

The Effect of Vitamin–Mineral Supplementation on Juvenile Delinquency Among American Schoolchildren: A Randomized, Double-Blind Placebo-Controlled Trial

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ABSTRACT

Context: Numerous studies conducted in juvenile correctional institutions have reported that violence and serious antisocial behavior have been cut almost in half after implementing nutrient-dense diets that are consistent with the World Health Organization's guidelines for fats, sugar, starches, and protein ratios. Two controlled trials tested whether the cause of the behavioral improvements was psychological or biological in nature by comparing the behavior of offenders who either received placebos or vitamin–mineral supplements designed to provide the micronutrient equivalent of a well-balanced diet. These randomized trials reported that institutionalized offenders, aged 13 to 17 years or 18 to 26 years, when given active tablets produced about 40% less violent and other antisocial behavior than the placebo controls. However, generalization could not be made to typical schoolchildren without a controlled trial examining violence and antisocial behavior in public schools.

Objectives: To determine if schoolchildren, aged 6 to 12 years, who are given low dose vitamin–mineral tablets will produce significantly less violence and antisocial behavior in school than classmates who are given placebos.

Design: A stratified randomized, double-blind, placebo-controlled trial with pretest and post-test measures of antisocial behavior on school property.

Settings and Subjects: Two "working class," primarily Hispanic elementary schools in Phoenix, Arizona. Approximately half of the potential schoolchildren participated, i.e., 468 students aged 6 to 12 years.

Intervention: Daily vitamin–mineral supplementation at 50% of the U.S. recommended daily allowance (RDA) for 4 months versus placebo. The supplement was designed to raise vitamin–mineral intake up to the levels currently recommended by the National Academy of Sciences for children aged 6 to 11 years.

Outcome Measure: Violent and nonviolent delinquency as measured by official school disciplinary records.

Results: Of the 468 students randomly assigned to active or placebo tablets, the 80 who were disciplined at least once between September 1st and May 1st served as the research sample. During intervention, the 40 children who received active tablets were disciplined, on average, 1 time each, a 47% lower mean rate of antisocial behavior than the 1.875 times each for the 40 children who received placebos (95% confidence interval, 29% to 65%, $< 5 .020$). The children who took

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active tablets produced lower rates of antisocial behavior in 8 types of recorded infractions: threats/fighting, vandalism, being disrespectful, disorderly conduct, defiance, obscenities, refusal to work or serve, endangering others, and nonspecified offenses.

Conclusions: Poor nutritional habits in children that lead to low concentrations of water-soluble vitamins in blood, impair brain function and subsequently cause violence and other serious antisocial behavior. Correction of nutrient intake, either through a well-balanced diet or low-dose vitamin-mineral supplementation, corrects the low concentrations of vitamins in blood, improves brain function and subsequently lowers institutional violence and antisocial behavior by almost half. This paper adds to the literature by enabling previous research to be generalized from older incarcerated subjects with a history of antisocial behavior to a normal population of younger children in an educational setting.

LITERATURE REVIEW

Violence and delinquency in public schools

According to a national survey, children are very likely to become the victims of violence and nonviolent antisocial behavior at school (National Institute of Education, 1977). Although teenagers spend only 25% of their time in school, 40% of the robberies and 36% of the physical attacks involving this age group occur in school. A more recent national survey shows that school crime has not abated (National Education Goals Panel, 1995). Forty percent (40%) of eighth grade students reported theft of their property during the previous year at school, 20% reported destruction of their property at school, 39% reported being threatened with or without a weapon at school, and 17% reported being physically injured in an attack at school. The national self-reported injury rate due to attacks on high school seniors at school reached 31% in 1994. Understandably, student victimization data are somewhat higher than staff victimization. Approximately 5% of teachers reported being physically attacked, and 13% reported being threatened during the 1994 school year (National Educational Goals Panel, 1995). Furthermore, juvenile antisocial behavior in school is a serious disruption to the educational process. Thirty-two percent (32%) of eighth grade students nationally report that their teachers "often" have to stop class to deal with student misbehavior, and 51% report that disruptions "occasionally" interfere with their own learning. The most chilling statistic is that American schools have averaged one mass murder per year on school grounds through-

out this decade with no evidence of recent abatement.

Angry and frightened parents point the blame in multiple directions: at the schools themselves; at the delinquents' families who provide inadequate supervision, discipline or love; and even at guns, gangs, peers, drugs, and/or the media. Each of these lay positions finds substantial support within the scientific literature (Siegal and Senna, 1997). Siegal and Sienna (1997) emphasize that there is particularly strong evidence that the school experience itself contributes to juvenile delinquency. School disciplinary problems rise steadily over the academic year, peaking in April and May, as do mass murders at school. At the end of summer vacation, in September, disciplinary problems tend to fall back to levels similar to the previous year and the cycle repeats. One theory states that most "problem" students get a fresh start each year, but gradually fall behind academic expectations again. In 1994, the national percentage of fourth graders who met the National Education Goals Panel's performance standards was only 43% of Asian-Americans, 32% of European-Americans, 11% of Hispanic-Americans, and 7% of African-Americans (National Educational Goals Panel, 1995). Falling behind has become the norm rather than the exception. Repeated academic failure produces loss of self-esteem, frustration, depression, alienation, isolation, acting out, defiance, aggression, and retaliation (Siegal and Senna, 1997).

On the other hand, criminologists have been quick to point out that ~~delinquency~~ and violence are multicausal and may be traced to so-

ciologic, psychologic, and even biologic factors. For example, approximately two-thirds of children never run foul of the law before they are legally adults. Of even more importance is the fact that just 6% to 7% of the juveniles commit more than two-thirds of all homicides, aggravated assaults, rapes, robberies, and all other serious offenses (Wolfgang et al., 1972). Any effective solution must deal with this small but very dangerous minority. They are readily identifiable in correctional institutions by examining official "rule violation" reports. These reports have been validated by the U.S. Department of Justice, Bureau of Justice Statistics as a measure of serious institutional crime, delinquency, and deviance (Prison Rule Violators, 1989). Similar to crime in the general public, these infractions inside institutions are highly concentrated among a few offenders. For example, the Bureau of Justice Statistics reports that approximately 34% of all inmates commit more than one infraction per year. Approximately 20% commit 2 to 5 incidents, 6% commit 6 to 10 incidents, and 8% commit 11 or more incidents per year. A similar pattern of high concentration among a few children has been reported in public schools (Schoenthaler and Bier, 1999). Among a sample of nearly 1,000 schoolchildren who committed 1,737 rule violations in 1 year, 54 children (5%) committed more than half the offenses, i.e., 758, with a range of 9 to 54 offenses per juvenile per year. In short, a surprisingly small percent of juveniles (5% to 7%) and adults (8%) are the habitual rule violators who make schools and correctional institutions unsafe. Equally important, conventional solutions are clearly not working on this dangerous minority who are repeatedly in trouble at school, on average more than once per month.

The link between diet and institutional violence and delinquency

There have been reports of open trials in which dietary changes made within juvenile correctional facilities have been followed by significant reductions in serious rule violations involving violence, theft, and other infractions (Schoenthaler, 1983a, 1983b, 1985a, 1985b, 1987; Schoenthaler et al., 1991). More specifically, 12

correctional institutions collectively exhibited 47% less antisocial behavior in 8,076 confined delinquents after changes in official diet policy. Furthermore, the youths whose behavior changes caused the improvements were primarily the 20% of the institutionalized population who are considered to be "chronic offenders" (Wolfgang et al., 1972). For them, conventional interventions have proven to be insufficient. The dietary changes increased nutrient density by replacing high-fat and high-sugar foods with fruits, vegetables, and whole grains in proportions recommended by the National Academy of Sciences' Food and Nutrition Board (National Research Council, 1984). These dietary changes adhered to the proportion of sugar, fat, starch, and protein ratios as established by the World Health Organization (WHO; World Health Organization Study Group, 1990). More specifically, WHO recommends that calories from fat and sugar be limited to no more than approximately 30% and 10% of the diet, respectively, with at least 48% of calories coming from starch and approximately 12% in protein. These findings raised the hypothesis that a balanced healthy diet, one rich in essential vitamins and minerals could correct low blood concentrations of the nutrients that are essential for proper brain function (Essman, 1987), and thus reduce violent behavior (Schoenthaler, 1985a). Unfortunately, none of the early studies in correctional institutions used conventional control groups, random selection, or nutritional assessment as reported in state of the art nutrition and behavior research (Crombie et al., 1990). The results should be viewed as highly suggestive rather than conclusive.

As a result, a three-part hypothesis was developed. The cause of the institutional violence may have been caused by habitual offenders having a poor diet that led to low blood concentrations of essential vitamins and minerals, which impairs brain function and increases antisocial behavior. If this theory was valid, correction of the low blood-nutrient concentrations in habitually violent teenagers should correct brain function and lower violence. There is considerable evidence in the literature to support this theory, but unfortunately it is fragmented across the medical, psychologic,

nutritional, and criminological literature with few cross-citations.

In a frequently cited study of electroencephalographic (EEG) abnormality and delinquency, 335 violent delinquents were grouped on the basis of their type and frequency of delinquency and measured on an EEG (Williams, 1969). Delinquents who committed only one violent act had the same EEG abnormality rate as the general population, i.e., 12%. In marked contrast, 57% of the habitually violent delinquents had an abnormal EEG, a rate that is almost five times as high as the normal rate. The psychologic literature has correlated abnormal EEG function with a variety of conditions associated with delinquency: poor impulse control, inadequate social ability, temper tantrums, destructiveness, and hyperactivity (Johnson and Pelham, 1987). Recently, differences in the location of the EEG abnormality have been reported between the impulsively habitually violent and those who premeditate and deliberate before attacking their victims (Raine et al., 1998). Abnormalities in the front of the brain are associated with impulsive violence whereas abnormalities in the right temporal region are associated with premeditated attacks. Thus, there is growing evidence concerning a causal link between brain function impairment and antisocial behavior (Essman, 1987).

The mainstream nutritional literature adds that specific nutrient deficiencies produce central nervous system impairments (Whitney and Sizer, 1997). For example, pyridoxine deficiency can produce abnormal brain wave patterns, irritability, and depression. Thiamine deficiency can produce confusion and irritability. Niacin deficiency can produce depression, irritability, and mental confusion progressing to psychosis or delirium. Folate deficiency can produce abnormal nerve function, irritability, confusion, and depression. Riboflavin deficiency can cause depression, hysteria, and psychopathic behavior before clinical signs are detected. Magnesium deficiency can produce marked personality changes and hyperirritability. Zinc deficiency can cause irritability and emotional disorders. The mental symptoms of iron-deficiency anemia include conduct disturbances, irri-

tability, decreased attentiveness, hyperactivity, learning disorders, and lowered intelligence (Whitney and Sizer, 1997). Because nutrient deficiencies within an individual are usually multiple, it follows that treatment with one nutrient alone will most probably not be effective. Nutritional status assessment of all vitamins and the above minerals should be undertaken before clinical intervention is attempted in target areas where risk of deficiencies exists.

The three previous controlled trials

To test the theory that delinquency rates fall causing correction of marginal nutrient deficiencies, low-dose vitamin-mineral tablets were created that contained the same amount of vitamins and minerals found in a well-balanced diet. Each tablet provided approximately 100% of the U.S. recommended daily allowance (RDA) for eight minerals, three fat-soluble vitamins, and folate. They also provided approximately 300% of the U.S. RDA for the remaining seven water-soluble vitamins. Sixty-six (66) confined juvenile delinquents, aged 13 to 17 years, were matched in pairs as closely as possible on the number of violent assaults each initiated while confined during the 13 weeks immediately prior to intervention. One member of each pair was randomly assigned to the active supplement group, and, the other was assigned to a placebo group for the following 13 weeks (Schoenthaler et al., 1997). Sixty-two (62) of the original 66 completed the trial; 3 were paroled and 1 had a medication change that necessitated exclusion during analysis. Both groups committed, on average, 0.39 violent acts per person, per week, for each of the 13 weeks before intervention. The 32 juveniles who received active tablets produced significantly less violent and nonviolent behavior during the 13-week intervention period compared to the 30 juveniles who received placebo tablets. During intervention, the difference between the active and placebo groups in mean violence rates, as measured by official disciplinary actions, was 28% (95% confidence interval 15% to 41%). This result provides evidence that vitamin-mineral supplementation can lower institutional violence. However, this result does not determine

if low blood concentrations of nutrients are the underlying medical cause.

In anticipation of the need to test the correcting-low-blood-concentration part of the hypothesis, 26 of the most habitually violent residents agreed to donate preintervention and postintervention blood samples. There was no significant change in violence among the 10 juveniles who maintained their preexisting blood vitamin levels throughout the trial, (i.e., 39 violent acts during baseline and 37 during intervention) regardless of group assignment. This suggests that vitamin-mineral tablets have no measurable effect on violence if low blood concentrations are not corrected. This could be due to preexisting nutritional deficiency or malabsorption. In marked contrast, the 16 subjects who corrected their low blood-vitamin concentrations during the intervention produced 131 violent acts during baseline and only 11 during intervention. This second finding suggests that the correction of low blood concentrations may have caused the reduction in violent acts and was a more powerful factor than even assignment to group. Six subjects taking placebo improved their diets during the study and thereby improved their blood levels of nutrients.

In anticipation of the need to test the brain function part of the hypothesis, security staff also identified the 10 residents of this group of 26 deemed to be the most unpredictable in their habitual violence. Review of their medical records showed that 6 of these 10 had no history of head trauma, neurologic disease, or any other history that might explain their unpredictable habitual violence. These 6 were pretested using brain electrical activity mapping (BEAM), given a course of placebo or active tablets similar to the other juveniles, and tested on the BEAM again. The neurologist was not informed of any juvenile's group assignment, blood-nutrient concentrations, or degree of change in violence. All 6 juveniles who underwent BEAM testing had abnormal EEG patterns at baseline and low blood vitamin concentrations. The 2 who received placebos had 8 pretest EEG abnormalities and 8 post-test EEG abnormalities. In contrast, the 4 who received active tablets had 14 pretest EEG abnormalities and only 2 had post-test EEG ab-

normalities. These 4 committed no violent infractions within 3 days of starting the supplementation and remained infraction free for the remaining 13 weeks of the intervention. The cessation of violence, simultaneous with the correction of EEG activity and the correction of low blood-nutrient concentrations, suggests a causal link compared to previous correlational studies and epidemiologic comparisons. The primary weakness of this study was the low number of subjects, i.e., 62.

As a result of the potential importance of the findings, the California legislature mandated replication under Welfare and Institutions Code Section 1760 (Gould's Penal Code Handbook of California, 1993), which was successfully completed for 402 young adult offenders aged 18 to 25 years (Schoenthaler, 1999). Offenders taking active tablets had 38% less serious rule violations than offenders taking placebos. More than two-thirds of the offenders donated preintervention and postintervention blood samples. Two corollary hypotheses were supported. Offenders with low blood vitamin concentrations were significantly more likely to commit rule violations than offenders with normal blood vitamin concentrations. Among offenders receiving supplementation, those with baseline low blood vitamin concentrations were significantly more likely to improve behaviorally when compared to offenders with no baseline low blood vitamin concentrations (Schoenthaler, 1999).

A third brief report has surfaced that the British Home Office has successfully replicated these trials for 156 adult prisoners inside Aylesbury Prison (Gesch, 1998). The *Times* reported that the difference in antisocial behavior between the supplement and placebo groups was sufficient for the principal investigator, Bernard Gesch of Surrey University, to request funding for follow-up government research.

Until now, no controlled study has investigated this hypothesis with typical schoolchildren who attend public school. This hypothesis has also not been tested on children under the age of 12, the period that serves as a precursor to teenage delinquency. The following report describes the first study to extend this research to typical American schoolchildren, aged 6 to 12 years.

METHODS

Site and subjects

The study was conducted in two working-class public schools in the Cartwright District of Phoenix, Arizona: John F. Long and Spitalny. Twenty-nine teachers volunteered to distribute vitamin–mineral tablets daily to their students aged 6 to 12 years. The parents of all students in these teachers' classes were informed of the study and invited to allow their children to participate after approval of the California State University, Stanislaus Human Subjects Research Committee. Parental consent for their child's participation was obtained for 468 of the 723 children (65%) and represented approximately half of the total students in grades 1 to 6. During the study, 80 students left school (17%) because their families moved out of the school district. The remaining 388 subjects completed the trial. This sample was tested on four variables: nonverbal intelligence, academic performance, hyperkinesis, and juvenile delinquency as measured by school disciplinary actions. This article focuses on the last variable. Between September 1 and May 1, 80 of these 388 children (21%) were formally disciplined for violating school rules. These 80 became the final study sample because, by definition, the remaining 308 children, who were never disciplined, could not improve behaviorally. Figure 1 illustrates this participant flow.

Although the disciplined children represented grades one through six, the majority who acted out were in the higher grades. Only 7 children were in grades one or two, 32 children were in grades 4 or 5, and 41 children in grades 5 or 6. This relationship with grade/age is consistent with the delinquency literature that shows gradual increases in behavior problems until age 17 when they peak (Senna and Siegal, 1997). Fifty-five (55) of the 80 disciplined children (69%) were male. The overrepresentation of males is also consistent with the delinquency literature. Juvenile delinquency among males runs three times as high as in females (Senna and Siegal, 1997). The 80 children were disciplined 93 times during the fall and 115 times during the spring, an increase of 22%. Although an increase over time during a school year is typical, the 22% rate is far

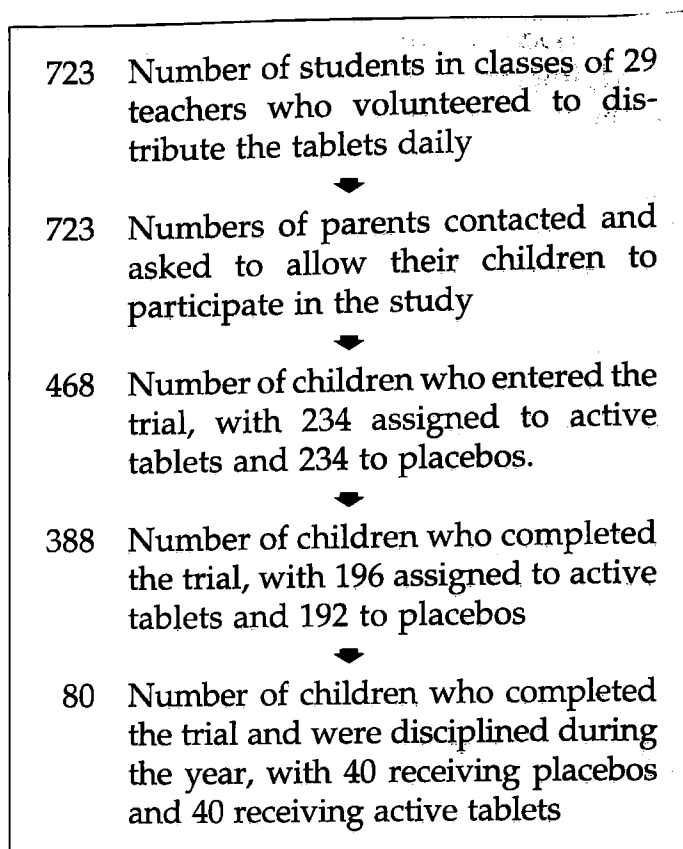


FIG. 1. Participant flow chart.

lower than expected. In marked contrast to the study participants, school records showed that rule violations for the entire study body more than doubled during the spring, a pattern that is more consistent with national trends. The disciplined children came from 20 of the 29 teachers' classes with a range of one to nine disciplined children per class. This breadth of discipline across classes is important for generalization. Most important of all, rule violations are highly skewed. During the fall, 38 of 80 disciplined children had no rule violations, 32 (40%) had one or two rule violations, and the remaining 10 (12.5%) had 51 violations (55%) with a range of 3 to 11 over 4 months. This skewed pattern is also consistent with national data (Bureau of Justice Statistics, 1989). Stated differently, only 10 of 388 children (2.5%) committed the majority of the 93 serious rule violations (55%) during September, October, November, and December.

Randomization

A stratified randomized design was used based on individual, preintervention, nonverbal intelligence scores within each of the 29 classes. The IQ tests, the Weschler Intelligence Scale for

Children-Revised (WISC-R) were administered approximately 2 months before the trial began. The use of an IQ test was thought to be a good measure on which to base stratification for two reasons. First, student failure, frustration, and alienation are widely perceived to be student precursors to antisocial behavior. The following model has sociologically explained this link between low IQ and delinquency: low IQ produces low school achievement, which in turn, promotes frustration and low self-esteem. Increased delinquency, rebellion, and dropping out are likely to follow (Hirschi and Hindelang, 1977). Second, stratified random sampling is likely to produce a more representative sample.

*The dependent variable of concern;
antisocial behavior*

When inappropriate student behavior becomes sufficiently serious to warrant school discipline, the antisocial behavior is reported to the principal's office for "fact finding" and disposition if found to be "true." The types of antisocial behavior for which these schoolchildren were often disciplined included fighting, threatening others, destruction of property, profanity, refusing to work or serve, being defiant or disrespectful, being disorderly, and endangering others. Rare infractions over the entire year in these schools included larceny ($n = 3$), weapons possession ($n = 2$), gang activity ($n = 1$), and truancy ($n = 1$), which were collapsed into the schools' category labeled "other." The number of serious rule violations for September, October, November, and December per child were summed and served as the preintervention covariate. The number of serious rule violations for January, February, March, and April served as the dependent variable of interest.

Tablet administration

Two chewable tablets were given to each participant at the beginning of school each day, with a double dose on Friday and Monday to make up for the pills missed over the weekend. When a child was absent for 1 or more days, a single double dose was given on the day of return. Each child's tablets were packed in individual bottles labeled with the child's name. As

soon as a class had finished being post-tested, all participants received active tablets for the remainder of the school year. None of the teachers, students, or testers was informed of which child was receiving active or placebo. Supplementation began at the beginning of January and ended at the end of April.

Supplements

To minimize any effect on the blinding caused by differences in odor between placebo and active tablets, all bottles had a large tablet of thiamin placed in the bottom. The tablet was wrapped in cheesecloth to prevent accidental flaking of the tablet onto the test materials. At the end of the study, each child was asked to guess whether he or she received the active or placebo tablets. The tablets contained the same vitamins and minerals in similar dosages as used in a previous trial (Schoenthaler et al., 1991) with one exception: the quantity of vitamin C per dose was increased to 40 mg. The other nutrients were set at approximately 50% of the U.S. RDA for all vitamins and most minerals, but were lower for bulky nutrients like calcium and magnesium.

Statistics

This classical randomized two-group design, with one pretest and one post-test, required an analysis of covariance with no interaction. Postintervention disciplinary actions served as the dependent variable, preintervention disciplinary actions as the covariate, and group assignment as the factor. The treatment effect of supplementation, which was adjusted for baseline differences, was the primary variable of interest. Because of the skewing of the rule violation rates per person, the data were normalized using \log_{10} transformations prior to inferential testing. Analysis of covariance allowed for numerous variables to serve as potential covariates: school, teacher's class, grade, age, sex, and student's IQ.

RESULTS

Official school records showed that 132 schoolchildren were disciplined between Sep-

tember 1 and May 1. Forty of these had received active tablets and 40 received placebos. The parents of the remaining 52 had declined to allow their child to participate. These 52 students were excluded from the analysis. There were no significant differences between the active and experimental group in age, sex, grade, school, intelligence, or preintervention disciplinary reports for September, October, November, and December. There was also no significant difference in the percent of each group at the end of the trial who guessed that they had received active or placebo tablets as illustrated in Table 1.

Primary analysis

During the 4-month intervention period, the active group's mean rate of rule violations was 1 per subject, while the placebo control's mean rate of rule violations was 1.875 per subject, a difference of 47%. Analysis of covariance, as illustrated in Table 1, showed that the preintervention rates of rule violation were significantly related to rule violation rates during the intervention time period ($F = 6.287$, $p = .014$). The difference between the groups in rule violations during the intervention time period was statistically significant ($F = 4.466$, $p = .038$). None of the potential covariates—school, teacher's class, grade, age, gender, and student's IQ—was significant and thus did not modify the final model (Table 2).

Secondary analyses

The primary analysis shows that the group on active tablets produced a significant 47% lower rate of rule violations, but says nothing about the nature of these conduct problems nor

TABLE 1. EFFECTIVENESS OF BLINDING: SUBJECTS' OPINIONS OF TABLET TYPE VS ACTUAL GROUP ASSIGNMENT

Subjects' opinion	Group assignment		Totals
	Placebo	Active	
Placebo	15 (41%)	12 (32%)	27 (36%)
Active	22 (59%)	26 (68%)	48 (64%)
Totals	37 (49%)	38 (51%)	75 (100%)

$\chi^2 = 0.6534$, $df = 1$, $p = .42$

Note: 5 of 80 participants did not answer this question.

TABLE 2. ANALYSIS OF COVARIANCE ON MEAN SERIOUS RULE VIOLATION REPORTS WITH PREINTERVENTION REPORTS AS THE COVARIATE

	Sum of squares	df	Mean squares	F	Sig. of F
Covariate	0.016	1	0.016	6.287	0.014
Main effects	0.011	1	0.011	4.466	0.038
Residual	0.192	77	0.002		

differences in the distributions within the active and placebo groups. The secondary analyses address these two questions. Table 3 addresses the nature of the change in antisocial behaviors by comparing the types of rule violations by group during the intervention time period.

The table shows lower rates of antisocial behavior in all categories of rule violations. However, substantial restraint must be used when examining the percentile change in each of these types of antisocial behavior because the number of cases is small. The data show a general pattern of improved conduct that may generally be classified as impulsive misconduct.

Because the preintervention rule violations were highly skewed toward a few children, i.e.,

TABLE 3. MEAN DIFFERENCE IN TYPES OF SERIOUS RULE VIOLATIONS DURING INTERVENTION

	Placebo ($n = 40$)	Active ($n = 40$)	Percent fewer violations
Vandalism	0.100	0.000	-100
Refusal to work/serve	0.125	0.000	-100
Uttering Obscenities	0.175	0.050	-71
Disrespectful	0.125	0.075	-40
Disorderly conduct	0.450	0.225	-50
Assault/battery	0.400	0.350	-13
Defiance	0.300	0.225	-25
Endangerment	0.225	0.175	-22
Other	0.475	0.275	-42
Mean violations per person	2.375	1.375	-42

Note: In May, the month after the trial ended, an additional 20 incidents in the placebo group and 15 incidents in the active group were committed and included in this table. They were not included in the analysis of covariance in Table 2 because they were beyond the intervention period. Their inclusion here raises the number of incidents to 95 and 55 in the placebo and active groups, respectively.

10 of 388 (2.5%) committed 55% of all serious infractions, it follows that examining the distribution of offenses during intervention by group may prove insightful. On one hand, it is possible that most delinquent schoolchildren are modestly effected or there may be a dramatic effect among only a few of the most delinquent schoolchildren. Table 4 allows examination of this question. Among the placebo controls, 31 of 40 subjects committed 31 rule violations with a range of 0 to 2 per subject. In marked contrast, the remaining 9 of the 40 subjects committed 44 infractions with a range of 3 to 10 per subject. Thus, serious antisocial behavior remains highly skewed among a few subjects in the placebo group just as it did across both groups during the preintervention period. Among the active subjects, 39 of 40 committed 37 rule violations with a range of 0 to 2 per subject. Their average rate of infractions is quite similar to the 31 subjects given placebos with a range of 0 to 2 incidents per subject. However, only 1 subject on active tablets produced more than 2 rule violations during the intervention period in the higher range and he produced just 3 violations. Table 3 shows that 9 of the 10 "habitually disruptive" schoolchildren (i.e., 3+ incidents) were in the placebo group. This lends support to the hypothesis that traditional interventions may work better on habitually disruptive offenders for the first time if nutritional intervention is utilized in conjunction with traditional disciplinary techniques.

TABLE 4. NUMBER OF RULE VIOLATIONS PER CHILD DURING INTERVENTION BY GROUP

<i>Number of incidents per child</i>	<i>Placebo</i>	<i>Active</i>
None	7 (18%)	10 (25%)
One	17 (43%)	21 (53%)
Two	7 (18%)	8 (20%)
Three	4 (10%)	1 (2.5%)
Four	2 (5%)	0 (0%)
Six	1 (2.5%)	0 (0%)
Eight	1 (2.5%)	0 (0%)
Ten	1 (2.5%)	0 (0%)

Note: Only 1 of 40 children receiving active tablets committed 3 or more offenses, while 9 of 40 children receiving placebo tablets committed 3 or more offenses.

DISCUSSION

The main finding is that among children who were disciplined during the school year, the 40 children who received active tablets were disciplined 47% less during the intervention period than the 40 children who received placebo. This 47% difference is identical to the 47% lower disciplinary rate previously reported among 8,076 incarcerated children who underwent dietary modification alone. This 47% difference is also consistent with the 38% difference reported among 402 incarcerated adults, and the 28% difference reported among 62 incarcerated juveniles (Schoenthaler, 1985b; Schoenthaler et al., 1997, 1999). A second finding states that the 47% difference between the groups may be explained by the reduced infractions of just 8 habitually reoffending children (20%) who received active tablets. This 20% figure is consistent with the earlier work showing that 20% of the 8,076 incarcerated children were responsible for a 47% reduction in antisocial behavior (Schoenthaler, 1985). These recent findings expand their scope in a previously untested population.

The types of behavior for which these children were less likely to be disciplined after treatment included violence toward persons (assault and battery 13%); violence toward property (vandalism 100%); and many nonviolent impulse-oriented offenses. The latter include such offenses as refusing to work or serve (100%); uttering obscenities (87%); and being disorderly (50%), disrespectful (40%), or defiant (25%). In each type of antisocial behavior, the active group had a lower mean rate of infractions than the controls.

There are important pragmatic implications from such research. These data do not imply that human behavior is not largely a learned phenomena. The fact that most children cease to be behavioral problems after one or two incidents is evidence that most children prefer rewards over escalating sanctions and they have learned from their experiences with the school administration. However, for a minority of children, neither rewards nor official sanctions produces conformity. This article provides evidence that for this minority, undiagnosed and untreated malnutrition may be impairing their

brain function to such an extent that normal learning from discipline does not occur. There may also be a causal connection between intelligence, academic performance, and antisocial behavior. "A child who chronically loses standing in the competition of the classroom may feel justified in settling the score outside, by violence, theft, and other forms of defiant illegality," (Wilson and Hernstein, 1985). The most well-known discovery of the late Marvin Wolfgang was that of the "chronic" offender (Wolfgang et al., 1972). It was based on a cohort of 9945 males born in Philadelphia, Pennsylvania, in 1945 who were followed until 18 years of age. He found that 627 (6%) were arrested as juveniles five or more times and eventually committed 71% of the homicides, 73% of the rapes, 82% of the robberies, and 69% of the aggravated assaults in Philadelphia. A follow-up study showed that 80% continued their criminal paths into adulthood. Society can either wait until children are convicted of serious felonies as teens and adults or take corrective steps during their preadolescent years using a variety of techniques that include consideration of medical/nutritional intervention.

CONCLUSIONS

Numerous studies conducted in juvenile correctional institutions have reported that violence and serious antisocial behavior can be cut almost in half after implementation of nutrient-dense diets. Two randomized, double-blind controlled trials, comparing placebo to active vitamin-mineral tablets, produced similar results. This suggested that the cause of the behavioral improvements was caused by the uptake of vitamins and minerals rather than a psychologic effect alone. However, generalization could not be made to typical schoolchildren without a controlled trial in public schools. This study found that 40 disruptive schoolchildren, ages 6 to 12 years, who were given low-dose vitamin-mineral tablets were involved in 47% less serious rule violations for 4 months when compared to 40 similarly disruptive schoolchildren who were given placebos. The same rate had been found

when 8047 incarcerated children were given nutrient-dense diets. The children given active tablets produced lower rates of antisocial behavior in vandalism, threats/fighting, being disrespectful, disorderly conduct, defiance, obscenities, refusal to work or serve, endangering others, and nonspecified offenses. Equally important, this study also found that the 47% difference between the two groups during the intervention period could be accounted for by the presence of nine habitual offenders in the control group and only one in the experimental group during the intervention phase.

Habitual offenders may have had sufficiently poor nutritional habits to cause low blood concentrations of water-soluble vitamins. These low blood-nutrient concentrations were corrected in the experimental group by the low-dose supplementation, which in turn, corrected impaired brain function. With normal brain function, these offenders were able to appreciate the seriousness of their actions and the disciplinary consequences. The nine habitual offenders in the control group presumably were not able to appreciate the consequences of their actions because of brain impairment, or cognition impairment, due to low blood nutrient concentrations. These deficiencies would not have been corrected with the placebo pills. This article provides evidence that suggests that, for this minority, undiagnosed and untreated malnutrition is likely to have impaired their brain function to such an extent that normal learning from discipline did not occur.

Correction of nutrient intake, either through a well-balanced diet or low-dose vitamin-mineral supplementation, usually corrects the low concentrations of vitamins in blood, improves brain function, and subsequently lowers institutional violence and antisocial behavior by almost half in both public schools and correctional facilities. This article adds to the literature by extending the above suggestion to older incarcerated subjects with histories of antisocial behavior to a normal population of younger disruptive children in an educational setting.

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REFERENCES

- Crombie IK, Todman J, McNeill G, Florey CD. Vitamin/mineral supplementation and intelligence. *Lancet* 1990;335:744-747.
- Essman W, ed. *Nutrition and Brain Function*. Basel, Switzerland: Karger Press, 1987.
- Gesch B. A report in the London Times on Natural Justice and the British Home Office study in Aylesbury prison. May, 1998.
- Gould's Penal Code Handbook of California. Altamonte Springs, FL: Gould Publications, Inc., 1993.
- Hirschi T, Hindelang M. Intelligence and delinquency: A revisionist review. *Am Sociol Rev* 1977;42:471-586.
- Johnson C, Pelham W. Teacher ratings predict peer ratings of aggression at 3-year follow-up in boys with attention deficit disorder with hyperactivity. *J Consult Clin Psychol* 1987;54:571-572.
- National Education Goals Panel. *Data for the National Education Goals Report. Volume 1: National Data*. Washington, D.C.: National Education Goals Panel, 1995.
- National Institute of Education. U.S. Department of Health, Education, and Welfare. *Violent Schools—Safe Schools: The Safe Schools Study Report to the Congress. Volume 1*. Washington, D.C.: 1977.
- National Research Council. *National Survey Data on Food Consumption: Uses and Recommendations*. Washington, D.C.: National Academy Press, 1984.
- Prison Rule Violators. U.S. Department of Justice, Office of Justice Programs, Bureau of Justice Statistics, Special Report, 1989.
- Raine A, Meloy R, Bihle S, Stoddard J, LaCasse L, Buchsbaum M. Reduced prefrontal and increased subcortical brain functioning assessed using positive emission topography in predatory and affective murderers. *Behav Sci Law* 1998;16:319-332.
- Schoenthaler SJ. Diet and crime. An empirical examination of the value of nutrition in the control and treatment of incarcerated juvenile offenders. *Int J Biosoc Res* 1983a;4:25-39.
- Schoenthaler SJ. Diet and delinquency: A multi-state replication. *Int J Biosoc Res* 1983b;5:70-78.
- Schoenthaler SJ. Diet and delinquency: Empirical testing of seven theories. *Int J Biosoc Res* 1985a;7:108-131.
- Schoenthaler S. Nutritional policies and institutional antisocial behavior. *Nutr Today* 1985b;20:16-24.
- Schoenthaler S. Malnutrition and maladaptive behavior. In: Essman W, ed. *Nutrition and Brain Function*. Basel: Karger Press, 1987:198-218.
- Schoenthaler S, Moody J, Pankow L. Applied nutrition and behavior. *J Appl Nutr* 1991;43:131-139.
- Schoenthaler SJ, Amos SP, Eysenck HJ, Peritz E, Yudkin J. Controlled trial of vitamin-mineral supplementation: Effects on intelligence and performance. *Pers Individual Differences*. 1991:351-362.
- Schoenthaler SJ, Amos SP, Doraz WE, Kelly MA, Wakefield J. The effect of randomized vitamin-mineral supplementation on violent and non-violent antisocial behavior among incarcerated juveniles. *J Nutr Environ Med* 1997;7:343-352.
- Schoenthaler SJ, Bier ID. Vitamin-mineral intake and intelligence: A macrolevel analysis of randomized controlled trials. *J Altern Complement Med* 1999;5:125-134.
- Schoenthaler S. Food addiction. In: Brostoff J, Challacombe S, eds. *Food Allergy and Intolerance*. London: W.B. Saunders, Inc., 1999.
- Siegal L, Senna J. *Juvenile Delinquency: Theory, Practice, and Law*. New York: West Publishing Company, 1997.
- Whitney E, Sizer F. *Nutritional Concepts and Controversies*. New York: West Publishing, 1997.
- World Health Organization Study Group, Geneva, 1990. *Diet, Nutrition and the Prevention of Chronic Diseases*. World Health Organization Technical Report Series, No. 797.
- Williams D. Neural factors related to habitual aggression—Consideration of differences between habitual aggressives and others who have committed crimes of violence. *Brain* 1969;92:503-520.
- Wilson J, Hernstein R. *Crime and Human Nature*. New York: Simon and Schuster, 1985.
- Wolfgang M, Figlio R, Sellin T. *Delinquency in a Birth Cohort Chicago*: University of Chicago Press, 1972.

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