Adapting the HEAT-PA module to incorporate a non-linear physical activity dose response function.

## Introduction:

We know that there exists a non-linear dose response relationship between physical activity and all-cause mortality, such that the greatest benefits from an extra unit of physical activity occur in those who are least active. When attempting to estimate the effects of changing the activity level of the population, public health economists would ideally like to estimate the change in the distribution of activity, allowing for these non-linear effects to be accounted for.

However, often data limitations mean that we do not know the initial distribution of physical activity in a population. In this case it is not possible to utilize a non-linear function and we must instead revert to assuming a linear relationship. The World Health Organization’s Health Economic Assessment Tool for Walking and Cycling (HEAT) is an example of an economic assessment tool which, due to limitations in data, assumes a linear relationship between physical activity and mortality.

This paper describes a method used to estimate country specific physical activity distributions where detailed physical activity data is not available. We go on to compare the estimates generated using a non-linear DRF applied to estimated PA distributions with the current method. We compare three basic scenarios of:

1. An extra 10mins/day of walking for every person.
2. Every adult in the country meeting WHO guidelines.
3. A 10% increase in physical activity levels of the entire population.

# Method:

The analysis described below uses data from the following sources. The data is available open source at the author’s GitHub account.

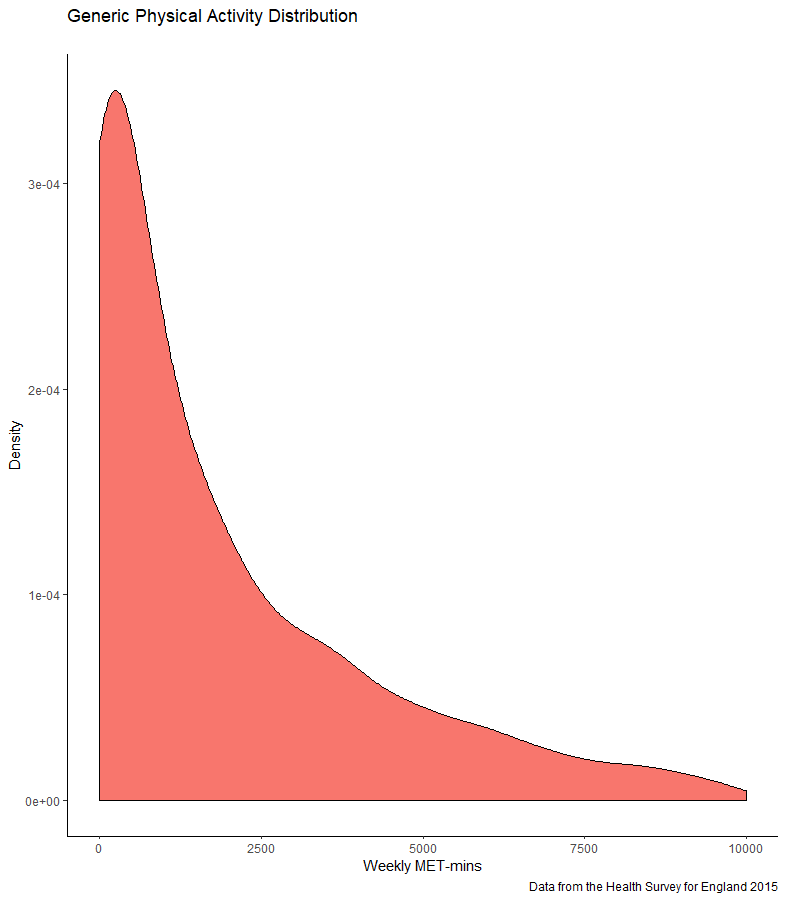
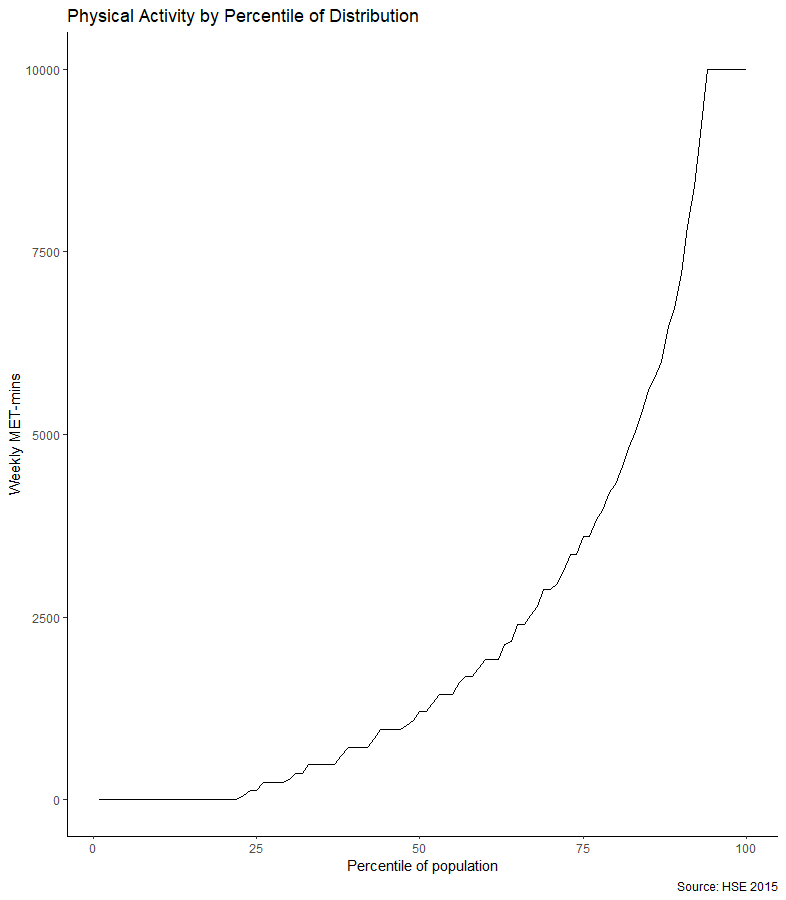
Table 1. Variable names, description and source of data used in analysis

|  |  |  |
| --- | --- | --- |
| Variable | Description | Source |
| Country.PIA | % of population inactive | Guthold et al. 2018, Appendix 5 |
| Generic.PAdist | Distribution of MET-mins | HSE\_2015, IPAQ Question answers |
| Country.MR | HEAT 20-74 mortality rate | HEAT team |
| Country.VSL | Value of a Statistical Life | HEAT team |
| Mort.DRF | Dose Response Function PA-Mortality | Aram et al. 2015 |

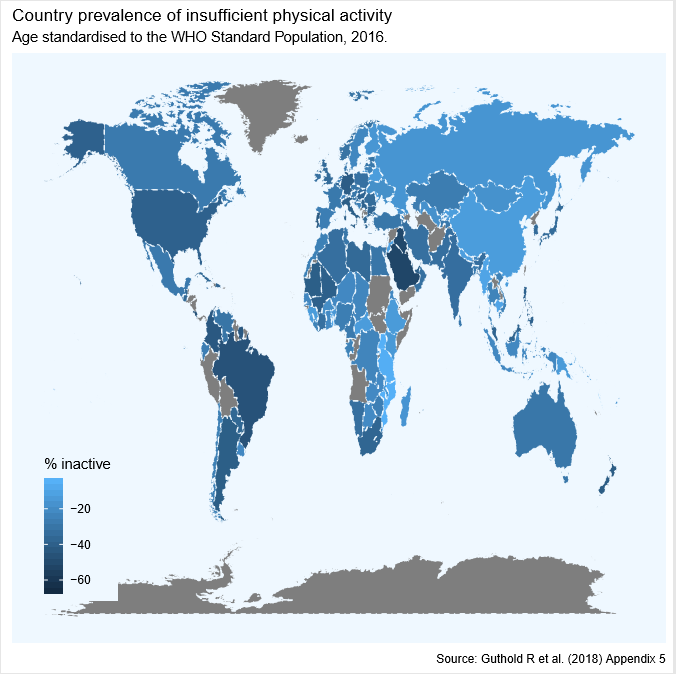
We follow the method described in Hafner et al. (2019) to estimate a baseline distribution of physical activity in each of the 49 HEAT countries previously analyzed by the authors in (Smith et al. 2019).

1. Create a generic distribution of physical activity for a country with good quality data. Estimate for this distribution what the MET-mins for each percentile are.

In this example I use the Health Survey for England 2015, which includes the IPAQ questionnaire. This results in a distribution which looks like this…

1. Download the prevalence of inactivity estimated by Guthold for each country …

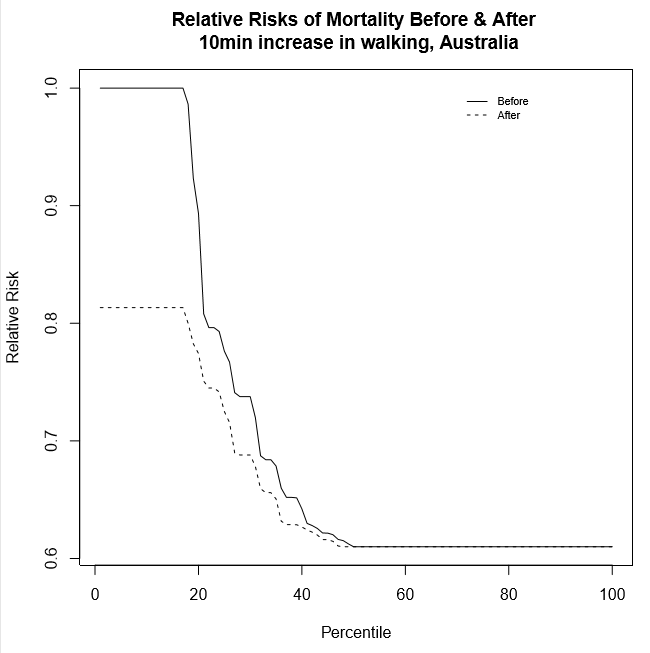
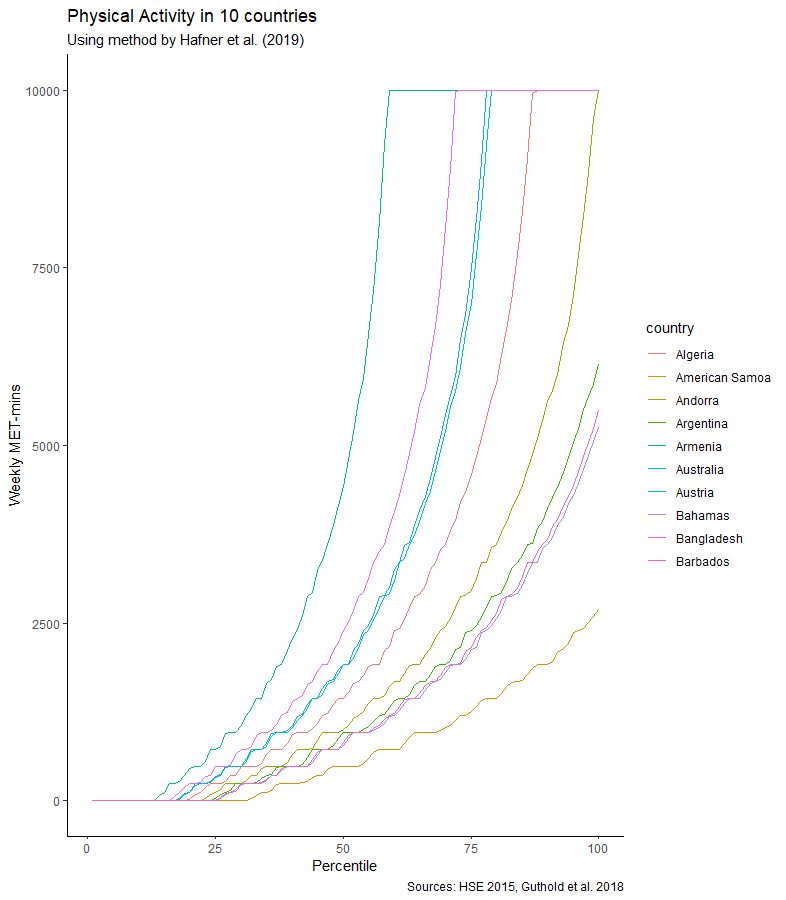


1. Use the method developed in Hafner et al. (2019) to estimate a distribution of physical activity for each HEAT country.

The method developed by Hafner and colleagues uses the equation below to estimate the weekly MET-mins,p, for each country c, at each percentile, n, from 1 to 100. The prevalence of inactivity, x, in the country, c, is divided by the prevalence of inactivity in the generic distribution to give a multiplier. At each estimated percentile the multiplier is used to estimate the difference between that percentile and the percentile before.

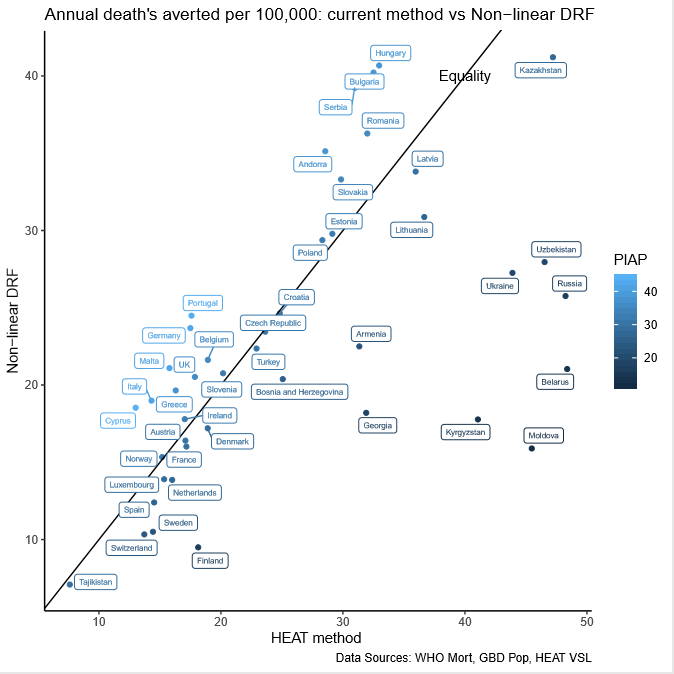
# Results

The distributions derived using these methods differ as shown below. American Samoa, a very inactive nation where 53% of individuals are inactive, has the lowest levels of physical activity while Armenia, a country where only 22% of individuals are inactive, has the highest levels of physical activity. For ease of displaying data in all cases physical activity is capped at 10,000METs, a level far exceeding that where the benefits of additional physical activity are negligible.

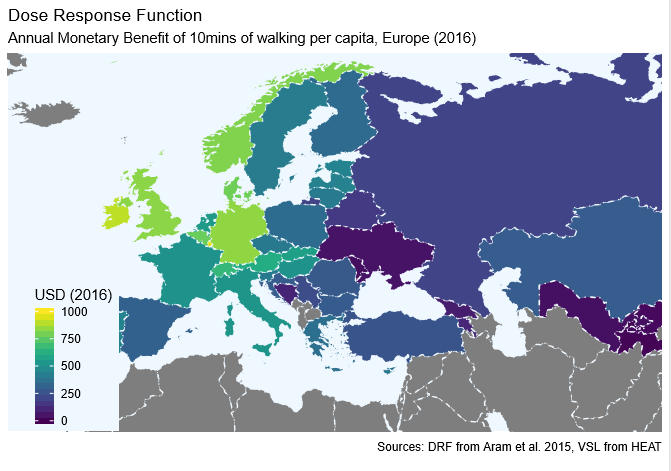
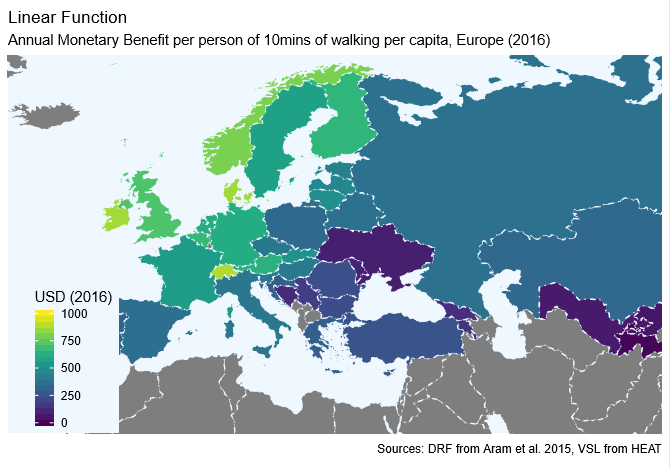


In order to estimate the effect of changing the method from linear to dose response I then run a scenario through the analysis… what if everyone in the country did an additional 10 minutes of walking per day, 70 mins of additional activity per week, at 3 METs is an additional 210 MET-mins/wk extra.

The result is that the countries where the physical inactivity prevalence (PIAP) is low (e.g. Belarus and Moldova) have lower benefits to increased physical activity using the new method relative to countries with higher prevalence of physical activity (e.g. Germany, UK, Serbia). This is what we would expect to see.



This results in substantially different net monetary benefit results by country, with much larger benefits in western Europe where the VSL is higher and the population is generally less active.

Guthold R, Stevens GA, Riley LM, Bull FC. Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1·9 million participants. Lancet Glob Health 2018

Hafner, M., Yerushalmi, E., Phillips, W.D., Pollard, J., Deshpande, A., Whitmore, M., Millard, F., Subel, S. and Van Stolk, C., 2019. The economic benefits of a more physically active population: An international analysis.