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Public Health Effects of Pesticide Use

Pestisit Kullanımının Halk Sağlığına Etkileri

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ABSTRACT

Pesticides include all classes of chemicals used to kill insects, fungi, vegetation, and rodents. Generally, human populations are exposed to different kinds of pesticides almost every day through different routes, including dermatological, gastrointestinal, neurological, carcinogenic, respiratory, reproductive, and endocrine routes. We aimed to determine the effects of pesticide use on public health emphasizing the position of Turkey.

Key words: Pesticides, preventive medicine, toxicity, protection

ÖZET

Pestisitler, böcekleri, mantarları, bitkileri ve kemirgenleri öldürmek için kullanılan kimyasalların tüm sınıflarını içerir. Genellikle, insan popülasyonları, dermatolojik, gastrointestinal, nörolojik, kanserojen, solunum, üreme ve endokrin yollar gibi farklı yollarla neredeyse her gün farklı türde pestisitlere maruz kalır. Bu çalışmada Türkiye'nin durumunu vurgulayarak pestisit kullanımının halk sağlığı üzerindeki etkilerini belirlemeyi amaçladık.

Anahtar kelimeler: Pestisid, koruyucu hekimlik, toksisite, korunma

Introduction

Pesticides include the whole group of chemicals used alone or in mixture, utilised for killing or repelling insects (insecticides), rodents (rodenticides), fungi (fungicides), and different kind of vegetation herbicides plant growth regulators. The main areas of use are agriculture to protect plants from pests, weeds or diseases, or public health to protect humans from malaria, schistosomiasis, dengue fever and other vector-borne diseases[1-3].

The chemical struggle, which has a share of more than 95% among the different methods of agricultural struggle against diseases, pests and weeds, still maintains its validity today. It is known that in the cases where pesticides are not used, the quality and yield are as low as 60% in the final products. For this reason, it is inevitable to use plant protection products in our country as well as in all the countries of the world in order to control harmful organisms causing product loss[4].

Different kinds of pesticides are known to affect human populations almost every day and through different routes, including direct or indirect residues in consumed food or liquids, occupational or home exposure, inhalation (or contact) of pesticide-contaminated air[5]. The numerous negative health effects that have been associated with chemical pesticides include, among other effects, dermatological, gastrointestinal, neurological, carcinogenic, respiratory, reproductive, and endocrine effects[6-8]. Some negative effects like birth defects, reduced birth weight, fetal deaths are also reported[9].

The aim of this review was to examine the published studies on the effects of pesticides on public health and to systematically study the data obtained from studies. There will be an opportunity for a general understanding of the frequency of use of pesticides and their impact on human health. For this purpose we searched PubMed and Turkish Citation Index (TCI) from 1999 to 2017, using pesticide, pesticide and health effects as keywords and used relevant findigns from these studies.

Classification of pesticides

Pesticides are sometimes classified by the type of target pest for which they are applied. As a fungicide is used to control the growth of fungi, miticides, insecticides, and herbicides are used for mites, insects, and weeds, respectively. Insecticides are capable of killing insects by penetrating into their bodies via direct contact (dermal entry), oral, and/or respiratory entry. Herbicides are used to kill plants by direct contact and/or by killing the weeds when they are absorbed through the leaves, stems, or roots. Some pesticides are capable of moving into untreated tissues after being absorbed by plants or animals. Such insecticides or fungicides can penetrate throughout the treated plants to kill certain insects or fungi. Other pesticides have also been developed to attack the nervous system or to act on the endocrine or hormone systems of pests for controlling them[10].

Rizzati et al. collected data from studies conducted in mammalian models in vitro and in vivo that were published between 2000 and 2014. When focusing on the function of herbicide, insecticide or fungicide pesticides, 46% of the mixtures were reported to contain insecticides alone, 15% fungicides alone, and 4.5% herbicides alone. Mixtures with effects associated with neurotoxicity were mainly composed of insecticides, and most studies on the effects of fungicide mixtures (90%) were associated with effects on endocrine regulation and/or reproduction.[11]

Many of these pesticides are resistant to chemical, physical and biological degradation, thus they are ubiquitously found in the environment despite restrictions on their use. Besides being effective in eradicating pests, many of the pesticides are also harmful to human health. Thus, there is widespread concern about the potential health effects of persistent organic pollutants (POPs) in human milk on infant growth and development. To date, most studies have used prenatal pesticides exposure and infant anthropometrical size at birth as a proxy measure of *in utero* development, and have failed to yield consistent results.[12,13] Aytaç et al. observed the presence of organochlorine pesticides (OC) in breast milk of 62.7% of 59 women within postpartum 1st -30th days residing in Adana, Turkey, with no difference with age, profession, place of residence, indicating that the whole population was under risk[14]

Table 1. Changes in pesticide consumption in the world according to the years (US $ million)

Years	1960 Sales	%	1970 Sales	%	1980 Sales	%	1990 Sales	%	2000 Sales	%	2005 Sales	%
Insecticides	310	36.5	1.002	37.1	4.025	34.7	7.655	29.0	7.559	27.9	7.798	25.0
Herbicides	170	20.0	939	34.8	4.756	41.0	11.625	44.0	12.885	47.5	14.971	48.0
Fungicides &Bactericidal	340	40.0	599	22.2	2.181	18.8	5.545	21.0	5.306	19.6	7.486	24.0
Others	30	3.5	159	5.9	638	5.5	1.575	6.0	1.354	5.0	936	3.0
Total	850	100	2.700	100	11.600	100	26.400	100	27.104	100	31.191	100

Pesticide Use in the World

The world's total pesticide consumption is around 3 million tons with significant changes observed when the subgroups of pesticides consumed in the world were compared (Table 1). Insecticide, fungicide/bactericide consumption rates increased despite the reduction in herbicide consumption rate[15,16] The amount of drugs used per unit area in Turkey remained very low compared to the developed countries with the highest consumption in fungicides group (45%) followed by herbicides (18%) and insecticides (15%)[15].

In Australia, dichlorodiphenyltrichloroethane (DDT) was first introduced in the 1940s and other pesticides such as heptachlor, aldrin, dieldrin, chlordane, hexachlorocyclohexane and hexachlorobenzene were registered for use in the 1970s[14]. Since the 1970s, production and application of DDT and most pesticides were restricted and prohibited in Western Australia.[17] However, as many of these POPs have long half-lives and high fat solubility properties, they tend to bio-magnify in wildlife, especially in species at the top of food chain, such as animals (e.g. seals and dolphins) and humans[18,19].

Effects of Pesticides on Health

The effect of pesticide use on human health is reported in various studies. Carpy et al. examined the available data published between 1985 and 1998 regarding the health risk assessments of the residual concentrations of pesticide mixtures found in human food and drinking water. They reported that both synergy and antagonism occurred within the same organism depending on the organ of target, and that interactions between compounds did not appear to be a common even at these levels[20,21.]

In another review, Hernandez et al. assessed a number of toxicological interactions in pesticide mixtures at the molecular level and their relevance to human health. They reported several examples of cocktail effects, such as the potentiation of the toxicity of some pesticides by others (e.g. malathion by isomalathion, pyrethroids (PYR) by anticholinesterase insecticides, organophosphorous (OP) by organochlorine (OC), carbaryl by OP, and OP by triazines (TRIAs)), the synergy between PYR and carbamate compounds, and the antagonism between TRIA herbicides and prochloraz[22].

Acute Pesticide Poisoning

Pesticides cause dermal, gastrointestinal, and inhalation toxicity in the body. Clinically, muscarinic manifestations such as increase in secretions, especially miosis, nausea-vomiting, urinary incontinence, shortness of breath, bradycardia, tachycardia, hypotension, muscle weakness, striped muscle findings such as fasciculations, confusion and some central nervous system influences. Late manifestations are polyneuropathy which starts 2-4 weeks after poisoning and the associated paralysis[23,24].

Pesticide poisoning, which may be the cause of accident or suicide, is a common cause of morbidity and mortality all over the world. It is estimated that there are approximately 3 million serious acute pesticide poisonings per year in the world, resulting in more than 220.000 deaths with 95% of fatal pesticide intoxications occurring in developing countries[25].

Cancer

In a study covering a female population from Tunisia, possible association between serum concentrations of OC pesticides (polychlorinated biphenyls) and xenoestrogenic effects were investigated; accordingly, their positive link with breast cancer risk was observed[26,27]. In another case-control study, 400 cases and 800 controls were enrolled from different hospitals in Pakistan, and the results indicated strong associations between pesticide exposure and lung cancer (OR=5.1, with 95% CI: 3.1-8.3)[28].

Several case-control studies analyzed rates of leukemia among children exposed to pesticides. Increased rates of all types of leukemia were observed in children whose parents had used insecticides in the garden and on indoor plants and whose mothers had been exposed during pregnancy[29]. From a prospective cohort study of 57,311 licensed pesticide applicators in Iowa and North Carolina, USA, significant risks of bladder cancer and colon cancer were linked with imazethapyr, a heterocyclic aromatic amine herbicide[28].

According to the results of the same study, significant excess risks of bladder and colon cancers were observed in the Agricultural Health Study among applicators exposed to the heterocyclic aromatic amine herbicide imazethapyr. For bladder cancer, participants in the highest exposure category of imazethapyr had a 137% higher risk than non-exposed pesticide applicators. For colon cancer, detailed analysis by sub-site revealed that imazethapyr use was significantly associated with a 173% increased risk of proximal cancers, but not with distal or rectal cancers[28]. One United States (US) study investigated more than 55 000 men who applied pesticides and found an increased risk of prostate cancer, especially among those with a family history of prostate cancer, and particularly with use of methyl bromide, a fumigant[30].

The causes of chronic illnesses, including cancers, are extremely complex. In their lifetime, individuals who differ in genetic make-up and susceptibility are exposed to a wide variety of carcinogens. Some chemicals by themselves are safe but may act as synergists or promoters in concert with other chemicals to cause illness. Future research as to how human health is affected by increasing exposure to all chemicals is of prime importance. The public is skeptical of what it reads and hears, and it is becoming more wary of being exposed to pesticides and other chemicals[5,31].

Neurological System

Ruifa Hu et al. evaluated the effects of pesticides exposure on hematological and neurological indicators over 3 years and 10 days respectively. A cohort of 246 farmers was randomly selected from 3 provinces (Guangdong, Jiangxi, and Hebei) in China. Long-term pesticide exposure was found to be associated with increased abnormality of nerve conductions, especially in sensory nerves. It also affected a wide spectrum of health indicators based on blood tests and decreased the tibial nerve compound muscle action potential amplitudes. Short-term health effects included alterations in complete blood count, hepatic and renal functions, and nerve conduction velocities and amplitudes. Overall, their results demonstrated that pesticide exposure had adversely affected blood cells, the liver, and the peripheral nervous system[32].

From a cohort study in the Netherlands, in which 58,279 men and 62,573 women (aged 55–69 years) were enrolled, a possible linkage between Parkinson's disease mortality and occupational exposure to pesticides was observed[33].

Endocrine System and Metabolism

Pesticides represent an increasingly widespread environmental exposure today and some of them (e.g. OC) have the potential to accumulate in human tissues either through direct exposure or through the food chain. Different types of pesticides including OC compounds have been directly associated with increased Type 2 diabetes (T2D) risk in a dose-response way as well as with diabetes risk factors including adiposity, insulin resistance and dyslipidemia[34].

In USA, a study was carried out covering 13,637 farmers' wives who were reported to have an experience of mixing or applying pesticides at enrollment (1993–1997). Accordingly, five pesticides were positively associated with incident diabetes (n= 688.5%): three organophosphates (fonofos (HR = 1.56, 95% CI: 1.11-2.19), phorate (HR = 1.57, 95% CI: 1.14-2.16), and parathion (HR = 1.61, 95% CI: 1.05-2.46)); the organochlorine dieldrin (HR = 1.99, 95% CI: 1.12-3.54); and the herbicide 2,4,5-T/2,4,5-TP (HR = 1.59, 95% CI: 1.0-2.51)[35].

OC pesticides have variable molecular and cellular targets and thus they cannot be considered to have a single mode of action. Inflammation in adipose tissue, ectopic lipid accumulation (lipotoxicity) in liver, muscle and pancreas, and mitochondrial dysfunction are primary mechanisms underlying the pathogenesis of T2D and all of them have been associated with OC pesticides[29].

Cytogenetic Effects

Studies among agriculture-exposed and pesticide exposed individuals and those who were not exposed to these compounds showed that structural and numerical chromosome anomalies and sister chromatid exchanges were replicated at high rates in pesticide exposed individuals[36]. The cytogenetic effects of four pesticides were investigated in a study by Piero Dolara et al. Dimethoate and omethoate were the two major organophosphate insecticides increasing the frequency of sister chromatid exchange in in-vitro conditions on human lymphocytes ($p < 0{,}01$). Insecticide, deltamethrin and systemic fungicide benomyl caused a milder rise in the frequency of sister chromatid exchange while not statistically confirmed. A mixture of these four pesticides caused an increase in sister chromatid exchange in a dose-dependent manner ($p<0.01$). The effects of this mix changed when different individual lymphocytes were used, so this difference was not statistically significant. When these pesticides were applied individually, it was observed that the frequency of sister chromatid exchange did not increase much, but when the same ratios were given as mixture, the sister chromatid exchange frequency increased[37].

In a study of workers working in the flower industry in Italy to reveal the incidence of chromosome anomalies and sister chromatid changes in peripheral blood cultures three groups were compared: (A) 32 healthy individuals working in the flower industry and exposed to pesticides, (B) 32 individuals with advanced and hospitalized bladder cancer, and (C) 31 individuals as control groups. When compared with the control group, the sister chromosome exchange frequencies of groups A and B were found to be significantly higher. In the same study chromosome anomalies were also investigated and the higher incidence of structural chromosomal anomalies was observed in both healthy individuals (A) and bladder cancer individuals (B) exposed to pesticide compared to the control group[36]. On the other hand in another study no evidence of DNA damage related to pesticide exposure was found[38].

Other Effects

In a cross-sectional study covering female farm workers (n=211) in Africa, the prevalence of ocular-nasal symptoms was positively associated with entering a pesticide-sprayed field (OR = 2.97; 95% CI: 0.93-9.50)[39]. Majority of pesticides including organophosphorus components are to affect the male reproductive system by such mechanisms as reduction of sperm activities (e.g., counts, motility, viability and density), inhibition of spermatogenesis, reduction of testis weights, damaging sperm DNA, and increasing abnormal sperm morphology[40,41].

Few studies have investigated specific pesticides and RA. In the Women's Health Initiative, self-reported use of residential insecticides was associated with risk of RA or a related autoimmune disease, systemic lupus erythematosus (SLE). The highest risks were observed for women who reported personally mixing or applying pesticides, especially if they had ever lived or worked on a farm[42].

Restriction of the Use of Pesticides

Pesticides before authorized and registered to be used in European Union member states undergo extensive chemical, biological (effectiveness), toxicological and environmental behavior investigations. This process contributes to better protection of agricultural production and at the same time it is ensuring that Plant Protection Product, when properly applied for the purpose intended, are sufficiently effective and have no unacceptable effects on plants and plant products, on the environment and there are no harmful effects on humans[43,44].

As pest control research focusing on the ecology of pests and on the agroecosystem as a whole, and dealing results from different regions of the world indicated that pesticide use could be reduced substantially. Sweden, Norway, Denmark, the Netherlands, and the Canadian province of Ontario have all adopted effective programs to reduce pesticide use by 50-75%. In Indonesia, for example, the investment of $1 million per year in ecological research in conjunction with extension programs that train farmers to conserve natural enemies is paying large dividends. Pesticide use for rice in Indonesia has been reduced 65%, while rice yields have increased by 12%. As a consequence, the Indonesian government has been able to eliminate $20 million in pesticide subsidies to farmers[45].

In the US, it is estimated that pesticide use can be reduced by as much as 50% at an estimated savings of at least $500 million per year without reducing crop yields or substantially reducing the "cosmetic standards" of fresh fruits and vegetables. By implementing Integrated Pest Management programs in the state of New York, for example, sweet corn processors saved $500,000 per year and maintained high yields while reducing pesticide treatments 55-65%. Pesticide use has been reduced on other crops in New York as well[45].

Conclusion

As a result, pesticides cause harm to other living organisms as well as the target they are applied to, but it is the most effective combat weapon used to prevent agricultural products from being wasted. Therefore, with proper use, the effects on the other organisms other than the target organisms should be tried to be minimized.

The public health professionals are the practitioners of life-long learning of the community. In the light of all the evidence collected, this should include, of course, the education regarding the health effects of pesticide use, especially cosmetic use of pesticides that can disproportionally affect children, pregnant women, and elderly people. Because most studies analyzed exposure to multiple rather than individual pesticides, our recommendation is to reduce exposure to all pesticides. The government is also responsible to revise the policy to reduce the pesticides production and application.

We suggest family doctors to consider questioning about pesticide exposure during periodic health examinations and to make recommendations about minimizing exposure. They should support use of protective clothing by people who use pesticides on the job and encourage them to be attentive to the timing of re-entry into recently sprayed areas. Family doctors can also defend for reductions in pesticide use in communities, schools, and hospitals and can educate patients about the potentially harmful effects of pesticides on health.

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