

## Industry and Cosmetic Uses of Talc with their Implication on Health

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Talc's softness, whiteness, lamellarity, inertness and affinity for organic chemicals make it valuable for industrial and domestic applications. The largest consumers are the paper and ceramic industry; only 5% is used as cosmetics. It is also used for preserving animal feed, and a carrier for drugs, insecticides, pesticides and chemicals. Talc was introduced as baby powder in 1894 and advertised aggressively worldwide. Widespread and indiscriminate use soon raised concerns about its implications for health. The IARC found that talc containing asbestiform fibres is carcinogenic to humans, but inadequate evidence to implicate talc not-containing asbestiform fibres. Pulmonary manifestations of talc inhalation include talcosis, talcosilicosis, and talco-asbestosis. Drug-users administering talc-adulterated oral medications intravenously develop pulmonary granulomas, fibrosis and irreversible pulmonary hypertension. Worldwide reports reveal talc inhalation is fatal to infants; it coats and dries mucus membranes, causes hemorrhage, edema, desquamation of bronchial epithelium, and clogs and compromises mucociliary clearance; larger quantities completely obstruct airways. Progressive diffuse pulmonary fibrosis is a recognized sequel to massive aspiration of baby powder. IARC has classified perineal use of talcum powder as a possible ovarian carcinogen, while a recent study has found that perineal talcum powder increases the risk of endometrial cancer among postmenopausal women. There is a need to raise public awareness of the serious risks associated with the use of talcum powder and for legislation to protect the health of the uninformed who represent the poorer segment of the community, and infants and young children. The dangers associated with cosmetic use of talc outweigh any possible benefits.

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Talc (talq) is derived from the Greek word meaning pure<sup>1</sup>. It is a mineral composed of hydrated magnesium silicate with the chemical formula  $H_2Mg_3(SiO_3)_4$  or  $Mg_3Si_4O_{10}(OH)_2$ . Its natural formation starts from soapstone composed of talc, chlorite, mica, quartz, tremolite, magnetite and iron. It is the softest rock on earth, non-porous, weighs around 9 kilograms per cubic foot, does not stain, burn, or attacked by acids. Being metamorphic, soapstone gradually changes over time, in the presence of carbon dioxide and water (carbonation), from hard dense serpentine to steatite that contains 50-80 percent talc. This more coarse-grained soapstone finally metamorphoses to pure talc. Some 7.052 million tonnes of talc is mined annually worldwide. Currently, after China, the world's largest talc-producing countries are the U.S., India, Finland, Brazil and France. Talc de Luzenac, part of Rio Tinto's Luzenac Group operates the world's largest talc mine in southwest France. Other producers are Spain, Australia, Austria, Italy, Russia, and Democratic Republic of Korea<sup>2</sup>.

### Industrial Uses of Talc

The five characteristics that make talc a valuable mineral for industrial and domestic applications are first its softness – that makes it valuable to industry; second, its chemical inertness, third, its lamellarity, fourth, its whiteness, and fifth is its affinity for organic chemicals<sup>3</sup>. Talc has been used since antiquity; the ancient craftsmen of Mohenjo-Daro and Harappa engraved seals with representations of animals and mythological figures, and created sculptures, vessels and bosses from steatite 5000 years ago. They subjected their work to heat to generate a hard, white lustrous, enameled surface. The incredible carvings in stone at Belur, Halebid and Sravanabelagola, India that date to 1100AD attest to the remarkable, workable, and durable qualities of talc<sup>4</sup>.

The largest current consumer of talc is the paper industry that that mixes talc with pulp for making its product. The talc acts as a filler that adds whiteness,

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smoothness and opacity to the paper. Another major user is the ceramic industry where talc is used for glazing and to give ceramic its shape and shine. Tiles, dinnerware, porcelain and electrical insulation are made with talc. Talc constitutes up to 65 percent of the composition of ceramic wall tiles. The construction industry also uses talc as a component in asphalt roofing and paint. It is also used in chewing gum-dusting, rubber-dusting and textile-filler. Talc is used in many general articles including powder, cosmetics, soap and in the manufacture of pill coating. Talc enhances the properties of plastic by improving hardness, tensile strength, stiffness, impact absorption, stability, electrical insulation, and the ability to resist chemicals and heat. As a good insulator, talc reduces energy loss from electrical devices. Talc helps give rubber its bounce and prevents stickiness. With its high heat resistance and bonding qualities, talc makes automobile rubber hoses less permeable. It is also used in the textile industry for loading and bleaching certain types of cotton goods. Talc's resistance to chemical acids and bases make it the ideal for counter tops used in laboratories, schools and factories<sup>5</sup>.

#### **Farming & Domestic uses of Talc**

The farming industry uses talc to help preserve cattle feed. Talc forms an anti-caking wrap that prevents moisture from entering or leaving the feed. Talc's inertness makes it an ideal carrier for drugs, insecticides, pesticides and chemicals. It limits bacterial growth by keeping products such as pills and fertilizers dry. It is sprinkled over food grains in godowns to prevent infestation from insects and pests, and helps reduce the bacteria in the animal feed troughs. Talc is used as smooth filler for walls and many other products. Talc's softness, adhesive qualities, and resistance to chemical acids and bases make it ideal for making putties, pencils, crayons, and tailor's chalk<sup>6</sup>.

#### **History of cosmetics and birth of talcum powder**

Animals including elephants love to roll in the mud before drying their bodies or alternatively, spray

themselves with dirt, as part of their body care ritual. Likewise, man has, since before the start of recorded history, used powders of various sorts for cosmetic purposes. Archeological evidence at Khuzestan reveals that Persian women used powder (sefidab) to lighten their skin 2000 – 4500 years BC<sup>1</sup>. In China, cosmetic powder derived from rice has been in vogue for face-painting since 500 BC; later pearls and costly spices were introduced. The Chinese empress, Wu Ze Tian (625 AD – 705 AD), applied pearl cream on her skin and regularly took pearl powder internally. At the age of 65 years, her skin was said to be as beautiful as that of a young woman.

In ancient Egypt and Rome, unaware of their dangerous consequences, women often used cosmetics containing mercury and white lead. Following the conquest of the Middle East and Persia, the use of cosmetics was tolerated by the Muslims, as long as these were not harmful. But in Middle Ages Europe, wearing makeup was considered a sin by the Church. During the Renaissance that followed, paleness of the skin was associated with the aristocracy that avoided exposure to the sun. Consequently, European women and even men resorted to lightening their skin to appear upper class. Many of the cosmetics they used may have contained white lead and arsenic that sometimes caused poisoning and death. Queen Elizabeth I of England, the "Virgin Queen" was a well-known user of white lead that she used to create her "Mask of Youth"<sup>7</sup>. The practice of using of pearl powder started becoming popular in Europe in the 1800's. Pearl powder continues to be used as a skin-lightener by modern Chinese and European women.

#### **Birth of talcum baby powder and the cosmetic industry**

A doctor consulted Johnson & Johnson (J&J) in 1890 concerning a patient who had developed skin irritation from one of their medicated plasters. In response, the company director, Dr Kilmer sent him some Italian talcum powder to be applied to the affected area. As this worked well, J&J began including talc with many of its plaster mixes, which in turn led to the

discovery that it also alleviated diaper rash. Because of demand, a retail version of Johnson's® Baby Powder was developed in 1894<sup>8</sup>. With the rapid growth of the advertising industry following World War I, Johnson & Johnson advertised their Baby Powder with the largest advertisement campaign in its history. This resulted in the baby powder and the company's other baby products taking off<sup>9</sup>. Baby powder was then promoted world-wide. Make-up became fashionable during the early part of the twentieth century in the United States of America and Europe due to the influence of ballet, theatre, and movie personalities. But it was the power of advertisement that brought about the explosion of the cosmetic industry. The ingredients of Johnson's® baby powder are talc, perfume, benzyl benzoate, benzyl alcohol, coumarin, citronellal, geraniol, benzyl alcohol, limonene, linalool, and benzyl salicylate.

Following widespread use, concerns have been raised about the possible health risks associated with the use of talc that needs to be addressed.

#### Assessment of Health Risk for Talc

In March 1992, the Office of Health and Environmental Assessment, U.S. Environmental Protection Agency studied the safety of talc and released their Health Assessment Document for Talc<sup>10</sup>. The following is a summary of their findings: the largest use of soft talc is in manufacture of ceramics and paint; only 5% is used in cosmetics.

The National Occupational Hazard Survey (NOHS, 1976) conducted by the National Institute for Occupational Safety and Health reported that 1,536,754 workers were potentially exposed to talc in 1972–74, while the Institute's National Occupational Exposure Survey (NOES, 1984) estimated that 18,872 workers, including 5,244 females were potentially exposed in the workplace in 1980.

#### Results of talc inhalation studies on animals

Following single inhalation exposures, it was found that talc is retained in the lungs of exposed hamsters. Talc clears slowly because it has a biological half-life of 7 to 10 days. The talc content decreases to control animal levels 4 months after exposure. Pulmonary deposition of talc following repeated exposure is dose dependent. Pulmonary clearance is by mucociliary activity and talc is eliminated in the faeces, with little, if any, absorption within 1 to 2 days of dosing. Talc deposition, retention, and clearance have not been adequately studied in humans.

Intra-tracheal instillation of talc in hamsters results in pulmonary toxicity as shown by biochemical and cellular changes. It results in typical granulomatous lesions consisting of dust-laden multinucleated foreign body giant cells, as well as some fibrosis with collagen formation in several animal species. Subchronic inhalation exposure (3 to 12 months) in rats results in pulmonary fibrosis that increases in severity as the exposure period increases. Chronic exposure by the intratracheal route results in dust-laden macrophage aggregation and accumulation of interstitial cells and histiocytes with some accumulation of proteinaceous exudates within the alveoli. No fibrosis or granuloma is observed. Talc alone causes moderate tissue destruction, slight metaplasia in the tracheobronchial region and moderate hyperplasia in the alveolar region. Limited data suggest talc is not carcinogenic following inhalation exposure in rats and hamsters, but one study suggests it may be a co-carcinogen following intratracheal administration in combination with benzo(a)pyrene once weekly for life.

Several cross-sectional morbidity studies of miners and millers from New York, Montana, Texas, North Carolina, and Vermont mines indicate increased respiratory symptoms, higher prevalence of pleural thickening or calcification and pneumoconiosis, and

decreased pulmonary function in workers exposed to talc containing various amounts of tremolite, anthophyllite, or silica fibers. The effect increases with the age of the workers, intensity of smoking, and duration of exposure. However, exposure to talc free of asbestiform fibers is associated with less pronounced effects.

#### **Intravaginal, intrauterine, and intraperitoneal instillation of talc in animals**

In rats, intravaginal and intrauterine instillation results in migration of talc particles into the ovaries but not in cynomolgus monkeys. Intraperitoneal administration has been shown to cause abdominal adhesions in rats and swine. In another study on rats, foreign-body granuloma with adhesions was found within 12 weeks of intraperitoneal injection of talc. Talc implanted surgically into the peritoneal cavity of rats produces extensive granulomatous peritonitis within 2 weeks that persists until week 13. Nodules appear and remain 52 weeks after exposure.

Limited data suggests that talc is not carcinogenic following inhalation exposure or intratracheal instillation in rats and hamsters. No evidence of carcinogenicity has been noted after intrapleural, intraperitoneal or oral administration in rats.

#### **Other studies**

In a study in rabbits, talc injection caused synovial inflammation with increase in local temperature, hyperemia, and venous congestion that facilitated anabolic activity and increased production of cartilage. Limited data suggest talc does not induce gene mutations in *Salmonella* or *Saccharomyces* at 200mg/cm<sup>3</sup>, chromosomal aberrations in bone marrow cells or dominant lethal mutations in germinal cells of male rats. Teratogenic and reproductive effect studies are not available.

#### **Lung Cancer**

In its 1987 review, the International Agency for

Research on Cancer (IARC) separated the talcs into those containing and not containing asbestiform fibres. It concluded that there was sufficient evidence for the carcinogenicity to humans of talc containing asbestiform fibres based on a series of epidemiological studies conducted in the populations of talc workers in New York State; and inadequate evidence for the talc not containing asbestiform fibres<sup>11</sup>. The latter assessment was based on four epidemiological studies among miners and talc miners<sup>12-15</sup>. The last three were not interpreted due to their non-standard methodology. Wild<sup>16</sup> reviewed the epidemiological evidence of lung cancer risk of talc not containing asbestiform fibres. He found no evidence of an increased lung cancer risk among workers exposed to talc not containing asbestiform fibres in the absence of other potential carcinogens. However few studies provide adequate exposure information; further studies of possible quantitative exposure-response relations are required. In populations in which talc was associated with other potential carcinogens, some lung cancer excesses were observed. The IARC<sup>17</sup> concluded that there is limited evidence in experimental animals for carcinogenicity of talc not containing asbestiform fibres. The overall evaluation was that inhaled talc not containing asbestos or asbestiform fibres is not classifiable as to its carcinogenicity (Group 3). There was inadequate evidence from epidemiological studies to assess whether inhaled talc not containing asbestos or asbestiform fibres causes cancer in humans.

#### **Ovarian tumor**

Perineal exposure to cosmetic talc in women has been suspected as a cause of ovarian cancer for many years. Several studies have reported a positive association between use of talcum powder on the perineal area and ovarian cancer risk<sup>18,19</sup>. In a meta-analysis, data from 16 studies suggested that talc may increase ovarian cancer risk by 30%<sup>19</sup>.

In 2006, the IARC classified perineal use of talc as a possible carcinogen<sup>20</sup>. The IARC re-examined the issue and the Working Group noted the following: the

eight more informative case-control studies as well as the less informative ones, provided overall estimates of excess risk that were remarkably consistent: seven of these eight examined exposure-response relationships; two provided evidence in support, two provided mixed evidence and three did not support an association. They concluded that the cohort study neither supports nor strongly refutes the evidence from the case control studies. In one study on rats, the implantation of talc on the ovaries did not increase the incidence of ovarian tumor. The Working Group reviewed studies on the potential retrograde movement of talc particles through the reproductive tract to the ovaries in women. They found the evidence for retrograde transport of talc to the ovaries in normal women to be weak. In women with impaired clearance function, some evidence of retrograde transport was found. The overall evaluation was that perineal use of talc-based body powder is possibly carcinogenic to humans.

A 2008 study<sup>21</sup>, analyzed interactions between talc use and genes in detoxification pathways [*glutathione S-transferase M1 (GSTM1)*, *glutathione S-transferase T1 (GSTT1)*, and *N-acetyltransferase 2 (NAT2)*] to assess whether the talc/ovarian cancer association is modified by variants of genes potentially involved in the response to talc. It analysed 1,175 cases and 1,202 controls from a New England-based case-control study, and 210 cases and 600 controls from the prospective Nurses' Health Study. It found that regular talc use was associated with increased ovarian cancer risk in the combined study. Independent of talc, the genes examined were not clearly associated with risk. However, the talc/ovarian cancer association varied by *GSTT1* genotype and combined *GSTM1/GSTT1* genotype. In the pooled analysis, the association with talc was stronger among women with the *GSTT1*-null genotype, particularly in combination with the *GSTM1*-present genotype. There was no clear evidence of an interaction with *GSTM1* alone or *NAT2*. These results suggest that women with certain genetic variants may have a higher risk of ovarian cancer

associated with genital talc use. Additional research is needed on these interactions and the underlying biological mechanisms.

### Endometrial cancer

The relationship between talcum powder use and other gynecologic malignancies such as endometrial cancer has not been examined previously, and little information is available on non-hormonal risk factors for endometrial cancer. Using data from the 1982 Nurses' Health Study on the perineal use of talcum powder<sup>22</sup>, a study recent from Harvard<sup>23</sup> analyzed 66,028 women with 599 incident cases of invasive endometrial adenocarcinoma diagnosed between 1982 and 2004. It found that although no association was observed overall, the association varied by menopausal status ( $p$ -interaction=0.02) and a positive association was observed among postmenopausal women; ever use of talcum powder was associated with a 21% increase in risk of endometrial cancer (95% CI: 1.02, 1.44), while regular use ( $\geq$  once/week) was associated with a 24% increase in risk (95% CI: 1.03, 1.48). In addition, a borderline increase in risk with increasing frequency of use ( $p$ -trend=0.04) was observed. They concluded that perineal talcum powder use increases the risk of endometrial cancer, particularly among postmenopausal women.

### Pulmonary manifestations of talcosis: inhalation deaths, pneumoconiosis, pulmonary granuloma, pulmonary fibrosis, pulmonary hypertension.

The dust hazard in tremolite talc mining industry including roentgenological findings in talc workers was first reported in 1943<sup>24</sup>. The problems of talc pneumoconiosis and pulmonary talcosis were re-highlighted in 1955 and 1959 respectively<sup>25,26</sup>. Four distinct forms of pulmonary disease caused by talc were defined. Three of them (talcosilicosis, talcoasbestosis, and pure talcosis) are associated with aspiration and differ in the composition of the inhaled

substance. The fourth form, a result of intravenous administration of talc, is seen in drug users who inject medications intended for oral use<sup>27</sup>.

The first report of a fatal case of inhaled baby powder appeared in the Japanese literature in 1961<sup>28</sup>. This was followed by another, in the following year<sup>29</sup>. Motomatsu *et al.*, reported two further deaths in infants, and conducted an experiment in rats that revealed talc inhalation is fatal; it coats and dries the mucus membranes, causes hemorrhage, edema and desquamation of the bronchial epithelium, clogs up and compromises mucociliary clearance in the airways, while larger quantities may completely obstruct airways<sup>30</sup>. Numerous other reports of respiratory distress and death after talc inhalation followed from all parts of the world<sup>31-44</sup>. Progressive diffuse pulmonary fibrosis is a sequel to massive aspiration of baby powder (talc) and should be considered in “idiopathic” pulmonary fibrosis in childhood and adult life. Intravenous injection of talc-containing drugs is now a well recognized cause of pulmonary granulomas, pulmonary fibrosis and pulmonary hypertension<sup>45-47</sup>. The reaction to talc is variable, in some patients widespread granulomata develops in the lung interstitium, in others this may eventually lead to progressive interstitial fibrosis and restrictive lung disease. The finding of plexiform lesions in the lungs indicates that pulmonary hypertension is irreversible<sup>48</sup>. The laboratory findings of talc granulomatosis are similar to sarcoidosis<sup>49</sup>. Talc granulomatosis mimicking sarcoidosis has been reported of in the absence of industrial exposure and intravenous drug use<sup>50</sup>. Even corn starch powder that has been introduced as an alternative to talcum powder is not deemed safe. The hazard of respiratory failure from aspiration of corn starch used in diaper changing has been reported<sup>51</sup>.

It is evident the dangers associated with cosmetic use of talc far outweigh any perceived benefits. The public should be warned and educated on the potential dangers associated with the use of talcum powder by national

health agencies, regulatory bodies, and the national and state consumer associations. Child protection laws should be enforced to ensure that infants and young children are protected from the application of noxious substances that are injurious to their health and have no proven health benefits. Should there be claims of perceived benefits, these claims should be subjected to rigorous clinical trials to prove such claims are evidence based.

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