

## CHAPTER 6. ADEQUACY OF THE DATABASE

Section 104(i)(5) of CERCLA, as amended, directs the Administrator of ATSDR (in consultation with the Administrator of EPA and agencies and programs of the Public Health Service) to assess whether adequate information on the health effects of DDT, DDE, and DDD is available. Where adequate information is not available, ATSDR, in conjunction with NTP, is required to assure the initiation of a program of research designed to determine the health effects (and techniques for developing methods to determine such health effects) of DDT, DDE, and DDD.

Data needs are defined as substance-specific informational needs that if met would reduce the uncertainties of human health assessment. This definition should not be interpreted to mean that all data needs discussed in this section must be filled. In the future, the identified data needs will be evaluated and prioritized, and a substance-specific research agenda will be proposed.

### 6.1 INFORMATION ON HEALTH EFFECTS

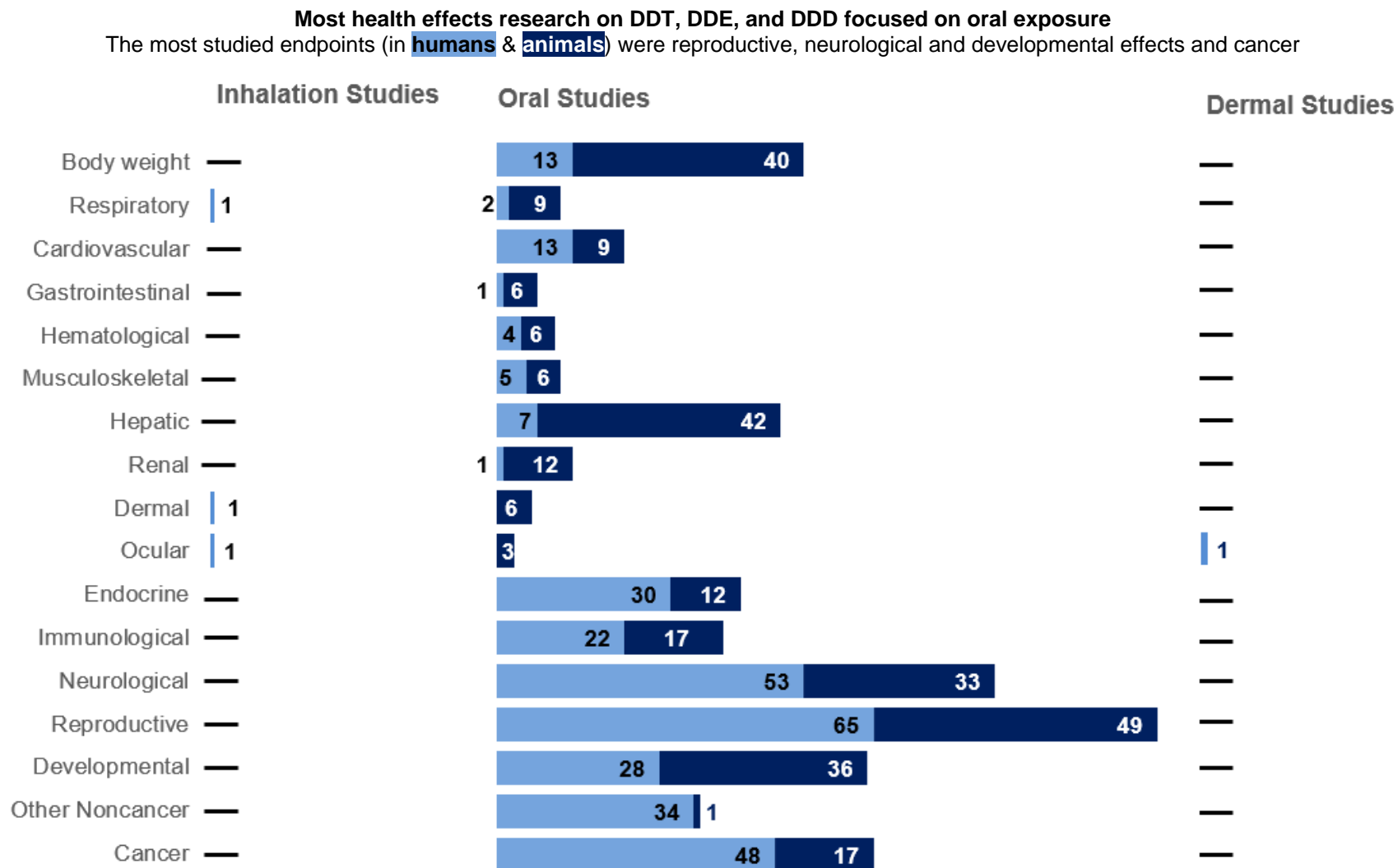
Studies evaluating the health effects of inhalation, oral, and dermal exposure of humans and animals to DDT, DDE, and DDD which are discussed in Chapter 2 are summarized in Figure 6-1. The purpose of this figure is to illustrate the information concerning the health effects of DDT, DDE, and DDD. The number of human and animal studies examining each endpoint is indicated regardless of whether an effect was found and the quality of the study or studies.

As illustrated in Figure 6-1, most of the data on the toxicity of DDT, DDE, and DDD come from epidemiology studies with a presumed oral route of exposure and from oral exposure studies in laboratory animals. A small number of studies have examined toxicity following inhalation or dermal exposure. Most of the oral exposure studies examined reproductive, neurological, cancer, and developmental endpoints.

### 6.2 IDENTIFICATION OF DATA NEEDS

Missing information in Figure 6-1 should not be interpreted as a “data need”. A data need, as defined in ATSDR’s *Decision Guide for Identifying Substance-Specific Data Needs Related to Toxicological Profiles* (ATSDR 1989), is substance-specific information necessary to conduct comprehensive public health assessments. Generally, ATSDR defines a data gap more broadly as any substance-specific information missing from the scientific literature.

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**Figure 6-1. Summary of Existing Health Effects Studies on DDT, DDE, and DDD By Route and Endpoint\***

\*Includes studies discussed in Chapter 2; the number of studies include those finding no effect; many studies examined more than one endpoint.

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**Acute-Duration MRLs.** Information on health effects following acute inhalation of DDT, DDE, or DDD in humans (Neal et al. 1944) was limited. Because of the lack of adequate inhalation data in humans or animals, an acute inhalation MRL for DDT, DDE, and DDD was not derived. Additional inhalation data are needed to identify critical targets of toxicity and evaluate concentration-response relationships.

With acute oral exposure to high doses, the nervous system appears to be the major target in both humans and animals. Acute oral exposure has been associated with tremors or convulsions in humans (e.g., Hsieh 1954; Velbinger 1947a, 1947b) and animals (e.g., Hong et al. 1986; Matin et al. 1981). An acute MRL for DDT, DDE, and DDD was based on neurobehavioral effects observed in adult mice following acute perinatal exposure to technical DDT (Eriksson et al. 1990a, 1990b, 1992, 1993; Johansson et al. 1995, 1996; Talts et al. 1998). Further acute oral exposure studies during critical windows of embryonic, fetal, or neonatal development in species may provide confirmatory evidence. Also of interest would be comparison of the neurodevelopmental toxicity of different isomers of DDT, DDD, and DDE. Of most interest would be studies on the isomer, *p,p'*-DDE, detected at the highest concentrations in environmental media, human tissues and fluids, and foods.

**Intermediate-Duration MRLs.** A single study of volunteers repeatedly exposed to oral doses up to 0.5 mg technical DDT/kg/day reported no effects on body weight, cardiovascular performance (e.g., blood pressure, heart rate), liver function tests, or self-reported neurological symptoms (Hayes et al. 1956). Numerous animal studies have evaluated the oral toxicity of DDT, DDE, or DDD and their related isomers following intermediate-duration exposure. These studies examined a wide range of potentially sensitive targets. The most sensitive outcomes were hepatic, reproductive, developmental, immunological, and neurological effects. A provisional intermediate-duration oral MRL was derived based on hepatic toxicity (hepatocellular hypertrophy) in rats fed *p,p'*-DDT for 26 weeks (Harada et al. 2003, 2006).

Additional inhalation data are needed to identify critical targets of toxicity and evaluate concentration-response relationships.

**Chronic-Duration MRLs.** Human data suitable for deriving chronic-duration MRLs are not available. At least 35 animal studies have evaluated the chronic oral toxicity of DDT, DDE, or DDD and their related isomers. These studies examined a wide range of potentially sensitive target and provide data suitable for deriving a provisional chronic-duration oral MRL. The most sensitive effects appear to be

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hepatic, body weight, developmental, hematological, and neurological outcomes. Liver effects were selected as the critical effect, because the lowest LOAEL was for liver effects and extensive supporting data support it as the most sensitive effect. A chronic-duration oral MRL was derived based on hepatocellular hypertrophy in rats fed *p,p'*-DDT for 2 years (Harada et al. 2003, 2006).

No chronic-duration inhalation toxicity studies in animals that could be used to establish concentration-response relationships were located; these data are needed for derivation of a chronic-duration inhalation MRL.

The derivation of acute, intermediate, or chronic oral MRLs based on human epidemiological data might be possible with additional research to develop and validate a human PBPK model that could reliably estimate oral intake levels from levels of DDT, DDE, or DDD in biological fluids or tissues. To date, limited but consistent epidemiological evidence has been provided for associations with risks for a few noncancer health outcomes (abortion or preterm births, wheeze in infant or child offspring, and DM2 in adults).

**Health Effects.** Toxicity studies of laboratory animals exposed by the inhalation or dermal routes are very small in number. Air monitoring data suggest that DDT and its metabolites are still present decades after its use was banned. Health effect studies are needed to evaluate possible health effects associated with long-term exposure to low concentrations of DDT in air.

Numerous epidemiological studies have examined possible associations between levels of DDT, DDE, or DDD in samples of biological fluids or tissues and a wide array of health outcomes. To date, consistent epidemiological evidence for positive associations (across studies) was provided for only a few health outcomes (abortion or preterm births, wheeze in infant or child offspring, DM2 in adults, and liver cancer).

In contrast, numerous studies of laboratory animals orally exposed to DDT, DDE, or DDD for acute, intermediate, and chronic durations and a few controlled-exposure studies of volunteers have identified several sensitive toxicity targets. For each of these toxicity targets, additional research comparing the potency of the various isomers and pertinent mixtures in various short-term *in vivo* or *in vitro* test systems may lead to refinements of the current MRLs, which are assumed to be applicable to exposure to any of the isomers or their mixtures.

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**Hepatic.** Recent mechanistic studies in rats indicate that *p,p'*-DDT initially induces (presumably through activation of the *CAR*) liver microsomal xenobiotic metabolizing enzymes and transient bursts in DNA synthesis and cell proliferation that lead to increased liver weight, hypertrophy, eosinophilic abnormal hepatic foci, and eventually liver tumors (Harada et al. 2003, 2006, 2016). Additional similar research with other isomers and other species may provide useful information to evaluate the relevance of DDT-induced liver effects in rodents to humans. Studies with micro-dissected liver tissues or liver tissue culture systems may be particularly useful, especially for cross-species extrapolation issues.

**Neurological and Neurodevelopmental.** Neurological symptoms such as tremors from relatively high oral doses of DDT and DDE isomers or mixtures like technical DDT have been observed in acutely exposed human adults and laboratory animals after acute, intermediate, or chronic oral exposure, but limited evidence indicates that this response does not occur in laboratory animals exposed to DDD (NCI 1978). Brain chemistry changes have been associated with these high-dose symptoms in adult laboratory animals (Hong et al. 1986; Hrdina et al. 1973; Hudson et al. 1985; Hwang and Van Woert 1978; Tilson et al. 1986), but brain neurochemical changes and behavioral changes have been observed after acute exposure to a very low dose of technical DDT (0.5 mg/kg/day) on PND 10, but not on PND 3 or 18 (Eriksson and Nordberg 1986; Eriksson et al. 1990a, 1990b, 1992, 1993; Johansson et al. 1995, 1996). As discussed for the acute-duration MRL data needs, additional acute oral exposure studies during critical windows of embryonic, fetal, or neonatal neurodevelopment using different isomers (e.g., *p,p'*-DDE) or mixtures or species may be informative.

**Reproductive and Developmental Reproductive.** Epidemiological studies examining possible associations between levels of DDT, DDE, or DDD in biological fluids or tissues and a wide array of reproductive health outcomes have provided inconsistent evidence for associations or no evidence for association, except for studies providing consistent evidence of increased risk for abortions or preterm births in women with elevated levels of biomarkers (Korrick et al. 2001; Longnecker et al. 2005; Ouyang et al. 2014; Torres-Arreola et al. 2003; Venners et al. 2005; Wood et al. 2007). Further case-control studies in regions where DDT continues to be used for insect control may be useful to better determine if increased risk for abortions or preterm birth is a human health outcome associated with DDT exposure. Studies of mature and developing laboratory animals orally exposed to DDT, DDE or DDD have reported effects on reproductive endpoints at dose levels  $\geq 5$  mg/kg/day. Additional reproductive toxicity animal studies are not

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needed, because reproductive effects in laboratory animals appear to be less sensitive effects from DDT, DDE, or DDD exposure than liver and neurodevelopmental effects.

**Immunological.** Epidemiological studies provided consistent evidence for associations between levels of DDE in cord blood or maternal serum during pregnancy and prevalence of wheeze (or airway obstruction) in infant or child offspring (Gascon et al. 2012; 2014; Hansen et al. 2016; Sunyer et al. 2005, 2006), but inconsistent evidence for associations with prevalence of asthma, blood levels of biomarkers associated with asthma, and prevalence of infections in offspring (Cupul-Uicab et al. 2014; Dallaire et al. 2004; Dewailly et al. 2000; Gascon et al. 2012; Glynn et al. 2008; Hansen et al. 2014; Jusko et al. 2016a, 2016b; Sunyer et al. 2006, 2010) and associations between serum levels of *p,p'*-DDE or *p,p'*-DDT and immune function biomarkers or immune-related conditions (Cooper et al. 2004; Miyake et al. 2011; Vine et al. 2001) and children (Karmaus et al. 2001, 2003, 2005a, 2005b; Meng et al. 2016; Perla et al. 2015). Suppression or stimulation of various immune responses have been observed in mature laboratory animals exposed for intermediate durations to dietary doses of technical DDT, *p,p'*-DDT, *p,p'*-DDE, *p,p'*-DDD, or *o,p'*-DDD ranging from about 2 to 20 mg/kg/day (Banerjee 1987a, 1987b; Banerjee et al. 1986, 1995, 1996, 1997a, 1997b; Hamid et al. 1974; Gabliks et al. 1975; Koner et al. 1998; Rehana and Rao 1992; Street and Sharma 1975). Additional studies of immune endpoints in laboratory animal offspring following gestational or early postnatal exposure may be useful to determine the relative sensitivity of developmental immune system effects, compared with liver and neurodevelopmental effects.

**Metabolic/DMT2 (Other Noncancer).** Numerous epidemiological studies provided consistent evidence for associations between serum levels of DDT, DDE, or DDD and DMT2 in adults (e.g., Evangelou et al. 2016; Fakhri et al. 2017; Lee et al. 2010, 2011b; Rignell-Hydbom et al. 2009; Tang et al. 2014; Taylor et al. 2013; Turyk et al. 2009; Wu et al. 2013). Results from a few mechanistic laboratory animal studies provided limited evidence for perturbations of energy metabolism and homeostasis from exposure to *p,p'*-DDE (Howell et al. 2014, 2015) or gestational and early life exposure to a mixture of *p,p'*-DDT and *o,p'*-DDT and chronic exposure to a high-fat diet (La Merrill et al. 2014a, 2014b). Additional research to better characterize DDT-, DDE-, or DDD-induced perturbations of energy-metabolism homeostasis (e.g., dependence on dose levels, duration of exposure, or critical windows of development) may be useful to better determine: (1) if exposure to DDT, DDE, or DDD is an important risk factor in the development

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of DMT2 and (2) the relative sensitivity of DDT-induced energy-metabolism perturbations, compared with liver and neurodevelopmental effects.

**Cancer.** Numerous epidemiological provide inconsistent evidence for associations, or consistent evidence for no association, between DDT, DDE, or DDD levels in biological fluids or tissue and increased risk for many types of cancer. In contrast, several epidemiological studies provide consistent evidence for association with increased risk of liver cancer, particularly in groups with relatively high levels of DDT, DDE, or DDD biomarkers (Cocco et al. 2000; McGlynn et al. 2006; Persson et al. 2012; Zhao et al. 2012). Chronic oral exposure of laboratory rats and mice to DDT, DDE or DDD has produced increased incidence of liver tumors in multiple studies and lung tumors in a few studies. Mechanistic studies in rats indicate that *p,p'*-DDT initially induces (presumably through activation of the *CAR*) liver microsomal xenobiotic metabolizing enzymes and transient bursts in DNA synthesis and cell proliferation that lead to increased liver weight, hypertrophy, eosinophilic abnormal hepatic foci, and eventually liver tumors (Harada et al. 2003, 2006, 2016). Additional mechanistic research with other isomers and liver tissues from other species (including human tissue) may help to better determine the relevance of the observed rat liver tumors to humans.

**Epidemiology and Human Dosimetry Studies.** Considerable epidemiological research has been conducted within the past 15–20 years to examine possible associations between levels of DDT, DDE, or DDD (and other persistent halogenated chemicals) in samples of biological fluids or tissues and a wide array of health outcomes. To date, consistent epidemiological evidence for positive associations (across studies) was provided for only a few health outcomes (abortion or preterm births, wheeze in infant or child offspring, DMT2 in adults, and liver cancer). Further epidemiological studies in geographical regions where DDT continues to be used for insect control may be useful to better determine if increased risk for these adverse health outcomes are associated with biomarkers of DDT exposure.

**Biomarkers of Exposure and Effect.** Levels of DDT, DDE, and DDD in biological fluids and tissues are widely used as biomarkers of exposure. Additional research is needed to develop and validate a human PBPK model that could reliably estimate oral intake levels from internal levels of DDT, DDE, or DDD in biological fluids or tissues.

**Absorption, Distribution, Metabolism, and Excretion.** The ADME and toxicokinetic properties of DDT, DDE, and DDD are well characterized. However, there are limited data to evaluate potential

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toxicokinetic differences associated with obesity or diabetes. These data would be useful given the associations between DDT/DDE exposure and obesity and DM2. Development, calibration, and application of animal and human PBPK models to extrapolate human intake levels from animal intake levels could decrease toxicokinetic uncertainties in the current MRLs, which are based on laboratory animal points of departure (PODs). A calibrated PBPK model for pregnant rats and fetuses has been developed by You et al. (1999c). The development of a similar model for pregnant mothers or nonpregnant humans is limited by the lack of suitable kinetics data for adult humans, human mother-fetus pairs or human mother-infant pairs to calibrate the model. As discussed earlier, the development of a human PBPK to predict intake levels from internal DDT, DDE, or DDD metrics also could aid in exploring the use of dose-response data from epidemiological studies to derive MRLs.

**Comparative Toxicokinetics.** The metabolism of DDT, DDE, or DDD in animals is similar to that in humans, but observed interspecies metabolic differences suggest that interspecies differences in susceptibility to the neurotoxicity or hepatotoxicity of these chemicals may exist. Comparisons of elimination rates of DDT from fat showed that the process is faster in rats followed by dogs and monkeys and slowest in humans (Morgan and Roan 1974). Rats eliminated DDT 10–100 times faster than humans. Morgan and Roan (1974) suggested that the differences in elimination rates could be due to differences in liver metabolism, gut bacterial metabolism, enterohepatic recirculation, or factors related to the accessibility of plasma-transported pesticide to the excretory cells of the liver. Some of this information could be useful to the development of a human PBPK model for DDT, DDE, or DDD.

**Children's Susceptibility.** There is little evidence about whether children or young animals differ from adults in their susceptibility to the toxicity of DDT, DDE, or DDD. Some animal studies found that young rats are less susceptible than older ones to the acute neurotoxic effects produced by a single dose of DDT, but the relevance of these findings to humans is unknown (Lu et al. 1965). Studies in animals have shown that DDT and related compounds can alter the development and maturation of the male and female reproductive system, but these effects have generally been observed at higher exposure levels than liver or neurodevelopmental effects (Bitman and Cecil 1970; Clement and Okey 1972; DUBY et al. 1971; Gellert et al. 1972; Gray et al. 1999; Kelce et al. 1995, 1997; Loeffler and Peterson 1999; Singhal et al. 1970; You et al. 1998, 1999a). There is evidence that acute perinatal exposure of mice to technical DDT at a critical developmental window (PND 10) results in altered behavioral responses measured in adulthood (Eriksson et al. 1992, 1993; Johansson et al. 1995, 1996; Talts et al. 1998). Additional acute oral exposure studies during critical windows of embryonic, fetal, or neonatal neurodevelopment using



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different isomers (e.g., *p,p'*-DDE) or mixtures or species are needed to better understand the effects of DDT, DDE, and DDD on early life neurodevelopment.

There are no adequate data to evaluate whether pharmacokinetics of DDT in children are different from adults. DDT and analogues can cross the placenta and are transferred to offspring via breast milk. It is unknown whether the efficiency of gastrointestinal absorption of DDT and analogues in nursing neonates differs from adults and what influence the fat content of human milk might make. Further information on the kinetics of DDT, DDE, or DDD during pregnancy and lactation would be useful. Important information was published on estimates of body burden of DDE that result from nursing by using a model that incorporates a wide array of variables (LaKind et al. 2000). The only calibrated PBPK model for DDT is that of You et al. (1999b), which focuses on pregnant and lactating Sprague-Dawley rats. There is no information to evaluate whether metabolism of DDT is different in children than in adults since the specific phase I and II enzymes involved in DDT metabolism have not been identified.

**Physical and Chemical Properties.** The physical and chemical properties of *p,p'*-DDT, DDE, and DDD are well described in the literature although there are some gaps in data for the *o,p'*- isomers (see Table 4-2). The *p,p'*- isomers are those of primary environmental concerns and the data available are sufficient to allow estimation of the environmental fate of DDT, DDE, and DDD.

**Production, Import/Export, Use, Release, and Disposal.** Since the banning of DDT in the early 1970s in the United States, there has been little information published on the production of DDT. DDT is no longer produced in the United States or in most countries in the world. The most recent information indicates that it is produced in at least two countries, and is used in some underdeveloped countries for vector control. However, data would be useful on the production and use of DDT worldwide. This type of information is important for estimating the potential for environmental releases from various uses, as well as estimating the potential environmental burden. In turn, this would provide a basis for estimating potential exposure and public health risk.

Disposal information is equally important for determining environmental burden and areas where environmental exposure may be high. Although disposal methods for DDT and its metabolites are reported to a limited extent, no current information on disposal sites and quantity disposed was located. Information on how the current users (e.g., hazardous waste clean-up crews) wash DDT equipment and dispose of the remaining waste would be helpful for estimating potential environmental and human exposure.

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**Environmental Fate.** DDT, DDE, and DDD released to the environment may be transported from one medium to another by the processes of solubilization, adsorption, bioaccumulation, or volatilization. The transport of DDT, DDE, and DDD between environmental compartments has been predicted mostly from their physical and chemical properties. Volatilization and adsorption account for loss of DDT and its metabolites from surface water and soil. Monitoring studies indicate that DDT and its isomers and metabolites are extremely persistent in soil (EPA 1986) and substantiate their predicted environmental fate. DDT, DDE, and DDD are highly lipid soluble. This, combined with their extremely long persistence, contributes to bioaccumulation of DDT and its metabolites in freshwater and marine life. Limited data were located on the soil degradation rates of DDT and its metabolites. Data are available for disappearance rates including losses due to transport processes. While adequate data are available on the time for the disappearance of 50% of the DDT initially applied to a variety of soils, there is abundant evidence that subsequent declines in DDT in soil occur at a much slower rate largely due to an aging process. More data on the biodegradation rates of DDT and its metabolites as well as how soil properties and aging affect these rates would be useful. Experimental information characterizing the environmental fate of DDT, DDE, and DDD, particularly on those properties that govern transport to air, would be helpful to further confirm their predicted environmental behavior and potential human exposure.

**Bioavailability from Environmental Media.** Limited information was located regarding the bioavailability of DDT, DDE, and DDD from environmental media. It has been shown that the bioavailability of DDT in soil declines with time (Alexander 1995, 1997; Robertson and Alexander 1998) and soil properties that influence the bioavailability of DDT and its toxicity to certain organisms have been studied (Peterson et al. 1971). More information regarding the aging process of DDT in soil and its effect on bioavailability would be helpful in identifying potential routes of human exposure. It is known that fish and some plants bioaccumulate these compounds and that those who consume these fish and plants will incur some exposure to these compounds. However, because of universal body burdens of these compounds, the relative contribution of any particular medium, especially soil and sediment, is not clearly understood. Even if DDT, DDE, and DDD concentrations in various media are known, the difference between the exposure level and the absorbed dose is still unknown.

**Food Chain Bioaccumulation.** Information was located regarding food chain biomagnification of total DDT in the arctic marine food web (Hargrave et al. 1992). Extensive monitoring of fish populations has been performed and a bioconcentration factor in fish is available. The steady-state BCF in rainbow trout was reported as 12,000, suggesting that bioconcentration in aquatic organisms is very high (Oliver

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and Niimi 1985). Although DDT has been detected in plants and vegetables, root uptake of DDT is considered low (Fuhremann and Lichtenstein 1980). A clearer understanding of the potential for bioaccumulation would aid in determining how levels in the environment affect the food chain and potentially influence human exposure levels. This type of information could be obtained by studying accumulation of these compounds in organisms from several trophic levels.

**Exposure Levels in Environmental Media.** Information on environmental levels of DDT, DDE, and DDD are abundant for the 1970s and 1980s (Blus et al. 1987; Carey et al. 1979b; Crockett et al. 1974; Ford and Hill 1990; Hargrave et al. 1992; Lichtenberg et al. 1970; Stanley et al. 1971). Subsequent monitoring data have been more limited in scope (Aigner et al. 1998; McConnell et al. 1998; Monosmith and Hermanson 1996). Continuation of data collection on environmental levels would contribute to the understanding of current worldwide concentrations and trends, especially in regions where DDT is currently used in vector control for malaria and as an agricultural pesticide.

Reliable monitoring data for the levels of DDT, DDE, and DDD in contaminated media at hazardous waste sites are needed. This information on levels of DDT, DDE, and DDD in the environment can be used in combination with the known body burden of DDT, DDE, and DDD to assess the potential risk of adverse health effects in populations living in the vicinity of hazardous waste sites.

Estimates of human intake have been limited to dietary intakes based on current market basket surveys (EPA 1980; Gartrell et al. 1985, 1986a, 1986b; Gunderson 1995a). Additional information is needed relating to the levels in environmental media to which the general population is exposed, particularly at or near hazardous waste sites, and the subsequent development of health effects.

**Exposure Levels in Humans.** Data are available on levels of DDT and its metabolites in adipose tissue, blood, and milk (CDC 2018; Hovinga et al. 1992; Lordo et al. 1996; Smith 1999).

**Exposures of Children.** More data are needed on the concentrations of DDT in breast milk of exposed women and on the DDT intake of breastfed infants. In addition, the oral availability of DDT from soil and dust is lacking. Such data would allow for the estimation of the exposure of children to DDT from eating soil and dust.

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**6.3 ONGOING STUDIES**

A number of ongoing studies were identified in the National Institutes of Health (NIH) RePORTER (2017); these studies are summarized in Table 6-1.

**Table 6-1. Ongoing Studies on DDT, DDE, and DDD**

Investigator	Affiliation	Research description	Sponsor
Eskenazi, B	University of California, Berkeley	Examination of the possible association between DDT exposure and puberty onset and neurodevelopment in Mexican-American girls	NIEHS
Eskenazi, B	University of California, Berkeley	Examination of the effect of indoor residual spraying with DDT neurodevelopment in children in South Africa; the study will also examine possible interactions between DDT and pyrethroid insecticides	NIEHS
Gan, J	University of California, Riverside	Evaluation of aging of DDT in sediment on its bioavailability	NIEHS
Grandjean, P	Harvard School of Public Health	Examination of the effect of prenatal exposure to DDE on glucose metabolism in adults living in the Faroe Islands	NIEHS
Holland, N	University of California, Berkeley	Examination of possible associations between DDT/DDE exposure in children, DNA methylation, and pubertal development	NIEHS
LaMerrill, M	University of California, Davis	Examination of the effect of perinatal exposure to DDT and the risk of metabolic syndrome	NIEHS
LaMerrill, M	University of California, Davis	Examination of the effect of perinatal exposure on insulin resistance in mice	NIEHS
Longnecker, M	NIEHS	Examination of health effects associated with DDT exposure in Mexico	NIEHS
Longnecker, M	NIEHS	Examination of DDT exposure and pregnancy loss in South Africa	NIEHS
Narayan, K	Emory University	Examination possible associations between serum DDT or DDE levels and diabetes in adults in India	NIEHS
Sandler, D	NIEHS	Examination of risk or type 2 diabetes among farmer's wives participating in the Agricultural Health Study	NIEHS
Sun, Q	Harvard School of Public Health	Examination of associations between <i>p,p'</i> -DDE exposure and type 2 diabetes among participants in the Nurses' Health Study II	NIEHS

DNA = deoxyribonucleic acid; NIEHS = National Institute of Environmental Health Sciences

Source: RePORTER 2017