

# Skeletal age

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18/10/2021

## Skeletal age for mapping the impact of fracture on mortality

```
library(gridExtra)
library(ggplot2)
library(dplyr)
```

### Packages

```
##
## Attaching package: 'dplyr'

## The following object is masked from 'package:gridExtra':
##
##      combine

## The following objects are masked from 'package:stats':
##
##      filter, lag

## The following objects are masked from 'package:base':
##
##      intersect, setdiff, setequal, union

#install.packages("cli", version = '3.4.0')
library(tidyverse)

## -- Attaching packages ----- tidyverse 1.3.1 --

## v tibble  3.1.8      v purrr   0.3.4
## v tidyr   1.2.0      v stringr 1.5.0
## v readr   2.1.3      v forcats 0.5.1

## -- Conflicts ----- tidyverse_conflicts() --
## x dplyr::combine() masks gridExtra::combine()
## x dplyr::filter()  masks stats::filter()
## x dplyr::lag()     masks stats::lag()
```

```
library(htmltools)
```

(1) **Figure 2: Association between specific fracture and mortality risk**

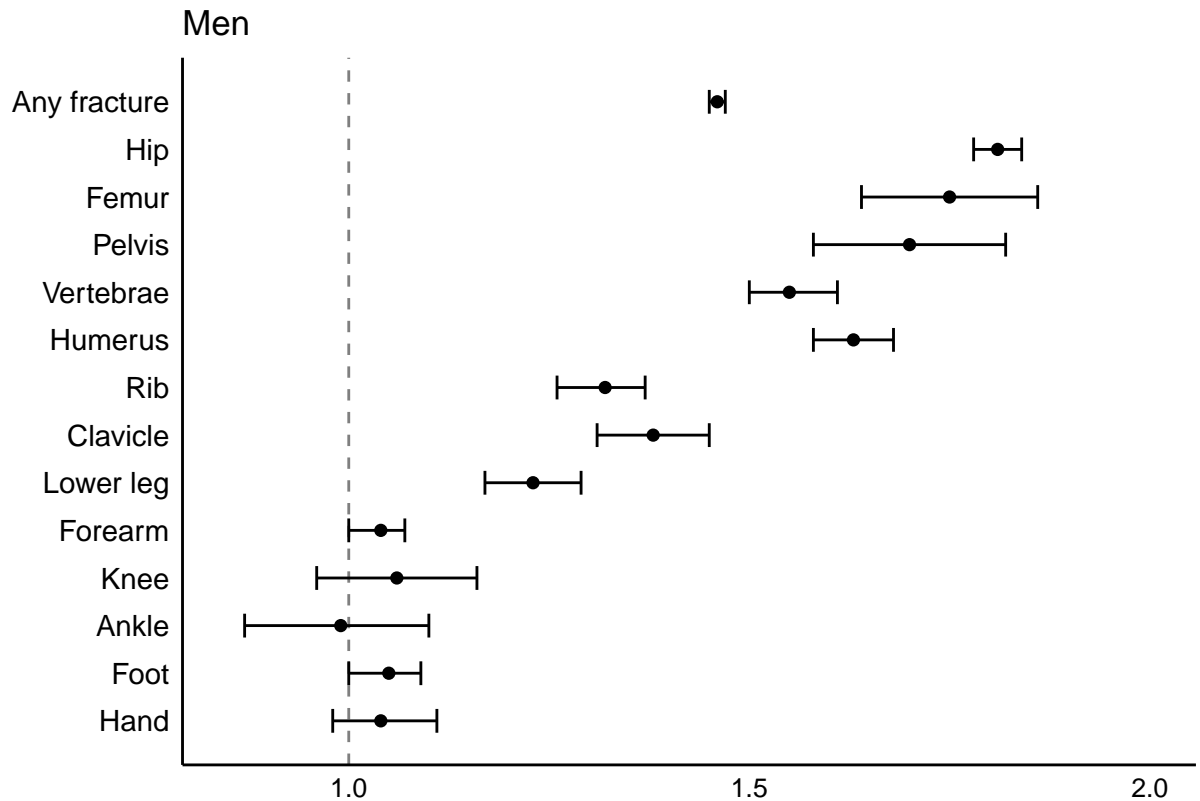
### (1.1) Aggregated data

```
fx.death <- data.frame(
  index = c(1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22,
  fx = c("Any fracture", "Hip", "Femur", "Pelvis", "Vertebrae", "Humerus", "Rib", "Clavicle",
  est = c(1.46, 1.81, 1.75, 1.70, 1.55, 1.63, 1.32, 1.38, 1.23, 1.04, 1.06, 0.99, 1.05, 1.10,
  LL = c(1.45, 1.78, 1.64, 1.58, 1.50, 1.58, 1.26, 1.31, 1.17, 1.00, 0.96, 0.87, 1.00, 0.99,
  UL = c(1.47, 1.84, 1.86, 1.82, 1.61, 1.68, 1.37, 1.45, 1.29, 1.07, 1.16, 1.10, 1.09, 1.11,
  gender = c("Men", "Men", "Men", "Men", "Men", "Men", "Men", "Men", "Men", "Men", "Men", "Men",
```

(1.2) Figure 2

```
fx.men = subset(fx.death, gender == "Men")

p.m = ggplot(data = fx.men, aes(y = index, x = est, xmin = LL, xmax = UL)) +
  geom_point(shape = 16, size = 2) +
  geom_errorbarh(height = .5) +
  scale_y_continuous(name = "", breaks = 1:14, labels = fx.men$fx, trans = "reverse") +
  scale_x_continuous(name = "", limits = c(0.85, 2), breaks = c(1, 1.5, 2), labels = c("1.",
labs(title = "Men", x = "Hazard ratios for mortality risk (95% CI)", y = " ") +
  geom_vline(xintercept = 1, color = 'black', linetype = 'dashed', alpha=.5) +
  theme_minimal() +
  theme(panel.border = element_blank(),
        panel.background = element_blank(),
        panel.grid.major = element_blank(),
        panel.grid.minor = element_blank(),
        axis.line = element_line(colour = "black"),
        axis.text.y = element_text(size = 11, colour = "black"),
        axis.text.x.bottom = element_text(size = 10, colour = "black"),
        axis.title.x = element_text(size = 14, colour = "black"))
)
p.m
```

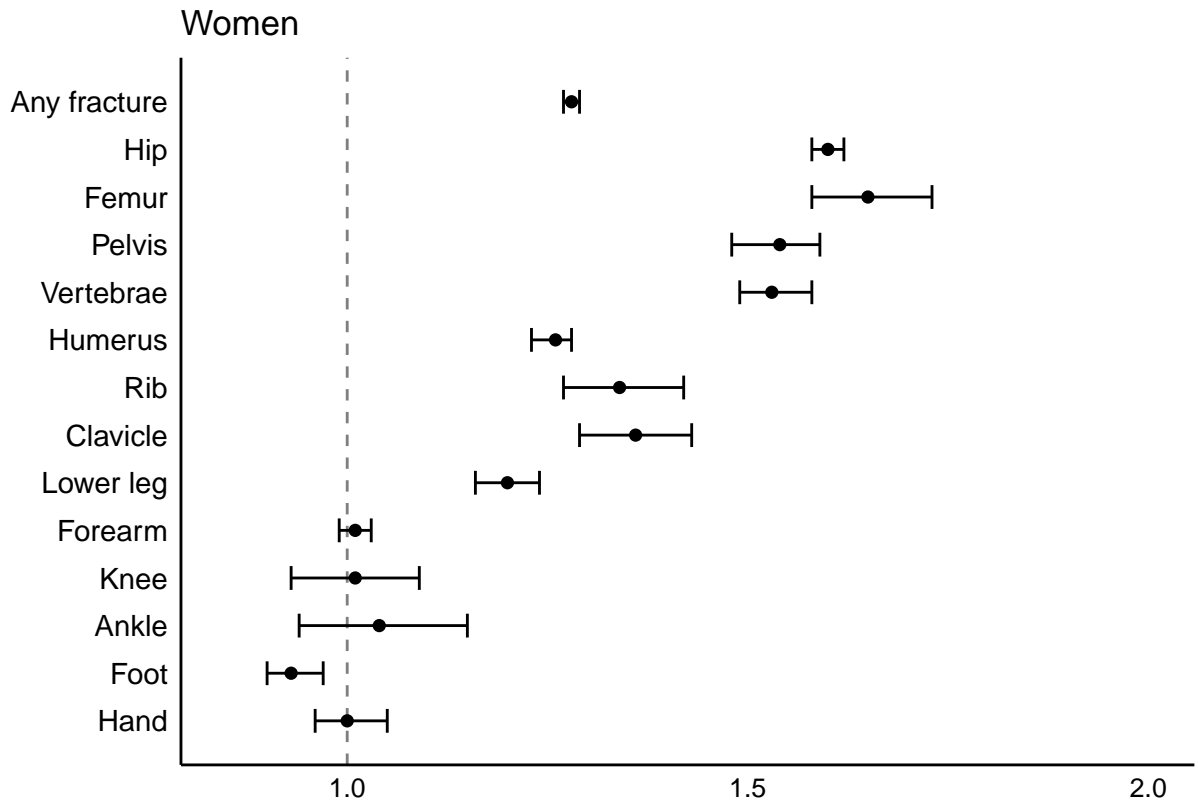


Men

#### Women

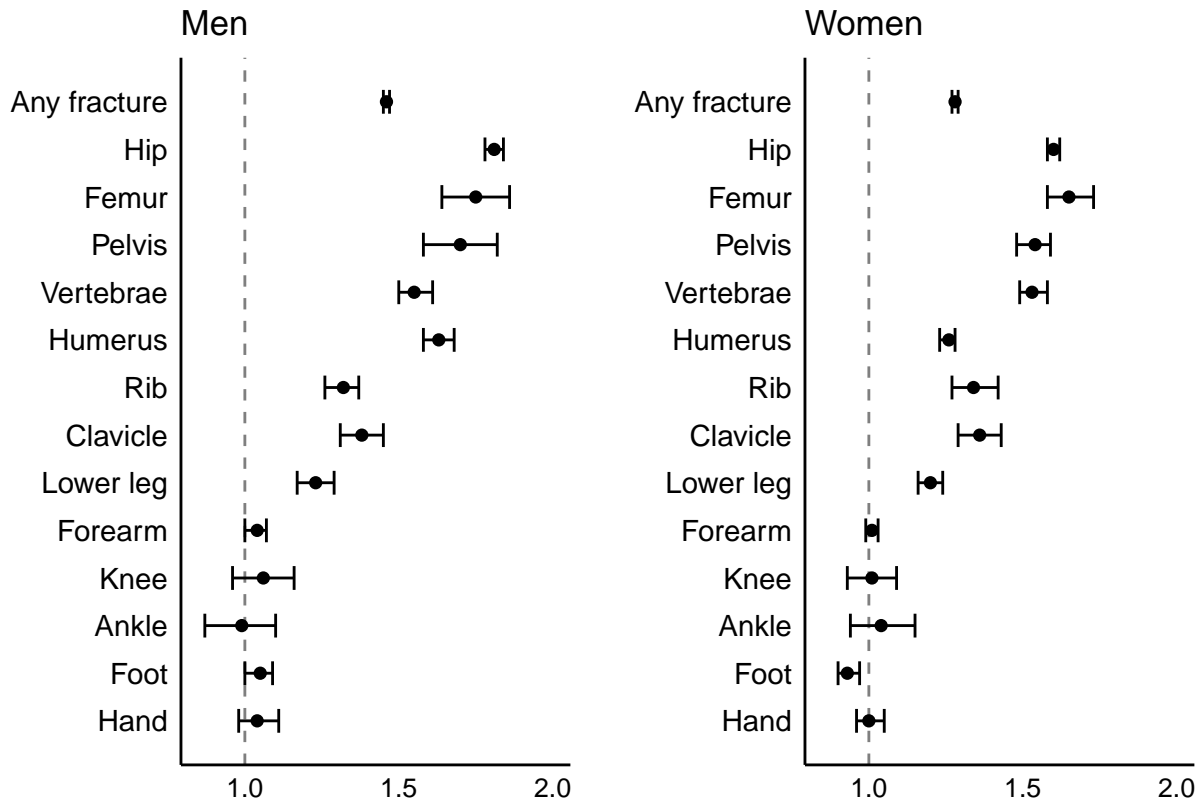
```
fx.women = subset(fx.death, gender == "Women")

p.w = ggplot(data = fx.women, aes(y = index, x = est, xmin = LL, xmax = UL)) +
  geom_point(shape = 16, size = 2) +
  geom_errorbarh(height = .5) +
  scale_y_continuous(name = "", breaks = 15:28, labels = fx.women$fx, trans = "reverse") +
  scale_x_continuous(name = "", limits = c(0.85, 2), breaks = c(1, 1.5, 2), labels = c("1.0", "1.5", "2")) +
  labs(title = "Women", x = "Hazard ratios for mortality risk (95% CI)", y = " ") +
  geom_vline(xintercept = 1, color = 'black', linetype = 'dashed', alpha = .5) +
  theme_minimal() +
  theme(panel.border = element_blank(),
        panel.background = element_blank(),
        panel.grid.major = element_blank(),
        panel.grid.minor = element_blank(),
        axis.line = element_line(colour = "black"),
        axis.text.y = element_text(size = 11, colour = "black"),
        axis.text.x.bottom = element_text(size = 10, colour = "black"),
        axis.title.x = element_text(size = 14, colour = "black"))
p.w
```



#### Both

```
grid.arrange(p.m, p.w, nrow = 1)
```



## (2) Skeletal age for fractures associated with increased mortality risk

```
sk.age <- data.frame(
  fx = c("Any fracture", "Hip", "Femur", "Pelvis", "Vertebrae", "Humerus", "Rib", "Clavicle", "Lower leg", "Forearm", "Knee", "Ankle", "Foot", "Hand"),
  est = c(1.66, 2.28, 2.15, 2.00, 1.82, 1.83, 1.41, 1.55, 1.38, 1.51, 1.94, 1.95, 1.73, 1.73, 1.38, 1.41),
  sex = c("Men", "Men", "Men", "Men", "Men", "Men", "Men", "Men", "Men", "Men", "Women", "Women", "Women", "Women", "Women", "Women"),
  stringsAsFactors = FALSE)
sk.age
```

#### Aggregated data

```
##      fx  est  sex
## 1 Any fracture 1.66 Men
## 2      Hip 2.28 Men
## 3      Femur 2.15 Men
## 4      Pelvis 2.00 Men
## 5  Vertebrae 1.82 Men
## 6      Humerus 1.83 Men
## 7        Rib 1.41 Men
## 8    Clavicle 1.55 Men
## 9   Lower leg 1.38 Men
## 10 Any fracture 1.51 Women
## 11      Hip 1.94 Women
## 12      Femur 1.95 Women
## 13      Pelvis 1.73 Women
```

(2.1) Men

6

```

    }

    Ex1 = Tx1 / Lx1
    Ex2 = Tx2 / Lx2

    Lx1 = round(Lx1)
    lx1 = round(lx1)
    Tx1 = round(Tx1)
    Ex1 = round(Ex1,1)

    Lx2 = round(Lx2)
    lx2 = round(lx2)
    Tx2 = round(Tx2)
    Ex2 = round(Ex2,1)
    Diff = Ex1- Ex2
    Skel.Age = age+Diff
    print(Skel.Age)
    df = data.frame(age, qx, Ex1, Ex2, Diff, Skel.Age)
    df$fx = fracture
    skage = subset(df, age>thres_age, select = c(age, fx, Skel.Age))
    skage
  }

```

## Analysis macro

```
any_fx_men = func_Skel_Age(sk.age, "Men", "Any fracture",49)
```

### (2.1.1) Any fracture

```
##      [1]    5.0    5.9    6.9    7.9    8.9    9.9   10.9   11.9   12.9   13.9   14.9   15.9
##     [13]   16.9   17.9   18.9   19.8   20.8   21.9   22.8   23.8   24.8   25.8   26.7   27.7
##     [25]   28.8   29.7   30.7   31.7   32.7   33.6   34.7   35.6   36.6   37.6   38.6   39.5
##     [37]   40.6   41.5   42.5   43.5   44.5   45.5   46.4   47.4   48.4   49.3   50.3   51.3
##     [49]   52.3   53.3   54.2   55.2   56.2   57.2   58.1   59.1   60.0   61.0   61.9   62.9
##     [61]   63.8   64.8   65.7   66.6   67.6   68.6   69.5   70.4   71.4   72.3   73.2   74.1
##     [73]   75.1   75.9   76.9   77.8   78.7   79.6   80.5   81.5   82.3   83.3   84.2   85.0
##     [85]   86.0   86.9   87.8   88.7   89.6   90.6   91.5   92.4   93.4   94.3   95.2   96.2
##     [97]   97.1   98.0   99.0  100.0  100.9  101.8  102.5  103.3  104.2  105.0    NA
```

```
names(any_fx_men)[names(any_fx_men) == "Skel.Age"] = "fracture"
any_fx_men = subset(any_fx_men, select = c("age", "fracture"))
any_fx_men$gender = "Men"
any_fx_men
```

```
##      age fracture gender
## 51    50     54.2    Men
## 52    51     55.2    Men
## 53    52     56.2    Men
## 54    53     57.2    Men
```

##	55	54	58.1	Men
##	56	55	59.1	Men
##	57	56	60.0	Men
##	58	57	61.0	Men
##	59	58	61.9	Men
##	60	59	62.9	Men
##	61	60	63.8	Men
##	62	61	64.8	Men
##	63	62	65.7	Men
##	64	63	66.6	Men
##	65	64	67.6	Men
##	66	65	68.6	Men
##	67	66	69.5	Men
##	68	67	70.4	Men
##	69	68	71.4	Men
##	70	69	72.3	Men
##	71	70	73.2	Men
##	72	71	74.1	Men
##	73	72	75.1	Men
##	74	73	75.9	Men
##	75	74	76.9	Men
##	76	75	77.8	Men
##	77	76	78.7	Men
##	78	77	79.6	Men
##	79	78	80.5	Men
##	80	79	81.5	Men
##	81	80	82.3	Men
##	82	81	83.3	Men
##	83	82	84.2	Men
##	84	83	85.0	Men
##	85	84	86.0	Men
##	86	85	86.9	Men
##	87	86	87.8	Men
##	88	87	88.7	Men
##	89	88	89.6	Men
##	90	89	90.6	Men
##	91	90	91.5	Men
##	92	91	92.4	Men
##	93	92	93.4	Men
##	94	93	94.3	Men
##	95	94	95.2	Men
##	96	95	96.2	Men
##	97	96	97.1	Men
##	98	97	98.0	Men
##	99	98	99.0	Men
##	100	99	100.0	Men
##	101	100	100.9	Men
##	102	101	101.8	Men
##	103	102	102.5	Men
##	104	103	103.3	Men
##	105	104	104.2	Men
##	106	105	105.0	Men
##	107	106	NA	Men



```
hip_fx_men = func_Skel_Age(sk.age, "Men", "Hip", 49)
```

### (2.1.2) Hip fracture

```
##      [1]      8.3      9.0     10.1     11.1     12.1     13.1     14.1     15.1     16.0     17.0     18.0     19.0
##     [13]     20.0     21.0     22.0     23.0     24.0     25.0     26.0     26.9     27.9     28.9     29.8     30.8
##     [25]     31.8     32.7     33.7     34.7     35.6     36.6     37.6     38.5     39.5     40.5     41.5     42.4
##     [37]     43.4     44.4     45.3     46.3     47.2     48.3     49.2     50.1     51.1     52.0     53.0     53.9
##     [49]     54.9     55.9     56.8     57.8     58.8     59.7     60.6     61.5     62.5     63.4     64.3     65.2
##     [61]     66.1     67.1     67.9     68.8     69.7     70.7     71.5     72.4     73.3     74.2     75.0     75.8
##     [73]     76.8     77.6     78.5     79.3     80.2     81.1     81.9     82.8     83.6     84.5     85.3     86.1
##     [85]     87.0     87.8     88.7     89.5     90.4     91.3     92.2     93.0     94.0     94.8     95.7     96.7
##     [97]     97.6     98.5     99.4    100.5    101.4    102.2    102.9    103.6    104.3    105.0      NA
```

```
names(hip_fx_men)[names(hip_fx_men) == "Skel.Age"] = "hip"
hip_fx_men = subset(hip_fx_men, select = c("age", "hip"))
hip_fx_men$gender = "Men"
hip_fx_men
```

```
##      age      hip gender
## 51     50     56.8     Men
## 52     51     57.8     Men
## 53     52     58.8     Men
## 54     53     59.7     Men
## 55     54     60.6     Men
## 56     55     61.5     Men
## 57     56     62.5     Men
## 58     57     63.4     Men
## 59     58     64.3     Men
## 60     59     65.2     Men
## 61     60     66.1     Men
## 62     61     67.1     Men
## 63     62     67.9     Men
## 64     63     68.8     Men
## 65     64     69.7     Men
## 66     65     70.7     Men
## 67     66     71.5     Men
## 68     67     72.4     Men
## 69     68     73.3     Men
## 70     69     74.2     Men
## 71     70     75.0     Men
## 72     71     75.8     Men
## 73     72     76.8     Men
## 74     73     77.6     Men
## 75     74     78.5     Men
## 76     75     79.3     Men
## 77     76     80.2     Men
## 78     77     81.1     Men
## 79     78     81.9     Men
## 80     79     82.8     Men
## 81     80     83.6     Men
```

```
## 82 81 84.5 Men
## 83 82 85.3 Men
## 84 83 86.1 Men
## 85 84 87.0 Men
## 86 85 87.8 Men
## 87 86 88.7 Men
## 88 87 89.5 Men
## 89 88 90.4 Men
## 90 89 91.3 Men
## 91 90 92.2 Men
## 92 91 93.0 Men
## 93 92 94.0 Men
## 94 93 94.8 Men
## 95 94 95.7 Men
## 96 95 96.7 Men
## 97 96 97.6 Men
## 98 97 98.5 Men
## 99 98 99.4 Men
## 100 99 100.5 Men
## 101 100 101.4 Men
## 102 101 102.2 Men
## 103 102 102.9 Men
## 104 103 103.6 Men
## 105 104 104.3 Men
## 106 105 105.0 Men
## 107 106 NA Men
```

```
femur_fx_men = func_Skel_Age(sk.age, "Men", "Femur", 49)
```

### (2.1.3) Femur fracture

```
## [1] 7.7 8.5 9.5 10.5 11.5 12.5 13.5 14.5 15.4 16.4 17.4 18.4
## [13] 19.4 20.4 21.4 22.4 23.4 24.4 25.4 26.3 27.4 28.3 29.2 30.2
## [25] 31.2 32.2 33.1 34.1 35.1 36.0 37.1 38.0 38.9 40.0 40.9 41.8
## [37] 42.9 43.8 44.8 45.8 46.7 47.8 48.7 49.6 50.6 51.5 52.5 53.4
## [49] 54.4 55.4 56.3 57.3 58.3 59.2 60.1 61.1 62.0 62.9 63.9 64.8
## [61] 65.7 66.6 67.5 68.4 69.4 70.3 71.1 72.0 73.0 73.8 74.7 75.5
## [73] 76.5 77.3 78.2 79.0 80.0 80.8 81.6 82.6 83.3 84.3 85.1 85.9
## [85] 86.8 87.7 88.6 89.4 90.3 91.2 92.1 92.9 93.9 94.7 95.7 96.6
## [97] 97.5 98.4 99.4 100.4 101.3 102.2 102.8 103.5 104.3 105.0 NA
```

```
names(femur_fx_men)[names(femur_fx_men) == "Skel.Age"] = "femur"
femur_fx_men = subset(femur_fx_men, select = c("age", "femur"))
femur_fx_men$gender = "Men"
femur_fx_men
```

```
## age femur gender
## 51 50 56.3 Men
## 52 51 57.3 Men
## 53 52 58.3 Men
```

## 54	53	59.2	Men
## 55	54	60.1	Men
## 56	55	61.1	Men
## 57	56	62.0	Men
## 58	57	62.9	Men
## 59	58	63.9	Men
## 60	59	64.8	Men
## 61	60	65.7	Men
## 62	61	66.6	Men
## 63	62	67.5	Men
## 64	63	68.4	Men
## 65	64	69.4	Men
## 66	65	70.3	Men
## 67	66	71.1	Men
## 68	67	72.0	Men
## 69	68	73.0	Men
## 70	69	73.8	Men
## 71	70	74.7	Men
## 72	71	75.5	Men
## 73	72	76.5	Men
## 74	73	77.3	Men
## 75	74	78.2	Men
## 76	75	79.0	Men
## 77	76	80.0	Men
## 78	77	80.8	Men
## 79	78	81.6	Men
## 80	79	82.6	Men
## 81	80	83.3	Men
## 82	81	84.3	Men
## 83	82	85.1	Men
## 84	83	85.9	Men
## 85	84	86.8	Men
## 86	85	87.7	Men
## 87	86	88.6	Men
## 88	87	89.4	Men
## 89	88	90.3	Men
## 90	89	91.2	Men
## 91	90	92.1	Men
## 92	91	92.9	Men
## 93	92	93.9	Men
## 94	93	94.7	Men
## 95	94	95.7	Men
## 96	95	96.6	Men
## 97	96	97.5	Men
## 98	97	98.4	Men
## 99	98	99.4	Men
## 100	99	100.4	Men
## 101	100	101.3	Men
## 102	101	102.2	Men
## 103	102	102.8	Men
## 104	103	103.5	Men
## 105	104	104.3	Men
## 106	105	105.0	Men
## 107	106	NA	Men

```
pelvis_fx_men = func_Skel_Age(sk.age, "Men", "Pelvis", 49)
```

#### (2.1.4) Pelvis fracture

```
##      [1]  6.9  7.7  8.8  9.8 10.8 11.8 12.7 13.7 14.7 15.7 16.7 17.7
##     [13] 18.7 19.7 20.7 21.7 22.7 23.7 24.7 25.6 26.6 27.6 28.5 29.5
##     [25] 30.5 31.5 32.4 33.4 34.4 35.3 36.4 37.3 38.3 39.3 40.3 41.2
##     [37] 42.2 43.2 44.1 45.1 46.1 47.1 48.0 49.0 50.0 50.9 51.9 52.8
##     [49] 53.8 54.8 55.7 56.7 57.7 58.7 59.6 60.5 61.5 62.4 63.3 64.2
##     [61] 65.2 66.1 67.0 67.9 68.9 69.8 70.7 71.6 72.5 73.4 74.3 75.1
##     [73] 76.1 76.9 77.8 78.7 79.6 80.5 81.3 82.3 83.1 84.0 84.9 85.7
##     [85] 86.6 87.5 88.4 89.2 90.1 91.1 92.0 92.8 93.8 94.6 95.5 96.5
##     [97] 97.4 98.3 99.3 100.3 101.2 102.1 102.7 103.5 104.3 105.0    NA
```

```
names(pelvis_fx_men)[names(pelvis_fx_men) == "Skel.Age"] = "pelvis"
pelvis_fx_men = subset(pelvis_fx_men, select = c("age", "pelvis"))
pelvis_fx_men$gender = "Men"
pelvis_fx_men
```

```
##      age pelvis gender
## 51    50   55.7    Men
## 52    51   56.7    Men
## 53    52   57.7    Men
## 54    53   58.7    Men
## 55    54   59.6    Men
## 56    55   60.5    Men
## 57    56   61.5    Men
## 58    57   62.4    Men
## 59    58   63.3    Men
## 60    59   64.2    Men
## 61    60   65.2    Men
## 62    61   66.1    Men
## 63    62   67.0    Men
## 64    63   67.9    Men
## 65    64   68.9    Men
## 66    65   69.8    Men
## 67    66   70.7    Men
## 68    67   71.6    Men
## 69    68   72.5    Men
## 70    69   73.4    Men
## 71    70   74.3    Men
## 72    71   75.1    Men
## 73    72   76.1    Men
## 74    73   76.9    Men
## 75    74   77.8    Men
## 76    75   78.7    Men
## 77    76   79.6    Men
## 78    77   80.5    Men
## 79    78   81.3    Men
## 80    79   82.3    Men
## 81    80   83.1    Men
```

```
## 82 81 84.0 Men
## 83 82 84.9 Men
## 84 83 85.7 Men
## 85 84 86.6 Men
## 86 85 87.5 Men
## 87 86 88.4 Men
## 88 87 89.2 Men
## 89 88 90.1 Men
## 90 89 91.1 Men
## 91 90 92.0 Men
## 92 91 92.8 Men
## 93 92 93.8 Men
## 94 93 94.6 Men
## 95 94 95.5 Men
## 96 95 96.5 Men
## 97 96 97.4 Men
## 98 97 98.3 Men
## 99 98 99.3 Men
## 100 99 100.3 Men
## 101 100 101.2 Men
## 102 101 102.1 Men
## 103 102 102.7 Men
## 104 103 103.5 Men
## 105 104 104.3 Men
## 106 105 105.0 Men
## 107 106 NA Men
```

```
vert_fx_men = func_Skel_Age(sk.age, "Men", "Vertebrae", 49)
```

### (2.1.5) Vertebral fracture

```
## [1] 6.0 6.8 7.9 8.8 9.8 10.8 11.8 12.8 13.8 14.8 15.8 16.8
## [13] 17.8 18.8 19.8 20.7 21.7 22.8 23.7 24.7 25.7 26.7 27.6 28.6
## [25] 29.6 30.6 31.5 32.6 33.5 34.5 35.5 36.5 37.4 38.5 39.4 40.3
## [37] 41.4 42.3 43.3 44.3 45.3 46.3 47.2 48.1 49.2 50.1 51.1 52.0
## [49] 53.0 54.1 54.9 56.0 56.9 57.9 58.8 59.8 60.8 61.7 62.6 63.6
## [61] 64.5 65.5 66.4 67.3 68.2 69.2 70.1 71.0 72.0 72.9 73.7 74.6
## [73] 75.6 76.4 77.3 78.2 79.2 80.1 80.9 81.9 82.7 83.7 84.5 85.4
## [85] 86.3 87.2 88.1 88.9 89.9 90.8 91.7 92.6 93.6 94.4 95.4 96.3
## [97] 97.3 98.2 99.1 100.1 101.1 101.9 102.6 103.4 104.2 105.0 NA
```

```
names(vert_fx_men)[names(vert_fx_men) == "Skel.Age"] = "vertebrae"
vert_fx_men = subset(vert_fx_men, select = c("age", "vertebrae"))
vert_fx_men$gender = "Men"
vert_fx_men
```

```
## age vertebrae gender
## 51 50 54.9 Men
## 52 51 56.0 Men
## 53 52 56.9 Men
```

## 54	53	57.9	Men
## 55	54	58.8	Men
## 56	55	59.8	Men
## 57	56	60.8	Men
## 58	57	61.7	Men
## 59	58	62.6	Men
## 60	59	63.6	Men
## 61	60	64.5	Men
## 62	61	65.5	Men
## 63	62	66.4	Men
## 64	63	67.3	Men
## 65	64	68.2	Men
## 66	65	69.2	Men
## 67	66	70.1	Men
## 68	67	71.0	Men
## 69	68	72.0	Men
## 70	69	72.9	Men
## 71	70	73.7	Men
## 72	71	74.6	Men
## 73	72	75.6	Men
## 74	73	76.4	Men
## 75	74	77.3	Men
## 76	75	78.2	Men
## 77	76	79.2	Men
## 78	77	80.1	Men
## 79	78	80.9	Men
## 80	79	81.9	Men
## 81	80	82.7	Men
## 82	81	83.7	Men
## 83	82	84.5	Men
## 84	83	85.4	Men
## 85	84	86.3	Men
## 86	85	87.2	Men
## 87	86	88.1	Men
## 88	87	88.9	Men
## 89	88	89.9	Men
## 90	89	90.8	Men
## 91	90	91.7	Men
## 92	91	92.6	Men
## 93	92	93.6	Men
## 94	93	94.4	Men
## 95	94	95.4	Men
## 96	95	96.3	Men
## 97	96	97.3	Men
## 98	97	98.2	Men
## 99	98	99.1	Men
## 100	99	100.1	Men
## 101	100	101.1	Men
## 102	101	101.9	Men
## 103	102	102.6	Men
## 104	103	103.4	Men
## 105	104	104.2	Men
## 106	105	105.0	Men
## 107	106	NA	Men

```
hum_fx_men = func_Skel_Age(sk.age, "Men", "Humerus", 49)
```

### (2.1.6) Humerus fracture

```
## [1] 6.0 6.8 7.9 8.9 9.9 10.9 11.9 12.9 13.8 14.8 15.8 16.8
## [13] 17.8 18.8 19.8 20.8 21.8 22.8 23.8 24.7 25.8 26.7 27.7 28.6
## [25] 29.7 30.6 31.6 32.6 33.6 34.5 35.6 36.5 37.5 38.5 39.5 40.4
## [37] 41.4 42.4 43.3 44.4 45.3 46.3 47.3 48.2 49.2 50.1 51.2 52.1
## [49] 53.1 54.1 55.0 56.0 57.0 58.0 58.9 59.8 60.8 61.7 62.7 63.6
## [61] 64.5 65.5 66.4 67.3 68.3 69.2 70.1 71.0 72.0 72.9 73.8 74.6
## [73] 75.6 76.4 77.4 78.3 79.2 80.1 81.0 81.9 82.7 83.7 84.6 85.4
## [85] 86.3 87.2 88.1 89.0 89.9 90.8 91.8 92.6 93.6 94.4 95.4 96.3
## [97] 97.3 98.2 99.1 100.2 101.1 101.9 102.6 103.4 104.2 105.0 NA
```

```
names(hum_fx_men)[names(hum_fx_men) == "Skel.Age"] = "humerus"
hum_fx_men = subset(hum_fx_men, select = c("age", "humerus"))
hum_fx_men$gender = "Men"
hum_fx_men
```

```
## age humerus gender
## 51 50 55.0 Men
## 52 51 56.0 Men
## 53 52 57.0 Men
## 54 53 58.0 Men
## 55 54 58.9 Men
## 56 55 59.8 Men
## 57 56 60.8 Men
## 58 57 61.7 Men
## 59 58 62.7 Men
## 60 59 63.6 Men
## 61 60 64.5 Men
## 62 61 65.5 Men
## 63 62 66.4 Men
## 64 63 67.3 Men
## 65 64 68.3 Men
## 66 65 69.2 Men
## 67 66 70.1 Men
## 68 67 71.0 Men
## 69 68 72.0 Men
## 70 69 72.9 Men
## 71 70 73.8 Men
## 72 71 74.6 Men
## 73 72 75.6 Men
## 74 73 76.4 Men
## 75 74 77.4 Men
## 76 75 78.3 Men
## 77 76 79.2 Men
## 78 77 80.1 Men
## 79 78 81.0 Men
## 80 79 81.9 Men
## 81 80 82.7 Men
```

```
## 82 81 83.7 Men
## 83 82 84.6 Men
## 84 83 85.4 Men
## 85 84 86.3 Men
## 86 85 87.2 Men
## 87 86 88.1 Men
## 88 87 89.0 Men
## 89 88 89.9 Men
## 90 89 90.8 Men
## 91 90 91.8 Men
## 92 91 92.6 Men
## 93 92 93.6 Men
## 94 93 94.4 Men
## 95 94 95.4 Men
## 96 95 96.3 Men
## 97 96 97.3 Men
## 98 97 98.2 Men
## 99 98 99.1 Men
## 100 99 100.2 Men
## 101 100 101.1 Men
## 102 101 101.9 Men
## 103 102 102.6 Men
## 104 103 103.4 Men
## 105 104 104.2 Men
## 106 105 105.0 Men
## 107 106 NA Men
```

```
rib_fx_men = func_Skel_Age(sk.age, "Men", "Rib", 49)
```

### (2.1.7) Rib fracture

```
## [1] 3.4 4.3 5.3 6.3 7.3 8.3 9.3 10.3 11.3 12.3 13.3 14.3
## [13] 15.3 16.3 17.3 18.3 19.2 20.3 21.3 22.2 23.3 24.2 25.2 26.2
## [25] 27.2 28.2 29.1 30.2 31.1 32.1 33.2 34.1 35.1 36.1 37.1 38.0
## [37] 39.1 40.1 41.0 42.1 43.0 44.1 45.0 45.9 47.0 47.9 49.0 49.9
## [49] 50.9 51.9 52.8 53.9 54.9 55.9 56.8 57.8 58.8 59.7 60.7 61.6
## [61] 62.6 63.6 64.6 65.5 66.5 67.5 68.4 69.3 70.3 71.3 72.2 73.1
## [73] 74.1 75.0 76.0 76.9 77.9 78.8 79.8 80.8 81.6 82.6 83.6 84.4
## [85] 85.4 86.3 87.3 88.2 89.1 90.2 91.1 92.0 93.0 93.9 94.9 95.9
## [97] 96.8 97.8 98.7 99.7 100.7 101.6 102.3 103.2 104.1 105.0 NA
```

```
names(rib_fx_men)[names(rib_fx_men) == "Skel.Age"] = "rib"
rib_fx_men = subset(rib_fx_men, select = c("age", "rib"))
rib_fx_men$gender = "Men"
rib_fx_men
```

```
## age rib gender
## 51 50 52.8 Men
## 52 51 53.9 Men
## 53 52 54.9 Men
```



## 54	53	55.9	Men
## 55	54	56.8	Men
## 56	55	57.8	Men
## 57	56	58.8	Men
## 58	57	59.7	Men
## 59	58	60.7	Men
## 60	59	61.6	Men
## 61	60	62.6	Men
## 62	61	63.6	Men
## 63	62	64.6	Men
## 64	63	65.5	Men
## 65	64	66.5	Men
## 66	65	67.5	Men
## 67	66	68.4	Men
## 68	67	69.3	Men
## 69	68	70.3	Men
## 70	69	71.3	Men
## 71	70	72.2	Men
## 72	71	73.1	Men
## 73	72	74.1	Men
## 74	73	75.0	Men
## 75	74	76.0	Men
## 76	75	76.9	Men
## 77	76	77.9	Men
## 78	77	78.8	Men
## 79	78	79.8	Men
## 80	79	80.8	Men
## 81	80	81.6	Men
## 82	81	82.6	Men
## 83	82	83.6	Men
## 84	83	84.4	Men
## 85	84	85.4	Men
## 86	85	86.3	Men
## 87	86	87.3	Men
## 88	87	88.2	Men
## 89	88	89.1	Men
## 90	89	90.2	Men
## 91	90	91.1	Men
## 92	91	92.0	Men
## 93	92	93.0	Men
## 94	93	93.9	Men
## 95	94	94.9	Men
## 96	95	95.9	Men
## 97	96	96.8	Men
## 98	97	97.8	Men
## 99	98	98.7	Men
## 100	99	99.7	Men
## 101	100	100.7	Men
## 102	101	101.6	Men
## 103	102	102.3	Men
## 104	103	103.2	Men
## 105	104	104.1	Men
## 106	105	105.0	Men
## 107	106	NA	Men

```
clav_fx_men = func_Skel_Age(sk.age, "Men", "Clavicle", 49)
```

### (2.1.8) Clavicle fracture

```
##      [1]  4.3  5.2  6.3  7.2  8.2  9.2 10.2 11.2 12.2 13.2 14.2 15.2
##     [13] 16.2 17.2 18.2 19.2 20.2 21.2 22.2 23.1 24.2 25.1 26.1 27.1
##     [25] 28.1 29.1 30.0 31.1 32.0 33.0 34.0 35.0 35.9 37.0 38.0 38.9
##     [37] 40.0 40.9 41.9 42.9 43.8 44.9 45.8 46.8 47.8 48.7 49.8 50.7
##     [49] 51.7 52.7 53.6 54.6 55.6 56.6 57.5 58.5 59.5 60.5 61.4 62.4
##     [61] 63.3 64.3 65.2 66.2 67.1 68.1 69.0 69.9 71.0 71.9 72.8 73.7
##     [73] 74.7 75.5 76.5 77.4 78.4 79.3 80.2 81.2 82.0 83.0 83.9 84.8
##     [85] 85.7 86.7 87.6 88.5 89.4 90.4 91.4 92.2 93.2 94.1 95.1 96.0
##     [97] 97.0 97.9 98.9 99.9 100.8 101.7 102.4 103.3 104.1 105.0    NA
```

```
names(clav_fx_men)[names(clav_fx_men) == "Skel.Age"] = "clavicle"
clav_fx_men = subset(clav_fx_men, select = c("age", "clavicle"))
clav_fx_men$gender = "Men"
clav_fx_men
```

```
##      age clavicle gender
## 51    50     53.6    Men
## 52    51     54.6    Men
## 53    52     55.6    Men
## 54    53     56.6    Men
## 55    54     57.5    Men
## 56    55     58.5    Men
## 57    56     59.5    Men
## 58    57     60.5    Men
## 59    58     61.4    Men
## 60    59     62.4    Men
## 61    60     63.3    Men
## 62    61     64.3    Men
## 63    62     65.2    Men
## 64    63     66.2    Men
## 65    64     67.1    Men
## 66    65     68.1    Men
## 67    66     69.0    Men
## 68    67     69.9    Men
## 69    68     71.0    Men
## 70    69     71.9    Men
## 71    70     72.8    Men
## 72    71     73.7    Men
## 73    72     74.7    Men
## 74    73     75.5    Men
## 75    74     76.5    Men
## 76    75     77.4    Men
## 77    76     78.4    Men
## 78    77     79.3    Men
## 79    78     80.2    Men
## 80    79     81.2    Men
## 81    80     82.0    Men
```

```
## 82 81 83.0 Men
## 83 82 83.9 Men
## 84 83 84.8 Men
## 85 84 85.7 Men
## 86 85 86.7 Men
## 87 86 87.6 Men
## 88 87 88.5 Men
## 89 88 89.4 Men
## 90 89 90.4 Men
## 91 90 91.4 Men
## 92 91 92.2 Men
## 93 92 93.2 Men
## 94 93 94.1 Men
## 95 94 95.1 Men
## 96 95 96.0 Men
## 97 96 97.0 Men
## 98 97 97.9 Men
## 99 98 98.9 Men
## 100 99 99.9 Men
## 101 100 100.8 Men
## 102 101 101.7 Men
## 103 102 102.4 Men
## 104 103 103.3 Men
## 105 104 104.1 Men
## 106 105 105.0 Men
## 107 106 NA Men
```

```
leg_fx_men = func_Skel_Age(sk.age, "Men", "Lower leg", 49)
```

### (2.1.9) Lower leg fracture

```
## [1] 3.2 4.1 5.1 6.1 7.1 8.1 9.1 10.1 11.1 12.1 13.1 14.1
## [13] 15.1 16.1 17.1 18.1 19.0 20.1 21.1 22.0 23.1 24.0 25.0 26.0
## [25] 27.0 28.0 28.9 30.0 30.9 31.9 33.0 33.9 34.9 36.0 36.9 37.9
## [37] 38.9 39.9 40.8 41.9 42.8 43.9 44.8 45.8 46.8 47.7 48.8 49.7
## [49] 50.7 51.8 52.7 53.7 54.7 55.7 56.6 57.6 58.6 59.6 60.5 61.5
## [61] 62.4 63.5 64.4 65.3 66.3 67.3 68.2 69.2 70.2 71.1 72.1 73.0
## [73] 74.0 74.9 75.9 76.8 77.8 78.7 79.7 80.6 81.5 82.5 83.5 84.3
## [85] 85.3 86.3 87.2 88.1 89.1 90.1 91.0 91.9 93.0 93.8 94.8 95.8
## [97] 96.8 97.7 98.6 99.7 100.6 101.5 102.3 103.2 104.1 105.0 NA
```

```
names(leg_fx_men)[names(leg_fx_men) == "Skel.Age"] = "lowerleg"
leg_fx_men = subset(leg_fx_men, select = c("age", "lowerleg"))
leg_fx_men$gender = "Men"
leg_fx_men
```

```
## age lowerleg gender
## 51 50 52.7 Men
## 52 51 53.7 Men
## 53 52 54.7 Men
```

##	54	53	55.7	Men
##	55	54	56.6	Men
##	56	55	57.6	Men
##	57	56	58.6	Men
##	58	57	59.6	Men
##	59	58	60.5	Men
##	60	59	61.5	Men
##	61	60	62.4	Men
##	62	61	63.5	Men
##	63	62	64.4	Men
##	64	63	65.3	Men
##	65	64	66.3	Men
##	66	65	67.3	Men
##	67	66	68.2	Men
##	68	67	69.2	Men
##	69	68	70.2	Men
##	70	69	71.1	Men
##	71	70	72.1	Men
##	72	71	73.0	Men
##	73	72	74.0	Men
##	74	73	74.9	Men
##	75	74	75.9	Men
##	76	75	76.8	Men
##	77	76	77.8	Men
##	78	77	78.7	Men
##	79	78	79.7	Men
##	80	79	80.6	Men
##	81	80	81.5	Men
##	82	81	82.5	Men
##	83	82	83.5	Men
##	84	83	84.3	Men
##	85	84	85.3	Men
##	86	85	86.3	Men
##	87	86	87.2	Men
##	88	87	88.1	Men
##	89	88	89.1	Men
##	90	89	90.1	Men
##	91	90	91.0	Men
##	92	91	91.9	Men
##	93	92	93.0	Men
##	94	93	93.8	Men
##	95	94	94.8	Men
##	96	95	95.8	Men
##	97	96	96.8	Men
##	98	97	97.7	Men
##	99	98	98.6	Men
##	100	99	99.7	Men
##	101	100	100.6	Men
##	102	101	101.5	Men
##	103	102	102.3	Men
##	104	103	103.2	Men
##	105	104	104.1	Men
##	106	105	105.0	Men
##	107	106	NA	Men

```
df_list = list(any_fx_men, hip_fx_men, femur_fx_men, pelvis_fx_men, vert_fx_men, hum_fx_men, rib_fx_men)
sa.men = Reduce(function(x,y) merge(x, y, all = FALSE), df_list)
head(sa.men)
```

### Dataset - Skeletal age for high-risk fracture sites in men

```
##   age gender fracture   hip femur pelvis vertebrae humerus   rib clavicle
## 1 100   Men   100.9 101.4 101.3 101.2   101.1 101.1 100.7   100.8
## 2 101   Men   101.8 102.2 102.2 102.1   101.9 101.9 101.6   101.7
## 3 102   Men   102.5 102.9 102.8 102.7   102.6 102.6 102.3   102.4
## 4 103   Men   103.3 103.6 103.5 103.5   103.4 103.4 103.2   103.3
## 5 104   Men   104.2 104.3 104.3 104.3   104.2 104.2 104.1   104.1
## 6 105   Men   105.0 105.0 105.0 105.0   105.0 105.0 105.0   105.0
##   lowerleg
## 1      100.6
## 2      101.5
## 3      102.3
## 4      103.2
## 5      104.1
## 6      105.0
```

### (2.2) Skeletal age for the high-risk fracture sites in women

```
func_Skel_Age <- function(sk.age, gender, fracture, thres_age){
  qx = c(1.331, 0.148, 0.072, 0.035, 0.034, 0.034, 0.067, 0.131, 0.032, 0.032)
  age = 0:106
  fx_hr = sk.age$est[sk.age$sex == gender & sk.age$fx == fracture]

  Lx1 = qx
  lx1 = qx
  Tx1 = qx
  Ex1 = qx

  Lx2 = qx
  lx2 = qx
  Tx2 = qx
  Ex2 = qx

  length = length(qx)-1

  Lx1[1] = 100000
  Lx1[length+1] = NA
  Tx1[length+1] = NA
  Ex1[length+1] = NA

  Lx2[1] = 100000
  Lx2[length+1] = NA
  Tx2[length+1] = NA
  Ex2[length+1] = NA
}
```

```

    for (x in 2:length) {
      Lx1[x] = Lx1[x-1]*(1-(qx[x-1]*1.00)/1000)
      Lx2[x] = Lx2[x-1]*(1-(qx[x-1]*fx_hr)/1000)
    }

    lx1 = (Lx1 + lead(Lx1))/2
    lx1[length] = 0
    lx1[length+1] = NA

    lx2 = (Lx2 + lead(Lx2))/2
    lx2[length] = 0
    lx2[length+1] = NA

    for (x in 1:length) {
      Tx1[x] = sum(lx1[x:length])
      Tx2[x] = sum(lx2[x:length])
    }

    Ex1 = Tx1 / Lx1
    Ex2 = Tx2 / Lx2

    Lx1 = round(Lx1)
    lx1 = round(lx1)
    Tx1 = round(Tx1)
    Ex1 = round(Ex1,1)

    Lx2 = round(Lx2)
    lx2 = round(lx2)
    Tx2 = round(Tx2)
    Ex2 = round(Ex2,1)
    Diff = Ex1- Ex2
    Skel.Age = age+Diff
    print(Skel.Age)
    df = data.frame(age, qx, Ex1, Ex2, Diff, Skel.Age)
    df$fx = fracture
    skage = subset(df, age>thres_age, select = c(age, fx, Skel.Age))
    skage
  }

```

## Analysis macro

```
any_fx_women = func_Skel_Age(sk.age, "Women", "Any fracture",49)
```

### (2.2.1) Any fracture

##	[1]	3.7	4.7	5.6	6.6	7.6	8.6	9.6	10.6	11.6	12.6	13.6	14.7
##	[13]	15.7	16.7	17.6	18.6	19.6	20.6	21.6	22.5	23.5	24.6	25.6	26.6
##	[25]	27.6	28.6	29.5	30.5	31.6	32.6	33.5	34.5	35.5	36.5	37.6	38.5
##	[37]	39.5	40.5	41.5	42.5	43.5	44.5	45.4	46.5	47.4	48.4	49.3	50.4
##	[49]	51.3	52.4	53.3	54.3	55.3	56.3	57.3	58.2	59.2	60.2	61.2	62.1

```
## [61] 63.1 64.1 65.0 66.0 66.9 67.9 68.9 69.8 70.8 71.7 72.7 73.7
## [73] 74.6 75.5 76.4 77.4 78.3 79.3 80.3 81.2 82.0 83.0 83.9 84.8
## [85] 85.7 86.7 87.7 88.6 89.5 90.4 91.3 92.2 93.2 94.1 95.1 96.0
## [97] 96.9 97.9 98.8 99.8 100.7 101.6 102.4 103.3 104.0 105.0 NA
```

```
names(any_fx_women)[names(any_fx_women) == "Skel.Age"] = "fracture"
any_fx_women = subset(any_fx_women, select = c("age", "fracture"))
any_fx_women$gender = "Women"
any_fx_women
```

```
##      age fracture gender
## 51    50      53.3  Women
## 52    51      54.3  Women
## 53    52      55.3  Women
## 54    53      56.3  Women
## 55    54      57.3  Women
## 56    55      58.2  Women
## 57    56      59.2  Women
## 58    57      60.2  Women
## 59    58      61.2  Women
## 60    59      62.1  Women
## 61    60      63.1  Women
## 62    61      64.1  Women
## 63    62      65.0  Women
## 64    63      66.0  Women
## 65    64      66.9  Women
## 66    65      67.9  Women
## 67    66      68.9  Women
## 68    67      69.8  Women
## 69    68      70.8  Women
## 70    69      71.7  Women
## 71    70      72.7  Women
## 72    71      73.7  Women
## 73    72      74.6  Women
## 74    73      75.5  Women
## 75    74      76.4  Women
## 76    75      77.4  Women
## 77    76      78.3  Women
## 78    77      79.3  Women
## 79    78      80.3  Women
## 80    79      81.2  Women
## 81    80      82.0  Women
## 82    81      83.0  Women
## 83    82      83.9  Women
## 84    83      84.8  Women
## 85    84      85.7  Women
## 86    85      86.7  Women
## 87    86      87.7  Women
## 88    87      88.6  Women
## 89    88      89.5  Women
## 90    89      90.4  Women
## 91    90      91.3  Women
## 92    91      92.2  Women
## 93    92      93.2  Women
```

```
## 94 93 94.1 Women
## 95 94 95.1 Women
## 96 95 96.0 Women
## 97 96 96.9 Women
## 98 97 97.9 Women
## 99 98 98.8 Women
## 100 99 99.8 Women
## 101 100 100.7 Women
## 102 101 101.6 Women
## 103 102 102.4 Women
## 104 103 103.3 Women
## 105 104 104.0 Women
## 106 105 105.0 Women
## 107 106 NA Women
```

```
hip_fx_women = func_Skel_Age(sk.age, "Women", "Hip", 49)
```

### (2.2.2) Hip fracture

```
## [1] 6.0 6.9 7.9 8.9 9.9 10.9 11.9 12.9 13.9 14.8 15.8 16.9
## [13] 17.9 18.9 19.9 20.9 21.8 22.8 23.8 24.8 25.8 26.8 27.8 28.8
## [25] 29.8 30.8 31.7 32.7 33.8 34.8 35.7 36.7 37.7 38.6 39.7 40.7
## [37] 41.7 42.6 43.6 44.6 45.6 46.6 47.5 48.5 49.5 50.5 51.4 52.4
## [49] 53.4 54.4 55.3 56.3 57.2 58.3 59.2 60.1 61.1 62.1 63.1 63.9
## [61] 64.9 65.9 66.8 67.7 68.6 69.6 70.5 71.4 72.4 73.3 74.2 75.2
## [73] 76.1 76.9 77.8 78.7 79.6 80.6 81.5 82.4 83.1 84.1 84.9 85.8
## [85] 86.7 87.6 88.5 89.4 90.2 91.1 92.0 92.8 93.8 94.7 95.6 96.5
## [97] 97.4 98.4 99.3 100.2 101.1 101.9 102.7 103.5 104.1 105.0 NA
```

```
names(hip_fx_women)[names(hip_fx_women) == "Skel.Age"] = "hip"
hip_fx_women = subset(hip_fx_women, select = c("age", "hip"))
hip_fx_women$gender = "Women"
hip_fx_women
```

```
## age hip gender
## 51 50 55.3 Women
## 52 51 56.3 Women
## 53 52 57.2 Women
## 54 53 58.3 Women
## 55 54 59.2 Women
## 56 55 60.1 Women
## 57 56 61.1 Women
## 58 57 62.1 Women
## 59 58 63.1 Women
## 60 59 63.9 Women
## 61 60 64.9 Women
## 62 61 65.9 Women
## 63 62 66.8 Women
## 64 63 67.7 Women
## 65 64 68.6 Women
```



```
## 66 65 69.6 Women
## 67 66 70.5 Women
## 68 67 71.4 Women
## 69 68 72.4 Women
## 70 69 73.3 Women
## 71 70 74.2 Women
## 72 71 75.2 Women
## 73 72 76.1 Women
## 74 73 76.9 Women
## 75 74 77.8 Women
## 76 75 78.7 Women
## 77 76 79.6 Women
## 78 77 80.6 Women
## 79 78 81.5 Women
## 80 79 82.4 Women
## 81 80 83.1 Women
## 82 81 84.1 Women
## 83 82 84.9 Women
## 84 83 85.8 Women
## 85 84 86.7 Women
## 86 85 87.6 Women
## 87 86 88.5 Women
## 88 87 89.4 Women
## 89 88 90.2 Women
## 90 89 91.1 Women
## 91 90 92.0 Women
## 92 91 92.8 Women
## 93 92 93.8 Women
## 94 93 94.7 Women
## 95 94 95.6 Women
## 96 95 96.5 Women
## 97 96 97.4 Women
## 98 97 98.4 Women
## 99 98 99.3 Women
## 100 99 100.2 Women
## 101 100 101.1 Women
## 102 101 101.9 Women
## 103 102 102.7 Women
## 104 103 103.5 Women
## 105 104 104.1 Women
## 106 105 105.0 Women
## 107 106 NA Women
```

```
femur_fx_women = func_Skel_Age(sk.age, "Women", "Femur", 49)
```

### (2.2.3) Femur fracture

```
## [1] 6.1 7.0 8.0 8.9 9.9 10.9 11.9 12.9 13.9 14.9 15.9 17.0
## [13] 18.0 18.9 19.9 20.9 21.9 22.9 23.8 24.8 25.8 26.9 27.9 28.8
## [25] 29.8 30.8 31.8 32.7 33.8 34.8 35.8 36.7 37.7 38.7 39.8 40.7
## [37] 41.7 42.7 43.6 44.7 45.6 46.6 47.5 48.6 49.5 50.5 51.5 52.5
```

```
## [49] 53.4 54.4 55.3 56.4 57.3 58.3 59.3 60.2 61.1 62.1 63.1 64.0
## [61] 64.9 65.9 66.8 67.8 68.7 69.7 70.6 71.5 72.4 73.3 74.2 75.2
## [73] 76.1 77.0 77.8 78.8 79.6 80.6 81.5 82.4 83.2 84.1 85.0 85.8
## [85] 86.7 87.6 88.5 89.4 90.3 91.1 92.0 92.8 93.8 94.7 95.6 96.5
## [97] 97.4 98.4 99.3 100.2 101.1 101.9 102.7 103.5 104.1 105.0 NA
```

```
names(femur_fx_women)[names(femur_fx_women) == "Skel.Age"] = "femur"
femur_fx_women = subset(femur_fx_women, select = c("age", "femur"))
femur_fx_women$gender = "Women"
femur_fx_women
```

```
##      age femur gender
## 51    50  55.3  Women
## 52    51  56.4  Women
## 53    52  57.3  Women
## 54    53  58.3  Women
## 55    54  59.3  Women
## 56    55  60.2  Women
## 57    56  61.1  Women
## 58    57  62.1  Women
## 59    58  63.1  Women
## 60    59  64.0  Women
## 61    60  64.9  Women
## 62    61  65.9  Women
## 63    62  66.8  Women
## 64    63  67.8  Women
## 65    64  68.7  Women
## 66    65  69.7  Women
## 67    66  70.6  Women
## 68    67  71.5  Women
## 69    68  72.4  Women
## 70    69  73.3  Women
## 71    70  74.2  Women
## 72    71  75.2  Women
## 73    72  76.1  Women
## 74    73  77.0  Women
## 75    74  77.8  Women
## 76    75  78.8  Women
## 77    76  79.6  Women
## 78    77  80.6  Women
## 79    78  81.5  Women
## 80    79  82.4  Women
## 81    80  83.2  Women
## 82    81  84.1  Women
## 83    82  85.0  Women
## 84    83  85.8  Women
## 85    84  86.7  Women
## 86    85  87.6  Women
## 87    86  88.5  Women
## 88    87  89.4  Women
## 89    88  90.3  Women
## 90    89  91.1  Women
## 91    90  92.0  Women
## 92    91  92.8  Women
```

```
## 93 92 93.8 Women
## 94 93 94.7 Women
## 95 94 95.6 Women
## 96 95 96.5 Women
## 97 96 97.4 Women
## 98 97 98.4 Women
## 99 98 99.3 Women
## 100 99 100.2 Women
## 101 100 101.1 Women
## 102 101 101.9 Women
## 103 102 102.7 Women
## 104 103 103.5 Women
## 105 104 104.1 Women
## 106 105 105.0 Women
## 107 106 NA Women
```

```
pelvis_fx_women = func_Skel_Age(sk.age, "Women", "Pelvis", 49)
```

#### (2.2.4) Pelvis fracture

```
## [1] 5.0 5.9 6.9 7.9 8.9 9.8 10.8 11.8 12.8 13.8 14.8 15.9
## [13] 16.9 17.9 18.8 19.8 20.8 21.8 22.8 23.7 24.7 25.8 26.8 27.8
## [25] 28.8 29.7 30.7 31.7 32.8 33.8 34.7 35.7 36.7 37.6 38.7 39.7
## [37] 40.7 41.6 42.6 43.7 44.6 45.6 46.5 47.6 48.5 49.5 50.5 51.5
## [49] 52.4 53.5 54.4 55.4 56.3 57.4 58.3 59.2 60.2 61.2 62.2 63.1
## [61] 64.1 65.0 66.0 66.9 67.8 68.9 69.8 70.7 71.7 72.6 73.5 74.5
## [73] 75.4 76.3 77.2 78.1 79.0 80.0 80.9 81.8 82.6 83.6 84.5 85.4
## [85] 86.3 87.2 88.1 89.0 89.9 90.8 91.7 92.6 93.6 94.4 95.3 96.3
## [97] 97.2 98.2 99.1 100.0 100.9 101.8 102.6 103.4 104.1 105.0 NA
```

```
names(pelvis_fx_women)[names(pelvis_fx_women) == "Skel.Age"] = "pelvis"
pelvis_fx_women = subset(pelvis_fx_women, select = c("age", "pelvis"))
pelvis_fx_women$gender = "Women"
pelvis_fx_women
```

```
## age pelvis gender
## 51 50 54.4 Women
## 52 51 55.4 Women
## 53 52 56.3 Women
## 54 53 57.4 Women
## 55 54 58.3 Women
## 56 55 59.2 Women
## 57 56 60.2 Women
## 58 57 61.2 Women
## 59 58 62.2 Women
## 60 59 63.1 Women
## 61 60 64.1 Women
## 62 61 65.0 Women
## 63 62 66.0 Women
## 64 63 66.9 Women
```

```
## 65 64 67.8 Women
## 66 65 68.9 Women
## 67 66 69.8 Women
## 68 67 70.7 Women
## 69 68 71.7 Women
## 70 69 72.6 Women
## 71 70 73.5 Women
## 72 71 74.5 Women
## 73 72 75.4 Women
## 74 73 76.3 Women
## 75 74 77.2 Women
## 76 75 78.1 Women
## 77 76 79.0 Women
## 78 77 80.0 Women
## 79 78 80.9 Women
## 80 79 81.8 Women
## 81 80 82.6 Women
## 82 81 83.6 Women
## 83 82 84.5 Women
## 84 83 85.4 Women
## 85 84 86.3 Women
## 86 85 87.2 Women
## 87 86 88.1 Women
## 88 87 89.0 Women
## 89 88 89.9 Women
## 90 89 90.8 Women
## 91 90 91.7 Women
## 92 91 92.6 Women
## 93 92 93.6 Women
## 94 93 94.4 Women
## 95 94 95.3 Women
## 96 95 96.3 Women
## 97 96 97.2 Women
## 98 97 98.2 Women
## 99 98 99.1 Women
## 100 99 100.0 Women
## 101 100 100.9 Women
## 102 101 101.8 Women
## 103 102 102.6 Women
## 104 103 103.4 Women
## 105 104 104.1 Women
## 106 105 105.0 Women
## 107 106 NA Women
```

```
vert_fx_women = func_Skel_Age(sk.age, "Women", "Vertebrae", 49)
```

### (2.2.5) Vertebral fracture

```
## [1] 5.0 5.9 6.9 7.9 8.9 9.8 10.8 11.8 12.8 13.8 14.8 15.9
## [13] 16.9 17.9 18.8 19.8 20.8 21.8 22.8 23.7 24.7 25.8 26.8 27.8
## [25] 28.8 29.7 30.7 31.7 32.8 33.8 34.7 35.7 36.7 37.6 38.7 39.7
```

```
## [37] 40.7 41.6 42.6 43.7 44.6 45.6 46.5 47.6 48.5 49.5 50.5 51.5
## [49] 52.4 53.5 54.4 55.4 56.3 57.4 58.3 59.2 60.2 61.2 62.2 63.1
## [61] 64.1 65.0 66.0 66.9 67.8 68.9 69.8 70.7 71.7 72.6 73.5 74.5
## [73] 75.4 76.3 77.2 78.1 79.0 80.0 80.9 81.8 82.6 83.6 84.5 85.4
## [85] 86.3 87.2 88.1 89.0 89.9 90.8 91.7 92.6 93.6 94.4 95.3 96.3
## [97] 97.2 98.2 99.1 100.0 100.9 101.8 102.6 103.4 104.1 105.0 NA
```

```
names(vert_fx_women)[names(vert_fx_women) == "Skel.Age"] = "vertebrae"
vert_fx_women = subset(vert_fx_women, select = c("age", "vertebrae"))
vert_fx_women$gender = "Women"
vert_fx_women
```

```
##      age vertebrae gender
## 51    50      54.4  Women
## 52    51      55.4  Women
## 53    52      56.3  Women
## 54    53      57.4  Women
## 55    54      58.3  Women
## 56    55      59.2  Women
## 57    56      60.2  Women
## 58    57      61.2  Women
## 59    58      62.2  Women
## 60    59      63.1  Women
## 61    60      64.1  Women
## 62    61      65.0  Women
## 63    62      66.0  Women
## 64    63      66.9  Women
## 65    64      67.8  Women
## 66    65      68.9  Women
## 67    66      69.8  Women
## 68    67      70.7  Women
## 69    68      71.7  Women
## 70    69      72.6  Women
## 71    70      73.5  Women
## 72    71      74.5  Women
## 73    72      75.4  Women
## 74    73      76.3  Women
## 75    74      77.2  Women
## 76    75      78.1  Women
## 77    76      79.0  Women
## 78    77      80.0  Women
## 79    78      80.9  Women
## 80    79      81.8  Women
## 81    80      82.6  Women
## 82    81      83.6  Women
## 83    82      84.5  Women
## 84    83      85.4  Women
## 85    84      86.3  Women
## 86    85      87.2  Women
## 87    86      88.1  Women
## 88    87      89.0  Women
## 89    88      89.9  Women
## 90    89      90.8  Women
## 91    90      91.7  Women
```

```
## 92 91 92.6 Women
## 93 92 93.6 Women
## 94 93 94.4 Women
## 95 94 95.3 Women
## 96 95 96.3 Women
## 97 96 97.2 Women
## 98 97 98.2 Women
## 99 98 99.1 Women
## 100 99 100.0 Women
## 101 100 100.9 Women
## 102 101 101.8 Women
## 103 102 102.6 Women
## 104 103 103.4 Women
## 105 104 104.1 Women
## 106 105 105.0 Women
## 107 106 NA Women
```

```
hum_fx_women = func_Skel_Age(sk.age, "Women", "Humerus", 49)
```

#### (2.2.6) Humerus fracture

```
## [1] 2.9 3.9 4.8 5.8 6.8 7.8 8.8 9.8 10.8 11.8 12.8 13.9
## [13] 14.9 15.9 16.8 17.8 18.8 19.8 20.8 21.8 22.8 23.8 24.8 25.8
## [25] 26.8 27.8 28.7 29.7 30.8 31.8 32.8 33.8 34.7 35.7 36.8 37.8
## [37] 38.7 39.7 40.7 41.8 42.7 43.7 44.7 45.7 46.7 47.6 48.6 49.7
## [49] 50.6 51.6 52.6 53.6 54.5 55.6 56.6 57.5 58.5 59.5 60.5 61.4
## [61] 62.4 63.4 64.4 65.3 66.3 67.3 68.2 69.2 70.2 71.1 72.1 73.1
## [73] 74.0 75.0 75.9 76.9 77.8 78.8 79.8 80.7 81.6 82.6 83.5 84.5
## [85] 85.4 86.4 87.3 88.2 89.2 90.1 91.0 92.0 93.0 93.9 94.8 95.8
## [97] 96.7 97.7 98.7 99.6 100.6 101.4 102.3 103.2 104.0 105.0 NA
```

```
names(hum_fx_women)[names(hum_fx_women) == "Skel.Age"] = "humerus"
hum_fx_women = subset(hum_fx_women, select = c("age", "humerus"))
hum_fx_women$gender = "Women"
hum_fx_women
```

```
## age humerus gender
## 51 50 52.6 Women
## 52 51 53.6 Women
## 53 52 54.5 Women
## 54 53 55.6 Women
## 55 54 56.6 Women
## 56 55 57.5 Women
## 57 56 58.5 Women
## 58 57 59.5 Women
## 59 58 60.5 Women
## 60 59 61.4 Women
## 61 60 62.4 Women
## 62 61 63.4 Women
## 63 62 64.4 Women
```

```
## 64 63 65.3 Women
## 65 64 66.3 Women
## 66 65 67.3 Women
## 67 66 68.2 Women
## 68 67 69.2 Women
## 69 68 70.2 Women
## 70 69 71.1 Women
## 71 70 72.1 Women
## 72 71 73.1 Women
## 73 72 74.0 Women
## 74 73 75.0 Women
## 75 74 75.9 Women
## 76 75 76.9 Women
## 77 76 77.8 Women
## 78 77 78.8 Women
## 79 78 79.8 Women
## 80 79 80.7 Women
## 81 80 81.6 Women
## 82 81 82.6 Women
## 83 82 83.5 Women
## 84 83 84.5 Women
## 85 84 85.4 Women
## 86 85 86.4 Women
## 87 86 87.3 Women
## 88 87 88.2 Women
## 89 88 89.2 Women
## 90 89 90.1 Women
## 91 90 91.0 Women
## 92 91 92.0 Women
## 93 92 93.0 Women
## 94 93 93.9 Women
## 95 94 94.8 Women
## 96 95 95.8 Women
## 97 96 96.7 Women
## 98 97 97.7 Women
## 99 98 98.7 Women
## 100 99 99.6 Women
## 101 100 100.6 Women
## 102 101 101.4 Women
## 103 102 102.3 Women
## 104 103 103.2 Women
## 105 104 104.0 Women
## 106 105 105.0 Women
## 107 106 NA Women
```

```
rib_fx_women = func_Skel_Age(sk.age, "Women", "Rib", 49)
```

### (2.2.7) Rib fracture

```
## [1] 3.1 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.1
## [13] 15.1 16.0 17.0 18.0 19.0 20.0 21.0 21.9 22.9 24.0 25.0 26.0
```

```
## [25] 27.0 28.0 28.9 29.9 31.0 32.0 33.0 33.9 34.9 35.9 37.0 38.0
## [37] 38.9 39.9 40.9 41.9 42.9 43.9 44.8 45.9 46.8 47.8 48.8 49.8
## [49] 50.8 51.8 52.7 53.8 54.7 55.7 56.8 57.7 58.7 59.7 60.7 61.6
## [61] 62.6 63.6 64.5 65.5 66.4 67.5 68.4 69.3 70.3 71.3 72.2 73.2
## [73] 74.2 75.1 76.0 77.0 77.9 79.0 79.9 80.8 81.7 82.7 83.6 84.5
## [85] 85.5 86.4 87.4 88.3 89.3 90.2 91.1 92.0 93.1 93.9 94.9 95.9
## [97] 96.8 97.8 98.7 99.7 100.6 101.5 102.3 103.2 104.0 105.0 NA
```

```
names(rib_fx_women)[names(rib_fx_women) == "Skel.Age"] = "rib"
rib_fx_women = subset(rib_fx_women, select = c("age", "rib"))
rib_fx_women$gender = "Women"
rib_fx_women
```

```
##      age  rib gender
## 51    50  52.7  Women
## 52    51  53.8  Women
## 53    52  54.7  Women
## 54    53  55.7  Women
## 55    54  56.8  Women
## 56    55  57.7  Women
## 57    56  58.7  Women
## 58    57  59.7  Women
## 59    58  60.7  Women
## 60    59  61.6  Women
## 61    60  62.6  Women
## 62    61  63.6  Women
## 63    62  64.5  Women
## 64    63  65.5  Women
## 65    64  66.4  Women
## 66    65  67.5  Women
## 67    66  68.4  Women
## 68    67  69.3  Women
## 69    68  70.3  Women
## 70    69  71.3  Women
## 71    70  72.2  Women
## 72    71  73.2  Women
## 73    72  74.2  Women
## 74    73  75.1  Women
## 75    74  76.0  Women
## 76    75  77.0  Women
## 77    76  77.9  Women
## 78    77  79.0  Women
## 79    78  79.9  Women
## 80    79  80.8  Women
## 81    80  81.7  Women
## 82    81  82.7  Women
## 83    82  83.6  Women
## 84    83  84.5  Women
## 85    84  85.5  Women
## 86    85  86.4  Women
## 87    86  87.4  Women
## 88    87  88.3  Women
## 89    88  89.3  Women
## 90    89  90.2  Women
```



```
## 91  90  91.1  Women
## 92  91  92.0  Women
## 93  92  93.1  Women
## 94  93  93.9  Women
## 95  94  94.9  Women
## 96  95  95.9  Women
## 97  96  96.8  Women
## 98  97  97.8  Women
## 99  98  98.7  Women
## 100 99  99.7  Women
## 101 100 100.6  Women
## 102 101 101.5  Women
## 103 102 102.3  Women
## 104 103 103.2  Women
## 105 104 104.0  Women
## 106 105 105.0  Women
## 107 106    NA  Women
```

```
clav_fx_women = func_Skel_Age(sk.age, "Women", "Clavicle", 49)
```

### (2.2.8) Clavicle fracture

```
## [1]  3.7  4.6  5.6  6.6  7.6  8.6  9.6 10.6 11.5 12.5 13.5 14.6
## [13] 15.6 16.6 17.6 18.6 19.5 20.5 21.5 22.5 23.5 24.6 25.5 26.5
## [25] 27.5 28.5 29.5 30.5 31.5 32.5 33.5 34.5 35.4 36.4 37.5 38.5
## [37] 39.5 40.4 41.4 42.5 43.4 44.4 45.4 46.4 47.4 48.3 49.3 50.3
## [49] 51.3 52.3 53.2 54.3 55.2 56.2 57.2 58.1 59.1 60.1 61.1 62.0
## [61] 63.0 64.0 65.0 65.9 66.9 67.9 68.8 69.7 70.7 71.7 72.6 73.6
## [73] 74.5 75.5 76.4 77.4 78.3 79.3 80.2 81.2 82.0 83.0 83.9 84.8
## [85] 85.7 86.7 87.6 88.5 89.5 90.4 91.3 92.2 93.2 94.1 95.0 96.0
## [97] 96.9 97.9 98.8 99.8 100.7 101.6 102.4 103.3 104.0 105.0    NA
```

```
names(clav_fx_women)[names(clav_fx_women) == "Skel.Age"] = "clavicle"
clav_fx_women = subset(clav_fx_women, select = c("age", "clavicle"))
clav_fx_women$gender = "Women"
clav_fx_women
```

```
##      age clavicle gender
## 51   50      53.2  Women
## 52   51      54.3  Women
## 53   52      55.2  Women
## 54   53      56.2  Women
## 55   54      57.2  Women
## 56   55      58.1  Women
## 57   56      59.1  Women
## 58   57      60.1  Women
## 59   58      61.1  Women
## 60   59      62.0  Women
## 61   60      63.0  Women
## 62   61      64.0  Women
```

```
## 63 62 65.0 Women
## 64 63 65.9 Women
## 65 64 66.9 Women
## 66 65 67.9 Women
## 67 66 68.8 Women
## 68 67 69.7 Women
## 69 68 70.7 Women
## 70 69 71.7 Women
## 71 70 72.6 Women
## 72 71 73.6 Women
## 73 72 74.5 Women
## 74 73 75.5 Women
## 75 74 76.4 Women
## 76 75 77.4 Women
## 77 76 78.3 Women
## 78 77 79.3 Women
## 79 78 80.2 Women
## 80 79 81.2 Women
## 81 80 82.0 Women
## 82 81 83.0 Women
## 83 82 83.9 Women
## 84 83 84.8 Women
## 85 84 85.7 Women
## 86 85 86.7 Women
## 87 86 87.6 Women
## 88 87 88.5 Women
## 89 88 89.5 Women
## 90 89 90.4 Women
## 91 90 91.3 Women
## 92 91 92.2 Women
## 93 92 93.2 Women
## 94 93 94.1 Women
## 95 94 95.0 Women
## 96 95 96.0 Women
## 97 96 96.9 Women
## 98 97 97.9 Women
## 99 98 98.8 Women
## 100 99 99.8 Women
## 101 100 100.7 Women
## 102 101 101.6 Women
## 103 102 102.4 Women
## 104 103 103.3 Women
## 105 104 104.0 Women
## 106 105 105.0 Women
## 107 106 NA Women
```

```
leg_fx_women = func_Skel_Age(sk.age, "Women", "Lower leg", 49)
```

### (2.2.9) Lower leg fracture

```
## [1] 2.3 3.3 4.2 5.2 6.2 7.2 8.2 9.2 10.2 11.2 12.2 13.3
```

```
## [13] 14.3 15.3 16.2 17.2 18.2 19.2 20.2 21.2 22.2 23.2 24.2 25.2
## [25] 26.2 27.2 28.2 29.2 30.2 31.2 32.2 33.2 34.2 35.1 36.2 37.2
## [37] 38.2 39.2 40.1 41.2 42.2 43.1 44.1 45.1 46.1 47.1 48.1 49.1
## [49] 50.1 51.1 52.0 53.1 54.0 55.0 56.1 57.0 58.0 59.0 60.0 60.9
## [61] 61.9 62.9 63.9 64.8 65.8 66.9 67.8 68.7 69.8 70.7 71.7 72.7
## [73] 73.6 74.6 75.5 76.5 77.5 78.5 79.4 80.4 81.3 82.3 83.2 84.2
## [85] 85.1 86.1 87.1 88.0 89.0 89.9 90.8 91.8 92.8 93.7 94.7 95.7
## [97] 96.6 97.6 98.5 99.5 100.4 101.3 102.2 103.2 104.0 105.0 NA
```

```
names(leg_fx_women)[names(leg_fx_women) == "Skel.Age"] = "lowerleg"
leg_fx_women = subset(leg_fx_women, select = c("age", "lowerleg"))
leg_fx_women$gender = "Women"
leg_fx_women
```

```
##      age lowerleg gender
## 51    50      52.0  Women
## 52    51      53.1  Women
## 53    52      54.0  Women
## 54    53      55.0  Women
## 55    54      56.1  Women
## 56    55      57.0  Women
## 57    56      58.0  Women
## 58    57      59.0  Women
## 59    58      60.0  Women
## 60    59      60.9  Women
## 61    60      61.9  Women
## 62    61      62.9  Women
## 63    62      63.9  Women
## 64    63      64.8  Women
## 65    64      65.8  Women
## 66    65      66.9  Women
## 67    66      67.8  Women
## 68    67      68.7  Women
## 69    68      69.8  Women
## 70    69      70.7  Women
## 71    70      71.7  Women
## 72    71      72.7  Women
## 73    72      73.6  Women
## 74    73      74.6  Women
## 75    74      75.5  Women
## 76    75      76.5  Women
## 77    76      77.5  Women
## 78    77      78.5  Women
## 79    78      79.4  Women
## 80    79      80.4  Women
## 81    80      81.3  Women
## 82    81      82.3  Women
## 83    82      83.2  Women
## 84    83      84.2  Women
## 85    84      85.1  Women
## 86    85      86.1  Women
## 87    86      87.1  Women
## 88    87      88.0  Women
## 89    88      89.0  Women
```

```
## 90 89 89.9 Women
## 91 90 90.8 Women
## 92 91 91.8 Women
## 93 92 92.8 Women
## 94 93 93.7 Women
## 95 94 94.7 Women
## 96 95 95.7 Women
## 97 96 96.6 Women
## 98 97 97.6 Women
## 99 98 98.5 Women
## 100 99 99.5 Women
## 101 100 100.4 Women
## 102 101 101.3 Women
## 103 102 102.2 Women
## 104 103 103.2 Women
## 105 104 104.0 Women
## 106 105 105.0 Women
## 107 106 NA Women
```

```
df_list = list(any_fx_women, hip_fx_women, femur_fx_women, pelvis_fx_women, vert_fx_women, hum_fx_women)
sa.women = Reduce(function(x,y) merge(x, y, all = FALSE), df_list)
head(sa.women)
```

#### Dataset - Skeletal age for high-risk fracture sites in women

```
## age gender fracture hip femur pelvis vertebrae humerus rib clavicle
## 1 100 Women 100.7 101.1 101.1 100.9 100.9 100.6 100.6 100.7
## 2 101 Women 101.6 101.9 101.9 101.8 101.8 101.4 101.5 101.6
## 3 102 Women 102.4 102.7 102.7 102.6 102.6 102.3 102.3 102.4
## 4 103 Women 103.3 103.5 103.5 103.4 103.4 103.2 103.2 103.3
## 5 104 Women 104.0 104.1 104.1 104.1 104.1 104.0 104.0 104.0
## 6 105 Women 105.0 105.0 105.0 105.0 105.0 105.0 105.0 105.0
## lowerleg
## 1 100.4
## 2 101.3
## 3 102.2
## 4 103.2
## 5 104.0
## 6 105.0
```

#### Supplementary File 2: Skeletal age by specific fracture site and chronological age at fracture

```
Fig.S2 = rbind(sa.men, sa.women)
Fig.S2
```

```
## age gender fracture hip femur pelvis vertebrae humerus rib clavicle
## 1 100 Men 100.9 101.4 101.3 101.2 101.1 101.1 100.7 100.8
```

## 2	101	Men	101.8	102.2	102.2	102.1	101.9	101.9	101.6	101.7
## 3	102	Men	102.5	102.9	102.8	102.7	102.6	102.6	102.3	102.4
## 4	103	Men	103.3	103.6	103.5	103.5	103.4	103.4	103.2	103.3
## 5	104	Men	104.2	104.3	104.3	104.3	104.2	104.2	104.1	104.1
## 6	105	Men	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0
## 7	106	Men	NA	NA	NA	NA	NA	NA	NA	NA
## 8	50	Men	54.2	56.8	56.3	55.7	54.9	55.0	52.8	53.6
## 9	51	Men	55.2	57.8	57.3	56.7	56.0	56.0	53.9	54.6
## 10	52	Men	56.2	58.8	58.3	57.7	56.9	57.0	54.9	55.6
## 11	53	Men	57.2	59.7	59.2	58.7	57.9	58.0	55.9	56.6
## 12	54	Men	58.1	60.6	60.1	59.6	58.8	58.9	56.8	57.5
## 13	55	Men	59.1	61.5	61.1	60.5	59.8	59.8	57.8	58.5
## 14	56	Men	60.0	62.5	62.0	61.5	60.8	60.8	58.8	59.5
## 15	57	Men	61.0	63.4	62.9	62.4	61.7	61.7	59.7	60.5
## 16	58	Men	61.9	64.3	63.9	63.3	62.6	62.7	60.7	61.4
## 17	59	Men	62.9	65.2	64.8	64.2	63.6	63.6	61.6	62.4
## 18	60	Men	63.8	66.1	65.7	65.2	64.5	64.5	62.6	63.3
## 19	61	Men	64.8	67.1	66.6	66.1	65.5	65.5	63.6	64.3
## 20	62	Men	65.7	67.9	67.5	67.0	66.4	66.4	64.6	65.2
## 21	63	Men	66.6	68.8	68.4	67.9	67.3	67.3	65.5	66.2
## 22	64	Men	67.6	69.7	69.4	68.9	68.2	68.3	66.5	67.1
## 23	65	Men	68.6	70.7	70.3	69.8	69.2	69.2	67.5	68.1
## 24	66	Men	69.5	71.5	71.1	70.7	70.1	70.1	68.4	69.0
## 25	67	Men	70.4	72.4	72.0	71.6	71.0	71.0	69.3	69.9
## 26	68	Men	71.4	73.3	73.0	72.5	72.0	72.0	70.3	71.0
## 27	69	Men	72.3	74.2	73.8	73.4	72.9	72.9	71.3	71.9
## 28	70	Men	73.2	75.0	74.7	74.3	73.7	73.8	72.2	72.8
## 29	71	Men	74.1	75.8	75.5	75.1	74.6	74.6	73.1	73.7
## 30	72	Men	75.1	76.8	76.5	76.1	75.6	75.6	74.1	74.7
## 31	73	Men	75.9	77.6	77.3	76.9	76.4	76.4	75.0	75.5
## 32	74	Men	76.9	78.5	78.2	77.8	77.3	77.4	76.0	76.5
## 33	75	Men	77.8	79.3	79.0	78.7	78.2	78.3	76.9	77.4
## 34	76	Men	78.7	80.2	80.0	79.6	79.2	79.2	77.9	78.4
## 35	77	Men	79.6	81.1	80.8	80.5	80.1	80.1	78.8	79.3
## 36	78	Men	80.5	81.9	81.6	81.3	80.9	81.0	79.8	80.2
## 37	79	Men	81.5	82.8	82.6	82.3	81.9	81.9	80.8	81.2
## 38	80	Men	82.3	83.6	83.3	83.1	82.7	82.7	81.6	82.0
## 39	81	Men	83.3	84.5	84.3	84.0	83.7	83.7	82.6	83.0
## 40	82	Men	84.2	85.3	85.1	84.9	84.5	84.6	83.6	83.9
## 41	83	Men	85.0	86.1	85.9	85.7	85.4	85.4	84.4	84.8
## 42	84	Men	86.0	87.0	86.8	86.6	86.3	86.3	85.4	85.7
## 43	85	Men	86.9	87.8	87.7	87.5	87.2	87.2	86.3	86.7
## 44	86	Men	87.8	88.7	88.6	88.4	88.1	88.1	87.3	87.6
## 45	87	Men	88.7	89.5	89.4	89.2	88.9	89.0	88.2	88.5
## 46	88	Men	89.6	90.4	90.3	90.1	89.9	89.9	89.1	89.4
## 47	89	Men	90.6	91.3	91.2	91.1	90.8	90.8	90.2	90.4
## 48	90	Men	91.5	92.2	92.1	92.0	91.7	91.8	91.1	91.4
## 49	91	Men	92.4	93.0	92.9	92.8	92.6	92.6	92.0	92.2
## 50	92	Men	93.4	94.0	93.9	93.8	93.6	93.6	93.0	93.2
## 51	93	Men	94.3	94.8	94.7	94.6	94.4	94.4	93.9	94.1
## 52	94	Men	95.2	95.7	95.7	95.5	95.4	95.4	94.9	95.1
## 53	95	Men	96.2	96.7	96.6	96.5	96.3	96.3	95.9	96.0
## 54	96	Men	97.1	97.6	97.5	97.4	97.3	97.3	96.8	97.0
## 55	97	Men	98.0	98.5	98.4	98.3	98.2	98.2	97.8	97.9

## 56	98	Men	99.0	99.4	99.4	99.3	99.1	99.1	98.7	98.9
## 57	99	Men	100.0	100.5	100.4	100.3	100.1	100.2	99.7	99.9
## 58	100	Women	100.7	101.1	101.1	100.9	100.9	100.6	100.6	100.7
## 59	101	Women	101.6	101.9	101.9	101.8	101.8	101.4	101.5	101.6
## 60	102	Women	102.4	102.7	102.7	102.6	102.6	102.3	102.3	102.4
## 61	103	Women	103.3	103.5	103.5	103.4	103.4	103.2	103.2	103.3
## 62	104	Women	104.0	104.1	104.1	104.1	104.1	104.0	104.0	104.0
## 63	105	Women	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0
## 64	106	Women	NA	NA	NA	NA	NA	NA	NA	NA
## 65	50	Women	53.3	55.3	55.3	54.4	54.4	52.6	52.7	53.2
## 66	51	Women	54.3	56.3	56.4	55.4	55.4	53.6	53.8	54.3
## 67	52	Women	55.3	57.2	57.3	56.3	56.3	54.5	54.7	55.2
## 68	53	Women	56.3	58.3	58.3	57.4	57.4	55.6	55.7	56.2
## 69	54	Women	57.3	59.2	59.3	58.3	58.3	56.6	56.8	57.2
## 70	55	Women	58.2	60.1	60.2	59.2	59.2	57.5	57.7	58.1
## 71	56	Women	59.2	61.1	61.1	60.2	60.2	58.5	58.7	59.1
## 72	57	Women	60.2	62.1	62.1	61.2	61.2	59.5	59.7	60.1
## 73	58	Women	61.2	63.1	63.1	62.2	62.2	60.5	60.7	61.1
## 74	59	Women	62.1	63.9	64.0	63.1	63.1	61.4	61.6	62.0
## 75	60	Women	63.1	64.9	64.9	64.1	64.1	62.4	62.6	63.0
## 76	61	Women	64.1	65.9	65.9	65.0	65.0	63.4	63.6	64.0
## 77	62	Women	65.0	66.8	66.8	66.0	66.0	64.4	64.5	65.0
## 78	63	Women	66.0	67.7	67.8	66.9	66.9	65.3	65.5	65.9
## 79	64	Women	66.9	68.6	68.7	67.8	67.8	66.3	66.4	66.9
## 80	65	Women	67.9	69.6	69.7	68.9	68.9	67.3	67.5	67.9
## 81	66	Women	68.9	70.5	70.6	69.8	69.8	68.2	68.4	68.8
## 82	67	Women	69.8	71.4	71.5	70.7	70.7	69.2	69.3	69.7
## 83	68	Women	70.8	72.4	72.4	71.7	71.7	70.2	70.3	70.7
## 84	69	Women	71.7	73.3	73.3	72.6	72.6	71.1	71.3	71.7
## 85	70	Women	72.7	74.2	74.2	73.5	73.5	72.1	72.2	72.6
## 86	71	Women	73.7	75.2	75.2	74.5	74.5	73.1	73.2	73.6
## 87	72	Women	74.6	76.1	76.1	75.4	75.4	74.0	74.2	74.5
## 88	73	Women	75.5	76.9	77.0	76.3	76.3	75.0	75.1	75.5
## 89	74	Women	76.4	77.8	77.8	77.2	77.2	75.9	76.0	76.4
## 90	75	Women	77.4	78.7	78.8	78.1	78.1	76.9	77.0	77.4
## 91	76	Women	78.3	79.6	79.6	79.0	79.0	77.8	77.9	78.3
## 92	77	Women	79.3	80.6	80.6	80.0	80.0	78.8	79.0	79.3
## 93	78	Women	80.3	81.5	81.5	80.9	80.9	79.8	79.9	80.2
## 94	79	Women	81.2	82.4	82.4	81.8	81.8	80.7	80.8	81.2
## 95	80	Women	82.0	83.1	83.2	82.6	82.6	81.6	81.7	82.0
## 96	81	Women	83.0	84.1	84.1	83.6	83.6	82.6	82.7	83.0
## 97	82	Women	83.9	84.9	85.0	84.5	84.5	83.5	83.6	83.9
## 98	83	Women	84.8	85.8	85.8	85.4	85.4	84.5	84.5	84.8
## 99	84	Women	85.7	86.7	86.7	86.3	86.3	85.4	85.5	85.7
## 100	85	Women	86.7	87.6	87.6	87.2	87.2	86.4	86.4	86.7
## 101	86	Women	87.7	88.5	88.5	88.1	88.1	87.3	87.4	87.6
## 102	87	Women	88.6	89.4	89.4	89.0	89.0	88.2	88.3	88.5
## 103	88	Women	89.5	90.2	90.3	89.9	89.9	89.2	89.3	89.5
## 104	89	Women	90.4	91.1	91.1	90.8	90.8	90.1	90.2	90.4
## 105	90	Women	91.3	92.0	92.0	91.7	91.7	91.0	91.1	91.3
## 106	91	Women	92.2	92.8	92.8	92.6	92.6	92.0	92.0	92.2
## 107	92	Women	93.2	93.8	93.8	93.6	93.6	93.0	93.1	93.2
## 108	93	Women	94.1	94.7	94.7	94.4	94.4	93.9	93.9	94.1
## 109	94	Women	95.1	95.6	95.6	95.3	95.3	94.8	94.9	95.0

##	110	95	Women	96.0	96.5	96.5	96.3	96.3	95.8	95.9	96.0
##	111	96	Women	96.9	97.4	97.4	97.2	97.2	96.7	96.8	96.9
##	112	97	Women	97.9	98.4	98.4	98.2	98.2	97.7	97.8	97.9
##	113	98	Women	98.8	99.3	99.3	99.1	99.1	98.7	98.7	98.8
##	114	99	Women	99.8	100.2	100.2	100.0	100.0	99.6	99.7	99.8
##			lowerleg								
##	1			100.6							
##	2			101.5							
##	3			102.3							
##	4			103.2							
##	5			104.1							
##	6			105.0							
##	7			NA							
##	8			52.7							
##	9			53.7							
##	10			54.7							
##	11			55.7							
##	12			56.6							
##	13			57.6							
##	14			58.6							
##	15			59.6							
##	16			60.5							
##	17			61.5							
##	18			62.4							
##	19			63.5							
##	20			64.4							
##	21			65.3							
##	22			66.3							
##	23			67.3							
##	24			68.2							
##	25			69.2							
##	26			70.2							
##	27			71.1							
##	28			72.1							
##	29			73.0							
##	30			74.0							
##	31			74.9							
##	32			75.9							
##	33			76.8							
##	34			77.8							
##	35			78.7							
##	36			79.7							
##	37			80.6							
##	38			81.5							
##	39			82.5							
##	40			83.5							
##	41			84.3							
##	42			85.3							
##	43			86.3							
##	44			87.2							
##	45			88.1							
##	46			89.1							
##	47			90.1							
##	48			91.0							

## 49	91.9
## 50	93.0
## 51	93.8
## 52	94.8
## 53	95.8
## 54	96.8
## 55	97.7
## 56	98.6
## 57	99.7
## 58	100.4
## 59	101.3
## 60	102.2
## 61	103.2
## 62	104.0
## 63	105.0
## 64	NA
## 65	52.0
## 66	53.1
## 67	54.0
## 68	55.0
## 69	56.1
## 70	57.0
## 71	58.0
## 72	59.0
## 73	60.0
## 74	60.9
## 75	61.9
## 76	62.9
## 77	63.9
## 78	64.8
## 79	65.8
## 80	66.9
## 81	67.8
## 82	68.7
## 83	69.8
## 84	70.7
## 85	71.7
## 86	72.7
## 87	73.6
## 88	74.6
## 89	75.5
## 90	76.5
## 91	77.5
## 92	78.5
## 93	79.4
## 94	80.4
## 95	81.3
## 96	82.3
## 97	83.2
## 98	84.2
## 99	85.1
## 100	86.1
## 101	87.1
## 102	88.0



```
## 103      89.0
## 104      89.9
## 105      90.8
## 106      91.8
## 107      92.8
## 108      93.7
## 109      94.7
## 110      95.7
## 111      96.6
## 112      97.6
## 113      98.5
## 114      99.5
```

```
write.csv(Fig.S2, "C:\\Garvan\\Skeletal age\\Analysis\\Skeletal_age_both.csv", row.names = FALSE)
```

### (2.3) Figure 3 to present skeletal age for high-risk fracture sites graphically

#### Plotting data

```
# Any fracture
any_fx = rbind(any_fx_men, any_fx_women)

p1 = ggplot(data = any_fx, aes(x = age, y = fracture, color = gender)) + geom_line() + geom_abline(intercept = 0, slope = 1)

## Warning: Using 'size' aesthetic for lines was deprecated in ggplot2 3.4.0.
## i Please use 'linewidth' instead.

# Hip fracture
hip_fx = rbind(hip_fx_men, hip_fx_women)

p2 = ggplot(data = hip_fx, aes(x = age, y = hip, color = gender)) + geom_line() + geom_abline(intercept = 0, slope = 1)

# Femur fracture
femur_fx = rbind(femur_fx_men, femur_fx_women)

p3 = ggplot(data = femur_fx, aes(x = age, y = femur, color = gender)) + geom_line() + geom_abline(intercept = 0, slope = 1)

# Pelvis fracture
pelvis_fx = rbind(pelvis_fx_men, pelvis_fx_women)

p4 = ggplot(data = pelvis_fx, aes(x = age, y = pelvis, color = gender)) + geom_line() + geom_abline(intercept = 0, slope = 1)

# Vertebral fracture
vert_fx = rbind(vert_fx_men, vert_fx_women)

p5 = ggplot(data = vert_fx, aes(x = age, y = vertebrae, color = gender)) + geom_line() + geom_abline(intercept = 0, slope = 1)

# Humerus fracture
hum_fx = rbind(hum_fx_men, hum_fx_women)

p6 = ggplot(data = hum_fx, aes(x = age, y = humerus, color = gender)) + geom_line() + geom_abline(intercept = 0, slope = 1)
```

```

# Rib fracture
rib_fx = rbind(rib_fx_men, rib_fx_women)

p7 = ggplot(data = rib_fx, aes(x = age, y = rib, color = gender)) + geom_line() + geom_abline(intercept

# Clavicle fracture
clav_fx = rbind(clav_fx_men, clav_fx_women)

p8 = ggplot(data = clav_fx, aes(x = age, y = clavicle, color = gender)) + geom_line() + geom_abline(inte

# Lower leg fracture
leg_fx = rbind(leg_fx_men, leg_fx_women)

p9 = ggplot(data = leg_fx, aes(x = age, y = lowerleg, color = gender)) + geom_line() + geom_abline(inte

grid.arrange(p1, p2, p3, p4, p5, p6, p7, p8, p9, nrow=3)

## Warning: Removed 2 rows containing missing values ('geom_line()').

## Warning: Removed 2 rows containing missing values ('geom_line()').
## Removed 2 rows containing missing values ('geom_line()').
## Removed 2 rows containing missing values ('geom_line()').
## Removed 2 rows containing missing values ('geom_line()').
## Removed 2 rows containing missing values ('geom_line()').
## Removed 2 rows containing missing values ('geom_line()').
## Removed 2 rows containing missing values ('geom_line()').

```

