

## Letter

## Health burdens of uranium miners will extend beyond the radiation exposure compensation act deadline

The US Radiation Exposure Compensation Act (RECA) is a government compensation programme, which provides partial restitution to individuals whose health was affected by nuclear weapons testing or uranium industry employment. RECA covers US uranium miners employed between 1942 and 1971 who developed or died from lung cancer, pulmonary fibrosis, silicosis, pneumoconiosis or cor pulmonale related to lung fibrosis. RECA is set to terminate this year. The filing deadline for living claimants or spouses of deceased claimants is 10 July 2022.<sup>1</sup> To assess evidence of whether uranium miners will continue to develop compensable diseases after the termination of RECA, we examined mortality rate trends within the US Colorado Plateau uranium miner cohort.

The US Colorado Plateau cohort includes 4137 underground uranium miners employed for at least 1 month and with one or more medical screenings between 1950 and 1960. Underlying cause of death was ascertained through 2016 using the US National Death Index. Person time began in 1960 when reference mortality rates were available. Person time ended at date of death, date lost to follow-up or the end of follow-up (2016). The cohort does not include millers or ore transporters. Details on cohort inclusion criteria, vital status, mortality ascertainment, outcome definition and standard population rates are reported in a previous study.<sup>2</sup>

We calculated standardised mortality ratios (SMRs) and corresponding 95% CIs overall and by decade of calendar period (1960–1969, ..., 2000–2009, 2010–2016) for silicosis, interstitial pulmonary fibrosis (IPF) and pneumoconiosis, which are compensable for uranium miners under RECA. SMRs were adjusted for age and calendar period (5-year groups) and racialisation (white or American Indian). Regional standard mortality rates for all outcomes were based on data from New Mexico, Arizona, Utah and Colorado for white miners, and New Mexico and Arizona for American Indian miners.<sup>3</sup>

From 1960 to 2016, there were 64 IPF deaths, 49 pneumoconiosis deaths and 52 silicosis deaths in the cohort. Overall,

the IPF mortality rates were 380% higher than the standard population (SMR 4.8; 95% CI 3.7 to 6.1), pneumoconiosis mortality rates were 3860% higher than the standard population (SMR 39.6; 95% CI 29.3 to 52.3), and silicosis rates were 4040% higher than the standard population (SMR 41.4; 95% CI 30.9 to 54.3).

For all three causes of death, rates were higher in more recent calendar periods. IPF rates were lowest in 1960–1969 (observed=2, SMR=2.0; 95% CI 0.2 to 7.1) and highest in 2010–2016 (observed=24, SMR=9.3; 95% CI 6.0 to 13.8). Pneumoconiosis mortality rates were most elevated in 2000–2009 (observed=12, SMR=68.7; 95% CI 35.4 to 120.0) but remained substantially elevated in the 2010–2016 period (observed=13, SMR=56.4, 95% CI 30.0 to 96.4). Silicosis mortality was also elevated in later calendar periods, with the highest SMR in 1980–1989 (observed=17, SMR=75.7; 95% CI 44.1 to 121.2). In 2010–2016, silicosis mortality rates remained substantively higher than the standard population (observed=6, SMR=61.5; 95% CI 22.4 to 133.8).

While the majority of US uranium mining activities ceased by the mid-1990s, the health effects of uranium mining persist. An important public health implication of our SMR analysis is that former uranium miners in the US continue to die of IPF, silicosis, and pneumoconiosis at a far higher rate than the comparable general population over our period of study; SMRs are elevated overall, increase with advancing calendar period and persist over time. This analysis suggests that former uranium miners will develop RECA-eligible diseases after RECA ends.

The inferences from these SMRs extend beyond the Colorado Plateau cohort. The Colorado Plateau uranium miner cohort represents only a small sample of the total US uranium miner population. The uranium industry employed tens of thousands of workers,<sup>1</sup> perhaps as many as 30 000 workers mined uranium underground.<sup>4</sup> So, the Colorado Plateau cohort represents only about 5%–15% of the total uranium miner population. This figure does not include the population of uranium millers, surface miners and ore transporters, who are also eligible for RECA funds. Based on the SMRs by calendar period and estimates of the total uranium miner population, it is expected that we will continue to observe many IPF, silicosis, and pneumoconiosis deaths in this group of workers after the

planned termination of RECA. Although only 11% of the cohort was still alive at the end of 2016 and the median age of surviving miners is over 80, there are younger RECA-eligible miners not in our Colorado Plateau cohort. The latest year of hire in the cohort was 1960, while RECA-eligible miners could have been hired through 1971. It is difficult to accurately estimate the number of miners that would be affected by the termination of RECA, but the approximations above indicate that a substantial number of miners could still develop compensable diseases.

This analysis was limited by using cause of death data rather than disease incidence data. Although these respiratory diseases are highly fatal, there are likely more miners in the cohort who developed these diseases but did not have deaths attributed to them. And, based on the long latency and induction periods of these respiratory diseases we expect additional incident cases to occur. This analysis is also limited because mortality follow-up only extends through 2016. But even if SMRs started to decrease subsequent to 2016, they would still likely be in excess compared with the standard population after 10 July 2022 when RECA terminates given that these SMRs have been substantially elevated since at least 1970, and for IPF, the number of observed cases appears to have increased since that time.

This analysis is based on uranium miners first employed between 1950 and 1960, but more contemporary miners are also at elevated risk of respiratory disease. Although they may be exposed at a lower intensity, these miners were still exposed to radon, silica dust and other agents that increase the risk of developing RECA-compensable diseases. A recent study from the large international Pooled Uranium Miner Analysis showed that miners first hired 1965 or later experience elevated lung cancer (observed=856, SMR=1.34; 95% CI 1.26 to 1.44).<sup>5</sup> Clinical data also indicate that workers employed after 1971 have a high burden of respiratory disease.<sup>6</sup>

The examination of non-malignant respiratory mortality rates in the Colorado Plateau cohort indicates that uranium mining conditions still cause a considerable health burden to workers that will continue into the foreseeable future. RECA has been amended in the past to be more consistent with scientific results, although these amendments were delayed.<sup>4</sup> This study finds that there will likely be more uranium miners who develop occupational disease after the planned termination of RECA benefits.

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