To the Editor:

In their recent paper published in *Food and Chemical Toxicology*, Barenys et al. (2014) performed a 24-hour dietary recall survey among a small group of rural Peruvians living within about 10 kilometers of the Minera Yanacocha S.R.L. gold mine (MYSRL) in Cajamarca, Perú. Based on reported daily food intakes and concentrations of metals in a small number of food and water samples, Barenys et al. calculated dietary intakes of several metals based on (1) on their survey, and (2) on intake rates reported in the official Perú Instituto Nacional de Estadística e Informática (INEI) survey (2012). Intakes based on Barenys et al.’s survey were around 20% higher than those based on the official INEI survey. Two of the “highlights” from this work are (1) the study population’s health is at serious risk due to exceedances of European Food Safety Authority (EFSA) dietary standards for As, cadmium Cd, and lead Pb, and (2) intakes of As and Pb increase the closer the population is to the gold mine.

Our review revealed critical flaws in the data and methodology used by Barenys et al. (2014). Contrary to the authors’ conclusions, our comparison of the Barenys et al. results with typical dietary intakes cited in EFSA scientific opinion documents and relevant risk-based comparison levels indicates that estimated dietary As, Cd, and Pb exposures in Cajamarca are of a magnitude similar to those currently existing in Europe and the U.S., and are not suggestive of adverse health effects. The only exceedances of World Health Organization (WHO) drinking water guidelines occurred in two water samples of unspecified provenance (save that they were collected somewhere in La Pajuela), which were primarily responsible for elevated “dietary” intakes. Thus, what the Barenys et al. (2014) study actually shows is that sampled Cajamarca residents have no greater dietary exposure to these metals and are at no greater resultant risk of toxicity than are average European consumers. We therefore conclude that the authors’ assertion that there are “serious concerns for the population’s health” and recommendation that “it is reasonable to advise to La Pajuela population not to drink from the water sources in their area” are scientifically unsubstantiated.

Key issues are briefly discussed in this letter.

**Critical Flaws in Barenys et al.’s Data and Methodology**

- **The lack of a reference area in the Barenys et al. study precludes meaningful risk characterization.** As, Cd, and Pb (along with many other elements) are naturally present in plant and animal tissues, including human bodies and food, particularly in naturally mineralized zones such as the area in and around MYSRL near Cajamarca. As a result, exposure to these metals is ubiquitous, and food is a major source of exposure for the general population (Fowler et al., 2015). It should also be recognized that the Cajamarca regional ecosystem had been influenced by human activities (*e.g.*, growing crops, livestock grazing, and mining) before modern mining began, with several introduced species of flora and fauna and high indexes of erosion of the soils on the steep slopes characteristic of the area. The water quality of area streams is influenced by the high mineral content of the rocks, causing acidity levels and metal concentrations that can be relatively high in some segments prior to mining, as well as by natural and agriculturally-induced erosion and other current and previous mining...
activities (Apoyo Consultoria 2009; INGETEC S.A., 2003; Morrison et al., 2007a, b, c; Teal and Benavides, 2010).

- **Inadequate information was provided regarding food and water sample collection and analysis.** A small number of food (n = 130) and water samples (n = 15) were collected for metals analysis in Porcón Bajo, La Ramada, Tual, La Pajuela, and in the regional Cajamarca city market. Neither the exact foods sampled nor their origins were specified. The majority of the sampled foods will not grow at the high elevations characteristic of the four communities or Cajamarca. In particular, rice, oranges, apples, carrots, onions, noodles, cabbage, and soft drinks are not produced within these four communities. No indication was provided of the proportion of diet obtained from home gardens or local growers vs. the regional market in Cajamarca city, or of seasonal variations in food choices and/or intake rates. No information was provided concerning water sampling methodology, including the use of field and trip blanks, type of water source (surface water, groundwater, spring), exact sampling location and conditions, piping materials, and number of people served. Whether or not water samples were filtered was not indicated. The presence of suspended particulate matter in unfiltered samples of water can significantly affect metals concentrations, and may not be representative of water as consumed.

- **Barenys et al. did not establish the existence of complete exposure pathways between MYSRL and various study locations, they merely assumed that all metals in all dietary samples originated from MYSRL.** Based on the international consensus conceptual framework and methodology for assessing potential toxicological risks described in many standard textbooks of occupational/environmental medicine and toxicology (e.g., Klaassen, 2013; Sullivan and Krieger, 2001) and integrated into numerous international regulatory guidance documents (e.g., U.S. Environmental Protection Agency (USEPA) (1989 and many others); WHO (1999, 2000; 2010 and many others), an investigation to determine that a health effect has been or could be caused by exposure to substances in the environment must proceed in a logical fashion that (1) establishes the presence of a complete exposure pathway\(^1\) linking a chemical source(s) to human receptors, (2) estimates the concentration(s) of any source-related chemical(s) under investigation at the receptor’s location via measurements or modeling over the exposure period, (3) calculates or measures the dose received by the individual(s) at the exposure point, and (4) characterizes the potential health effects of the chemical(s) under investigation based upon the route of exposure and chemical-specific dose-response relationship(s). Barenys et al. failed to establish the existence of complete exposure pathways, let alone a forensic demonstration of a mine-related exposure gradient for As and Pb -- which depended solely on two water samples of unspecified provenance.

- **Rice, a major contributor to Barenys et al.’s estimated As and Cd intakes, is not grown in Cajamarca, and hence could not be influenced by MYSRL or any other local source.** As, Cd, and other metals are well known to accumulate to particularly high levels in rice (Adomako et

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\(^1\) Defined as “the course a chemical or physical agent takes from a source to an exposed organism.” A complete exposure pathway includes a source or release from a source, an environmental transport/exposure medium (or media), an exposure point (location of potential contact between an organism and a chemical or physical agent), and an exposure route (i.e., ingestion, inhalation, dermal contact) (EPA 1989).
al., 2011; Fowler et al., 2015; Meharg et al., 2013; Meharg and Zhao, 2012; Norton et al., 2013; Norton et al., 2014; Williams et al., 2007; Williams et al., 2009), one of the main dietary items in Cajamarca. As indicated in Figure 3 of the publication, rice is a dominant source of dietary As and Cd exposure in Cajamarca, significantly contributing to the “elevated” intakes of these metals reported in Tables 4 and 5 of the publication. Given the authors’ recognition that rice is not grown in Cajamarca, their contention that “…the gold mine cannot be excluded as the origin of this contamination [of rice]” is puzzling, and their failure to discuss the implications of other sources for the major source of dietary intakes of these metals further undermines the credibility of their analysis and conclusions.

- Barenys et al. did not define their population of interest, and as acknowledged by the authors, the subject group was not representative of the local population in sex or age. No information was given regarding subject recruitment, and no characterization of any of the 11 locations whence the subjects were drawn from is provided (save location and distance from the mine). Of the small population sample examined by Barenys et al. (n = 36), the majority were males aged 12 to 17 (n = 20) – proportionally one of the smallest age groups in the population (INEI, 2013), while only eight were female (22%). This bias towards young males is problematic as it is unlikely that young males would have accurate knowledge of and/or involvement in day-to-day food planting/harvesting, purchasing and preparation. Only 21 of the 36 individuals involved in the study lived in locations that also had food and water sampling. Importantly, the dietary habits of residents of La Pajuela, the settlement closest to the mine which Barenys et al. assert is most affected by releases from the mine, were not determined. Body weights were reportedly only measured for 25 of the 36 subjects, further reducing the accuracy of estimated daily intake rates.

Results of Comparison of Barenys et al.’s Data with Relevant International Standards

Food Items

Because Barenys et al. did not present the primary data underlying their calculations – the concentrations and forms of metals detected in food and water samples, detection frequencies, individual intake rates, and body weights. Two emailed requests for this information directed to the corresponding author were not answered. Therefore, we undertook to estimate metals concentrations in dietary items by (1) reading daily intakes from Figure 3 of the publication, and (2) dividing them by daily intakes from Barenys et al.’s survey as listed in Table 1 of the publication. These estimates are summarized in Error! Reference source not found..
Table I. Estimated Concentrations of Metals in Foodstuffs in Barenys et al. (2014)

<table>
<thead>
<tr>
<th>Metal</th>
<th>Rice</th>
<th>Potatoes</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>94.2</td>
<td>408.9</td>
<td>1153.7</td>
</tr>
</tbody>
</table>

- Reported daily intake rate of foodstuff (g/day)\(^a\)
- Daily intake rate of metal in foodstuff (μg/day)\(^b\)
- Concentration in foodstuff (ppm)\(^c\)

\(^a\) Daily foodstuff intake rates from Barenys et al.'s dietary survey (Table 1 of Barenys et al. 2014)
\(^b\) Metals intakes estimated from Figure 3 of Barenys et al. (2014)
\(^c\) Metals concentrations estimated by dividing estimated daily metal intake by daily intake of foodstuff

- As
  - Rice: 15
  - Potatoes: 5\(^d\)
  - Water: 16\(^f\)
- Cd
  - Rice: 12
  - Potatoes: 0.13
  - Water: 0.014
- Pb
  - Rice: 5\(^e\)
  - Potatoes: 0.012
  - Water: 75\(^f\)

- As
  - Rice: 0.16
  - Water: 0.07
- Cd
  - Rice: 0.13
  - Water: 0.012
- Pb
  - Rice: 0.012
  - Water: 0.07

- The estimated concentration of As in La Pajuela water, 0.014 ppm, was only slightly above the WHO drinking water guideline of 0.01 ppm (WHO, 2011), and typical of many water supplies in the U.S. (e.g., Focazio et al., 2000) and Europe (e.g., Katsyiannis et al., 2014). The estimated concentration of Pb in La Pajuela water, 0.07 ppm, exceeds the WHO provisional drinking water guideline of 10 ppb (WHO, 2011). However, because of the small number of samples collected and their lack of information on the sampling location(s), neither the relevance of these samples to drinking water quality in La Pajuela nor the degree of potential health risk can be determined. Filtered water samples collected by representatives of Newmont from multiple locations in the study area in September 2014 contained only <0.002 to 0.009 ppm As, with 70% below detection limits, and <0.0009 to 0.05 ppm Pb, with 87% below detection limits. Unfiltered concentrations were similar, except in two samples that contained high concentrations of total suspended solids due to recent rain (data available upon request). Thus, the existence of elevated Pb concentrations in drinking water is not supported by the low concentrations of this metal found in recently collected samples in the study area.

- The estimated concentrations of total As and Cd in rice samples from the Cajamarca market (0.16 ppm and 0.13 ppm, respectively) are within the range of concentrations reported in market rice samples worldwide (Meharg and Zhao, 2012; U.S. Food and Drug Administration, 2013). Importantly, the estimated concentrations are below the Codex Alimentarius Commission Maximum Levels (MLs) for these elements in polished rice of 0.2 ppm and 0.4 ppm for As and Cd, respectively (Joint FAO/WHO Food Standards Programme Codex Alimentarius Commission, 2014), indicating no potential risk in excess of that prevailing elsewhere in the world.

- The estimated concentrations of Cd and Pb in potato samples (both 0.012 ppm), apparently maximal in two different areas, are below typical concentrations in Europe (EFSA, 2009a;
2012b). These concentrations are also below the ML for Cd and Pb in potatoes of 0.1 ppm (Joint FAO/WHO Food Standards Programme Codex Alimentarius Commission, 2014), indicating relatively low exposure and potential risk due to dietary Cd and Pb exposure in Cajamarca.

**Dietary Intake**

- **Upperbound mean daily dietary intakes of total As in Europe range from 0.6 to 4.6 μg/kg BW-day, and 95th percentile dietary intakes range from 1.8 to 11.2 μg/kg BW-day (EFSA, 2009b). The upperbound mean dietary As intakes calculated by Barenys et al. are therefore at the low end of typical European exposures, and at the lower end of the EFSA benchmark range for arsenic in the diet (0.3 to 8 μg/kg BW-day, indicating neither As exposure nor risk in excess of that prevailing throughout the world. (Barenys et al. do not appear to appreciate that the EFSA standard is in fact a range, and not only its lower bound.)**

- **Upperbound mean daily dietary intakes of Cd in Europe range from 0.26 to 0.36 μg/kg BW-day, and 95th percentile dietary intakes range from 0.41 to 0.73 μg/kg BW-day (EFSA, 2012a). The upperbound mean dietary Cd intakes calculated by Barenys et al. based on INEI dietary intakes are therefore entirely within the range of typical European exposures, and those based on Barenys et al.’s much more limited dietary survey data are largely within the range. The upper ranges of both European and Cajamarca intake estimates slightly exceed the EFSA benchmark for dietary Cd intake of 0.36 μg/kg BW-day (EFSA, 2011), indicating dietary Cd exposure and risk levels in Cajamarca are of a magnitude similar to that existing in Europe.**

- **Upperbound mean daily dietary intakes of Pb in Europe range from 0.6 to 1.3 μg/kg BW-day, and upperbound 95th percentile dietary intakes range from 1.1 to 2.6 μg/kg BW-day (EFSA, 2009b). The upperbound mean dietary Pb intakes calculated by Barenys et al. are therefore within the range of typical European exposures, with the exception of the maximum estimated intake based on Barenys et al.’s intake assumptions in La Pajuela, which is driven entirely by the high concentration of Pb in a water sample collected there. This datum is also responsible for the slight exceedance of the range of adult EFSA benchmarks for Pb in La Pajuela. The upper ranges of the European dietary intake estimates also exceed these benchmarks. Thus, dietary Pb exposure and risk levels in Cajamarca are of a magnitude similar to that existing in Europe.**

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