Regulatory Toxicology and Pharmacology 70 (2014) 363–369

Contents lists available at ScienceDirect

Regulatory Toxicology and Pharmacology

journal homepage: www.elsevier.com/locate/yrtph

Public health decisions: Actions and consequences ☆

H.R. Pohl *, D.E. Jones, J.S. Holler, H.E. Murray

Agency for Toxic Substances and Disease Registry, US Department of Health and Human Services, Atlanta GA, USA

ARTICLE INFO

Article history:
Received 11 December 2013
Available online 1 August 2014

Keywords:
Chemical regulations
Insecticides
Gasoline additives
Wood preservatives
Risk management decisions

ABSTRACT

The goal of public health is to promote the best possible health for the whole population. Public health issues are numerous and can be unbelievably complex in form, scope, and possible consequence. Most public health decisions involve assessing several different options, weighing the respective benefits and risks of those options, and making difficult decisions that hopefully provide the greatest benefit to the affected populations. Many risk management decisions involve a variety of societal factors which modify risk assessment choices. The purpose of this paper is to point out difficulties in making decisions that impact public health. The intent of such decisions is to improve public health, but as illustrated in the paper, there can be unintended adverse consequences. Such unplanned issues require continued attention and efforts for responsible officials in the protection of environmental public health. This article presents examples of such events, when in the past, it was necessary to assess and regulate a number of potentially hazardous chemicals commonly used as insecticides, gasoline additives, and wood preservatives.

Published by Elsevier Inc.

1. Introduction

Most facets of 21st century living involve complex public health issues and correspondingly difficult public health decisions. One of the more complex and perhaps least understood of these is that of exposure to hazardous chemicals. There are millions of chemicals known to man, over 100,000 currently in production (Encyclopedia of Global Change, 2001). Many have never been evaluated for toxicity. Those charged with protecting public health are often tasked with evaluating potential risks associated with various chemicals in order to set acceptable exposure standards and rules for use. Often these decisions are not straightforward. Information on toxicity may be missing or incomplete and inter- and intra-species differences in sensitivity may further complicate the interpretation of both risks and benefits. Decisions that affect public health can be difficult, not only because of their complexity, but also because they have the potential to impact both positively and negatively the well-being of a great number of people. The purpose of this paper is to point out the difficulties in making decisions that impact public health. The intent of such decisions is to improve public health, but as illustrated in the paper, there can be unintended adverse consequences.

2. Examples of chemicals in our lives and their regulation

2.1. Insecticides: dichlorodiphenyl trichloroethane (DDT)

2.1.1. Problem definition: mammalian toxicity of bio-persistent chemicals versus increased mortality from malaria that is preventable via vector (e.g., mosquitoes) control

DDT was first synthesized in 1874, but it was not until 1939 that Müller and his coworkers discovered its insecticidal properties (ATSDR, 2002). Restrictions put in place for DDT use in the 1970's (EPA, 1972) were mainly due to concerns regarding the chemical's persistence in the environment, bioaccumulation in biota and exposure-related health effects such as cancer, neurological, reproductive, and developmental effects (ATSDR, 2002). EPA assigned DDT, DDE, and DDD a weight-of-evidence classification of B2, probable human carcinogens (IRIS, 2008). Studies in humans support the conclusion that DDT and the metabolites are endocrine disruptors (ATSDR, 2002). There is sufficient information from laboratory animal studies that DDT (and the metabolites) causes reproductive and developmental effects (ATSDR, 2002). Similar reports come from observations in wildlife (Blomquist et al., 2006; Guillette et al., 1994; Hamlin and Guillette, 2010; Kolaja and Hinton, 1977).

☆ The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the Agency for Toxic Substances and Disease Registry.

* Corresponding author. Address: ATSDR, 1600 Clifton Rd.;MS-F57, Atlanta, GA 30333, USA.

E-mail address: hpohl@cdc.gov (H.R. Pohl).

http://dx.doi.org/10.1016/j.yrtph.2014.07.023
0273-2300/Published by Elsevier Inc.

Results from the National Health and Nutrition Examination Survey (NHANES) indicate that mean serum levels of DDT and DDE in the U.S. population are declining (CDC, 2012). Anderson et al. (1998) estimated that, since the 1970's, levels have declined up to ten-fold. For example, serum *p,p′*-DDT (lipid adjusted) levels in the 95th percentile of the population were 28.0 ng/g (ppb) in 1999–2000, but had dropped to 19.5 ng/g (ppb) in 2003–2004. However, occupational exposures are much higher. For example, the mean DDT serum level in a group of 26 malaria control sprayers in Brazil was 76.9 μg/L and ranged from 7.5 to 473.5 μg/L, whereas 16 unexposed workers had a mean serum level of 16.1 μg/L (range: 5.1–32.9 μg/L) (Minelli and Ribeiro, 1996). *p,p′*-DDT and *p,p′*-DDE serum levels in the exposed workers ranged from 1.6 to 62.9 and 5.9–405.9 μg/L, respectively.

DDT alternatives for fighting malaria include textile nets, impregnated with the pyrethroid insecticide permethrin, that are used on windows and doors of dwellings (Trembley, 2006). Permethrin-treated nets decreased malaria-related mortality in children by 20%. Permethrin, like all synthetic pyrethroids, kills insects by strongly exciting their nervous systems (ATSDR, 2001a). The mode of action is similar to that of DDT, and permethrins display a large variety of mammalian toxicity, as well. New methods for malaria control such as transmission-blocking vaccines and genetically modified mosquitoes are being developed (Ito et al., 2002; Richie and Saul, 2002); however, their usefulness has been questioned. Alternative environmental modification programs to eradicate mosquito larvae have also been investigated (Chanon et al., 2003; Guimaraes et al., 2007). They include methods such as intermittent irrigation in agriculture, removal of emerging vegetation to eliminate mosquito breeding sites, or introduction of larvicidal biological agents (e.g., bacteria, fungi, and some algae).

The use of DDT has eradicated malaria in different parts of the world (Najera et al., 2011).

However, with restrictions on DDT use in place, the global malaria control policy changed in favor of methods utilizing adulticides (i.e., insecticides killing adult mosquitoes) with domestic preferences to less toxic and less effective chemicals. Following the change, the incidence of malaria increased. A clear causal link between decreased spraying of homes with DDT and increased malaria was reported in South America (Roberts et al., 1997). According to the WHO, there were 300–500 million clinical cases of malaria each year resulting in 1.5–2.7 million deaths – mostly in sub-Saharan Africa (Hileman, 2006; IDRC, 1996). More than half of the deaths were children. Since 1972, malaria has killed over 50 million people worldwide. The effectiveness of DDT was demonstrated in South Africa which used DDT and found that malaria cases were kept very low (Hileman, 2006). In 1996, South Africa switched to other pesticides and the incidence of malaria rose sharply thereafter. In December 2000, South Africa approved a ruling allowing for the continued use of DDT in malaria vector control as the United Nations Environment Program concluded the negotiations on 12 persistent organic pollutants (POPs) (MFI, 2000). The program decided that DDT can still be used for spraying interior walls in regions where malaria is a problem (SCPOP, 2001). The US EPA participated in those negotiations. In September 2006, the World Health Organization (WHO) declared its support for the indoor use of DDT in African countries where malaria remains a major health problem, citing that benefits of the pesticide outweigh the health and environmental risks (WHO, 2006). This is consistent with the Stockholm Convention on POPs, which bans DDT for all uses except for malaria control.

According to the latest WHO (2013) data, there were about 219 million malaria cases (with an uncertainty range of 154–289 million) and an estimated 660,000 malaria deaths (with an uncertainty range of 490,000–836,000) in 2010 world-wide. Increased prevention and control measures have resulted in a decrease in malaria mortality rates by more than 25% globally since 2000 and by 33% in the WHO African Region.

In addition to being effective, DDT is a relatively cheap tool to fight malaria. For example, the cost of spraying one house with DDT per year in Ecuador was estimated as $1.44 (Roberts et al., 1997). Alternative insecticides are much more costly (e.g., malathion is five times more expensive than DDT and has its own toxicity issues ATSDR, 2004). This is a major problem for developing countries with limited resources. On a greater scale, eradication of malaria brings economic growth and prosperity. When Gallup and Sachs (2001) analyzed the growth in gross domestic products per capita between 1965 and 1990, they reported that countries with substantial occurrence of malaria grew 1.3% per year less than countries with little or no malaria and that a 10% reduction in malaria was associated with 0.3% higher growth per year.

When DDT was first recognized as an environmental hazard, it was considered to be harmful to use in vector control efforts. However, with a greater understanding of both the adverse impacts and potential benefits of this chemical, those views are now changing. DDT usage is a prime example of choosing a course of action that will provide the best net benefit for adversely-affected populations in specific circumstances. These beneficial effects are now widely recognized, and DDT application in localized areas and situations has been shown to reduce morbidity and mortality from vector-transmitted diseases.

2.2. Gasoline additives: lead, methyl tert-butyl ether (MTBE), and ethanol

2.2.1. Problem definition: mammalian toxicity of gasoline additives and potential for increased environmental pollution

The evolution of the United States society in the 20 century is inextricably tied to the evolution of the automobile as a part of individual and family life. However, the necessary application of additives to gasoline in powering the automobile has resulted in a variety of challenges in the public health sector. (McGarity, 2004)

Gasoline is a mixture of organic chemicals including straight-chain alkanes, branched alkanes, cycloalkanes, aromatics (benzene less than 1% in U.S.), and alkenes (ATSDR, 1995). Although gasoline can induce a wide range of toxic effects, major discussions related to public health effects of gasoline are not about gasoline per se but about additives that serve to make gasoline a better product.

Tetraethyl lead was initially added to gasoline (from 1920's) to prevent non-uniform combustion differential that can potentially damage the engine.(Seyferth, 2003) Prior to EPA regulation of lead content in gasoline during the early 1970s, approximately 250,000 tons/year of organic lead were added to gasoline in the United States (Giddings, 1973). By 1984, combustion of leaded gasoline was responsible for approximately 90% of all anthropogenic lead emissions.

With increasing lead levels in the environment concerns about lead toxicity emerged. Neurotoxicity of lead in humans is well established and children are even more sensitive to lead toxicity than adults (ATSDR, 2007). An extensive compilation of pediatric patients identified encephalopathy at levels in the range of 90–800 μg/dL in blood (NAS, 1972); signs include hyperirritability, ataxia, convulsions, stupor, and coma. Histopathologic findings in fatal cases of lead encephalopathy in children include cerebral edema, altered capillaries, and perivascular glial proliferation. Non-fatal cases are at great risk for neurological and cognitive impairments. Renal effects, hypertension, and decreased fertility were reported at level 40 μg/dL (ATSDR, 2007). Several cross-sectional studies of asymptomatic children with relatively high lead body burdens were published in the 1970s that identified a