**Supplementary material: Matlab code**

This paper´s suplementary material include Matlab code (R2021a, MathWorks Inc., 2021) designed to calculate posterior probabilities of two hypotheses.

clear all

% Two hypothesis of death cause

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%----------INPUT------------

input = load('input3.txt'); % CRA, sigma, estimated age mean, estimated age sigma, grave

cal = load('IntCal20\_part.txt'); % year, CRA, sigma...

...ref Reimer et al. 2020 Radiocarbon 62.

famine = 1318;

plague = 1348;

death = [famine, plague]; % two hypothesis of possible death cause

%----------MONTE CARLO SAMPLING, LIKELIHOOD, POSTERIOR------------

mc = 500000\*2; % number of sampled points

j = 0;

PP = zeros(length(input(:,1))/2, 3); % posterior probability matrix

for i = 1:2:length(input(:,1)-1)

j = j + 1;

% Lag times based on age

age = input(i, 3);

age\_sigma = input(i, 4);

lag = lag\_calc(age, age\_sigma)';

% Monte Carlo samples

t = zeros(mc, 3); % death, bone, tooth

t(1:mc/2, 1) = famine;

t(mc/2+1:end, 1) = plague;

t(:, 2) = t(:, 1) - normrnd(lag(1), lag(2), [mc, 1]);

t(:, 3) = t(:, 1) - normrnd(lag(3), lag(4), [mc, 1]);

% % Plotting sampled space for control

% plot(t(:,2),t(:,3),'yo')

% hold on

% xlabel('bone age')

% ylabel('tooth age')

% Calibration by interpolation

a = zeros(mc, 4); % cra bone, cra tooth, likelihood bone, likelihood tooth

a(:, 1) = interp1(cal(:, 1), cal(:, 2), t(:, 2), 'linear');

a(:, 2) = interp1(cal(:, 1), cal(:, 2), t(:, 3), 'linear');

% Likelihoods with combine uncertainties

sigma\_combined\_b = sqrt(cal(:, 3).^2 + input(i, 2)^2); % Bone

sigma\_combined\_t = sqrt(cal(:, 3).^2 + input(i + 1, 2)^2); % Tooth

a(:, 3) = normpdf(a(:, 1), input(i, 1), interp1(cal(:, 1), sigma\_combined\_b, t(:, 2), 'linear')); % Bone

a(:, 4) = normpdf(a(:, 2), input(i + 1, 1), interp1(cal(:, 1), sigma\_combined\_t, t(:, 3), 'linear')); % Toot

% Posterior probabilities

sumFamine = sum(a(1:mc/2, 3));

sumPlague = sum(a(mc/2+1:end, 4));

PP(j, 1) = input(i, 5);

PP(j, 2) = sumFamine / (sumFamine + sumPlague);

PP(j, 3) = sumPlague / (sumFamine + sumPlague);

end

%----------PLOTTING------------

f = find(PP(:, 2) > 0.5);

p = find(PP(:, 3) > 0.5);

size(f)

size(p)

plot\_colors = {'r', 'k'}; % Colors for famine, plague

plot\_markers = {'x'};

hold on

% Posterior probability due to famine

scatter(PP(f(:), 1), PP(f(:), 2), 100, plot\_colors{1}, plot\_markers{1});

% Posterior probability due to plague

scatter(PP(p(:), 1), PP(p(:), 3), 100, plot\_colors{2}, plot\_markers{1});

xlabel('No of grave');

ylabel('Normalized posterior probability of death');

lgd = legend('\color{red} Famine', '\color{black} Plague');

set(lgd, 'fontsize', 13);

legend('show', 'Location', 'best');

xticks(1:1:19);

xticklabels({'1', '2', '9', '10', '11', '12', '13', '14', '15', '16', ...

'18', '21', '22', '25', '29', '31', '32', 'Ind', 'Ind II'});

box on

%----------LAGS------------

% lag death-bone as piecewise function

... ref Ubelaker et al. 2015 Forensic Science International 251.

% lag death-tooth, uncertainty, ...

... ref Ubelaker 1989 Human skeletal remains

function lag = lag\_calc(age, age\_sigma)

if age < 60

lagb = -1.77224+0.50818\*age;

lagb\_sigma = 0.50818\*age\_sigma;

else

lagb = 31.875;

lagb\_sigma = 1.214;

end

lagt = age-13;

lagt\_sigma = sqrt(age\_sigma.^2 + 3.^2);

lag = [lagb, lagb\_sigma, lagt, lagt\_sigma];

end