Reducing lead in gasoline. Mexico's experience

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REDUCING LEAD IN GASOLINE

Mexico's Experience

Lead in the bloodstream has been shown to have toxic effects in children, including lower intelligence and behavioral dysfunctions. In older adults, lead exposure raises blood pressure, with attendant increased risks of heart attacks, strokes, and death. Given the high blood lead levels in some large cities in the developing world, and the significant contribution of lead in gasoline to blood lead, the question arises whether the use of lead in gasoline should be curtailed in industrializing countries. Mexico is one country that has answered "yes" to this question.

Studies of the effects of blood lead on children's mental development have shown intelligence quotient deficits of an estimated 0.25 points for every microgram per deciliter (μg/dL) increment in blood lead levels (*1*). (Lead may have this effect by interfering with the role of calcium in brain cell development.) On a societal basis, the aggregate loss of cognitive acuity due to lead exposure can be enormous. Acknowledging these impacts, the U.S. Centers for Disease Control (CDC), the principal advisory agency for child health in the United States, recently established a goal of reducing children's blood lead levels to below 10 μg/dL (*2*).

Lead exposure reductions can be very cost effective. CDC has noted that preventing a blood lead level of 25 μg/dL or higher in a child saves $4631 in medical and special education costs (1990 U.S. dollars), and increased productivity for each microgram per deciliter of avoided blood lead in a child has a net present value of $1147 (*1*). These

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figures suggest that reducing lead exposure is a globally useful public health endeavor.

Lead enters the body through inhalation or ingestion. The combustion of leaded gasoline produces both airborne lead and, after fallout, lead in dust or soil. Other sources of airborne lead include smelters and incinerators; another source of lead in dust is leaded paint. Children are at particularly high risk for exposure to lead because they ingest dust and soil through normal mouthing activities as infants and toddlers. Two sources of dietary lead that are significant in Mexico are lead-glazed ceramic ware fired at low temperatures and food cans with lead seams.

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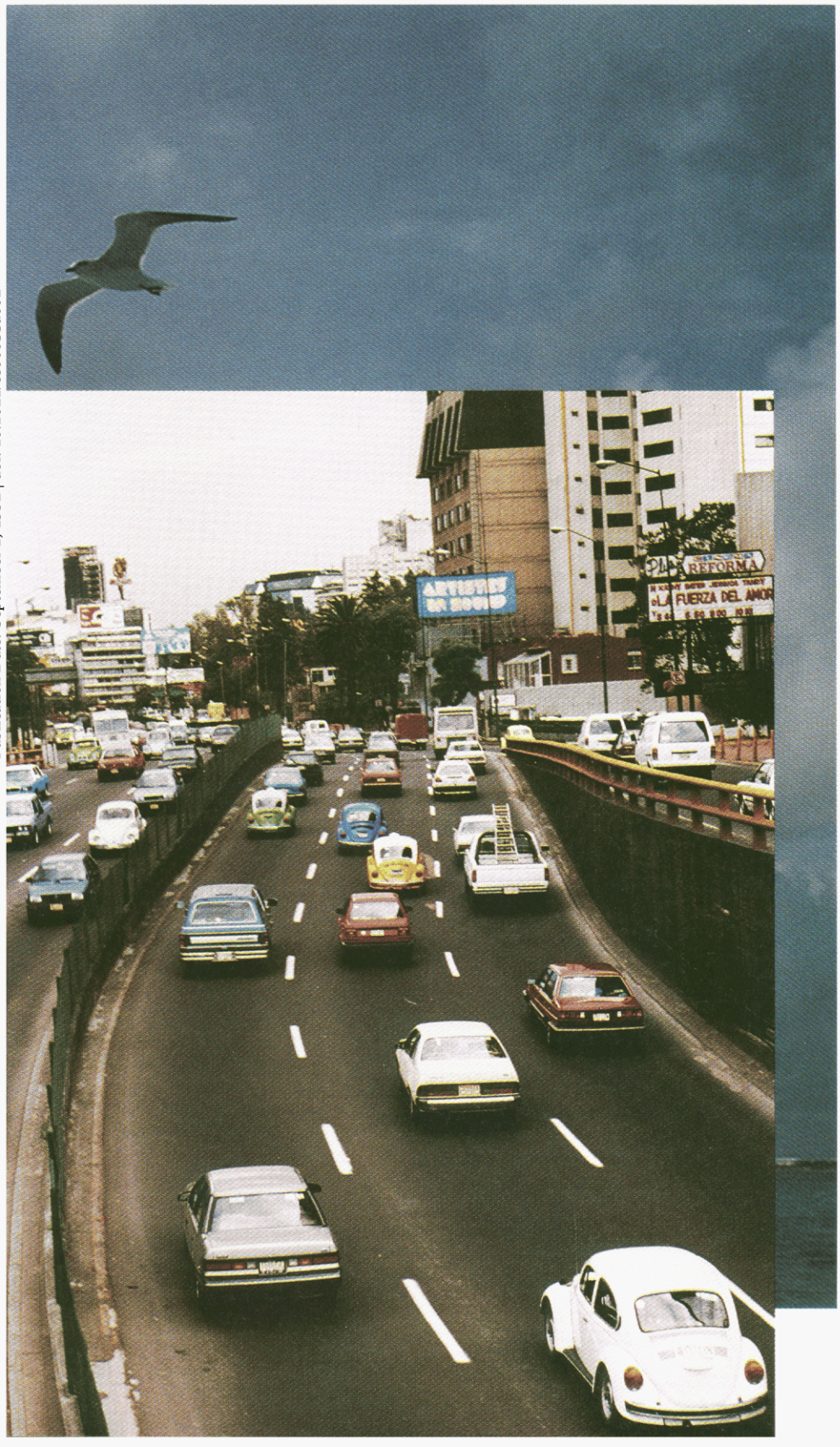


The U.S. experience

Gasoline lead has been found to be a substantial source of blood lead. The best evidence may be the 37% decline in average blood lead levels in the United States from 1976 to 1980—from 14.6 μg/dL to 9.2 μg/dL—while the usage of leaded gasoline declined 55%. EPA prohibited the use of leaded gasoline in cars manufactured after 1975. (These cars are equipped with catalytic converters, which are rendered ineffective by leaded gasoline.) Studies have demonstrated that the decline in levels of blood lead was not likely to have been caused by changes in exposure from leaded paint or other sources of lead (*3*). Moreover, a study in Italy using lead isotopic fingerprinting found that leaded gasoline can be the source of up to 50% of all blood lead (*4*).

Since 1980, U.S. blood lead levels have continued to decline with the decrease in leaded gasoline use. Still, the most recent national blood lead study estimated that in 1984, 17% of all U.S. preschool children had blood lead levels above 15 μg/dL (*5*). In 1986, the U.S. reduced the lead limit for leaded gasoline to 0.026 g/L (0.1 g/gal), the residual level permitting the use of cars built before 1975, in which lead serves to lubricate engine valves. A U.S. ban on leaded gasoline will take effect in 1995.

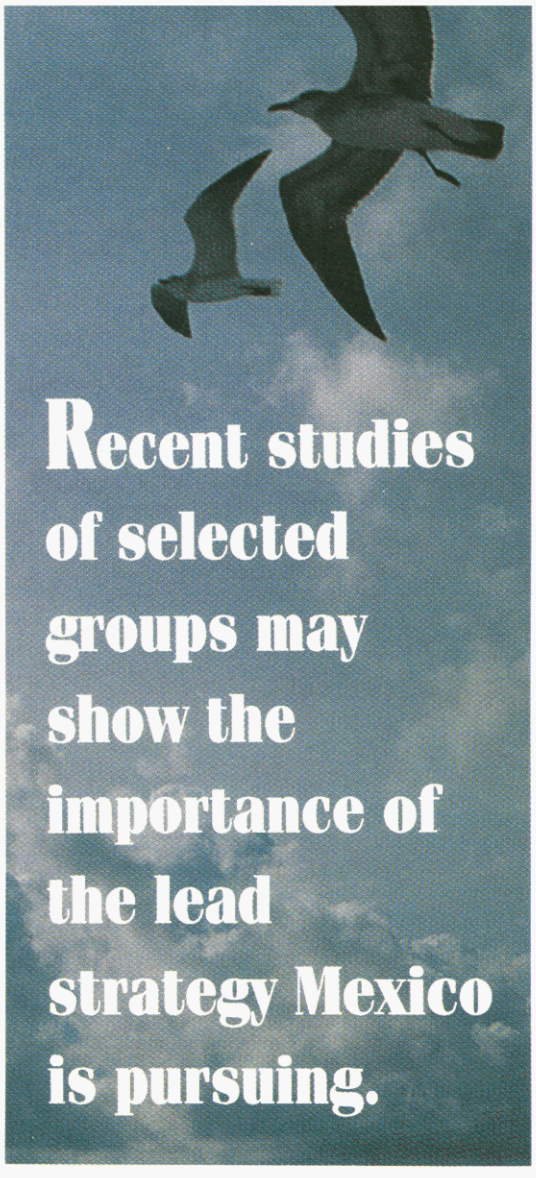
Other developed countries also have addressed this question. The European Community requires catalytic converters for its largest new cars, and Japan, Australia, Canada, and Switzerland require catalytic converters in all new cars. Japan has banned the sale of leaded gasoline and Canada has halted its sale for automobiles.

Lead is added to gasoline because it is the least expensive way to increase gasoline's antiknock properties (or octane number). We refer to simple production costs without factoring in the huge long-term public health and environmental costs. Other, organic additives that can be used to raise octane include ethanol, methanol, and methyl *tert*-butyl ether (MTBE). These additives, known as oxygenates, also reduce carbon monoxide and hydrocarbon emissions. Methanol vapors have been shown to be toxic in animal studies, but the relationship

of these findings to human exposure is not yet clear (*6*). Also, it has not been determined whether methanol vapors and combustion products pose greater health threats than gasoline vapors and combustion products.

Two metal-based alternatives, methylcyclopentadienyl tricarbonyl manganese (MMT) and ferrocene, also can raise octane. Although the use of MMT is permitted in Canada, EPA does not permit its use in the United States because of concern that it may cause increased vehicle emissions. Tests of the public health impacts of ferrocene are under way in Europe; tests of the effects of ferrocene on automotive emissions and the durability of emission control systems have not been performed.

Alternatively, octane may be raised by changing the chemical structure of the hydrocarbon molecules in gasoline using refinery processes known as isomerizing, alkylating, and catalytic reforming. The first two processes may produce fuels with lower overall emissions and lower ozone-producing potential. The last process, however, produces benzene, a carcinogen, and other aromatic compounds that contribute to the formation of ground-level ozone.



Reducing lead in Mexico

Mexico is one industrializing country that is reducing the lead content of leaded gasoline, increasing the sales of unleaded gasoline, and taking other steps to reduce lead exposure. Mexico's lead policies are in response to several studies. One study conducted in 1981 and 1983 by the World Health Organization and the United Nations showed abnormally high blood lead levels among schoolteachers in Mexico (*7*). Mexico's environmental ministry, the Secretaría de Desarrollo Urbano y Ecología (SEDUE), together with the health ministry, the Secretaría de Salud, have acted to reduce exposure to all sources of lead. (SEDUE's ecological functions are now the responsibility of the Secretaría de Desarollo Social; SEDUE was dissolved in May 1992.) Lead emissions from smelters and lead in tin cans are now being better controlled, the manufacture of leaded paint for nonindustrial uses has been banned, and artisans making lead-glazed earthenware pottery are being assisted in upgrading their technology and equipment through a credit line at Nacional Financiera, a government-owned bank.

Most importantly, Mexico is making a transition from leaded to low-lead and unleaded gasoline. Two blends of gasoline are available in Mexico: high-octane, unleaded Magna Sin, available nationwide since July 1990, and regular-octane, leaded Nova Plus. As of April 1992, Nova Plus sold in Mexico City at a retail price of $1.34 (U.S.) per gallon, and Magna Sin at $1.49.

In September 1988, SEDUE established a timetable for progressively stricter emissions standards for new vehicles, which could be met through the use of catalytic converters. SEDUE revised the unleaded gasoline specifications in 1989 to guarantee proper performance of catalytic converters. Beginning with the 1993 model year, vehicles must meet the following emissions standards: HC, 0.25 g/km; CO, 2.11 g/km; and NO_x, 0.62 g/km. The 1992 standards were less stringent, but most manufacturers preferred to meet the 1993 standards this year; thus, much of this year's fleet is equipped with catalytic converters.

No detailed study has been conducted in Mexico to quantify the misfueling (with leaded gasoline) of cars equipped with catalytic converters. Nevertheless, a wide octane number gap and a narrow price gap between leaded and unleaded gasoline should discourage misfueling. Moreover, newer cars running on unleaded gasoline have engines with higher compression ratios. The difference in gasoline price is offset by the higher efficiency of new cars. The growth in demand for unleaded gasoline in Mexico City corresponds to the growth in consumption that is expected, given the number of new cars.

Also, Petróleos Mexicanos (PEMEX), the state company that manages Mexican refineries, has decreased the lead content in gasoline by closing down small and medium-sized refineries not equipped with hydrotreating and reforming facilities, and by adding 5% by weight of MTBE to gasoline used in Mexico City.

In 1991, unleaded gasoline sales accounted for 10.2% of total gasoline sales in Mexico, and for 7.2% in Mexico City. Unleaded gasoline sales in Mexico City in 1991, the first full year of sales of automobiles equipped with catalytic converters, were 38.8% higher than the previous year. To cope with the growing demand for Magna Sin, PEMEX is constructing additional hydrotreating, isomerizing, fluid catalytic cracking, and reforming capacity. New facilities to alkylate naphtha and to manufacture MTBE and methyl *tert*-amyl ether are under way. These plants are expected to be completed in 1994. PEMEX also is planning to build a large refinery which will make only high-octane lead-free gasoline.

At the same time that Mexico is displacing leaded with unleaded gasoline, it is substantially reducing the lead content of leaded gasoline. From 1990 to 1991, the lead content of leaded gasoline sold in Mexico declined from 0.21 to 0.13 g/L. The lead content in Mexico City was reduced even further during this period, from 0.18 to 0.09 g/L. By comparison, the 1983 average lead level in gasoline in Mexico City was 0.30 g/L. As shown by these figures,

Mexico's strategy to reduce lead in gasoline is proving quite successful.

Mean blood lead levels for current populations of cities in Mexico are not known, but recent studies of selected groups may show the importance of the lead strategy Mexico is pursuing. For example, one of us found that in a sample of more than 150 newborn infants from Mexico City, 41% were born with blood lead levels above 10 μg/dL, and 75% had blood lead levels above 10 μg/dL at 24 months of age. In a sample of 1200 adults receiving medical examinations at a private Mexico City hospital between mid-1990 and the end of 1991, 73% had mean blood lead levels above 10 μg/dL; there is a marked downward trend in the data that intensifies in 1991 (E. Palazuelos, unpublished data.) This may be due, in part, to the lower lead content of gasoline and better control of smelters. The annual average lead level in particulate matter collected at Pedregal Station in the residential area south of Mexico City showed a decrease from 1 $\mu g/m^3$ in 1988 to 0.6 $\mu g/m^3$ in 1991; at Xalostoc Station located in the industrial north, an average lead level of 3.9 $\mu g/m^3$ measured in 1988 was reduced to 1.7 $\mu g/m^3$ in 1991.

Applications to other countries

In Mexico, catalytic converters and unleaded gasoline are used to control both ground-level ozone and lead emissions. In other developing countries, a low-lead or no-lead gasoline policy could be considered separately from a policy requiring catalytic converters. The health benefits of lead restrictions could be evaluated using the current CDC methodology for the costs of lead's effects on children and a methodology developed by EPA for the costs of increased adult blood pressure due to lead exposure (*8*). These benefits could be compared to projected refinery costs.

A low-lead policy that imposes moderate costs on a developing country's relatively wealthy consumers of gasoline will be more equitable than a policy of unlimited lead use, under which gasoline consumers retain the benefits of leaded gasoline (i.e., its lower price) while externalizing the health costs to the general population.

Where to test for blood lead

The U.S. Centers for Disease Control (CDC) recommend universal blood lead testing of children, at age six months for those at high risk, and at 12–15 months for all others, with follow-up testing where appropriate. In most U.S. communities, the county or municipal health department conducts blood lead tests. Alternatively, the child's pediatrician or family physician can arrange such testing. The test costs $15 or more if conducted by a health department, and $30–40 or more if privately arranged.

In Mexico, blood lead tests are available through many commercial laboratories. Two laboratories, at the National Institute of Neurology and the American–British Cowdray Hospital, have external quality assurance for their testing provided by the CDC. The National Institute of Perinatology also offers testing, performed by a qualified U.S. laboratory. In addition, the Mexican government is developing a quality assurance program for blood lead testing by national laboratories. The cost per test is $20–30 (U.S.).

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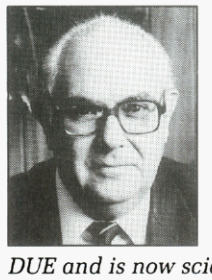

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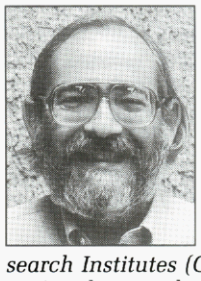

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