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The Honorable Floyd D. Spence
U.S. House of Representatives
2405 Rayburn Building
Washington, DC 20515-4002

Subj.: THE ASSIGNMENT OF WOMEN TO SUBMARINE CREWS

Dear Congressman Spence:

I am writing to express my concern about making any changes to the current Navy policy that restricts the assignment of women to the crews of submarines for the following reasons: (a) the risk to the fetus from chemical insults inherent in the submarine atmosphere; (b) the risk of complications associated with the occurrence of an ectopic pregnancy in a female crew member; and, (c) the lack of any sociological or psychological research on the effects of gender mixing will have on group dynamics during submarine operations.

By way of introduction, I am a retired Navy medical officer with extensive experience in Undersea Medicine. My background includes qualification as a Submarine Medical Officer and also as a Deep Sea Diving Medical Officer. I have served as Medical Officer on both submarine squadron and submarine group echelons. From 1983 to 1986, I had been Director of Undersea Medicine and Radiation Health, at the Bureau of Medicine and Surgery. As Director, I had the responsibility for advising the Department of the Navy on medical issues and physical standards regarding submarine and diving duty. Also, I have worked with the National Academy of Sciences, Committee on Toxicology, Commission on Life Sciences, National Research Council regarding the issue of submarine air quality in the development of its published report on "Emergency and Continuous Exposure Limits for Selected Airborne Contaminants, in Submarines".

Submarine Atmosphere

To sustain life on board a submarine, the air within the closed environment is re-used after recycling through processes which remove carbon monoxide, carbon dioxide and Freon gases by dedicated air purification equipment, hydrocarbons by charcoal filter beds and aerosols by precipitators, and add oxygen by the electrolysis of water. Despite all of these measures, the principal limitation of man-made air is that all of the atmospheric contaminants can never be removed. So, it is impossible to achieve a submarine atmosphere that is similar to country air.

One of the more serious problems associated with living in the sealed environment of a submarine is the off-gassing of several thousand organic trace contaminants from known sources within the boat, including those introduced in the construction and maintenance of the submarine. The Subcommittee on Submarine Air Quality of the National Academy of Sciences, National Research Council has evaluated more than two hundred potentially toxic chemicals in the submarine atmosphere. A review of the Subcommittee's findings indicated that there are no demonstrable gender differences to the potentially hazardous substances that are known to be present in trace quantities under normal conditions in a submarine that would indicate a greater risk to women, as long as they were not pregnant. During the first trimester of pregnancy, the embryo-fetus is most sensitive to and at the greatest risk for injury from the toxicological effects of the environment.

In addition to the trace contaminants, there is also a risk to the fetus posed by exposures to increased levels of carbon monoxide and carbon dioxide in the submarine atmosphere. Fires, cigarette smoking, equipment malfunction, overheated insulation, the oxidation of paint and snorkeling can produce carbon monoxide in submarines.

While normal adults have a reserve capacity and a compensatory response that enable them to handle moderately high carboxyhemoglobin concentrations, the fetus under normal situations can be functioning close to a critical level

with respect to tissue oxygen supply, so even moderate carbon monoxide exposure could decrease the oxygen transport capacity of maternal and fetal hemoglobin and result in interference in fetal tissue oxygenation during important developmental stages. It is very likely that the current maximum permissible concentrations for carbon monoxide used by the Navy are too high to ensure fetal well being in case of equipment malfunction or a fire.

In the case of carbon dioxide, for design reasons, the mean concentration of the gas in a submerged nuclear submarine is 0.5%, which is over 10 times that in the open atmosphere, i.e., 0.036%. As a result, reversible metabolic changes occur in crewmembers during the exposure period. While extensive studies of male submariners have shown there to be no evidence of long-term ill health effects, there are no similar studies to explore the effects of this exposure on female fertility, or on the embryo/fetus in a pregnant female crewmember. There is, however, some animal evidence of teratogenicity (congenital deformities) at exposure levels of 6% carbon dioxide that cannot be ignored.

Consequently, no categorical assurances can be provided regarding the safety of the fetus to exposures to carbon monoxide, carbon dioxide and other hazardous materials found in the submarine atmosphere. With the paucity of information and the low probability of ever obtaining such human experimental data on the exposure of pregnant women to increased levels of carbon monoxide and carbon dioxide, it is not possible to make risk assessments or to recommend maximum permissible concentrations with any degree of confidence about the possible effects of long term exposure on women and the fetus.

At this point one might ask, "Why not remove all of the submarine atmosphere contaminants?" Atmospheric contaminants only can be removed by utilizing a chemical reaction, either oxidation or the formation of a compound. The efficiency of any chemical reaction is directly proportional to the concentration of the reacting substances. Therefore, the lower we desire to keep the concentration of any contaminant the larger by many times must be the reacting surface or absorption column and the more times per unit time must be passed over the reacting surface. To achieve the latter, it would require a significant increase in the size and capability of the ventilation system to move the required volume of air. While it may be theoretically possible to design a submarine with an ideal atmospheric control system, the sheer size would preclude the room to carry any weapons and carry out its normal mission.

Ectopic Pregnancy

With the assignment of mixed gender crews on submarines, it would not be unreasonable to expect the occurrence of pregnancies and associated obstetrical complications in some of the female crewmembers, such as ectopic pregnancy.

Ruptured ectopic pregnancy is the leading cause of pregnancy-related deaths in the first twenty-weeks of gestation. The Committee should be aware of certain facts about ectopic pregnancy and its high potential for endangering the life of the woman and adversely affecting the mission. According to the Centers for Disease Control and Prevention, (CDCP) ectopic pregnancy has an incidence of 1 in every 60 of all pregnancies, and 1 in 100 to 1 in 200 in diagnosed pregnancies.

Women comprise about 10 percent of the active duty Navy, and about 9 percent of that number is pregnant at any one time. While the total number of pregnancies for Navy women is not precisely known, and given that many of the pregnancies do not go to term, or are diagnosed before 6 to 8 weeks, the period of known pregnancy for the most part averages less than 6 months. Therefore, it is reasonable to conclude that to have 9 percent of Navy women known to be pregnant at any one time, there would have to be twice that number of pregnancies per year, or about 18 percent.

Accordingly, by that analysis, there will be about 180 pregnancies, 3 o 4 of which will be ectopic per year for every 1000 Navy women. In doing a cross check on those numbers, it was noted that in a 6-month period, from November 1992 to April 1993, there had been four documented ectopic pregnancies occurring in the 2200 women serving aboard the Submarine Tenders in the Atlantic Fleet. Based on those numbers, the rate of ectopic pregnancies among the women on the Tenders was 3.8 per year, per 1000 women, which was consistent with the numbers predicted by the CDCP.

Of particular note, all four of the affected women were unaware that they were pregnant until the time they experienced their acute symptoms. Testing all women for pregnancy will not remove the risk because the pregnancy test may not be positive in very early pregnancy, the time at which ectopic pregnancy poses the greatest problem.

In suspected cases, the standard of practice requires that the patient have a transvaginal or abdominal ultrasound examination to determine the placement of the embryo. That kind of equipment is not available aboard a submarine. Even if a tubal pregnancy is diagnosed before rupture, the treatment still is surgical. In those cases, every effort is made to conserve the tube by a salpingotomy and evacuation of the products of conception, with repair of the tube to preserve the reproductive function of the patient. A ruptured ectopic pregnancy is a life threatening condition that requires immediate surgical treatment and intensive blood and fluid replacement.

Ectopic pregnancy is incompatible with submarine operations, and would pose an unreasonable risk on the woman and a great burden on the medical department of a submarine. A medevac from a submarine is a particularly dangerous process for all involved. If the boat is operating in a remote area, it may take hours or days to reach a designated rendezvous point to transfer the patient, which may be too late.

Socio-psychological Aspects

Because there are no good mixed gender comparisons when considering all of the unique mission and environmental conditions of a submarine, there is great uncertainty about the effect that gender mixing will have on group dynamics during normal submarine operations and under combat conditions. In no other institutions, including schools, prisons, Antarctica, the space shuttle, or other military operational units are men and women forced to live isolated from the outside world, in such unrelenting close contact with minimal privacy, and in less than satisfactory accommodations for extended periods of time.

The key variable in the effectiveness of a submarine is not just technical abilities, although a certain level of technical competence is necessary, but the ability of the crew to maintain cohesiveness under all possible conditions, including ship casualties and combat situations. Thus it is essential that every effort be made to identify any factors that can adversely affect unit cohesiveness and morale.

Since there is no available sociological or psychological research on this particular issue, any recommendation about the efficacy of a gender mixed crew would be more speculative than factual. When considering that unit cohesiveness, morale, and combat effectiveness of the U.S. Submarine Force and strategic defenses of the country are in the balance, it would be prudent to avoid making any hasty decisions before having all of the facts.

Summary

Congressman Spence I believe that there are a number of health-related issues that argue against any change in the current submarine assignment policy restricting women from serving as crewmembers. Health and safety issues should take precedence over matters of career and equality. Unless a categorical assurance can be given to women that service in submarines will not cause any increase risk to their health (female fertility) or to a product of conception, i.e. embryo/fetus, no change in the policy should be considered. Such assurances cannot be given regarding the safety of fetal exposures to carbon monoxide, carbon dioxide, aerosols, and other hazardous substances found in the submarine atmosphere. The predicted rate of ectopic pregnancy, 4 per 1000 Navy women per year, poses a serious risk under the best conditions; however, if the condition occurs while deployed on a submarine crew, the likelihood of a fatal outcome is greatly increased. Finally, although there is no available studies on the socio-psychological effects of gender mixing on submarine operations, it would be reasonable to expect that the change would alter the existing dynamic, which has seemed to work fine during the past century.

Mr. Spence, I trust that this letter will be helpful to you and to the other members of Congress regarding the proper disposition of the women in submarines issue.

Sincerely,

Hugh P. Scott