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EFFECT OF PESTICIDES ON HUMAN HEALTH: EXTENSIVE REVIEW

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Abstract

The chemical burden on natural ecosystems has risen as the agriculture sector has become more industrialized. Pesticide usage in agriculture has grown further due to the rapidly expanding human population, which is expected to reach 8.5 billion by 2030, raising concerns about the impact of this population on food security. Agrochemicals known as pesticides are applied to agricultural fields, public health initiatives, and urban green places to protect people and plants from numerous diseases. In both advanced and developing countries, using various pesticides to eradicate weeds and pests is a crucial aspect of agricultural practice. There is no doubt that it has increased crop yields and reduced post-harvest losses. The remnant in food creates a widespread concern about the harmful impacts of these chemicals on mankind. Their side effects, however, can be a significant environmental health risk factor due to their proven capacity to have a wide range of detrimental health and environmental impacts. It is clear that pesticide exposure is highest among agricultural workers. Pesticides may pose the greatest risk of exposure to significant toxic amounts. This document is therefore structured to provide a comprehensive review of pesticides in relation to their types, distribution in the environment, and health effects.

Keywords: Pesticide; Classification; Target pest; Vector-borne diseases; Toxicity; Environmental effects; Air pollutants; Pathways of exposure; Human health effects.

INTRODUCTION

Pesticides are a kind of toxic materials spread intentionally into the surroundings (environment) to kill harmful microorganisms. For weeds we use herbicides, insect's; insecticides are used, fungus (fungicides) and for rodents, rodenticides are used. Though the word "pesticide" is mostly misunderstood to refer only to the use of insecticides. It's also applicable to herbicides, fungicides and different substances used to prevent the unwanted microorganisms. Pesticides, frequently used in nationwide health programmes to inhibit vector-borne diseases (e.g., Malaria and dengue) and unwanted plants (e.g., grass and weeds) in ornamental crop lands, parks, gardens, etc. They have been used for inhibiting or preventing the growth of pests, insects, fungi, algae and bacteria in electrical equipment, paints, carpets, paper cardboard. Moreover, unintentional pesticides exposure can be extremely dangerous to mankind as well as to different species because they are designed to behave toxic. It also might be harmful to those people who are exposed to pesticides through occupational use, ingestion of foods or liquids having pesticide residues, and breathing air contaminated with pesticides. Even low levels of insecticide exposure could have adverse health condition at an early stage of development. Children's physical, behavioural & physiological characteristics make them more susceptible to pesticides than adults. Exposure to pesticides can develop various diseases like cancer, hormonal disorder, asthma, allergies, and hypersensitivity. A number of systematic, methodical, and research-based data exists for the negative impacts of pesticide exposure causing reduced birth weight, birth defects, etc. Based on scientific data, the actual, predicted, and perceived risks of pesticides to human health and the environment are legitimate. In relation to pesticide pollution and its effects, this review has been organised chronologically to illustrate the common features of pesticides with respect to classification, the level of pollution, the channel of transfer, and the effects on human health. The purpose of this study is to undertake a comprehensive analysis of the information that has been published about the usage of pesticides and their detrimental impact on human health.

What are Pesticides

"Pesticides are any substances or mixture of substances made up of chemical or biological ingredients and intended to repel, destroy or control pests, or to regulate plant growth." [1]

If enhanced food and fibre production, better vector-borne illness management, and larger economic potential are among the advantages of pesticides, then their disadvantages include grave harm to both human and environmental health. There is now a plethora of evidence showing that many of these chemicals do have negative environmental consequences and may be dangerous for humans and other living things. Although it is an unfair burden, people in underdeveloped countries and high-risk groups in each country are the ones who must cope with the potentially negative health effects of pesticide exposure because no segment of the population is completely immune. About 1 million people each year die or develop chronic illnesses as a result of pesticide poisoning worldwide. Pesticides can be categorised using a number of factors, including chemical classifications and toxicity. Based on several factors, pesticides are categorised in Table 1. Most insecticides include organic or inorganic active components. Compared to inorganic pesticides, organic pesticides often contain more complex and water-insoluble compounds.

On the basis of toxicity

Because pesticides are poisonous materials, therefore they are classified on the basis of toxicity. In table 1. It has been seen that different types of pesticides (e.g., Ia, Ib, II, U) have a level of hazards they can pose to the target species as well as the non-target species via orally or through the skin surface.[2]

Table 1. Toxicity criteria of different pesticide

Types	Degree of toxicity	LD_{50}[a] for the mouse (mg/kg body weight)	
		Oral	Skin surface
Ia	Extremely hazardous	<5	<50
Ib	Highly Hazardous	5-50	50-200
II	Less Hazardous	50-2000	200-2000
U	Not likely to pose a serious hazard	50000 or more	

On the basis of the target pest

While certain herbicides can successfully regulate a plant's ability to turn light into food, others can mimic the action of plant growth regulators.[3] The production of certain chemicals by the fungus can also be slowed down by some fungicides, while others may influence cell division. Pesticides are often categorized according to the type of target pest for which they are sprayed. Miticides, insecticides, and herbicides are used to restrict the growth of mites, insects, and weeds in the same way as fungicides are used to inhibit the growth of fungus. Insecticides can kill insects via entering their bodies directly (through skin contact), orally, and/or respiratory. There are different types of Pesticides often used to prevent pests. Moreover, these pesticides target specific pests and leave their effect behind. Table 2 shows various effects seen after the application of pesticides.

Table 2. Effect of different types of Pesticides on target Pest.

S. No.	Types of pesticide	Target Pest	Effects on the target pest
1	Algaecide	Algae	Stops photosynthesis, Cause algae cell walls to burst.
2	Avicide	Birds	Nervous system poisoning, Thinning of eggshell.
3	Bactericide	Bacteria	Affect the bacterial cell wall.
4	Fungicide	Fungi	Destroy the cell membrane, inactivate critical enzymes or protein.
5	Herbicide	Weeds	Restrict cell division.
6	Insecticides	Insects	Damage nerve cells

7	Miticide	Mites	Directly kills the mites
8	Molluscicide	Snails, Slugs	Initiates organ failure, and disturbs water balance.
9	Nematicide	Nematodes	Inhibits division
10	Piscicide	Fish	Inhibits cellular respiration, restrict the ability to use dissolved oxygen.
11	Rodenticide	Rodents	Causes spontaneous bleeding.

Classification of Pesticide based on Molecular Formulae

Aldrin, chlordane, dichlorodiphenyltrichloroethane (DDT), dieldrin, endrin, heptachlor, and hexachlorobenzene are a few pesticides that include persistent organic pollutants (POPs) that may withstand environmental degradation and last for years.[4] Pests are killed by harmful chemicals called chemical pesticides. Major pesticides are divided into the following categories based on their chemical makeup:

- **Organochlorines:** These are essentially chlorinated organic substances. Organochlorines are lipophilic and have a strong affinity for animal fatty tissue. Organochlorines degrade relatively slowly in the body and accumulate in the environment, creating severe issues. Several significant organochlorine instances include (a) DDT, (b) Aldrin and (c) Lindane.
    a) **DDT (dichlorodiphenyltrichloroethane):** The most well-known insecticide in the world, DDT, is also a pollutant since it does not biodegrade. DDT use to crops results in soil, water, and air contamination. The greatest concentration of DDT in the world—13–31 ppm—can be found in human body fat in India as a result of extensive DDT usage. DDT accumulates in the body after dissolving in

water and is amplified in higher organisms of the food chain. For the freshwater crustacean Daphnia, the DDT tolerance level is 10 ppm, and above that level, Daphnia will perish.

b) **Aldrin:** In order to avoid termites, foundations of buildings are treated with an insecticide called Aldrin. In Asian nations, it has been used to successfully manage grasshoppers and locusts. The insecticides Aldrin, Dieldrin, and Endrin are very toxic.

c) **Lindane:** Michael Faraday created γ-hexachlorocyclohexane/Gammaxene/Lindane for the first time in 1825, while Dupire in France and Leicester in England separately identified its insecticidal properties in 1941 and 1942, respectively. The majority of pesticides used in India, or around 50% of all pesticides used in India, are Lindane. Lindane is more harmful than DDT since it may bio-accumulate in the food chain. Shampoos and lotions both contain Lindane.

- **Organophosphates**: Schrader made the discovery that organophosphates had insecticidal characteristics. The insecticides that are most hazardous to vertebrates are organophosphates. The enzyme cholinesterase, which is necessary for the transmission of nerve impulses across the synapse, is inhibited by organophosphates. The three most common organophosphates used in Asian nations are malathion, parathion, and fenitrothion. One of Flit's two active chemicals is malathion; the other is pyrethrin, which comes from the plant Chrysanthemum cinerariifolium.
- **Carbamates:** Carbamates are carbonic acid derivatives that include the - OCON = group. Carbofuran (Furadan), Propoxur (Baygon), and Aldicarb are a few of the carbamates that are often employed (Temik). The herbicides phenyl carbamates and thiocarbamates, as well as the fungicides dithiocarbamates, are derivatives of carbamates. Carbamates are effective against snails and nematodes. The way that carbamates work is quite similar to how organophosphates work.
- **Triazines:** A class of herbicides called triazines (Simazine, Atrazine, etc.) is generated from urea. Triazines are used to get rid of weeds in cotton fields, tea and tobacco fields.

Bordeaux Mixture: In France in 1882, Millardet made the discovery of the Bordeaux combination. It is made by combining 40gm of calcium hydroxide and 40gm of copper sulphate in 5ltr of water. Bordeaux combination was originally used to treat grape-wine downy mildew disease, which is brought on by the fungus

Plasmopara viticola. To combat the ascomycete fungus Venturia inaequalis, which causes apple scab and potato blight, a Bordeaux combination is utilized.

Pesticides are chemical compounds having different molecular formulas and molecular weight, Table 3. Indicates the information about the chemical proportions of atoms that compose a particular pesticide compound.

Table 3. Molecular formula and weight of common pesticides with examples.

S. No	Type	Example	Molecular Formulae	Molecular Weight
1	Organochlorine	Dichlorodiphenyltrichloroethane	$C_{14}H_9Cl_5$	354.5g/mol
		Lindane	$C_6H_6Cl_6$	290.8g/mol
		Endosulfan	$C_9H_6Cl_6O_3S$	406.9g/mol
		Aldrin	$C_{12}H_8Cl_6$	364.9g/mol
2	Organophosphorus	Parathion	$C_{10}H_{14}NO_5PS$	291.26g/mol
		Malathion	$C_{10}H_{19}O_6PS_2$	330.4g/mol
3	Inorganic	Benomyl	$C_{14}H_{18}N_4O_3$	290.32g/mol
		Oxine copper	$C_{18}H_{14}CuN_2O_2$	353.9g/mol

Pesticide effect on the Environment

Pesticides can have significant negative environmental effects on other living things as well as various media, such as air, soil, or water since they are made to be poisonous to certain groups of organisms. Because pesticides are supposed to be toxic, it has some negative impact on the environment, over the use of pesticide on crops gradually decreases the fertility of soil as well as causes harm to beneficial microorganisms and earthworms. Because losing both the bacteria and fungi could result in the degradation of soil. For e.g., plants are dependent on the variety of soil microorganisms that help in the transformation of atmospheric nitrogen into nitrates, using herbicides may disrupt this process. These toxic pesticides restrict the soil bacteria and hinder the transformation of ammonia into nitrates.[5] Apart from that, using pesticides on the cropland reaches the underground water level and contaminates the water. In addition to this, it also causes eutrophication, a process where the environment gets enriched with nutrients. It is

generally associated with water bodies This eutrophication causes toxic algal bloom which often consumes the dissolved oxygen of the water bodies and results in the death of marine species. Pesticides also have an immense contribution to the killing of beneficial insects especially honey bees, which often results in decreased pollination. Due to this, the specific plant species might get endangered.

Contamination of water surface

Pesticides can enter surface water through soil runoff and plants that have been treated. Pesticide contamination of water is common. In the early to mid-1990s, the U.S. Geological Survey conducted a comprehensive series of studies on the nation's major river basins, and the results were surprising. More than 90% of the water and fish samples taken from all streams tested positive for one or, more frequently, multiple pesticides. 99 percent of samples from urban streams and 100% of samples from large rivers with impacts from both agriculture and urban land use included pesticides. The USGS also discovered that pesticide concentrations in urban streams frequently surpassed standards for protecting aquatic life. The Puget Sound Basin's streams contained 23 chemicals, including 17 herbicides. Urban streams were found to have more pesticides than agricultural streams, according to USGS.

Soil contamination

Pesticides and TPs can be divided into the following categories: (a) Pesticides that are tightly bonded to soil and are hydrophobic, persistent, and bio accumulative. Organochlorine pesticides as DDT, Endosulfan, endrin, heptachlor, Lindane, and its TPs display this tendency. Even though most of them are already restricted in agriculture, their residues are however still prevalent. (b) Polar pesticides, which mostly consist of herbicides, can also contain carbamates, fungicides, and certain insecticides that contain organophosphorus. They can be drained from the soil through runoff and leaching, which creates a concern for the population's access to clean drinking water. Depending on how the characteristics of the soil and pesticide interact, soils retain pesticides and their TPs to varying degrees. The amount of organic matter in the soil has the most impact. The adsorption of pesticides and TPs increases with increasing organic matter content.

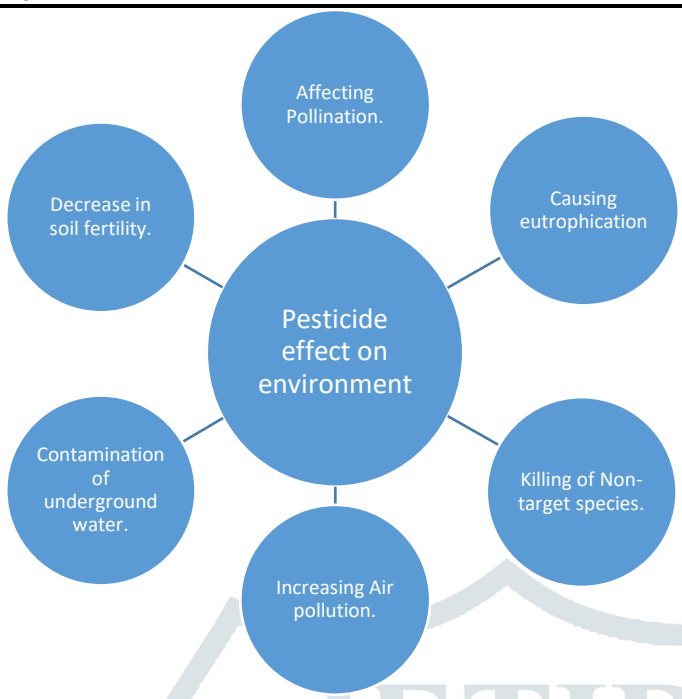

Figure 1 Shows the effect of pesticides on environment

Pathways of pesticide exposure to human

Pesticide exposure can be acquired directly through work, agriculture, and household usage as well as indirectly through food. The major pathway of exposure by pesticides to human is Food Chain, soil, air, water, flora, and fauna.[6] Pesticide is distributed throughout the body via the bloodstream, on the other hand may be excreted through urine, skin, and exhalation. There are 4 general pathways of pesticides to get in the human body: skin, oral cavity, eye, and respiratory tract. The toxicity of Pesticides may vary depending upon the types of exposure to dermal, oral, or through inhalation. The risk of pesticide contamination often rises with dose (concentration) and crucial intervals, in addition to the target chemical's toxicity, as would be predicted. The high-risk occupational categories exposed to pesticides include agricultural farm workers, factory employees, formulators, sprayers, mixers, and loaders. Because the procedures involved in manufacturing and formulation are not risk-free, the likelihood of risks may be increased. Workers are more at risk in industrial workplaces because they handle a variety of hazardous compounds, including pesticides, raw materials, poisonous solvents, and inert carriers.

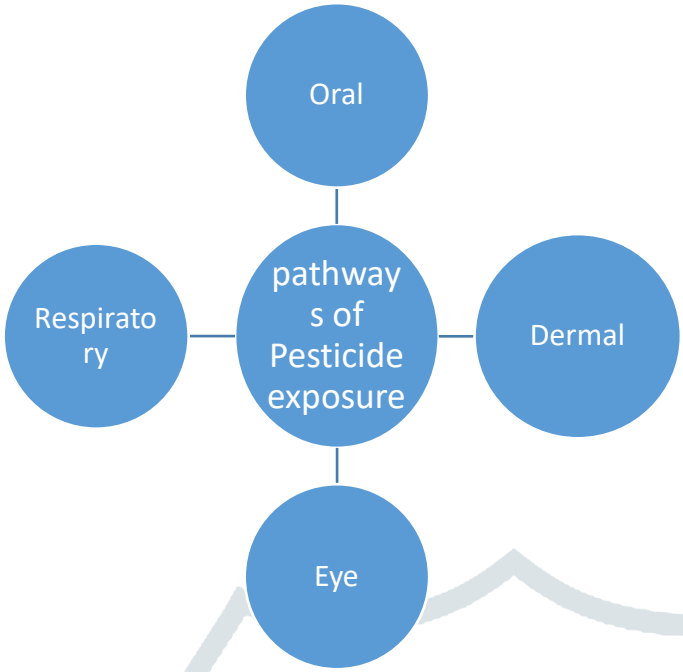

Figure 2 shows the pathways from which the pesticides enter in the human body

Dermal exposure

Skin absorption of pesticides is most frequent in the workplace. This kind of exposure is also referred to as occupational exposure. Workers might be exposed to chemical splashes when mixing or spraying pesticides. Skin exposure may cause the pesticide to get inside the body immediately upon contact with skin or eyes. Pesticides may also get inside the body through the skin by touching protective clothing, surfaces, or equipment contaminated with pesticides. Pesticide splashes can damage the eyes.

Oral exposure

The most serious poisoning could take place when the pesticides enter via oral exposure. Oral exposure to pesticides is usually accidental, either inadvertently or deliberately. The majority of incidents of unintentional oral exposure have been linked to the transfer of pesticides from labelled containers to unmarked bottles or food containers. There have been several cases of people becoming poisoned after drinking pesticides or pesticide-contaminated bottled water from soft drink bottles. Workers using pesticides or pesticide application equipment may ingest chemical if they don't wash their hands prior eating and smoking. Therefore, the spreader must be carefully trained in the handling of pesticides.

Respiratory exposure

Exposure through the respiratory system might be harmful because pesticide particles frequently make their way into the bloodstream. When dealing with powders, airborne droplets or mists, and vapours, inhalation is also a possibility. When low pressure application equipment is utilised, the danger of inhaling droplets is minimal since the particles are too large to be suspended long enough in the air to do harm. The danger of inhalation, however, may be increased if pesticides are applied using high pressure, ultra-low volume, or fogging equipment since the tiny droplets created during these operations may remain and travel a long way in the air. There are instructions for using a respirator on the label of pesticides with a high inhalation risk.

Eye exposure

There is a high probability of chemical damage to the eye tissue. Few pesticides are reported to enter the eye in sufficient amounts to create serious illness or fatal disease. Given the size and weight of the individual particles, granular pesticides are particularly hazardous to the eyes. When applying pesticides with high-powered equipment, pellets may bounce back at high speeds from other surfaces, causing eye harm. Eye protection is also crucial while measuring or blending concentrated or very poisonous pesticides. When spraying pesticides, face shields or eye protection are required.

Pesticide and human disorders/ diseases

Research has shown that pesticides may be linked to a number of diseases, including cancer, leukaemia, and asthma. The health risk of pesticide exposure depends on the level of exposure and toxicity of the ingredient.[7] Also, some people, such as children, pregnant women, or the elderly, may be more vulnerable to pesticide exposure than others. Neurological symptoms were found in 21% of the employees (N=356) in four units making HCH in India, according to research done on a worker. These symptoms were correlated with the level of exposure. The National Institute of Occupational Health evaluated the level of toxicity risk associated with the field application of the carbamate pesticide methomyl. Data on reproductive toxicity was gathered from 1,106 couples whose men were exposed to pesticides (OC, OP, and carbamates) while working in cotton fields.

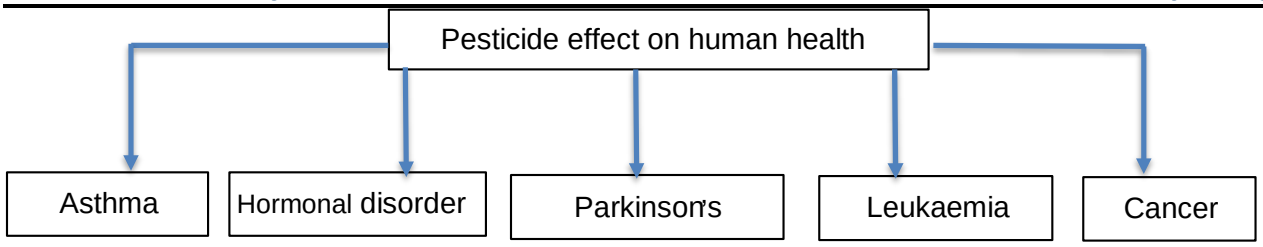

Figure 3 showing the diseases associated with the use of pesticide

Cancer

Many studies have investigated the impact of pesticide exposure on cancer risk. Associations have been found with leukaemia, lymphoma, brain cancer, kidney cancer, breast cancer, pancreatic cancer, liver cancer, lung cancer, and skin cancer. This increased risk occurs both at home and in occupational exposure. Cancer rates are being shown to increase among agricultural workers who use these chemicals. Occupational exposure of the mother to pesticides during pregnancy increases her baby's risk of developing leukaemia, Wilms' tumor, and brain cancer. Pesticide exposure in-home and outdoor herbicides have been linked to blood cancer in children.

Asthma

Numerous epidemiological studies have found a link between asthma symptoms, bronchial hyperreactivity, and pesticide exposure. The bronchial mucosa can be directly harmed by several pesticides, causing the airway very susceptible to allergens or other stimuli. By increasing bronchial hyperresponsiveness, pesticides may raise the likelihood of developing asthma, aggravate an existing asthmatic condition, or even initiate asthma attacks.

Hormonal disorder

Some pesticides may interfere with female hormone function, which would have a detrimental impact on the reproductive system. Several studies focused on estrogen and androgen receptor interference. Most pesticides containing organophosphorus compounds strike the male reproductive system through mechanisms such as decreasing sperm activity (e.g., number, motility, viability, and density), inhibiting sperm production, decreasing testicular weight, and damage to sperm DNA.

Precautions while working with Pesticides

Almost all pesticides are poisonous to humans and other animals, however their levels of toxicity vary. Therefore, using pesticides improperly or excessively might be dangerous for both humans and the domesticated animals they keep. Humans' skin and respiratory systems become irritated by pesticides. Therefore, appropriate precautions must

be taken to protect those using pesticides. Pesticides can enter the body by ingestion, absorption through the skin, and absorption through the eyes.[8] It's crucial to cover as much of the body as you can because the skin often receives the greatest exposure. Before opening the pesticide bottle, make sure you're wearing the necessary protective equipment as specified on the label.

Table 4. shows Do's and Don'ts while handling pesticides.

Do's	**Don'ts**
Read all the instructions carefully prior application of pesticide.	Do not use pesticides in excessive quantity. Using pesticides in small amounts is advisable to prevent damage to the environment.
Wear gloves and goggles to prevent any damage to eyes and skin while handling pesticides.	Never use a pesticide which is labelled "for outdoor use only" inside the house.
Preparation of pesticides should be done outside or in ventilated areas.	Do not store Pesticide in house Premises.
After the application of pesticides, wash hands prior eating.	Do not eat or drink during the application of pesticide.
Proper disposal is mandatory after the use of pesticide.	Do not spray pesticide during windy conditions.
Personal accessories such as toys, clothing or tool should be removed from the sprayed area to prevent contamination.	Don not apply pesticides on very hot days (90°F) as the chemical ingredients can vaporize and flow onto non-target surfaces.

CONCLUSION

Pesticides have been developed to prevent, eliminate, or control harmful pests, but many studies have raised concerns about the risks of pesticides to the environment and to human health. Available evidence suggests that most of these exposures occur in mixtures of several chemicals, and the life-threatening effects of these exposures are unknown, especially over long periods of time. Improving the accuracy of pesticide dosing, along with an enhanced safety

profile, is important to eliminate potential serious effects on human health and the environment. One must also concentrate on determining which type of chemical or formulation is best for ecological pest management. Therefore, it is recommended that natural biological agents be employed in agriculture, such as beneficial bacteria, viruses, insects, and nematodes. In addition, greater effort has to be made in research, product creation, and product testing, evaluation, the use of pesticides, and the promotion of pesticide awareness by both the public and commercial sectors, including government agencies, NGOs, and manufacturers.

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