

The Theory? Diet Causes Violence. The Lab? Prison.

In a more ambitious study than any before, psychologist Bernard Gesch is leading a research team hoping to replicate controversial results showing that nutritional supplements can reduce violence among prisoners

FALKIRK, SCOTLAND—The officer tenses slightly as he approaches a junction in the corridors that connect buildings in the Polmont prison compound. Two groups of prisoners are about to converge.

Her Majesty's Young Offenders Institution Polmont is Scotland's most violent prison—based on its record of assaults—but a peaceful atmosphere usually prevails. The officers seem to be on good terms with their charges—about 700 young men between the ages of 16 and 21, many of whom will go on to adult prisons to serve life sentences. When the violence happens, it erupts in a flash, and typically in hot spots like this junction where groups of prisoners encounter each other. The officers usually intervene well before serious damage is done. But not always. There have been stabbings, and some weeks ago a prisoner was sent to the hospital after a kettle of boiling water was thrown in his face.

The boisterous young men arrive from opposite directions, each led by an officer. Both prisoner groups are from Monro level 4, the ward for those at the highest risk for harm. Some of them are targeted in gang-related feuds. Some carry the dangerous stigma of being sex offenders, referred to as “beasts” by the others. The prison carefully coordinates everyone's movements with a computer system similar to air traffic control. The two lines merge and file past without incident.

Violence is what landed many of these young men in prison, some for crimes so horrible that they shocked the nation. But violent behavior also brought another group of people to Polmont: a team of scientists.

At lunchtime, prisoners emerge from their cells and begin gathering at a steaming buffet cart. After piling their trays with a typical meal—bread, sausage, and soup—the prisoners stream by a table staffed by the scientists, all wearing identical bright pink shirts that set them apart from the prison staff.

One of the young inmates pauses, setting his tray on the table. Lisa Gilmour, a psychologist, finds his name on a list of prisoners who have volunteered for the study. Next to his name is a code that corresponds to a sachet containing his allotments of pills. She gives them to the prisoner and watches as he pops them in his mouth and chases them down with water.

Those pills were either a standard supplement of vitamins, minerals, and essential fatty acids, or starch placebo pills designed to look and taste just like the supplement. The prisoner has no way of knowing which it was, and neither does Gilmour, because an independent third party randomly assigned the prisoners to the two groups. The officers, who also have no idea which prisoners are in the treatment or control groups, monitor their charges' behavior as usual, recording every infraction from threatening language to physical assault. The goal of this double-blind trial is to definitively answer a question that has bedeviled behavioral science for a century: Are nutritional imbalances a cause of violence?

Watching silently in the background is the study's

leader, Bernard Gesch, a nutrition and criminology researcher at the University of Oxford. To most people outside Gesch's field, his hypothesis—that, simply stated, improving diet helps prevent fights—sounds crazy. But he has evidence to back the claim. In 2002, he published the results of a double-blind trial with more than 200 young prisoners in Aylesbury, England. Those who received nutrient supplements committed significantly fewer violent offenses compared with the placebo group.

After years of wooing funding bodies and fighting for access to prison populations, Gesch now has an even more ambitious study approved and bankrolled. Impressed by the strength of his earlier results and the rigor of his experimental design, the U.K.'s Wellcome Trust announced last year that it would provide \$2.3 million for a nutritional supplement trial involving more than 1000 prisoners from Polmont and two other U.K. prisons. The 3-year trial, which started this spring, includes blood chemistry analysis and a battery of computer-based behavioral and cognitive tests designed to address the question that the earlier study could not: If a balanced diet does stem violence, how exactly does it do so?

It appears that the nutrition-violence hypothesis is gaining momentum. A study within the Dutch prison service, similar to Gesch's 2002 study, has also recently found that supplements reduce violence. (As *Science* went to press, that study was in review for publication.) If Gesch's larger study confirms the effect, “policies

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Diet plan. Bernard Gesch suggests supplements can stem violence.

◀ **Good behavior?** Polmont prison (*left*) is home to violent offenders, but nutritional supplements may help keep the peace.

will have to change,” predicts Stephen Schoenthaler, a nutrition and criminology researcher at California State University, Stanislaus, in Turlock. But that may be an optimistic view. Decades of studies by Schoenthaler and others have supported a connection between nutrition and violence, but for a variety of reasons—some scientific, others political—it hasn’t yet translated into policy.

You are what you eat

“The idea of a link between diet and antisocial behavior is not new,” says Gesch. As far back as 1892, the Italian criminologist Cesare Lombroso reported that many bomb-throwing terrorists suffered from pellagra—malnutrition due to a corn-based diet deficient in vitamin B-3—and proposed a connection. But nutrition-violence theories didn’t gain traction until chemistry and physiology began to reveal molecules in food that could regulate hormones and neurotransmitters—and thus conceivably behavior. By the 1960s, some argued that nutrition can not only cause behavioral problems but cure them; Nobel Prize-winning chemist Linus Pauling made the case for “orthomolecular psychiatry” in *Science* (19 April 1968, p. 265), defining it as “the treatment of mental disease by the provision of the optimum molecular environment for the mind.” According to Pauling, psychological disorders as severe as depression and schizophrenia could be fully treated with the right balance of vitamins and micronutrients.

Pauling’s proclamation symbolizes a problem in this area of behavioral research. “This field has seen a lot of exaggerated claims and not enough solid placebo-controlled research,” says Eugene Arnold, a psychiatrist and former director of the Nisonger Center at Ohio State University, Columbus. Studies have shown that “there clearly is a connection” between nutrients and behavioral disorders—for example, between nutrition and depression—but rigorous research has been the exception, he says. Most studies of the effects of nutrition on antisocial behavior are dismissed because of poor experimental design. And Arnold notes that misleading claims by the booming nutrient supplement industry have brought the taint of pseudoscience to those studying diet and behavior. “Even good scientists in this field have been treated as guilty by association,” he says.

Into this skeptical atmosphere entered Gesch, who certainly didn’t see nutrition or behavioral research on his horizon when he

went to university. “I trained as a physicist, but all the job prospects seemed to be in weapons,” he says. “I wanted to make a positive difference, so I went into social work.” In the mid-1980s, while working with young offenders in Cumbria, England, Gesch stumbled upon a simple but surprisingly effective strategy. “I invited them over for meals,” he says. “We cooked and ate together around a table like a family.” The goal was to get the young offenders to open up and share crucial information, such as the troubles in their family and school environments. Gesch says the youngsters transformed, becoming healthier and often abandoning the antisocial behaviors that had gotten them into trouble. He began to believe that shedding their scattershot diets of junk food was central to the behavioral shift, perhaps even more so than the family-like socializing.

myself hoarse,” he recalls with a laugh. The prisoners wouldn’t listen to him.

Gesch switched to a subtler tactic. “I asked around to find out who the ‘daddy’ was, the biggest, toughest guy around,” he says. A one-on-one meeting allowed Gesch to make his case. “I just explained that the study was completely in their own interest, and that it had nothing to do with the prison staff or the government,” he says. Once that prisoner signed on, 231 others voluntarily took part over the course of the 2-year study.

The results, published in 2002 in *The British Journal of Psychiatry*, revealed a significant effect: Prisoners given nutritional supplements committed 35% fewer violent incidences than those given the placebo. Gesch braced himself for a wave of doubt and criticism, but “the reception was surprisingly



On the menu. A typical meal at Polmont prison.

Over the next decade, diet and behavior became Gesch’s obsession. He founded a program to handle dietary education as part of criminal sentencing. He also created a charity, called Natural Justice, dedicated to researching the links between nutrition and criminal behavior and getting those insights translated into policy. In 1995, eager to rigorously test his idea, the then-36-year-old stood before hundreds of convicts in Aylesbury prison. The governor had agreed to let him run a double-blind study with nutritional supplements, but Gesch would have to persuade the prisoners to volunteer himself.

Gesch has piercing blue eyes and a neat crop of blond hair that tends to stand up like a cock’s comb as the day wears on. “I yelled

positive. Even the press treated us kindly,” he recalls. “There was clearly something there,” says Stephen Wong, a veteran criminal psychologist and visiting scholar at the Institute of Mental Health in Nottingham, U.K. “It needed to be replicated.”

Easier said than done. Getting permission to run a ramped-up version of the 2002 study in U.K. prisons required “years of lobbying,” says John Stein, a physiologist at the University of Oxford who is co-leading the current trial with Gesch. The reason, says David Ramsbothom, former chief inspector of the U.K. prison service, is “an enormous amount of resistance to any effort to improve prisons, in part because of simple-minded, ‘get tough on crime’ politics.”

But once the prison system permissions were secured, Gesch's grant application was approved by the Wellcome Trust in a matter of months. "We are all used to nutritional guidelines for our physical health, but this study could lead to revisions taking into account our mental health as well," announced Wellcome Trust Director Mark Walport.

The recipe for violence

Polmont's prisoners universally complain that meals are neither tasty nor fresh, and it's no wonder why. The food budget amounts to a few dollars per prisoner per day. And by the time it travels from the central kitchen facility, through the layers of security and up to each ward's dining area, foods such as fried potatoes are lukewarm and limp. Still, the prison governor, Derek McGill, says he never suspected that the prison food itself might be a cause of violence.

There are nearly as many theories for how nutrition affects behavior as there are nutrients in the body. For example, Adrian Raine, a psychologist at the University of Pennsylvania, is testing whether supplements of omega-3 fatty acids in particular can reduce anti-social behavior by helping young brains mature properly. Stein also proposes a role for omega-3's, noting that these acids are required in large amounts by Magna cells, a type of neuron crucial for attention and impulse control. Other nutrition-violence theories look to the vitamin B complex, which is crucial for everything from brain tissue maintenance to learning. Gesch and Stein hope that data from the study's blood sampling and behavioral testing will ultimately reveal which of more than two dozen nutrients—interacting with as many behavioral traits—makes a difference in violent behavior (see table, above).

They don't expect a simple answer. "Nutrition is about balance," says Gesch. "It's not like pharmacology." But even if the biochemistry of violent behavior turns out to be too complex to tease apart from the data, some

key insights may emerge. "Control of impulsivity may turn out to be very important," notes Stein. For example, a nutritional imbalance could suppress the ability to resist punching someone in the face in spite of strong emotions of fear or anger. If so, then prisoners who receive the nutritional supplements should do better than the placebo group on an impulsivity "stop-go" test—challenging prisoners to respond to "go" signs as quickly as possible while also heading "stop" signs—that Gesch's team is administering before and after treatment.

One of the subjects in the study proposes a

of a connection between diet and violence—at least for prison populations. But even if it does, the debate over what to do with that knowledge is just getting started.

For some, the answer is already clear. "The [nutrition-violence] effect is obviously real, and it has been researched for 30 years," says Iver Mysterud, a behavioral psychologist at the University of Oslo in Norway. "The policy implications are obvious: Get rid of sugar and highly processed foods, improve the diet," and for prisoners with nutrient imbalances, "give [them] supplements with minerals, vitamins, and fatty acids."

Others are withholding judgment until the new data are in. "I'm skeptical, mainly because so many other assertions of vitamins on health and well-being have been proved wrong," says Randy Nelson, a neuroscientist at Ohio State University, Columbus, who specializes in the mechanisms of aggression. "However, the study design is very good and the preliminary data seem compelling." If prison violence can be prevented through diet, then "government agencies ought to put this into policy actions as soon as possible."

Why stop at prisons? If the nutrition-violence effect is confirmed with prisoners, could poor diet explain some of the violence and antisocial behavior in schools, or even in neighborhoods? Many researchers have argued this, but the link may not hold for the wider community, says Mysterud. Only a double-blind nutrition study in a community setting could settle that. Some are already under way, such as Raine's study of omega-3 supplements with children in Singapore and Philadelphia, Pennsylvania, with plans for another in Mauritius.

But Gesch and others stress that improving diet can be only part of the answer to violence and antisocial behavior. "Nutrition sounds like a silver bullet," says Wong. "But crime control has no simple solution."

—JOHN BOHANNON

DIET OF DISAFFECTION: NUTRIENT INTAKES FROM A SAMPLE OF DISADVANTAGED YOUNG PEOPLE		
Nutrient	Percentage getting adequate intakes	Possible effects of low intakes on the brain
B-12 Cobalamin	94%	Pernicious anemia. Spinal cord damage. Raised homocysteine; this has been linked to cvs disease and hostility.
B-6 Pyridoxine	83%	Cofactor for conversion of tryptophan to serotonin (5HT) and regulation of homocysteine. Depression. Alzheimer's.
B-1 Thiamin	61%	'Dry beriberi': peripheral neuropathy, Wernicke's and Korsakoff's encephalopathy. Reduced learning ability associated with impaired hippocampal neurogenesis in animal models.
B-2 Riboflavin	33%	Cofactor in electron transport chain, energy metabolism, reduces ischemic brain injury.
Iodine	33%	Thyroid hormones—low intake of iodine is the commonest cause of mental deficiency worldwide
Folic acid	28%	Methylation agent in synthesis of serotonin. Low intakes are associated with depression and raised homocysteine.
Zinc	28%	Found in over 100 enzymes, affecting membrane structure, neurogenesis, neurotransmitters, fatty acid metabolism. Low zinc intakes have been associated with ADHD and criminality.
Calcium	28%	Neural hyperexcitability, paresthesia, impulsivity.
Iron	22%	Anemia. Also required for dopamine synthesis. Low iron is associated with impaired cognitive development in humans and aggression in animal studies.
Magnesium	17%	Involved in glycolysis and cerebral blood flow. Low intakes are associated with hyperexcitability and in animal studies with the severity of behavioral deficits.
Selenium	0%	Low intakes are associated with reduced cognitive function.
Omega-3 from fish	0%	Impaired attention, impulsivity, reduced memory, impaired cognition, depression, excess inflammation

similar hypothesis himself. "It comes down to a moment—you can hit someone or just walk away," says Craig, a towering 19-year-old with gang tattoos who is serving a 9-year sentence for culpable homicide. "And diet definitely makes a difference." He was one of several prisoners who shared their perspective on prison food and violence with *Science* (see the reporter's notebook online).

So far, the scientists working in Polmont have experienced violence themselves only once. One of the prisoners pulled out a plastic knife and threatened one of the researchers out of frustration. "He wanted his pills immediately," says Gesch. No one was harmed.

No simple solutions

Criminology researchers agree that Gesch and Stein's study should settle the question