American Journal of Obstetrics and Gynecology (2006) **194**, 203–10

ELSEVIER

American Journal of Obstetrics & Gynecology

www.ajog.org

Correlates of intake of folic acid–containing supplements among pregnant women

S. L. Carmichael, PhD,[a,*] G. M. Shaw, DrPH,[a] W. Yang, MS,[a] C. Laurent, MS,[a] A. Herring, ScD,[b] Marjorie H. Royle, PhD,[c] M. Canfield, PhD,[d] and the National Birth Defects Prevention Study

March of Dimes Birth Defect Foundation/California Department of Health Services, California Birth Defects Monitoring Program, Berkeley, CA[a]; Department of Biostatistics, The University of North Carolina at Chapel Hill[b]; Family Health Services, New Jersey Department of Health and Senior Services, Trenton, NJ[c]; Birth Defects and Epidemiology Branch, Texas Department of State Health Services, Austin, TX[d]

Received for publication March 4, 2005; revised April 25, 2005; accepted June 1, 2005

KEY WORDS
Folic acid
Supplements
Pregnancy

Objective: This study describes the timing and correlates of folic acid supplement intake among pregnant women.
Study design: Data from 2518 women with estimated delivery dates from 1997 to 2000, collected for the National Birth Defects Prevention Study, a population-based case-control study, were analyzed. Multinomial logistic regression was used to identify correlates of supplement intake.
Results: Fifty-three percent of women began taking folic acid supplement during the periconceptional period, 35% during early pregnancy, and 8% during late pregnancy (ie, 3 months before through 1 month after conception, 2-3 months after conception, or more than 3 months after conception, respectively). Women who did not take folic acid supplement periconceptionally tended to be nonwhite, speak Spanish, have low education, be younger than 25 years old, be nulliparous, smoke, have no previous miscarriage and no fertility treatments, begin prenatal care and become aware of their pregnancy after the first trimester, have nonplanned pregnancies, and eat less breakfast cereal.
Conclusion: This study identifies correlates of folic acid supplement intake, which may contribute to the design of interventions to improve intake during early pregnancy.

The Public Health Service and the Institute of Medicine recommend that women of child-bearing age consume at least 400 μg/day of synthetic folic acid (FA),[1,2] an amount that is present in most multivitamin/mineral supplements. The recommendation was originally intended to prevent neural tube defects. FA also may prevent other birth defects,[3-7] other adverse reproductive outcomes,[8] and chronic diseases.[8] Taking FA-containing supplements remains the most likely route of

Supported by a cooperative agreement from the Centers for Disease Control and Prevention, Centers of Excellence (Award no. U50/CCU913241) and National Institutes of Health Grant R01 HD042538-01.

* Reprint requests: Dr. Suzan Carmichael, March of Dimes/California Birth Defects Monitoring Program, 1917 Fifth Street, Berkeley, CA 94710.
E-mail: sca@cbdmp.org

0002-9378/$ - see front matter © 2006 Mosby, Inc. All rights reserved.
doi:10.1016/j.ajog.2005.06.018

meeting the recommended intake level, even after considering folate intake from fortified foods.[9,10] By the end of pregnancy, most women are taking FA supplements,[11] but in the first few weeks, before pregnancy is clinically evident, closer to one third of women take supplements daily.[4,11-14] Intake during early pregnancy is critical because most birth defects occur during the first few weeks of pregnancy. For example, neural tube closure is completed by day 28 after conception, or 6 weeks after the last menstrual period.

Information on patterns of FA supplement intake during pregnancy and correlates of this behavior is critical to the design of effective interventions to improve intake. Few studies have examined correlates of supplement intake during pregnancy in relatively large and diverse study populations and included multivariable analysis.[11,15,16] We are aware of only 1 study that examined whether predictors of supplement intake varied as pregnancy progressed, and its data are from births that occurred in 1988, before the issuance of major public health recommendations regarding FA.[11] This study describes the pattern of intake of FA supplements among pregnant women and examines correlates of FA supplement intake, comparing correlates of intake during the periconceptional period and later during pregnancy, using recent data from a large, multistate, population-based, case-control study.

Material and methods

This study included data on deliveries that had estimated due dates from October 1997 to December 2000 and were part of the National Birth Defects Prevention Study.[17] This study is an approved activity of the institutional review boards of the participating study centers and the Centers for Disease Control and Prevention. Each study site randomly selected approximately 100 nonmalformed, liveborn controls per study year from birth certificates (Iowa, Massachusetts, and New Jersey) or birth hospitals (Arizona, California, Georgia, New York, and Texas) to represent the population from which the subjects were derived. Live-born infants with major malformations were ineligible as controls. This analysis included data from controls only. Maternal interviews were conducted using a standardized, computer-based questionnaire, primarily by telephone, in English or Spanish. Interviews were conducted with 2594 control mothers, representing 71% of eligibles, on average 8.6 months after delivery. We excluded 76 women who were missing data on supplement intake, leaving 2518 women for analysis.

Exposures to many factors were assessed, relative to the woman's estimated date of conception, which was derived by subtracting 266 days from the woman's expected due date (EDD). The EDD was based on mother's self-report; if unknown, the EDD was estimated from information in the medical record (less than 2% of subjects). A shortened version of the Willett Food Frequency Questionnaire (FFQ) assessed frequency of intake of 58 food items during the year before pregnancy.[18] Separate, more detailed questions assessed intakes of breakfast cereals, tea and coffee, sodas, and food supplements (ie, products that are sometimes mixed into drinks, like protein powder) during the 3 months before pregnancy. The U.S. Department of Agriculture version 16 nutrient database served as the source of nutrient values.[19] Final nutrient values incorporate data from the FFQ, cereals, beverages, and food supplements combined. The dietary data were treated as missing for 78 women with more than 1 missing food item in the FFQ ($n = 31$) and/or average daily kilocalorie consumption less than 500 or more than 5000 ($n = 63$).

Women were queried about their intake of vitamin and mineral dietary supplements during the 12 weeks before conception through the date of delivery. For each supplement product, they reported start and stop dates and frequency of intake; women who did not know the exact start or stop date of intake reported duration of intake; this information was recoded to correspond to month-long (ie, 30-day) increments before or after the date of conception. All products were hand reviewed to assess whether they contained FA. Women were divided into four groups: (1) periconceptional intake, in which intake began during the 3 months before conception (or earlier) or during the first month after conception; (2) early pregnancy intake, in which intake began during the second or third month after conception; (3) late intake, in which intake began during the fourth month or later during pregnancy; or (4) no intake during the 3 months before conception or during pregnancy. Within these groups, we identified women as having continuous or sporadic intake (ie, intake was continued until delivery or was discontinued before delivery).

Potential correlates of supplement intake included mother's race-ethnicity; nativity; language of interview; education; household income; employment during the 3 months before conception through the time of delivery; age; prepregnancy body mass index; number of previous live births; previous miscarriage; fertility treatments (based on a positive response to any of the following three questions: "Did you have any surgical procedures … [to help you become pregnant]?"; "in the 2 months before you became pregnant with [baby's name], did you take any medications to help you become pregnant?"; or "did you have any other procedures to help you become pregnant …?"); nausea or vomiting during the first trimester; cigarette smoking, alcohol consumption, and recreational drug use during the 3 months before conception through the time of delivery; trimester of first prenatal care visit; trimester when pregnancy was recognized; pregnancy wantedness (defined below); daily intake of dietary folate equivalents[19]; daily servings of