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Literature Review: Cancers Among Workers Exposed to Perfluorooctane Sulfonate (PFOS)

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Abstract

Introduction: Cancer is a disease with a high mortality rate in Indonesia. One of the chemical exposures that can cause cancer is perfluorooctanesulfonyl fluoride/perfluoro octane sulphonate (PFOS). PFOS is a chemical that is widely used due to its diverse functions, including use in fire extinguishers, waterproof materials in food boxes and furniture, and household hygiene products. Long-term exposure to workers affected by PFOS is suspected to be one of the risk factors for cancer.
Methods: The author conducted a literature search of online search engines in 3 sources PubMed, Google Scholar, and JSTOR databases. The inclusion criteria in this study are articles in English, full text available, and conducted on the working population. The author has not restricted search within the last 5 years due to the limited reference of the topic.
Results: Out of a total of 5 articles examined, the authors found the incidence of bladder cancer in workers as much as 1.28 times, there was even a death rate of 12.77 times in workers with PFOS exposure due to bladder cancer, although the results did not statistically significantly. Other studies have shown increased levels of PFOS in the blood but were not associated with changes in other laboratory examinations associated with health problems in workers.
Conclusions: The results of the literature study found no significant association in cancer occurrence based on the length of PFOS exposure in workers. The literature search results also found no direct association between PFOS exposure to possible health problems.
Keywords: perfluoro octane sulfonate, PFOS, cancer, occupational exposure

Abstrak

Pendahuluan: *Kanker merupakan penyakit dengan angka kematian cukup tinggi di Indonesia. Salah satu bahan pajanan kimia yang dapat mengakibatkan kanker adalah perfluorooctanesulfonyl fluoride/ perfluorooctane sulphonate (PFOS). PFOS adalah bahan kimia yang digunakan secara luas karena fungsinya yang beragam, diantaranya penggunaan dalam alat pemadam api, material tahan air pada kotak makanan dan furniture, dan produk kebersihan rumah tangga. Pajanan jangka Panjang pada pekerja yang terkena PFOS diduga menjadi salah satu factor risiko terjadinya kanker.*
Metode: *penulis melakukan pencarian literatur terhadap mesin pencarian online di 3 sumber yaitu PubMed, Google Scholar dan JSTOR. Kriteria inklusi pada studi ini yaitu artikel dalam Bahasa Inggris, tersedia teks penuh dan dilakukan pada populasi pekerja. Penulis tidak membatasi pencarian dalam waktu 5 tahun terakhir disebabkan terbatasnya acuan topik tersebut.*
Hasil: *Total 5 artikel yang ditelaah, penulis menemukan kejadian kanker kandung kemih pada pekerja sebanyak 1.28 kali, bahkan terdapat angka kematian sebesar 12.77 kali akibat kanker kandung kemih pada pekerja dengan pajanan PFOS, walaupun hasil tersebut tidak bermaksa secara signifikan. Studi lain menunjukkan adanya peningkatan kadar PFOS dalam darah, namun tidak berhubungan dengan adanya perubahan pemeriksaan laboratorium lain yang berhubungan dengan gangguan kesehatan pada pekerja.*
Simpulan*: Dari hasil studi literatur tidak menemukan hubungan yang signifikan dalam kemungkinan kanker berdasarkan lamanya paparan PFOS pada pekerja. Dari hasil penelusuran literatur juga tidak ditemukan hubungan langsung dengan paparan PFOS dengan kemungkinan masalah kesehatan berupa kanker.*
Kata kunci: *perfluoro octane sulfonate, PFOS, kanker, pajanan kerja*

Introduction

Cancer is one of the non-communicable diseases that cause death in the general population, from Riset Kesehatan Dasar Indonesia 2018, there is a significantly increased number of people who have cancer, in Indonesia 2017 happened approximately 1.79 cases per 1000 population, compared from 2013 there were 1.4 cases per 1000 population. In 2018, World Health Organization (WHO) noted cancer in about 348.809 new cases.[1–3] The most leading cancer-caused death is lung cancer, followed by hepatic cancer, breast cancer, and cervical cancer.[2] Humans exposed to the chemical in long term can cause cancer, and one of the chemicals suspected is perfluorooctanesulfonyl fluoride/ perfluoro-octane sulphonate (PFOS), one member of the polyfluoroalkyl substances (PFAS) class.[4]

PFAS is a large class of fluorinated chemicals, the characteristic of this chemical is both hydrophobic and lipophobic in the environment and extremely persistent due to the strength of the carbon-fluorine bond. Two widely-used classes of these chemicals have been PFOS and perfluorooctanoic acid (PFOA). PFOS is a chemical with a long carbon strain structure and hydrophobic, and have been used in a variety of products and procedures including firefighter foams, carpets, leather things, fabric materials, food packaging, manufacturing and domestic cleaning products, insecticides, photographic uses, semi-conductor production, hydraulic fluids, catheters, and metal paint.[4–6]

The health impact of PFOS is actively being studied and discussed among scientists. Research shows that PFOS/PFOA-exposed communities from nearby chemical plants are correlative with the occurrence of cancer, especially positively associated with kidney and testicular cancer. Recent studies have linked a variety of PFOS substances to many humans' health effects such as cardiovascular disease, reproductive system, metabolic disease, respiratory disease, and maternity problems. The varied dispersal of perfluoroalkyl materials such as PFOS, in a complex level organism such as humans, is strongly suggestive of the possibility for bio-accumulation and/or bioconcentration of these substances.[4,7–9]

Occupational exposure to PFOS long has been addressed as possible as a risk factor for cancer occurrence. However, cancer resulting from PFOS is not as clearly defined. In this review, some of the evidence implicating PFOS in causing cancer is summarized.

Methods

A literature review was conducted on April 20, 2020. The search was done in PubMed, Google Scholar, and JSTOR databases to find all published observational studies evaluating the relationship between PFOS occupational exposure with cancers. Furthermore, the authors conducted a search using the keyword listed in table 1, with inclusion criteria using English, available full text, and studies in the worker population. The process of article selection presented in figure 1. The authors decided not to favor articles that were published only in the last five years, as the information regarding this topic is limited. The designated article will have a critical appraisal using the Centre of Evidence-Based Medicine (CEBM), University of Oxford from cross-sectional studies. The results of the article's appraisals were described in Tables 2,3,4,5 and 6.

Table 1. Search Strategy Using Keywords

Database	Keyword	Found	Selected	Filter
Pubmed	Search: ((("pfos"[Title/Abstract]) OR ("perfluorooctane sulfonate"[Title/Abstract])) AND ("workers"[Title/Abstract])) AND ("cancer"[Title/Abstract])	9	1	Title/abstract
Google Scholar	"PFOS" OR "perfluorooctane sulfonate" AND "workers" AND "cancer"	761	2	Title/abstract
JSTOR	"PFOS" OR "perfluorooctane sulfonate" AND "workers" AND "cancer"	62	2	Title/abstract

Result

The study by Alexander, B H et al found among 2083 workers identified, a total of 145 death and three of them caused by bladder cancer. This study is a retrospective cohort study for death among workers follows all workers with at least work at the cumulative environment at least for a year. The exposure of this chemical was divided into 3 groups, there were highly exposed, low exposed, and non-exposed. They agglomerate this sub-group established on biological monitoring data that has been held for exposure of perfluorooctane sulphonate (PFOS). Among all death, sixty-five deaths occurred between workers still employed in the group of highly exposed to PFOS. Suspected mortality from all causes for cohort and sub-cohort studies is lower than the general population. They had resulted in two deaths from cancer cases from hepatic cancer and were known to be workers with at least 1 year of exposure at high or low exposure the standardized mortality ratio (SMR) 3.08 (with 95% Confidence Interval 0.37- 11.10). Another death found was bladder cancer, and this case enlarged for the entire cohort study (three detected, SMR 4.81, 95% Confidence Interval 0.99 to 14.06). Among three bladder cancer followed in the group of high exposure jobs with SMR 12.77 (95% I 2.63–37.35). Workers that engaged in high contact groups had a major number of deaths from cancer, particularly bladder malignancy, however it is still not strong enough if these three cases can be connected to fluorochemical revelation at work, especially PFOS.[10]

Alexander, BH et al undergo another analysis among manufacturing employees exposed to perfluorooctane-sulfonyl fluoride, particularly PFOS. Their purpose is to establish whether bladder cancer is related to experiencing PFOS exposure in occupational settings. Postal questionnaire distributed to all living current and former workers correspondence of the plant to 1895 workers and for the dead worker using death certificates as much as 188 cases. The contact of PFOS at work is divine with the estimation of contact with work description archives and measured with biological monitoring information. Standardized incidence ratios (SIRs) were assessed for participants by contact group and the others assessment by weight exposure of

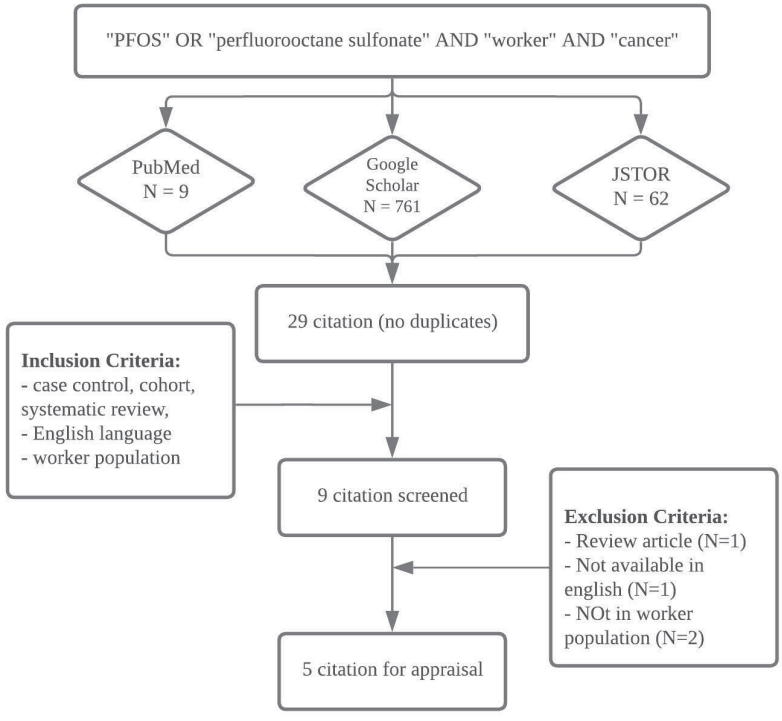

Figure 1. The Process of Article Selection

PFOS. From 1895 questionnaires distributed, 1400 were returned, presumed alive. From eleven events of primary bladder malignancy, from the survey known 6 workers and 5 workers from death documentations. The SIRs were 1.28 (with 95% CI 0.64–2.29) for the entire cohort and the ever employed in high exposed job is 1.74 (with 95% CI 0.64–3.79). The result invites that bladder cancer occurrence in this study is similar to U.S Population and the risk of bladder malignancy occurrence does not seem to be suggestively induced through workers employed the PFOS interaction were more probable. The study was restricted by the number of the cohort cases; however, this study of occupational setting is one of only an insufficient study in the world, and the major number and time of period monitored, this setting performed in PFOS manufactured and related chemical used for this study, this circumstance offer the chance to assess the possible health consequence of exposure PFOS among workers. The outcome from this article does not approve the effect of the possibility for bladder malignancy that stated in the death study of these people exposed to PFOS. Nevertheless, the opportunity still residues for slighter risk (nearly 1.5 up to 2-fold) in the group of greater exposure of PFOS.[5]

Olsen, Geary W observed expected episodes of the visit to healthcare experience from 652 employees at a fluorochemical (PFOS) production facility and related with 659 non-fluorochemical (film) plant employees at the same period in Decatur, Alabama. The population of this study consisted of all full-time and inactive employees at Decatur sites as described in the work history database as of January 1993. Investigation of an episode for seeking healthcare therapy was inspected by whether the worker was deliberated working at the chemical plant or film plant worker.

Table 2. Critical Appraisal Checklist for Cohort Study (Article 1)

Title	**Mortality of Employees of a Perfluorooctanesulphonyl Fluoride Manufacturing Facility**
Author(s)	Alexander B H et al (2003)
Level of Evidence	2B
Did the study address a clearly focused question/issue?	Yes, this study assessed mortality in workers exposed to PFOS
Is the research method (study design) appropriate for answering the research question?	Yes, studies using cohort methods to find out the incidence of cancer due to PFOS
Were there enough subjects (employees, teams, divisions, organizations) in the study to establish that the findings did not occur by chance?	Yes, they identified a total of 145 death among 2083 workers to study the cause of death
Was the selection of the cohort/panel based on external, objective, and validated criteria?	No, the sample obtained only employees who worked in the specific plants
Was the cohort/panel representative of a defined population?	Yes, the study design selection is appropriate to find out the possible causes of cancer.
Was the follow-up of cases/subjects long enough?	Yes, observations were made for 25 years on this population
Were objective and unbiased outcome criteria used?	Yes, the criteria used are in workers with a diagnosis of urinary tract cancer
Are objective and validated measurement methods used to measure the outcome?	Yes, they use death certificates and medical records data to determine cancer
Is the size effect practically relevant?	No, the risk of death from bladder cancer is not significantly significant
How precise is the estimate of the effect? Were confidence intervals given?	Yes, the confidence interval for bladder cancer was given but not precise at 0.99 to 14.06.
Could there be confounding factors that haven't been accounted for?	No, several factors have been described in the study, including work processes, habits, and other works
Can the results be applied to your organization?	Yes, it is known that high cancer rates increase deaths from bladder cancer

Table 3. Critical Appraisal Checklist for Cross-Sectional Study (Article 2)

Title	**Bladder Cancer in Perfluorooctanesulfonyl Fluoride Manufacturing Workers**
Author(s)	Alexander B H et al (2007)
Level of Evidence	2B
Did the study address a clearly focused question/issue?	Yes, this study assessed the incidence of urinary tract cancer in workers with PFOS exposure
Is the research method (study design) appropriate for answering the research question?	Yes, studies using methods to find out the incidence of bladder cancer due to PFOS
Were there enough subjects (employees, teams, divisions, organizations) in the study to establish that the findings did not occur by chance?	Yes, they divided the subjects by the time worker ever did the job.
Was the selection of the cohort/panel based on external, objective, and validated criteria?	No, the sample obtained only employees who worked in the specific plants
Was the cohort/panel representative of a defined population?	Yes, the population represents workers with PFOS exposure according to the length of exposure time.
Was the follow-up of cases/subjects long enough?	Yes, the duration of the person-year in this study was 43739
Were objective and unbiased outcome criteria used?	No, some risk factors in urinary cancer have not been in exclusion in this study
Are objective and validated measurement methods used to measure the outcome?	Yes, they use death certificates and medical records data to determine the occurrence of bladder cancer
Is the size effect practically relevant?	Yes, they calculate for bladder cancer using SIRs.
How precise is the estimate of the effect? Were confidence intervals given?	Yes, the confidence interval for bladder cancer described in this study (0.64-2.29).
Could there be confounding factors that haven't been accounted for?	No, several confounding factors such as smoking as one of the risk factors for cancer have been described.
Can the results be applied to your organization?	Yes, bladder cancer incidence rate can be used as a reference in determining the incidence of cancer in workers exposed to PFOS

Table 4. Critical Appraisal Checklist for Cross-Sectional Study (Article 3)

Title	**Analysis of Episodes of Care in a Perfluorooctanesulfonyl Fluoride Production Facility**
Author(s)	Olsen G W et al (2003)
Level of Evidence	2C
Did the study address a clearly focused question/issue?	Yes, the study focused on a predicted episode of care experience worker at a fluorochemical plant facility.
Is the research method (study design) appropriate for answering the research question?	Yes, the study design finds disease by searching in the medical record.
Were there enough subjects (employees, teams, divisions, organizations) in the study to establish that the findings did not occur by chance?	Yes, they divided the subjects by the time worker ever did the job.
Was the selection of the cohort/panel based on external, objective, and validated criteria?	No, the sample obtained only employees who worked in the specific plants
Was the cohort/panel representative of a defined population?	Yes, a total of 1311 study subjects was obtained for this study, whether workers were still employed at the manufacture or retired.

Was the follow-up of cases/subjects long enough?	No, they included all samples available from the manufacture at the time studied
Were objective and unbiased outcome criteria used?	Yes, the eligible workers' rate for this study is 96%
Are objective and validated measurement methods used to measure the outcome?	Yes, they use medical records (Ingenix Employer Group)
Is the size effect practically relevant?	Yes, they calculate for a malignant tumor of the colon and rectum,
How precise is the estimate of the effect? Were confidence intervals given?	Yes, the confidence interval for tumor colon and rectum.
Could there be confounding factors that haven't been accounted for?	Yes, there is another factor such as smoking did not count in this study
Can the results be applied to your organization?	Yes, but this study is limited to the worker at perfluorooctanesulfonyl production.

Table 5. Critical Appraisal Checklist for Cross-Sectional Study (Article 4)

Title	**Epidemiologic Assessment of Worker Serum Perfluorooctane-sulfonate (PFOS) and Perfluorooctanoate (PFOA) Concentrations and Medical Surveillance Examinations**
Author(s)	Olsen G W et al (2003)
Level of Evidence	4
Did the study address a clearly focused question/issue?	Yes, the study focused on the value of PFOS levels in workers.
Is the research method (study design) appropriate for answering the research question?	Yes, the study design is to address the number of an episode of care among workers
Is the method of selection of the subjects (employees, teams, divisions, organizations) clearly described?	Yes, they described the worker based on working plant sites
Could the way the sample was obtained introduce (selection)bias?	No, the sample obtained only employees who worked at the production plant, there is no bias in the assessment of this study.
Was the sample of subjects representative with regard to the population to which the findings will be referred?	Yes, a total of 518 study subjects was obtained for this study, whether workers were still employed at the manufacture or retired.
Was the sample size based on pre-study considerations of statistical power?	No, they included all samples available from the manufacture
Was a satisfactory response rate achieved?	Not known described in this study
Are the measurements (questionnaires) likely to be valid and reliable?	Yes, they examine a blood serum sample for PFOS value using LCMS and another examination for hematologic, lipid, and urine analysis
Was the statistical significance assessed?	Yes, they found mean serum PFOS 0.91 ppm
Are confidence intervals given for the main results?	Yes, they gave the confidence interval for PFOS value 0.06-10.06 ppm
Could there be confounding factors that haven't been accounted for?	Yes, there is another factor such as another confounding disease did not describe in this study
Can the results be applied to your organization?	No, this study is not addressed for determining the relationship between PFOS levels and cancer incidence rate in workers

The employee distributed to the group whether they (1) ever labored in chemical, film, or both plants, (2) still labored in the chemical, film or both plant when the study observed, and (3) labored continuously in the chemical or film plant for complete 10 years earlier study stage (1993). By the completion of the interval report (December 31, 1998), a total of 78% of chemical workers remained working and 11% had given up work from the plant. Between the film manufacture worker, 71% were still working and for a total 17% had left from the manufacture. Half of the events of care there were categorized in the Malignancy and Benign Growth class were from 2 subclasses, there were benign colon polyps and benign tumors of the skin. Affirmative relations found for tumor of skin was recognized to malignant melanoma of the skin and also benign tumor. From the detected result of this study, the priory attention of projected incident of care proportions was comparable for fluorochemical manufacture and film manufacture was liver cancers or disorder, thyroid, and lipid disorders metabolism conditions, bladder cancer, reproductive, pregnancy, and perinatal conditions, and cystitis reccurence.[11]

A previous study done also by Olsen et al tried to assess serum PFOS and PFOA concentration and medical examination among workers. Workers from two perfluoroocatnyl-plant sites (Antwerp, Belgium and Decatur, Alabama) were participated in this study in episodic health surveillance monitoring, contained hematology test, clinical blood chemistry value, thyroid hormones, and also urine analysis. Workers of the two manufacturing operations are comparable,

Table 6. Critical Appraisal Checklist for Cross-Sectional Study (Article 5)

Title	**Exposure to perfluoroalkyl substances in a cohort of women firefighters and office workers in San Francisco**
Author(s)	Trowbridge J et al (2020)
Level of Evidence	4
Did the study address a clearly focused question/issue?	Yes, the study focused on firewomen and office workers to compare blood serum of PFOS.
Is the research method (study design) appropriate for answering the research question?	Yes, the study design is appropriate for finding the value of PFOS among workers
Is the method of selection of the subjects (employees, teams, divisions, organizations) clearly described?	Yes, they divided the subjects into firewomen and office workers
Could the way the sample was obtained introduce (selection) bias?	Yes, the sample obtained in each group of exposure PFOS among firewomen can be biased by the placement of employees
Was the sample of subjects representative with regard to the population to which the findings will be referred?	Yes, a total of 170 participants was obtained for this study, 86 among firewomen and 84 among office worker
Was the sample size based on pre-study considerations of statistical power?	No, they included all samples there were eligible for this study
Was a satisfactory response rate achieved?	No, from 798 announcements sent, only 170 participants were included in this study
Are the measurements (questionnaires) likely to be valid and reliable?	Yes, they use a questionnaire to obtain demographic data and examination of blood serum samples for PFOS value (LC-MS/MS)
Was the statistical significance assessed?	Yes, they calculate the value of PFOS serum level
Are confidence intervals given for the main results?	Yes, they calculated CI for PFOS value
Could there be confounding factors that haven't been accounted for?	Yes, there is another factor such as personal hygiene and cleaning of personal protection equipment not yet assessed in this study
Can the results be applied to your organization?	No, this study is not addressed to determine the relationship between PFOS levels and cancer incidence rate in workers.

fluorochemical manufacture happens in numerous buildings, wherever the PFOS as base produce occurs via electrochemical fluorination. Additional plant PFOS stating substantially is responded to make fluorochemicals aminoalkyl and more will make the form of fluorochemicals. They measure serum con-centration of PFOS via mass spectrometry methods. From 255 (75%) Antwerp workers and 263 (52%) Decatur workers who participated voluntarily, the arithmetic mean serum PFOS was 0.80 ppm with geometric means was 0.33 ppm. The results found in participants from Decatur sites was 1.32 ppm with geometric means of 0.91 ppm. Adapting for hypothetical confusing factors, there were no considerable modifications in another laboratory findings hematologic, lipid, hepatic, thyroid, or urine sample examination[12]

Across-sectional study among women firefighter workers compare to office workers and found women firefighters are exposed to higher levels of several PFAS compounds, including PFOS comparison to office employees, and recommended that some of these contacts may be associated to an occupational setting. Their purpose is to address the gap between firewomen who are exposed to carcinogen compounds and high rates of certain malignancies compared to the overall population, but yet that research exclusively on men. The sample workers were gathered from 86 women firewomen and 84 office employees in San Francisco, then blood serum sample was collected and analyzed using LC-MS/MS (liquid chromatography-tandem mass spectrometry) to measure the quantity and compare PFAS quantities among firewomen employees and office employees. From a total of 12 PFAS classes, they define 7 congeners found in at least 70% of workers, and 4 congeners were detected in 100% study population.

A total of 170 samples from women firefighters and office workers were included in this study, from the demographic characteristic, both groups had similar in terms of ages and racial/cultural character. Firewomen had an average of 17 years of working in the San Francisco Fire Department (SFFD), however, office employees had an average of 14 years of service within the City and Country of San Francisco. The majority of assigned positions in firewomen were in airport stations, 25 firewomen reported using firefighter foams in the year before the sample was collected and mostly using the substance of class A or both foams of class A and B altogether. They found workers developing the occupational site of firewoman or officer (versus who worked as a driver) was linked with greater standard serum value of PFOS.[13]

Discussion

There is currently no confirmation that perfluoroalkyl undertakes breakdown in the human body. Therefore, specific pathways changes in elimination patterns are not predicted. Selected findings in which removal half-life time (i.e., $t_{½}$) of perfluoroalkyl have been determined demonstrate that, in general, removal $t_{½}$ numbers are similar following blood circulatory, intraperitoneal excretion, and oral exposures. In humans, absorbed perfluoroalkyl is excreted in the urine. Assuming that 99% of the serum PFOS and PFOA was linked to albumin, <0.1% of clarified perfluoroalkyl were excreted in the urine, recommending a large amount of reabsorption purified PFOA and PFOS in the renal tubule. [6]

Captivated PFOA and PFOS are similarly excreted via bile in persons, but the biliary tract is not a main excretory passageway since PFOA and PFOS are reabsorbed after biliary excretion. Investigation of kinetics serum of PFOS concentrations in retired U.S fluorochemical manufacture employees yielded a mean serum elimination $t_{½}$ estimate of 5.4 years (95% CI = 3.9-6.9 years) in subjects whose blood serum PFOS concentrations ranged from 37-3.490 ng/mL[11,14] The Commission for Human Biomonitoring (HBM Commission) of the Federal Environment Agency (UBA) has established reference concentrations for PFOS and PFOA in the blood plasma of the German population, 20µg/L for women, 25µg/L for men (UBA 2009).[15]

In the study Alexander had done, there were deaths from bladder cancer as many as 3 employees. Although the results of this study cannot be concluded this condition is caused by PFOS exposure, it cannot be removed also that in workers who have exposure to these chemicals do not cause cancer. This has the same result as research in the second journal, the presence of bladder malignancies in workers at perfluoroalkyl production plants, by looking from cancer mortality rates in employees with PFOS exposure in Alabama, with 11 cancer incidences, 6 of which were obtained from the questionnaire and 5 from death certificates. The SIRs were 1.28 (95% CI 0.64-2.29) for the entire

group of employees and 1.74 (95% CI 0.6-3.79) for those ever placed in a highly exposed job. The effects are still uncertain, whether PFOS is a factor that can cause bladder cancer (confidence interval crossing 1).[5] The relative risk of bladder cancer was 0.83 (95% CI = 0.15-4.65) for time exposure 1 to less than 5 years, 1.92 (95% CI = 0.30-12.06) for time exposure 5 to less than 10 years, and 1.52 (95% CI = 0.21-10.99) for time placed at the exposed experience of PFOS 10 years).[5,10]

Olsen et al saw the character of the time worked for 5 years (1993-1998) for episodes of treatment in workers at fluorochemicals plant and found patients with a diagnosis of bladder cancer and liver tumors in the working population. Then, they continued the research by finding out the level of PFOS in workers and obtained results in the worker serum was at the level of 1.32 ppm (geometric mean 0.91, range 0.06–10.06 ppm). As in Trowbridge, J et al studied which looked for levels of PFOS in the blood in women fire extinguishers, it was found that there was a PFOS value of 4.11 (95% CI 3.68–4.59). Although serum or blood examination to find PFOS concentration is a standard examination, but the results of research related to PFOS results in the blood will only describe exposure and absorption in the body of workers, but this cannot be said to be stated to the emergence of health problems, especially cancer incidence among workers.[6,13,14]

Examination of these biomarkers also has no specific standard or limit value to determine the effects of its toxicity. In addition, there were also no other disorders in blood examination such as hematology, lipid examination, hepatic and thyroid or urine examination. It was also explained by ATSDR in the explanation of biomarker effects wherein workers with PFOS exposure did not have a specific examination of the biomarkers of PFOS exposure effects.[6]

Conclusion

PFOS does not undergo metabolism in the human body, thus exposure from the work environment will be removed again in its intact form when eliminated. PFOS has a long half-life that will put this substance at the difficulty of degradation. The study found a mean blood serum eliminated $t_{1/2}$ of PFOS is 5.4 years, which can be done to assess the level of PFOS in the blood by measuring concentration directly. From the results of this scientific review assessment, the recommendation is that if workers get a diagnosis of cancer, it is necessary to do further examination and anamnesis related to their work. If it is known at work to have PFOS exposure, it is best to continue with an assessment of the adequacy of exposure at work. The literature found no significant association in the likelihood of cancer-based on the length of exposure of PFOS in workers. The results of the literature search also found no direct link to PFOS exposure with the possibility of health problems in the form of cancer.[6] Workers with a clinical diagnosis of cancer, and found in history taking or workplace examination had exposure to PFOS, this has not yet confirmed PFOS is a substance that causes cancer.

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