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Good Practice Guide

Health and the environment

writing and editing

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- A Legal/Medical tool aimed at protecting both the public and the medical professional.

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1 Introduction

Sustainability is changing our society, which raises the question of whether the Health Sciences are also changing? And if they are, in what way? Or perhaps it would be better to ask how healthcare and sustainability should interact in order to define a future model of society. Our current behavior produces dangerous contradictions, as changes aiming to improve the sustainability are causing health issues.

Let us look at some examples of how sustainability is changing our current model of society. The type of vehicles on our streets have changed, with a gradual reduction in carbon dioxide (one cause of climate change) emissions, no lead emissions, more energy efficient and hybrid models with some even being fully electric or hydrogen-fuelled. The most sold taxi vehicle this year was a hybrid model... New buildings are more energy efficient, use renewable energy, avail of local climate characteristics, have green areas, do not use toxic materials... Even the new economic model that could rescue us from the crisis is the green economy, with its variants of the "New Industrial Revolution" called for by William McDonough, the "Blue Economy" by Gunter Pauli or the "Natural Capitalism" by Paul Hawken...

In this context, would it not, therefore, be logical to think that the Health Sciences are also undergoing change? Of course it would, and this paper goes to show that. We wish to analyze the impact of environmental factors (indoor and outdoor air quality, electromagnetic radiation, noise, new biological agents) on our health. We will look at how we can prevent diseases by controlling this type of pollution, and how to treat the diseases caused.

But there is another more important issue here: the lack of integration between healthcare and sustainability in creating this new society. The sustainability of our modern society is being studied in the context of climate change, desertification, ecologic biodiversity loss, and so forth, but health issues are only scarcely touched. This is a huge mistake and I will mention just two examples to illustrate this. Regulations now ensure that new vehicles emit far less carbon dioxide to prevent climate change, but they emit more nitrogen oxides which is currently the most hazardous pollutant for health in urban areas. So where were the health criteria when these new regulations were established? Another example is that we now wish to use photocatalytic materials in construction to combat nitrogen oxide pollution, but in ammonia-rich atmospheres like many cities, these materials increase the presence of fine ammonium nitrate particles, equally damaging to health if not used correctly.

Therefore, it would appear that our approach must be to prevent and treat diseases of environmental origin, while at the same time participating in discussions on future sustainable criteria to provide health strategies and regulations relating to the environment and, ultimately, the future of our society.

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2 Aim of this *Good Practice Guide*

We wish to reveal the invisible epidemic produced by the effect of environmental pollution on our health.

As the authors of *Nuestra Contaminación Interna*[1] (Our Internal Pollution) say "medical and health science professionals have a moral obligation and the clinical opportunity to make visible and help control a process that is too often excessively invisible: the causal connection between some serious diseases and certain chemicals agents in the environment".

We would like this publication to be viewed as a tool to raise awareness and provide knowledge and a good practice guide for doctors, especially clinicians who devote their practice to caring for people, so they can respond with scientific evidence (if it exists) to problems and questions from their patients and to guide their research or training tasks.

3 The environment as a determinant of health

For many, health is still seen as the absence of disease, and this concept is directly related to the healthcare system. This encourages the growing medicalization of everyday life, and causes us to overlook the role played by economic, social and environmental aspects in health.

Nonetheless, public health professionals have known for many years that the determinants of health are many and varied, and providing a healthcare system can only address a very small part of the effects of these determinants. There are other more important elements than the healthcare system for health including: socio-economic conditions (income, education, housing, etc.), life-styles (diet, physical activity, dependencies) and the environmental conditions in which we live and work (water quality, sanitation, waste, pollution, work environment, social and political relations, gender inequality, etc.).

This paradigm of health became widespread in 1974 when Marc Lalonde, Minister of Health in Canada presented to the Canadian Parliament his famous report, known as the Lalonde Report , in which he stated that the determinants of health could be grouped into four areas:

- Human biology (inheritance, genetics, sex, age)
- Life-styles
- Environmental conditionals
- Healthcare system

One of the limitations of the model proposed in the Lalonde Report is that the relationship between the more general factors (such as the general social, economic, environmental and cultural conditions) may have with other determinants (health services, the work environment, housing, social networks or lifestyle) is not taken into consideration. In this model, determinants are structured hierarchically showing how they are inter-related (Segura Benedito A, 2010)[3] (Acheson D, 1998)[4] and is represented graphically with a proposal by Dahlgren and Whitehead **(Figure 1)**.

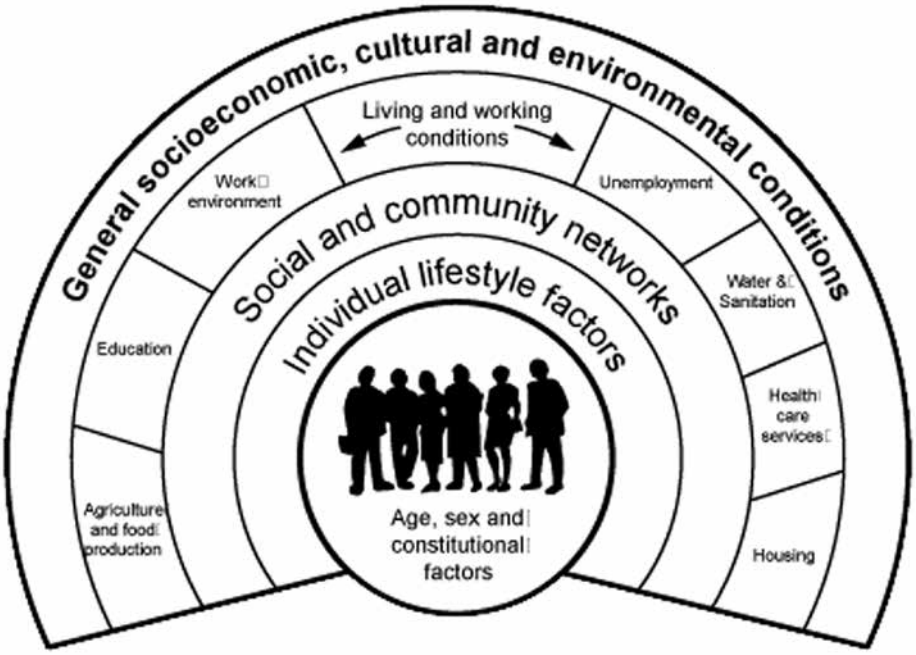

Figure 1. Model of main health determinants and how they are inter-related by Dahlgren and Whitehead. Taken from Acheson D, 1998.

In Catalonia, the Public Health Agency in Barcelona has being using the health determinant model[5] of the WHO/Europe for a number of years in its annual reports *(La Salut a Barcelona)*. More recently, the WHO[6] established a working commission on social health determinants. After an arduous process, this report was finally presented at the 62nd World Health Assembly in May 2009 and a number of recommendations were issued for member states, in particular regarding working towards policies in a transversal manner to improve equity and social determinants of health.

It is evident that the environment is an increasingly important determinant for health at present and in future generations. The relationship between the environment and health is very complex, because the quality of air, water, food, radiation, the urban environment, housing and the work environment can affect human health in many ways, and especially in the most vulnerable population groups, such as the unborn child, infants and children, women, chronic patients, the elderly and the most disadvantaged social groups.

Ambitious strategic goals must be established with clear indicators that can be evaluated and prevention policies must be implemented if we wish to safeguard public health in terms of environmental issues.

3.1. Necessary and urgent training of health professionals and citizen involvement

But we can hardly expect political leaders who represent community interests, or Public Administration employees to implement strategies and prevention programs on environmental health risks, if we as health professionals in public or private care are not aware of this invisible epidemic or the need for preventive action and public education.

To make up for lost time, Health Science courses at university must teach this subject (the European Parliament calls it Environmental Medicine) and provide continuous education for professionals, with special emphasis on those working in primary care and community health.

As concluded in the CAPS 2010 report[7] "information, citizen participation and involvement in decisions about environmental sustainability and health are essential. We must fully embrace the culture of public consultation and public debate even before the approval of plans and projects or the implementation of measures which affect the environmental or health by the Public Administrations or private companies".

"In researching environmental health issues, citizens should be asked about the issues that concern them, or which they think should be prioritized for research. This can be done by consulting with interested citizens and organizations or even via public surveys as has been done in other countries."

4 Atmospheric pollution and health

Deteriorating air quality either by natural or anthropogenic causes adversely affects human health and ecosystems[8,9,10,11] and, on a worldwide scale, contributes to climate change[12].

Anthropogenic or manmade causes have currently the most negative effect, and have increased in recent decades. These produce atmospheric contaminants such as carbon dioxide (CO_2), carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen monoxide (NO), nitrogen dioxide (NO_2), troposphere ozone (O_3), ammonia (NH_3), sulfuric acid (H_2S), particles of very diverse sizes and composition (metals, inorganic compounds, persistent organic pollutants (POPs), volatile organic compounds). It is the size of these particles that affects how harmful they are, with the most harmful being those with a respirable size <10 µm, particularly fine <2.5 µm and very fine <1 µm particles.

At present, the main atmospheric contaminants in large European cities are suspended particles (particulate matter or PM_{10} and $PM_{2.5}$) and nitrogen oxides (NO_2), which are due primarily to road traffic emissions and industrial activities and services. Scandinavian cities have lower PM_{10} levels of about 20 to 25 µg/m^3, in cities such as Berlin, London or Amsterdam the levels are 30 to 35 µg/m^3, while in Madrid and Barcelona these levels are 35 to 50 µg/m^3 (the limit established by the European Directive is a maximum of 40 µg/m^3).[13] It is important to point out that the limits recommended by the World Health Organization as not harmful are < 20 µg/m^3.

4.1. State of Knowledge

The latest epidemiological studies on the acute effects of air pollution on health reveal some clear relationships, and we are becoming increasingly aware of the importance of these[14].

Air pollution causes a significant increase in mortality, the same day and on successi-

ve days attributed to increased suspended particles concentrations less than 10 µm (PM_{10}). Ozone concentrations, particularly in the summer, also has this acute affect, while other contaminants, such as SO_2, NO_2, CO, metals and others tend to cause more chronic diseases.[15,16,17]

The most common diseases caused by this mortality are respiratory and cardiovascular events. The following are some of the most important studies in this respect: the NMMAPS (The National Morbidity, Mortality, and Air Pollution Study) study conducted across 20 of the most populated cities in the USA;[13] the APHEIS (Air Pollution and Health: a European Information System) study in 29 European cities (including Barcelona)[14] and the EMECAM[15] (Spanish initials: Spanish multicenter study on the relationship between air pollution and mortality) study conducted in 13 of the largest cities in Spain.

The biological, pathophysiological and toxicological causes of this epidemiological situation are currently under investigation, especially the role of the smallest particle size (particles smaller than 2.5 µm and 1 µm). These particles enter blood circulation via alveoli in the lungs and produce acute cardiovascular events (they can even trigger heart attacks) and other diseases (respiratory, cancer, immune disorders, diabetes, growth and brain disorders in children, etc.). They are also under investigation and we now have sufficient scientific knowledge[18,19,20,21] to conclude that minute but sustained concentrations of these pollutants can lead to decreased lung function and chronic diseases, and it is children,[22] smokers and patients with existing diseases (such as chronic obstructive pulmonary disease and heart failure) who are most vulnerable. In the long term, theses particles lead to mortality.

More recent studies, such as that conducted by researchers at CREAL (Center for Research in Environmental Epidemiology)[23] in the Barcelona metropolitan area estimated that the annual benefits of reducing medium exposure (only) of PM_{10}, in the studied area (57 municipals) to annual values recommended by the WHO (20 µg/m3). These findings reveal that benefits would be 3,500 fewer deaths per year (which would be an increased average life expectancy of 14 months), 1,800 fewer hospital admissions with cardiorespiratory complaints, 5,100 fewer cases of chronic bronchitis in adults, 31,100 fewer cases of acute bronchitis in children and 54,000 fewer asthma attacks in all ages. These figures are shocking, considering that the number of deaths in traffic accidents last year (2009) was 450, eight times less.

4.2. Measures of the health impact of improvements to air pollution

Several papers, either through modeling or from epidemiological monitoring of population groups, have measured the health benefits using various indicators. We have already looked at the study by the CREAL group in Barcelona, which quantified deaths and number affected by diseases which could have been avoided if the Barcelona metropolitan area had current levels of PM_{10} (a single contaminant) at 20 µg/m^3, the level recommended by the WHO.[24] This group quantified the improvement in life expectancy at 14 months, with these measures.

In a study published in 2009, Pope[25] described even further improvements in life expectancy: up to 7.3 months for each decrease of 10 µg/m^3 in fine particles.

In 2000, Samet[26] published that for every 10 µg/m^3 decrease in PM_{10} general mortality in the exposed population decreased by 0.51% and mortality due to cardiorespiratory causes by 0.68%. The study refers to 20 cities in the USA.

Studies conducted under the APHEIS project across 19 European Union [27]

cities concluded that reducing the mean PM_{10} in these cities to 20 µg/m^3 would reduce premature deaths by 43 per 100,000 inhabitants. While with the same APHEIS project in five Spanish cities (with a mean PM_{10} > 50 µg/m^3), the premature deaths avoided would be 68 per 100,000 inhabitants.[28]

In 2009, Mailing[29] published the results from 15 cities in the state of California (USA) and the health benefits per level of environmental improvement were greater than those described nine years earlier by Samet.[24] With each 10 µg/m^3 reduction of PM_{10}, the decrease in all cause mortality was 0.70% and deaths due to cardiorespiratory disease fell by 1.30%.

4.3. Level of certain atmospheric pollutants permitted by the European Directive

Suspended particles with diameter less than 10 micrometers (PM_{10})

	PERIOD	VALUE
Daily limit to protect human health	24 hours	50 µg/m^3 (not to be exceeded over 35 times per year)
Annual limit to protect human health	1 calendar year	40 µg/m^3

Air quality goals for PM_{10} according to Royal Decree 1073/2002

Nitrogen dioxide and nitrogen oxides (NO_2 i NO_x)

	PERIOD	VALUE
Hourly limit to protect human health	24 hours	*200 µg/m^3 de NO_2 (not to be exceeded over 18 times per year)*
Annual limit to protect human health	1 calendar year	*40 µg/m^3 de NO_2*
Hourly limit for protection of vegetation*	1 calendar yearl	*30 µg/m^3 de NO_2*
Alert threshold**	1 hour	*400 µg/m^3*

Air quality objectives for NO_2 and NO_x according to Royal Decree 1073/2002

**For the application of this value limit, only the data from stations of representative vegetation that requires protection are considered*
***Measured over three consecutive hours at locations representative of air quality over at least 100 km2 or an entire zone or agglomeration, whichever is the smaller.*

Suspended particles with diameter less than 2.5 micrometers ($PM_{2,5}$)

	PERIOD	VALUE	VL+MDT	DATE BY WHICH TARGET VALUE SHOULD BE MET
Target value	1 calendar year	*25 µg/m³*		*01/01/2010*
Limit value	1 calendar year	*25 µg/m³*	*29,3 µg/m³*	*01/01/2015*
Exposure concentration obligation	1 calendar year	*20 µg/m³*		*01/01/2015*

Air quality target for $PM_{2,5}$ according to Directive 2008/50/CE

5 Climate change and health

Climate change and its anthropogenic origin have now been widely demonstrated by the scientific community so there is no need to enlarge on this here. However, what could change in the future will depend on current trends in greenhouse gas (GHG) emissions and the speed of global warming, and if we can reverse these[30]. For further information on this, consult the Intergovernmental Panel on Climate Change (IPCC) in the United Nations and the report on climate change in Catalonia. The first was published in 2005 by CADS and the second report in 2010[31] based on the mandate issued by the Inter-ministerial Committee on Climate Change (CICC) of the Catalan government.

These global changes to our planet have a major impact on the health and quality of life of its inhabitants. In fact, a panel of experts organized in 2009 by the prestigious journal Lancet and the University of London estimated that climate will become one of the most important health determinants of the 21st century[32]. And above all, it will increase health inequity, with a greater negative impact in developing countries and the most socially and economically vulnerable populations.[33] For this reason and the fact that we are talking about risk to human health in the years to come (i.e. they are still invisible) it is possible that citizens and their politicians are not giving this issue the necessary preventive treatments (we should remember the results of the Copenhagen summit).

The principal effects on health are due to the following elements:[34]

- Increase of extreme temperatures (hot and cold) associated with air pollution, will increase premature mortality, particularly in the most vulnerable: the elderly, children and chronically ill.
- More infections due to increased vectors and other causes (particularly in the Third World).
- Decreased food production and, therefore, nutrition due to falling water resources, loss of arable land (especially in large deltas), salination, increased sea temperature with a reduction in edible species.
- Extreme climatic episodes with their catastrophic effects.
- Increased sea water levels with the loss

of land and displacement of large population centers.
- Reduction of ozone (O_3) layer with increased risk of cancer.

Among the more direct and acute effects of extreme temperatures, we include "heat stroke". Over 70,000 cases of premature deaths were reported in Europe with the heat wave in 2003.[35]

The first record of mortality during a heat wave in New York City was in the summer of 1966.

More indirect and delayed effects of climate change on health are seen with the loss of cultivated and inhabited lands. One example is in Bangladesh: the Ganges delta makes up about 80% of the land in Bangladesh, 144,000 km^2 where 110 million people live. A 1-m sea level rise would produce a 17% land loss due to flooding and the displacement of 11 million people.

As for the increased incidence of skin cancer due to ozone depletion, the figures vary depending on latitude, but the correlation always remains the same: the greater the loss of ozone the higher the cancer rates (UNEP 1994).

5.1. Measures to reduce air pollution

Time and resources must be allocated to preventive measures. These, in turn, will lead to cost saving both in health spending and by avoiding more costly measures that would have to be implemented in the future.

The problem of air quality in Catalonia occurs mainly in large cities and the metropolitan area of Barcelona. The main cause of air pollution is transportation (private, goods, and urban transport), but a very important factor is the high density of private transport. In Barcelona, there are 6,100 cars per km^2 (in Paris, London or Rome = 1,500/km^2) which means that a lot of cars must be removed from our cities.

This fact is exacerbated by the type of fuel used by cars (private and public). In Spain, 65% of our vehicles are diesel, which is more polluting than gasoline, while in California only 5% are diesel and in London the aim is to lower diesel vehicles to 10% by 2020. We must gradually reduce this type of fuel and promote hybrid and electric cars in our cities.

Other sources of air pollution in Catalonia include emissions from industries and services, energy production, cement plants, waste and biomass incineration, the port and airports.

GOOD PRACTICE RECOMMENDATIONS FOR AIR POLLUTION AND CLIMATE CHANGE

- The problem of air quality in Catalonia occurs mainly in the large cities and the metropolitan area of Barcelona. The main cause of air pollution is traffic.Other sources of air pollution in Catalonia include emissions from industries and services, energy production, cement plants, waste and biomass incineration, the port and airports.
- Effort and resources must be allocated to preventive measures. This means that a lot of cars must be removed from the cities and the use of hybrid and electric cars favored.
- City planning must contemplate reducing and slowing down traffic, widening sidewalks, beltways, increase pedestrian zones, cycle lanes, school walk routes, increasing green areas, etc.
- Promoting consortium of goods delivery which use of clean fuels.
- Informing the public and raise awareness about the need for traffic restrictions in specific areas of the city, with deterrent measures or banning depending on the quality of the vehicles following the model of *Low Emission Zones*.
- Limit traffic speed in areas of high PM or NOx pollution (cities and metropolitan areas from 30 to 60) to 80 km/h, or better yet implement controlled variable speed to maintain steady speed flow: a verified measure for the reduction of pollution, energy saving and reduction of accidents.
- Mandatory reporting requirement for Department of Health in licensing of potentially polluting activities.
- Really promote renewable energy sources (solar, wind, geothermal) and energy efficiency, thereby reducing consumption in both domestic and industrial services.

6 Chemical pollution and health

The human race has always lived by extracting products and substances from nature, but since the last century the number of substances that have been transformed or synthesized by humans has been increasing, so that we now have over 100,000 chemicals reported in the EU and each year about 5,000 new substances are added. Of these, about 80,000 are actually used and, of these, about 8,000 are suspected as being potentially toxic.

In fact, the proliferation of these substances is not the issue, but the safety and impact they might have on the environment and human health. 1962 (over 50 years ago) saw the publication of a book that can be considered the forerunner of scientists and ecologists warning about the environmental impact that many of these products may cause: the title was "The Silent Spring" (in Spanish *La Primavera Silenciosa*) and the author was an

American biologist called Rachel Carson. A few years later, another book was published "Our Stolen Future" (Spanish title *Nuestro futuro robado*) by Theo Colbon, Dianne Dumanoski and Pete Myers, which was also a seminal book for environmental information and awareness.

We, some of the authors and consultants of this document, produced a report in 1980 under the title *El medi ambient i la salut*[36] (Environment and Health) for the GAPS study group revealing the health risks (30 years ago) and the complexity of obtaining scientific evidence of this invisible epidemic, and hence, the difficulties of the preventive action.

The situation of risk has not changed very much (see the WHO Europe report 2010).[37] We have to face the challenge of safety and intervention with new research method, new models and with information and awareness for the public and their politicians to make this growing epidemic more visible. But this is no easy task. Thirty years ago, R. Saiegh[34] was already saying that our approach to health and illness is very reductionist (the biology of a specific system or organ), lacking the broader view of the relationship of people with their environment as a basic determinant of health. He also stressed the difficulty of risk assessment methods and what scientific "evidence" was necessary and sufficient in order to accept the causes of this harm and to be able to intervene.

Josep Maria Antó, at a conference about endocrine disruptors organized by the CAPS and IMIM in 1999 in Barcelona, said[38] that the current model of risk detection is reactive - it will take decades to obtain solid evidence- acting only when the damage is already done, claiming that this is ethically unacceptable as it is based on providing evidence of the damage (sometimes in a large part of the population) and not the risk. By way of response, a "precautionary principle" is advocated, which means that its safety has to be reasonably demonstrated before authorizing a new chemical or new technology. Also, adds Dr. Antó, the potential effects are so broad and causal variables and reactions so complex, that current research models are of little use; we need new analysis models.

6.1. Endocrine disruptors

Today we know that many of these chemical substances, as well as being toxic at certain doses, are also capable of causing hormonal changes that can affect sexual function, fertility, immunity, growth and metabolism. They interfere with the normal metabolism of hormones by supplanting or blocking them or increasing or decreasing their action and may exert these effects with the absorption of very minute quantities, but over prolonged periods. Over the decades, studies of endocrine disruption chemicals have changed some traditional toxicology concepts, in particular dogma that *"Sola dosis facit venenum"* (the dose alone makes the poison), given that there may be adverse effects with low doses unforeseen with the effects of higher doses.[39]

6.2. Persistent organic pollutants (POPs) and their accumulation in humans

The year 2009 saw publication of a seminal book for anyone wishing to study the current state of the science, and the reality in Catalonia regarding contamination by these compounds, N*uestra Contaminación Interna* (Our Internal Contamination).[40] This book published the research work led by Miquel Porta (IMIM-UAB) with a paper titled: Distribution of persistent organic pollutants (POPs) concentrations in the general population in Catalonia. Selection of the main results. The study measures blood levels of 19 POPs in a representative sample of the population of Catalonia.

The results of this research are alarming, given some of the conclusions:

- Although the majority of the 19 compounds analyzed have already been banned for some time, they are still found in 85% of the people tested. This shows how persistent these products are in the environment, how they accumulate in the food chain, the long distant transported and human contamination mainly through food.
- None of the sample analyzed remained completely free of the 19 compounds tested, the minimum was 3 and the maximum was all 19. The average number found in the population was 11.3 compounds.
- Concentrations varied greatly, but in generally they are higher than those detected in studies of the USA and German population.
- The toxic compounds and their concentrations increase with age (as is to be expected), they are higher in obese people (accumulation in adipose tissue) and in women (except multiparous women who breastfed which "purified" these compounds passing them onto the infant).

6.3. Air pollution inside buildings

The interior of the buildings, be they large service buildings, companies or facilities, may become contaminated from various structural products or other products such as paints, cleaning products like bleach, cosmetics, insecticides, solvents, etc. Many of these products are POPs, as described above, and very small doses of these can accumulate in the body. Many of these chemicals act as toxins causing allergies (the most common) and others may act as endocrine disruptors. Some of these chemicals, like insecticides, are designed and their effectiveness depends on their neurotoxic potential. They have caused various diseases in people working in certain work sites and these were treated as irritant or sensitivity conditions, such as MCS (multiple chemical sensitivity), endocrine or cognitive disorders. If these problems have occurred in the working population, we must work towards controlling the use of these harmful products in our homes, swimming pools, gardens, nurseries and sports areas, where sensitive population groups (such as children or pregnant women or people with existing illnesses that are likely to worsen) may be exposed.

The most serious cases of acute poisoning in Catalonia have been in buildings where pesticides were dispersed inside the building. These substances were applied repeatedly, and some treatments were clearly unnecessary as they were used on a routine seasonal preventive basis at several centers.[41] From 1994 to 2002, the Center for Occupational Health and Safety in Barcelona, Department of Business and Employment, together with the Labor Inspectorate studied 30 accidents including 580 workers involved in insecticide treatments inside various work centers (schools, health centers, social service centers, municipal centers, banks, hotels, shopping centers, citizen advice centers...). [42,43] They largely consisted of outbreaks and mainly affected women.

50% of workers presented different acute symptoms associated with the insecticides used. With the initial symptoms, it was impossible to suspect the type of sequelae, mostly neurological, that the most symptomatic groups of workers began to develop.

It was possible to describe the negative effects on health of collective poisoning where significant doses of these products were used, but we lack epidemiological and clinical studies to demonstrate that this silently poisoning is also happening in homes and could be one of the causes of the conditions discussed below.

6.4. Emerging diseases and environmental pollution: multiple chemical sensitivity syndrome, fibromyalgia and chronic fatigue syndrome

The health consequences due to exposure to environmental toxins and xenobiotics are not fully established, but we do know that they are many, and in many cases caused by specific agents, such as organochlorine agents, asbestos, lead, organophosphates, dioxins and mercury. Also, we are beginning to see emerging diseases with abrupt or insidious onset following occupational, environmental or accidental exposure.[44] lthough it is difficult to determine the overall impact on human health of exposure to pesticides or solvents, the relationship between exposure and various forms of cancer, birth defects, endocrine disruption and neurotoxicity is well established.[45]

The study and monitoring of over 193 people with occupational exposure to pesticides and solvents and their followed-up for fifteen years demonstrated that this exposure resulted in multiple chemical sensitivity[46,47], chronic fatigue and fibromyalgia.[48] As shown below, there is evidence that in some people these three disorders may have a common element relating to environmental exposure to common products which simultaneously affect the central nervous system and the oxidation-reduction system in the mitochondria of most cells in the body.

6.5. Effects of environmental toxins on reproductive health[49]

The effect of environmental toxins and pesticides in decreasing spermatogenesis and male semen quality is well known. In the last 40 years, the number of sperm has decreased by half in European men.[50] But the effects that we have been able to evaluate on women's health include:

- Polycystic ovary syndrome (4-8% of population).
- Increased metrorrhagia and short menstrual cycles with deficient luteal phase.
- Endometriosis (5-8% of population and increasing).
- Uterine fibroids.
- Fetal implantation defects: miscarriage, placenta previa, placental maturity.
- Fibrocystic breast (fetal exposure).
- Premature puberty.
- Prolonged lactation (protection factor).

The health consequences due to exposure to environmental toxins and xenobiotics are not fully established, but emerging diseases are starting to appear with abrupt or insidious onset associated with occupational, environmental or accidental exposure[51]. Although it is difficult to determine the overall impact on human health of exposure to pesticides or solvents, the relationship with various cancers, birth defects, endocrine disruption and neurotoxicity is well established. [52]

Table 1

EFFECTS OF SOME PERSISTENT TOXIC CHEMICALS (PTC) ON HEALTH

This summary of the negative health effects for humans is extracted for publication of the Public Health Service of Barcelona (ASPB) and Agency for Toxic Substances and Disease Registry in the United States, published by the researcher Dr. Miquel Porta et al. in the book *Nuestra Contaminación Interna*.[53]

COMPOUND	EFFECTS
ARSENIC	Risk of cancer (lung and bladder); Nausea; Skin (irritation and dermatitis); Cardiovascular disorders (hypertension, arrhythmias); Increased miscarriage; Low birth weight
BENZENE	Increased risk of leukemia; Genotoxic effects; Anemia; Gastritis; Neurologic effects
CADMIUM	Possible carcinogen
CHLORDANE AND HEPTACHLOR	Possible carcinogens Immunosuppressants Endocrine disruptors
ALDRÍALDRIN, DIELDRIN AND ENDRIN	Possible carcinogens Possible endocrine disruptors
DDT AND ANALOGS	Possible carcinogens; Asthma; Low birth weight; Stunted growth; Neurologic effects; Endocrine disruptors
DIOXINS AND FURANS	Carcinogens; Chloracne; Endocrine disruptors; Endometriosis and fertility problems; Developmental disorders; Immunosuppressants; Liver and kidney problems
LINDANE	Possible carcinogenic, neurotoxic and oxidative stress
LEAD	Neurologic effects; Anemia; Hypertension; Miscarriage; Lower sperm quality; Possible carcinogen
MERCURY	Personality disorders; Loss of muscle coordination; Neuronal loss; Tremor; Memory loss; Kidney failure; Affects neurobehavioral development in children
PCB (POLYCHLORINATED BIPHENYLS)	Carcinogens; Endocrine disruptors; Chloracne; Developmental disorders
PAH (POLYCYCLIC AROMATIC HYDROCARBONS)	Possible carcinogens
PBDE (POLYBROMINATED DIPHENYL ETHERS)	Possible carcinogens
BISPHENOL A	Endocrine disruptor

Source: Nuestra Contaminación Interna. M. Porta et al. Los libros de la catarata, 2009. Taken from l'ASPB and l'ATSDR.

Much research is currently being conducted to find potential biomarkers to detect carcinogens[54] and to be able to evaluate the dose-response at low doses.
In **Table 1** you can see effects of some persistent toxic chemicals (PTC) on health.

6.6. Reproductive health and endocrine disruption

A review published by Bretveld and colleagues in 2006 demonstrates the effect of exposure to endocrine disruptors and reproductive system abnormalities in women[55] (although there are also consequences for men). Disruption can occur at all stages of hormonal regulation: synthesis, release and storage, transport and elimination, recognizing the hormone and the receptor and its coupling, post-receptor hormone activation, thyroid function and the central nervous system.

The use of insecticides in the workplace and not adhering to clear preventive guidelines has had serious health consequences for both men and women. Repeated low doses have caused neurological disorders, initially presenting with mental confusion, frontal headache, loss of response speed, loss of memory and concentration, muscle cramps and paresthesias of upper and lower extremities, loss of muscle strength and fatigue.

These symptoms appeared immediately after exposure and gradually worsened in people who had been exposed. This syndrome has been described in the literature as Chronic Organophosphate-induced Neuropsychiatric disorder (COPIND). In addition, immune system abnormalities[56] such as increased autoantibodies, especially anti-thyroid antibodies have been described. Hypothyroidism occurred in 73% of affected persons and hyperthyroidism in 5%, these figures are three times higher than the normal population. Abnormal menstrual cycles are also described with increased metrorrhagia and short menstrual cycles. Increased secretion of growth hormone (GH) was also observed, two to three fold above normal, but these values did not reach those indicative of acromegaly. Examination of the pituitary revealed enlargement in 30% of cases.

People who continued working, even if exposed to low doses, experienced more serious and chronic central nervous system disorders, and 70% of cases suffered fibromyalgia. The papers by Pall[57] (2004), Bell[58] (1998 and 2003) and Slotkoff revealed the possibility that 70% of cases of fibromyalgia[59] are caused by exposure to chemicals in the workplace (insecticides, solvents and others) often associated with multiple chemical hypersensitivity.

Multiple chemical sensitivity, fibromyalgia and chronic fatigue syndrome often occur together, as observed among Gulf War veterans. Among those presenting with chronic fatigue syndrome, 42% also presented with chemical sensitivity and 6% [60] with fibromyalgia (Pollet et al., 1999). Comorbidity of all three conditions ranges from 30 to 88% depending on the studies.[61] Currently, this comorbidity is already being described as central sensitivity syndrome.

6.7. Environmental hazards and breast cancer

A review of the scientific literature[62] shows that various environmental factors are involved in increasing the risk of breast cancer, including hormones and endocrine disruptors, organic chemical products and byproducts of vehicles and industrial combustion and ionizing and non-ionizing radiation.

6.8. Xenoestrogens as endocrine disruptors

The possibility that the bioaccumulation of environmental estrogens (xenoestrogens) could cause breast cancer has already been suggested in epidemiological studies on occupational or environmental exposure. [63] Xenoestrogens could explain the growing and high incidence of positive androgen receptor breast cancer.[64]

A study conducted in Canada[65] associated the presence of atmospheric dioxins and dimethyl sulfate with the onset of breast cancer, in relation to the distance from industries that emit dioxins, and the susceptibility is greater the younger the women. The susceptibility increases in women under 30 years.

The probability of an adverse effect from early, intermittent and simultaneous exposure to dioxin and dimethyl sulfate manifests as breast cancer after a latency period of at least 26 years depends on age at first exposure, the emission source and the distance from the emitting source (**Table 2**).

Under the Community strategy on endocrine disruption, a number of chemicals are listed as representing a potential risks to human health (toxins) for which studies and evaluations with special methodology are required. Some possible endocrine disruptors are being regulated and are currently restricted, other are on lists of priority substances or chemical agents with proposals for withdrawal, while others are unregulated and a large number of other chemicals have not even been studied (in this respect). The

Table 2

CHEMICALS WITH ENDOCRINE DISRUPTING EFFECTS

Some pesticides and herbicides	*Atrazine, dichlorodiphenyldichloroethylene (DDT breakdown product), dieldrin, DDT (banned, but still in environment), endosulfan, heptachlor, lindane, metoxiclor, hexachlorobenzene (HCB) (fungicide).*
Polychlorinated biphenyls (PCB)	*Used in construction, electrical transformers, industrials oils, adhesives, lubricants, paints. Banned in Europe, but remains in the environment.*
Dioxins and furans	*These are unintentional byproducts, resulting from combustion of coal, petroleum derivatives, biomass, urban waste incineration, chlorinated materials in papermaking and others. These are mainly absorbed into body via food.*
Bisphenol A (BPA)	*As an antioxidant in the manufacture of plastics and resins, food and water containers, bottles, dental sealants.*
Parabens (various)	*Used as preservatives and antioxidants in cosmetics: liquid soaps, creams, deodorants.*
Alkylphenols	*In plastics, paints, detergents, textiles. Absorption through the respiratory and digestive tract and skin.*
Sun filters	*4-methyl-benzylidene camphor (4-MBC) in sunscreen lotion and blocks.*
Phthalates	*In plastic (PVC) manufacturing.*
Oral contraceptive pill	*Ethinyl estradiol, is also a xenoestrogen.*
Others	*Hydroxyanisole butyl (BHA) food preservative, nonylphenol (surfactants, emulsifiers, detergents, pesticides), phenosulfothiazine (a red dye).*

Source: Health and Environmental Alliance www.env-health.org and IV Conference on Endocrine Disruptors. Quadern CAPS No, 29 www.caps.cat /publicacions.

types of substances listed by the European Community are: a large number of pesticides, metals, incineration byproducts (waste), various natural hormones or identical to natural ones and other natural substances for industrial use. With regard to pesticides, we should mention that not only are these used in agriculture for phytosanitary use but also in our homes, gardens and public areas. For a number of years we have been gaining more information on the impact of this exposure on human pathology.

In the list of limit values for occupational exposure, we now have an "ed" (endocrine disruptors) marking associated with different chemicals. The limits assigned to these agents which have an "ed" marking have been established to prevent the possible effects of endocrine disruption, which justifies proper medical surveillance. [66,67,68,69,70]

6.9. Organochlorines, dioxins and PCB

Organochlorine products and other substances (see table in section on emerging diseases) have a long half-life of up to 40 years in the human body, especially in adipose tissue, serum and milk. DDT and its metabolite, DDE, tend to persist much longer in the body and these pesticides have estrogenic properties in the body and act as endocrine disruptors. DDT was banned in 1972, and in Spain in 1977, but it continued to be used for many years, and it is still used in African countries.

In 1995, Leon Bradlow[71] reported that many organochlorine products, such as DDT, atrazine, hexachlorobenzene, PCB and endosulfan I and II stimulate production of an estrogen metabolite (16 alpha hydroxiestrone) that is a potent agent that causes tumors and alters genes.

Studies by the Nicolás Olea research group in Granada have demonstrated the relationship between organochlorines and breast cancer.[72] Examining the combined effect of environmental estrogens, measured as total effective xenoestrogen burden (TEXB-alpha), revealed an increased risk of breast cancer in thinner women, especially in the post-menopause group, with higher pesticides levels, especially aldrin and lindane.

6.10. Heavy metals and breast cancer

Experimental studies with MCF-7 breast cancer cell lines have demonstrated the ability of some divalent metals to activate the alpha estrogen receptor and stimulate cell proliferation. These metals include: cadmium, copper, cobalt, nickel, lead, mercury, tin and chrome.[73,74] Some amino acids have been shown to mediate the effects of the metal by activating the receptor through the formation of a complex within the estrogen-binding domain of the receptor. Cadmium acts in the human body as if it were a potent estrogen[75,76] leading to proliferation of milk and alveolar ducts.

An epidemiological study showed that women with creatinine-adjusted cadmium urine levels over 0.58 micrograms/g have twice the breast cancer risk than those with levels below 0.26 micrograms/g.[77] A significant difference was found between serum cadmium concentrations among women with normal breast tissue and those with breast cancer.[78,79]

GUIDELINES FOR GOOD PRACTICES TO REDUCE CHEMICAL POLLUTION

- To reduce chemical pollution, we must first be convinced of the problem and they apply the concept of *clean production.* To combat the risk of toxic compounds, we must find alternative sustainable and healthy products and processes.
- As occupational chemical risks are closely linked to environmental hazards and public health, we need to integrate preventive strategies, public health and the environment.
- We must review the occupational disease registry, and recognize all chemical hazards, not widely understood in Spain.
- For this, we must actively involve citizens, technicians, trade unions and the business sector.
- We must provide the public with greater information about the risks associated with daily use of certain products in the home (cleaning products, disinfectants, insecticides, cosmetics, deodorants, additives, etc.) and force manufacturers to list compounds that may be hazardous to health or the environment on their product labels.
- We need to incorporate the use of exposure biomarkers for general monitoring or in specific population groups (e.g. children and pregnant women).
- In environmental impact assessments and reporting of new activities, we must systematically include health risk assessments. If the event of insufficient scientific evidence but a suspected risk (theoretical prediction, toxicology, etc.), the precautionary principle should apply.
- We propose to continue limiting insecticide and herbicide use in agriculture, to promote organic farming production and consumption, and to control the presence of parabens and other toxins in cosmetics and other household products.
- We recommend including new environmental health risks in the training of health professionals and in particular for primary care practitioners and gynecology specialists.
- There is evidence that some people suffering from fibromyalgia, chronic fatigue, and all those with multiple chemical sensitivity have been exposed to chemicals, pesticides, solvents, PCB and other persistent organic products that affect people's health due to their effects on the central nervous system, endocrine disruption and by altering the energy function of mitochondria.
- There is also evidence that type II diabetes and obesity are related to exposure to endocrine disruptors, even at the fetal stage. We propose that Catalonia comply with the Stockholm Convention for the elimination of persistent organic products and control endocrine disruptor levels in food, water and air.
- We must include a patient's employment, environmental, domestic and radiological history in patient records in order to be able to properly treat specific diseases and investigate them.

7 Non-ionizing radiation (mobile phones, Wi-Fi and other technologies)

The atmosphere is full of radiations that, according to many scientists (and the strong support of the entire telecommunications industry) are not harmful to our health, or to other organisms or the planet. Despite this, there is an increasing number of cases of the so called "electrosensitivity" and several authors and studies reaffirm the conviction that this radiation is harmful to humans and especially to children.

With such diverse opinions, the World Health Organization (WHO) has recently classified the electromagnetic fields produced by mobile phones as "possibly carcinogenic to humans", but has yet to review current regulations. Some countries have reduced exposure limits for this type of electromagnetic waves to below WHO recommendations, and even have gone one step further and are willing to remove Wi-Fi networks from educational centers and move phone antennas further away. At the 23rd World Congress of Environmental Epidemiology, held in Barcelona in September 2011, the fact that mobile phones can cause brain cancer in children was recognized, with the recommendation to use of headphones or speakers, and text messaging.

7.1. Basic concepts

Electromagnetic radiation is a form of energy generated from the interaction between electrically charged particles. It is emitted as a wave and defines an area called an electromagnetic field. People are naturally subject to these types of fields, but are also subject to artificial fields from all electrical devices.

There are two types of radiations:

- **Ionizing radiations:** are capable of exciting electrons and releasing them from the atom. It is well known that these can have serious consequences for cells, like in the case of X-rays, radionuclides or nuclear radiation.
- **Non-ionizing radiations:** are unable to break the chemical bonds, are lower frequencies waves and have less energy content. The spectrum includes ultraviolet rays, visible light, microwaves, radio frequency and extremely low frequency (ELF). The most important sources of this type of radiation are cell and wireless phones, telephone antennas, Wi-Fi networks, power lines, radio and TV waves and domestic appliances. The health impact of this non-ionizing radiation is what generates all the controversy.

The frequency of electromagnetic radiation, measured in hertz (Hz), is used as a reference to evaluate the potential health repercussions. Electric field is measured using volts per meter (V/m) and the magnetic fields expressed as teslas (T).

7.2. Risks and effects on health

Non-ionizing radiation has a thermal effect which increases the temperature of tissues, and a non-thermal effect that could cause cell damage in the long term. The study in humans is complicated by numerous intervening factors including ethical reasons and the latency of certain effects. However, some findings such as the effects described in animals could alert us to the health issues. One example is the disappearance of bees from "electromagnetically contaminated"

atmospheres (studies being conducted in Austria, India or Germany). In all cases, it seems that the microwaves alter the bee orientation system and increase their stress and aggression. These facts, although they cannot be transferred to humans, have ecological repercussions and could serve to raise doubts about the safety of these waves.

7.3. Effects relating to cancer

In 2001, IARC (International Agency for Research on Cancer) declared ELF as possibly carcinogenic[80] and, in 2011, the WHO did the same for magnetic fields produced by cell phones. This move followed years of research studies showing that radio frequency radiation is not harmless in genetically-modified animals, and some of the associated diseases include various types of cancers such as lymphoma and leukemia[81] or brain tumors.[82] Already in 1985, an increase was detected in workers exposed to these types of fields.[83]

Current studies on the effect of cell or cordless phones[84,85] indicate that prolonged use for 10 years or more may increase the risk of brain tumors (gliomas and acoustic neuromas). There is discord about the firmness with which this claim is made: while some quote it as evidence[86] and provide figures indicating that the risk is multiplied by two,[87] others are more cautious highlighting the need for more studies[88,89,90] while others deny having found any evidence of acoustic neuroma.[91] Some also argue that the tumor risk increases according to latency times and the accumulation of hours of use.[92] Others mention the possibility of inducing meningioma,[93] but also express the need for further studies.

One fact where scientists do agree is the relationship between the side of the head used to talk on the phone and the side where the tumor appears[94,95] and affirm that the risk is greater if the phone is used on only one side of the head.[96]

Other studies on the location of cell-phone transmitter stations (antennas) claim that people living near any of these stations for many years have a 4.15 times higher risk of increased cancer incidence[97] and that ELF exposure of women in their workplace may be a risk factor for breast cancer (long-term exposure to 1 μT and higher).[98]

The biological mechanisms by which electromagnetic waves induce cancer are also under study. Some authors suggest that changes in the calcium ion due to exposure to radio frequency could activate oncogenes,[99] and also indicated that there must be a genetic predisposition. Others say that chronic exposure to cell-phone microwaves may rupture cell DNA[100] and act as a fractal antenna (for the range of ELF and radio frequency).[101]

While some studies in rats found no link between breast cancer and exposure to cell phones[102,103,104] or electromagnetic fields,[105] others affirm that prolonged exposure to ELF does increase the risk, which could be related to decreased melatonin levels.[106]

A study in genetically-modified mice shows that they have a higher predisposition to develop lymphoma when irradiated,[107] as demonstrated also in histopathological studies.[108]

7.4. Effects on the nervous and endocrine systems

Electromagnetic fields emitted by cell phones can affect the electrical activity of the brain.[109] Most studies have examined only the short-term effects. Thus, the long-term effects of this exposure are not fully understood, but according to some studies there is evidence that links long-term exposure to magnetic fields and neurodegenerative diseases such as Alzheimer's,[110] given that

in the specific case of cell-phone transmitter it is known that there is an accumulation of toxic molecules in the brain.[111] There could also be a link between exposure to electromagnetic fields and amyotrophic lateral sclerosis.[112]

Radio frequencies affect brain receptors and could cause depression and memory loss, as well as alteration of periods of sleep and wakefulness,[113] as well as affecting the various sleep phases,[114] disturbances that may be related to a reduction in melatonin. This hormone could also be related to the detection of an increase number of suicides in workers exposed to ELF. Further studies are necessary.[115]

7.5. Effects at cell level

Even very low levels of ELF and radio frequency can trigger the production of stress proteins and oxidative stress in cells cultured *in vitro* (even at levels below current safety limits).[116] This means that the cell recognizes this exposure as harmful. Increasing radio frequency energy breaks DNA strands[117] and this can disrupt the recombination frequency of DNA repair.[118]

On the other hand, an in vivo study in humans concluded that exposure to cell-phone radiation might alter protein expression in human skin.[119]

7.6. Electrosensitivity or microwave syndrome

Some people living within close proximity to telephone antennas and other electromagnetic fields show symptoms now known as electrosensitivity or "microwave syndrome", including headaches, insomnia, dizziness, visual and gait disturbances, skin disorders, depressive tendency, chronic fatigue, allergies, difficulty concentrating and loss of appetite. Some symptoms may be due to the fact that excess positive ions in the air they breathe (largely due to the continuous exposure to electromagnetic radiation) can alter the blood electric balance.[120]

These cases, which are not easy to diagnose (due to false positives, psychological cases and nocebo effects), serve as a warning to the rest of the population since they serve as sentinel organisms. The number of cases is increasing (as well as the number of people exposed to electro pollution or *electrosmog*) and, for the first time, the Social Court No. 24 of Madrid ruled that a teacher suffered a permanent disability due to this. Sweden has long accepted this condition as a disability.

7.7. Effects on the reproductive system

In women, low-frequency microwaves can damage mitochondrial DNA in ovarian follicles in such a way that mutations may be passed on to offspring.[121]

In men, cell phones could adversely affect sperm quality as it may decrease sperm motility, morphology, viability and number[122] and cause testicular carcinogenesis and infertility,[123] although other papers do not find consistent data to permit a causal relationship to be established.[124]

7.8. Effects on the immune system

There is substantial evidence that ELF and radio frequency can cause inflammatory reactions, allergies and changes to immune function.[125] Another study examined blood samples from a population resident under a 50kV electric distribution line and found abnormal immunological parameters.[126] I*n vitro* studies have shown that immune system cells may be damaged and the defenses altered when irradiated.[127] Lymphocyte DNA damage has also been observed and the presence of micronuclei which could result in chromosome lesions.[128]

7.9. Effects on the cardiovascular and hematopoietic systems

Abnormalities were found in the hemogram of people living near repeater antennas: reduction in red or white blood cell count, increased lymphocytes, irregular MCV (mean corpuscular volume) and hemoglobin levels lower than normal.[129]

On the other hand, there are studies that show how exposure to frequency waves emitted by cell phones increases brain blood flow (dorsolateral and prefrontal cortex),[130] suppresses glucose metabolism locally in the brain[131] and can alter the permeability of the blood-brain barrier. [132]

In addition, electromagnetic waves could cause major disruption to the glycemic index in type I diabetes (fluctuating diabetes).[133]

7.10. Effects on children

One of the effects where there seems to be greater consensus is that exposure to ELF can cause childhood leukemia.[134] One study shows that residential exposure to magnetic fields of 0.4 μT or more increased the risk of developing acute childhood leukemia children by 100% compared to exposure to less than 0.1 μT.[135] Those children diagnosed with leukemia with greater exposure have poorer outcomes.[136] Furthermore, there is evidence that other childhood cancers may be caused by exposure to ELF.[137]

In terms of the nervous system in children, the electromagnetic fields of cell phones affect brain responses while developing cognitive processes.[138]

To prevent constant exposure of children to radiation and other effects that this pollution may be causing, telephone antenna were removed from a school in Lyon where there was a high leukemia incidence. In some countries, they are trying to switch from Wi-Fi to cables in schools.

As for mobile phones, one study indicates that their (cell or cordless phones) use increases the risk of glioma in the whole population, but adds that this risk is higher in people who start using the phone before the age of twenty years.[139] Also, according to the Australian neurosurgeons, Teo and Khurana, the risk of a brain tumor after ten years of cell phone use will double in the general population, and will increase 5 fold in children who begin to use these phones before the age of twenty years.

Another point of great importance is the effect during pregnancy. In this regard, one study links exposure of pregnant mothers to electromagnetic fields with a higher incidence of asthma in children.[140] Prenatal exposure to cell phones has also been associated with behavioral disorders such as hyperactivity or emotional disorders [141,142]

7.11. Other effects

Semicircular lipoatrophy consists of loss of fatty tissue in thighs (and at times in arms) related to a feeling of fatigue and associated with electric wiring in offices. It mainly affects women and is reversible. Although the causes are still under study we know that they are related to the working environment: low relative humidity, desks with metal structures, no grounding of cables, which favors electrostatic discharges. Postural habits could also play a role. In Catalonia, this condition is recognized as an occupational injury/accident for office workers.

7.12. Exposure limits

One of the most controversial issues with regard to the effect of electromagnetic fields is the maximum recommended exposure levels to avoid health problems. Official limits take into account only the thermal effects of electromagnetic fields that cause tissue burning. Some scientists believe these levels to be insufficient as possible non-thermal effects (which have not been fully demonstrated) could occur with lower intensities, and the long-term effects are not taken into account.

There are no unified criteria in the international sphere regarding electromagnetic radiation pollution. At present, the most widely accepted limits are those published in 1998 by the ICNIRP (International Commission on Non-ionizing Radiation Protection), a non-governmental organization recognized by the WHO.

RECOMMENDATIONS

Based on the studies conducted to date regarding the health impact of electromagnetic radiation, in May 2011 the Parliamentary Assembly of the Council of Europe made, among others, the following recommendations to its member states:[143]

- Reduce electromagnetic fields as far as possible.
- Reconsider ICNIRP levels and apply lower levels, covering both thermal effects and the athermic effects and their impact of health.
- Put in place information and awareness campaigns especially targeting children and young people.
- Protect electrosensitive people and create wave-free areas as much as possible.
- Raise awareness of risk of cordless phones and baby monitors.
- Regulate the use of cell phones at schools and opt for wired Internet connections.
- Determine location of new phone antennas in consultation with government, residents and citizens associations

Wi-Fi

- Replace Wi-Fi networks with fiber optic cables.
- Avoid Wi-Fi areas.
- Turn it off when not in use

Cell and cordless phones

- Use as little as possible and use landlines whenever possible.
- Do not use cell phone as an alarm clock.
- Turn off cell phone when not in use.
- Do not bring the phone to your ear until you have established communication because at the time of establishing connection the emission is stronger.
- Use headphones, speakerphones or the hands free feature when talking on the phone.
- Do not carry cell phone in pocket of your pants.
- No not use the same side of head every time you use the phone.
- Modulate the frequency amplitude of the phone.
- Send a text message instead of calling, if possible.

Phone antennas

- Share a single antenna between different telephone operators.
- Increase the distance from the houses.
- Do not place them within 300 meters of schools and hospitals

Electrical appliances

- Avoid placing the computer tower and power supply under the legs.
- Use LCD television and computer screens and avoid plasma screens.
- Keep electrical appliances out of bedrooms.
- Unplug appliances when not in use.

8 Medical applications of radiation and patient safety

8.1. Medical applications of radiation

Because of some of its properties, radiation is used in medicine for processes such as diagnostic imaging (radiology and nuclear medicine) or therapeutic oncology (radiotherapy).

Like many medical procedures, radiation can be beneficial while at the same time posing a risk to human health and therefore should be used with caution and a clear clinical need. Both radiation with all the different techniques (radiography, CAT, PET, mammography, interventional, etc.) and techniques using radioactive isotopes are ionizing radiations. This means that they act on cell DNA splitting chromosome chains or modifying cell components by ionization. If these lesions are significant and cannot be repaired by the physiological processes in the body, they can cause mutations and chromosomal aberrations, leukemia and other cancers, if the affected cell is reproductive it may have genetic effects.

When these effects were still unknown, many researchers and workers using these technologies died of cancer or aplastic anemia: W.R. Roentge, who discovered X-ray died of cancer in 1923; Maria Skolodowska (Madame Curie) in 1934, and her daughter, Irène Joliot-Curie in 1956 of aplastic anemia.

Due to the risks of these procedures, maximum annual doses for the general population have been legally implemented, as well as maximum doses for occupationally-exposed personnel, who are given radiation dosimeters.

8.2. Types of ionizing radiation

- **Alpha radiation** (α), are radiating particles emitted by high-energy nuclei (two protons and two neutrons), they scarcely penetrate biological tissue and are dangerous if they reach internal tissue or organs causing cell damage by proximity.

- **Beta radiations** (β) —are negatively charged electrons emitted by nuclei and have greater penetration capability.

- **Gamma radiations** (γ) radiation and X-rays are highly penetrating and only blocked by lead barriers. This penetration which passes through the human body it used in radiology to make a record on a plate. From outside the body, the gamma radiation of the radioactive isotope inserted into a specific organ or tissue is detected. These isotopes have very short half-lives (hours or days) and are eliminated in the urine.

8.3. Exposure to natural radiation

The unit of measurement of the effective dose is a milisievert (mSv). Tissues and organs vary in their sensitivity to radiation. These techniques must be used with caution in children and pregnant women.

The current legal limit of maximum effective dose per year for the general population (not including medical and natural radiation) is 1 mSv/year and up to 50 mSv/year for professionally exposed personnel (in 1925 the first limit was set at 500 mSv/year, international regulations in 1934 established 300 mSv/year, and currently the limit for professionals is set

at 100mSv accumulated over 5 years, with a maximum of 50 mSv/year during those five years).

8.4. Exposure to natural radiation

All living beings are exposed to radiation from natural background sources: cosmic rays (more intense at higher altitudes, such as air travel), radioactivity of land and building materials, natural potassium and other radionuclides (such as polonium in tobacco), radon gas in enclosed spaces, etc. The average annual dose from natural sources in Spain is estimated to be between 0.6 and 1.2 mSv/year depending on the area. In this respect, it is interesting to compare the effective doses of various medical procedures with exposure to natural background sources (**Table 3·I and 3·II**) and the relative cancer-causing risk. The risk of cancer described in the table indicates 1/10,000 to 1/1,000 as a low risk and 1/1,000 to 1/500 as a moderate risk.

8.5. Information and patient safety, as important as the diagnostic aid

The decision to conduct a test that involves radiation should be jointly taken by physician and patient. Evidently, these tests must be clinically relevant and the individual circumstances of each patient must be considered: pregnant women, breastfeeding women (some radioactive isotopes for gammagraphs are eliminated via breast milk), growing children… and very importantly, a history of previous radiations.

This history of previous radiations is very important especially for persons who have had high-dosed scans, such as CT scans using contrast material, etc. or prolonged radiological monitoring of certain diseases. This history should be borne in mind when prescribing a radiological examination or an alternative (if possible), such as an MRI or ultrasound (echography) as these do not involve a radiation risk.

It would, therefore, be useful to have a "Medical Imaging Record" card for each patient, as proposed by the American Radiology societies and cited in **Table 3·I and 3·II**.

Table 3 (I)

RADIOLOGICAL SOCIETY OF NORTH AMERICA (RSNA) AND AMERICAN COLLEGE OF RADIOLOGY (ACR)
www.RadiologyInfor.org

FOR THIS PROCEDURE:	* THE APPROXIMATE EFFECTIVE RADIATION DOSE IS:	COMPARABLE TO NATURAL BACKGROUND RADIATION FOR:	** ADDITIONAL LIFETIME RISK OF FATAL CANCER FROM EXAMINATION:
Abdominal region:			
Computed Tomography (CT) -Abdomen and Pelvis	15 mSv	5 years	Low
Computed Tomography (CT) -Abdomen and Pelvis, repeated with and without contrast material	30 mSv	10 years	Moderate
Computed Tomography (CT) -Colonography	10 mSv	3 years	Low
Intravenous Pyelogram (IVP)	3 mSv	1 year	Low
Radiography (X-ray) -Lower GI Tract	8 mSv	3 years	Low
Radiography (X-ray) -Upper GI Tract	6 mSv	2 years	Low
Bones:			
Radiography (X-ray) -Spine	1,5 mSv	6 months	Very low
Radiography (X-ray) -Extremity	0,001 mSv	3 hours	Negligible
Central nervous system:			
Computed Tomography (CT) -Head	2 mSv	8 months	Very low
Computed Tomography (CT) -Head, repeated with and without contrast material	4 mSv	16 months	Low
Computed Tomography (CT) -Spine	6 mSv	2 years	Low

Table 3 (II)

FOR THIS PROCEDURE:	*THE APPROXIMATE EFFECTIVE RADIATION DOSE IS:	COMPARABLE TO NATURAL BACKGROUND RADIATION FOR:	**ADDITIONAL LIFETIME RISK OF FATAL CANCER FROM EXAMINATION:
Chest:			
Computed Tomography (CT) -Chest	7 mSv	2 years	Low
Computed Tomography (CT) -Chest Low Dose	1.5 mSv	6 months	Very low
Radiography-Chest	0.1 mSv	10 days	Minimal
Dental:			
Intraoral X-ray	0,005 mSv	1 day	Negligible
Heart:			
Coronary Computed Tomography Angiography (CTA)	16 mSv	5 years	Low
Cardiac CT for Calcium Scoring	3 mSv	1 year	Low
Men's imaging:			
Bone Densitometry (DEXA)	0,001 mSv	3 hours	Negligible
Women's imaging:			
Bone Densitometry (DEXA)	0,001 mSv	3 hours	Negligible
Mammography	0,4 mSv	7 weeks	Very low

Note for pediatric patients: Pediatric patients vary in size. Doses given to pediatric patients will vary significantly from those given to adults.

** The effective doses are typical values for an average-sized adult. The actual dose can vary substantially, depending on a person's size as well as on differences in imaging practices.*

*** Legend:*

RISK LEVEL	APPROXIMATE ADDITIONAL RISK OF FATAL CANCER FOR AN ADULT FROM EXAMINATION:
Negligible:	less than 1 in 1.000.000
Minimal:	1 in 1.000.000 to 1 in 100.000
Very low:	1 in 100.000 to 1 in 10.000
Low:	1 in 10.000 to 1 in 1.000
Moderate:	1 in 1.000 to 1 in 500

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9 General recommendations on environment and health

1. The epidemic caused by pollution must be made visible in order to combat it.

2. As the causes of environmental determinants of health are economic and social, collective political measures are necessary. Public Administrations must take responsibility for environmental health.

3. A special organism must be created to integrate and coordinate services of all departments with environmental competences and health consequences in Catalonia, under the auspices of the Public Health Agency.

4. In addition to clarifying powers and responsibilities, and allocating the resources needed to undertake prevention and health protection activities to the various levels of Public Administration, strong political leadership with public support is also necessary.

5. Strong educational support on the growing importance of environmental determinants of health for health professionals involved in direct patient care; furnishing new emerging knowledge and enabling them to practice following the principles of good practice.

6. Incorporate environmental health risks into daily clinical practice (family history, medical history, research, etc.) as well as lifestyle and other individual behavioral risks.

7. Officially promote information for citizens, their participation and involvement in decision-making on matters relating to a sustainable and healthy environment. One possible tool for this would be participatory health councils.

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Good Practice Guide

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