

Features

**INEQUALITIES IN THE NUCLEAR AGE:
IMPACT OF RACE AND GENDER ON
RADIATION EXPOSURE AT THE SAVANNAH
RIVER SITE (1951-1999)***

**KIM A. ANGELON-GAETZ
DAVID B. RICHARDSON
STEVE WING**

ABSTRACT

Changes in the workforce during the civil rights movement may have impacted occupational exposures in the United States. We examined Savannah River Site (SRS) employee records (1951-1999) for changes in radiation doses and monitoring practices, by race and sex. Segregation of jobs by race and sex diminished but remained pronounced in recent years. Female workers were less likely than males to be monitored for occupational radiation exposure [odds of being unmonitored = 3.11; 95% CI: (2.79, 3.47)] even after controlling for job and decade of employment. Black workers were more likely than non-black workers to have a detectable radiation dose [OR = 1.36 (95% CI: 1.28, 1.43)]. Female workers have incomplete dose histories that would hinder compensation for illnesses related to occupational exposures. The persistence of job segregation and excess radiation exposures of black workers shows the need for further action to address disparities in occupational opportunities and hazardous exposures in the U.S. South.

*This project was supported by a training grant [T32ES7018] from the National Institute of Environmental Health Sciences (NIEHS) and a U.S. Department of Education Foreign Language and Area Studies (FLAS) fellowship.

INTRODUCTION

The division of labor in the United States by occupation and industry has a clear racial and gender structure. This structuring of employment in the U.S. tends to lead to concentrations of black workers in inherently dangerous types of jobs that involve hazardous and/or unpleasant working conditions [1, 2]. Even between workers holding similar jobs, there are often racial and gender differences in occupational hazards [1, 3]. One study which examined coke oven workers in the 1950s found that a higher percentage of black workers had long-term employment in topside positions (where the highest exposures occurred) than white workers [4]. Compounding these differences, women and African-American men were less likely to get high-paying, salaried positions than white men [3, 5]. Therefore, female and African-American male industrial workers received less compensation for exposure to workplace hazards than white males [3].

In the U.S. South, *de jure* racial segregation persisted into the 1960s. During the 1950s-1970s, social struggle spilled into every aspect of life, including labor, organizing around the civil rights movement and later sparking the resurgence of the modern women's rights movement [1]. In the 1950s, African-American workers were often made to train white workers for skilled positions that were off-limits to them due to segregated systems of promotion and inequalities in formal education [2, 3, 6].

Recruited into higher paying industrial jobs during World War II, women were laid off or pressured by management to quit after men returned from the war in 1945. One sample of women working in the early 1940s at a Ford manufacturing plant showed that over half received good performance ratings, but most of those who did not voluntarily quit were laid off after the war [7]. For African-American women, it was rare to be hired for industrial work at all before the 1960s [3].

Mandating improvement of working conditions and hiring policies, Title VII of the Civil Rights Act of 1964 aimed to liberate all workers from "any discrimination based on race, color, religion, sex, or national origin" [8]. The restructuring of the industrial workforce by race and gender opened jobs previously inaccessible to women and people of color. Despite the increase in opportunities for women and African-American men, however, these workers were still placed in more dangerous work environments than their white, male counterparts. Interviews with former workers revealed continuing evidence of racial inequalities, including lack of proper safety training and equipment for African-American workers [1, 3]. In southern paper mills, the backlash against desegregation by white workers often included physical and verbal threats to black workers, refusal to assist and train new black workers entering "white jobs," and sabotage of new workers' equipment [3]. A study of workers in North Carolina (1977-1991) found that African-American men had higher fatal occupational injury rates compared to white men even after adjustment for

employment patterns [9]. Women were still unwelcome in the traditionally male jobs and were often “hazed” by removal of safety equipment from their work areas or by placement in the dirtiest, most labor intensive positions [5].

In this article, we evaluate the jobs and radiation exposures of workers employed from 1951 to 1999 at the Savannah River Site, a large U.S. Department of Energy (DOE) nuclear weapons facility located in the Southeast U.S. The Savannah River Site (SRS) was built in Aiken County, South Carolina, across the river from Augusta, Georgia. When SRS began operating in 1951, Aiken County was predominantly rural. The facility attracted a diverse mix of laborers, scientists, clerical, and administrative workers—all necessary for the task of building nuclear weapons—from both within and outside of Aiken County. The nuclear weapons facility brought the residents of Aiken County higher paying job opportunities with federal employment benefits. SRS created over 10,000 new jobs during its first decade of operation. The facility’s location and status as one of the area’s major employers through the civil rights movement makes it an appropriate setting for studying how social struggles may have impacted occupational exposures.

Of particular interest in these analyses are the employment and radiation exposure experiences of female and black workers in the U.S. nuclear industry during this time of social transition. The study encompasses a diverse range of occupations, and the majority of workers were individually monitored for radiation exposures. These records provide quantitative annual exposure estimates collected over nearly five decades.

MATERIALS AND METHODS

To maintain comparability with previous studies of SRS workers, we examined occupational records from the same cohort of 18,883 workers employed for at least 90 days between January 1, 1951 and December 31, 1986 with complete information on name, social security number, sex, and dates of birth and hire [10-12]. No workers were lost to follow-up during employment. Although SRS used many temporary workers and subcontractors, only permanent employees of E.I. du Pont de Nemours and Company (Du Pont), the company that managed and operated the plant until 1989, have been included in this cohort [13]. Of the 21,204 people hired by Du Pont between 1950 and 1986, 1,355 temporary workers (employed < 90 days) were excluded, and 251 workers were excluded due to missing information on date of birth, sex, or date of hire [12]. Workers known to have been employed at another U.S. Department of Energy facility ($n = 715$) were excluded since dose history from other facilities was not available.

Demographic characteristics of Aiken County (location of SRS) were obtained from the U.S. Census Bureau records [14-18].

Estimates of occupational exposures to ionizing radiation from external sources were derived from personal dosimeters designed to measure shallow and

penetrating doses. Previous studies describe the data in more detail and have assessed their reliability for use in epidemiologic studies [19]. Annual whole body ionizing radiation dose estimates (in milliRem, mRem) were compiled for the period January 1, 1951 and December 31, 1999 from site records.

Demographic information, job title, and pay code (monthly, weekly, or hourly-paid) were abstracted from payroll and employment records. A single job title for each year was assigned based on the longest held occupation in that year. As in previous studies, the variable “pay code” (monthly, weekly, or hourly) was assigned based on pay status at first hire and was used as a measure of socioeconomic status. Hourly workers held unskilled and skilled technical jobs, weekly workers held clerical and office positions, and monthly workers filled professional positions.

We constructed an analytical file with one record for each calendar year in which an individual was employed; we refer to this as a work-year. For the regression models, we considered both fixed and time-dependent predictor variables. Race, gender, and pay code were fixed. Job title, calendar period, annual radiation dose, and radiation monitoring status varied over time. Race was coded dichotomously as black and non-black (referent) since 99% of the cohort members were classified as either “black” or “white.” Pay code was highly correlated with job title, and thus was dropped from all models. Detailed job titles were classified into 33 major occupational categories and codified based on the 1980 U.S. Census of Occupations. Job title was entered into the model as a classification variable with general service operator as the referent due to the large number of work-years contributed by workers in this job category. Work-years with unrecorded job titles were excluded from all regression models. Since dosimeter technology and annual exposure trends varied more between than within decades, calendar period was categorized into decades and coded using indicator variables.

We first evaluated predictors of whether or not employees were monitored for radiation exposure. An employee was considered monitored during a work-year if a whole body radiation dose was recorded for that year. We looked at preliminary trends in monitoring over time for each demographic group. Then using logistic regression, we examined the effects of gender and race on odds of being monitored with adjustment for job title and decade. Because the work-years represent multiple observations per person, we used a Generalized Estimating Equation (GEE) to account for clustering by person with an exchangeable correlation matrix, assuming more variation between subjects than between work-years for one subject. We modeled the combined effects of race and gender by adding an interaction term to the adjusted GEE model and calculating the odds ratio for being monitored for each demographic group using non-black males as the referent.

The next outcome examined was whether workers’ annual whole body radiation doses were above or below the detection limit. Work-years with missing

dose-estimates (considered in the previously described monitoring analysis) were excluded from these analyses. If all of a worker's dosimeter results in a year were below the detection limit, his or her annual dose was recorded as zero. Annual doses greater than 0 mRem are referred to as "exposed," and those equal to 0 mRem are referred to as "unexposed." We first examined changes in mean annual doses over time for each demographic group. Then, since we were interested in comparing annual rather than cumulative exposures, we analyzed the effects of gender and race on odds of being exposed using multivariate logistic GEE regression models adjusted for job title and decade with an exchangeable correlation matrix. Using these models, we also quantified the magnitude of effect measure modification (EMM) between gender and race on exposure status. GEE logistic regression models were run to estimate effects of gender and race on odds of having an annual dose greater vs. less than 50 and 300 mRem, after adjustment for job title and decade. The cut point (> 50 mRem) represents doses clearly over the maximum dose recording threshold (30mRem) for any time point in cohort follow-up [19]. For further reference, the average background exposure for a resident of the United States, recently estimated to be about 300 mRem annually, was chosen for the final cut point [20, 21].

RESULTS

Over 50% of SRS cohort members were hired during the 1950s. Between the 1950 and 1960 census, Aiken County's population grew by 52.5%, while the proportion of black residents decreased from 36.3% to 26.3%. In addition, the median income in Aiken County for a family of two or more people increased by 157% from 1949 (\$1,912) to 1959 (\$4,913) compared to a 99% increase (from \$1,921 to \$3,821) in the median family income for the state.

Only 5.4% of new hires in 1950 were black despite the fact that at the same time, over one-third (36.3%) of the population of Aiken County was black. One-third of all new hires in the 1970s were black, compared to less than one-fifth in every other decade. In contrast, about a quarter (range: 23.9%-26.3%) of Aiken County's population from 1960 to 1990 was black.

Though the percent of new hires who were black males was less than the percent of black males in Aiken County in the 1950s and 1960s, 22.7% of new hires in the 1970s were black males compared to 11.4% of Aiken County residents. In 1967, the number of black male workers hired surpassed the number of non-black females hired. In the 1980s, the proportions of black males in both populations were approximately equal [14]. In the 1950s and 1960s, non-black males were greatly over-represented among new hires at SRS (82.0% in the Fifties and 70.5% in the Sixties) compared to the Aiken County population (31.3% in 1950 and 36.5% in 1960). In the 1970s and 1980s, slightly more than 50% of all new hires at SRS were non-black males though the proportion of non-black male Aiken County residents remained similar to that in 1960.

Although the county had more female than male residents in every decade of follow-up, only 12.6% of workers hired in the 1950s were female. The proportion of female new hires at SRS steadily increased to 29.0% in the 1980s. Only one black female worker was hired in the 1950s. This group also represented the smallest number of new hires in every other decade (range: 2.9%-10.7%), despite making up 12.6% to 13.8 % of Aiken County's population from 1960 to 1980. For every decade, the proportion of non-black females hired at SRS was approximately half of the proportion of non-black females in the Aiken County population.

Between 1951 and 1999, the cohort contributed 277,735 work-years. Most work-years were contributed by non-black males (75.5%) and over half of all work-years were from hourly workers (50.6%). The largest percent of work-years accrued during the 1980s (25.8%). The limited number of work-years during the 1990s (12.9%) was directly related to the cohort entrance criterion (workers hired before 1986).

Less than 5% of work-years had unrecorded job titles. Non-black males were employed in almost all possible occupational categories (33 total) in every decade of follow-up (1950s through the 1990s). In contrast, black males were employed in only 11 different categories in the 1950s and 18 categories in the 1960s. Since the 1970s, black male workers have attained work in an increasing variety of job types (> 25) including managerial, supervisory, scientific, and engineering positions. Female workers were typically hired as clerical workers or technicians before the 1970s but later attained positions as radiation monitors and supervisors in the 1980s and 1990s. Non-black females were employed in < 15 job categories in the 1950s and 1960s, with a sharp increase in job variety in the 1970s, bringing them almost equal to the men by the 1980s. Though in the 1960s, black female workers were still only employed in five job categories, they had the largest increase in job variety over time. In the 1970s and 1980s, the number of job categories held by black females rose sharply, though never equaled that of non-black females in any given decade.

The shift in employment demographics was also reflected in changes in professional status for black and female workers. Figure 1 illustrates the changes in pay code at first hire for each demographic group over time. Pay code was recorded for all workers. Women were typically paid weekly and worked in clerical positions. However, a greater percentage of female SRS workers were hired into hourly and monthly-paid positions during the 1980s and 1990s. Non-black males had the highest percentage of monthly-paid workers, representing most of the "white collar" jobs, throughout all five decades. Black male workers were typically paid hourly and held more "blue collar" positions, though they were hired into more monthly and weekly-paid positions starting in the 1970s.

At SRS, 7.3% of work-years were unmonitored. Figure 2 shows that monitoring was more complete for all demographic groups during later years of follow-up. Non-black female workers had large proportions of work-years

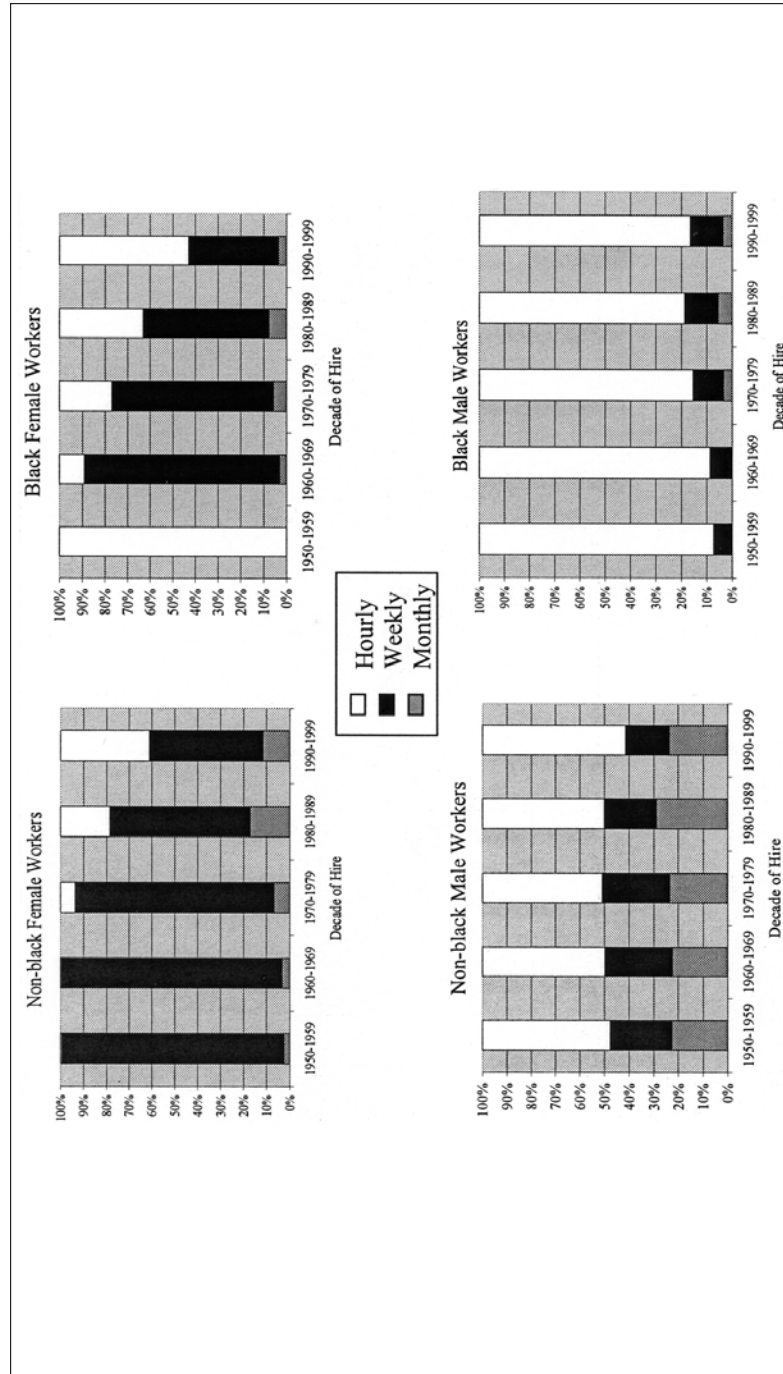


Figure 1. Changes in pay code of newly hired Savannah River Site workers by race and gender.
(Note: Only one African-American woman worked in the 1950s.)

unmonitored until the early 1970s. After adjusting for job and decade, female workers had 3.11 (2.79, 3.47) times the odds of male workers being unmonitored. Looking at the effect of race alone, black workers had 0.80 (0.71, 0.90) times the odds of non-black workers being unmonitored. Black female workers had lower odds [OR = 1.96 (1.55, 2.46)] of having a missing dose than non-black female workers [OR = 3.20 (2.86, 3.57)] (see Table 1). Nonetheless, black female workers had almost twice the adjusted odds of missing a dose compared to non-black males.

Figure 3 graphs the average annual radiation dose for Savannah River Site workers by demographic group. Black female workers had the highest annual mean dose of any demographic group, 718.3 mRem in 1968. From the late 1970s until the mid 1980s, black workers of both sexes received higher average annual doses than non-black workers. Over the entire study period, the crude mean whole body dose was highest for non-black male workers (222.1 mRem, SE = 464) and lowest for non-black females (64.5 mRem, SE = 217). Black female workers had a higher mean dose (99.3 mRem, SE = 270) between 1951 and 1999 than non-black females; however, black male workers had a lower mean dose (188.5 mRem, SE = 392) than non-black males. In the late 1990s, the mean annual dose for all four groups was close to the recording threshold.

Controlling for job and decade, female workers had lower odds [OR = 0.75 (0.70, 0.79)] of having a detectable dose (> 0 mRem) than male workers. Black workers had higher odds [OR = 1.36 (1.28, 1.43)] of detectable dose compared to non-black workers, controlling for job and decade. Table 2 reports the adjusted odds of having a recorded whole body dose above 0 mRem, 50 mRem, and 300 mRem. Non-black female workers had the lowest odds of having an annual whole body dose > 0 mRem and black male workers had the highest odds. Black men had higher odds of being exposed at lower doses compared to non-black men. After controlling for job and decade, non-black women had lower odds than non-black men of being in the higher dose category at every cut point; however, black women had higher odds than non-black women of being in the higher dose category at every cut point (see Table 2).

DISCUSSION

There is a large body of literature describing segregation of labor, positing impacts on occupational hazards. However, rarely do we have the opportunity to investigate questions about the impact of racial and gender discrimination on the magnitude of occupational exposures. The nuclear industry is unique in that large groups of workers were systematically and individually monitored for radiation exposures. SRS is interesting as a federal facility, located in the southeastern United States, with employment and occupational radiation monitoring records dating back to the early 1950s.

Labor was highly divided by gender in the 1950s and 1960s, with women mostly hired for clerical work at the SRS and elsewhere. The difference between

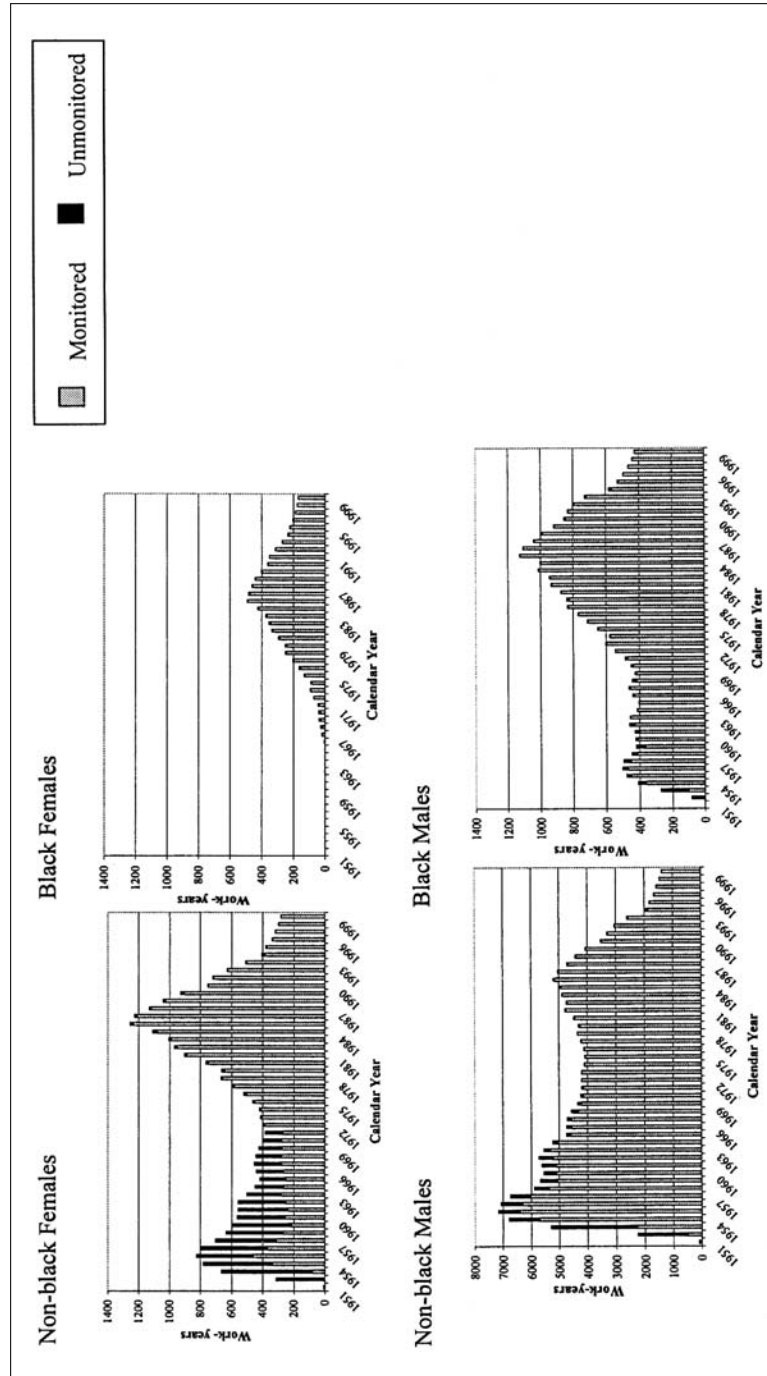


Figure 2. Number of work-years by radiation monitoring status and calendar year.
 (Note: The y-axis scale differs for non-black males due to the large number of years worked by this group.)

Table 1. Adjusted Odds Ratio for Monitoring Status of Savannah River Site Workers, 1951-1999*

Contrast	Effect estimate	Worker demographic group**			
		Non-black male	Non-black female	Black male	Black female
Unmonitored vs. monitored	OR (95% CI)	Ref.	3.20 (2.86, 3.57)	0.87 (0.77, 0.99)	1.96 (1.55, 2.46)

*Accounting for repeated measures on 18,883 workers, adjusted for decade and job title.

**N = 257,370 work-years total; dose missing for 20,365 work-years.

the predominant pay codes given to women (weekly) versus men (hourly and monthly) also testifies to the division between male and female workers. The “family wage” was ideally contributed by men as the breadwinners of the family, while women were considered dependents and temporary workers, not in need of a steady salary or decent wages [6].

Our findings suggest that job opportunities opened up to black and female SRS workers over the last three decades of cohort follow-up. However, even in the 1990s large racial differences remained in pay code, an indicator of socioeconomic status. For example, 3.7% of black men, compared to 23.7% of non-black men, held monthly paid jobs (see Figure 1). Furthermore, racial and gender issues related to radiation safety monitoring and work environment lingered. The highest odds of being unmonitored for radiation exposure were found in non-black female workers even after controlling for job and decade, whereas black male workers had lower odds than non-black males. The greater completeness in monitoring for black males is consistent with their higher average doses given that health physics staff tended to focus monitoring efforts on those with higher exposure potential.

At the Savannah River Site, the mean annual whole body dose of ionizing radiation for female workers rose until 1982. This may indicate the entry of women into jobs from which they were previously excluded. Unfortunately, gaining more equal status with men in the workplace also meant that women endured higher occupational exposures. Controversy arose over how low to set the maximum allowable dose for women with reproductive potential [22]. After much disagreement over how much radiation exposure would be harmful to a developing embryo, regulators decreed that the dose limit for an embryo or fetus should not exceed 500 mRem [22, 23]. To put this in perspective, the increased risk of childhood leukemia following in utero exposure has been estimated to be approximately 50% per Rem [24]. In 1991, the U.S. Supreme Court ruled that companies could not ban women from “hazardous jobs,” a practice which many

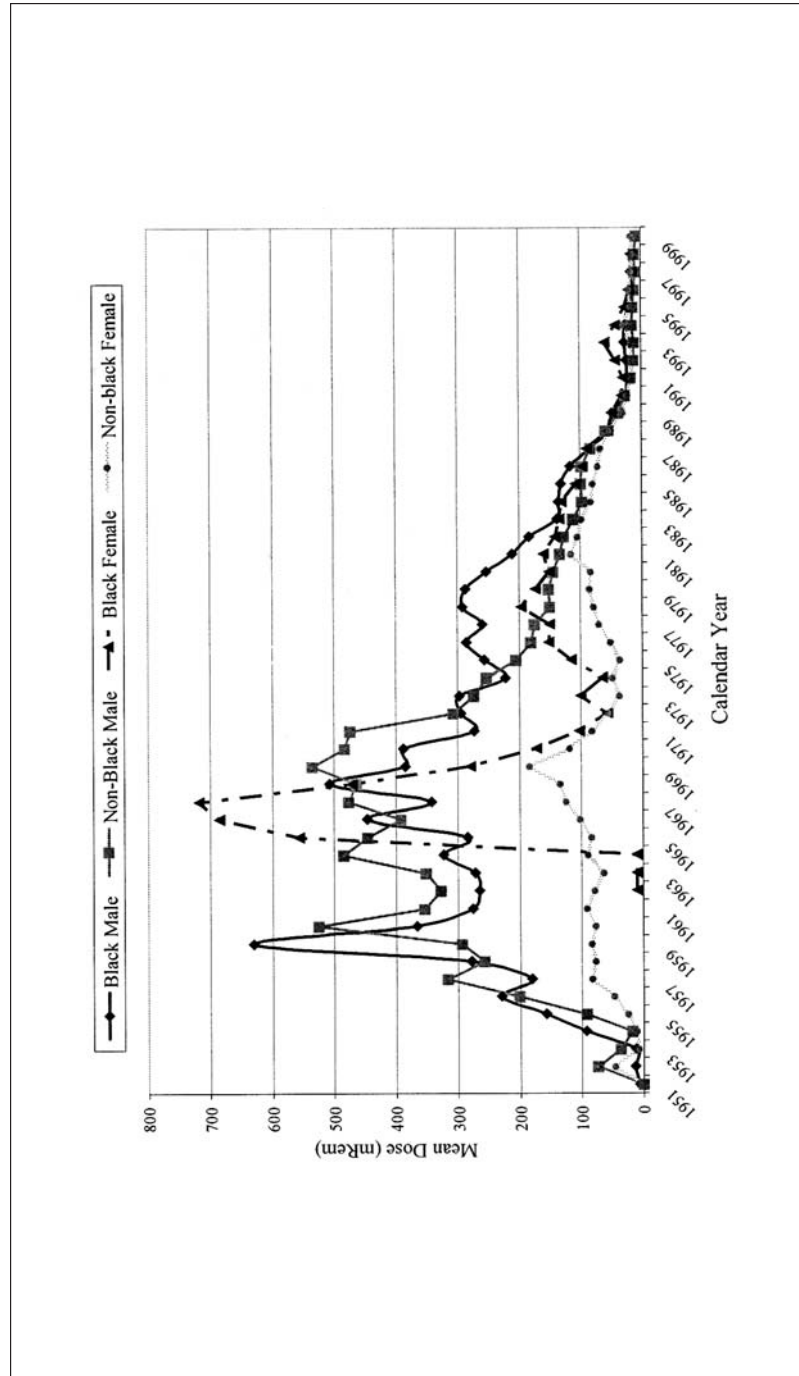


Figure 3. Mean annual radiation dose of Savannah River Site workers by demographic group.

Table 2. Adjusted Odds Ratio for Radiation Dose Above the Specified Cut Point. Savannah River Site Workers, 1951-1999*

Contrast	Effect estimate	Worker demographic group**			
		Non-black male	Non-black female	Black male	Black female
0 mRem vs. > 0 mRem	OR (95% CI)***	Ref.	0.74 (0.70, 0.79)	1.35 (1.27, 1.43)	1.03 (0.94, 1.13)
≤ 50 mRem vs. > 50 mRem	OR (95% CI)***	Ref.	0.75 (0.68, 0.83)	1.30 (1.21, 1.41)	1.12 (0.98, 1.26)
≤ 300 mRem vs. > 300 mRem	OR (95% CI)***	Ref.	0.71 (0.62, 0.82)	1.13 (1.03, 1.24)	1.01 (0.85, 1.20)

*Accounting for repeated measures on 18,883 workers, adjusted for decade and job title.

**N = 257,370 work-years total; dose missing for 20,365 work-years.

***Analysis among monitored individuals.

companies used to avoid the costs of implementing special safety measures for women of reproductive age [5, 25].

Overall, male workers at SRS had higher odds than female workers of having a detectable whole body dose in a given year even after controlling for job and decade effects. Due to previously mentioned suspicions that ionizing radiation posed risks to women of reproductive age, women may have been protected from work tasks that involved detectable levels of radiation [5]. When the gender groups are stratified by race, however, the odds of black female workers being in higher dose categories were comparable to non-black males and higher than the odds for non-black females. On the contrary, non-black female workers were less likely to have a detectable dose than non-black males. Racism and class differences may help explain why black female workers were more likely to accrue higher radiation exposures than non-black females, despite the low levels of radiation typically received by female workers [6].

In general, black workers had higher odds than non-black workers of the same gender of having an annual dose > 0 mRem and > 50 mRem after controlling for job and decade. For black men, this association was closer to the null as the dose cut point increased. One interpretation may be that jobs which regularly received the highest doses were very skilled jobs not traditionally open to black male workers and female workers. For all categories, the confidence intervals increased as the dose cut point increased, due to the small sample sizes in the higher dose categories. Since job titles were assigned by human resources for administrative purposes, job title and work task were not identical. Hence two

people might have had the same job title and yet could have performed different tasks with different exposure potentials.

For the purposes of our study, workers with no recorded radiation dose for a year were considered unmonitored for that year. Unfortunately, employees without dose records must rely on dose reconstructions as evidence in compensation claims for cancers that may have resulted from occupational radiation exposure [26]. Our study suggests that unmonitored workers were likely to be female. A recent mortality study of SRS employees found that female workers had more deaths than expected from kidney and skin cancer [11].

Odds of being exposed and monitored are highly affected by the employment period. Naturally, trends in mean annual radiation doses were influenced by demands in production. The dwindling mean annual doses of all workers after the late 1980s, parallels decreases in demand and production caused by the thawing of Cold War tensions [27]. In 1988, three reactors were closed, and the U.S. Environmental Protection Agency (EPA) started regulating SRS a year later [13].

Changes in regulations may have affected both the average doses and the monitoring procedures. Although since the recorded, average annual whole body doses for SRS workers in every decade remained below even the current occupational dose limit enacted in 1991, it is unlikely that earlier changes in dose limits greatly affected these doses [22, 23]. Workers were monitored monthly and annually by film badges, until 1970 when they were replaced by the more accurate thermoluminescent dosimeters, further improved in 1982 [13]. The advances in dosimeter technology may have affected the accuracy of the actual recorded doses; however, they are not expected to have changed the relative dose differences comparing one worker to another within the same time period.

We focused on long-term, permanent, contract, nuclear workers. SRS employees who were employed for < 90 days or those employed by subcontractors were not included in our analysis because dose records for these workers were often unavailable or unreliable. Temporary workers and subcontractors, however, were often hired for “planned special exposures,” cleaning or production tasks that involved high radiation exposure potential (up to 10 Rem at a time and 25 Rem in a lifetime) to prevent permanent workers from reaching their dose limits [22, 23]. This population is often left out of occupational radiation research due to a lack of records and difficulty of tracing mobile populations. However, these workers may be more vulnerable to race and gender discrimination than long-term workers.

In addition, our study focused on the information that we could glean from occupational records, including dose and monitoring history and pay status. We are unable, however, to determine the provision and usage of personal protective equipment (PPE). One history of the Savannah River Site asserts that safety was “always of key importance to Du Pont” and indicates that workers received at least some of the protective equipment free of charge [13].

Since each worker's occupational information was summed up for each year, the longest job title in that year was recorded for each worker. If a worker was removed from his or her position early in the year after reaching the maximum allowable dose limit, the annual dose attributed to that worker's longest job title may be higher than expected for that job title. However, since only three recorded whole body doses were > 5000 mRem in one year, the potential for misclassification of job title by exposure is restricted to these three work-years.

CONCLUSION

The Savannah River Site data revealed evidence of job segregation that persisted after the passing of Title VII. Title VII codes took some time to implement, given the slow process of integration. Historical research suggests that the struggles of the civil rights movement extended well beyond the 1960s and are carried on today in the "long" civil rights movement [3, 6].

Continued monitoring of SRS workers is necessary to maintain safety standards with regard to protection of vulnerable workers. As the demographics of the South change with the influx of Hispanic immigrants into rural communities, public health officials must be especially vigilant to enforce proper safety training and safety equipment orientation for new workers in their native languages and equal radiation monitoring for all nuclear workers. Future studies may reveal whether jobs at SRS today are equitably distributed among workers regardless of race and gender and whether monitoring of workers continues to improve. It is time to move past integration to fully ensuring an equally safe work environment for all workers.

ABBREVIATIONS

CI = confidence interval
DOE = Department of Energy
EMM = effect measure modifier
EPA = Environmental Protection Agency
GEE = Generalized Estimating Equation
mRem = milliRem
N = sample size
OR = odds ratio
PPE = personal protective equipment
SE = Standard Error
SRS = Savannah River Site
SSN = Social Security Number

ACKNOWLEDGMENTS

The authors would like to thank Dr. Thomas McQuiston for his formative discussions on the background of this article and to acknowledge Dr. James Ruttenber (deceased), whose work inspired our research questions. The authors are also grateful to Susanne Wolf for all of her background knowledge and organization of the data and to Dr. Mary Beth Ritchey for her technical assistance.

REFERENCES

1. M.K. Honey, *Black Workers Remember: An Oral History of Segregation, Unionism, and the Freedom Struggle* (Berkeley: University of California Press, 1999).
2. R.B. Olwell, *At Work in the Atomic City: A Labor and Social History of Oak Ridge, Tennessee*, 1st ed. (Knoxville: University of Tennessee Press, 2004).
3. T.J. Minchin, *The Color of Work: The Struggle for Civil Rights in the Southern Paper Industry, 1945-1980* (Chapel Hill: University of North Carolina Press, 2001).
4. C.K. Redmond, A. Ciocco, J.W. Lloyd, and H. W. Rush, "Long-Term Mortality Study of Steelworkers. VI. Mortality from Malignant Neoplasms among Coke Oven Workers," *Journal of Occupational Medicine* 14, 8 (1972): 621-629.
5. W. Chavkin, *Double Exposure: Women's Health Hazards on the Job and at Home* (New York: Monthly Review Press, 1984).
6. J.D. Hall, "The Long Civil Rights Movement and the Political Uses of the Past," *The Journal of American History* 91, 4 (2005): 1233-1263.
7. S.A. Kossoudji and L.J. Dresser, "Working Class Rosies: Women Industrial Workers during World War II," *The Journal of Economic History* 52, 2 (1992): 431-446.
8. Civil Rights Act of 1964, Public Law 88-352, 78 Statute 241 (1964).
9. D. Loomis and D. Richardson, "Race and the Risk of Fatal Injury at Work," *American Journal of Public Health* 88, 1 (1998): 40-44.
10. D.L. Cragle, R.W. McLain, J.R. Qualters, J.L. Hickey, G.S. Wilkinson, W.G. Tankersley, et al., "Mortality among Workers at a Nuclear Fuels Production Facility," *American Journal of Industrial Medicine* 14, 4 (1988): 379-401.
11. D.B. Richardson, S. Wing, and S. Wolf, "Mortality among Workers at the Savannah River Site," *American Journal of Industrial Medicine* 50, 12 (2007): 881-891.
12. D.B. Richardson and S. Wing, "Leukemia Mortality among Workers at the Savannah River Site," *American Journal of Epidemiology* 166, 9 (2007): 1015-1022.
13. M.B. Reed, M. Swanson, S. Gaither, J.W. Joseph, W. Henry, T. Fedor, et al., *Savanna River Site at Fifty* (Washington, D.C: U.S. Dept. of Energy Supt. of Docs., U.S. Government Printing Office, distributor, 2002).
14. United States Bureau of the Census, *1980 Census of Population. Volume 1, Part 42, Characteristics of the Population. South Carolina* (Washington, DC: U.S. Dept. of Commerce, 1981).
15. United States Bureau of the Census, *1970 Census of Population. Volume 1, Part 42, Characteristics of the Population. South Carolina* (Washington, DC: U.S. Dept. of Commerce, 1973).
16. United States Bureau of the Census, *1990 Census of Population. CP-1-42, General Population Characteristics. South Carolina* (Washington, DC: U.S. Dept. of Commerce, 1991), electronic source accessed January 15, 2009.

17. United States Bureau of the Census, *U.S. Census of Population: 1960. Volume 1, Part 42, Characteristics of the Population. South Carolina*. (Washington, DC: U.S. Dept. of Commerce, 1961).
18. United States Bureau of the Census, *Census of Population: 1950. Volume II, Part 40, Characteristics of the Population, South Carolina*. (Washington, DC: U.S. Dept. of Commerce, 1952).
19. D.B. Richardson, S. Wing, and R.D. Daniels, "Evaluation of External Radiation Dosimetry Records at the Savannah River Site, 1951-1989," *Journal of Exposure Science and Environmental Epidemiology* 17.1 (2007):13-24.
20. K. Shrader-Frechette, "Trimming Exposure Data, Putting Radiation Workers at Risk: Improving Disclosure and Consent through a National Radiation Dose-registry," *American Journal of Public Health* 97, 10 (2007): 1782-1786.
21. National Research Council, *Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII, Phase 2* (Washington, DC: National Academies Press, 2006).
22. J.S. Walker, *Permissible Dose: A History of Radiation Protection in the Twentieth Century* (Berkeley: University of California Press, 2000).
23. U.S. Nuclear Regulatory Commission. Title 10, Chapter I of the *Code of Federal Regulations*. Part 20-Standards for Protection against Radiation. Subpart C—Occupational Dose Limits (1991): 20.1201-20.1208.
24. R. Wakeford, "Childhood Leukemia following Medical Diagnostic Exposure to Ionizing Radiation In Utero or After Birth," *Radiation Protection Dosimetry* 132, 2 (2008): 166-174.
25. U.S. Department of Health and Human Services, "Protecting Workers Exposed to Lead-based Paint Hazards: A Report to Congress," *DHHS [NIOSH] Publication* (1997): Chapter 1, 98-112.
26. Energy Employees Occupational Illness Compensation Program Act of 2000. Public Law 106-398, [title XXXVI], 114 Statute 1654 (2000).
27. B. Lightbody, *The Cold War* (New York: Routledge, 1999).

Direct reprint requests to:

Kim A. Angelon-Gaetz
 Department of Epidemiology
 University of North Carolina at Chapel Hill
 McGavarn-Greenberg Hall, CB# 7435
 Chapel Hill, NC 27599
 e-mail: Kangelon@email.unc.edu