# AGE Mixing Model Overview

The model for mixing considers three key components: age, sex, and race.

In general, we model contacts between the following groups:

* MSM (men who have sex with men) with other MSM, heterosexual men, or women.
* Heterosexual men with MSM, other heterosexual men, or women.
* Women with MSM or heterosexual men.

## Age Mixing Model

For the age component, Todd utilized data from a study in Australia that reported the ages of each pair of partners. Based on these data, the following model was assumed to represent differences in partner ages:

Age difference=N(μ,σ) where

μ=B0+B1×a

σ=L0+L1×a

This gives us:

Diff(a)=N(B0+B1×a,L0+L1×a)

Here, a represents the age of the individual, and B0,B1, L0, and L1 are coefficients estimated from the data.

Using this model, we estimate three separate age models for females, heterosexual men, and MSM. These are stored in PAIRING.INPUT.MANAGER$sex.age.models.

### Age Mixing Matrices

The next step is to compute the age mixing matrices, which represent the *proportion of contacts that occur between different age groups*. Since we have categorical age groups, we need to determine the proportion of the population that falls into specific age years. For example, within the age group 25-34, we calculate the proportion of individuals who are 25, 26, 27, and so on.

In a simplified case, we can assume a uniform distribution across ages within an age group, meaning that each year represents 1 tenth of the total population for that group. We can then estimate the proportion of contacts from a "mixture normal distribution."

For example, to estimate the proportion of contacts for women aged 25-34 that occur with individuals in the 13-24 age group:

P(13−24)=0.1×pnorm(13−24, μ25, σ25)+0.1×pnorm(13−24,μ26,σ26)+…+0.1×pnorm(13−24,μ34,σ34)P(13−24)

In JHEEM, Todd used a more sofisticated method for maping popualtion proportions based on census in each location

* get.heterosexual.male.single.year.age.counts()
* get.female.single.year.age.counts()
* get.msm.single.year.age.counts()

Using this approach, we estimate three age mixing matrices: one for females, one for heterosexual males, and one for MSM.

### Age of Sexual Debut and Availability

Additionally, we must model the reduction in sexual availability for the youngest and oldest age groups. This is handled using the get.sexual.availability() function, which maps changes in sexual availability across ages. The model reflects an increase in sexual activity starting from age 13, reaching 100% at ages 20 to 64, and gradually tapering off until age 85, the final age group.

### Calibration

All the parameters introduced so far are estimated from data and remain fixed. However, we include one additional parameter specifically for calibration—a multiplier applied to the standard deviation in the age model. This calibration parameter adjusts the variability in age assortativity (age.mixing.sd.mult)

* Larger values of the multiplier increase the variability in age differences, resulting in less age assortativity (i.e., individuals tend to partner with others from a wider range of ages).
* Smaller values decrease the variability in age differences, leading to greater age assortativity (i.e., individuals tend to partner with others closer to their own age).

This allows us to fine-tune the model to reflect observed patterns in age mixing.

## Sex Mixing Model

We aim to construct a 3x3 matrix representing the proportion of partnerships between females, heterosexual males, and MSM (men who have sex with men). In this model, only female-female partnerships are excluded, while all other pairings can have a positive value.

**Logic**

Consider the case for females: if there is no sex assortativity, the proportion of female partners who are MSM or heterosexual males is proportional to their population distribution in a given location. For example, if 20% of men in Baltimore are MSM, then females would be expected to have 20% MSM and 80% heterosexual male partners. This implies that the **observed-to-expected (OE) ratio** for MSM partnerships would be equal to 1. However, when there is assortativity (i.e., a preference for partnering within specific groups), the OE ratio will deviate from 1—being either greater than or less than one, depending on the degree of assortativity.

### Estimating proportion of females contacts with msm and male hetrosexuals

We estimate the prior value for the OE ratio from a single study:

name=′oe.female.pairings.with.msm′, value=0.0895(Pathela 2006)

Using this value, we can estimate the proportion of female partnerships that are with MSM or heterosexual males in each location as follows:

* Pmsm=0.089×prop.males.msm / (0.089×prop.males.msm+prop.males.not.msm)
* Phet.male=prop.males.not.msm/ (0.089×prop.males.msm+prop.males.not.msm)

Since these are the only two options, the total must satisfy:

* Pmsm+Phet.male=1

This approach allows us to estimate the proportions of MSM and heterosexual male partnerships for females across different locations.

The oe.female.pairings.with.msm is also used for calibration

### Estimating proportion of male contacts with msm and male heterosexuals

What fraction of hetrosexual males have contact with other men: fraction.heterosexual.male.pairings.with.male, value =0.004

What fraction of msm

## Race mixing model

Similar to sex mixing, this relies on observed to expected proportion of contact between difference racial groups