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The Honorable Ike Skelton
Chairman, House Armed Services Committee
U.S. House of Representatives
2206 Rayburn House Office Building
Washington, D.C. 20515-2504

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Subject: The Assignment of Women on Submarines: Issues of Concern

Enclosure: Memorandum Assignment of Women to Submarines—Issues and Concerns

Dear Congressman Skelton,

Ten years ago, I had sent a letter to the HASC in which I expressed my concerns about making any changes to the submarine all-male assignment policy. There are many quality of life issues to consider, but my letter focused on health-related issues associated with the submarine environment and the lack of an adequate onboard medical capability to provide life-saving emergency surgical care for the occurrence of abnormal pregnancy complications while underway. Now that Navy leaders have announced their intention to change the current policy and assign women to submarines, I am writing to reiterate my initial concerns, which remain unchanged. The House Armed Services Committee should be aware of all of the health related risks, in preparation for its meeting with the Navy on this issue.

By way of introduction, I am a retired Navy medical officer, qualified in submarines and medical deep sea diving. I had served as Medical Officer in both Submarine Group and Squadron echelons, and as Director of Undersea Medicine and Radiation Health, at the Bureau of Medicine and Surgery. As Director, I had been involved with the National Academy of Sciences, Committee on Toxicology, Commission of Life Sciences, National Research Council for an operational issue associated with the use and quality of submarine air, which resulted in the publication by the Committee of a report titled: Emergency and Continuous Exposure Limits for Selected Airborne Contaminants, in Submarines. Based on that experience, I have serious concerns about the risk to the safety and normal development of an embryo-fetus in the submarine environment.

The significant number of operational deferments granted to women for the occurrence of unintended pregnancies, while serving on sea-duty, suggests that this pattern would also occur with the assignment of women on submarines. However, unlike surface ships, the sealed environment of the submarine atmosphere poses an increased risk to the normal development of a woman's embryo-fetus. In addition, the nature of the operational mission coupled with a very limited medical capability aboard a submarine will significantly increase the risks of survival for women who may be stricken with complications of abnormal pregnancies while underway.

These health-related issues argue against any change in the current submarine all-male assignment policy. Congressman Skelton, I ask that you and other members of the House Armed Services Committee ask the Secretary of Defense to answer a

series of specific questions, starting with these:

How does the Navy intend to resolve the unintended pregnancy problem?

How does the Navy plan to manage the consequences of abnormal pregnancy complications occurring while underway, and out of range for a timely medevac?

How will the Navy protect the embryo-fetus from the risk posed to its normal development if a pregnancy is detected while the boat is deployed?

If the Navy cannot resolve these problems, why are officials planning to assign female sailors to submarines?

I hope you will agree that the lack of sociological or psychological research on the effect of gender mixing on individual and group dynamics during submarine operations is reason for concern and immediate intervention by Congress.

Health and safety issues must take precedence over matters of career and equality. No change in the policy should be considered unless the Navy can give categorical assurances to women that service in submarines will not cause any increase risk to their health (female fertility), or injure a product of conception, i.e. the embryo/fetus.

Such assurances cannot be given, due to the unavoidable risk of fetal exposure to carbon monoxide, carbon dioxide, aerosol trace elements, 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 that pregnancy complication occurs while deployed on a submarine, the likelihood of a fatal outcome is greatly increased.

Finally, although there are no available studies on the socio-psychological effects of gender mixing on submarine operations, it would be reasonable to expect that the proposed assignment policy change would alter the existing dynamic and quality of life in the hazardous and demanding undersea environment.

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.

The enclosed Memorandum sets forth several Issues of Concern regarding medical realities that should be of concern to House Armed Services Committee members. I trust that this information will be helpful to you and to the other members of Congress with the responsibility for oversight on the women in submarines issue.

If I can be of assistance in discussing these matters with committee members or staff, please let me know.

Very Respectfully

Hugh P. Scott

CC: Ranking Member, HASC

The Assignment of Women to Submarines Issues of Concern

Summary

There is a high likelihood for the occurrence of unintended pregnancies just before deployment or while underway (PWU), some of which will be abnormal in nature, and associated with life-threatening symptoms. These could include severe bleeding and hemorrhagic shock resulting in death, unless immediate surgery is performed to stop the bleeding along with the administration of blood and fluids to treat the hemorrhagic shock. Assignment policies that expose women to chemical contaminants present in submarine air create an unacceptably high risk to the normal development and viability of a female sailor's embryo-fetus. In the case of a ruptured ectopic pregnancy, her life may be threatened or her future fertility reduced. These medical concerns, which are serious and unavoidable in the submarine environment, support the continuance of current assignment policies.

High Likelihood for Unintended Pregnancy on Submarines

When young men and women live together in close quarters, sexual and romantic relationships inevitably follow. The Navy has a major problem in that regard due to rising rates of unintended pregnancies, especially among women serving aboard deployed Navy surface ships.

On 25 August 2009, *Navy Times* reported that during a 25-month period from June 2006 to August 2008, operational deferments for pregnancy increased from 1,770 to 3,125. These increases, described as a 50% jump in two-years, occurred despite constant education and other strategies to discourage conception.

When sailors on Navy surface ships become pregnant, they are transferred at their 20th week of gestation to shore-based commands that are close to a Navy medical center. Women complete their pregnancy, childbirth, and additional 12-month extended postpartum time before returning to sea-duty. (21 months)

Despite Navy's concerted efforts to reduce the rate of unintended pregnancies, the problem in terms of readiness persists. It is more than likely that if the Navy assigns women to submarine crews, this same pattern of unintended pregnancies and unplanned losses also will occur. The consequences, however, would be more complicated, consequential, and potentially dangerous for all concerned.

Submarine Atmosphere

Unlike surface ships, one of the more serious problems of living in the sealed environment of a submarine is the continual contamination of the atmosphere by the off-gassing of several thousand organic trace contaminants from known sources within the boat. These substances arise from submarine construction and maintenance, from the crew and their activities, and from substances generated by the processes used to remove the first two.

To sustain life aboard a submarine, the air within the closed environment is re-used after recycling through processes that remove carbon monoxide, carbon dioxide and Freon gases by dedicated air purification equipment, hydrocarbons by charcoal filter

beds, 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 completely. So, it is impossible to achieve a submarine atmosphere that is similar to outside fresh air. For this and other reasons, comparisons to women's service on surface ships cannot justify their assignment to submarines.

Risk to the Embryo-Fetus from Submarine Air

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.ⁱ The report noted that *as long as a woman was not pregnant*, there were no demonstrable gender differences to the potentially hazardous substances known to be present in trace quantities under normal conditions in a submarine, which would indicate a greater risk to women.

In addition to the Subcommittee, the Royal Navy's Institute of Naval Medicine (INM) in Portsmouth, UK, after extensive literary review and consultation with experts, concluded that there were 29 contaminants in the submarine atmosphere that required additional study to define maximal permissible concentrations (MPC) in regard to reproductive health and fetal development.ⁱⁱ

The first trimester is one of the most critical times for the embryo-fetus due to the extensive development that is taking place; the developing organism is highly vulnerable to developmental abnormalities, due to the high proportion of chemical sensitive cells and the criticality of cellular activities. Cells are proliferating, dividing, differentiating, interacting and migrating very rapidly at this time to form complex organs. Different exposures may affect the fetus in different ways and the same exposure may have different effects depending on the timing. The highest-risk period is in the earliest weeks, when the sailor may not know she is pregnant.

Exposures to chemical toxicants (e.g., halogenated hydrocarbons) in submarine air can interfere with cell division and formation of the developing embryo. Some exposures may damage the organs or produce a physical defect, while others delay normal growth and development.

In addition to the trace contaminants (i.e., halogenated hydrocarbons), there is a risk to the in-utero development of the embryo-fetus by exposures to increased levels of carbon monoxide and carbon dioxide. Cooking, smoking, oxidation of paint, equipment malfunction, overheated insulation, snorkeling, and fires, all are sources of carbon monoxide, on a submarine. Respiration by the crew is the major source of carbon dioxide, which is discussed below

Effects of Carbon Monoxide (CO)

Under normal conditions, oxygen is transported to the body's tissues almost entirely by hemoglobin (Hb), the principal oxygen carrying compound in the red blood cells. However, the affinity of Hb for CO in adults is approximately 200-250 times greater than its affinity for oxygen; and in the fetus, the Hb has a 10 percent to 15 percent higher affinity for CO than in adults. When CO binds with Hb, it forms carboxyhemoglobin (COHb), which is incapable of carrying oxygen resulting in decreased transport, delivery, and utilization of oxygen by the body.

While normal adults have a reserve capacity and a compensatory response that enable them to handle moderately high carboxyhemoglobin concentrations, the embryo-fetus under normal situations can be functioning close to a critical level with respect to tissue oxygen supply. Even moderate carbon monoxide exposure could decrease the oxygen transport capacity of maternal and fetal hemoglobin to result in interference of fetal tissue oxygenation during important developmental stages.

Elimination of CO is slower in the embryo-fetus, leading to accumulation of CO. The level of fetal mortality in acute CO poisoning is significant, so even despite mild maternal poisoning, or following maternal recovery, severe fetal poisoning or death can still occur.

A recent study by UCLA noted that chronic exposure during pregnancy to minuscule levels of CO (25 parts per million) damaged the cells of the fetal brain, resulting in permanent impairment. ⁱⁱⁱThe current maximum permissible concentrations for CO permitted by the Navy are safe for adults, but very likely too high to ensure fetal well being in case of equipment malfunction or a fire.

Effects of Carbon Dioxide (CO₂)

For design reasons, the mean concentration of the carbon dioxide 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 do occur in crew members 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 kind of prolonged 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. Given the lack of human tests, these findings cannot be ignored or withheld from prospective female submarine crewmembers.

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 a woman and her embryo-fetus. For that reason, complete and candid information regarding health risks should be provided to women of child-bearing age who are being recruited for service on submarines. Goals for achieving a "critical mass" of submarine-qualified female crewmembers are not likely to be achieved when women are fully informed of irresolvable health risks to themselves and their families.

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. It may be theoretically possible to design a submarine with an ideal atmospheric control system, but the sheer size would limit significantly the room to carry weapons and perform its normal mission.

Complications of Abnormal Pregnancy – Ruptured Ectopic Pregnancy

As soon as a normal pregnancy is known or detected, the woman should be removed as soon as possible to avoid the risk of injury to the normal development and the viability of the embryo-fetus.

Ectopic pregnancy, which is the leading cause of pregnancy-related deaths in the first 20 weeks of gestation, is incompatible with submarine operations. Such emergencies would pose an unreasonable risk on the woman and a great burden on the medical department of a submarine.

Ruptured ectopic pregnancy is the leading cause of pregnancy-related death 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.^{iv}

Women comprise 15 percent of the total force, 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 per 1000 women, 3 or 4 of which will be ectopic per year. 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 among 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 could not be made available aboard a submarine without the removal of operational equipment. Even if a tubal pregnancy is diagnosed before rupture, the treatment still is surgical. In a civilian hospital, 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. Surgical errors can result in permanent loss or reduction of fertility.

Moreover, a ruptured ectopic pregnancy is a life threatening condition that requires immediate surgical treatment and intensive blood and fluid replacement. A mid-ocean helicopter 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 what effect 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, including health risks, which could 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.

Navy officials have noted that women have earned about half of all of the technical engineering bachelor degrees since 2000, making them a rich resource of talent for the Submarine Force officer accession programs.^v However, the retention rate among current crop of nuclear trained female surface officers is only two-percent. Intelligent women also are practical, and many vote with their feet. Engineering skills are transferable to the civilian sector, where women are welcomed as engineers. In civilian occupations women get to go home every night, marry when they want and have their families—all without the risk of birth defects on top of the usual rigors of arduous sea duty. It is very doubtful that submarine duty would result in higher retention rates. Increasing the opportunities for sea duty for women is not a very good investment.

More information on quality of life and operational issues related to submarine service is available in a 59-page report titled *Submarine Assignment Policy Assessment*, which was prepared by the Science Applications International Corporation (SAIC).^{vi} The 59-page report, which SAIC prepared for the Navy in 1995, remains the most comprehensive analysis ever done on this subject. It should be reviewed by all members of Congress and Pentagon officials with responsibility for this issue.

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- ⁱⁱ Brittain A. Dean MR, Holden HJ, Brown DC, McMillan GHG, Mixed Manning in Submarines: Foetal Health, Alverstoke, UK, Institute of Naval Medicine
- ⁱⁱⁱ Ivan A Lopez, Dora Acuna, Luis Beltran-Parrazal, Ivan E Lopez, Abhimanyu Amarnani, Max Cortes John Edmond: Evidence for oxidative stress in the developing cerebellum of the rat after chronic mild carbon monoxide exposure (0.0025% in air); Journal BMC (BioMed Central) Neuroscience online edition <http://www.biomedcentral.com/1471-2202/10/53>
- ^{iv} Current Trends Ectopic Pregnancy, CDC MMWR Report January 27, 1995 / 44(03);46-48 -- United States, 1990-1992
- ^v Mary Beth Marklein: College gender gap widens: 57% are women, USA Today, 19 Oct 2005
- ^{vi} The SAIC Report is available at <http://cmrlink.org/CMRNotes/SAPA%20020195.pdf>.