

**EFFECTS OF QUATERNARY AMMONIUM DISINFECTANTS  
ON  
MOUSE REPRODUCTIVE FUNCTION**

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## Exposure to common quaternary ammonium disinfectants decreases fertility in mice



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### ABSTRACT

Quaternary ammonium compounds (QACs) are antimicrobial disinfectants commonly used in commercial and household settings. Extensive use of QACs results in ubiquitous human exposure, yet reproductive toxicity has not been evaluated. Decreased reproductive performance in laboratory mice coincided with the introduction of a disinfectant containing both alkyl dimethyl benzyl ammonium chloride (ADBAC) and didecyl dimethyl ammonium chloride (DDAC). QACs were detected in caging material over a period of several months following cessation of disinfectant use. Breeding pairs exposed for six months to a QAC disinfectant exhibited decreases in fertility and fecundity: increased time to first litter, longer pregnancy intervals, fewer pups per litter and fewer pregnancies. Significant morbidity in near term dams was also observed. In summary, exposure to a common QAC disinfectant mixture significantly impaired reproductive health in mice. This study illustrates the importance of assessing mixture toxicity of commonly used products whose components have only been evaluated individually.

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### 1. Introduction

The impetus for this investigation of the effects of quaternary ammonium compounds (QACs) on reproductive performance in the laboratory mouse was changes in breeding performance in mouse colonies used by the Hunt and Hrubec laboratories. Both groups noted abrupt changes in colony productivity and reductions in maternal and fetal health that coincided with the introduction of disinfectants containing QACs, Alkyl (60% C14, 25% C12, 15%

C16) dimethyl benzyl ammonium chloride (ADBAC) and didecyl dimethyl ammonium chloride (DDAC).

QACs are commonly found in cleaning solutions used in residential, commercial and medical settings, as well as in restaurants and food production facilities. The ability to adapt and optimize QAC structure for specific functions has increased the utilization of these compounds in consumer products [1,2] and, as a result, several generations of QACs exist. The earliest QACs were benzalkonium chloride compounds that were developed as antimicrobial agents. All QACs are permanently charged ions with four alkyl side chains, and biocidal activity is conferred through alkyl chain length [3–5]. Modifications to alkyl chain length have been used to optimize cleaning and antimicrobial properties. Specifically, through substitution of aromatic ring hydrogen with chlorine, methyl, and ethyl groups to increase antimicrobial efficiency and improve detergent strength, different generations of QAC compounds have been generated. Twin-chain or dialkyl quaternary QACs represent the newest generation and exhibit a wide spectrum of activity. These new synthetic polymeric QACs contain multiple positively charged amine centers that confer antimicrobial, anti-static, and surfactant properties in solution.

QACs are often used in shampoos and laundry products to neutralize negative static charges and in cosmetics to preserve products

**Abbreviations:** QAC, quaternary ammonium compound; ADBAC, alkyl dimethyl benzyl ammonium chloride; DDAC, didecyl dimethyl ammonium chloride; DDA, dimethyl didecyl ammonium; HWS-256, disinfectant mixture of alkyl (60% C14, 25% C12, 15% C16) dimethyl benzyl ammonium chloride (ADBAC) and didecyl dimethyl ammonium chloride (DDAC); GC-MS, gas chromatography-mass spectrometry; HPLC, high-performance liquid chromatography; LC-MS, liquid chromatography-mass spectrometry; CWRU, Case Western Reserve University; WSU, Washington State University; VPI, Virginia Polytechnic Institute and State University.

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