DATA PRIVACY AND ANONYMIZATION IN R

Introduction to Anonymization (I)

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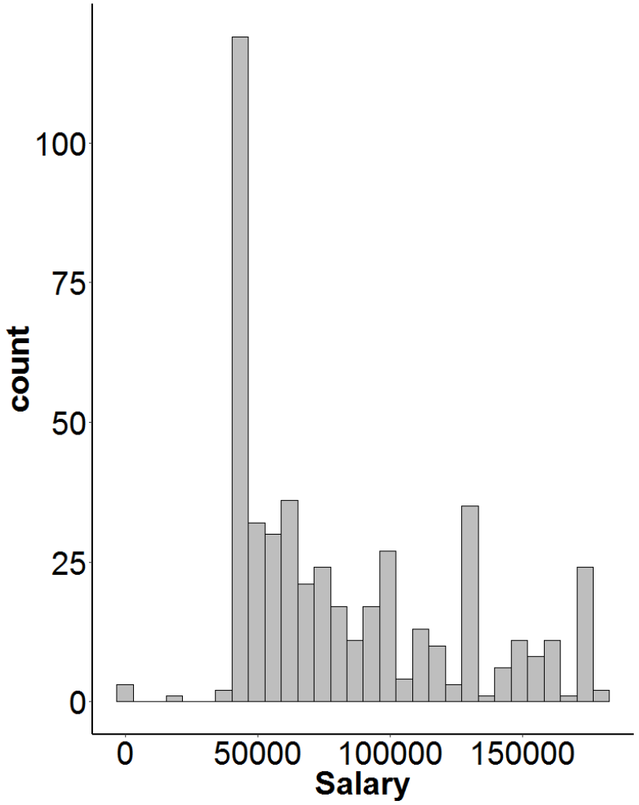
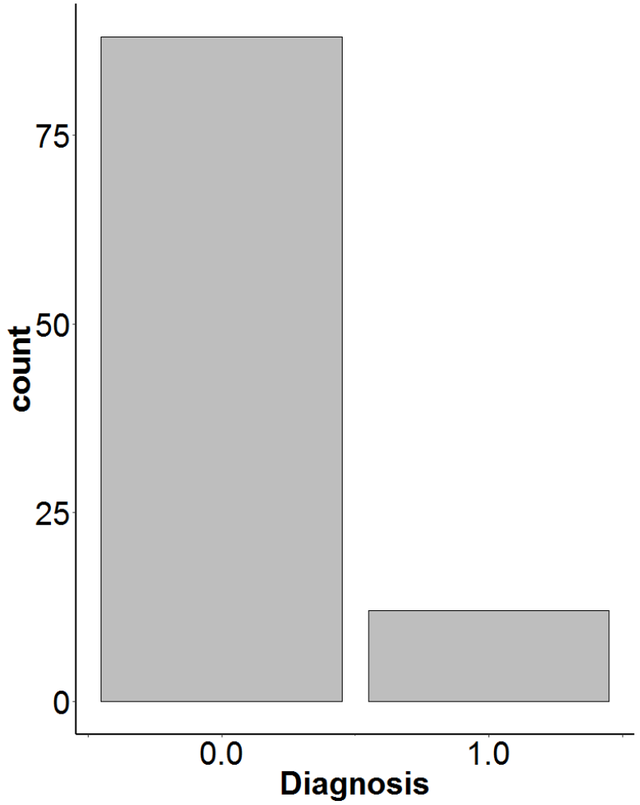
MEDICAL
MEDICAL
MEDICAL
MEDICAL
MEDICAL
MEDICAL
Health Care
Doctor
Hospital
Pharmacist
Nurse
Dentist
First Aid
Surgeon
Emergency

Course Outline

- **Chapter 1:** removing identifiers and generating synthetic data
- **Chapter 2:** differential privacy and Laplace mechanism
- **Chapter 3:** differentially private properties
- **Chapter 4:** differentially private data synthesis

White House Salary and Fertility data sets





The White House Salary data

```
> library(dplyr)

> whitehouse

# A tibble: 469 x 5
                   Name   Status Salary     Basis
                  <chr>    <chr>  <dbl>     <chr>
 1      Abrams, Adam W. Employee  66300 Per Annum
 2        Adams, Ian H. Employee  45000 Per Annum
 3      Agnew, David P. Employee  93840 Per Annum
 4        Albino, James Employee  91800 Per Annum
 5 Aldy, Jr., Joseph E. Employee 130500 Per Annum
 6     Alley, Hilary J. Employee  42000 Per Annum
 7 Amorsingh, Lucius L. Employee  56092 Per Annum
 8  Anderson, Amanda D. Employee  60000 Per Annum
 9 Anderson, Charles D. Employee  51000 Per Annum
10     Andrias, Kate E. Employee 130500 Per Annum
# ... with 459 more rows, and 1 more variables: Title <chr>
```

Removing Identifiers and Rounding

Removing Identifiers

```
> whitehouse %>%
    mutate(Name = 1:469)
```

Rounding

```
> whitehouse %>%
    mutate(Salary = round(Salary, digits = -3))
```

DATA PRIVACY AND ANONYMIZATION IN R

Let's practice!

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The White House Salary data

```
> whitehouse
# A tibble: 469 x 5
                    Name   Status Salary     Basis
                   <chr>    <chr>  <dbl>     <chr>
 1      Abrams, Adam W. Employee  66300 Per Annum
 2        Adams, Ian H. Employee  45000 Per Annum
 3      Agnew, David P. Employee  93840 Per Annum
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 8  Anderson, Amanda D. Employee  60000 Per Annum
 9 Anderson, Charles D. Employee  51000 Per Annum
10     Andrias, Kate E. Employee 130500 Per Annum
# ... with 459 more rows, and 1 more variables: Title <chr>
```
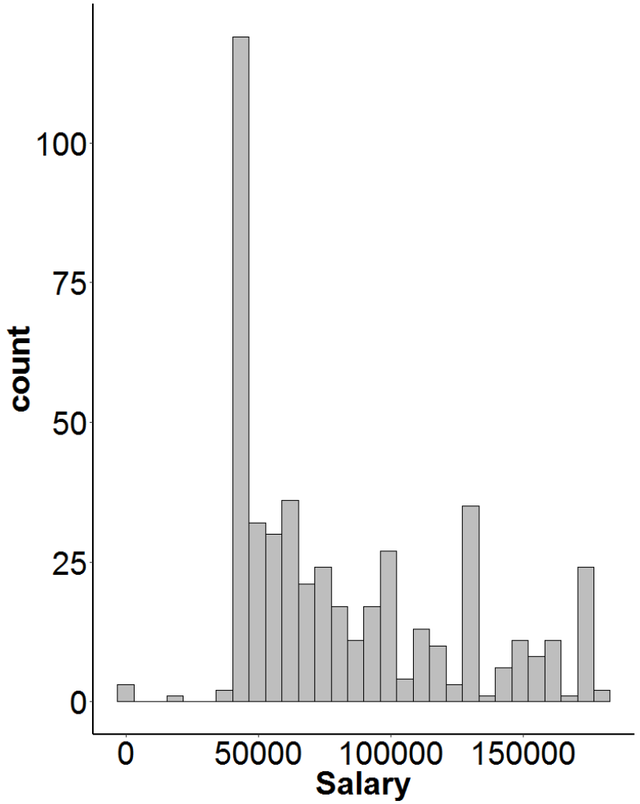

Histogram of Salaries



Generalization

```
> whitehouse.gen <- whitehouse %>%
    mutate(Salary = ifelse(Salary < 100000, 0, 1))

> whitehouse.gen
# A tibble: 469 x 5
                   Name   Status Salary     Basis
                  <chr>    <chr>  <dbl>     <chr>
 1      Abrams, Adam W. Employee      0 Per Annum
 2        Adams, Ian H. Employee      0 Per Annum
 3      Agnew, David P. Employee      0 Per Annum
 4        Albino, James Employee      0 Per Annum
 5 Aldy, Jr., Joseph E. Employee      1 Per Annum
 6     Alley, Hilary J. Employee      0 Per Annum
 7 Amorsingh, Lucius L. Employee      0 Per Annum
 8  Anderson, Amanda D. Employee      0 Per Annum
 9 Anderson, Charles D. Employee      0 Per Annum
10     Andrias, Kate E. Employee      1 Per Annum
# ... with 459 more rows, and 1 more variables: Title <chr>
```

Top Coding

```
whitehouse.top <- whitehouse %>%
    mutate(Salary = ifelse(Salary >= 165000, 165000, Salary))

> whitehouse.top %>%
    filter(Salary >= 165000)
# A tibble: 27 x 5
                   Name   Status Salary     Basis
                  <chr>    <chr>  <dbl>     <chr>
 1    Axelrod, David M. Employee 165000 Per Annum
 2    Barnes, Melody C. Employee 165000 Per Annum
 3     Bauer, Robert F. Employee 165000 Per Annum
 4     Brennan, John O. Employee 165000 Per Annum
 5  Brown, Elizabeth M. Employee 165000 Per Annum
 6    Browner, Carol M. Employee 165000 Per Annum
 7    Cutter, Stephanie Employee 165000 Per Annum
 8   Donilon, Thomas E. Employee 165000 Per Annum
 9     Emanuel, Rahm I. Employee 165000 Per Annum
10 Favreau, Jonathan E. Employee 165000 Per Annum
# ... with 17 more rows, and 1 more variables: Title <chr>
```

Quick intro to ...

- `count()`
- `summarise_at()`

count()

```
> whitehouse %>%
+     count(Status)
# A tibble: 3 x 2
  Status                    n
  <chr>                 <int>
1 Detailee                 31
2 Employee                437
3 Employee (part-time)      1
```

count()

```
> whitehouse %>%
+     count(Status, Title, sort = TRUE)
# A tibble: 279 x 3
   Status   Title                                              n
   <chr>    <chr>                                          <int>
 1 Employee STAFF ASSISTANT                                   23
 2 Employee RECORDS MANAGEMENT ANALYST                        15
 3 Employee ANALYST                                           10
 4 Employee SPECIAL ASSISTANT TO THE PRESIDENT AND ASSO…      10
 5 Employee SPECIAL ASSISTANT TO THE PRESIDENT FOR LEGI…      10
 6 Employee ASSOCIATE DIRECTOR                                 9
 7 Employee SENIOR ANALYST                                     8
 8 Employee ASSISTANT DIRECTOR                                 7
 9 Employee SPECIAL ASSISTANT                                  7
10 Employee ASSISTANT SHIFT LEADER                             6
# ... with 269 more rows
```

summarise_at()

```
> whitehouse %>%
    summarise_at(vars(Salary), sum)
# A tibble: 1 x 1
    Salary
     <dbl>
1 38796307
```

summarise_at()

```
> whitehouse %>%
    summarise_at(vars(Salary), funs(mean, sd))
# A tibble: 1 x 2
      mean       sd
     <dbl>    <dbl>
1 82721.34 41589.43
```

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Data Synthesis

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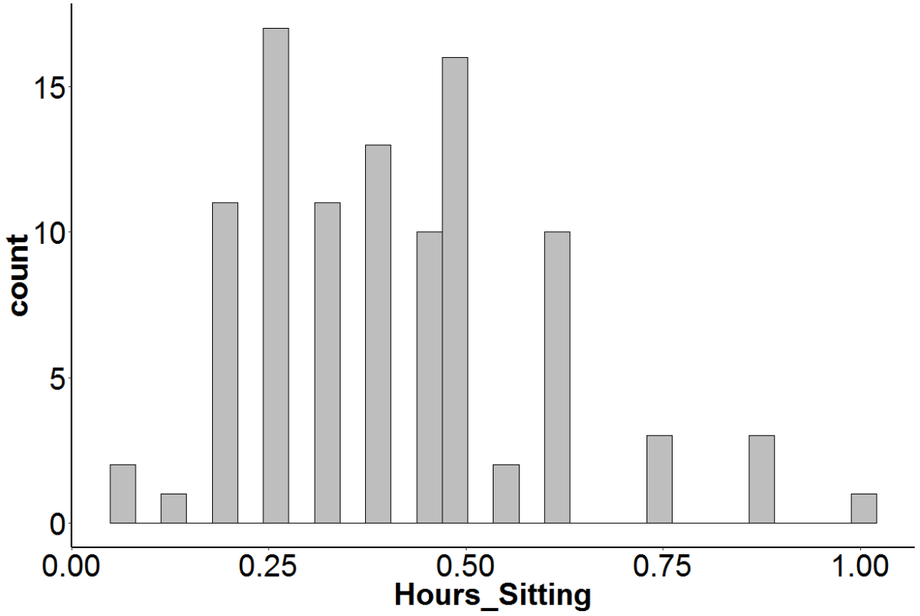
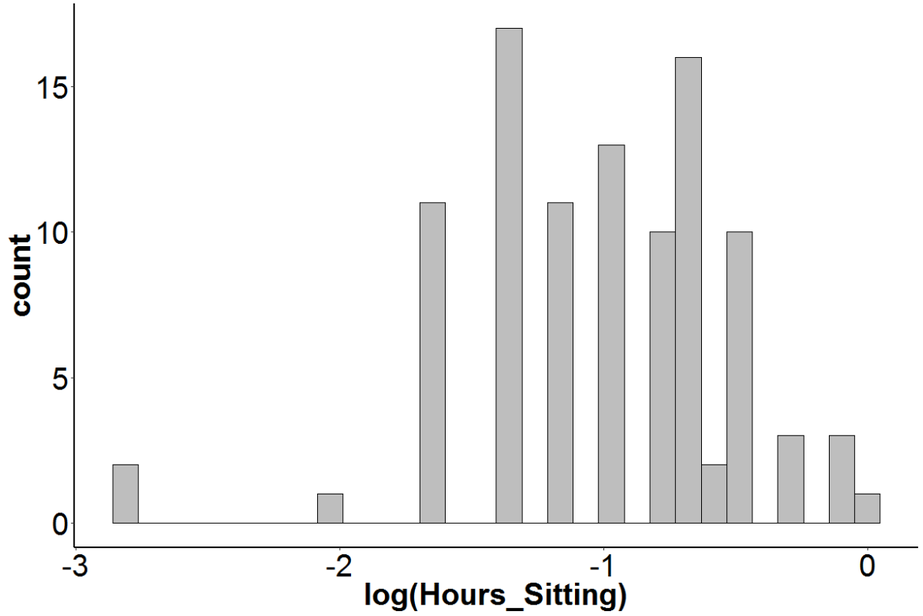
Probability Distributions





Male Fertility Data

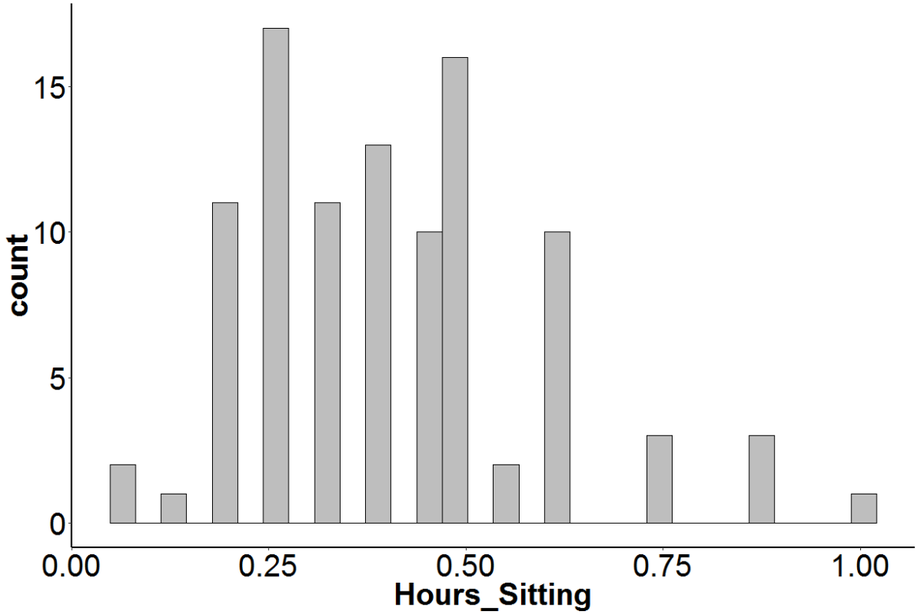
```
> library(dplyr)

> fertility

# A tibble: 100 x 10
   Season   Age Child_Disease Accident_Trauma Surgical_Intervention
    <dbl> <dbl>         <int>            <int>                <int>
 1  -0.33  0.69             0                1                    1
 2  -0.33  0.94             1                0                    1
 3  -0.33  0.50             1                0                    0
 4  -0.33  0.75             0                1                    1
 5  -0.33  0.67             1                1                    0
 6  -0.33  0.67             1                0                    1
 7  -0.33  0.67             0                0                    0
 8  -0.33  1.00             1                1                    1
 9   1.00  0.64             0                0                    1
10   1.00  0.61             1                0                    0
# ... with 90 more rows, and 5 more variables: High_Fevers <int>,
#   Alcohol_Freq <dbl>, Smoking <int>, Hours_Sitting <dbl>, Diagnosis <int>
```

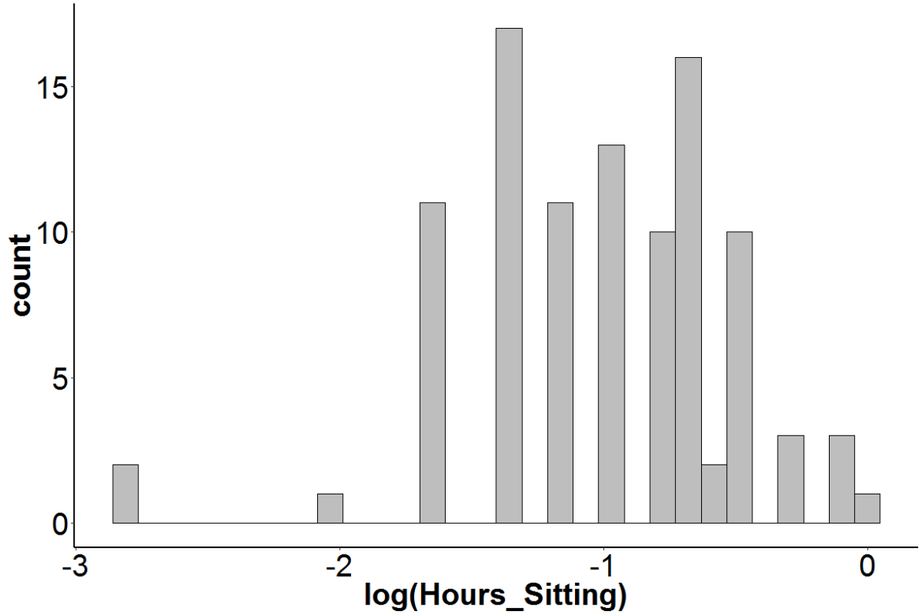
Generating Synthetic Data Part 1

Sampling from a Binomial Distribution

```
> fertility %>%
    summarise_at(vars(Child_Disease), mean)

# A tibble: 1 x 1
  Child_Disease
          <dbl>
1          0.87

> set.seed(42)
> child.disease <- rbinom(100, 1, 0.87)

> sum(child.disease)
[1] 83
```

Examining the Data





Generating Synthetic Data Part 2

Sampling from a Normal Distribution

```
> fert <- fertility %>%
    mutate(Hours_Sitting = log(Hours_Sitting))

> fert %>%
    summarise_at(vars(Hours_Sitting), funs(mean, sd))

# A tibble: 1 x 2
    mean        sd
   <dbl>     <dbl>
1 -1.012244 0.5047788

> set.seed(42)
> hours.sit <- rnorm(100, -1.01, 0.50)

> hours.sit <- exp(hours.sit)
```

How to Handle Improper Values

Hard Bounding

```
> hours.sit[hours.sit < 0] <- 0
> hours.sit[hours.sit > 1] <- 1

> range(hours.sit)
[1] 0.0815495 1.0000000
```

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