CORRESPONDENCE

Using GIS Mapping to Track Hot Spots of Kidney Disease in California

TO THE EDITOR: Chronic kidney disease of unknown origin is a leading cause of death in adults living in dry, lowland farming regions of Sri Lanka, Nicaragua, El Salvador, and India. The Central Valley of California has a high annual incidence of end-stage renal disease (ESRD) of 545 cases per million population, as compared with 382 cases per million population in the United States.[1] The climate, topography, and agricultural activity in this region overlap substantially with international regions where chronic kidney disease of unknown origin is endemic, but it remains unclear whether agricultural activity is linked to the incidence of ESRD in California. We mapped the nitrate level in groundwater — a proxy for agricultural activity, fertilizer use, and pesticide application[2] — and superimposed hot spots of unexplained ESRD in California.
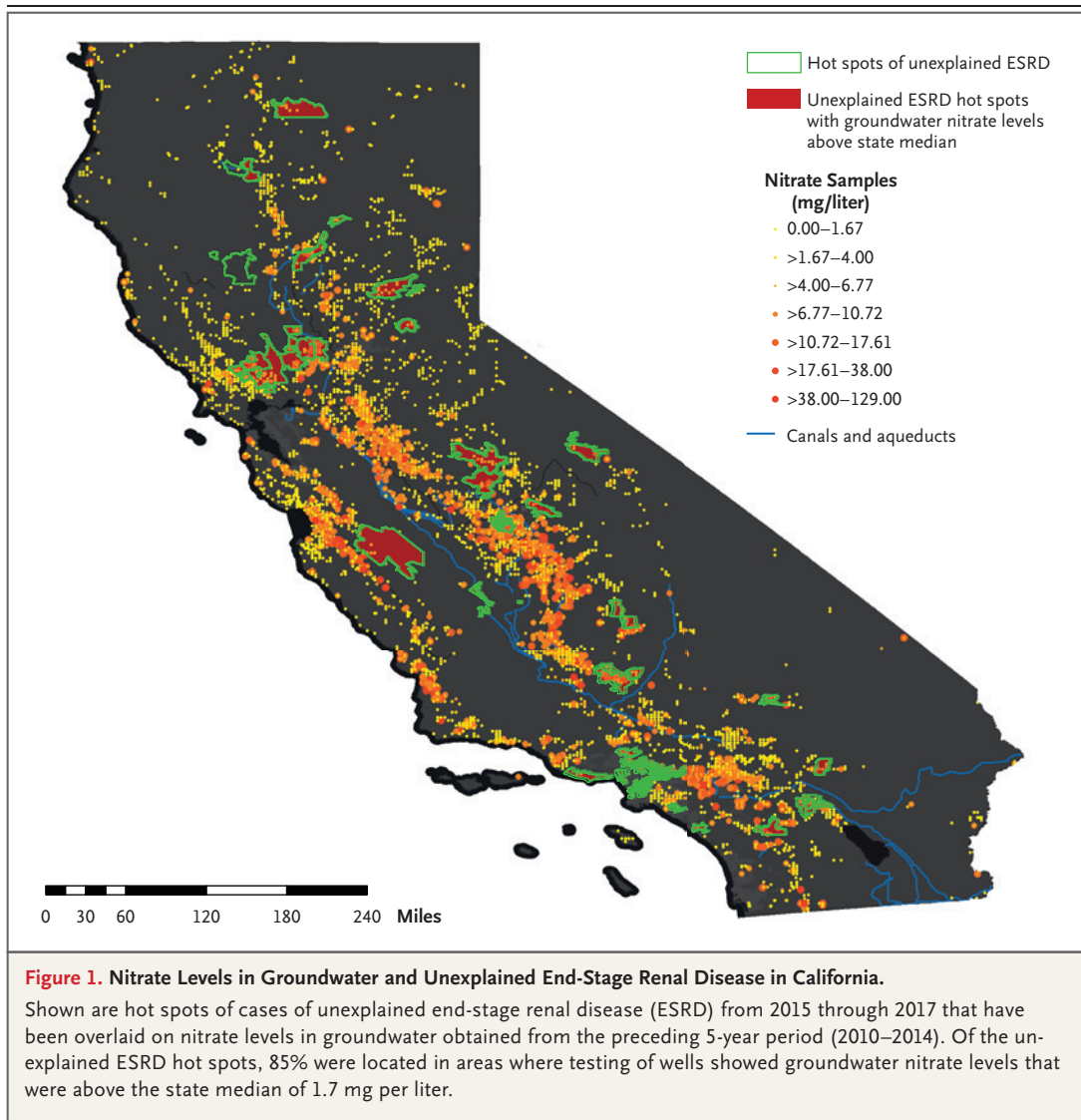
We first obtained groundwater nitrate levels from wells sampled statewide and annually by the California Water Board during a 5-year period (2010–2014) and restricted our analysis to ZIP Code tabulation areas (ZCTAs) that had more than 10 samples, which resulted in the inclusion of 1066 ZCTAs with 134,901 samples from 13,666 wells. On the basis of consensus recommendations[3,4] and using data obtained from all adults with incident ESRD in the U.S. Renal Data System from 2015 through 2017, we identified cases of unexplained ESRD in California. We defined unexplained ESRD as interstitial nephritis, ESRD of unknown cause, or ESRD that was attributed to hypertension in patients between the ages of 18 and 60 years. We then calculated the percentage of ESRD cases that were classified as unexplained in each ZCTA. To determine geographic hot spots of unexplained ESRD, we used the ARC GIS (Global Information System) Getis-Ord Gi* analysis tool, which identifies spatial clusters of high values, with a prespecified fixed-distance band of 10 miles and an alpha level of 0.05. We mapped the gradient of nitrate level (in milligrams per liter) in groundwater and overlaid hot spots of unexplained ESRD.

Statewide, the median of the average levels of nitrate in groundwater in a ZCTA (representing multiple wells over multiple years) was 1.7 mg per liter (interquartile range, 0.5 to 4.1), and the median maximum level was 5.6 mg per liter (interquartile range, 1.8 to 10.8). The hot-spot analysis identified 120 ZCTAs as having a high percentage of unexplained cases of ESRD (Fig. 1).

Figure 1. Nitrate Levels in Groundwater and Unexplained End-Stage Renal Disease in California.

Shown are hot spots of cases of unexplained end-stage renal disease (ESRD) from 2015 through 2017 that have been overlaid on nitrate levels in groundwater obtained from the preceding 5-year period (2010–2014). Of the unexplained ESRD hot spots, 85% were located in areas where testing of wells showed groundwater nitrate levels that were above the state median of 1.7 mg per liter.

The mean (±SD) percentage of ESRD cases that were classified as unexplained was 40±23% in the hot spots and 18±18% in other areas of the state. In hot spots of unexplained cases of ESRD, the median average level of nitrate was 2.7 mg per liter (interquartile range, 0.9 to 5.2), and the median maximum level was 7.6 mg per liter (interquartile range, 3.2 to 11.3). A total of 85% of the hot spots had wells in which levels of nitrate in groundwater exceeded the state median value during the sampled years.

A strength of our study is that we used data available uniquely in California to investigate geographic hot spots of unexplained cases of ESRD. Higher antecedent levels of nitrate in groundwater were present in areas of California where an increased percentage of patients with ESRD were either young or middle-aged and had unexplained ESRD. Limitations of our study are the inclusion of a residence history at only a single time point, registry data defining the cause of ESRD, and lack of patient-level data regarding access to health care. In short, residents of agricultural areas in California had a higher incidence of unexplained ESRD than those in the general population, a finding that is similar to the results of studies conducted in other regions of the world in which chronic kidney dis-

ease of unknown origin is endemic. Further studies could ascertain data with respect to lifelong residence and work history and, when linked to environmental surveillance data available in the United States, generate estimates for individual-level environmental exposures and risks of incident ESRD.

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Death from Covid-19 of 23 Health Care Workers in China

TO THE EDITOR: The National Health Commission of the People's Republic of China has reported that as of February 24, 2020, a total of 3387 of 77,262 patients with Covid-19 (4.4%) in China were health care workers or others who worked in medical facilities.[1,2] According to the Chinese Red Cross Foundation, the National Health Commission of the People's Republic of China, and public media, as of April 3, a total of 23 of the health care professionals among these 3387 persons had died from Covid-19 after they became infected during the practice of medicine in Wuhan and elsewhere in China.[3,4]

The median age of the 23 health care workers who died was 55 years (range, 29 to 72); 17 were men and 6 were women. Eighteen of the health care workers were from Wuhan, 4 were from areas of Hubei Province outside Wuhan, and 1 was from Hainan Province (see Table S1 in the Supplementary Appendix, available with the full text of this letter at NEJM.org). Eleven of these persons had been rehired after retirement, and at least 5 were known to have had a chronic condition such as hypertension, atrial fibrillation, or post-polio syndrome. Thirteen were physicians who provided direct patient care (5 practiced in community health centers or in private clinics, 3 practiced Chinese medicine, 2 were internal medicine physicians, 2 were physicians in respiratory medicine, and 1 was a gastroenterologist); 8 were surgeons (including 3 ophthalmologic surgeons); 1 was an electrocardiography technician; and 1 was a nurse.

The median period from the onset of symptoms of Covid-19 to hospital admission in the 19 health care workers for whom these data were available in public media reports was 6 days (range, 0 to 15). Three of them died in late January, 17 died in February, and 3 died in early March. The median period from hospital admission to death in all 23 health care workers was 19 days (range, 1 to 47). In 16 of the health care workers, acute respiratory distress syndrome (ARDS) rapidly progressed, and their condition then deteriorated quickly; all but 3 of these persons were 50 years of age or older. After their condition deteriorated, 12 of the 23 health care workers were transferred from the hospitals where they were first admitted to specialized intensive care units in other hospitals or to hospitals that specialize in infectious diseases. In addition to ARDS, the complications of Covid-19 in these patients included cardiac injury, septic shock, multiple organ dysfunction syndrome, hypercoagulability, intracardiac thrombus, and bacteremia.

Only 2 of the 23 health care workers were