins + zinc, vitamins b complex + c), and number of medications.

CRP and decreased blood/serum vitamin and/or mineral concentrations are not. As people age, there is a greater risk of developing disease (2), particularly chronic kidney disease (31,32), resulting in the activation of inflammatory responses and down regulation of red cell production hormones, consequently affecting red cell production (34,35). Understanding this interaction emphasizes the importance of managing chronic disease, specifically chronic kidney disease, in the older population and finding ways to attenuate the interaction of disease and anemia.

Previous studies on "younger" older adult populations have shown an increased prevalence of anemia among African Americans (3,36). Interestingly, although being African American was a strong predictor of anemia (data not shown) in octogenarians and in centenarians in the initial model, it was not a predictor of anemia in the subset of anemia in centenarians with complete demographic, biochemical, and anthropometric data. Although this may be partly due to the reduced sample size and low representation of African Americans in the study, the question remains as to whether or not race remains a strong factor in the prevalence of anemia in the very old. Perhaps other contributors to anemia, such as low ferritin, high CRP, and/or poor renal function, become more important than race with advanced age.

Previous studies on the very old have shown a higher prevalence of anemia among men than women (10,29,33,37). Accordingly, we also found that male centenarians were more than twice as likely to have anemia as compared with centenarian females, although this result was no longer significant when those missing key data parameters were excluded from the regression analysis. Although our finding of a lower prevalence of anemia in octogenarian men than women is in contrast to previous studies in this age group, this is likely due to the low overall number of octogenarians and predominance of females (67%) in this population-based sampling.

In the present study, residing in a skilled nursing facility was not a significant predictor of anemia status. Some studies have found the prevalence of anemia in skilled nursing facilities to be in the range of 40%–60% (9,38,39), which is much higher than the 10%–11% prevalence of anemia in the general population, aged 65 years and older (10). However, few studies have done direct comparisons of anemia prevalence in older adults residing in the community versus skilled nursing facilities, and to our knowledge none have been previously conducted in the very old. Given the high overall prevalence of anemia in Georgia centenarians and strong association of anemia with both age and biomarkers of chronic disease, the finding of similar prevalence of anemia in the skilled nursing facility as compared with community-dwelling participants is perhaps not surprising. Nonetheless, additional studies are required to confirm these findings in the very old.

One of the strengths of this study is the advanced ages of the participants. Many studies on anemia focus on a much younger population, but there can still be many years to be lived, even after age 65 (40). Focusing on octogenarians and centenarians provides insight on disease trends that occur in a unique and less-studied population. An additional strength of this study is the attempt made to obtain a representative sample of the Georgia population, covering a broader spectrum of the population than a convenience sample.

There are several limitations to this study, including the small sample size. We note, however, that our sample includes nearly one in five centenarians from the geographic area surveyed (15), and so this is an inherent limitation of working with such a rare population. Even with the small numbers in the different groups, trends were detected,

which may have been significant had the sample size been larger. Another limitation was in the way that renal function was characterized. Several formulas for estimating renal function have been suggested (16,41,42), although these formulas have not been validated in the very old.

In conclusion, anemia is a very insidious disease, particularly in older adults. A major concern is the high prevalence of anemia in the centenarians—over 50%. The high prevalence of anemia, combined with the increasing number of individuals reaching "centenarian" status, and the negative health conditions associated with anemia make for an increasing need to understand anemia in the very old. Future studies may include the assessment of anemia's impact on the quality of life in the very old and specifically focus on anemia's association with cognitive and physical function. In addition, a better understanding of the etiology of anemia may lead to better treatment and potentially fewer negative consequences associated with anemia in the very old, thus leading to a higher quality of life and lower health care costs.

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