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Adolescent Anemia Screening During Ambulatory Pediatric Visits in the United States

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Abstract

The Centers for Disease Control and Prevention recommends anemia screening for reproductive age women every 5–10 years and annually for those with risk factors. Due to the lower risk of anemia among males, screening for men is recommended only if risk factors exist. The study objective was to examine health care professionals' current anemia screening patterns for male and female adolescents. Data are from the 2001–2004 National Ambulatory Medical Care Survey, a nationally representative sample of ambulatory visits to primary care practices. The frequency of anemia screening during preventive care visits by 12–21-year-olds was estimated by sex using a reported hemoglobin/hematocrit or complete blood count as an indicator of screening. Multivariable logistic regression identified patient, provider and practice-level factors associated with screening. During the study period, 1,263 preventive care visits occurred for 12–21 year-olds. In bivariate analysis, higher odds of anemia screening were observed for both younger females (OR 1.85; 95% CI [1.09–3.14]) and older males (1.83 [1.02–3.26]) compared to older females (> 16 years). In the multivariable model, odds of screening increased with non-white race 3.29 (1.84–5.88), tobacco use 3.57 (1.94–6.58), longer visit length 1.03 (1.01–1.06), and practice site acceptance of managed care plans 2.08 (1.04–4.14). Patient sex and age were not statistically significant predictors of screening. Although anemia is more prevalent among older adolescent females, they were not more likely to be screened. This suggests providers are not targeting groups at highest risk of anemia for screening.

Keywords

anemia; iron-deficiency; screening; adolescents

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Iron deficiency anemia affects 3.3 million reproductive age women in the United States (US) with clearly documented morbidity [1]. Data from the National Health and Nutrition Examination Survey reinforces the higher prevalence of iron deficiency anemia among women, demonstrating a prevalence of 2–5% among women aged 12–49 years compared to < 1% of males in this age group [1–3].

For adolescent females in particular, rapid growth combined with menstruation and overall lower body iron lead to an increased risk of iron deficiency anemia [2, 4]. Anemic adolescent females experience negative effects on scholastic achievement, cognitive function and audiovisual reaction time [5–7]. These effects may impact future academic and workplace success. Symptoms improve rapidly with iron supplementation [6, 7].

As part of routine preventive care services, pediatric healthcare providers screen adolescents for anemia. This strategy misses non-anemic iron-deficient adolescents who will also benefit from iron treatment. However, current screening is anemia-based due to lack of a single, simple, inexpensive test for iron-deficiency available for point-of-care testing [2]. The Centers for Disease Control and Prevention (CDC) recommends blood test screening “all non-pregnant women for anemia every 5-10 years throughout their childbearing years during routine health examinations.” Women with risk factors (extensive menstrual or other blood loss, low iron intake, previous diagnosis of iron-deficiency anemia) are recommended for annual screenings [2]. Screening men is recommended only in the presence of risk factors [2]. While the *Bright Futures* preventive care guidelines reference the CDC recommendations, the periodicity schedule indicates a risk assessment of both adolescent women and men should be done at preventive care visits followed by laboratory testing of those at high risk for anemia [4, 8]. *Bright Futures* acknowledges the lack of controlled trials to support current screening recommendations for adolescent anemia [8].

Little is known about the factors influencing objective anemia screening in ambulatory pediatric settings in the US. The goal of this study was to describe current anemia screening of adolescents by providers to inform the development of future screening algorithms. We hypothesized that the frequency of anemia screening would be higher among adolescent females, as this group is at increased risk of iron deficiency anemia, when compared with males in the same age group [1–3]. Older adolescent females were hypothesized to have increased screening rates based on our prior analysis of risk factors for adolescent anemia [9]. Additionally, we hypothesized that the lack of evidence and inconsistency between guidelines would amount to a large variation in screening practices based on patient, provider and practice-level factors.

Materials and Methods

Data Source and Design

We analyzed data from the National Ambulatory Medical Care Survey (NAMCS) to estimate the frequency of anemia screening in adolescents during ambulatory care visits for preventive care in the US. We combined data collected in the surveys between years 2001 and 2004. These years were selected as they are the only ones in which hemoglobin, hematocrit or complete blood count (CBC) were included as part of the survey. Hemoglobin

and hematocrit, commonly performed as point-of-care testing for anemia, were no longer included in NAMCS after 2004 and limited the number of years that could be evaluated for this analysis.

The National Center for Health Statistics (NCHS) administers the NAMCS annually to meet the need for objective, reliable information about the provision and use of ambulatory medical care services in the US [10]. The survey is used to collect information about patient demographics, diagnoses, medications prescribed, and procedures performed [11]. Additionally, provider characteristics, including physician sex, year of birth, race/ethnicity, and foreign graduate status, and practice characteristics, such as practice size, are included in a restricted dataset. The restricted data files were accessed through the Research Data Center [12]. The study was determined non-human subjects research by the Institutional Review Board of Penn State College of Medicine.

The NCHS uses a 3-stage probability sample procedure to administer the NAMCS during office visits [13, 14]. The NCHS samples 112 geographic primary sampling units (PSUs), physician practices within PSUs, and visits within practices. For each visit, the NCHS provides a visit weight equal to the inverse probability of that visit being sampled [13, 14]. These weights allow for the generation of nationally representative estimates by using data from the NAMCS [14]. In this study, we analyzed data from visits to offices for preventive care only.

Study Population

We defined the study population to include all preventive care visits by patients aged 12 to 21 years-old at US ambulatory care offices between 2001 and 2004. Age 21 years reflects the upper age limit of many pediatric practices, but more specifically the upper age limit with specific screening recommendations for children and adolescents as detailed in the text, *Bright Futures* [4, 8]. Anemia screening was defined as having occurred if it was recorded on the survey instrument that a hemoglobin, hematocrit or CBC had been ordered by the physician. Providers distinguished visits for preventive care from those for acute or chronic care by using a check box on the survey instrument that denoted the “major reason for the visit” [15].

Analysis

The goal of our study was to determine factors associated with ordering of anemia screening in adolescents, aged 12 to 21 years, during a preventive care visit. Because the NAMCS data are from a complex probability sample, the selected data were weighted appropriately as per NAMCS study guidelines to be representative of the current US population for all analyses. All statistical analyses were performed using SAS software, version 9.3 (SAS Institute Inc., Cary, NC), in particular the procedures SURVEYMEANS, SURVEYFREQ, and SURVEYLOGISTIC, specifically designed for complex survey analyses, which take into account the sampling weights and complex study design to calculate proper variances of estimates were used. All reported percentages are weighted percentages.

First, bivariate analyses using logistic regression were conducted to assess the association of potential predictors with the outcome of interest (i.e., anemia screening). The potential predictors included: patient characteristics (age, sex, race/ethnicity, tobacco use), physician characteristics (year of birth, sex, race/ethnicity, foreign medical graduate, specialty, patient's primary care provider [yes vs. no], patient seen before, physician degree [M.D. vs. D.O.]), and practice characteristics (length of time spent with physician, geographic region, availability of laboratory services, practice size, percentage of revenue from various insurances [Medicare, Medicaid, managed care, private insurance, etc.]). Potential predictors that were nominally associated with anemia screening (i.e., $p < 0.10$) were then used as a candidate pool of predictors to construct a multivariable logistic regression model using backward variable selection with the criteria for a variable to remain in the multivariable model set to a significance level of 0.05.

In examining the overall prevalence of anemia screening by sex, it was noted that the overall screening rates were higher for males than females. In particular, screening rates declined for older adolescent females. Thus, the interaction of age and sex was examined and was found to be nominally associated with anemia screening in a bivariate analysis ($p=0.09$). Furthermore, the interaction of age and sex was considered as a candidate variable in the subsequent multivariable analyses.

There are an extensive number of provider categories in the NAMCS dataset. Providers were separated into "pediatric" trained and other. "Pediatric" trained included general pediatricians as well as any pediatric subspecialist. However, it was anticipated that the selection of only preventive care visits would limit the number of subspecialty providers involved, such that the bulk of providers would be from general pediatrics, family medicine and internal medicine.

For the multivariable model, the concordance index (c-index), also referred to as the area under the curve, is reported. The c-index, a measure of predictive ability, is the proportion of all pairs of adolescents with different outcomes (anemia screening vs. no anemia screening) in which the adolescent with the higher predicted probability of anemia screening was indeed the adolescent who had anemia screening. A c-index value of 0.50 indicates completely random predictions while a value of 1.0 indicates perfect predictions. For the c-index, Hosmer and Lemeshow refer to "acceptable discrimination" if $0.7 \leq \text{c-index} < 0.8$ and "excellent discrimination" if $0.8 \leq \text{c-index} < 0.9$ [16].

Results

Frequency of Anemia Screening by Sex and Age

During the 4-year study period there were 1263 ambulatory visits for preventive care by adolescents 12 to 21 years-old, representing over 60 million visits when the appropriate sample weights were applied. Overall, anemia screening was ordered during 171 ambulatory visits (weighted percentile 13.5%). In 93 visits (7.9%) this was based on CBC alone, 60 visits (4.5%) hemoglobin/hematocrit alone and in 18 visits (1.1%) both blood tests were ordered. The remaining 1092 visits (86.5%) had no anemia screening ordered.

Anemia screening was ordered in 12.3% of female and 16.2% of male preventive care visits. Among those aged < 16 years, 17.9% of females and 14.8% of males were screened. For those aged ≥ 16 years 10.5% of females and 17.7% of males were screened. Anemia screening for adolescent females declined by age, but increased for older males (interaction $p=0.09$; Figure). Females < 16 years old demonstrated increased odds of anemia screening compared with females ≥ 16 years old (OR 1.85, 95% CI 1.09-3.14). Males ≥ 16 years old were also more likely to be screened than similarly aged females (OR 1.83, 95% CI 1.02-3.26).

Bivariate Analyses

Bivariate comparisons demonstrated that of the patient demographic variables examined, race and tobacco use were associated with anemia screening at preventive care visits (Table 1). When the patient self-identified as non-white, the odds of ordering anemia screening were three times that (OR 3.12, 95% CI 1.92-5.07) when the visit occurred with a white patient.

Many physician characteristics were not strongly associated with anemia screening (sex, race, foreign graduate status, new vs. existing patient for the provider/practice, medical degree [MD vs. DO]). Anemia screening was more likely to be conducted by older physicians (OR 1.02, 95% CI 1.00-1.05). Anemia screening was also more likely if the physician had pediatric training (general pediatrician or pediatric subspecialist; OR 1.88, 95% CI 1.17-3.00) or was the primary care provider (OR 1.81, 95% CI 1.06-3.10).

Several practice factors were associated with increased anemia screening including longer patient visit duration, geographic location in the Northeast, the availability of onsite laboratory services, and greater than one quarter of patient care revenue from managed care.

Multivariate Analyses

Multivariable logistic regression demonstrated factors associated with increased odds of anemia screening included non-white race, patient tobacco use, longer patient visit duration, and acceptance of managed care (Table 2). In particular, patient age, sex and their interaction were not retained in the final model due to non-significance. None of the provider factors remained significant in the final model.

Discussion

Adolescent anemia screening is influenced by patient- and practice-level variables. Given that anemia is known to be much more common among females, current screening practices do not reflect this disparity. The relatively higher screening rates for males and younger females suggest that providers are not preferentially targeting those at greatest risk for anemia. For females specifically, the higher prevalence of screening at a younger age may miss those who become anemic over the course of adolescence due to the cumulative effects of menstruation and perhaps other lifestyle factors.

The consequences of missing anemia are not insignificant. With documented negative effects of iron deficiency anemia on cognitive abilities and scholastic performance in

adolescents [5–7], there is a potential long-term impact on success in higher education and the workplace. Young women with iron deficiency anemia who eventually become pregnant are known to be at increased risk for preterm delivery and delivery of a low-birth weight infant, which places both maternal and child health at risk [2]. Yet, once iron deficiency anemia is identified, treatment can be successfully completed with oral iron supplementation [2].

The decline in the prevalence of anemia screening in adolescent females by age suggests in following the CDC guidelines on anemia screening in reproductive age women, pediatric providers test young adolescent females for anemia and may not repeat the screen in subsequent years. For example, a 13 year-old adolescent female who has no risk factors and a normal hemoglobin may not be screened again by her pediatric provider (with the assumption her next anemia screen is due at 23 years-old) [2, 4, 8]. Although it was not statistically significant, the observation that adolescent males are overall *more* likely to be screened for anemia is very surprising, suggesting providers may be misinterpreting the guidelines for males.

Adolescent males present for routine well-child care less often than their female counterparts [17]. One possible explanation for the unexpectedly high anemia screening rates for older adolescent males may be that those men who keep visits for routine care are more likely to have an underlying medical issue. This may increase the likelihood anemia screening is conducted, despite the low anemia prevalence among males, especially if laboratory testing is obtained for other reasons.

Considering that the prevalence of iron deficiency anemia is much higher among adolescent females as compared to males, these results raise concerns about the practical application of the current guidelines [1–4, 8]. Reevaluating the guidelines with specific age recommendations for anemia screening of adolescent females in the periodicity schedule for pediatric preventive care may standardize and improve current screening practices. Additionally, a clearer understanding of anemia risk factors specific to adolescent females may better assist providers in selecting adolescent girls who warrant more frequent testing throughout adolescence.

If a screening test is utilized uniformly by providers (e.g. the newborn screen done prior to nursery discharge), one anticipates there will be minimal variation in the use of the test based on individual factors. For the case of adolescent anemia screening, however, the guidelines are relatively vague, which likely contributes to the variation based on perception of an individual patient's risk factors for anemia combined with practice factors (i.e. time spent on the visit and insurance coverage).

The patient factors which remained significant in the multivariable model included race and tobacco use. An increased prevalence of anemia among non-whites is supported by the literature [18]. Tobacco use was included as a variable in the analysis for a potential association with poor general health, poor nutrition and food insecurity [19]. It is known that cigarette smoking artificially elevates hemoglobin levels and potentially masks anemia [20].

In examining visit characteristics retained in the multivariable model, longer visit length was associated with increased odds of anemia screening. Perhaps this was related to the physician eliciting additional symptoms of concern, an underlying medical issue, or simply having additional time to consider all the necessary screenings. The association of managed care with anemia screening merits additional discussion. It may be that those on managed care plans, especially those with a preventive care focus, are more likely to have routine screenings performed.

We acknowledge several limitations to this study. First, it is possible that NAMCS does not capture all anemia screening due to provider documentation oversight. Further, the nature of this study made it impossible to know with certainty the reason for the laboratory testing. Hemoglobin/hematocrit is typically done only for anemia. However, a CBC also includes a white blood cell count and platelet count as well as various cell indices. Done in the setting of well-child care it is unlikely the CBC would have been ordered to screen for infection or document a normal platelet count, but this is an unknown.

As the unit of measurement in NAMCS is the patient visit and not the individual patient this analysis could not report on the percentage of adolescents who had anemia screening performed. However, as pediatric patients are typically seen on an annual basis for well-child care (preventive care), this number is unlikely to be diluted by multiple preventive care visits from the same individual. As adolescent females are more likely to present for both preventive care and other (i.e., acute) visits, the setup of the database makes it impossible to account for a female adolescent having a hemoglobin/hematocrit or CBC ordered for another indication during a sick visit scheduled shortly before her well-visit.

Lastly, it is acknowledged that these data reflect practice patterns from a decade ago. These years were specifically selected so that hemoglobin, hematocrit and CBC could be examined in the context of anemia screening. However, there have been no changes to screening guidelines over this timeframe.

Conclusions

Current screening practices do not reflect the higher prevalence of anemia among adolescent females. In following guidelines, pediatric providers may focus on screening younger adolescent females without considering repeat testing for older adolescent women. Reevaluating the guidelines with specific age recommendations for anemia screening of adolescent females in the periodicity schedule may standardize and improve current screening practices. Understanding anemia risk factors specific to adolescent females may better assist providers in selecting adolescent girls who warrant more frequent testing throughout adolescence.

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Figure.

Graphical representation of adolescent anemia screening by age(years)*sex interaction term (overall significance $P=0.09$). Pairwise comparisons are listed below.

Females Aged < 16 vs. Females Aged > 16, OR=1.85; 95% CI: (1.09-3.14); $P=0.02$

Males Aged < 16 vs. Females Aged > 16, OR=1.45; 95% CI: (0.81-2.69); $P=0.20$

Males Aged > 16 vs. Females Aged > 16, OR=1.83; 95% CI: (1.02-3.26); $P=0.04$

Males Aged < 16 vs. Females Aged < 16, OR=0.80; 95% CI: (0.43-1.47); $P=0.47$

Males Aged > 16 vs. Females Aged < 16, OR=0.99; 95% CI: (0.55-1.77); $P=0.96$

Males Aged < 16 vs. Males Aged > 16, OR=0.81; 95% CI: (0.41-1.58); $P=0.54$

Table 1

Bivariate associations of patient-, provider-, and practice-level factors associated with anemia screening for adolescents during preventive care visits (n=1263)

Characteristic	Number of sampled preventive care visits	Weighted percentage of visits with anemia screening	Significance (P)	OR (95% CI) for anemia screening ^a
Patient				
Sex			0.14	
Male	368	16.2		1.37 (0.90–2.08)
Female	895	12.3		Reference
Age			0.09	
<16 years	417	16.4		1.43 (0.94–2.17)
16 years	846	12.1		Reference
Patient race			<0.001	
Non-White	213	27.1		3.12 (1.92–5.07)
White	1050	10.6		Reference
Patient ethnicity			0.84	
Hispanic or Latino	169	14.6		1.07 (0.56–2.03)
Not Hispanic or Latino	954	13.8		Reference
Patient tobacco use			<0.001	
Yes	105	32.5		3.60 (2.22–5.83)
No	1158	11.8		Reference
Provider				
Physician age (years) ^b	1263	48.1 (0.5)	0.07	1.02 (1.00–1.05)
Physician sex			0.58	
Female	417	12.4		0.87 (0.52–1.44)
Male	846	14.0		Reference
Physician race			0.91	
Non-White	267	12.8		0.97 (0.55–1.71)
White	624	13.2		Reference
Foreign (non-United States) graduate			0.48	
Yes	222	15.6		1.24 (0.68–2.28)
No	922	12.9		Reference
Specialty pediatrics			0.009	
Yes	342	19.6		1.88 (1.17–3.00)
No	921	11.5		Reference
Primary care provider			0.03	
Yes	709	16.3		1.81 (1.06–3.10)
No	466	9.7		Reference
Patient seen before by provider/practice			0.85	
Yes	1087	13.5		0.94 (0.52–1.73)
No	172	14.1		Reference

Characteristic	Number of sampled preventive care visits	Weighted percentage of visits with anemia screening	Significance (P)	OR (95% CI) for anemia screening ^a
Medical degree			0.96	
D.O.	119	13.8		1.02 (0.44–2.38)
M.D.	1144	13.5		Reference
Practice				
Patient visit duration (minutes) ^b	1263	16.6 (0.5)	<0.001	1.03 (1.02–1.06)
Geographic location			0.002	
Midwest	301	6.5		0.27 (0.14–0.53)
South	420	13.7		0.62 (0.32–1.21)
West	275	13.6		0.62 (0.33–1.17)
Northeast	267	20.3		Reference
Lab services available			0.05	
Yes	744	15.7		1.62 (1.00–2.64)
No	519	10.3		Reference
Number of physicians in the practice			0.16	
10	792	12.0		0.71 (0.44–1.14)
< 10	471	16.2		Reference
Percent of patient care revenue from Medicaid			0.35	
>25%	387	11.4		0.76 (0.43–1.35)
25%	759	14.5		Reference
Percent of patient care revenue from Medicare			0.60	
>25%	229	11.7		0.83 (0.42–1.67)
25%	924	13.7		Reference
Percent of patient care revenue from Managed Care			0.02	
>25%	701	14.9		2.19 (1.13–4.24)
25%	225	7.4		Reference
Percent of patient care revenue from Private Insurance			0.37	
>25%	897	14.0		1.33 (0.72–2.46)
25%	257	10.9		Reference
Percent of patient care revenue from Other Sources			0.59	
>25%	69	10.5		0.76 (0.29–2.02)
25%	1028	13.3		Reference

^a OR=odds ratio, CI=confidence interval

^b continuous variables are reported as the weighted mean (standard error) for visits with anemia screening ordered

Table 2

Multivariable logistic regression model of factors associated with adolescent anemia screening

Predictor	OR (95% CI) ^a	Significance (<i>P</i>)
Patient race		
Non-White vs. White	3.29 (1.84–5.88)	<0.001
Patient tobacco use		
Yes vs. No	3.57 (1.94–6.58)	<0.001
Length of time patient spent with physician (minutes) ^b	1.03 (1.01–1.06)	0.006
Percent of patient care revenue from Managed Care	2.08 (1.04–4.14)	0.038
>25% vs. 25%		

^a OR=odds ratio, CI=confidence interval^b continuous predictor

c-index=0.71