Chapter 4 Demographic Arrays

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Setup

```
library(bdefdata)
library(dembase)
library(dplyr)
```

Population Counts

The raw data:

```
popn <- bdefdata::twelve_population
popn
```

```
##        name time age region
## 1      Anna 1980  10   East
## 2     Bella 1980  20   West
## 3     Cindy 1980  32   West
## 4      Doha 1980  33   West
## 5      Emma 1980  35   West
## 6    Fatima 1980  72   East
## 7    Isabel 2010   4   East
## 8  Kristina 2010  12   East
## 9      Jana 2010  29   West
## 10     Anna 2010  40   East
## 11    Bella 2010  50   West
## 12      Lan 2010  57   West
## 13    Cindy 2010  62   East
## 14     Doha 2010  63   West
```

Convert exact ages to age groups, and drop names:

```
popn <- popn %>%
  mutate(age = ageToAgeGroup(age, breaks = c(0, 30))) %>%
  select(-name)
popn
```

```
##    time  age region
## 1  1980 0-29   East
## 2  1980 0-29   West
## 3  1980  30+   West
## 4  1980  30+   West
## 5  1980  30+   West
## 6  1980  30+   East
## 7  2010 0-29   East
## 8  2010 0-29   East
## 9  2010 0-29   West
```

```
## 10 2010  30+   East
## 11 2010  30+   West
## 12 2010  30+   West
## 13 2010  30+   East
## 14 2010  30+   West
```

Cross-tabulate:

```
popn <- popn %>%
  xtabs(~ age + region + time, data = .) %>%
  Counts()
popn
```

```
## An object of class "Counts"
##
## name:     age       region     time
## length:   2         2          2
## dimtype:  age       state      time
## dimscale: Intervals Categories Points
## first:    0-29      West       1980
## last:     30+       East       2010
##
## , , time = 1980
##
##       region
## age    West East
##   0-29    1    1
##   30+     3    1
##
## , , time = 2010
##
##       region
## age    West East
##   0-29    1    2
##   30+     3    2
```

Death Counts

The raw data:

```
deaths <- bdefdata::twelve_deaths
deaths
```

```
##     name time age region
## 1  Grace 1995   9   East
## 2 Fatima 1997  89   West
```

Convert exact years to periods, convert exact ages to age groups, and drop names:

```
deaths <- deaths %>%
  mutate(time = timeToPeriod(time, breaks = c(1980, 2010)),
         age = ageToAgeGroup(age, breaks = c(0, 30))) %>%
  select(-name)
deaths
```

```
##        time  age region
```

```
## 1 1981-2010 0-29   East
## 2 1981-2010  30+   West
```

Cross-tabulate:

```
deaths <- deaths %>%
  xtabs(~ age + region + time, data = .) %>%
  Counts()
deaths
```

```
## An object of class "Counts"
##
## name:     age       region     time
## length:   2         2          1
## dimtype:  age       state      time
## dimscale: Intervals Categories Intervals
## first:    0-29      West       1981-2010
## last:     30+       East       1981-2010
##
## , , time = 1981-2010
##
##       region
## age    West East
##   0-29    0    1
##   30+     1    0
```

Movements

The raw data:

```
movements <- bdefdata::twelve_movements
movements
```

```
##     name time age region_orig region_dest
## 1 Fatima 1988  80        East        West
## 2  Grace 1992   6        West        East
## 3  Cindy 1992  44        West        East
## 4   Anna 1998  28        East        West
## 5   Hong 2002   3        West        East
## 6   Anna 2003  33        West        East
## 7   Emma 2003  58        West        East
## 8   Hong 2005   6        East        West
```

Convert exact years to periods, convert exact ages to age groups, and drop names:

```
movements <- movements %>%
  mutate(time = timeToPeriod(time, breaks = c(1980, 2010)),
         age = ageToAgeGroup(age, breaks = c(0, 30))) %>%
  select(-name)
movements
```

```
##        time  age region_orig region_dest
## 1 1981-2010  30+        East        West
## 2 1981-2010 0-29        West        East
## 3 1981-2010  30+        West        East
## 4 1981-2010 0-29        East        West
```

```
## 5 1981-2010 0-29        West        East
## 6 1981-2010  30+        West        East
## 7 1981-2010  30+        West        East
## 8 1981-2010 0-29        East        West
```

Cross-tabulate:

```
movements <- movements %>%
  xtabs(~ region_orig + region_dest + age + time, data = .) %>%
  Counts()
movements
```

```
## An object of class "Counts"
##
## name:     region_orig region_dest age       time
## length:   2           2           2         1
## dimtype:  origin      destination age       time
## dimscale: Categories  Categories  Intervals Intervals
## first:    West        West        0-29      1981-2010
## last:     East        East        30+       1981-2010
##
## , , age = 0-29, time = 1981-2010
##
##            region_dest
## region_orig West East
##        West    0    2
##        East    2    0
##
## , , age = 30+, time = 1981-2010
##
##            region_dest
## region_orig West East
##        West    0    3
##        East    1    0
```

Alternative representations of changing statuses

```
movements %>%
  collapseOrigDest(to = "pool") %>%
  aperm(c("region", "direction", "age", "time"))
```

```
## An object of class "Pool"
##
## name:     region     direction  age       time
## length:   2          2          2         1
## dimtype:  state      state      age       time
## dimscale: Categories Categories Intervals Intervals
## first:    West       Out        0-29      1981-2010
## last:     East       In         30+       1981-2010
##
## , , age = 0-29, time = 1981-2010
##
##       direction
## region Out In
```

```
##   West   2  2
##   East   2  2
##
## , , age = 30+, time = 1981-2010
##
##       direction
## region Out In
##   West   3  1
##   East   1  3
```

```
movements %>%
  collapseOrigDest(to = "net")
```

```
## An object of class "Net"
##
## name:     region     age       time
## length:   2          2         1
## dimtype:  state      age       time
## dimscale: Categories Intervals Intervals
## first:    West       0-29      1981-2010
## last:     East       30+       1981-2010
##
## , , time = 1981-2010
##
##       age
## region 0-29 30+
##   West    0  -2
##   East    0   2
```

```
popn1980 <- twelve_population %>%
  filter(time == 1980) %>%
  select(name, origin = region)
popn2010 <- twelve_population %>%
  filter(time == 2010) %>%
  select(name, destination = region)
popn1980
```

```
##     name origin
## 1   Anna   East
## 2  Bella   West
## 3  Cindy   West
## 4   Doha   West
## 5   Emma   West
## 6 Fatima   East
```

```
popn2010
```

```
##       name destination
## 1   Isabel        East
## 2 Kristina        East
## 3     Jana        West
## 4     Anna        East
## 5    Bella        West
## 6      Lan        West
## 7    Cindy        East
## 8     Doha        West
```

```
transitions <- inner_join(popn1980, popn2010, by = "name")
transitions
```

```
##    name origin destination
## 1  Anna   East        East
## 2 Bella   West        West
## 3 Cindy   West        East
## 4  Doha   West        West
```

```
transitions <- transitions %>%
  mutate(period = "1980-2000") %>%
  select(period, origin, destination)
transitions
```

```
##      period origin destination
## 1 1980-2000   East        East
## 2 1980-2000   West        West
## 3 1980-2000   West        East
## 4 1980-2000   West        West
```

```
transitions <- transitions %>%
  xtabs(~ origin + destination + period, data = .) %>%
  Counts()
transitions
```

```
## An object of class "Counts"
##
## name:     origin     destination period
## length:   2          2           1
## dimtype:  state      state       time
## dimscale: Categories Categories  Intervals
## first:    West       West        1980-2000
## last:     East       East        1980-2000
##
## , , period = 1980-2000
##
##       destination
## origin West East
##   West    2    1
##   East    0    1
```

Non-Demographic Events

The raw data:

```
taxes <- bdefdata::twelve_taxes
taxes
```

```
##    name time age region amount
## 1 Bella 1998  28   West     50
## 2 Cindy 2002  54   East     80
## 3  Emma 1986  41   West     90
## 4  Emma 1995  50   West     60
```

Convert years to periods, convert ages to age groups, and drop names:

```
taxes <- taxes %>%
  mutate(time = timeToPeriod(time, breaks = c(1980, 2010)),
         age = ageToAgeGroup(age, breaks = c(0, 30))) %>%
  select(-name)
taxes
```

```
##        time  age region amount
## 1 1981-2010 0-29   West     50
## 2 1981-2010  30+   East     80
## 3 1981-2010  30+   West     90
## 4 1981-2010  30+   West     60
```

Cross-tabulate:

```
taxes <- taxes %>%
  xtabs(amount ~ age + region + time, data = .) %>%
  Counts()
taxes
```

```
## An object of class "Counts"
##
## name:     age       region     time
## length:   2         2          1
## dimtype:  age       state      time
## dimscale: Intervals Categories Intervals
## first:    0-29      West       1981-2010
## last:     30+       East       1981-2010
##
## , , time = 1981-2010
##
##       region
## age    West East
##   0-29   50    0
##   30+   150   80
```

Exposure

Approximate only

```
exposure <- exposure(popn)
exposure
```

```
## An object of class "Counts"
##
## name:     age       region     time
## length:   2         2          1
## dimtype:  age       state      time
## dimscale: Intervals Categories Intervals
## first:    0-29      West       1981-2010
## last:     30+       East       1981-2010
##
## , , time = 1981-2010
##
##       region
```

```
## age    West East
##   0-29   30   45
##   30+    90   45
```

Age, Period, and Cohort

```
immigration <- bdefdata::twelve_immigration
immigration
```

```
##       name time age region
## 1     Jana 1990   9   West
## 2 Kristina 2000   2   East
## 3     Doha 2002  55   West
## 4      Lan 2005  52   West
```

Rates, Proportions, Means, and Ratios

Birth Rates

```
births <- bdefdata::twelve_births %>%
  mutate(age = ageToAgeGroup(age, breaks = c(0, 30))) %>%
  mutate(time = timeToPeriod(time, breaks = c(1980, 2010))) %>%
  xtabs(~ age + region + time, data = .) %>%
  Counts()
births
```

```
## An object of class "Counts"
##
## name:     age       region     time
## length:   2         2          1
## dimtype:  age       state      time
## dimscale: Intervals Categories Intervals
## first:    0-29      West       1981-2010
## last:     30+       East       1981-2010
##
## , , time = 1981-2010
##
##       region
## age    West East
##   0-29    1    0
##   30+     1    1
```

```
birth_rates <- (births / exposure) %>%
  round(3)
birth_rates
```

```
## An object of class "Values"
##
## name:     age       region     time
## length:   2         2          1
## dimtype:  age       state      time
```

```
## dimscale: Intervals Categories Intervals
## first:    0-29      West       1981-2010
## last:     30+       East       1981-2010
##
## , , time = 1981-2010
##
##       region
## age     West  East
##   0-29 0.033 0.000
##   30+  0.011 0.022
```

Proportion in West Region

```
propn <- popn %>%
  collapseDimension(dimension = "age") %>%
  prop.table(margin = "time") %>%
  subarray(region == "West") %>%
  round(3)
propn
```

```
##  1980  2010
## 0.667 0.500
```

Mean Tax Payments

```
exposure_exact <- Counts(array(c(44, 83, 38, 38),
                               dim = c(2, 2, 1),
                               dimnames = list(age = c("0-29", "30+"),
                                               region = c("West", "East"),
                                               time = "1981-2010")))
mean_payments <- (taxes / exposure_exact)
round(mean_payments, 2)
```

```
## An object of class "Values"
##
## name:     age       region     time
## length:   2         2          1
## dimtype:  age       state      time
## dimscale: Intervals Categories Intervals
## first:    0-29      West       1981-2010
## last:     30+       East       1981-2010
##
## , , time = 1981-2010
##
##       region
## age    West East
##   0-29 1.14 0.00
##   30+  1.81 2.11
```

Ratio of Immigrations to Emigrations

```
immigrations <- bdefdata::twelve_immigration %>%
  mutate(age = ageToAgeGroup(age, breaks = c(0, 30)),
         time = timeToPeriod(time, breaks = c(1980, 2010))) %>%
  xtabs(~ age + region + time, data = .) %>%
  Counts()
immigrations
```

```
## An object of class "Counts"
##
## name:     age       region     time
## length:   2         2          1
## dimtype:  age       state      time
## dimscale: Intervals Categories Intervals
## first:    0-29      West       1981-2010
## last:     30+       East       1981-2010
##
## , , time = 1981-2010
##
##       region
## age    West East
##   0-29    1    1
##   30+     2    0
```

```
emigrations <- bdefdata::twelve_emigration %>%
  mutate(age = ageToAgeGroup(age, breaks = c(0, 30)),
         time = timeToPeriod(time, breaks = c(1980, 2010))) %>%
  xtabs(~ age + region + time, data = .) %>%
  Counts()
emigrations
```

```
## An object of class "Counts"
##
## name:     age       region     time
## length:   2         2          1
## dimtype:  age       state      time
## dimscale: Intervals Categories Intervals
## first:    0-29      West       1981-2010
## last:     30+       East       1981-2010
##
## , , time = 1981-2010
##
##       region
## age    West East
##   0-29    1    0
##   30+     1    1
```

```
immigrations / emigrations
```

```
## An object of class "Values"
##
## name:     age       region     time
## length:   2         2          1
## dimtype:  age       state      time
```

```
## dimscale: Intervals Categories Intervals
## first:    0-29      West       1981-2010
## last:     30+       East       1981-2010
##
## , , time = 1981-2010
##
##       region
## age    West East
##   0-29    1  Inf
##   30+     2    0
```

Collapsing Dimensions

Population Counts

```
popn80 <- bdefdata::twelve_population %>%
  filter(time == "1980") %>%
  mutate(age = ageToAgeGroup(age, breaks = c(0, 30))) %>%
  select(name, age, region)
popn80
```

```
##     name  age region
## 1   Anna 0-29   East
## 2  Bella 0-29   West
## 3  Cindy  30+   West
## 4   Doha  30+   West
## 5   Emma  30+   West
## 6 Fatima  30+   East
```

```
popn80 <- popn80 %>%
  xtabs(~ age + region, data = .) %>%
  Counts()
popn80
```

```
## An object of class "Counts"
##
## name:     age       region
## length:   2         2
## dimtype:  age       state
## dimscale: Intervals Categories
## first:    0-29      West
## last:     30+       East
##
##       region
## age    West East
##   0-29    1    1
##   30+     3    1
```

```
collapseDimension(popn80, dimension = "region")
```

```
## An object of class "Counts"
##
## name:     age
```

```
## length:   2
## dimtype:  age
## dimscale: Intervals
## first:    0-29
## last:     30+
##
## age
## 0-29  30+
##    2    4
```

Taxes

```
round(mean_payments, 2)
```

```
## An object of class "Values"
##
## name:     age       region     time
## length:   2         2          1
## dimtype:  age       state      time
## dimscale: Intervals Categories Intervals
## first:    0-29      West       1981-2010
## last:     30+       East       1981-2010
##
## , , time = 1981-2010
##
##       region
## age    West East
##   0-29 1.14 0.00
##   30+  1.81 2.11
```

```
exposure_exact
```

```
## An object of class "Counts"
##
## name:     age       region     time
## length:   2         2          1
## dimtype:  age       state      time
## dimscale: Intervals Categories Intervals
## first:    0-29      West       1981-2010
## last:     30+       East       1981-2010
##
## , , time = 1981-2010
##
##       region
## age    West East
##   0-29   44   38
##   30+    83   38
```

```
total_taxes <- mean_payments * exposure_exact
total_taxes
```

```
## An object of class "Counts"
##
## name:     age       region     time
## length:   2         2          1
```

```
## dimtype:  age       state      time
## dimscale: Intervals Categories Intervals
## first:    0-29      West       1981-2010
## last:     30+       East       1981-2010
##
## , , time = 1981-2010
##
##       region
## age    West East
##   0-29   50    0
##   30+   150   80
```

```
total_taxes_no_age <- collapseDimension(total_taxes, dimension = "age")
total_taxes_no_age
```

```
## An object of class "Counts"
##
## name:     region     time
## length:   2          1
## dimtype:  state      time
## dimscale: Categories Intervals
## first:    West       1981-2010
## last:     East       1981-2010
##
##       time
## region 1981-2010
##   West       200
##   East        80
```

```
exposure_no_age <- collapseDimension(exposure_exact, dimension = "age")
exposure_no_age
```

```
## An object of class "Counts"
##
## name:     region     time
## length:   2          1
## dimtype:  state      time
## dimscale: Categories Intervals
## first:    West       1981-2010
## last:     East       1981-2010
##
##       time
## region 1981-2010
##   West       127
##   East        76
```

```
(total_taxes_no_age / exposure_no_age) %>%
  round(2)
```

```
## An object of class "Values"
##
## name:     region     time
## length:   2          1
## dimtype:  state      time
## dimscale: Categories Intervals
## first:    West       1981-2010
```

```
## last:     East       1981-2010
##
##       time
## region 1981-2010
##   West      1.57
##   East      1.05
```

```
collapseDimension(mean_payments,
                  dimension = "age",
                  weights = exposure_exact) %>%
  round(2)
```

```
## An object of class "Values"
##
## name:     region     time
## length:   2          1
## dimtype:  state      time
## dimscale: Categories Intervals
## first:    West       1981-2010
## last:     East       1981-2010
##
##       time
## region 1981-2010
##   West      1.57
##   East      1.05
```