# eAppendix

## A. Notes on wildfire evacuation zones, boundaries, and exposure definition

We obtained shapefiles of the Woolsey and Getty fire boundaries from <https://frap.fire.ca.gov/mapping/gis-data/>. These files describe boundaries around all areas burned by the fires. In reality, the fire boundaries were smaller at the beginning of the fires, and expanded as they burned. We used these static boundaries to identify exposed ZCTAs.

The Woolsey fire, in particular, burned for 13 days. Therefore, ZCTAs that were close to the fire boundary and defined as ‘exposed’ in our study may not have been proximal to the fire at first, and may not have been truly exposed until later. Unfortunately, fire boundaries were not recorded early in either fire, so data describing the smaller boundaries isn’t available. Boundaries that are available are here: <https://data-nifc.opendata.arcgis.com/search?tags=Category%2Chistoric_wildlandfire_opendata>.

Just as the fire boundaries changed, evacuation zones also changed throughout each fire. GIS evacuation zone data was not available for either fire, though there were several maps available of evacuation zones at different points during each fire. We reviewed the following webpages containing maps of the evacuation zones, and traced what we believed to be an accurate boundary around all areas evacuated in each fire in QGIS.42 The evacuation zone boundaries we defined are plotted in Figure 1, along with the fire boundaries. As always, our code is available at <https://github.com/heathermcb/kaiser_wildfires>.

| Getty fire: |
| --- |
| 1. <https://www.newsweek.com/getty-fire-evacuation-map-update-california-los-angeles-1468222> |
| 1. <https://www.newsweek.com/getty-center-fire-map-evacuation-los-angeles-california-1468100> |
| 1. <https://www.express.co.uk/news/world/1196943/getty-fire-evacuation-map-405-fire-update-los-angeles-fire-evacuation-road-school-closures> |
| 1. <https://www.flyertalk.com/forum/los-angeles/1993097-getty-fire-405-closed-sepulveda-pass-now-open.html> |
| 1. <https://heavy.com/news/2019/10/getty-fire-los-angeles/> |

| Woolsey fire: |
| --- |
| 1. <https://www.kclu.org/local-news/2018-11-10/map-shows-boundaries-of-woolsey-hill-brush-fires-and-evacuation-areas> |
| 1. <https://wildfiretoday.com/tag/woolsey-fire/> |
| 1. <https://www.dailynews.com/2018/11/08/this-map-shows-where-the-hill-fire-and-woolsey-fire-are-burning/> |
| 1. <https://www.mercurynews.com/2018/11/09/map-of-woolsey-and-hill-fires-highway-101-closed-malibu-evacuated/> |
| 1. <https://woolseylawyers.com/woolsey-fire-map/> |

## B. Higher-level groupings of ZCTAs

We created higher-level groupings of ZCTAs using the numerical ZCTA codes. We used a bespoke method, and then tested the resulting spatial groupings to make sure that ZCTAs grouped together had similar exposure measurements, to guard against exposure misclassification. We grouped ZCTAs together if all their numerical codes differed by 1 in sequence. For example, codes 90001-90008 and 90011-90014 were in the study area. We grouped codes 90001 - 90008 together, as they are all sequentially 1 digit apart, while 90011-90014 formed a second grouping. This method resulted in groupings of ZCTAs that were all adjacent, since similar codes tend to be geographically close.

Using this method, we created 274 groups containing 1-19 ZCTAs each, with a mean and mode group size of 2. We assessed the correlation between wildfire PM2.5 within each group and between all ZCTAs regardless of group, concluding that wildfire PM2.5 measurements within groups were highly correlated (mean within-group correlation was r = 0.96), while mean correlation of PM2.5 between any two ZCTAs was 0.48. We also mapped the groups to confirm that all ZCTAs grouped together were adjacent. The code that creates these groupings and assesses them is available at <https://github.com/heathermcb/wildfires_and_DME.>

## C. Parallel trends assumption

The following are plots of mean weekly visits of each type throughout the study period. Red and blue lines represent mean visits in areas exposed to the Getty Fire and Woolsey Fire respectively, while black lines are respective unexposed areas. We concluded that the parallel trends assumption held in all cases.



**D. Tables from sensitivity analyses on the size of the proximity buffers**

| **Risk ratio for exposure to fire during fire (DID estimator), [95% confidence interval]** | | |
| --- | --- | --- |
| **Outcome** | **Woolsey Fire** | **Woolsey Fire sensitivity – 30 km buffer** | |
| All-cause outpatient | 0.89 [0.79, 1.00] | 0.89 [0.78, 1.02] | |
| All-cause inpatient | 1.35 [0.93, 1.96] | 1.29 [0.85, 1.96] | |
| All-cause ED | 1.13 [0.85, 1.49] | 1.29 [0.85, 1.96] | |
| Inpatient: cardiorespiratory concerns | 1.45 [0.99, 2.12] | 1.40 [0.91, 2.15] | |
| ED: cardiorespiratory concerns | 1.07 [0.78, 1.45] | 1.07 [0.75, 1.52] | |

| **Risk ratio for exposure to fire during fire (DID estimator), [95% confidence interval]** | | |
| --- | --- | --- |
| **Outcome** | **Getty Fire** | **Getty Fire – 30 km buffer** | |
| All-cause outpatient | 1.02 [0.93, 1.13] | 0.97 [0.86, 1.09] | |
| All-cause inpatient | 0.93 [0.60, 1.45] | 0.78 [0.45, 1.36] | |
| All-cause ED | 0.97 [0.73, 1.27] | 0.78 [0.55, 1.09] | |
| Inpatient: cardiorespiratory concerns | 0.96 [0.61, 1.50] | 0.77 [0.43, 1.37] | |
| ED: cardiorespiratory concerns | 0.92 [0.67, 1.26] | 0.74 [0.50, 1.09] | |

| **Risk ratio for exposure to evacuation during fire (DID estimator), [95% confidence interval]** | | |
| --- | --- | --- |
| **Outcome** | **Woolsey Fire** | **Woolsey Fire – 30 km buffer** | |
| All-cause outpatient | 0.86 [0.72, 1.03] | 0.88 [0.78, 1.00] | |
| All-cause inpatient | 1.53 [0.90, 2.62] | 1.22 [0.82, 1.82] | |
| All-cause ED | 1.18 [0.78, 1.80] | 1.05 [0.77, 1.44] | |
| Inpatient: cardiorespiratory concerns | 1.72 [1.00, 2.96] | 1.30 [0.86, 1.95] | |
| ED: cardiorespiratory concerns | 1.13 [0.72, 1.78] | 1.00 [0.71, 1.40] | |

| **Risk ratio for exposure to evacuation during fire (DID estimator), [95% confidence interval]** | | |
| --- | --- | --- |
| **Outcome** | **Getty Fire** | **Getty Fire – 30 km buffer** | |
| All-cause outpatient | 0.88 [0.69, 1.12] | 1.03 [0.93, 1.15] | |
| All-cause inpatient | 0.19 [0.02, 1.60] | 0.94 [0.61, 1.46] | |
| All-cause ED | 0.65 [0.30, 1.42] | 1.03 [0.78, 1.36] | |
| Inpatient: cardiorespiratory concerns | 0.21 [0.02, 1.73] | 0.86 [0.54, 1.37] | |
| ED: cardiorespiratory concerns | 0.66 [0.27, 1.62] | 1.03 [0.76, 1.41] | |

**E. Example map of residuals from spatial autocorrelation test**

Moran’s I stat for this test was = 0.03, with a p-value of 0.077.



**F. Detailed description of wildfire PM2.5 modelling strategy.**

We measured wildfire smoke exposure by estimating daily wildfire and non-wildfire PM2.5 concentrations at the ZCTA level using a multistage approach. This approach is described in detail in Aguilera et al. 2021.

First, we estimated daily levels of PM2.5 (from any source) at the ZCTA level using a validated ensemble model combining multiple machine learning algorithms (e.g., random forest, gradient boosting) and multiple predictors (e.g. PM2.5 measurements from US EPA Air Quality System (AQS), meteorological factors such as temperature, precipitation or wind patterns, satellite-derived aerosol optical depth or land-use variables). We identified smoke-plume exposed ZCTA codes/days with the National Oceanic and Atmospheric Administration’s (NOAA) Hazard Mapping System (HMS) using a smoke binary variable by intersecting ZCTA polygons with smoke polygons. We then estimated the counterfactual PM2.5 values in the absence of wildfire smoke using spatio-temporal imputation models (relying on estimated PM2.5 on surrounding days and ZCTA). We finally estimated the difference between such counterfactual values (i.e. PM2.5 that would have been observed in the absence of the smoke event on a given ZCTA/day) to observed values of PM2.5 during an exposure to wildfire smoke. This difference between counterfactual values and observed estimated during a smoke event on a given ZCTA/day can thus be interpreted as daily/ZCTA levels of wildfire smoke PM2.5.

Said differently, after identifying ZCTA/days exposed to wildfire smoke (yes/no, using HMS products), we imputed the level of PM2.5 that would have been observed in the absence of the smoke event on a given ZCTA/day and then compared this *counterfactual* value to what has been actually observed in such ZCTA/days to obtain wildfire smoke PM2.5. This ensemble model achieved high accuracy with R2 of 0.86 and RMSE of 3.48 (Aguilera et al., 2021).