CAREX Nicaragua and Panama:

Worker Exposures to Carcinogenic Substances and Pesticides

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This study provides data on numbers of workers exposed at work to selected carcinogens and pesticides in Nicaragua (35 substances) and Panama (31), based on a modification of the CAREX data system. Population censuses provided industry- and sex-specific workforce numbers. The activity- and sex-specific proportions of exposed workers were estimated by experts from governmental agencies, workers' organizations, and employers' representatives. Finally, the numbers of those occupied in each activity/sex category were multiplied by the proportions of those exposed in the same categories, yielding numbers of those exposed in these categories for each agent. The study revealed high proportions (> 9%) of occupationally exposed workers in both countries for solar radiation and diesel engine emissions; environmental tobacco smoke in Panama; and some pesticides in Nicaragua. A high proportion of exposed was found for men for lead (12%), silica dust (10%), and hexavalent chromium (10%) in Panama.
Key words: CAREX, carcinogenic substances, register system, occupational exposure, developing countries, exposed workers

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INTRODUCTION

The focus of national policies and programs in chemical safety necessitates identification of the chemical hazards to which humans and the environment are exposed. Toxicity, intensity, and the extent of exposure then become some of the central issues.[1] CAREX (CARcinogen EXposure) is an international database of occupational exposures to known and suspected carcinogens that links routine workforce data with expert-based exposure assessments in categories of economic activity in order to provide estimates of the number of workers exposed to selected carcinogenic substances in various nations.

CAREX originated in the European Union countries. The European CAREX and its applications have been described in detail elsewhere.[2–5] In short, it estimates the national numbers of workers occupationally exposed to selected carcinogens by multiplying the working population sizes in 55 industrial classes by data- and expert-based proportions of exposed workers in these classes. The proportions were estimated for 85 chemical and physical agents or groups of agents in all Groups 1 and 2A occupational carcinogens International Agency for Research on Cancer (IARC), and selected agents in Group 2B, based on the IARC classification as of 1995.

The first CAREX application outside Europe was the Costa Rican modification[6–8] within the Central American Program for Work and Health (SALTRA). This application evaluated the extent of exposure to 27 carcinogens that were considered common in Central America, added seven major groups of pesticides and individual pesticides, and included sex as a further basic classifier. While the European results identified, in order of number of exposed workers, solar radiation, environmental tobacco smoke (ETS), crystalline silica, diesel exhaust, radon, and wood dust as the most common occupational carcinogenic agents during the period 1990–1993,[3] the Costa Rican data for 2000, ranked solar radiation, diesel engine exhaust, ETS, hexavalent chromium compounds, benzene, and silica dust in the order of commonality among carcinogens. Paraquat/diquat, mancozeb/maneb/zineb, and chlorothalonil were the most common occupational toxic pesticide exposures in Costa Rica.[6–8] Agriculture, construction, various services, and transport emerged as conspicuous hazardous industries in Costa Rica in terms of estimated absolute numbers of personal exposures to the 27 carcinogens and seven toxic pesticides. A further analysis of the numbers of exposures to workforce volumes revealed forestry and logging, fishing, mining, woodworking, and pottery as further hazardous industries.

This is a report on the continuation of the CAREX project in Central America in the SALTRA program, describing the CAREX applications and their results in Nicaragua and Panama.

As for a general orientation, Nicaragua is territorially the largest of the seven Central American nations,

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bordering on Honduras to the north, Costa Rica to the south, the Caribbean coast on the east with two autonomous regions, and the Pacific Coast on the west. Its population is 5.6 million. High unemployment rates have been the main reasons for a massive migration out of Nicaragua in the last decades.[9] The Nicaraguan development indicators are, in general, among the lowest in the seven Central American nations, for a great part owing to its history of political upheavals, periods of repression, civil war, corruption, and natural catastrophes. Nicaragua represents the second lowest position among the seven Central American countries in the United Nations Human Development Index, ranking 120 of 179 countries in the world. In 2005, 62% of the population lived in poverty. In 2009, Nicaragua declared having overcome illiteracy.

Panama is the southernmost of the Central American nations, situated between Costa Rica in the north and Colombia in the south. The Panama Canal cuts across the Isthmus of Panama. The population of Panama is 3.3 million, of which 66% is urban. Along with Costa Rica, the Panamanian development indicators are, in general, favorable among the Central American nations. It has the second highest United Nations Human Development Index among the seven countries in Central America, ranking 58th among all countries in the world, and has the second lowest Central American poverty rate.

DATA AND METHODS

The European and the Costa Rican CAREX methodology was applied in the Nicaraguan and Panamanian CAREXes, with modifications. The industry- and sex-specific workforce numbers that were needed for Nicaragua were those for the economically active population (EAP or supply of labor) related to 2005: a total of 2,080,899, with 1,296,626 men and 784,726 women (2005 census). The employed (including self-employed) population (92.9% of the EAP) of Panama, on which the CAREX Panama was based, totaled 960,500 for 2000 (657,659 men, 302,841 women; General Auditing Office of Republic of Panama). These numbers included both the formal and the informal workers in the two countries. Data from both formal and informal workers were based on national censuses using a standard questionnaire and should, therefore, be roughly equally valid in terms of the industry assignment (see following) between the two worker categories, which were, however, not separated in the analysis because of lack of separate data about industry-specific exposures in these categories.

The workforce numbers were categorized into 44 industries according to the International Standard Industrial Classification of All Economic Activities (ISIC) Rev. 2; these particular economic activities (industries) thereby became the units of analyses, further stratified by sex. Thirty-one agents or groups of agents (27 carcinogens and four pesticides) were chosen for both the Nicaraguan and Panamanian CAREXes, shown in Table 1. Excluded were agents that were very rare in Europe (such as benzidine) or in Costa Rica (such as methyl bromide). In addition, trichloroethylene, chlorophenoxy herbicides, and the organophosphate insecticides methamidophos and chlorpyrifos were evaluated in Nicaragua.

In line with the original European CAREX and the Costa Rican application that focused on the extent of exposures among the working populations, intensity of exposure was, by definition, not of concern, except for the definition of "exposure," which required a minimum level to be considered occupational exposure. This was considered, in line with the original European CAREX, the exceedance of the average nonoccupational background level of respiratory and/or dermal human exposure. Occupational exposure to solar radiation was considered exposure to sunlight for > 75% of the workshift.

Because very few exposure surveys and measurements have been conducted in Nicaragua and Panama, expert judgment was heavily relied on in the exposure assessment. Thus, the activity- and sex-specific proportions of exposed were modified or completely reconstructed by 25 experts in Nicaragua: the Ministry of Labor (MITRAB), the Ministry of Health (MINSA), the Ministry of Agriculture and Forestry (MAGFOR), the Ministry of Environment and Natural Resources (MARENA), the Nicaraguan Institute of Social Security (INSS), the Workers Unions Central "Jose Benito Escobar" (CST-JBE), the Sandinist Workers Central (CST), Workers' National Front (FNT), the Industrial Chamber, the Construction Chamber, the Nicaraguan Association of Hygiene and Safety Professionals (ANISHA), the National Autonomous University of Nicaragua (UNAN-Managua and UNAN-Leon), the National University of Engineering (UNI), the Agrarian National University (UNA), and 25 experts in Panama (professionals at the Ministry of Health, the Ministry of Labor and Labor Development, the National Secretariat for Science and Technology (SENACYT), the Institute for Scientific Research and Services in High Technology (INDICASAT), the Technical Board of Agriculture (CTA), the National Authority for Environment (ANAM), the System for Social Security (CSS), the University of Panama, and the Technological University of Panama).

In many cases, the Costa Rican proportions of exposed workers served as the starting default values. For pesticides in Nicaragua, experts from the Ministry of Agriculture and Forestry (MAGFOR) and the Ministry of Health (MINSA) were asked to propose a list of pesticides that should be included in the Nicaraguan CAREX. MAGFOR used WHO classifications of pesticide toxicity to propose a list of the most

TABLE 1 Carcinogens and Toxic Pesticides Selected for Exposure Assessment[6]

Agent	IARC Group	Target Organ for Cancer[6,10–13]	General Sources of Occupational Exposure (adapted from[6])
Arsenic	1	Lung, skin, urinary bladder	Outdoor work
Artificial mineral fibers, excl. ceramic	2B		Heat insulation
Asbestos	1	Lung, mesothelioma, larynx, ovary	Heat insulation, friction materials, filters, textiles, demolition, repair, shipyards
Benomyl			Mixing and spraying applications
Benzene	1	Leukemia	Solvent mixtures, gasoline, refineries, gasoline transport and distribution, chemical industry, laboratories
Cadmium	1	Lung	Electroplating, pigments, batteries, fungicides, plastics
Ceramic fibers	2B		Heat insulation
Chlorothaloni	2B		Mixing and spraying applications
Chlorophenoxy herbicides	2B		Mixing and spraying applications
Chlorpyrifos			Mixing and spraying applications
Chromium (hexavalent)	1	Lung, nose	Cement, welding, corrosion inhibition, wood preservation, dyes, tanning
Cobalt and cobalt compounds	2B		Chemical industry, glass and ceramics, steel, pigments, catalysts
Diesel engine emissions	2A	Lung	Diesel engine combustion
Environmental tobacco smoke	1	Lung	Bars, restaurants, unregulated and smoker spaces, homes
Epichlorohydrine	2A		Epoxy resin production, coating, solvent mixtures
Ethylene oxide	1	Leukemia	Instrument sterilization, epoxides, chemical industry, pesticides
Formaldehyde	1	Nasopharynx, leukemia	Particle board and plywood manufacture, textiles, lacquers, foundries, laboratories
Ionizing radiation: X, gamma, neutrons	1	Lung	Medicine, nuclear power generation, mining, air transport
Lead and inorganic lead compounds	2B		Pipes, cables, soldering, coatings, batteries, glass, paints, smelting
Mancozeb, maneb, zineb	3		Mixing and spraying applications
Methamidophos			Mixing and spraying applications
Methylene chloride (dichloromethane)	2B		Chemical industry, degreasing, paint removal, semiconductors, pesticide formulations, pharmaceutics
Nickel and nickel compounds	1	Lung, nose	Alloys, stainless steel, electroplating, arc welding, batteries, computer components
Paraquat, diquat			Mixing and spraying applications
Polyaromatic hydro-carbons, excl. ETS and diesel emissions	1–3	Lung, skin	Incomplete combustion of organic matter, tars, mineral oils, creosote
Radon and its decay products	1	Lung	Underground operations, confined spaces, mineral processing
Solar radiation	1	Skin	Outdoor work
Silica (quartz) dust	1	Lung	Mining, construction, glass manufacture, ceramics operations, founding
Strong inorganic acids containing sulfuric acid	1	Larynx, lung	Manufacture of isopropanol, ethanol, soap and detergents, phoshpate fertilizer and battery production, acid treatment of metals, laboratories
Styrene	2B		Plastic products (polystyrene, foam), boat making
Tetracloroethylene	2A		Degreasing in metal industry and dry cleaning
Triazines	3		Mixing and spraying applications
Trichloroethylene	2A		Degreasing in metal industry and dry cleaning
Vinyl chloride	1	Liver	Plastics industry
Wood dust	1	Nose, nasopharynx	Logging, sawmilling, furniture and cabinet making, construction carpentry, turning and lathing of wood products

IARC Group: International Agency for Research for Cancer classification (www.iarc.fr). 1: Carcinogenic. 2A: Probably carcinogenic. 2B: Possibly carcinogenic. 3: Not classifiable as to its carcinogenicity to humans. (Pesticides in *italics*)

TABLE 2 Percentages of Workers Occupationally Exposed to Carcinogenic Agents and Toxic Pesticides, Calculated out of the Economically Active Population. Nicaragua 2007 and Panama 2006

	Nicaragua			Panama		
Agent	Men	Women	All	Men	Women	All
Arsenic (1)	0.4	0.03	0.2	0.3	0.07	0.2
Artificial mineral fibers, excl. ceramic (2B)	0.6	0.1	0.4	1.0	0.1	0.7
Asbestos (1)	0.6	0.5	0.6	0.5	0.6	0.5
Benomyl	3.2	0.4	2.1	0.9	0.03	0.6
Benzene (1)	5.6	0.8	3.8	6.1	0.4	4.3
Cadmium (1)	0.2	0.04	0.1	0.05	0.01	0.04
Ceramic fibers (2B)	0.1	0.01	0.1	0.04	—	0.04
Chlorothalonil (2B)	6.5	0.4	4.2	0.4	—	0.3
Chlorophenoxy herbicides	1.8	0.1	1.2	ND	ND	ND
Chlorpyrifos	5.6	1.2	4	ND	ND	ND
Chromium (hexavalent) (1)	4.7	0.1	3	9.6	0.05	6.6
Cobalt and cob alt compounds (2B)	0.4	0.1	0.3	0.3	0.1	0.2
Diesel engine emissions (2A)	18.2	22.1	19.6	31.4	17.3	26.9
Environmental tobacco smoke (1)	3.9	5.9	4.7	25.2	43.9	31.1
Epichlorohydrine (2A)	0.2	0.1	0.1	0.01	0.04	0.02
Ethylene oxide (1)	0.4	0.1	0.3	0.1	0.2	0.2
Formaldehyde (1)	1	1	1	0.4	0.4	0.4
Ionizing radiation: X, gamma, neutrons (1)	0.1	0.1	0.1	0.5	0.5	0.5
Lead and inorganic lead compounds (2B)	0.5	1.7	1	12.4	2.5	9.3
Mancozeb, maneb, zineb (3)	8.4	0.4	5.4	3	0.2	2.2
Methamidophos	14.9	3	10.4	ND	ND	ND
Methylene chloride (dichloromethane)(2B)	0.5	0.6	0.5	1	0.7	0.9
Nickel and nickel compounds (1)	0.1	0.1	0.1	0.2	0.05	0.2
Paraquat, diquat	18.4	0.1	11.5	5.1	0.2	3.6
Polyaromatic hydrocarbons, excl. ETS and diesel emissions (1–3)	0.8	1.2	0.9	1	0.3	0.7
Radon (1)	0.8	1.1	0.9	—	—	—
Solar radiation (1)	42.9	8.2	29.8	43.5	16.7	35.1
Silica (quartz) dust (1)	2.3	0.3	1.5	9.9	0.1	6.9
Strong inorganic acids containing sulfuric acid (1)	0.4	0.1	0.3	0.6	0.9	0.7
Styrene (2B)	0.1	0.1	0.1	0.1	0.1	0.1
Tetracloroethylene (2A)	0.3	0.7	0.5	0.6	0.9	0.7
Triazines (3)	1	0.01	0.6	2.8	—	1.9
Trichloroethylene (2A)	0.1	0.3	0.2	ND	ND	ND
Vinyl chloride (1)	0.1	0.1	0.1	0.01	—	0.01
Wood dust (1)	3.4	0.3	2.3	3.2	0.4	2.3

ETS: Environmental tobacco smoke. ND: No data; —; very low or zero prevalence of exposed; pesticides in italics

hazardous pesticides among those authorized for import. MINSA presented a list of the pesticides most frequently involved in poisonings. Then both lists were compared to the TICAREX's list of pesticides. All pesticides were in the TICAREX except methamidophos and chlorpyrifos, which were added due to their high frequency of use in Nicaragua. In Panama, a group of agronomists estimated the cultivated land areas and frequencies of pesticide application in these, using the sex-specific population figures in agriculture to estimate the frequencies of those exposed on the basis of the average number of persons in agriculture per sprayed land area.

Finally, numbers from each activity/sex category were multiplied by the proportions of exposed in the same categories, yielding numbers of exposed in these categories for each agent. Adding the numbers of those exposed and dividing the sums by the workforce numbers yielded the total proportions of those exposed for each agent.

Table 1 shows the agents included in the study, their carcinogenicity classification according to the International Agency for Research on Cancer (IARC; www/iarc.fr), and general sources of occupational exposure for each.

RESULTS

Table 2 shows the exposure rates by agent, country, and sex. Among men, the most common carcinogenic agents (prevalence > 3%) were similar in both countries, though the prevalence order of the agents varied somewhat. These agents in Nicaragua and Panama were solar radiation (43%, 44%, respectively), diesel engine emissions (18%, 31%, respectively), environmental tobacco smoke (4%, 25%, respectively), ben-

TABLE 3 Common Agents (Prevalence > 10% in Either Sex) in Selected Industries

Industry	Country	Labor Force Men 10^3	Labor Force Women 10^3	Labor Force All 10^3	% Exposed (Men + Women)
Agriculture	NIC	513.7	63.6	577.3	Solar radiation 79; paraquat 59; mancozeb 10; benzene 9; chlorothalonil 8
	PAN	184.6	10.3	194.9	Solar radiation 72; paraquat 18; mancozeb 10; benzene 10; triazines 9
Fishing	NIC	12.2	0.9	13.1	Solar radiation 81, benzene 33, diesel emissions 24
	PAN	11.8	0.7	12.5	Solar 72; diesel emissions 24; benzene 20
Mining	NIC	4.1	1.2	5.3	Silica dust 40; diesel emissions 32; solar radiation 19; radon 13; nickel 9
	PAN	1.7	-	1.7	Solar radiation 64; chromium VI 27; silica dust 22
Woodwork	NIC	33.4	1.6	35	Wood dust 71; formaldehyde 12
	PAN	23.3	2.1	24.4	Wood dust 56
Construction	NIC	90.9	1.7	92.6	Chromium VI 64; solar radiation 60; silica dust 26; diesel emissions 13
	PAN	86.8	3.4	90.2	Solar radiation 73; chromium VI 68; silica dust 68; lead 48; wood dust 10
Transport	NIC	68	2.9	70.9	Diesel emissions 66; solar radiation 15
	PAN	45.1	4	49.1	Diesel emissions 81; lead 37; benzene 35; ETS 33; solar radiation 22
Sales & repair	NIC	ND	ND	ND	ND
	PAN	78.8	45.9	124.7	ETS 95; diesel emissions 50; lead 20
Private domestic services	NIC	18,4	100.3	118.7	Solar radiation 20; diesel emissions 18; lead 12; ETS 11
	PAN	6.3	58.3	64.6	ETS 40; solar radiation 17

ETS: Environmental tobacco smoke. ND: No data.

zene (6%, 6%, respectively), hexavalent chromium (5%, 10%, respectively), silica dust (2%, 10%, respectively), and wood dust (3%, 3%, respectively). Lead was less common among men in Nicaragua (0.5%) than in Panama (12%). Men had markedly higher carcinogenic exposure rates than women for solar radiation, silica dust, benzene, hexavalent chromium, and wood dust in both countries, and for diesel engine emissions and lead in Panama only.

Men had substantially higher exposure rates for pesticides. High male rates were encountered especially in Nicaragua for paraquat (18% Nicaragua, 5% Panama), methamidophos (15% Nicaragua, not assessed in Panama), mancozeb (8% Nicaragua, 3% Panama), chlorothalonil (6% Nicaragua, 0.4% Panama), chlorpyrifos (6% Nicaragua, not assessed in Panama), and benomyl (3% Nicaragua, 0.9% Panama). The workers exposed to pesticides in agriculture were predominantly men. Women's exposure rates were lower than men's for most carcinogenic agents and all the pesticides. The most common women's exposure rates were found for environmental tobacco smoke, with a marked difference between the countries (6% Nicaraguan, 44% Panama), diesel engine emissions (22% Nicaragua, 17% Panama), and solar radiation (8% Nicaragua, 17% Panama). Women had higher exposure rates than men had particularly for ETS and tetrachloroethylene in both countries; diesel engine emissions, lead, and PAHs in Nicaragua; and for strong inorganic acids containing sulfuric acid in Panama.

DISCUSSION

This study revealed high (> 9%) proportions of occupationally exposed workers in both Nicaragua and Panama for solar radiation and diesel engine emissions, and for ETS in Panama. High rates were also found for the pesticides paraquat/diquat and metamidophos in Nicaragua. Considering men only, a high proportion of those exposed was found also for lead (12%), silica dust (10%), and hexavalent chromium (9.6%) in Panama.

It may be worthwhile to compare the Nicaraguan and Panamanian results with those of the European Union and Costa Rica, though the EU data are from 1990–1993, covering the then 15-member states, and the Costa Rican data were from 2000. In general, the EU proportions of exposed are on roughly the same level with Nicaragua and Panama, except that they are lower in the EU for benzene, hexavalent chromium, and diesel engine emissions (likely because of stricter regulations), and for solar radiation (for less frequent outdoor jobs).

The Costa Rican proportions are closer to the Nicaraguan and Panamanian ones but are lower for solar radiation and, for the pesticides, higher for paraquat, especially when compared with Panama. Notable exceptions were found between Costa Rica and Panama in solar radiation (prevalence 25% Costa Rica, 36% Panama), environmental tobacco smoke (6% Costa Rica, 31% Panama), lead (2% Costa Rica, 9% Panama), silica dust (2% Costa Rica, 7% Panama), paraquat (13% Costa Rica, 4% Panama) and chlorothalonil (3% Costa Rica, 0.3% Panama). Most of the differences may be explained by the proportion of workers in each industrial activity between countries. For instance, differences in solar radiation exposure between Costa Rica and Panama could be related to less outdoor work in Costa Rica. Indeed, in Panama the proportion of workers in agriculture and construction were 20% and 9%, respectively, while in Costa Rica the proportions were 12% and 8%, respectively. The profiles were more similar between Nicaragua and Costa Rica.

Comparing Nicaragua and Panama, the outstanding differences included the much higher proportions of exposed men and women for ETS and lead in Panama; a higher silica exposure rate in Panama among men; and the overall higher exposure rates of pesticides in Nicaragua. As there were and are extensive building construction and canal extension projects ongoing in Panama (the proportion of the workforce in construction was 9% in Panama, and 4% Nicaragua, in the present data), the silica and lead exposures were common, compared with Nicaragua.

The higher proportion of workers in agriculture in Nicaragua (28%), compared with Panama (20%), explains part of the extensive exposures to pesticides in Nicaragua but probably also because of higher use of pesticides per cultivated land unit in Nicaragua.[14,15]

Exposure to silica dust is a matter of particular interest, as a worldwide eradication program of silicosis is in progress,[16] meaning reduction of occupational exposure that occurs particularly in mining, construction, glass manufacturing, ceramics operations, and founding. The available Latin American estimates of proportion of workers occupationally exposed to silica dust are 5.4% for Chile[17] and 5.6% for Brazil,[18] 2.1% for Costa Rica (possibly an underestimate),[6] 1.5% for Nicaragua, and 7% for Panama from this study. In all these countries, the data will be used for targeting the exposure reduction measures in particular industries and jobs.

Intercountry differences reflect differences in the industrial activity compositions of the labor force and in the exposures within activities between countries, such as different pesticide use patterns, regulation, and enforcement. Some of the differences may also be due to regulations (such as the restriction of smoking tobacco in public places, or regulation of the use of chemicals in occupational settings in some European countries), or differences in processes (such as the common use in Latin America of gas station attendants who are exposed to benzene in gasoline and diesel exhaust from passing traffic, or the emission controls of diesel-driven vehicles in Europe). For instance, the intercountry differences for ETS between Nicaragua and Panama may be explained by the compositions of the labor force in the tourist industry, and the differences in the exposure assessment procedures, where standardization between countries is seldom perfect. A three-country (Nicaragua-Panama-Costa Rica) workshop was held before the exposure assessment, two years prior to the assessment procedure itself, which relied more on the standardization of procedures within the national assessment teams.

The differences between men's and women's exposure patterns are explained by the different industry and job distributions between men and women. Thus, women very seldom do pesticide spraying, and consequently, have much lower exposure rates to these substances. ETS was somewhat similar to women's exposures, due to service jobs where customers smoke. The higher rate for tetrachloroethylene in women is probably due to the fact that women are employed in the dry cleaning industry more often than men.

As for the validity of the present study, the industrial classification used (44 categories) certainly resulted in insensitivity, especially within the manufacturing industries, as a number of subcategories with different exposure profiles were collapsed. An unknown degree of uncertainty in the exposure assessment is also evident, given the scanty direct or even indirect data on many industry-specific exposures, a matter with much better possibilities in a country such as Finland with a long tradition of industrial hygiene measurements. Still, an extensive scope of data sources and knowledgeable persons were in the exposure assessment in both countries, along with the supposedly roughly comparable Costa Rican industry-specific data, which would guarantee a reasonable, though not perfect, validity of the exposure assessments.

We did not calculate total national numbers of exposed persons to all exposures pooled, as these numbers would depend, first, on the agents included, and second, on the numbers of persons with multiple exposures. The number of multiple exposures depends practically on the combinations of the 44 agents assessed; the number of the possible combinations in the present set of 44 agents assessed for both countries running in huge numbers. We do not know the numbers of multiple exposed persons for any combination of agents. For a related bit of information, the original European CAREX estimated an average of 1.3 exposures (agents) for each exposed worker within a set of 86 agents, with a very wide range of frequency of exposure between the different agents.[2]

In its original form and in the Central American applications this far, CAREX does not differentiate between levels of exposure except for the minimum definitional level of exposure. Similarly, the Chilean and Brazilian developments for silica exposure assessment consider classes of exposure frequency (rather than intensity). Along with developments elsewhere, these specifications may be feasible also in Central America in the future. We hope this work is going to be used by the regulators and stakeholders in both countries to prioritize interventions to reduce the number of exposed workers and policies to control the substances used in occupational settings. As a matter of fact, in Nicaragua as a consequence of the results on silica, the National Council on Occupational Safety and Hygiene created a commission to propose a normative to limit workers' exposure to silica. We are working on the institutionalization of the matrix, so its periodical evaluation might be continued. Nevertheless, the started collaboration between academy and regulators must keep going on, so an integrated multidisciplinary approach to this and other problems can be developed.

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