

# Incidence of malignant lymphoma in adolescents and young adults in the 58 counties of California with varying synthetic turf field density

Archie Bleyer<sup>a,\*</sup>, Theresa Keegan<sup>b</sup>

<sup>a</sup> Oregon Health and Science University and University of Texas Medical School at Houston, United States

<sup>b</sup> University of California Davis Comprehensive Cancer Center, United States



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## ABSTRACT

**Background:** Case reports of cancer among soccer players raised concerns that the crumb rubber infill in synthetic turf fields may cause malignant lymphoma. One prior epidemiologic study on the topic found no association.

**Methods:** An ecologic evaluation of county-level incidence of lymphomas by race/ethnicity and socioeconomic status for the state of California with data obtained from the National Cancer Institute Surveillance, Epidemiology, and End Results Program. Synthetic turf field density by county was obtained from the Synthetic Turf Council. During 2000–2013, 7214 14- to 30-year-old Californians were diagnosed with malignant lymphoma.

**Results:** Annual lymphoma county incidence trends were not associated with the county-level synthetic turf field density. None of 20 sub-analyses by race/ethnicity, sex and county median household income indicated a correlation of lymphoma incidence with synthetic turf field density. In California, there was no evidence at the county-level that synthetic turf fields are associated with an increased incidence of lymphoma in adolescents and young adults.

**Conclusion:** Our findings in the state with the greatest number of such fields and a large, diverse patient population are consistent with those of a prior study observing no association between individual-level exposures to turf fields and cancer incidence. Avoidance of synthetic turf fields for fear of increased cancer risk is not warranted.

## 1. Background

A University of Washington soccer coach noticed an apparent cluster of young adult soccer players, particularly goalkeepers, who had been diagnosed with lymphoma [1]. The crumb rubber infill in the synthetic turf fields on which they played became the primary suspect since it contains some potentially carcinogenic chemicals such as polycyclic aromatic hydrocarbons [2]. The synthetic turf fields are now the focus of intense toxicology research efforts in California and elsewhere in the United States [3–8]. These are expected to require years to complete, with collection of tire crumb rubber from recycling facilities and installed fields, extensive physical and chemical analysis of the material, and estimation of the nature and duration of exposures to players [9]. Meanwhile, some school systems and park departments have abandoned plans to install synthetic turf fields and playgrounds, and some states have introduced bills to ban such installations [10].

Recently, the Washington State Department of Health [11] evaluated soccer players in Washington who were diagnosed with cancer

during 2002–2015 while 6 to 24 years of age, and compared their cancer incidence with expected age-specific cancer incidence. This study found no evidence for a greater-than-expected increase in the observed numbers of lymphoma or other cancers in the soccer players, regardless of age, intensity of play, or as goalkeepers, who are more contact with crumb rubber. The study found that goalkeepers and outfield players had lymphoma rates that were statistically-significantly lower than expected [11].

Lymphoma incidence in young Americans varies with race/ethnicity and socioeconomic status ([12–17], Supplementary Fig. S1), factors that were not assessed by the Washington State investigators. They also had to make several assumptions about the number and ages of players, and the upper age limit of 24 years they chose may also have missed diagnoses of cancer that occurred more years after exposure to the fields. Therefore, using data from California, the state with the greatest number of synthetic turf fields, we examined whether the incidence of lymphoma in 14 to 30 year-olds is higher or increasing to a greater extent in regions with higher density of synthetic turf fields.

\* Corresponding author at: Oregon Health and Science University, 2884 NW Horizon Dr. Bend, OR 97703, United States.  
E-mail addresses: [ableyer@gmail.com](mailto:ableyer@gmail.com) (A. Bleyer), [tkeegan@ucdavis.edu](mailto:tkeegan@ucdavis.edu) (T. Keegan).

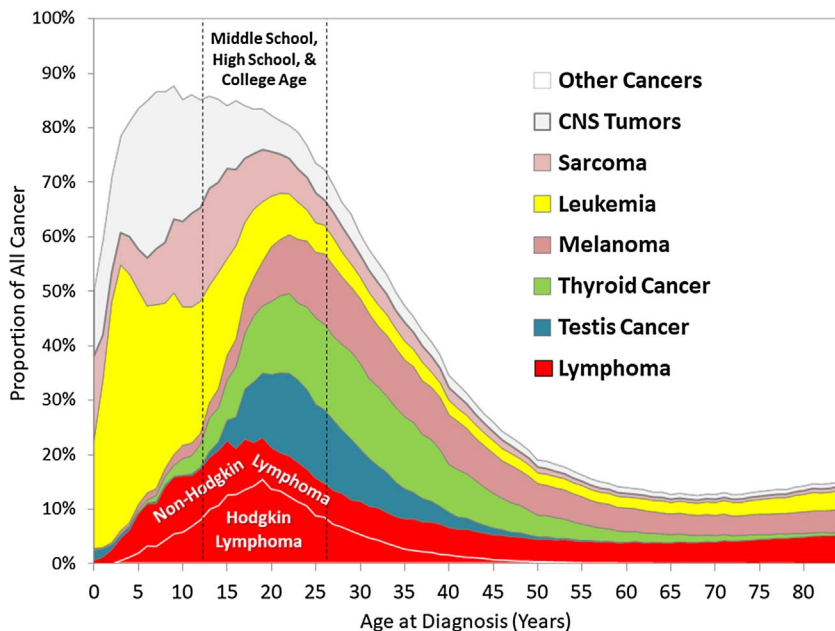


Fig. 1. Proportion of All Invasive Cancer of the Seven Most Common Malignancies in Adolescents and Young Adults, 2000–2014, by Age at Diagnosis. Data Source: SEER18 regions [18]

2. Methods

2.1. Lymphoma incidence

Race/ethnicity composition and median family income for each of California’s 58 counties were obtained from the National Cancer Institute Surveillance, Epidemiology and End-Results (SEER) Program [18]. Eligible lymphoma cases were those diagnosed between 14 and 30 years of age with first primary, malignant Hodgkin or non-Hodgkin lymphoma. This age group was chosen to include high school and college age players, allow several years after college for the lymphoma to become clinically detectable, and generally match the age range of players in the original report [1,11]. Hodgkin and non-Hodgkin lymphoma were combined because of their overlapping peak prevalence in the selected age group (Fig. 1) [15] and the mixture of both types of lymphoma in the reported cases [19]. Incidence rates were age-adjusted by the SEER Program at 1-year age intervals to the 2000 U.S. Standard Population [20].

2.2. Synthetic turf field density

The number of synthetic turf fields in each California county as of 2016 was obtained from the Office of Environmental Health Hazard Assessment, California Environmental Protection Agency [21]. All of the fields were outdoors and installed after 1995, but their surface area and specific turf product were not identified. Synthetic turf field density was defined as the number of fields per 100,000 average annual population of 14 to 30 year-olds during the years evaluated. The annual lymphoma incidence was evaluated by year during 2000–2013 (and for two counties explained below, 1975–2013). Also, with the installment of synthetic turf fields during the past decade and reports of field-associated lymphoma dating back to 2009 [1,22], analyses of the associations between synthetic turf field density and lymphoma incidence were conducted with 2009–2013 data. To ensure that the numbers of cancer cases were sufficient in subset analyses, only counties with populations of > 15,000 14 to 30 year-olds were evaluated.

The 58 counties of California were either divided into two or three groups of synthetic turf field density, depending on the parameter evaluated: *low* or *high* if the field density was above or below 8.5 synthetic fields per 100,000, respectively; *low*, *intermediate*, or *high* for those having a density of < 4, 4–11, and > 11 synthetic fields per

100,000, respectively (Supplementary Table S1). These criteria were based on gaps in the distribution of the fields by synthetic turf field density that suggested such separations.

2.3. Race/ethnicity and income

For subgroup analyses of race/ethnicity and county median family income, the synthetic turf field densities were divided into two groups and the county median family income below or above \$50,000 in 2000 (Supplementary Table S2). Some counties had too small a population to include in specific analyses such as 4 of the 58 counties for correlation assessment of APC and synthetic turf field density. Sub-analyses of race/ethnicity and income required elimination of more counties, such as 20, 21 and 37 counties for Hispanics, Asians and blacks, respectively. In each of these instances, a minimum population of 15,000 of the study group was required.

The two counties with the highest synthetic turf field density, Marin and San Mateo counties, are in the original SEER registry (SEER9, with reliable cancer incidence data back to 1975). They are also in the upper tier of median county family income and hence would be more likely, with a higher expected lymphoma incidence and the greatest synthetic turf field density, to demonstrate a relationship over the longest evaluable interval of time. Hence, the annual incidence of lymphoma for 1975–2013 was also assessed for these two counties combined, using the SEER9 database [23]. Only whites were evaluable for a race/ethnicity subgroup over the entire 1975–2013 span, since Hispanics and Asians were not identified until 1992 and the black population in these counties was less than 15,000.

2.4. Statistical analysis

Regressions were analyzed for statistical significance with the ANOVA F-test. Average percent change (APC) of incidence was either provided by SEER\*Stat [14,23] based on logarithmic values of annual incidence rates or calculated from logarithmic values for data not provided by SEER. Since the APC calculation cannot be applied to zero values, original values of 0 cannot have a discrete logarithm value were assigned a logarithm equivalent of 1 and 1 was added to all other logarithm values.

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