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Child Food Insecurity and Iron Deficiency Anemia in Low-Income Infants and Toddlers in the United States*

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Objective: Examine the association between child-level food insecurity and iron status in young children utilizing community-based data from the Children's Sentinel Nutrition Assessment Program (C-SNAP). *Methods*: A cross-sectional sample of caregivers of children ≤36 months of age utilizing emergency department (ED) services were interviewed between 6/96–5/01. Caregiver interviews, which included questions on child-level food security, were linked to a primary clinic database containing hemoglobin, red blood cell distribution width, mean corpuscular volume, free erythrocyte protoporphyrin and lead values. Children *a priori* at-risk for anemia: birthweight ≤2500 g, with HIV/AIDS, sickle cell disease, or lead values ≥10.0 ug/dL, and children ≤6 months of age were excluded from the analysis. Only laboratory tests 365 days prior or 90 days after interview were examined. Iron status was classified in four mutually exclusive categories: 1) Iron Sufficient-No Anemia (ISNA), 2) Anemia (without iron deficiency), 3) Iron Deficient-No Anemia (IDNA), 4) Iron Deficient with Anemia (IDA). *Results*: 626 ED interviews linked to laboratory data met the inclusion criteria. Food insecure children were significantly more likely to have IDA compared to food secure children [Adjusted Odds Ratio = 2.4, 95% CI (1.1–5.2), $p = 0.02$]. There was no association between child food insecurity and anemia without iron deficiency or iron deficiency without anemia. *Conclusion*: These findings suggest an association between child level food insecurity and iron deficiency anemia, a clinically important health indicator with known negative cognitive, behavioral and health consequences. Cuts in spending on food assistance programs that address children's food insecurity may lead to adverse health consequences.

KEY WORDS: food insecurity; iron deficiency; food assistance; children.

INTRODUCTION

Households living in poverty face serious constraints on their incomes and must make choices that may result in food insecurity. Food insecurity refers to a household's having "limited or uncertain availability of food, or limited or uncertain ability to acquire acceptable foods in socially acceptable ways," as a result of inadequate financial resources (1). Health consequences of food insecurity and hunger among children in wealthy industrialized countries such as the United States have not been fully examined. Alaimo *et al.* using the US National Health and Nutrition Examination Survey (NHANES III) data, evaluated the United States Department of Agriculture (USDA)'s single "food sufficiency question" as a proxy measure for food security status in preschool

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Table I. 18-Item U.S. Food Security Survey Module

Item description in order of severity	Caregivers affirming $N = 626$ N	(%)
Household items		
Q2-Worried food would run out	191	(30.7)
Q3-Food bought just didn't last	140	(22.5)
Q4-Couldn't afford to eat balanced meals	90	(14.5)
Adult-specific items		
Q8-Adults cut size of meals or skipped meals	63	(9.8)
Q9-Adult ate less than felt s/he should	79	(12.7)
Q8a-Adult cut size of meals or skipped meals 3 or more months	6	(1.0)
Q10-Adult hungry but didn't eat	51	(8.2)
Q11-Adult lost weight	36	(5.8)
Q12-Adults did not eat for whole day	28	(4.5)
Q12a-Adults did not eat whole day, 3 or more months	19	(3.3)
Child-specific items		
Q5-Relied on few kinds of low-cost foods for children	104	(16.8)
Q6-Couldn't feed children balanced meal	58	(9.4)
Q7-Children were not eating enough	36	(5.8)
Q13-Cut size of child's meal	20	(3.3)
Q15-Child hungry but couldn't afford more food	19	(3.1)
Q14-Child skipped meal	16	(2.6)
Q14a-Child skipped meals, 3 or more months	10	(1.7)
Q16-Child did not eat for whole day	4	(0.7)

Source. Nord M, Bickel G. Measuring Children's Food Security in US Households, 1995–1999 Food and Rural Economics Food and Nutrition Research Program, Report No 25, Division, Economic Research Service, US Department of Agriculture, April 2002.

and school-aged children and found no significant relationship between iron deficiency and food insufficiency (2).

A recent methodological advance in measurement opens the way to more detailed exploration of these issues, permitting clearer evaluation of the determinants and outcomes of child-level food insecurity (3, 4). Recently, a child food security scale has been developed using the 8 child-specific items from the 18-item U.S. Food Security Survey Module (Table I). This scale permits more accurate calculation of the prevalence of the *children's* (as opposed to the household's) lack of access to food sufficient for an active and healthy life.

Iron deficiency, and iron deficiency anemia (IDA), are the most prevalent nutritional deficiencies in the United States and worldwide (5, 6). Recent studies have reported a prevalence of IDA in children of up to 18% in some high risk populations in the U.S. (5–9). While the relative impact of iron deficiency without anemia (IDNA) remains controversial, iron deficiency anemia during the first 2 years of life is an established correlate of impairments in cognitive, mental and psychomotor development (10–14) that persist even after treatment of the iron deficiency. A recently published randomized trial of iron supplementation among healthy infants offers further evidence of the effects of iron deficiency on the developing brain and the developmental and behavioral consequences of IDA (15).

In the developing world a large body of research has demonstrated how dietary supplementation improves iron stores leading to improved developmental and cognitive outcomes in children (16–18). Dietary intake data have often been compared with measures of food sufficiency or food security as a means to validate these measures (19, 20), but there has been little detailed examination of the interrelationships between food security status measures and individuals' dietary intake patterns.

Although clear links have been demonstrated between micronutrient deficiencies and psychosocial effects, a wide body of research in wealthy, as well as developing nations, has shown that iron deficiency anemia is associated with biophysical effects (21). There is some evidence that food insecurity results in decreased nutrient intake (22, 23). Food deprived states, such as fasting, skipping meals, hunger and

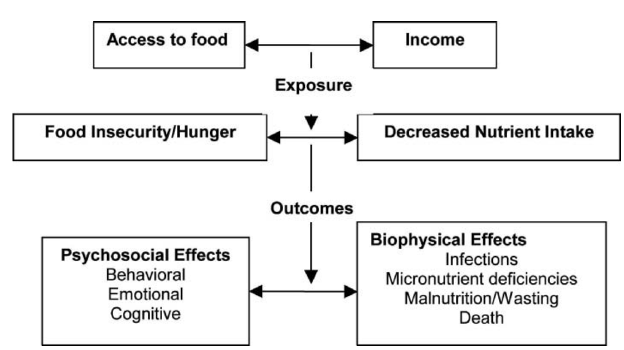

Fig. 1. Theoretical relationship between food insecurity and iron deficiency.

malnutrition have all been associated with psychosocial effects, including cognitive, behavioral, and emotional in children suggesting a common linkage (24–30). Malnutrition, as an increasingly severe outcome of food insecurity, has been directly correlated with severe biophysical effects like growth deficiency in the developing world (31). In the developed world food insecurity has been associated with adverse health outcomes among human infants and toddlers (32). The authors hypothesize a model (see Fig. 1) whereby lack of access to foods for various reasons, a primary one being lack of income, exposes individuals to both/either food insecurity or decreased nutrient intake which results in a continuum of negative effects, increasing in severity from a state of food insecurity to micronutrient deficiency, wasting and even death.

In light of the world wide prevalence and developmental importance of iron deficiency anemia in early life, this study examines whether depressed iron status is an objective physiological correlate of caregivers' subjective perception of child-level food insecurity in a sample of primarily low-income children less than 3 years of age utilizing an urban North American medical center for primary care and emergency services.

SUBJECTS AND METHODS

Data for this study were obtained from Boston Medical Center (BMC), Boston Massachusetts.

Between June 1996 and May 2001, 3209 consenting caregivers of young children utilizing the Pediatric Emergency Department (ED) were interviewed during emergency care visits as part of the Children's Sentinel Nutrition Assessment Program (C-SNAP), a cross-sectional cohort study of low-income children younger than 3 years of age. Institutional Review Board approval was obtained from Boston Medical Center. Caregivers were asked socioeconomic, program participation, and health questions. A complete sample description may be found elsewhere (33). The 8 child-level questions (See Table I) from the 18-question U.S. Food Security Survey Module were used to ascertain child-level food security during the previous 12 months.

Children with established diagnoses known to increase the risk of anemia were excluded (e.g., those with low birthweight [≤2500 g], HIV/AIDS, sickle cell disease, or lead level >10 mcg/dl). Infants less than 6 months of age were also excluded, since there is a high prevalence of physiologically decreased hemoglobin but low prevalence of iron deficiency in this age group (34).

Hematologic data obtained for the subset of eligible children receiving primary care at BMC were linked through medical record number to their ED interviews. Only children for whom all measures were available (Hgb, MCV RDW, FEP, Pb) were included in this analysis. The standard of care in this primary care practice is to obtain a complete blood count by electronic cell counter, lead level, and erythrocyte protoporphyrin (EP) by venipuncture at 9-12 months and again at 15–18 months as screening tests for iron deficiency and lead exposure.

The U.S. Food Security Survey Module measures household food insecurity and hunger during the 12 months prior to time of interview (1). Therefore, laboratory data were included in the analysis sample if obtained within 365 or fewer days prior to, or 90 days following, the interview date to account for subsequent periods in which biochemical manifestations of iron deficiency may occur.

Table II. Child Food Security Scoring and Classification

Number of child-specific affirmative responses	Child food security status	Dichotomous classification
0—1	Child food secure	Child food secure
2—4	Reduced diet quality	
5—8	Child Hunger	Child food insecure

Measure of Child Food Security

Responses from the eight child-referenced items were scaled and scored according to standard procedures to determine child food security status (1, 3, 4). With the child-specific scale, households that affirm five or more of the eight child-referenced questions (shown in Table II) are classified as having hunger among children. This threshold classifies "child hunger" by affirming that a child or children in the household have frequently "skipped meals" or "did not eat for a whole day." This threshold has been defined as indicating clear evidence of food deprivation and hunger. A "reduced diet quality" threshold has also been defined by 2–4 affirmative responses to the child-referenced questions (4). These questions indicate that nutrient intake is curtailed

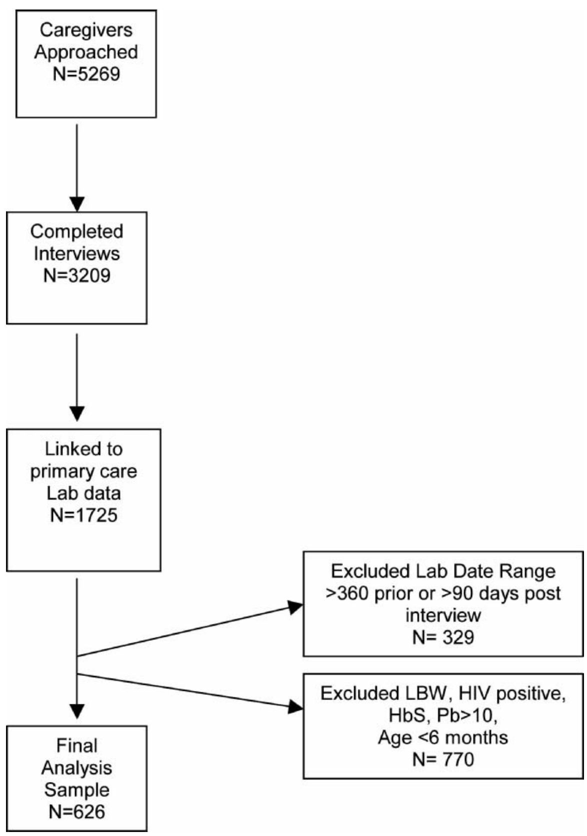

Fig. 2. Analysis sample selection, ($N = 626$).

and diet quality compromised if a caregiver affirms that "children were not eating enough" or "I cut the size of child's meals." An underlying presumption of the scale is that food insecurity is a continuum of successive stages of food insecurity as the condition becomes more severe, therefore only items exceeding in increasing severity of the designated thresholds are classified as "child hunger" or "reduced diet quality" (1, 3, 4).

To maximize cell sizes for analysis child food insecurity was classified dichotomously (child food secure, child food insecure). Caregivers' report of either "reduced dietary quality" or "hunger" was classified as, "child food insecure" as outlined in Table II. Therefore, child food insecurity is a composite variable ranging in severity from *reduced diet quality* to *hunger*.

Measure of Iron Status

Norms for iron status measures defined in current guidelines from the Centers for Disease Control and Prevention (CDC) and the Third National Health and Nutrition Examination Survey (NHANES III) were used (6, 36). Four mutually exclusive iron status groups were created: 1) Iron sufficient-no anemia (ISNA), 2) Anemia (without other evidence of iron deficiency), 3) Iron deficient-no anemia (IDNA), and 4) Iron deficient with anemia (IDA). Anemia was defined as Hgb < 11.0 g/dL for children age 0–2 years and Hgb <11.1 g/dl for those age 2–3 years. Iron deficiency at all ages was defined as the presence of at least two of the following three indicators: 1) red blood cell distribution width (RDW) >14.5%, 2) mean cell volume (MCV) < 70fL, 3) erythrocyte protoporphyrin (EP) >35 ug/dl. Those who were iron deficient by these criteria, but not anemic were classified as IDNA. Finally, IDA was defined as having both anemia and having at least two of the three indicators of iron deficiency outlined above.

STATISTICAL ANALYSIS

Confounding variables (i.e., those associated in this sample with child food security) were controlled in multivariate analysis. These include whether the caregiver was U.S.-born, caregiver education, employment, and welfare status, household size and whether the child was ever breastfed. Logistic regression analysis was used to examine differences in the odds of iron deficiency anemia among children described as food secure compared to those meeting the criteria for child food insecurity, adjusting for potential confounding variables.

RESULTS

Sample Characteristics

Of the 5269 families screened in the BMC ED, 1735 children received primary care at BMC and had laboratory tests available. Of the total linked subjects, 626 met the inclusion criteria and were examined to determine iron and food security status (Fig. 2). The 1099 children not meeting the inclusion criteria differed slightly in age from the study sample (15.1 vs. 14.4 months, $p = 0.1$), but did not differ in race/ethnicity, insurance, admission to hospital or food security status. Of those excluded, 329 subjects had hematological tests more than 365 days before

Table III. Characteristics of Caregivers of Analysis Sample by Child Food Security Status

Variables	Child food secure *N* (%)	Child food insecure *N* (%)	[a]*P* values
Total *N*	561(89.6)	65(10.4)	
Caregiver characteristics			
US born[b]	359 (64.1)	25 (38.5)	0.0001
% Single	325 (58.1)	40 (61.5)	0.69
Technical/college education[b]	189 (33.7)	12 (18.5)	0.01
Caregiver employed[b]	315 (56.3)	28 (43.1)	0.04
Receives WIC	458 (82.1)	58 (89.2)	0.15
Receives food stamps	160 (28.7)	18 (27.7)	0.86
Receives welfare[b]	163 (29.1)	14 (21.5)	0.01
Mean household size within age groups:			
Residents 0–4 years old	1.3 ± 0.6 SD	1.3 ± 0.6 SD	0.67
Residents 5–17 years old	1.0 ± 1.2 SD	0.8 ± 1.1 SD	0.22
Residents 18+ years old	2.0 ± 1.1 SD	2.0 ± 0.9 SD	0.66
Household size >5[b]	117 (21.0)	21 (32.3)	0.03
Subsidized housing	225 (41.0)	26(42.6)	0.76
Moved ≥2 times in past 12 months	141 (27.5)	20 (36.4)	0.17
Child characteristics			
Child race/ethnicity			
African American	384 (68.7)	43 (67.2)	0.38
Hispanic	119 (21.3)	18 (28.1)	
White	43 (7.7)	2 (3.1)	
Asian	13 (2.3)	1 (1.6)	
Child mean age in months	15.1 ± 8.1 SD	15.4 ± 8.2 SD	0.78
Public insurance status	482 (85.9)	54 (83.1)	0.53
Breastfed ever[b]	345 (61.5)	49 (75.4)	0.03
Received iron therapy	68 (12.1)	8 (12.3)	0.97
Chronic health problem[c]	98 (17.5)	7 (10.8)	0.17
Child health "fair/poor"	64 (11.4)	11 (16.9)	0.19
At-risk for undernutrition[d]	53 (10.1)	8 (13.8)	0.38
At-risk obesity[e]	90 (17.1)	11 (18.9)	0.73
History of 1 or more hospitalizations	133 (23.8)	24 (37.5)	0.02

[a]Chi-square test for categorical data.
[b]Covariates included in multivariate analysis.
[c]Parent report of chronic health problem (e.g. asthma, sickle cell).
[d]<5th percentile weight/age and/or < 10th percentile weight/height.
[e]>95th percentile weight/age and/or >90th percentile weight/height.

or 90 days after the interview date and 770 had either low birthweight, were less than 6 months of age, or were HIV positive, had sickle cell disease or had lead values >10 ug/dL. In the final analysis sample, 54% of the lab values preceded the interview date. On average laboratory measures obtained by clinicians were within 83 (±104) days of the interview.

In the Overall analysis sample, 10.4% of caregivers reported child food insecurity: 7.8% of the caregivers reported reduced diet quality and 2.6% reported child hunger. As Table III shows, compared to caregivers who did not report child food insecurity, caregivers reporting child food insecurity were more likely to be immigrants to the United States, have less than a college education, to be unemployed, and to not be receiving welfare. Food insecure children were more likely than food secure children to have had one or more hospitalizations, live in households with five or more members and to have been ever breastfed, but were not more likely to be at risk for energy protein undernutrition or overweight by composite anthropometric criteria.

Food Insecurity and Iron Status

In the overall analysis sample, 61% were ISNA, 21% had Anemia without meeting criteria for iron deficiency, 7% were IDNA, and 11% had IDA. Table IV shows the prevalence of iron status for food secure and food insecure children. The percent of children classified with Anemia and IDNA did not differ significantly at the $p < 0.05$ level between food secure and food insecure children. However, food insecure children were significantly more likely to have IDA than food secure children (unadjusted 18% vs. 10%). In logistic regression analysis, adjusting for possible confounders, food insecure children had 2.4 greater odds of having IDA [AOR, 2.4; 95% CI, 1.1–5.2, $p = 0.02$] compared to food secure children.

LIMITATIONS

There are several important limitations of this study. This study links household food security survey data to hospital-based hematological data. This analysis was performed on a convenience sentinel sample of low-income children utilizing both emergency and primary care services at Boston Medical Center. These are preliminary results based on a relatively small sample which cannot be generalized with confidence to the larger low-income child population in the United States or in other countries. As in all cross-sectional studies, this analysis can show possible associations but not causality or temporal sequencing.

Collecting food security data in a medical setting may have led to some underestimation of child-level

Table IV. Association of Child Food Insecurity with Compromised Iron Status[a]

	Child food secure N (%)	Child food insecure N (%)	Adj. odds ratio	95% CI[b]
Total sample	561 (89.6)	65 (10.4)		
Iron deficiency anemia (IDA) $N=68$	56 (10.0)	12 (18.5)	2.4	1.1–5.2
Anemia, without iron deficiency $N=131$	113 (20.1)	18 (27.7)	1.60	0.8–3.1
Iron deficient, not anemia (IDNA) $N=45$	44 (7.8)	1 (1.5)	0.3	0.04–2.5
Iron sufficient, not anemia (ISNA) $N=382$	348 (62.0)	34 (52.3)	1.00	Referent group

[a]Adjusted for US born caregiver, Caregiver education, employment, welfare status, household size, child ever breastfed.Iron-Sufficient, Not Anemic Referent Group.
[b]CI, Confidence Interval.

hunger, since caregivers may be reluctant to disclose this information for fear of being reported to child protective services. Child food insecurity and indicators of iron deficiency were obtained at different times from two distinct hospital service areas. It was not possible to obtain hematological data that necessarily followed exposure to child food insecurity in temporal sequence. However, the food security measures document food security during the period 12 months prior to the time of interview, the window which was used for reporting hematologic outcomes. Recent evidence indicates that about two-thirds of food insecure households experience the condition as recurring, while one-fifth of the households experience food insecurity as a frequent or chronic condition, supporting the validity of our approach (36).

Our ability to examine the role of child food insecurity on iron deficiency-no anemia was limited due to the lack of biochemical tests such as serum ferritin or transferrin saturation, which together could detect IDNA with greater sensitivity. The possibility of misclassification of children with IDNA as ISNA, and children with IDA, as anemic without iron deficiency however, suggests this study may have underestimated the relationship between child food insecurity and iron deficiency.

DISCUSSION

In spite of these limitations, to our knowledge this is the first published study describing the relationship between child food insecurity and iron deficiency anemia. In this sample food insecurity in children 6 months to 3 years of age was significantly and independently associated with iron deficiency anemia.

Prior research on the relationships between food insecurity and deficiencies in micronutriture relies primarily on proxy-reported dietary intake not validated by objective laboratory measures. Kaiser *et al.* in a study of low-income Mexican-American preschool-aged children, found child hunger was associated with a diet less likely to meet Food Guide Pyramid recommendations (22). Several studies have found evidence to indicate that adults who live in families without enough food to eat are more likely to have lower intakes of several nutrients and foods (23, 37, 38). Additionally, research during the economic recession of the mid-1970s linked rising costs of foods rich in micronutrients (vegetables, meats) to increases in prevalence of iron deficiency anemia among low-income school-aged children (39).

While the relationship between food insecurity reported by caregivers and objective indicators of nutrient deficiency measured in children is not clearly delineated, there is accumulating evidence of a negative association of food insecurity with a number of more distal health and developmental outcomes. Recent research, principally focusing on school-aged children, has described relationships between household food insecurity (or the earlier measure termed “food insufficiency” [having not enough food to eat]) and children’s reported health status (2, 40), overweight status (41), and cognitive, academic (42), and behavioral development (43, 44).

The mechanisms by which child-level food insecurity, in the absence of severe energy protein malnutrition, impacts the development of infants and toddlers are unknown. We speculate that IDA may be one such physiologic mechanism between child food insecurity and developmental consequences since it is a known risk factor for adverse cognitive and behavioral outcomes (7–15). Iron-deficiency anemia does not develop immediately. Instead, there are stages of iron deficiency, beginning with iron depletion, in which the amount of iron in the body is reduced but the amount of iron in the red blood cells remains constant. If iron depletion is not corrected, it progresses to iron deficiency, eventually leading to iron-deficiency anemia. Iron deficiency anemia may develop for several reasons: 1) food deprivation; 2) poor food choices; 3) preceding state of poor health resulting in inability to ingest or absorb of iron rich foods.

US Department of Agriculture research has shown that participation in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) program significantly improves children's intakes of iron, folate, and vitamin B-6 (45). Participation in WIC also improves the Healthy Eating Index scores for the household (46). In a retrospective cross-sectional and longitudinal analysis by Kahn *et. al.* anemia was found to emerge and persist in children participating in the program (47). Despite ongoing receipt of WIC benefits, many children developed anemia or remained anemic. The authors concluded that implementation of mandatory follow-up of all anemic infants by WIC or health care providers may be warranted. The findings published here suggest that food insecurity in WIC recipient households may be an underlying cause of persisting anemia as a result of dietary deficiency.

In 2002, over 14.6% of households were food insecure, an increase by 2.1 million households, including 1.1 million households with children since 1999 (48, 49). In low income populations and in preschool children in the U.S. access to the federal food stamps program (FSP) is associated with improved food security and micronutrient intake, yet reaches only 61.5% of eligible households (50, 51).

Despite the proven benefits of WIC and FSP, residual nutritional risk may persist even in recipient families because the programs are designed to supplement the food budget rather than support the food budget in total. Since the late 1990's housing and utility costs have risen faster than food costs. The programs designed to be supplemental now may constitute the major source of families' nutrition (52, 53).

This publication shows evidence of the adverse physiologic impact of food insecurity among children, indicating a need for more efforts to protect this vulnerable population from this condition. Other C-SNAP publications (33, 54) have shown that food assistance and income maintenance programs can buffer low-income families from food insecurity. As of this writing, food assistance and income maintenance programs serving millions of children in the United States have been slated for reductions in funding. There are currently no budget proposals to increase funding of these programs, despite the fact that there are still many eligible children who are not receiving assistance (55).

CONCLUSIONS

In this low-income urban sample accessing medical care in the United States, child food insecurity and iron deficiency anemia are associated, suggesting one important pathophysiologic pathway by which food insecurity can have deleterious health, social, behavioral and cognitive consequences for children. Policy makers need to consider expanding programs and services providing food assistance to families with young children. Although the results are biologically plausible, this study's findings need to be replicated and validated in larger and more representative multinational samples.

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