

Lead in Gasoline - International Patterns of Use

How much leaded gasoline is used and how much lead is in the gasoline vary strikingly around the world. In some regions, virtually no leaded gasoline whatever is used, and none is used for automobiles, trucks, or other road transportation. In other areas, only leaded

gasoline is available, and levels of lead in it are among the highest found anywhere. In addition to these geographic variations, there are strong relationships between the wealth of nations and their use of lead in gasoline.

Geographic Patterns

Nations Where Unleaded Gasoline Appears to be Unavailable

Map 4 depicts the availability of unleaded gasoline worldwide. For some nations, no data were available, particularly for countries undergoing transition from centrally planned to market economies. (Maps present information on gasoline sold, as reported by Associated Octel, Ltd.)

The regional differences are quite striking. For example,

in Africa, where data were available for 52 nations, only two (both in North Africa) had any unleaded gasoline available. In contrast, of 28 European countries for which data were available, only one country reported no unleaded gasoline. (Data were unavailable for 13 countries, all except one of which were in Eastern or Southeastern Europe). Of 32 American countries for which data were available, eight reported only leaded gasoline; four were in South

America, and two each in Central America and the Caribbean.

Data for Asian nations vary considerably across subcontinental regions.

Thus, for example, in Southeast Asia (excluding Australia and the Pacific Islands), only one of nine nations reported no unleaded gasoline. In Western

Unlike data on exposure, data on lead use is easily available.

Production of Lead Additives for Gasoline

Between 1970 and 1993, the total amount of lead added to gasoline worldwide dropped 75 percent, from more than 375,000 tons to less than 100,000 tons. At present, lead additives for gasoline appear principally to be produced by a single company, Associated Octel, Ltd. The original producer, Ethyl Corporation, no longer manufactures tetraethyl lead, but rather purchases it from Octel. Much smaller amounts are independently produced in Germany and Russia. (45, 47, 51).

Reliability of Fuel Data

Much of the data in this chapter comes from Associated Octel, Ltd., which appears to be the only commercial producer of ethyl lead compounds for gasoline. The Octel report presents more recent and more comprehensive data than other sources. Other data sources are not always consistent with the Octel report. Probably the most complete alternative data set for maximum lead levels and unleaded market share is that published by the World Bank (31). These data are primarily from 1993, but also include more recent information (in some cases as recent as 1996) for some nations. For the 112 nations for which both Octel and World Bank report data on maximum lead levels, the data agree in 66 cases. For 24 countries, Octel reports a lower value than the World Bank, and in 22 cases, a higher value. In roughly half of the cases where Octel reports a higher value, the World Bank data are more recent; they may thus indicate cases where lead levels have recently been reduced. Similarly, in some cases where Octel reports a lower value, it may reflect the use of newer information.

Other comparisons reveal similar results. For example, Earth Summit Watch (ESW) published data on leaded gasoline use for 58 countries in 1995, as part of an effort to document progress on reducing lead exposures under Agenda 21; these data were not always current as of 1994. For 32 nations, data on maximum lead content were the same as those collected by Octel. For 21, ESW reported higher lead levels than Octel. This could reflect dated information in some cases (if countries were decreasing the lead content of their gasoline) or differences between the maximum permitted level of lead in gasoline and the maximum lead content of gasoline actually sold (the latter is what Octel reports). For example, the ESW reports the European Union limit on lead in gasoline as the maximum value for both the Czech Republic and Denmark. The actual Czech maximum is apparently lower, and Danish consumption of leaded gasoline has ceased. Similarly, a recent Egyptian analysis (12) notes a maximum permitted lead content of 0.65 g/l; the maximum value sold, from the Octel data, is 0.28 g/l.

For five nations, ESW reported lower maximum lead levels for gasoline than did Octel. This may reflect the fact that Octel reports a range of possible lead levels in a given grade of gasoline. (Maps in this report use the maximum value in the range.) In the Russian Federation, for example, national authorities indicate that lead content varies between 0.15 and 0.37 g/l (44). Octel reports two grades (0.17 and 0.37), while ESW reports a single value (0.2).

Similar small discrepancies affect the reporting of quantities of gasoline consumed. For example, the International Energy Agency routinely publishes gasoline consumption data for seven OECD countries, while the OECD published similar data on 24 countries in 1993. In general, the Octel data were consistent with both, but there are notable differences. The largest difference with IEA data was that Octel data for France were 13 percent higher for 1995 than annual values estimated from third-quarter 1996 values published by IEA. These same Octel data were 12 percent lower than the 1993 OECD estimate for France. For the rest of comparisons with 1993 OECD data, the median absolute value of the difference was 8 percent. The Octel estimate was higher than OECD in 11 of 24 cases, and lower in 13. In only one case was the discrepancy greater than 20 percent (Denmark, where the Octel value was 37 percent higher than the OECD value).

In sum, the numbers used to generate the maps in this chapter are likely to have some degree of error. Comparison with data from other sources, however, revealed no evidence of any systematic bias in the data.



and Southern Asia, in contrast, 14 of 21 nations with data reported only leded gasoline.

Also notable is the lack of data for Central Asia and Eastern Europe. More recent data from the World Bank (32) indicate that unleaded gasoline has a significant market share in four of the countries in Eastern Europe. In Lithuania, leded gasoline has a very small market share, and leded gasoline has only about a 30 percent market share in Belarus and Ukraine. In Latvia, the market appears approximately equally split between leded and unleaded gasoline.

Maximum Lead Content in Gasoline Worldwide

In reality, emissions of lead from gasoline into the environment reflect far more than simply the availability of unleaded gasoline. For countries that have both kinds of gasoline and those that appear to use only leded gasoline, the amount of lead in a liter of gasoline varies widely. Lead content ranges from a low of 0.02 grams per liter of gasoline (approximately 50 percent more lead than the United States' standard for unleaded gasoline) to a high of 0.84 grams of lead (more than 40 times higher).

Maps 5A through 5E present data by continent on the maximum lead content of gasoline sold, as collected by Associated Octel, Ltd. (6). The maps present the most recent data available at the time this report was prepared. Where available, 1995 data

are shown; 1994 data are presented where 1995 information was not available.

To generate these maps, countries were sorted into four equal groups (quartiles), excluding nations for which data were unavailable. Thus, countries plotted in red are in the top twenty-five percent of nations in terms of maximum lead content in gasoline (between 0.7 and 0.84 g/l). Those shown in medium shading are in the next-highest quartile (0.4 to 0.7 g/l). Those in the lightest red shading are in the next-to-lowest quarter (0.15 to 0.4 g/l), while countries shown in blue are in the lowest quarter (up to 0.15 g/l maximum lead content). Where data were unavailable, the countries are shown in gray.

Perhaps the most striking observation from Maps 5A through 5E is that the countries of Africa not only depend almost entirely on leded gasoline, but also have among the highest lead content in gasoline in the world. For the 52 nations for which data are available, 20 are in the highest 25 percent for maximum lead levels worldwide, and 14 of those have the worldwide maximum lead content (0.84 g/l). A further 16 nations have maximum lead values in the next lower category. Thus, more than two-thirds of the nations in Africa have maximum lead levels above the worldwide median value. Sixteen African nations had values in the next-to-lowest category, while no African nations have maximum lead levels in the lowest category.

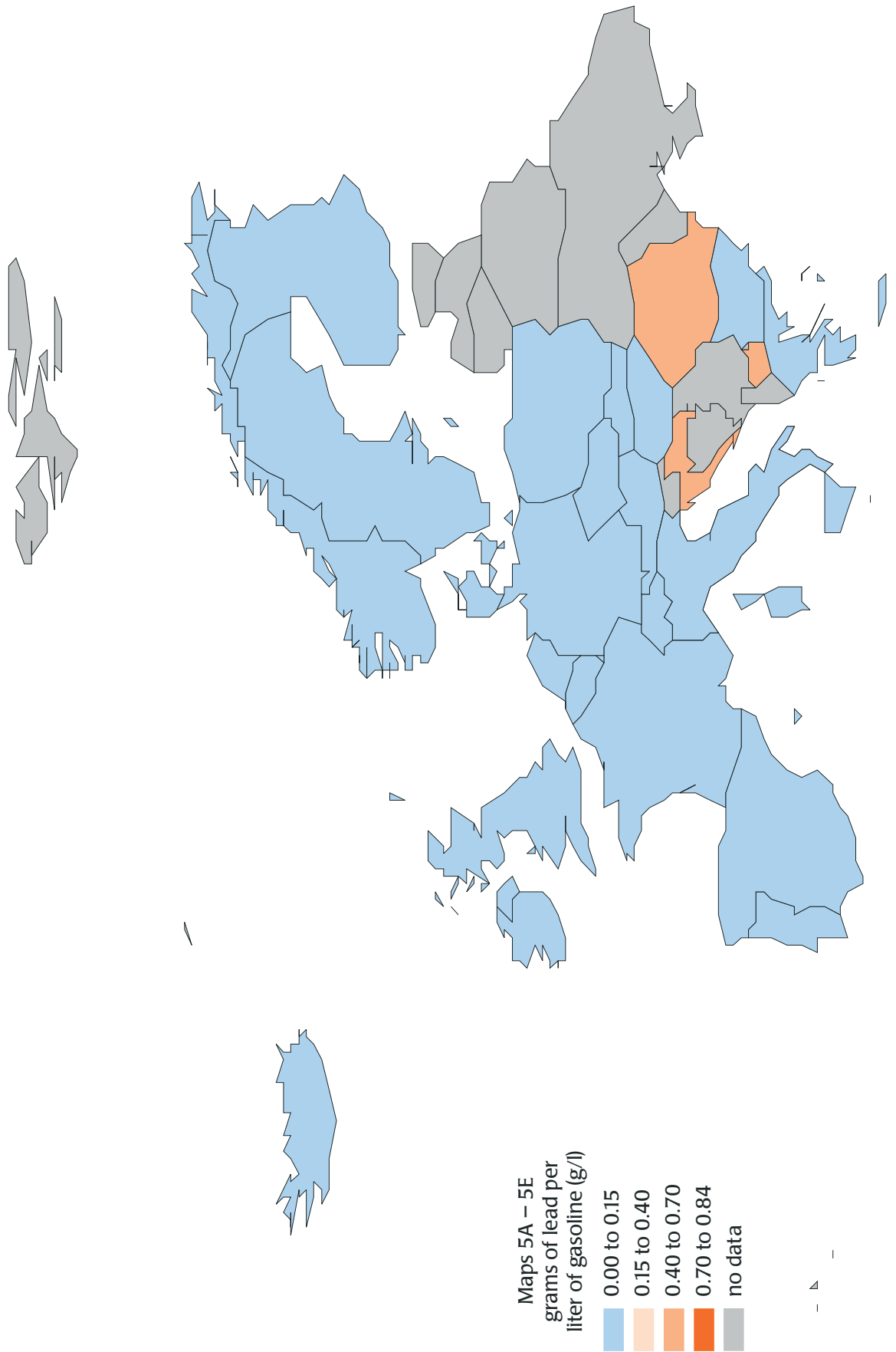
In Europe, in contrast, no nations were found with maximum lead levels in the highest range, and only three with values in the next-highest. All of the remaining countries for which data could be obtained (25 nations) were in the lowest category. Similarly, two of the three North American countries are in the lowest range, while the third is in the next-to-lowest.

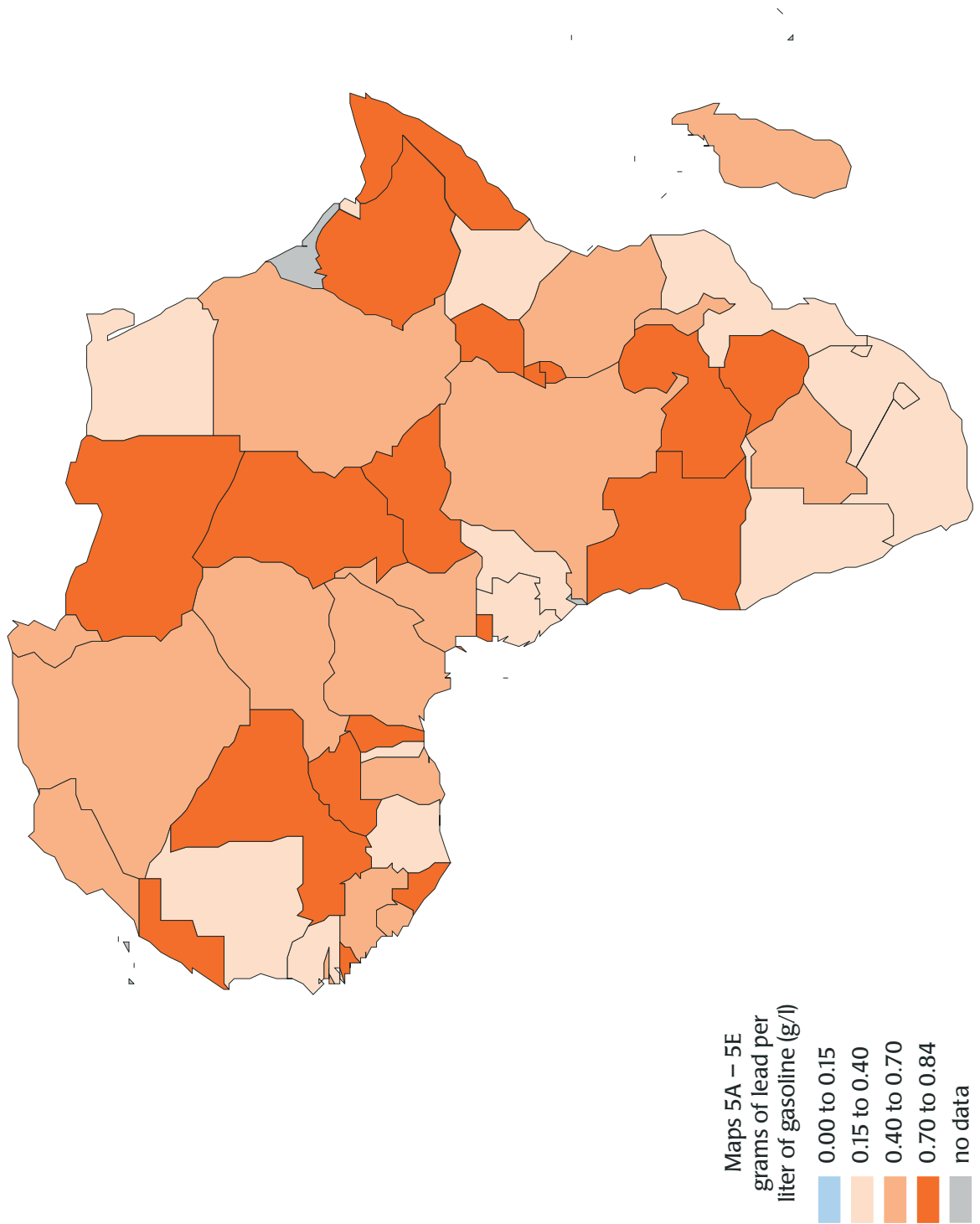
In the Caribbean, however, maximum lead levels are high. Six of 10 nations for which data were available were at the highest value (0.84 g/l), while two were in the next-highest range. Two were in the lowest range.

In Central and South America, maximum lead levels cover the entire range observed worldwide. Of the 19 nations for which data were available, five had maximum lead levels in the highest range, four in the next highest, and five in each of the two lowest. Four of these nations used no leded gas.

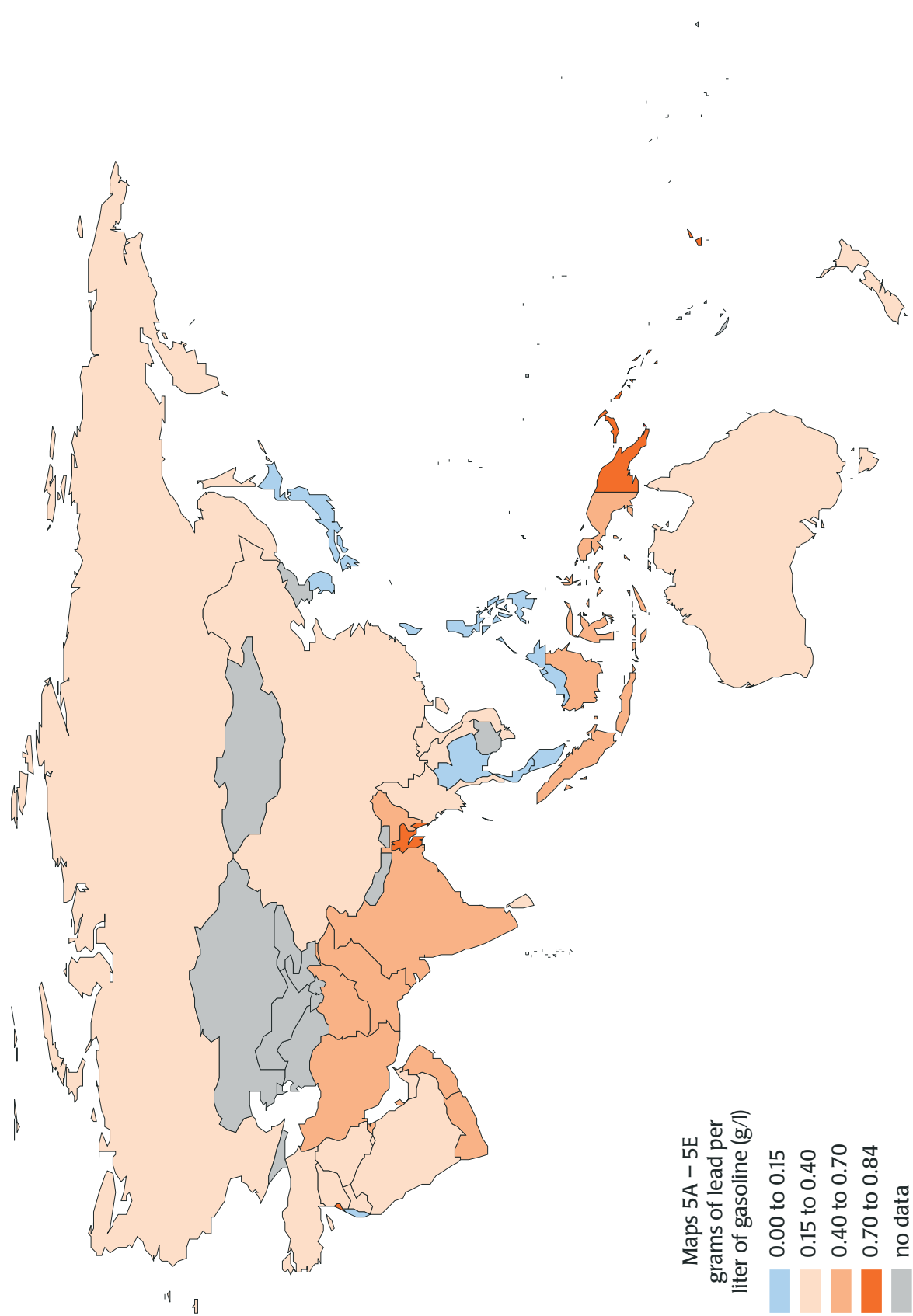
In Asia, patterns vary considerably by sub-region. With the exception of the Russian Federation, no data were available for Central Asia. Of five South Asian nations, one had a maximum lead content in the highest range, three in the second-highest, and one in the second-lowest. In East and Southeast Asia, (excluding Australia and Oceania), eight of 13 states for which values were available had maximum lead content in the lowest range, while four had values in the next lowest. In West Asia, virtually all of the countries (13 of 15) had

Maximum Lead Content in Gasoline: Europe



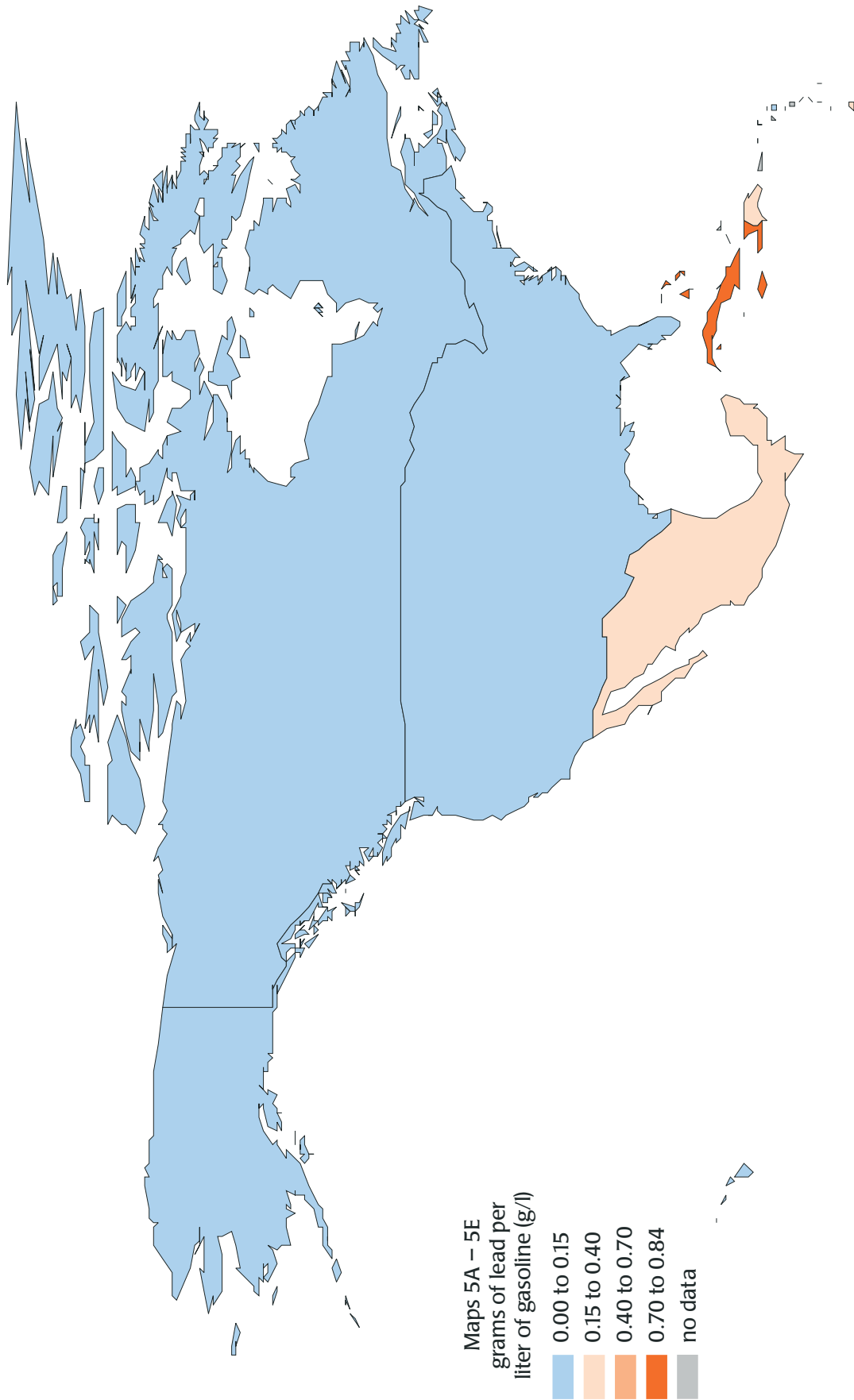


Maximum Lead Content in Gasoline: Asia and Australia Map 5C

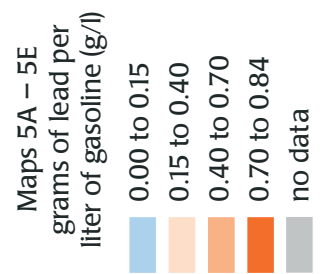
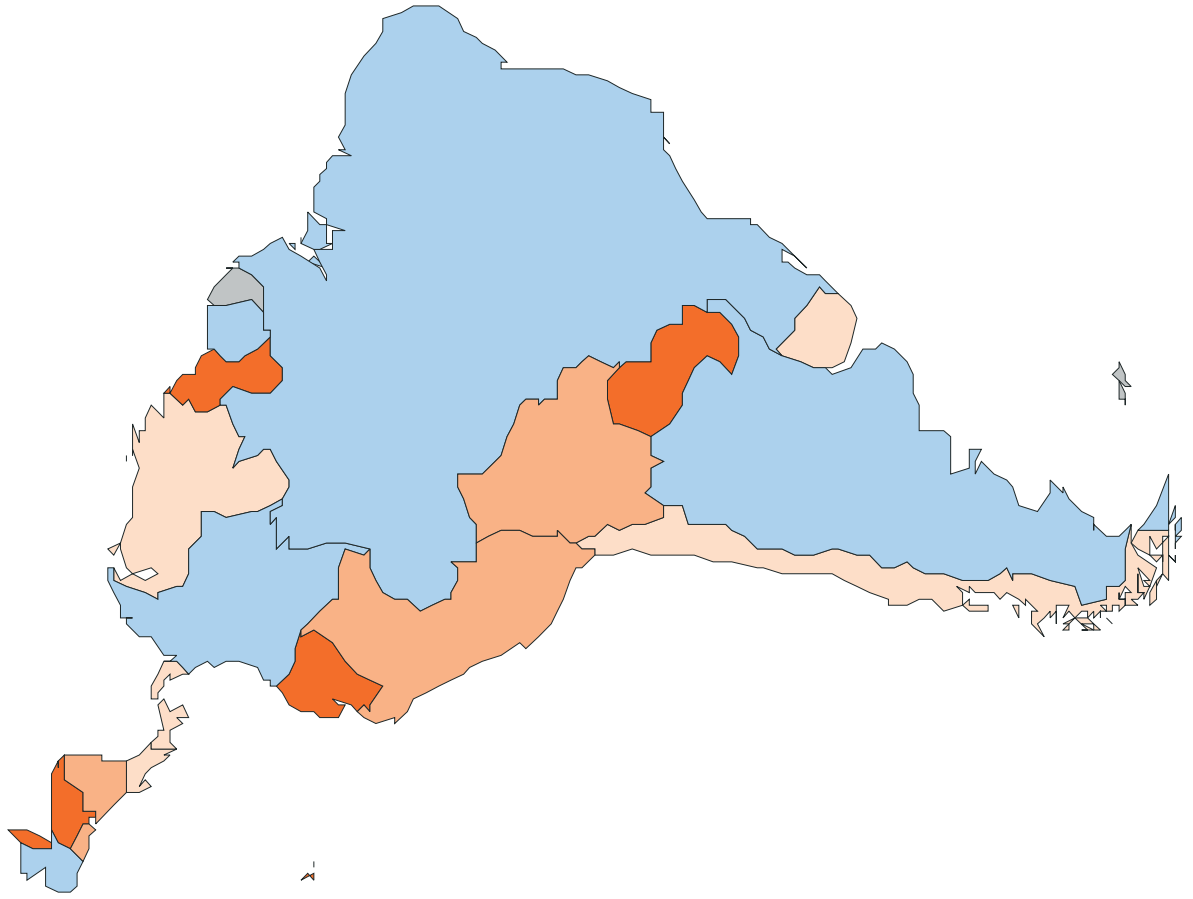


Maximum Lead Content in Gasoline: North America

Map 5D



Maximum Lead Content in Gasoline: South America



maximum lead values in the mid-range, with five in the second-highest range and eight in the second-lowest. One country had a value in the highest range and one in the lowest.

Of the Pacific Island states for which data were available, all but Australia and New Zealand had maximum lead values in the highest range. These two larger countries had values in the next-to-lowest range.

Average Lead Content of Gasoline Used

While the maximum amount of lead allowed in gasoline can indicate lead use that exceeds any automotive benefit, it serves only as a very indirect measure of exposure to lead from gasoline. This is particularly true in the nations that have several grades of gasoline and those in which unleaded gasoline has more than a negligible market share.

Maps 6A through 6E illustrate the average lead content of gasoline for countries where data were available on the consumption of different grades of leaded gasoline, as well as countries where all gasoline has comparable lead content. This data set is smaller than that for maximum levels of lead in gasoline (133 nations versus 153). Where a range of possible lead contents is indicated for a particular grade of gasoline, the mid-point of the range was used. Thus, if 'premium' gasoline ranges from 0.4 to 0.6 g/l lead in a country, a value of

0.5 g/l was applied for that 'premium' gasoline.

As might well be expected, the range for average lead content is generally lower than for maximums. The highest and lowest amounts mapped are unchanged, because some countries have only gasoline with 0.84 g/l lead available, so that their maximum and average lead content is the same, and some countries at the low end of the scale have similar results. Again dividing the data into four groups containing an equal number of countries produces four quartile ranges:

- 0.6 to 0.84 g/l
- 0.36 to 0.6 g/l
- 0.09 to 0.36 g/l
- none to 0.09 g/l

For Africa, the average lead content in gasoline could be calculated for 42 nations. Of these, more than half (22 countries) were in the highest quartile of global values. African nations thus account for two-thirds of the nations in the highest range, worldwide. Thirteen additional countries are in the next highest quartile, and seven in the third-highest. None of the African nations is in the lowest range of gasoline lead content.

Data on average lead content reveal differences among European countries with regard to leaded gasoline that are not apparent in the data on maximum lead content. This reflects the fact that the European Union imposes a maximum lead content of 0.15 g/l on its member states. Actual practice, however, reaches from

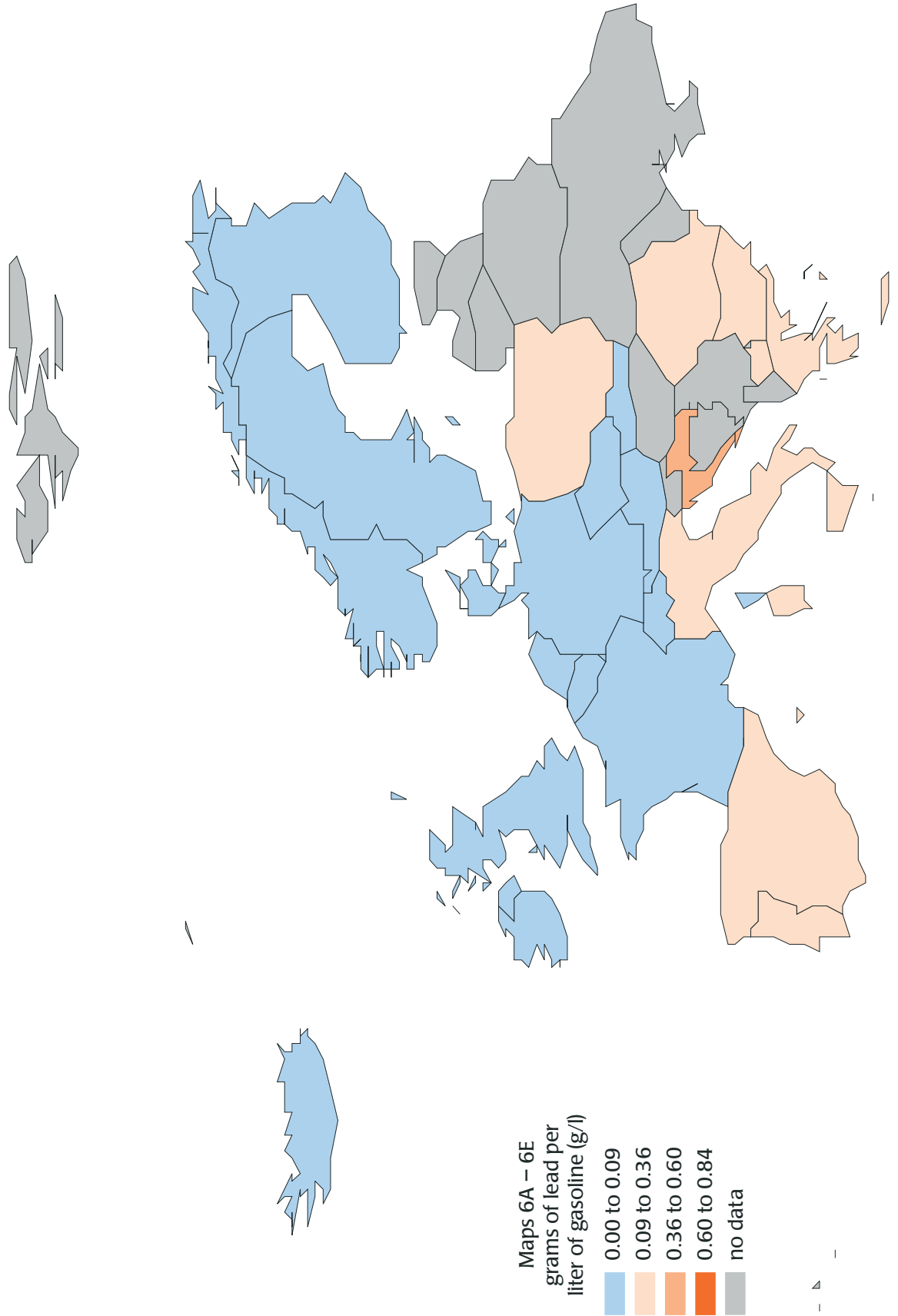
nearly exclusive use of leaded gasoline to nearly exclusive use of unleaded gasoline. While no European nation has an average gasoline lead content in the highest range, one is in the second-highest range (a non-European Union country), and nine are in the next-to-lowest (four of them non-EU). The remaining 16 are in the lowest range. In general, more lead is used in nations in Eastern and Southern Europe than in Northern and Western, although there are several exceptions. Five European nations have essentially only unleaded gasoline (average lead concentration less than 0.013 g/l).

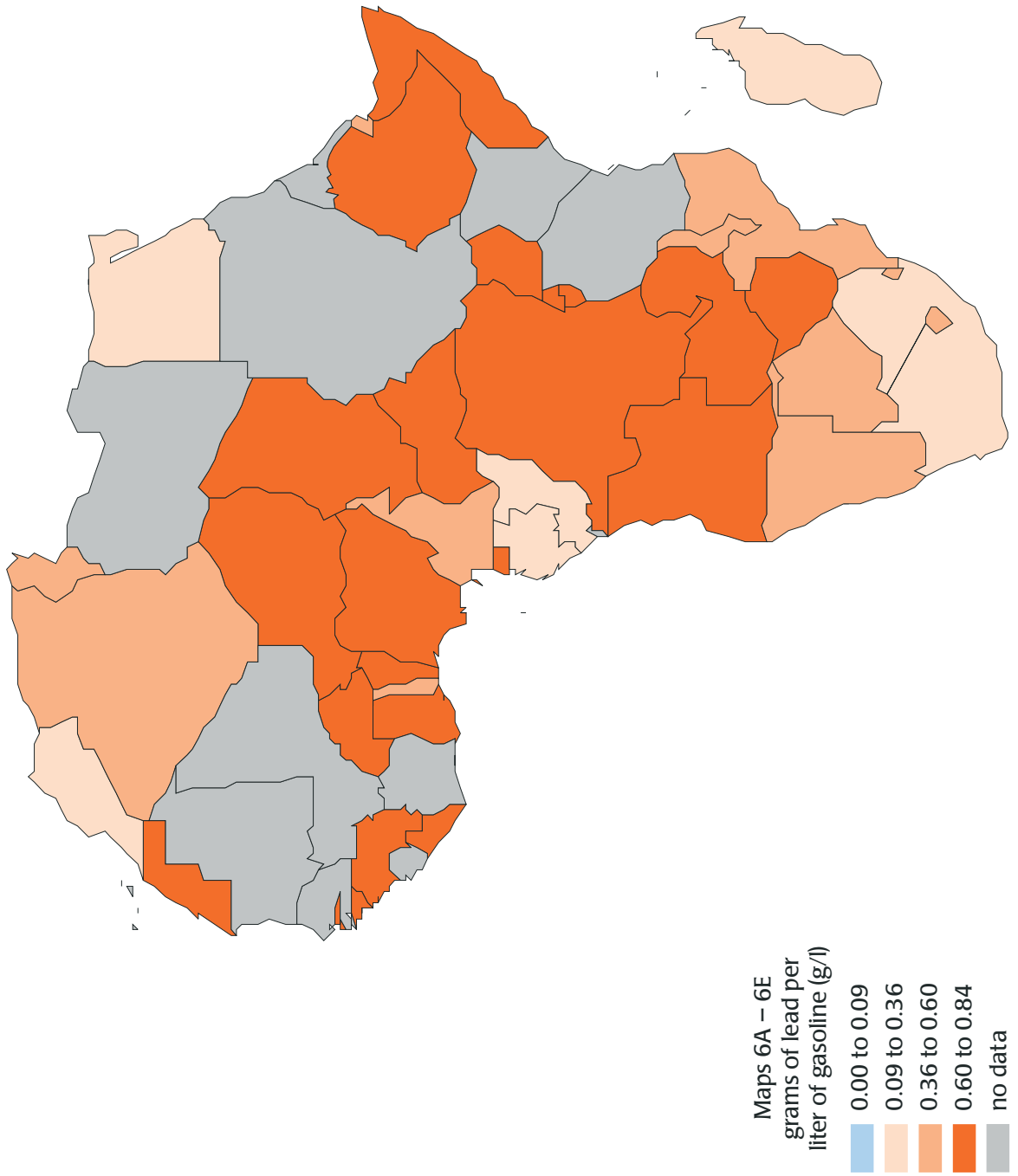
All three North American nations have average gasoline lead contents in the lowest range. In contrast, of the eight Caribbean nations for which data are available, four have average lead concentrations in the highest range, two in the next highest, and only one in the lowest.

In Central and South America, data on average lead content were available for 17 nations. Unlike the case for maximum lead content, where these nations were more or less equally divided among the ranges, for average lead content two-thirds of these Latin American countries were in the lowest two ranges. Only two countries were in the highest range.

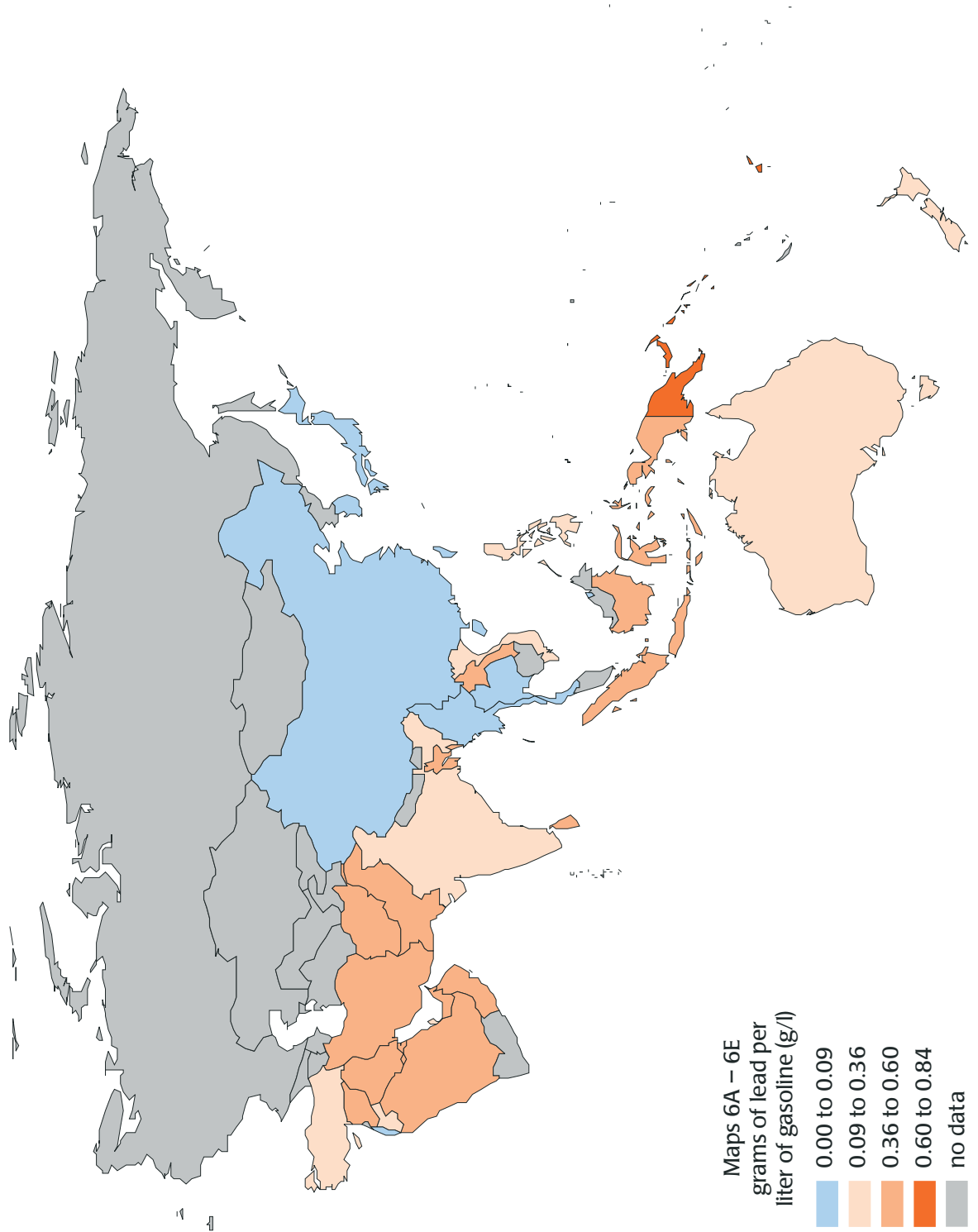
In Asia, the pattern of average gasoline lead content is similar to that of maximum lead content, with a few notable changes. The five South Asian na-

Average Lead Content in Gasoline: Europe





Average Lead Content in Gasoline: Asia and Australia Map 6C



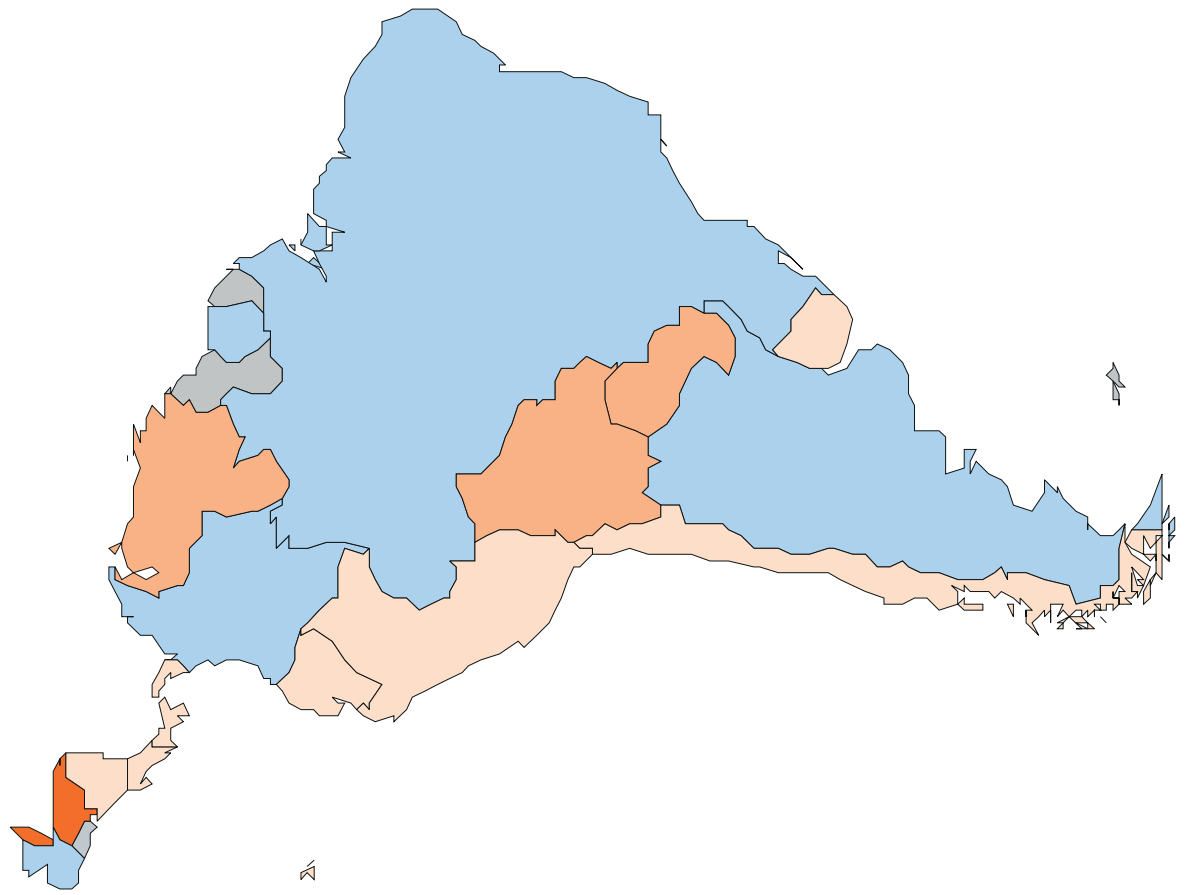
Average Lead Content in Gasoline: North America

Map 6D

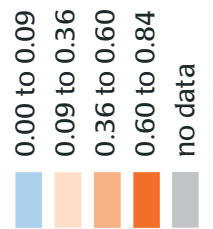


Average Lead Content in Gasoline: South America

Map 6E



Maps 6A – 6E
grams of lead per
liter of gasoline (g/l)



tions are again clustered in the middle ranges, with four in the second-highest, and one in the second-lowest. In East and Southeast Asia, eight nations had average lead content in the lowest range, while two each had values in the middle two ranges. Both China and

India had average lead concentrations in a lower quartile than maximum lead concentrations. In West Asia, average lead content was generally higher (in relative terms) than was maximum lead content; eight of 13 nations had

average lead values in the second highest range, with all but one of the rest in the second-lowest.

The pattern of average lead levels in the Pacific Island states essentially mirrored that of maximum lead content.

Economic Patterns

Very high lead levels are most often seen in the poorest nations.

The geographic pattern of differences in the lead content of gasoline suggests differences in lead use between wealthier and poorer nations. This proves true when national data are sorted by per capita Gross Domestic Product (GDP).

Figure 8 presents data on the average and maximum lead content of gasoline for nations divided into five classes on the basis of GDP. Data for 1995 were available for 187 UN member states (Table 6) (50). Due to the

greater availability of gasoline data for wealthy countries, representation in the wealthiest category is more complete than for the others.

As is evident from the figures, some nations in each economic class allow a very high maximum level of gasoline lead. The wealthiest nations, however, are more likely to have stringent limits on the lead content of gasoline. Thus, the lowest maximum lead level specified is higher in the two lowest GDP classes than in the three higher GDP classes. More strikingly, the median value of the maximum lead content in each class shows a strong,

consistent trend. The wealthier the country, the lower the maximum lead level is likely to be.

A substantially similar pattern is seen for the average lead content of gasoline. Two differences are noteworthy. First, there are countries in the lowest GDP class that have essentially eliminated the use of leaded gasoline, although a substantially higher lead content would be permitted. That is, gasoline with very high lead content is available in these countries, but it has a negligible market share. Second, none of the wealthiest countries has an average gasoline lead content above 0.53 g/l.

Table 6

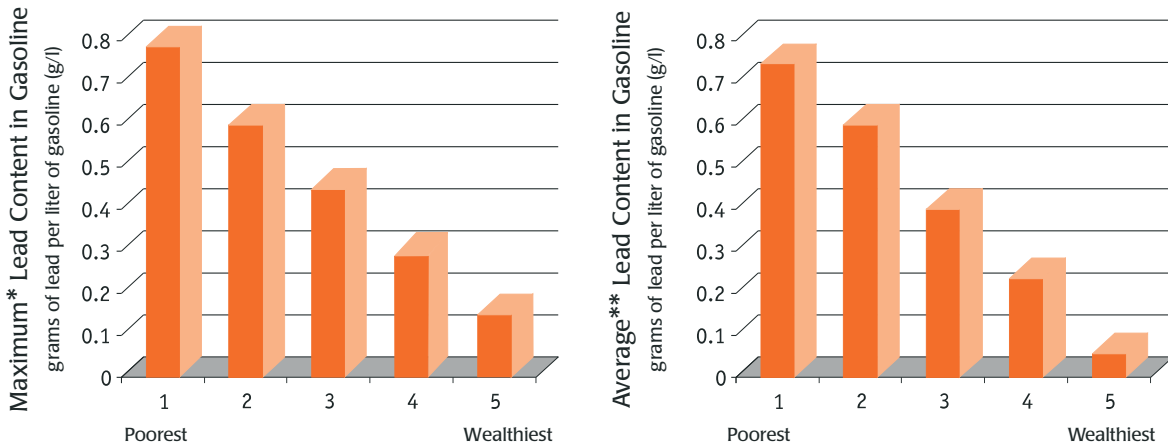
Lead Content and National Wealth: Data Availability

Countries Classified by Gross Domestic Product

Class	Number of Countries	Range of GDPs	Median GDP	Number of Countries	
				Maximum Lead Content Is Known	Average Lead Content Can Be Calculated
1	37	\$300-1,040	\$800	29	24
2	38	\$1,080-2,200	\$1,490	25	20
3	38	\$2,310-4,700	\$3,200	29	26
4	37	\$4,800-11,000	\$6,600	32	27
5	37	\$12,000-27,500	\$19,000	34	33

All GDP values in US dollars.

Maximum and Average Lead Content in Gasoline for Countries Grouped by Per Capita Gross Domestic Product

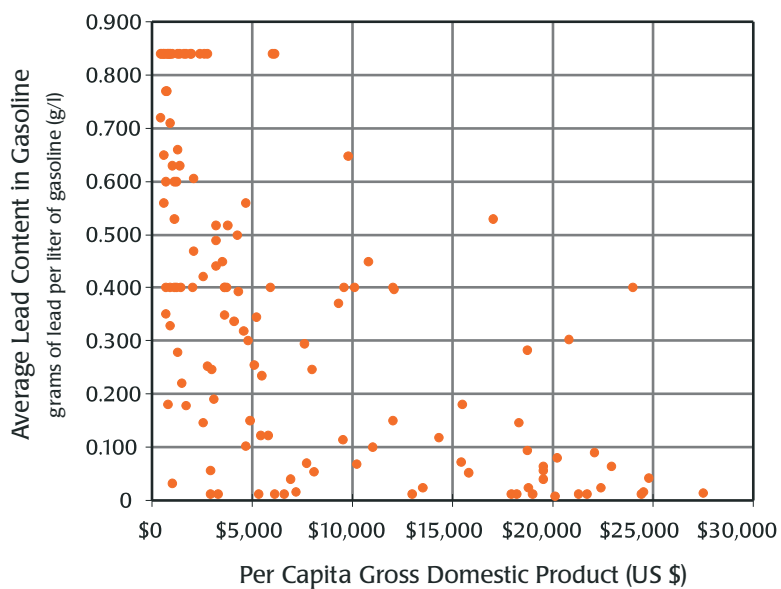


Countries Grouped by Per Capita Gross Domestic Product
Each Category = 20% of All Countries with Available Data

* Maximum lead content = median value of the maximum lead content for each country. Half of the countries in each class have higher average values and half have lower.

** Average lead content = median value of the average lead content for each country. Half of the countries in each class have higher average values and half have lower.

Average Lead Content in Gasoline for Countries by Per Capita Gross Domestic Product



Recent Changes in Use of Leaded Gasoline

The data presented above are, as noted, from 1995 or 1994. A more recent set of consistent data covering a similar range of countries was not available. For selected nations, however, more recent information is available. In some cases, this reflects major changes in the use of leaded gasoline.

Latin America has made great strides in eliminating lead from gasoline.

Lead reduction initiatives in Africa have been very limited.

Additional Countries Using Only Unleaded Gasoline by 1996

North America

United States

Central America

Belize
Costa Rica
El Salvador
Honduras
Nicaragua

South America

Argentina
Bolivia

see Map 4 for countries converting to only unleaded gasoline before 1996

Initiatives in the Americas

In the data above, six countries in the Americas had already completed the transition to exclusive use of unleaded gasoline. By the end of 1996, another seven Latin American nations, plus the United States, had completely eliminated the use of lead in gasoline for on-road vehicles

As a result, only one Central American nation and one North American nation were using any leaded gasoline in 1997. Four more (three in the Caribbean and one in South America) have planned to eliminate lead in gasoline completely by 2001. Thus, in the next century, fewer than half of the American nations for which data were available will be using any leaded gasoline, and the expected market share of unleaded gasoline in the Americas will be 83 percent. (14)

Several other Latin American nations, while allowing the use of leaded gasoline, report significant market share for unleaded gasoline. In countries such as Chile and Mexico, the requirement that new vehicles be equipped with catalytic converters can be expected to gradually prod an increase in market share for unleaded gasoline.

Other National Initiatives

In Europe, two nations with very low levels of leaded gasoline usage (Switzerland and Slovakia) have also

completely eliminated the use of leaded gasoline, as part of ongoing phase-out programs. Denmark and Finland, which, like Germany, had effectively no market share for leaded gasoline in 1995, also became formally lead-free in 1995. The Russian Federation also announced a program in March 1996 to increase production of unleaded gasoline by 65 percent by the year 2000. (14, 32, 44)

Some of the rapidly industrialized nations of Southeast Asia have also noted continuing progress in reducing or eliminating leaded gasoline. For example, Thailand (with World Bank assistance) restructured its petroleum refinery to meet reformulated gasoline specifications, and leaded gasoline was phased out completely by the end of 1995 (57).

In contrast, none of the nations of Africa and Asia with high lead content in gasoline appears to have a program for eliminating or phasing-out the use of lead in gasoline. Egypt planned to reduce maximum gasoline lead content to 0.15 g/l and to introduce unleaded gasoline by 1995 (progress to date is not known). Unleaded gasoline was apparently introduced in South Africa in 1996. Also in 1996, Australia announced adoption of a single national standard more restrictive than most of its current state standards (0.2 g/l). (8, 31, 43)

International Initiatives

Agenda 21 of the United Nations Conference on Environment and Development includes a commitment to reduce lead exposure, although this does not specifically call for actions with regard to lead in gasoline.

At the Summit of the Americas, held in December 1994, 34 western-hemisphere nations entered a Partnership for Pollution Prevention, which included the development and implementation of national action plans to phase out lead additives in gasoline (14). As noted above, considerable progress in eliminating the use of lead in gasoline has been made in this hemisphere.

In February 1996, the OECD Council of Ministers issued a formal statement on Risk Reduction for Lead. Annex I to this document called on member nations to “Progressively phase-down the use of lead in gasoline except where needed for essential or specialized uses for which there are no practical, viable alternatives.” (37) While most OECD member states have already substantially reduced or entirely eliminated the use of leaded gasoline, this policy may lead to further reductions.

At the April 1996 Transatlantic Automotive Industry Conference on International Regulatory Harmonization, automotive industry representatives from Europe and the Americas supplied joint recommendations for

automotive standards to the United States government and the European Union. This group also noted as an “Area of Potential Cooperation with Respect to Other Countries (e.g., Emerging Markets)” implementation of a lead phase-out as a necessary step to regulatory harmonization.

In May 1996, the World Bank announced an initiative calling for a worldwide phase-out of leaded gasoline to reduce rampant urban health problems linked to lead (56). This general initiative has been reflected in a series of specific projects, including support for several national governments in developing tax, price, and market liberalization policies to facilitate lead phase-out (57).