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Potential Impact of Occupational and Environmental Cancer Risks in Nigeria

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Abstract

Throughout their life people are exposed to a wide range of environmental and occupational pollutants from different sources in the work place, at home and in the general environment. Several chemicals, metals, dusts, fibres, and occupations have been established to be causally linked to an increased risk of cancer. Air pollution, from outdoor (mainly industrial and traffic related) and indoor (heating and cooking) sources, has been identified as a significant contributor to the environmental cancer burden. The annual global burden of occupational cancer deaths is estimated to be between 300,000 to 600,000. This estimate has large uncertainty as, firstly, for many established carcinogens the dose-response relationship is not well described, secondly, exposure prevalence is unknown in many settings, and, thirdly, there are plausible hypotheses for further environmental carcinogens for which causation has not been established. With an estimated 102,000 new cancer cases in 2012, Nigeria has a substantially lower cancer burden which is about three times lower compared to high income countries. However, this is most likely underestimating the true cancer burden, as not all patients are seen in medical treatment centres. Lung cancer incidence is particularly low in Nigeria. Many carcinogenic risks in the workplace, at home or in the general environment are modifiable and the cancers therefore preventable. Given the long induction period of many cancers, successful primary prevention shows its benefit mainly in the long run. Nevertheless, primary prevention has to be implemented as early as possible, to reverse increasing trends in cancer occurrence. Cancer control plans including environmental and workers protection are therefore urgently needed for Nigeria.

Introduction

Cancer is an emerging public health challenge in Africa. This is because of the growth of the population, the increasing life expectancy, the traditionally high burden of infectious-related cancers in Africa; and the increasing prevalence of cancer risk factors related to lifestyle and behaviour typical in higher income countries such as cigarette smoking, obesity, low physical activity, and unhealthy diet (Jemal *et al.,* 2012). For 2012, the cancer burden for Africa was estimated to be 1.234 million newly diagnosed cases and

899,000 deaths attributable to cancer (Ferlay *et al.,* 2015).This is presently the lowest cancer burden across all continents; for instance compared to 3.156 million newly diagnosed cancer cases in North America. However, it is expected the cancer burden in Africa will double within the next 20 years. Tragically, cancer survival remains poor in Africa, illustrated by the fact that the ratio between incidence and mortality is only 1.4 in Africa compared to 3.0 in North America (Torre *et al.,* 2015).

In Africa, several cancers are attributable to infections such as Human Papilloma Virus - HPV (cervical cancer), Hepatitis B (liver cancer), Hepatitis C (liver cancer and lymphomas), Epstein Barr Virus - EBV (lymphomas), HIV (Kaposi sarcoma and lymphomas), and Helicobacter pylori (stomach cancer). Aflatoxins, which are chemicals produced by certain moulds (liver cancer), and Schistosoma, a parasitic flatworm (bladder cancer), also contribute to the cancer burden (Sylla and Wild, 2012). Worldwide, tobacco use, and in particular cigarette smoking, is the single largest preventable cause of cancer. Cancer risk in former smokers decreases progressively with increasing time after smoking, showing beneficial effects on the lung cancer risk already after 5 years since cessation (IARC, 2007). In addition to increasing use of cigarettes, economic advancement often comes with even more known cancer hazards, particularly related to obesity, physical inactivity, and unhealthy diet (WCRF, 2013). In the UK in 2010 it was estimated that diet accounted for 9.2%, overweight and obesity for 5.5%, and physical inactivity for 1.0% of all incident cancers (Parkin *et al.,* 2011). Alcohol consumption is another major preventable contributor to cancer (IARC, 2012).

Hence, with regard to prevention, vaccination programmes against Hepatitis B and HPV would dramatically reduce the burden of two very common cancers in Africa (Sylla and Wild, 2012), and practical primary prevention strategies such as pre-harvest mycotoxin control and post-harvest proper storage to reduce aflatoxin exposure exist to reduce the liver cancer burden (Wild and Gong, 2010). Tobacco prevention is an important feature in cancer control and must be implemented also in countries with presently lower prevalence, to avoid an epidemic rather than attempting to reverse a trend once the epidemic has appeared. The European Code against Cancer is a set of 12 recommendations how individuals can reduce their or their children's cancer risk and illustrates which major cancer risk factors come with economic growth if prevention is not implemented as early as possible (Schüz *et al.,* 2015).

Despite being highly relevant, exposures to pollutants in the workplace, at home or in the general environment contributing to the cancer burden in Africa have not received a lot of attention, as reviewed by McCormack and Schüz (McCormack and Schüz, 2011).

Examples of major economic sectors with potential carcinogenic exposures are mining, agriculture, construction, textile industry, waste management, and petrochemical industry. While high levels of exposure are expected in the work place, many industries lead also to environmental pollution in the general environment or at home, for instance through drifts from agriculture or mine tailings. Indoor and outdoor air pollution may occur at home, in the general environment or in the work place. Air pollution has recently been established as a human carcinogen (IARC, 2015).

Cancer related to pollutants in the work place, at home or in the general environment.

Cancer Burden in Nigeria

For Nigeria in 2012, the International Agency for Research on Cancer (IARC) in their GLOBOCAN 2012 database estimated about 37,400 new cancer cases in men and 64,700 new cancer cases in women (GLOBOCAN, 2012). Figure 1 shows the ten most frequent cancers in Nigeria. Among men, about half are cancers of the prostate and of the liver, followed by colorectal cancer and non-Hodgkin lymphoma. Lung cancer, one of the commonest cancers worldwide and the one most commonly related to occupations, was only 1.2% of male cancers

with the absolute number estimated to be lower than 500; this is even slightly less than bladder cancer, another cancer observed in relation to some occupations. Overall, the estimated crude incidence of cancer in men was 44.3 per 100,000, and 79 per 100,000 age-adjusted to the World Standard Population; in comparison, the age-adjusted incidence rate in the USA was 347/100,000 men (i.e. more than 4 times higher) in 2012. The lung cancer rate in the US was about 40 times higher than in Nigeria. Among women, breast cancer was 42% of all cancers in women and cervical cancer 21% together explaining almost 2 out of 3 cancers in Nigerian women. Lung cancer was also rare in women (estimated to be just slightly over 500 cases and thereby representing 0.8% of all cancers in women). Overall, the crude incidence rate was 78.7 per 100,000 women and the age-adjusted incidence rate 121.7 per 100,000 women, compared to an age-adjusted incidence rate of 297.4 per 100,000 women in the USA. Lung cancer is about 30 times more common in US women compared to Nigerian women.

These figures however have to be interpreted with caution. The estimates stem from average rates from three regional cancer registries from Abuja (2009-2012), Calabar (2009-2011), and Ibadan (2006-2009) applied to the 2012 national population (GLOBOCAN 2012). Not only that those registries cover only part of the Nigerian population, they are mainly based on which patients reach the tertiary medical centres for diagnostics and/or treatment. Patients with cancer who do not reach those centres could not be counted. One reason is because of dying early; if untreated, many cancers are rapidly leading to death. Another reasons is that patients are not going to such medical centres because they cannot afford diagnostic examinations or treatment (or even the travel to the treatment center). Distrusting the medical services is another possible reason for not going to the treatment centers or going when it is too late to treat the cancer. It is therefore believed that current cancer counts are underestimates of the true cancer burden, but to what extent is not known, and it most likely differs by cancer site.

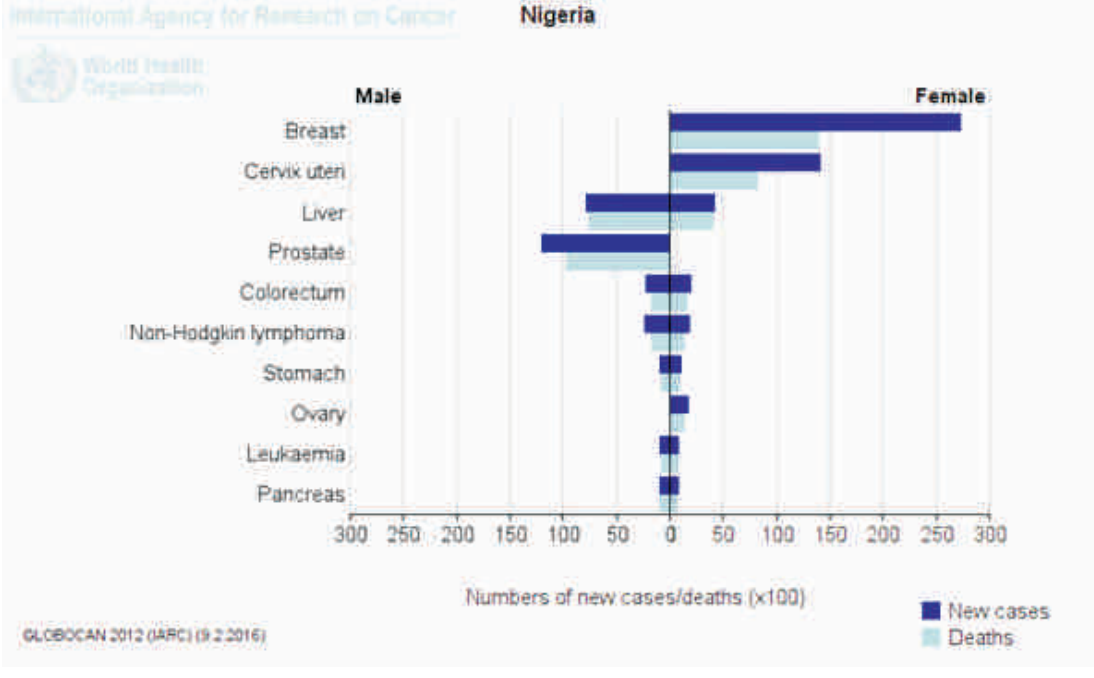

Figure 1: Ten most common cancers estimated in 2012 in Nigeria, in absolute number of newly diagnosed cases and number of deaths; estimates based on three regional cancer registries from Abuja (2009-2012), Calabar (2009-2011), and Ibadan (2006-2009) applied to the 2012 national population (GLOBOCAN 2012).

Lung cancer may be particularly underestimated given that several early symptoms such as coughing are also symptoms of the much more common infectious diseases, especially tuberculosis or malaria.

Cancer Risk Factors in the Work Place or in The General Environment

People are exposed throughout life to a wide range of environmental and occupational pollutants from different sources at home, in the

Table 2: Selected Agents Classified as Carcinogenic to Humans (Group 1) by the IARC Monographs, Volumes 1–109

Substance	IARC Monographs volume/s*:	Latest Publication Year
Aflatoxins	56, 82, 100F, Sup 7	2012
Alcoholic beverages	44, 96, 100E	2012
Aluminium production	34, Sup 7, 92, 100F	2012
Aristolochic acid	82, 100A	2012
Aristolochic acid, plants containing	82, 100A	2012
Arsenic and inorganic arsenic compounds	23, Sup 7, 100C	2012
Asbestos (all forms)	14, Sup 7, 100C	2012
Auramine production	Sup 7, 99, 100F	2012
Benzene	29, Sup 7. 100F	2012
Benzidine	29, Sup 7, 99, 100F	2012
Benzo[a]pyrene	Sup 7, 92, 100F	2012
Beryllium and beryllium compounds	Sup 7, 58, 100C	2012
Betel quid with and without tobacco	Sup 7, 85, 100E	2012
Cadmium and cadmium compounds	58, 100C	2012
Chromium (VI) compounds	Sup 7, 49, 100C	2012
Coal gasification	Sup 7, 92, 100F	2012
Coal, indoor emissions from household combustion	95, 100E	2012
Coal-tar distillation	92, 100F	2012
Coal-tar pitch	35, Sup 7, 100F	2012
Coke production	Sup 7, 92, 100F	2012
Engine exhaust, diesel	46, 105	2013
Formaldehyde	Sup 7, 62, 88, 100F	2012
Haematite mining (underground)	1, Sup 7, 100D	2012
Ionizing radiation (all types)	100D	2012
Iron and steel founding (occupational exposure)	34, Sup 7, 100F	2012
Isopropyl alcohol manufacture using strong acids	Sup 7, 100F	2012
Leather dust	100C	2012
Mineral oils, untreated or mildly treated	33, Sup 7, 100F	2012
Nickel compounds	Sup 7, 49, 100C	2012
Outdoor air pollution	109	In prep.
Outdoor air pollution, particulate matter in	109	In prep.
Painter (occupational exposure as a)	47, 98, 100F	2012
Polychlorinated biphenyls (PCBs 77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169, 189)	107	In prep.
Processed meat (consumption of)	114	In prep.
Rubber manufacturing industry	28, Sup 7, 100F	2012
Silica dust, crystalline, in the form of quartz or cristobalite	Sup 7, 68, 100C	2012
Solar radiation	55, 100D	2012
Tobacco smoke, second-hand, and smokeless	83, 100E	2012
Vinyl chloride	Sup 7, 97, 100F	2012
Wood dust	62, 100C	2012

* Soon to be added: Lindane, volume 113, in preparation

workplace or in the general environment; exposures that normally cannot be directly controlled by the individual. Several chemicals, metals, dusts, fibres, and occupations have been established to be causally associated with an increased risk of specific cancers, in particular cancers of the lung, skin and urinary bladder, and mesothelioma (Espina *et al.*, 2015). The IARC Monograph Program evaluates agents according their carcinogenicity to humans (Cogliano *et al.,* 2011). The Table shows common agents classified as carcinogenic to humans, updated from a previous publication (Cogliano *et al.,* 2011) and selected by the authors with an expectation of having some relevance for Nigeria and in general the Sub-Saharan African setting (including based on the review by McCormack and Schüz, 2011).

Globally, it is estimated that annually around half a million cancers are caused by work-related exposures; the Institute of Health Metrics (IHME) estimated 304,000 by selected carcinogens and the International Labour Organisation estimated a total of 666,000 work-related cancers (Murray *et al.,* 2012; Nenonen *et al.,* 2014; Forounzafar *et al.,* 2015), with 50-75% of them due to lung cancer alone. For the UK, asbestos is the main cause of occupationally related cancers, with mineral oils, silica, diesel exhaust, polycyclic aromatic hydrocarbons (PAH), paints and dioxins playing some but lesser role than asbestos (Rushton *et al.,* 2012). Notably, a proportion of work-related cancers were also not due to work place chemicals but natural environmental factors or behaviours of other people at the workplace, for instance cancers due to solar radiation in outdoor workers, to naturally occurring radon, or to environmental tobacco smoke. For the US several estimations of occupationally related cancers were reported, recently reviewed by Purdue *et al.* (2015), suggesting the estimated occupation-attributable fraction for total cancer ranges between 2% and 8% (men, 3%-14%; women, 1%-2%). For Nigeria or other Sub-Saharan African countries, a quantification is at present almost impossible to make, due to lack of underlying reliable data. This does not only relate to exposure levels but also different magnitudes in risk, that could be influenced by starting to work at an early age, more direct contact with carcinogens, lack of protection equipment, and synergistic effects through different mixed exposures to carcinogens (McCormack and Schüz, 2011). In relation to environmental exposures, air pollution is certainly an exposure of high concern in Nigeria, both related to common indoor fuel combustion when cooking and heating but also outdoors from industry and traffic, as demonstrated by air pollution measurement series (Ana *et al.,* 2012).

Exposures to environmental and occupational carcinogens canbe reduced or eliminated, and the cancers resulting from these exposures can be prevented through policies promoting healthy working and living environments (Pruss-Ustun and Corvalan, 2007; Espina *et al.,* 2013). As thoroughly discussed by Espina et al., there are many successful examples of population-based policies and legislative tools to reduce environmental and occupational risks related to cancer (Espina *et al.,* 2013). At the workplace these include regulations for substitutions of carcinogenic substances in the workplace, provision of worker protection equipment, regulation via threshold limit values, safe storage and disposal of hazardous waste, or offering incentives to companies encouraging elimination of harmful agents. Individual-based interventions to prevent environmental exposures include avoiding open burning of organic matters, ensuring ventilation or reduce indoor burning of fuel, proper disposal of hazardous substances (especially in the case of asbestos), and raising public awareness on healthier environment.

Challenges related to environmental and occupational cancers

With 30-50% of causes of cancer being identified, this leaves another major proportion of cancers for which the causes are unknown, hence leaving the opportunity open to identify yet undetected environmental carcinogens (Schüz *et al.,* 2015).

When exposure is ubiquitous at similar levels it is difficult to identify increased risks in observational studies. For many environmental factors it remains unclear if and what magnitude of risk they pose at low environmental levels.

This is even true for some well-established carcinogens such as ionising radiation, where it was just recently confirmed in studies of nuclear power workers that there were no safe levels of radiation and the risk increases, albeit very small in magnitude, at cumulative exposures below 100 mSv (Leuraud *et al.,* 2015). Often epidemiological studies apply rather simplifications in exposure modelling as not all pathways are known or can be adequately assessed. Discussing potential exposure scenarios of environmental uranium contamination in the West Rand area of Gauteng, South Africa, inhalation of contaminated dust, ingestion of contaminated soil through geophagia, and ingestion of contaminated drinking water, as well as routes through the food chain due to inhalation and ingestion of uranium by cattle, illustrates the complexity of modelling cumulative exposure (Schonfeld *et al.,* 2014a). In addition, cancer is multi-causal, and quantifying the effect of one carcinogen requires disentangling it from the effects of other carcinogens. Figure 2 shows results from an international lung cancer consortium looking at lung cancer in certain occupations with taking the smoking history of people into account. As it can be seen, some occupations show an increased lung cancer risk after adjustment for smoking while in others, for example hairdressers, the higher lung cancer risk in this occupation can be attributed to the hairdressers' smoking behaviour (Olsson *et al.,* 2013).

Synergistic effects between carcinogens are also possible, as observed in the case of radon and smoking.

Even when the risk is scientifically established, there are additional obstacles for immediate successful prevention. For cancer, with its long induction periods, the benefits of primary prevention become often only obvious in the long run. It took decades that the growing evidence of asbestos causing lung disease was translated into worker protection and finally banning of asbestos in some, but not all, countries. But even where it was banned the asbestos-related cancer burden continues to rise; for instance in Germany, where it was banned in the early 1990s, mesothelioma

Figure 2:. Relative risks of lung cancer in various occupations adjusted for lifetime smoking; occupationally related increased lung cancer risks remain among bricklayers, painters, miners, and welders, while the increased lung cancer incidence among cooks and hairdressers is most likely explained by their smoking; no increased risk was seen in bakers

mortality is predicted to rise until 2020 when the peak burden is finally reached and mortality rates will start to decline (Schonfeld *et al.,* 2014b). Hence, the reversal of the trend occurs more than 30 years after the implementation of the prevention measure. It is therefore a challenge to convince all stakeholders to commit to the implementation of prevention that may require investments in the beginning but the pay back occurring several decades later.

Conclusion

Although the presently registered cancer burden is seemingly lower in Nigeria and many other countries in Sub-Saharan Africa compared to high income countries, it is most likely already an underestimation of the real cancer occurrence especially as not all affected patients reach respective medical centers and also because registration is likely to be incomplete. But more importantly, the cancer burden is expected to increase dramatically due to the increase in life expectancy, improved survival from other fatal diseases, and change in risk factor profile, in particular the expected rise in prevalence of many behaviours typically related to economic growth that are also known to cause cancer. With the lack of systematic early detection programs and lack of affordable treatment, survival from cancer in Sub-Saharan Africa is poor and many of those diagnosed with cancer will eventually die from it. This puts primary prevention in the focus, as many cancers are preventable if scientific knowledge is appropriately and rigorously implemented at the earliest possible time. Major primary prevention efforts include tobacco and alcohol control, promotion of healthy diet and physical activity, organised vaccination programmes, and reduction of mycotoxin exposure.

Most occupational and many environmental exposures can be avoided or reduced and therefore must be part of any cancer control plan. Investment in healthy workplaces is not only beneficial in terms of reduction of morbidity but also for the productivity by healthy workers and progressing economic growth, often overlooked when worker protection is short-sightedly considered as costly and slowing down progress. Air pollution, both outdoor and indoor, is a major issue in Nigeria and preventive measures need to be undertaken.

Most importantly, the implementation of cancer prevention needs to be started before the increased burden emerges, as due to the slow development of the disease cancers occurring today have been initiated long ago in the past, and those initiated today will occur mostly in several decades ahead. This is why strong political commitment and visionary thinking is needed as successes in cancer control will mostly become obvious only in the long run. A cancer control plan for Nigeria that includes cancer prevention in the work place, at home and in the general environment must be developed now and implemented as quickly as possible.

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