

## ***Does Synthetic Turf Rubber Crumb Cause Cancer?***

**Incidence of Malignant Lymphoma in Adolescents and Young Adults (AYAs)  
in 18 States and Regions of the United States with Varying Synthetic Turf Field Density  
and Selected Counties in California with Highest Densities**

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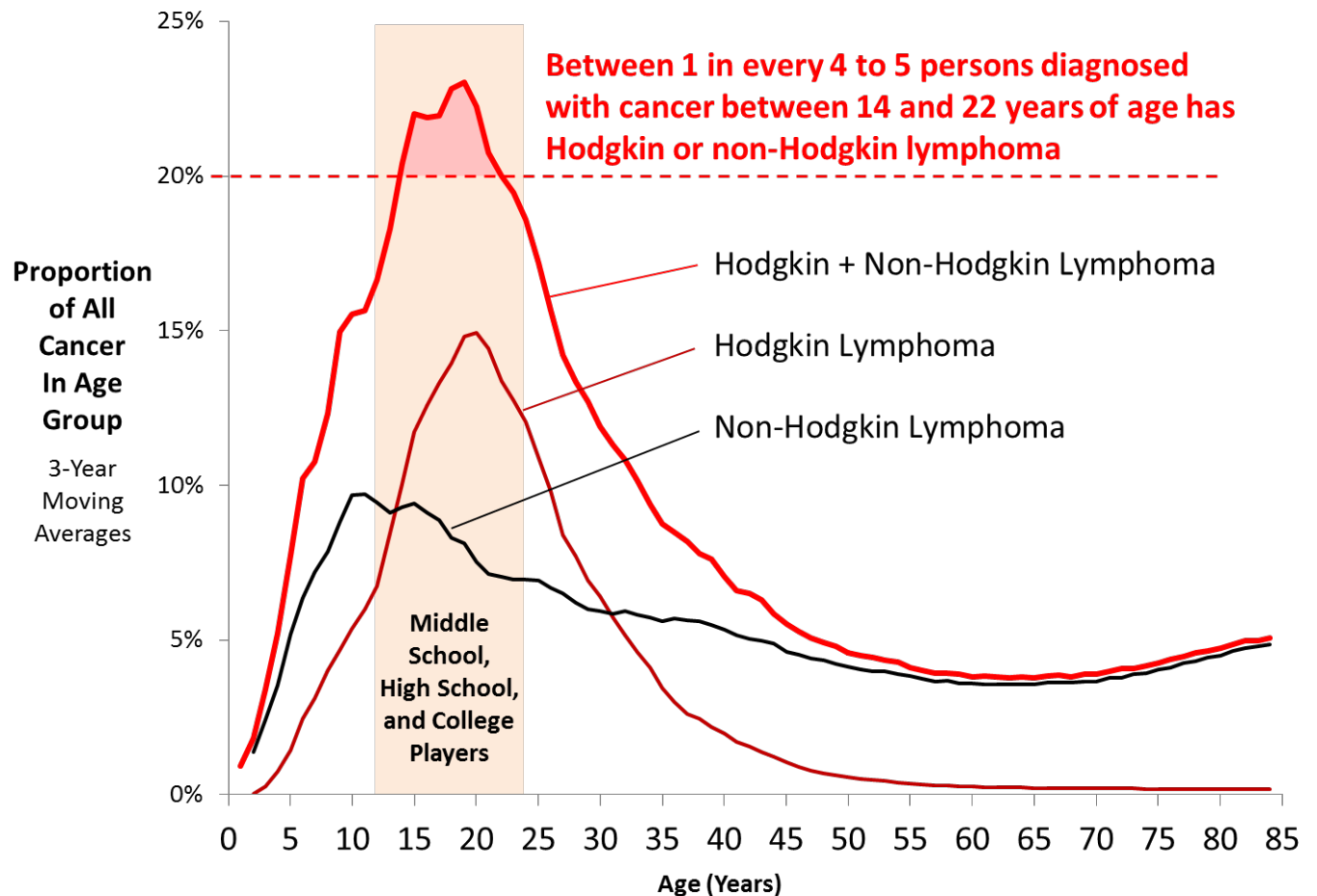
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# Background

An associate coach at the University of Washington has collected cases of Hodgkin and non-Hodgkin lymphoma in adolescent and young adult (AYA) soccer players who practiced and played on synthetic turf fields, some of whom were goalkeepers. Thus synthetic turf and particularly the crum rubber derived from tires in the material, and to which goalkeepers are more exposed, is thereby suspected of causing lymphoma.

Lymphoma is the most common malignancy in the age group (Fig. 1) and hence it would be expected to be the cancer in the age group. The question is whether the incidence is higher than expected and thus can implicate the fields.

Figure 1  
**Prevalence of the Suspect Cancers in AYA Soccer Players**



## Null-Hypothesis

Regions in the U.S. with a higher prevalence of synthetic turf fields have had an increasing and higher incidence of lymphoma among adolescents and young adults.

## Methods

- Because lymphoma is strongly race/ethnicity dependent (Fig. 2), variation of lymphoma by environmental exposure has to be evaluated by race/ethnicity.
- The 18 National Cancer Institute SEER registries are distributed throughout the U.S. to enable race/ethnicity analysis and should therefore be evaluable for the prevalence of synthetic turf fields, given the regions with the highest socioeconomic status (California metropolitan areas, Seattle/Puget Sound) and adverse weather (Seattle-Puget Sound) have the greatest prevalence (e.g., Los Angeles and San Francisco Bay Area have 856 fields) whereas the southern and rural states (e.g., Louisiana, Georgia, New Mexico, Utah, Hawaii) have the lowest incidence (Appendix 3). Connecticut and metropolitan Atlanta were analyzed as either having high, intermediate or low prevalence since these areas were more difficult to predict for synthetic field density than other regions.
- Both the county-level incidence of cancer since 2000 and current number of synthetic turf fields (Supplementary Appendix 1 ) are known in California, as well as the race and ethnicity of persons living in the state, thereby enabling all 58 California counties to be assessed for a relationship between lymphoma incidence and synthetic turf field density (number of fields per population).

## Methods (continued)

- The incidence of lymphoma in AYAs is also directly proportional to the socioeconomic status of the community in which the AYA lived (Fig. 3).
- Hence the 18 SEER regions were evaluated for lymphoma incidence since 2000 among AYA age groups by race/ethnicity, socioeconomic status, and region.

Figure 2

### Incidence of Lymphoma (Hodgkin and Non-Hodgkin) in Middle School, High School and College Age Persons, U.S. SEER, 2000-2013, by 5-Year Age Intervals and Race/Ethnicity

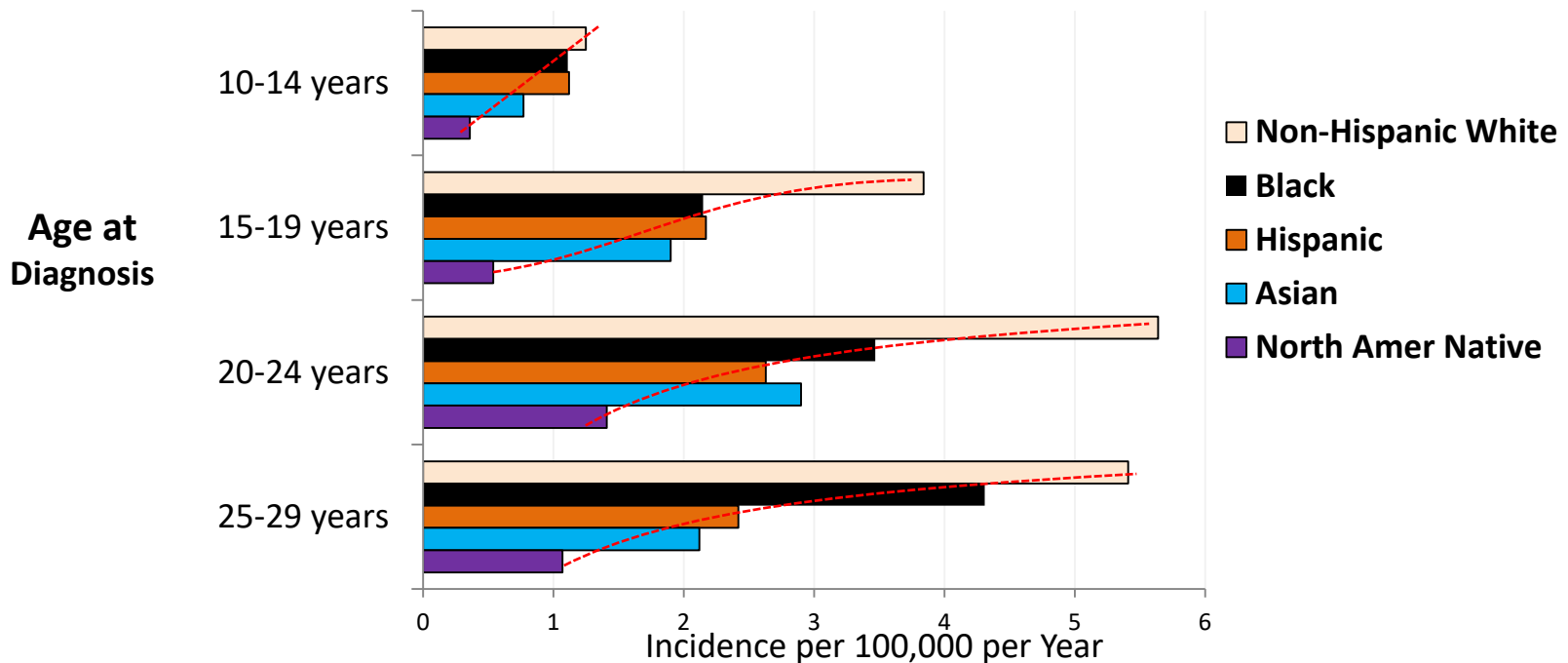


Figure 2 (continued)

### Incidence of Malignant Lymphoma during 2000-2013 in 14- to 30-Year-Olds, U.S. SEER,\* by Race/Ethnicity

Age 14-30 Years

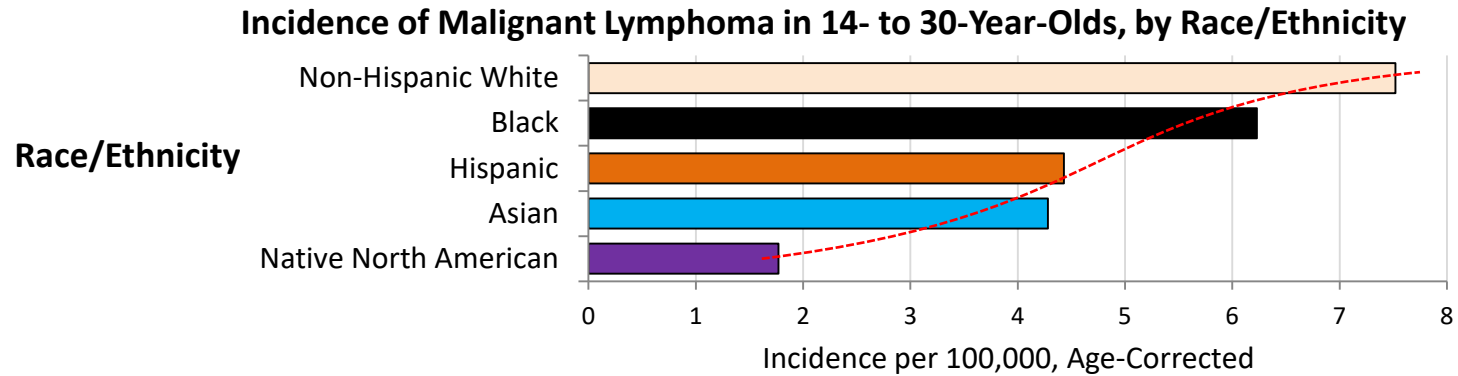
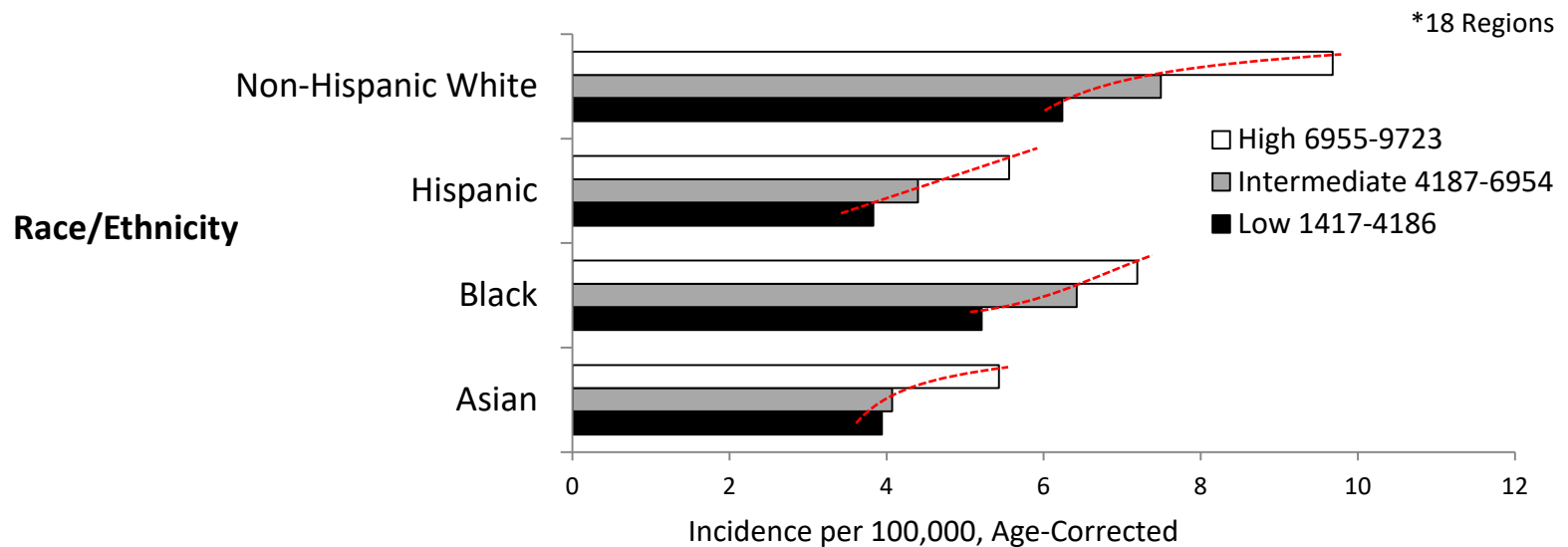


Figure 3

### Incidence of Malignant Lymphoma during 2000-2013 in 14- to 30-Year-Olds, U.S. SEER,\* by Race/Ethnicity and Cost-of-Living-Adjusted Median Family Income, 2000



## U.S. SEER, 2000-2013

Figure 4 depicts the incidence of lymphoma in 14- to 30-year-olds across 18 regions of the U.S. according to the estimated local synthetic turf field density for each of the major race/ethnicities in the U.S. There is no correlation between the estimated synthetic turf density and the incidence of lymphoma in AYAs who are most likely to use such fields.

Figure 4

### Incidence of Malignant Lymphoma (Hodgkin and Non-Hodgkin) in High School and College Age Persons (Age 14-30), by Estimated Synthetic Turf Field Prevalence, U.S. SEER,\* 2000-2013

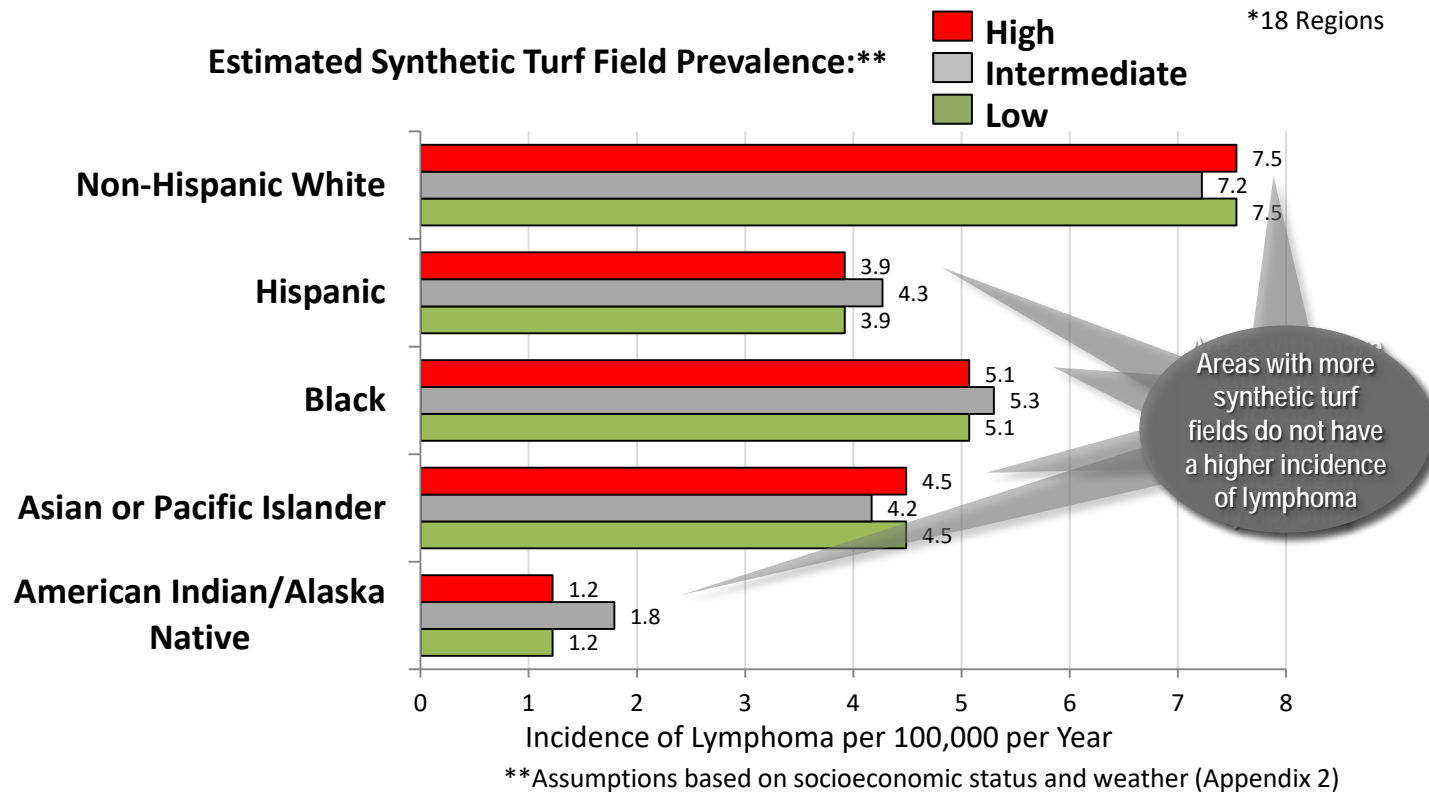
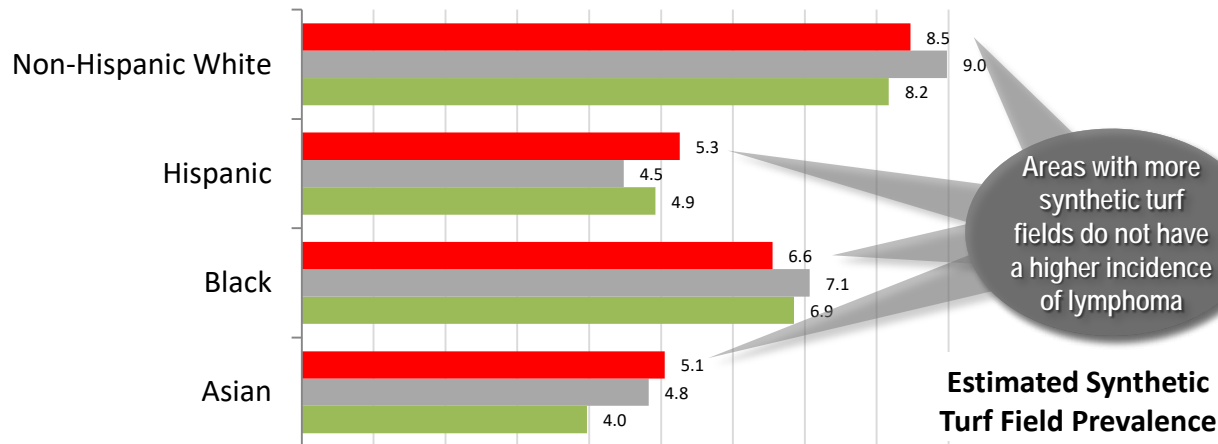


Figure 5  
**Incidence of Malignant Lymphoma in 14- to 30-Year-Olds, 2000-2013, SEER18,  
 by Estimated Synthetic Turf Field Prevalence, Race/Ethnicity, and Median Family Income**

When household income within race/ethnicity groups is applied to the SEER registries grouped according to likelihood of synthetic turf field prevalence, there is also no correlation between lymphoma incidence and synthetic turf field prevalence (Fig. 5).

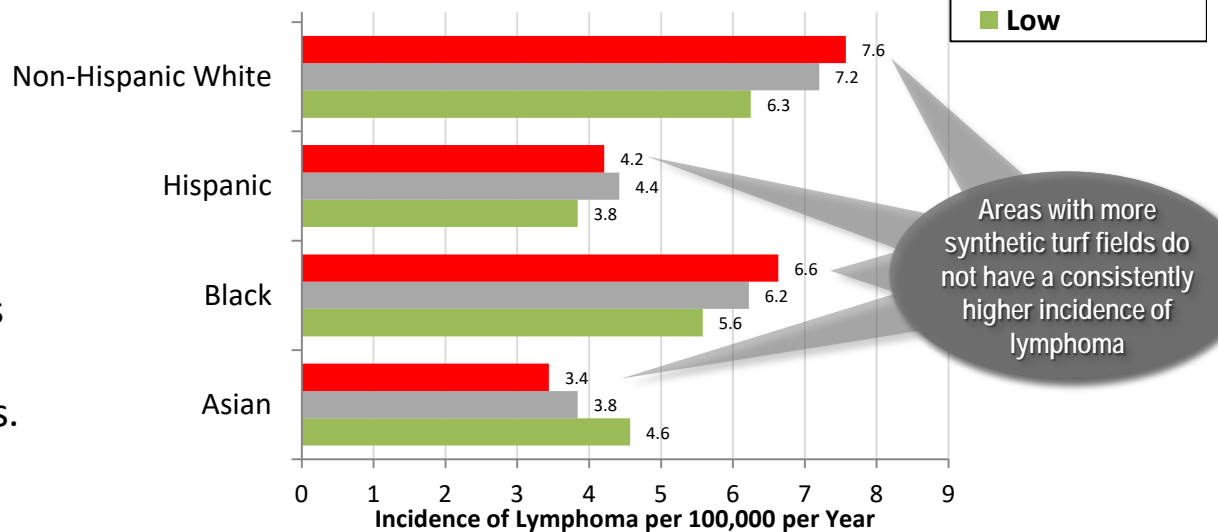
The lack of correlation was apparent whether Connecticut and Atlanta were considered as high, intermediate or low synthetic-field prevalence areas.

**HIGH MEDIAN HOUSEHOLD INCOME (6000-9723 Rating)**



Areas with more synthetic turf fields do not have a higher incidence of lymphoma

**LOW MEDIAN HOUSEHOLD INCOME (1417-5999 Rating)**



Areas with more synthetic turf fields do not have a consistently higher incidence of lymphoma

**Estimated Synthetic Turf Field Prevalence**

- High
- Intermediate
- Low

Incidence of Lymphoma per 100,000 per Year

## Annual Incidence of Malignant Lymphoma among 14 to 30 Year-Olds in California's Counties with the Greatest Density of Synthetic Turf Fields, 1974-2013 (SEER9) and 1992-2013 (SEER13), All Races/Ethnicities

Synthetic turf fields with crumb rubber were **first installed in 1997** and **more than 900 have since been installed in California**. If they are strong lymphomagenic vectors, counties with most of the fields and highest usage should have had some evidence for a trend since 1997 in an increase in lymphoma incidence in adolescents and young adults (AYAs).

- As shown by the **brown** SEER9 data in Figure 6, there has been no evidence for an increase in lymphoma incidence among AYAs in the two California counties with the highest density of synthetic turf fields, San Mateo and Marin (56 fields in a 2-county area of 190,000 14-30 year-olds), during the 40 years from 1974 to 2013.
- As shown by the **purple** SEER13 data in Figure 6, there is no evidence for an increasing incidence trend since 1992 in AYAs in the 8 counties with the highest density of synthetic turf fields (219 fields in a population of 970,000 14-30 year-olds) .
- Compared to AYA females, AYA males are more likely to have had an increase since they have a greater exposure to the fields. In this ecologic analysis they also have a greater sensitivity to demonstrate a turf field effect. As shown by the **blue** data in Figures 7 and 9, neither the 2 highest density counties nor the 8 counties among the highest tier of densities have evidence for an increase in lymphoma since 1992 in males (or females).

These ecologic findings are inconsistent with a hypothesis that synthetic turf fields containing crumb rubber cause lymphoma in AYAs.

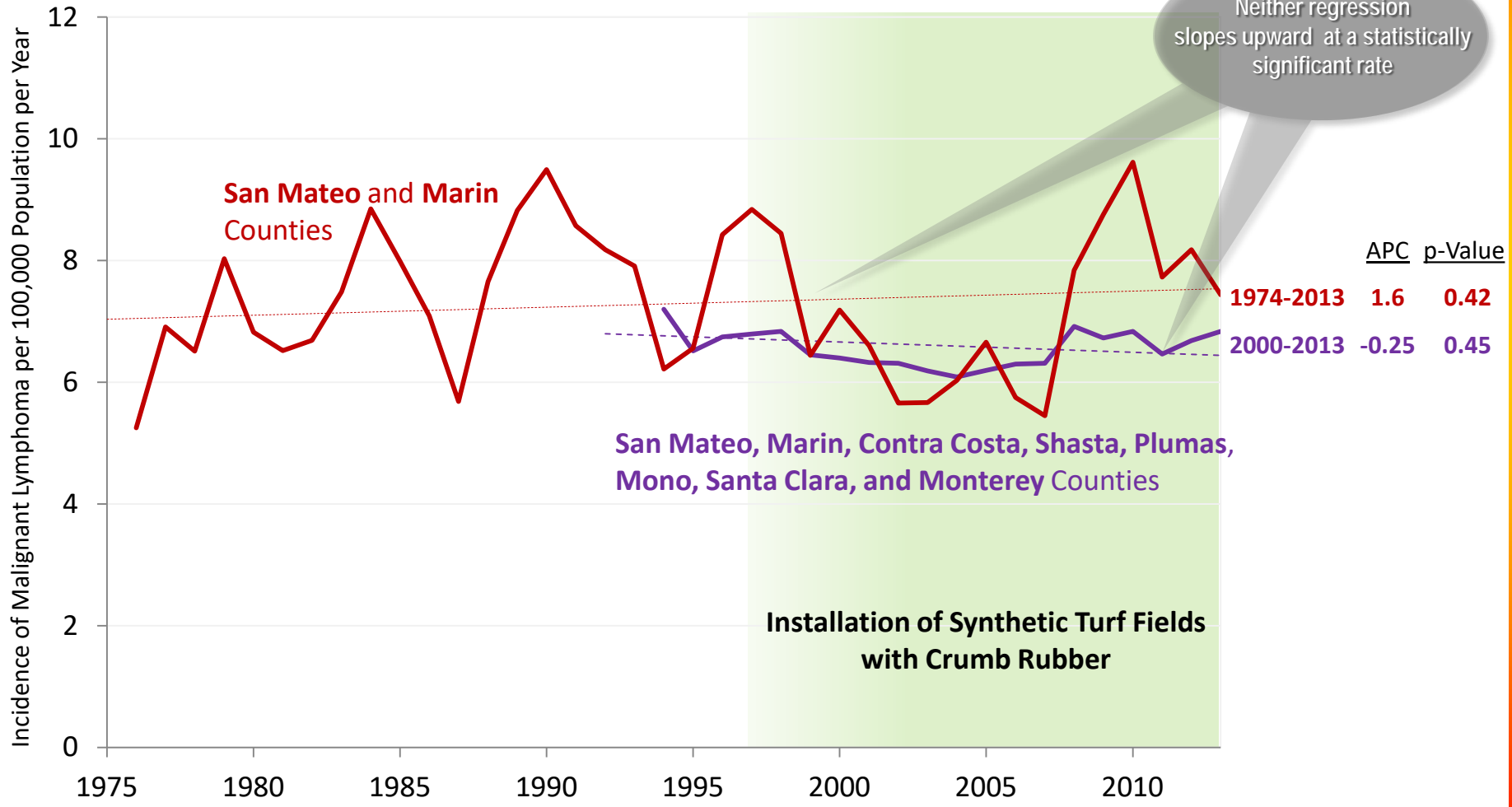


# California, 1975-2013

Figure 6

## Annual Incidence of Malignant Lymphoma among 14 to 30 Year-Olds in California's Counties with the Greatest Density of Synthetic Turf Fields, 1974-2013 (SEER9) and 1992-2013 (SEER13), All Races/Ethnicities

3-year moving averages Dashed lines: linear regressions



Neither regression slopes upward at a statistically significant rate

San Mateo and Marin Counties

San Mateo, Marin, Contra Costa, Shasta, Plumas, Mono, Santa Clara, and Monterey Counties

Installation of Synthetic Turf Fields with Crumb Rubber

Figure 7

**Annual Incidence of Malignant Lymphoma among 14 to 30 Year-Olds in the Two California Counties with the Greatest Density of Synthetic Turf Fields, San Mateo and Marin Counties, during 1974-2013 (SEER9), All Races/Ethnicities**

3-year moving averages    Dashed lines: linear regressions

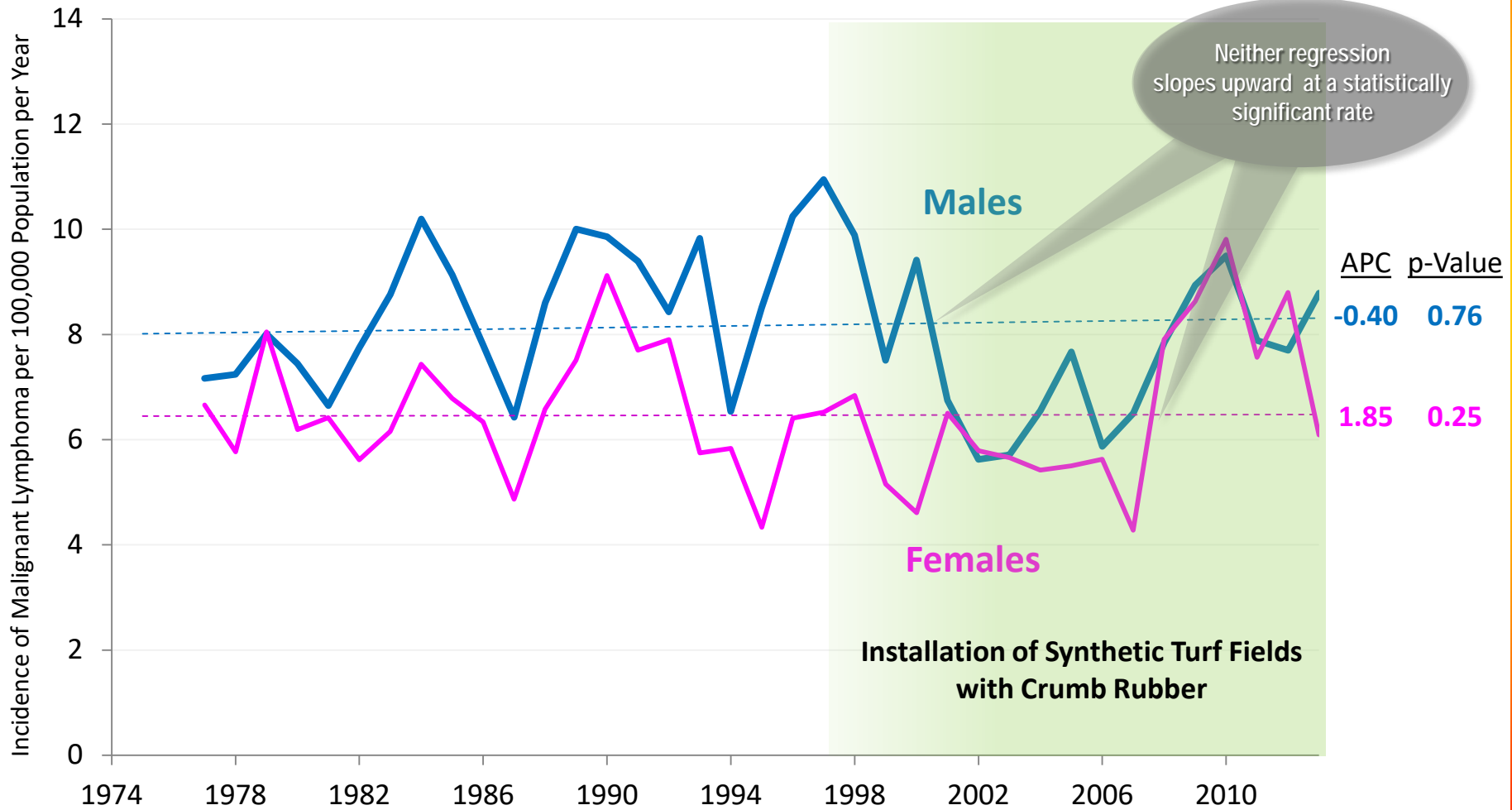
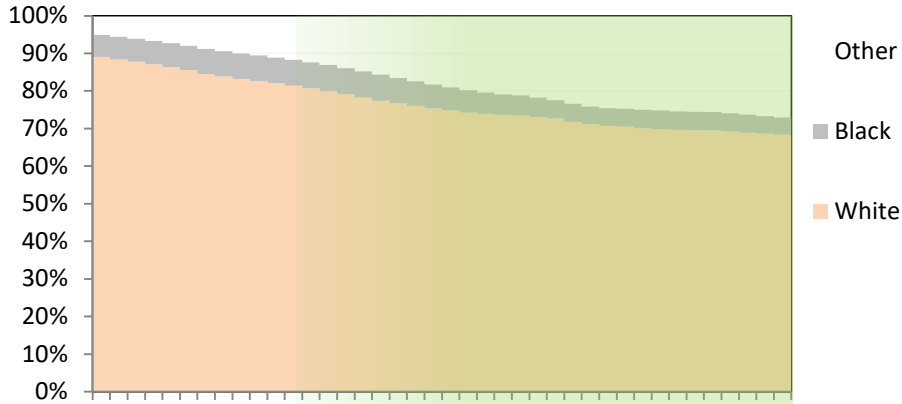


Figure 8

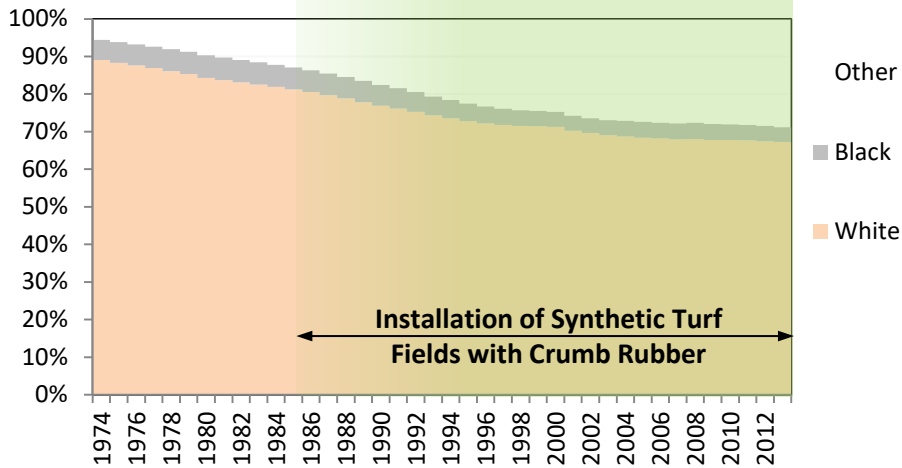
# Annual Race and Ethnicity Population Distribution of among 14 to 30 Year-Olds in California's Two Counties with the Greatest Density of Synthetic Turf Fields, 1974-2013

## San Mateo and Marin Counties

Males

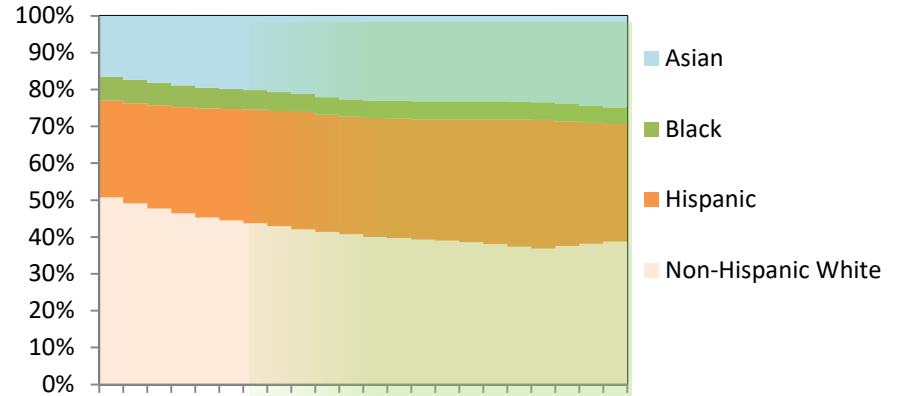


Females

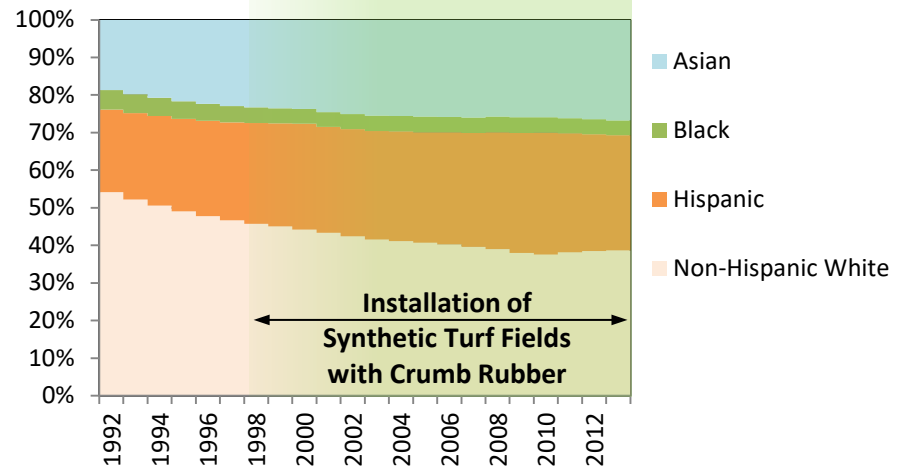


Installation of Synthetic Turf Fields with Crumb Rubber

Males



Females



Installation of Synthetic Turf Fields with Crumb Rubber

Figure 9

**Annual Incidence of Malignant Lymphoma among 14 to 30 Year-Olds in California's SEER13 Counties with the Greatest Density of Synthetic Turf Fields, 1992-2013, All Races/Ethnicities**

**San Mateo, Marin, Contra Costa, Santa Clara and Monterey Counties**

2-year moving averages    Dashed lines: linear regressions

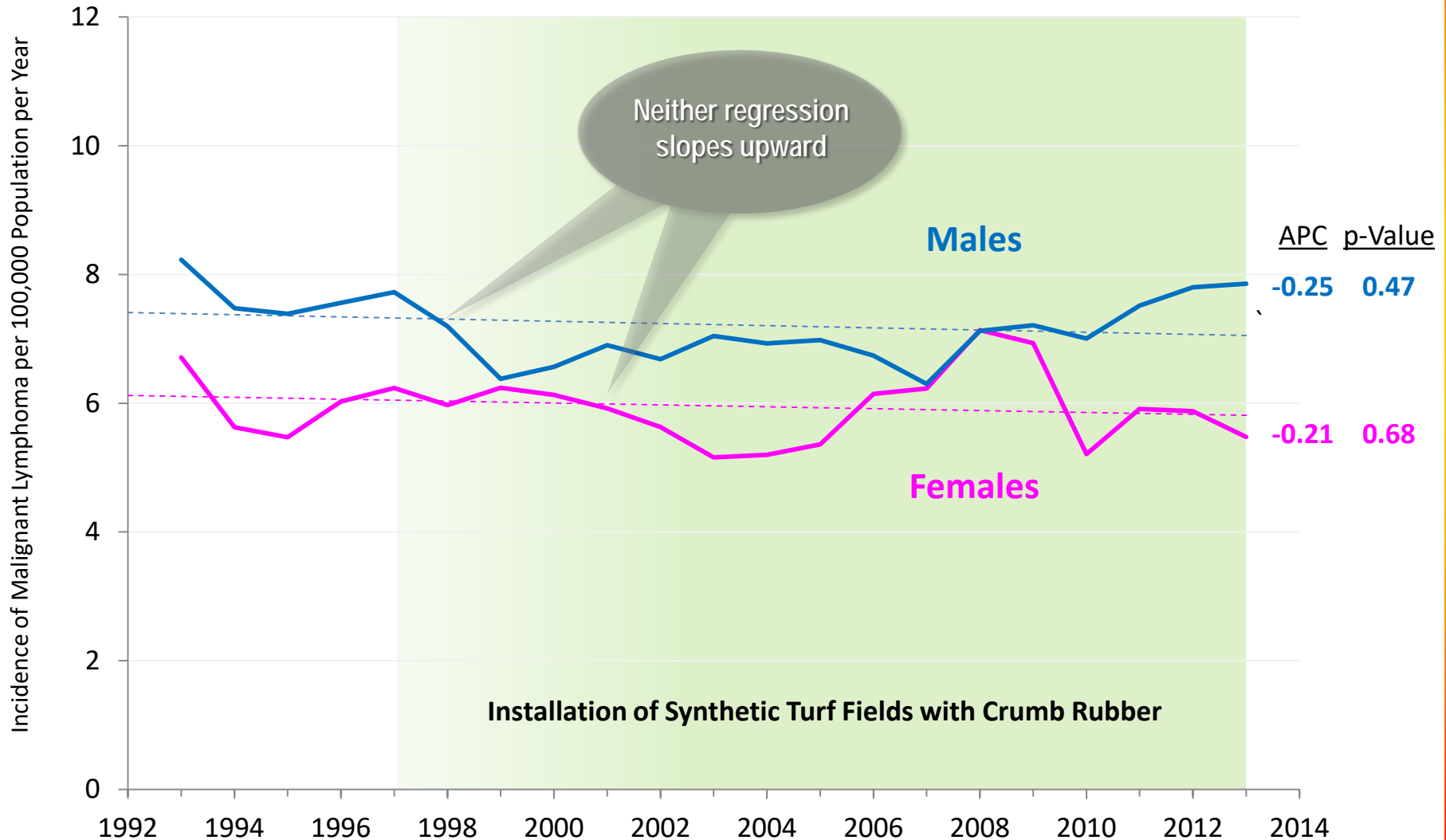
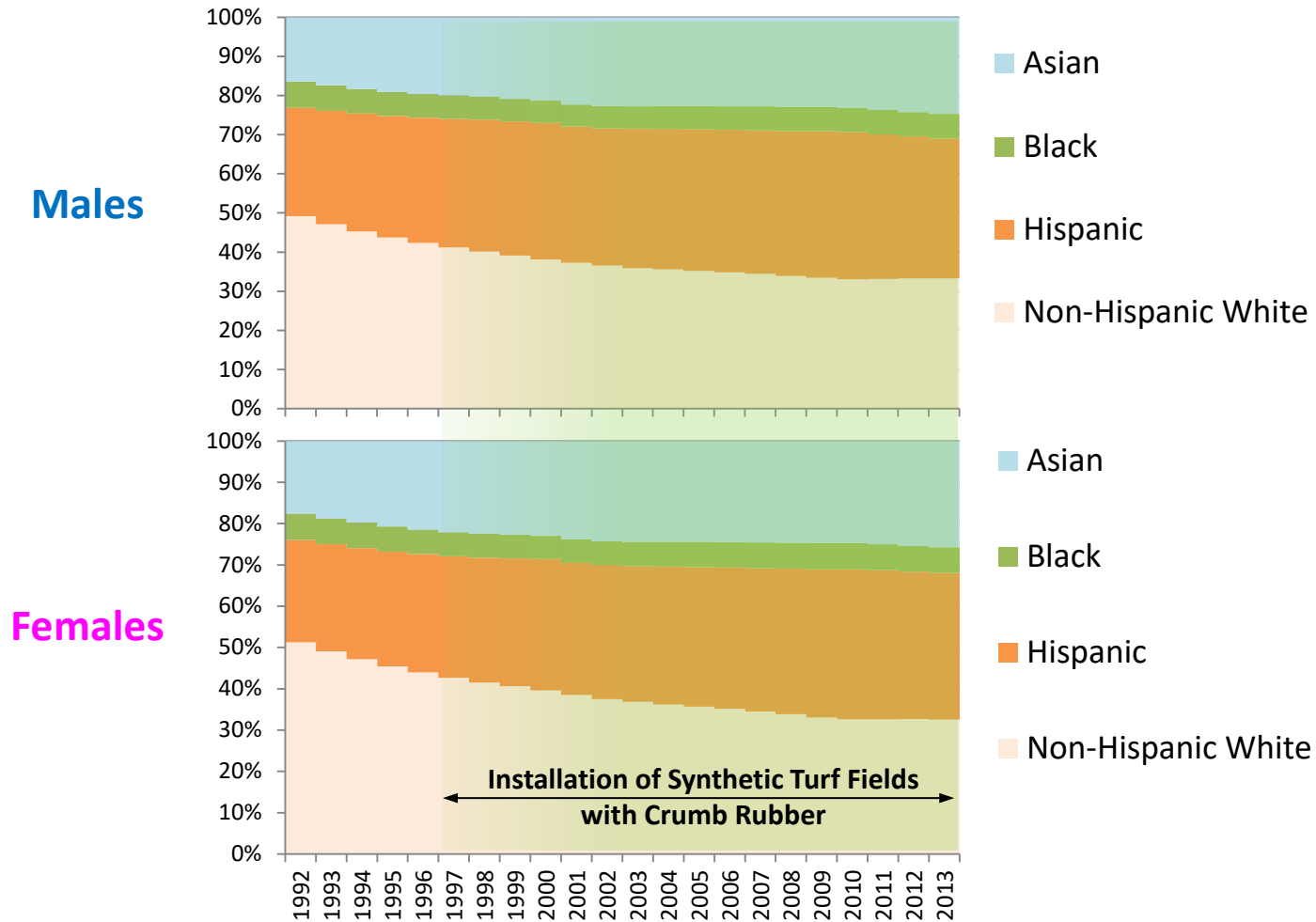


Figure 10

# Annual Race and Ethnicity Population Distribution of among 14 to 30 Year-Olds in California's SEER13 Counties with the Greatest Density of Synthetic Turf Fields, 1992-2013

San Mateo, Marin, Contra Costa, Santa Clara and Monterey Counties



Figures 8 and 10 show the racial/ethnic population distribution in the two and five counties with the greatest synthetic turf field densities as a function of calendar year since 1974 for whites, blacks and other races and since 1992 for non-Hispanic whites, Hispanics, Asians and black when the race/ethnicity data became available. In general the changes in race/ethnicity distribution do not affect the overall finding of a lack of correlation between the development of synthetic turf fields containing crumb rubber and the incidence of malignant lymphoma in California's counties with the highest density of fields. There was a trend in a decrease in the non-Hispanic white proportion that in the presence of no change in lymphoma incidence could be argued to be consistent with lymphomagenic hypothesis, but the decrease in the non-Hispanic white proportion from 1997, when the suspect fields were first installed to 2009 was 7-9% (Figs. 8 and 10), ceased after 2009 (Figs. 8 and 10), and in the two counties with the greatest field densities, increased thereafter (Fig. 8).

## **Discussion**

The lack of correlation of lymphoma incidence with estimated synthetic turf field density across the United States in the 18 states and regional areas monitored closely by the National Cancer Institute with the prevalence of such fields in any of the major races and socioeconomic categories is evidence against a causal relationship. The lack of incidence trend consistent with the implementation of the fields in the counties in California with the greatest density of synthetic turf fields supports the lack of correlation in the national data.

Synthetic turf fields are more likely in metropolitan areas, in regions of higher socioeconomic status that can afford such fields, and where local weather favors synthetic fields. Figures 2 and 3 predict that lymphoma should be more frequent in adolescents and young adults who live near synthetic turf fields because of their race/ethnicity and socioeconomic status. Thus, middle-school, high-school and college age soccer players who live in areas with synthetic turf fields would be expected to have a higher rate of malignant lymphoma because of the race/ethnicity and socioeconomic status and not because of the fields. The incidence of malignant lymphoma in this age group of soccer players is consistent with this relationship, as shown in Figures 4-8 , and thus mitigates against synthetic turf is a causative factor.

## Conclusion

The null-hypothesis is rejected: The incidence of **malignant lymphoma in older adolescents and young adults is not increased** in regions with a higher prevalence of synthetic turf fields. If increased, it is due to the race, ethnicity and socioeconomic status of those who live in areas that have such fields and likely not to the fields. This population level study does not eliminate crumb rubber in synthetic turf as a potential contributing factor to the development of lymphoma in those who use the fields, but it is consistent with a lack of such effect.

## Limitations of This Type of Ecologic Analysis

As to how sensitive this ecologic type of analysis may be, the counties with the highest synthetic turf field densities allow some estimates, based on the following assumptions and deductions.\*

- A soccer game involves 25-28 players; multiple games are played each weekend; a practice session averages 40 persons; at least 2 practice sessions are held each weekday; there are 3 seasons (Spring, Fall, Summer) of different leagues of players.
- If the players use the fields twice weekly (1 practice and 1 game), and each field averages 10 teams per week, and there are three league seasons, the number of exposed players is approximately 33,600 (56 fields x 20 players per team x 10 teams per week x 3 seasons/leagues).
- That's 18% of the 190,000 14-30 year-olds in the two counties, San Mateo and Marin counties with 56 fields.
- For the five counties in the highest tier density with 219 fields, the comparable values is 14% of 970,000 AYAs.
- At 14-18%, the ecologic findings should be able to detect a strong lymphomagenic effect of synthetic turf fields in the evaluated counties.