

Analysis of Queue Time & Service Times

SGH PAC Data (2020–2021)

Vincent Leonardo

Sunday, 11 April 2021

Contents

| | | |
|----------|--|-----------|
| 1 | Introduction | 1 |
| 2 | Assumptions | 2 |
| 3 | Methodology | 2 |
| 4 | Data Cleaning | 2 |
| 4.1 | Raw Data | 2 |
| 4.2 | Cleaned Data | 4 |
| 5 | Finding Distributions | 14 |
| 5.1 | Planned and Walk-In Appointments | 14 |
| 5.2 | Planned Appointments | 34 |
| 5.3 | Walk-In Appointments | 54 |
| 6 | Summary and Conclusion | 74 |
| 6.1 | Planned and Walk-In Appointments | 74 |
| 6.2 | Planned Appointments | 74 |
| 6.3 | Walk-In Appointments | 75 |

1 Introduction

In forming our queuing model for SGH PAC, the role and aim in this section is to extract distributions for these two variables:

1. *Queueing time.* This is the variable that indicates the amount of time taken between the arrival of a patient and the consult with the anaesthesiologist.
2. *Service time.* This is the variable that indicates the amount of time taken in a consult with the anaesthesiologist.

The data given to us is from 2019 to 2021 for both planned appointments and walk-in appointments. However, we will only focus on data from 2020 onwards due to SGH's claim that the 2019 data may not be as reliable.

2 Assumptions

Acknowledging that the real world data may not be ideal, we would like to lay down some assumptions regarding the data that will help with the model-fitting.

1. There is no exact data for queueing time. Therefore, it will be assumed that the queueing time is the total duration that the patient is in PAC subtracted by the actual consult duration. Implicitly, the other PAC stations (e.g. Radiology) where patients are assessed are considered as a “queue” in this case. For our purposes, this decision is justified as the project focuses on the anaesthesiologists and the consults thereof.
2. That any service time below 15 minutes is considered a data error. We must also acknowledge the assumption that any data above that is fully accurate to a reasonable degree, except when in the case that it is unrealistically high.
3. Seasonality near the Chinese New Year, which is usually in February. This information is provided to us by SGH through their past experience.

3 Methodology

This is a mostly quantitative analysis. The data will be cleaned, meaning that any data error will be removed, and appropriate data types shall be applied to each variable. Data from 2020 and 2021 will then be aggregated into two tibbles (in essence, a better version of a data frame for R), one for planned appointments and walk-in appointments. From the master tibble, they will be split based on both seasonality (February versus the rest of the months) and ASA Score (measure of health in a pre-surgery assessment). There will be sixteen tibbles formed through this split, knowing that ASA Scores range from 1 to 4. However, there may not be enough data to form a distribution for the ASA Score of 4 due to its rarity.

The sixteen tibbles will be analysed using descriptive statistics in the beginning, and then we will try to fit likely distributions to it. Ideally, the distributions will all be exponential. The main test that will be done to corroborate the distribution and its parameters will be the chi-squared test at $\alpha = 0.05$.

4 Data Cleaning

4.1 Raw Data

4.1.1 2020 Planned Appointments

```
## # A tibble: 6 x 21
##   `PAC Date` `Visit Time` Identifier Age   `Visit dept. OU` `Procedure Code`
##   <chr>       <chr>        <chr>     <chr> <chr>           <chr>
## 1 1/7/20      8:00        44013879ZGG 63    H&N - ENT      SJ802T
## 2 1/7/20      8:00        44013201IGJ 71    Orthop Surg     SB741S
## 3 1/7/20      8:00        44013138HIG 36    Orthop Surg     SB700H
## 4 1/7/20      8:00        44013339ZGG 47    Gynaecology    SI710V
## 5 1/7/20      8:30        44013492ZAZ 3     Otolary        SM701E
## 6 1/7/20      8:30        44013516ZGH 69    Orthop Surg     SB810K
## # ... with 15 more variables: No Show / Attended <chr>, Listing Date <chr>,
## #   No. of days between PAC date and listing date <chr>, Surgery Date <chr>,
## #   Lead time to Surgery <chr>, Admit Specialty <chr>, ASA Score <chr>,
```

```

## #  PAC Registration Time <chr>, PAC End Time <chr>,
## #  PAC Consult Duration <chr>, TOSP Table Code <chr>,
## #  Complexity of Surgery <chr>, TPS Patient (Yes/No) <chr>,
## #  TPS Patient (Recruited before PAC / Onsite) <chr>, X21 <lgl>

```

4.1.2 2020 Walk-In Appointments

```

## # A tibble: 6 x 20
##   `PAC Date` `Visit Time` Identifier Age   `Visit dept. OU` `Procedure Code`
##   <chr>       <chr>        <chr>     <chr> <chr>           <chr>
## 1 1/7/20      8:00        44013585ENB 22   Orthop Surg    SB703K
## 2 1/7/20      10:00       44013980AKI  35   Orthop Surg    SB840H
## 3 1/7/20      11:00       44013923ABC  66   VASCULAR SUR  SD817A
## 4 1/7/20      9:30        44013272ANF  67   Colorec Surg   SF802C
## 5 1/7/20      10:00       44013680FGG  85   Colorec Surg   SF802C
## 6 1/7/20      14:30       44013335III  47   Gynaecology   SI725U
## # ... with 14 more variables: No Show / Attended <chr>, Listing Date <chr>,
## #  No. of days between PAC date and listing date <chr>, Surgery Date <chr>,
## #  Lead time to Surgery <chr>, Admit Specialty <chr>, ASA Score <chr>,
## #  PAC Registration Time <chr>, PAC End Time <chr>,
## #  PAC Consult Duration <chr>, TOSP Table Code <chr>,
## #  Complexity of Surgery <chr>, TPS Patient (Yes/No) <chr>,
## #  TPS Patient (Recruited before PAC / Onsite) <chr>

```

4.1.3 2021 Planned Appointments

```

## # A tibble: 6 x 20
##   `PAC Date` `Visit Time` Identifier Age   `Visit dept. OU` `Procedure Code`
##   <chr>       <time>       <chr>     <chr> <chr>           <chr>
## 1 4/1/21      08:00       44200586JIG 23   Urology        SJ802T
## 2 4/1/21      08:00       44200015FDG 57   GI/BARIATRIC  SB715K
## 3 4/1/21      08:00       44200377JGH 88   Orthop Surg    SB816S
## 4 4/1/21      08:00       44200448ZNC 75   GI/BARIATRIC  SB727S
## 5 4/1/21      08:00       44200247HKC #N/A  EYE            #N/A
## 6 4/1/21      08:00       44200829FEF 74   HRM            SB810K
## # ... with 14 more variables: No Show / Attended <chr>, Listing Date <chr>,
## #  No. of days between PAC date and listing date <chr>, Surgery Date <chr>,
## #  Lead time to Surgery <chr>, Admit Specialty <chr>, ASA Score <chr>,
## #  PAC Registration Time <chr>, PAC End Time <chr>,
## #  PAC Consult Duration <chr>, TOSP Table Code <chr>,
## #  Complexity of Surgery <chr>, TPS Patient (Yes/No) <chr>,
## #  TPS Patient (Recruited before PAC / Onsite) <chr>

```

4.1.4 2021 Walk-In Appointments

```

## # A tibble: 6 x 21
##   `PAC Date` `Visit Time` Identifier Age   `Visit dept. OU` `Procedure Code`
##   <chr>       <chr>        <chr>     <chr> <chr>           <chr>

```

```

## 1 4/1/21    13:30      44200185FGB 62   Colorec Surg    SF836A
## 2 4/1/21    15:00      44200222HGZ 37   Gynaecology   SI843U
## 3 4/1/21    8:00       44200230EID 27   Gynaecology   SF836A
## 4 5/1/21    14:30      44201892EEG 41   GI/BARIATRIC SF703S
## 5 5/1/21    11:30      44201820DOH 85   VASCULAR SUR  SD712A
## 6 5/1/21    13:30      44201147ANI 76   VASCULAR SUR  SD821A
## # ... with 15 more variables: No Show / Attended <chr>, Listing Date <chr>,
## # No. of days between PAC date and listing date <chr>, Surgery Date <chr>,
## # Lead time to Surgery <chr>, Admit Specialty <chr>, ASA Score <chr>,
## # PAC Registration Time <chr>, PAC End Time <chr>,
## # PAC Consult Duration <chr>, TOSP Table Code <chr>,
## # Complexity of Surgery <chr>, TPS Patient (Yes/No) <chr>,
## # TPS Patient (Recruited before PAC / Onsite) <chr>, X21 <lgl>

```

4.2 Cleaned Data

4.2.1 Planned Appointments Aggregate

```

## # A tibble: 6 x 3
##   asa   queue_time consult_duration
##   <chr>     <int>           <int>
## 1 1          52              33
## 2 2          69              46
## 3 1          72              28
## 4 1          28              20
## 5 2          90              30
## 6 2         413             17

```

Table 1: Descriptive statistics for planned appointments

| ASA Score | Queue Time | Consult Duration |
|---------------|---------------|------------------|
| Min. :1.000 | Min. : 13.0 | Min. : 15.00 |
| 1st Qu.:2.000 | 1st Qu.: 94.0 | 1st Qu.: 21.00 |
| Median :2.000 | Median :131.0 | Median : 29.00 |
| Mean :1.822 | Mean :144.6 | Mean : 35.18 |
| 3rd Qu.:2.000 | 3rd Qu.:180.0 | 3rd Qu.: 42.00 |
| Max. :4.000 | Max. :556.0 | Max. :319.00 |

Seeing the histogram for consult duration, it might be a bit more useful to think of it as the amount of time beyond 15 minutes the consult will take. Hence, we will translate the consult duration by 15 minutes to the left.

4.2.2 Walk-In Appointments Aggregate

```

## # A tibble: 6 x 3
##   asa   queue_time consult_duration
##   <chr>     <dbl>           <int>
## 1 1          52              33
## 2 2          69              46
## 3 1          72              28
## 4 1          28              20
## 5 2          90              30
## 6 2         413             17

```

Histogram for Queue Times for Appointments in PAC
From 1 July 2020 to 5 March 2021

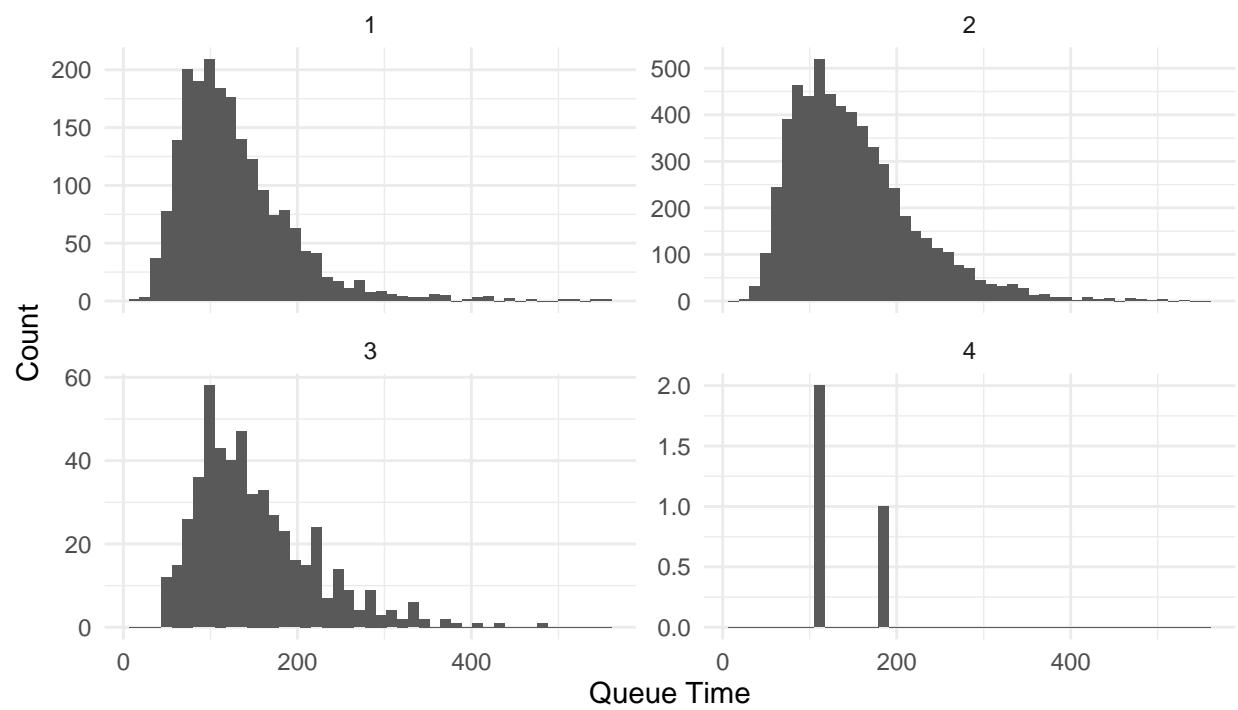


Figure 1: Histogram for queuing time for appointments in PAC

Histogram for Consult Duration for Appointments in PAC
From 1 July 2020 to 5 March 2021

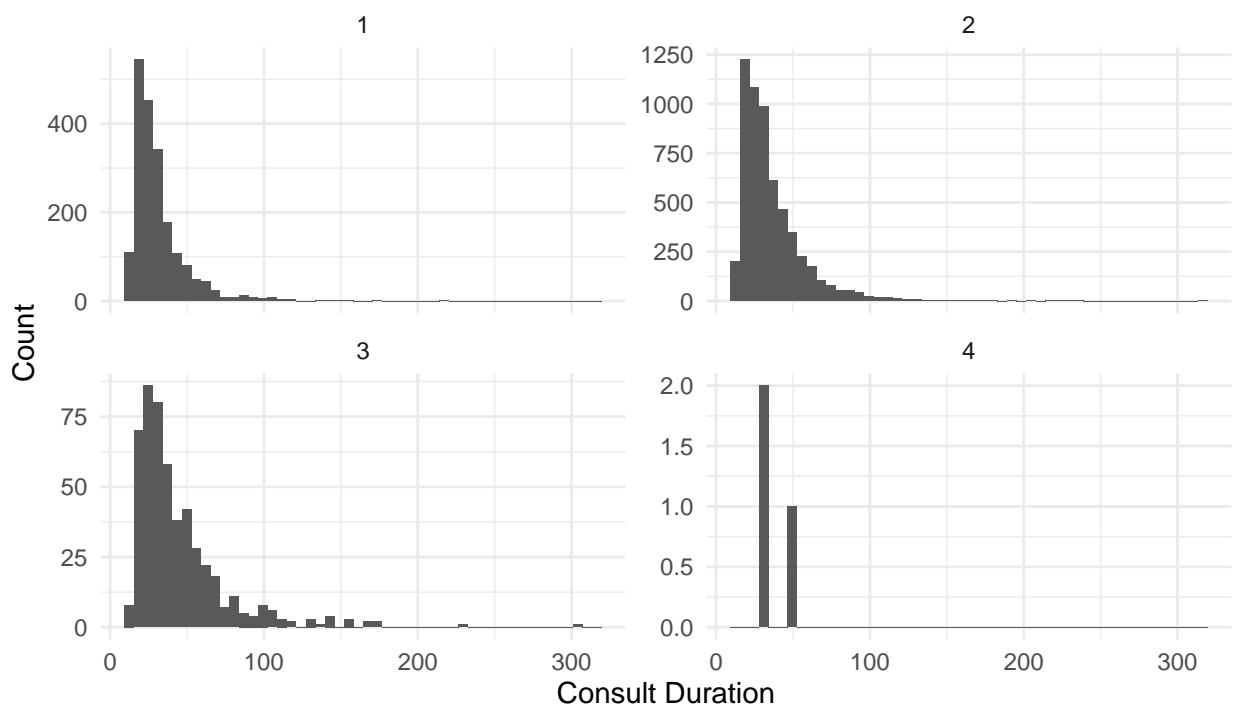


Figure 2: Histogram for consult duration for appointments in PAC

Histogram for Adjusted Consult Duration for Appointments in PAC
From 1 July 2020 to 5 March 2021

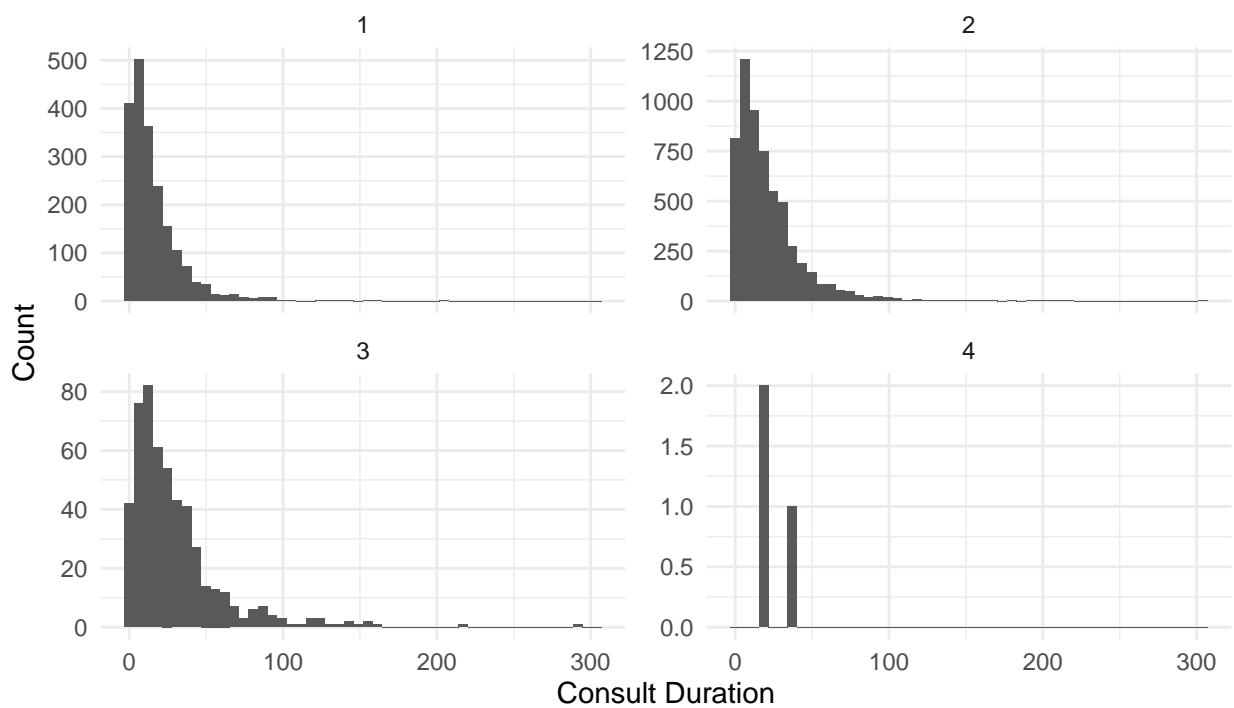


Figure 3: Histogram for adjusted consult duration for appointments in PAC

| | | |
|--------|-----|----|
| ## 1 1 | 80 | 17 |
| ## 2 3 | 189 | 41 |
| ## 3 3 | 136 | 74 |
| ## 4 2 | 334 | 23 |
| ## 5 2 | 291 | 68 |
| ## 6 1 | 59 | 18 |

Table 2: Descriptive statistics for walk-in appointments

| ASA Score | Queue Time | Consult Duration |
|---------------|---------------|------------------|
| Min. :1.000 | Min. : 16.0 | Min. : 15.00 |
| 1st Qu.:1.000 | 1st Qu.: 95.0 | 1st Qu.: 20.00 |
| Median :2.000 | Median :139.0 | Median : 28.00 |
| Mean :1.794 | Mean :160.9 | Mean : 34.61 |
| 3rd Qu.:2.000 | 3rd Qu.:206.0 | 3rd Qu.: 40.00 |
| Max. :3.000 | Max. :585.0 | Max. :185.00 |

Similarly to the planned appointments, the three figures below describe the queue time and consult duration in histograms.

Histogram for Queue Times for Walk–Ins in PAC

From 1 July 2020 to 5 March 2021

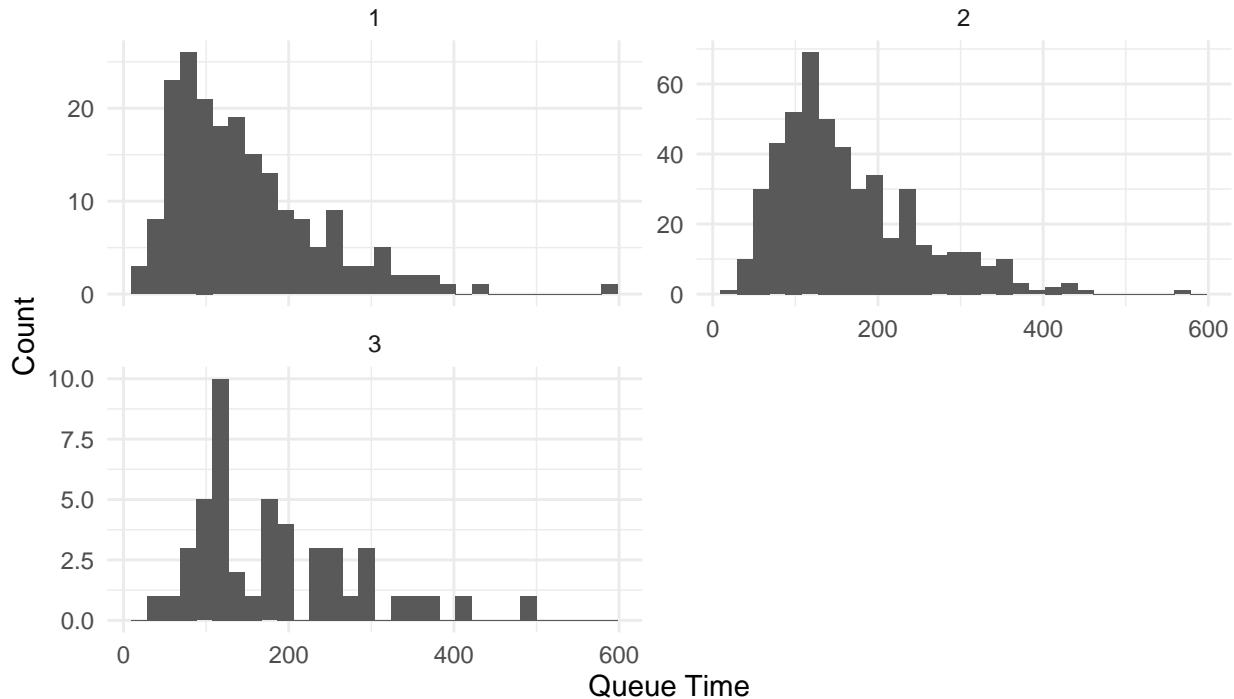


Figure 4: Histogram for queuing time for walk-ins in PAC

Histogram for Consult Duration for Walk–Ins in PAC
From 1 July 2020 to 5 March 2021

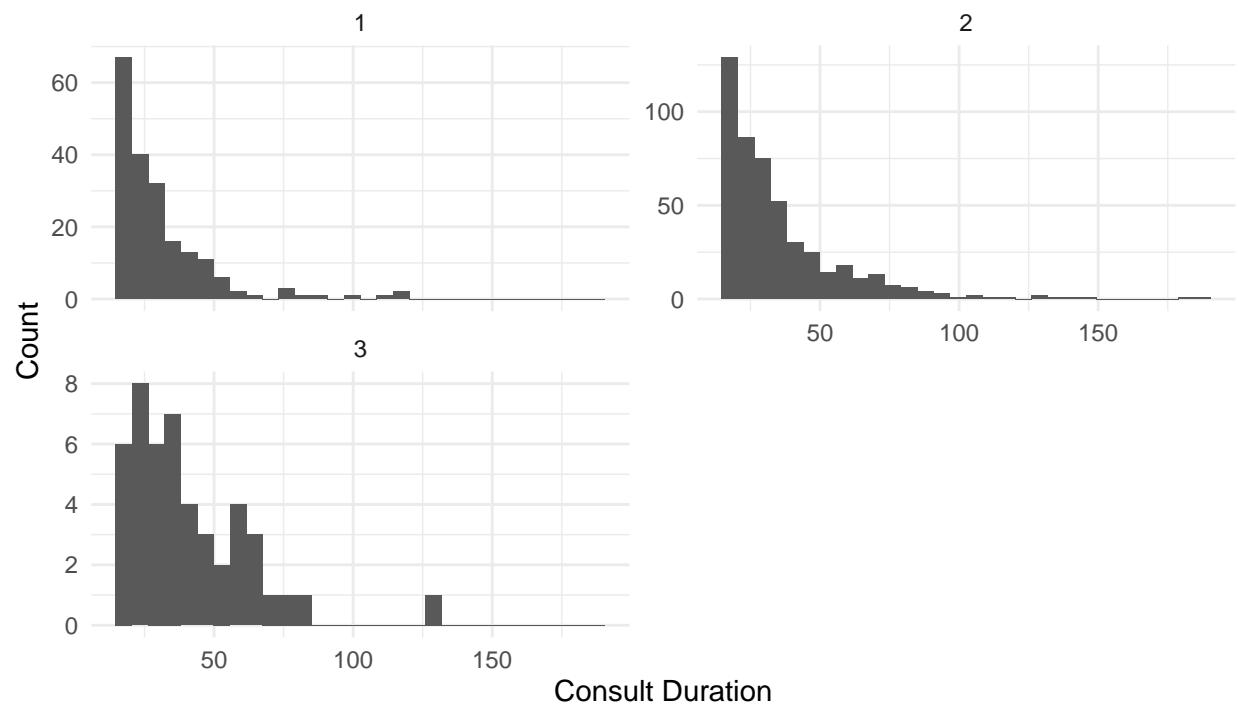


Figure 5: Histogram for consult duration for walk-ins in PAC

Histogram for Adjusted Consult Duration for Walk-Ins in PAC
From 1 July 2020 to 5 March 2021

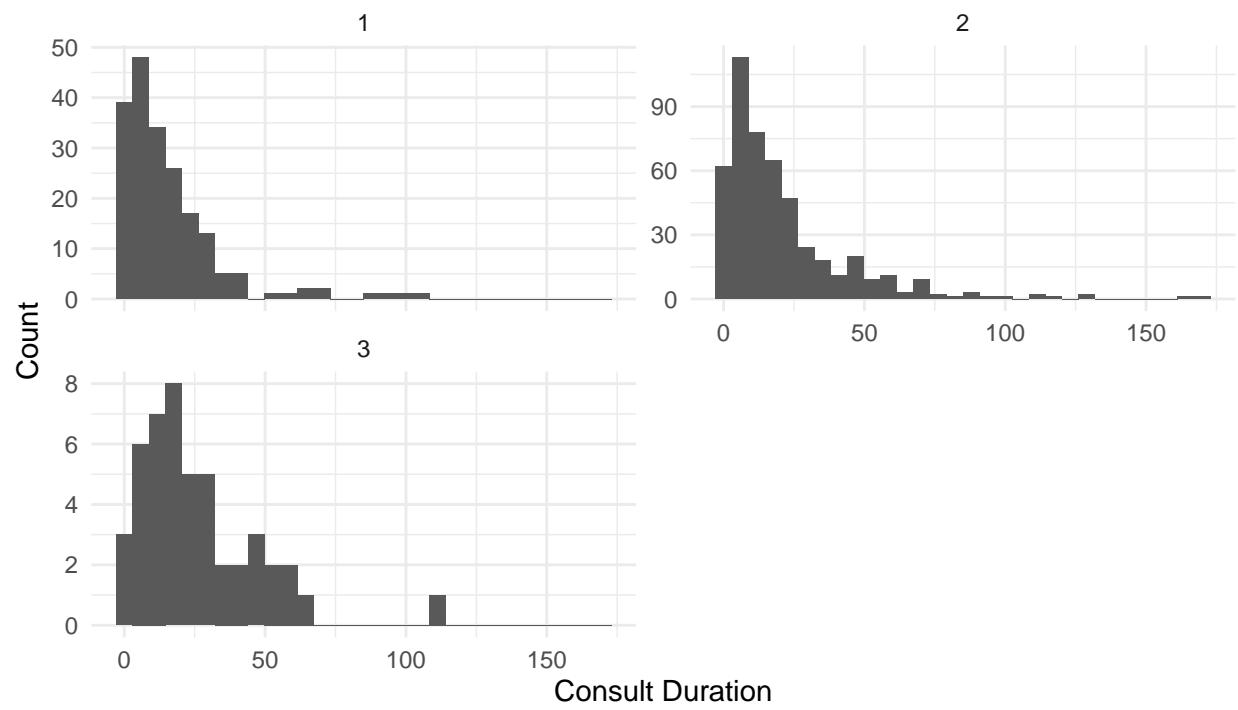


Figure 6: Histogram for adjusted consult duration for walk-ins in PAC

4.2.3 Appointments Aggregate

```
## # A tibble: 6 x 3
##   asa    queue_time consult_duration
##   <chr>      <dbl>            <int>
## 1 1          52              33
## 2 2          69              46
## 3 1          72              28
## 4 1          28              20
## 5 2          90              30
## 6 2         413             17
```

Histogram for Queue Times in PAC

From 1 July 2020 to 5 March 2021

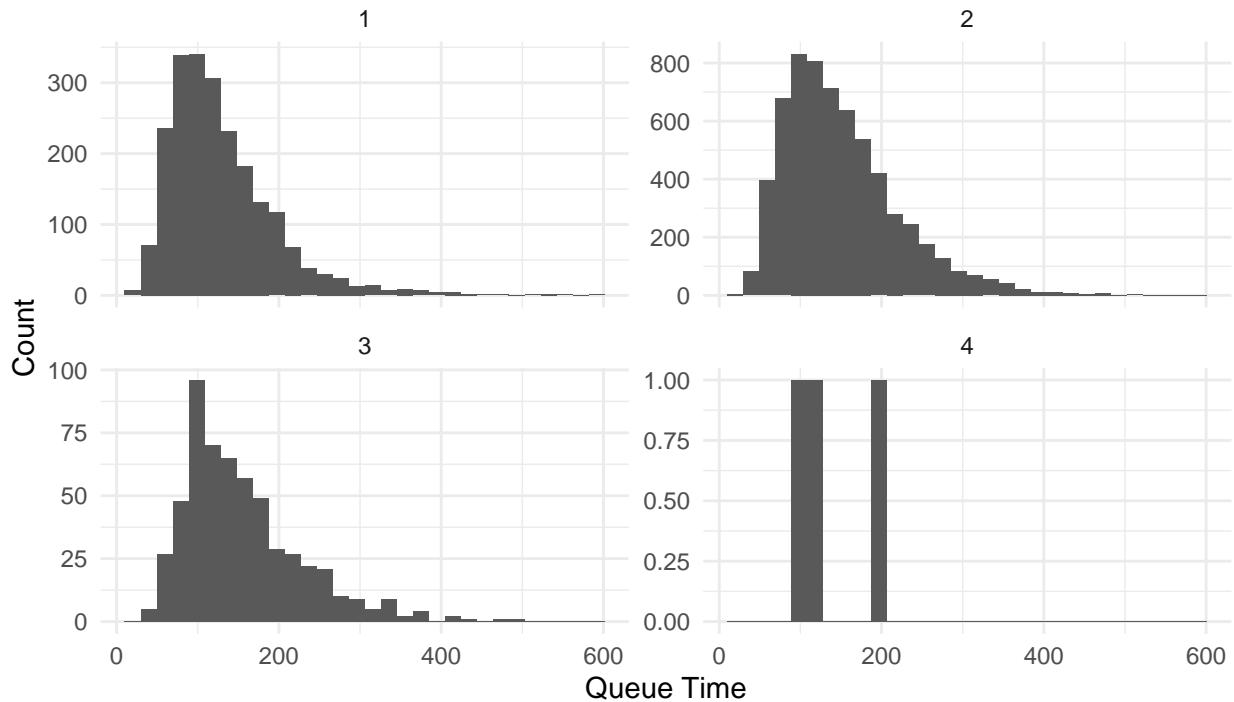


Figure 7: Histogram for queuing time in PAC

Histogram for Consult Duration in PAC
From 1 July 2020 to 5 March 2021

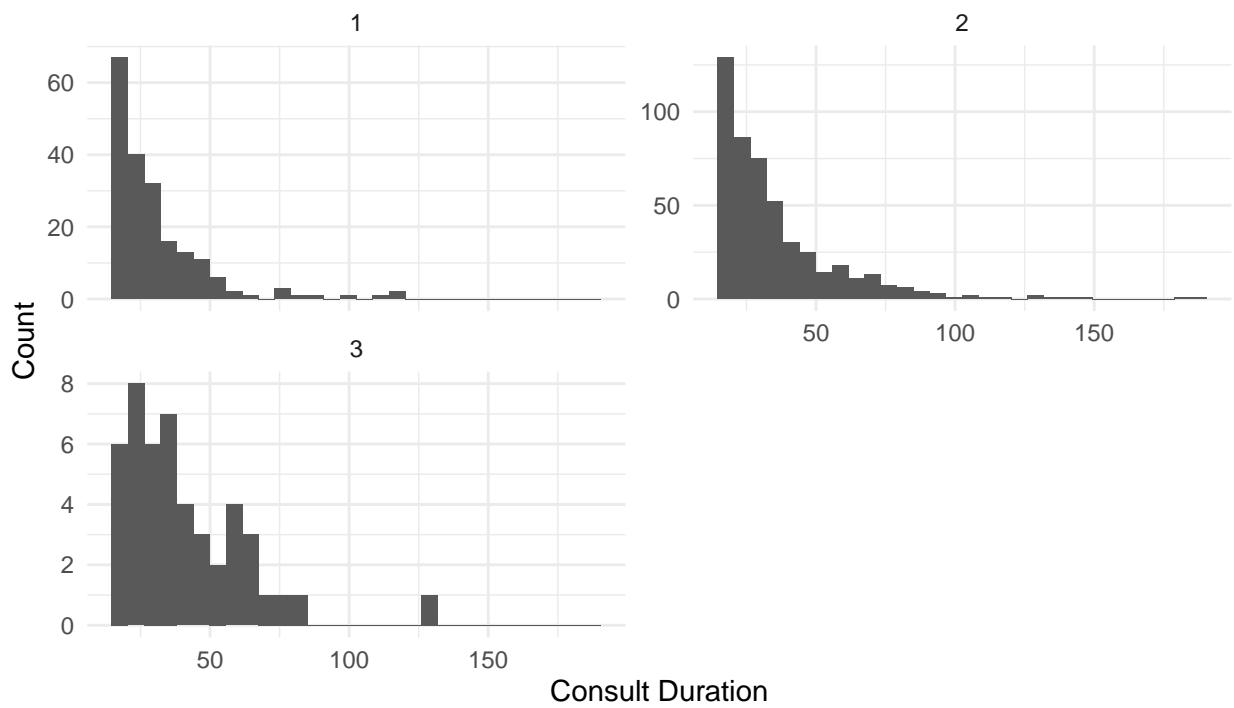


Figure 8: Histogram for consult duration in PAC

Histogram for Adjusted Consult Duration in PAC
From 1 July 2020 to 5 March 2021

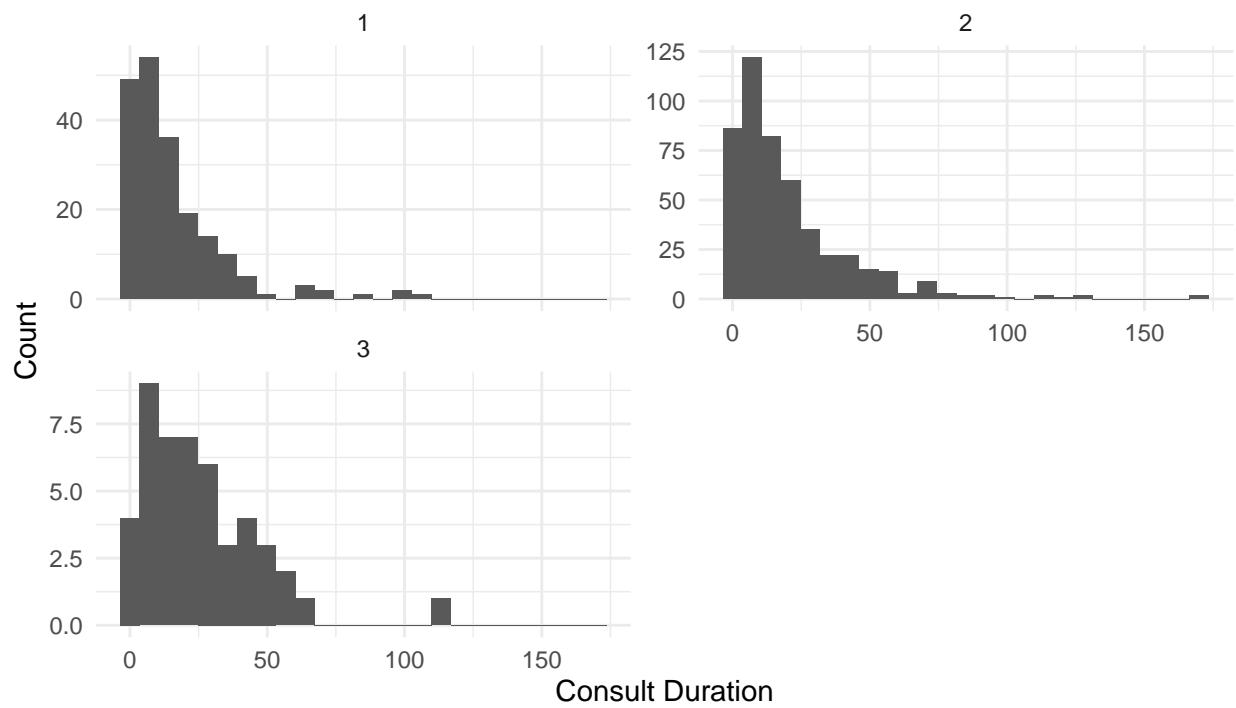


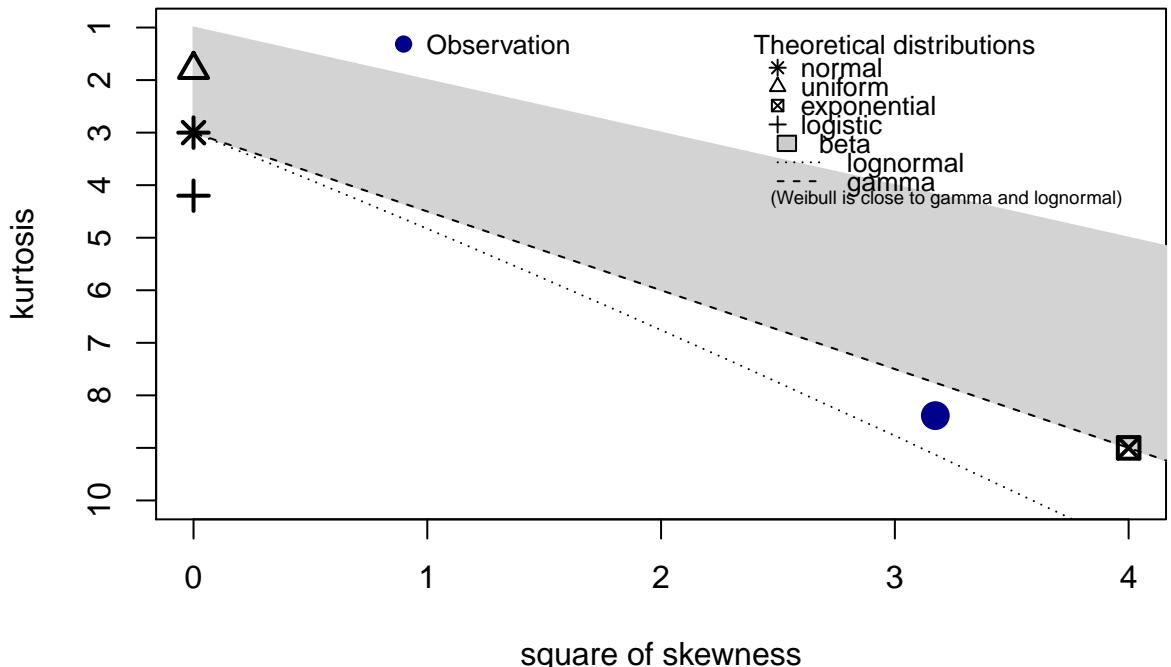
Figure 9: Histogram for adjusted consult duration in PAC

5 Finding Distributions

5.1 Planned and Walk-In Appointments

5.1.1 Queue Time

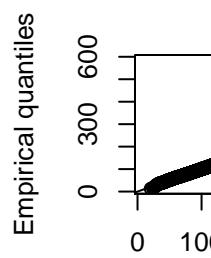
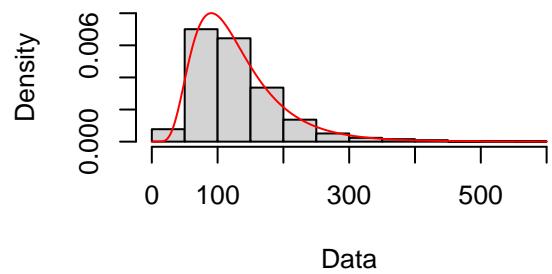
Cullen and Frey graph



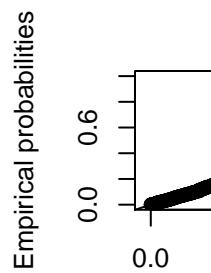
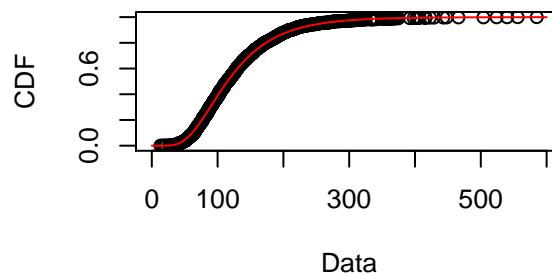
5.1.1.1 ASA1

```
## summary statistics
## -----
## min: 13   max: 585
## median: 115
## mean: 129.4893
## estimated sd: 67.28252
## estimated skewness: 1.78132
## estimated kurtosis: 8.385513
```

Empirical and theoretical dens.



Empirical and theoretical CDFs

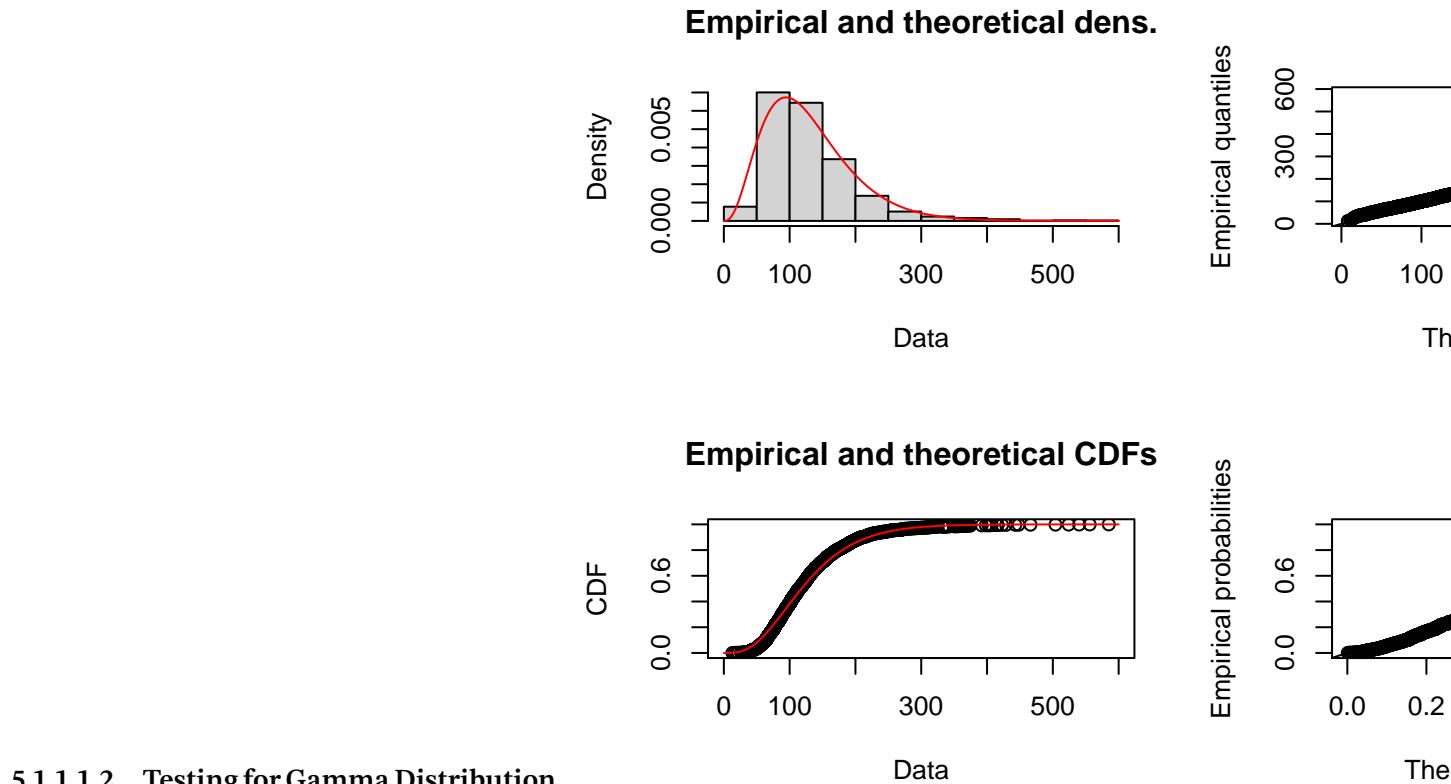


5.1.1.1 Testing for Lognormal Distribution

```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-lnorm
## Kolmogorov-Smirnov statistic   0.0179067
## Cramer-von Mises statistic    0.0603894
## Anderson-Darling statistic    0.6085893
##
## Goodness-of-fit criteria
##                               1-mme-lnorm
## Akaike's Information Criterion 23851.54
## Bayesian Information Criterion 23862.92
##
## [[2]]
## Fitting of the distribution ' lnorm ' by matching moments
## Parameters :
##       estimate
## meanlog 4.7441447
## sdlog   0.4887809
## Loglikelihood: -11923.77 AIC: 23851.54 BIC: 23862.92
```

Table 3: Chi-Squared Test for Lognormal Distribution with
MeanLog 4.7441447 and SdLog 0.4887809

| Pass | Error | Critical Value |
|--------------|----------|----------------|
| Not rejected | 3.790103 | 9.487729 |



5.1.1.1.2 Testing for Gamma Distribution

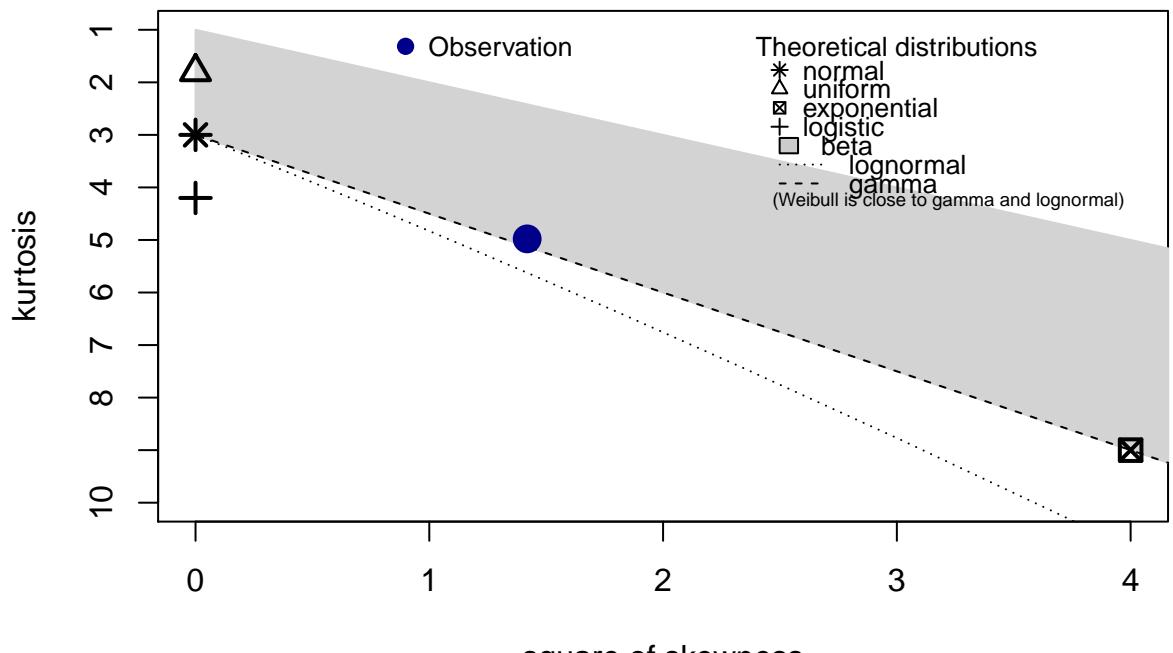
```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-gamma
## Kolmogorov-Smirnov statistic 0.05277488
## Cramer-von Mises statistic  1.55534146
## Anderson-Darling statistic 12.68223134
##
## Goodness-of-fit criteria
##                               1-mme-gamma
## Akaike's Information Criterion    23981.55
## Bayesian Information Criterion   23992.94
##
## [[2]]
## Fitting of the distribution 'gamma' by matching moments
## Parameters :
##       estimate
## shape 3.70562271
## rate  0.02861722
```

```
## Loglikelihood: -11988.78 AIC: 23981.55 BIC: 23992.94
```

Table 4: Chi-Squared Test for Gamma Distribution with Shape 3.70562271 and Rate 0.02861722

| Pass | Error | Critical Value |
|----------|----------|----------------|
| Rejected | 39.74268 | 9.487729 |

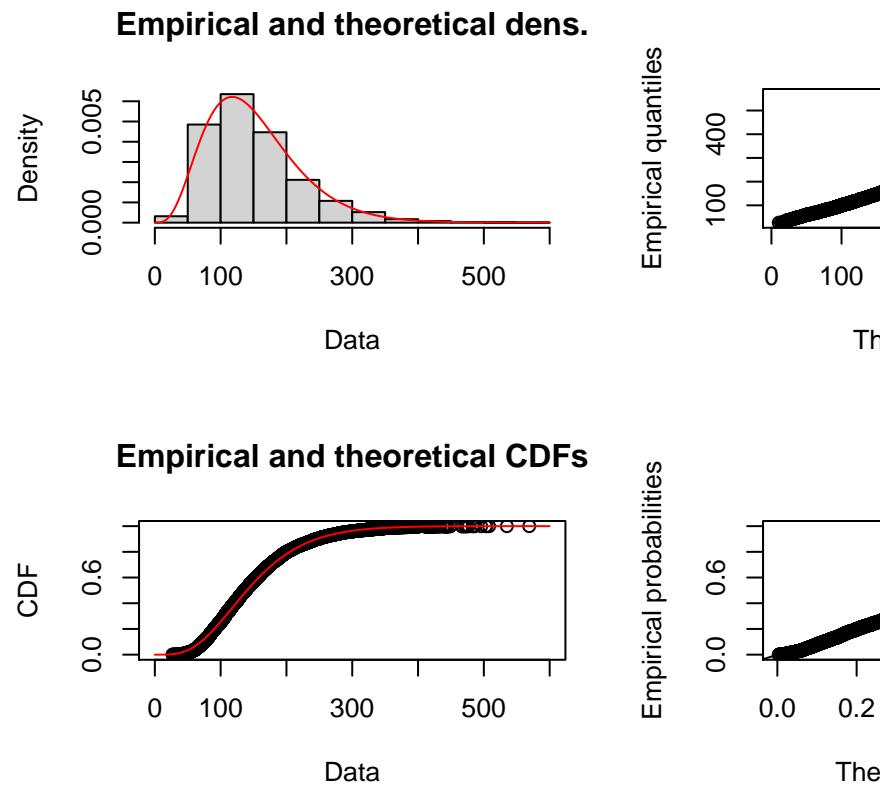
Cullen and Frey graph



5.1.1.2 ASA 2

square of skewness

```
## summary statistics
## -----
## min: 27   max: 569
## median: 137
## mean: 150.9156
## estimated sd: 71.03786
## estimated skewness: 1.191075
## estimated kurtosis: 4.97947
```



5.1.1.2.1 Testing for Gamma Distribution

```

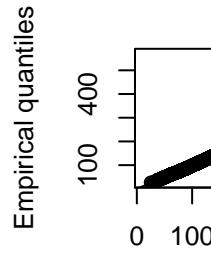
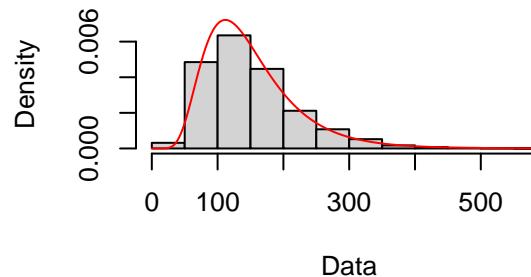
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-gamma
## Kolmogorov-Smirnov statistic 0.02898534
## Cramer-von Mises statistic  1.13535433
## Anderson-Darling statistic 10.55945776
##
## Goodness-of-fit criteria
##                               1-mme-gamma
## Akaike's Information Criterion    69662.87
## Bayesian Information Criterion   69676.35
##
## [[2]]
## Fitting of the distribution ' gamma ' by matching moments
## Parameters :
##       estimate
## shape 4.51396193
## rate 0.02991051
## Loglikelihood: -34829.43 AIC: 69662.87 BIC: 69676.35

```

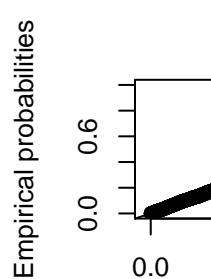
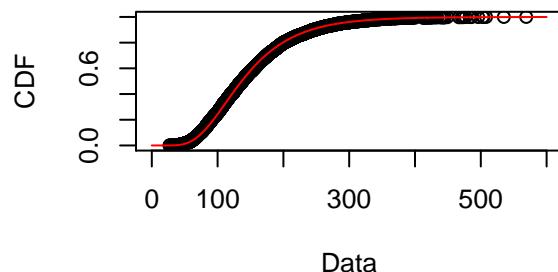
Table 5: Chi-Squared Test for Gamma Distribution with Shape 4.51396193 and Rate 0.02991051

| Pass | Error | Critical Value |
|--------------|----------|----------------|
| Not rejected | 17.96091 | 18.30704 |

Empirical and theoretical dens.



Empirical and theoretical CDFs



5.1.1.2.2 Testing for Lognormal Distribution

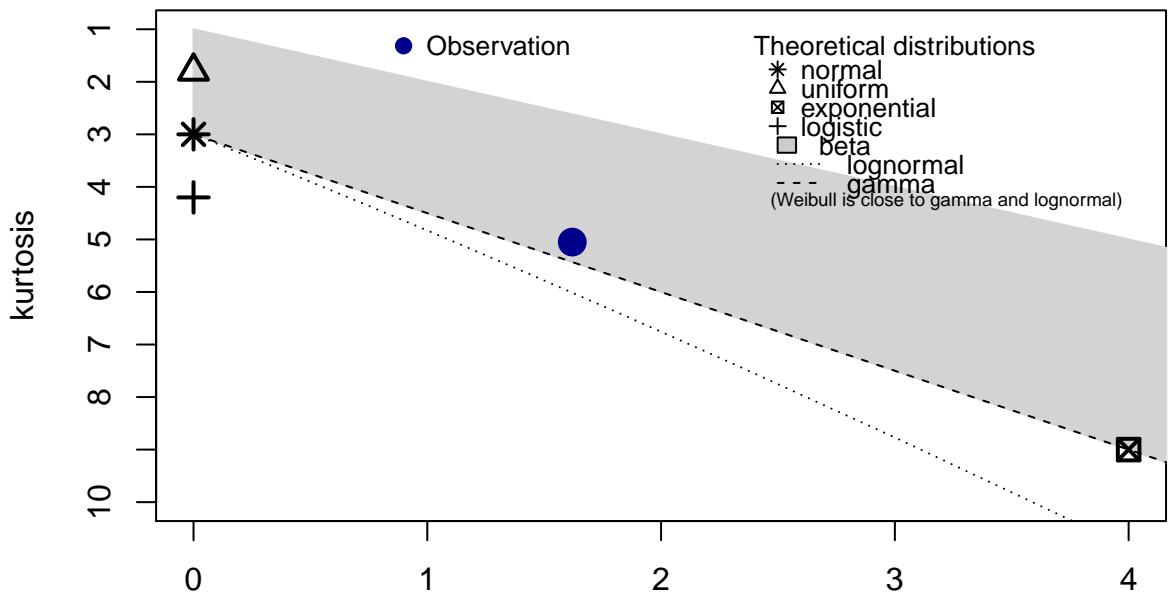
```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-lnorm
## Kolmogorov-Smirnov statistic 0.02405473
## Cramer-von Mises statistic  0.69879880
## Anderson-Darling statistic  4.89547405
##
## Goodness-of-fit criteria
##                               1-mme-lnorm
## Akaike's Information Criterion    69527.77
## Bayesian Information Criterion   69541.25
##
## [[2]]
## Fitting of the distribution 'lnorm' by matching moments
## Parameters :
##       estimate
## meanlog 4.9166666
## sdlog   0.4473345
```

```
## Loglikelihood: -34761.88 AIC: 69527.77 BIC: 69541.25
```

Table 6: Chi-Squared Test for Lognormal Distribution with MeanLog 4.9116591 and SdLog 0.4419957

| Pass | Error | Critical Value |
|----------|----------|----------------|
| Rejected | 29.33012 | 19.67514 |

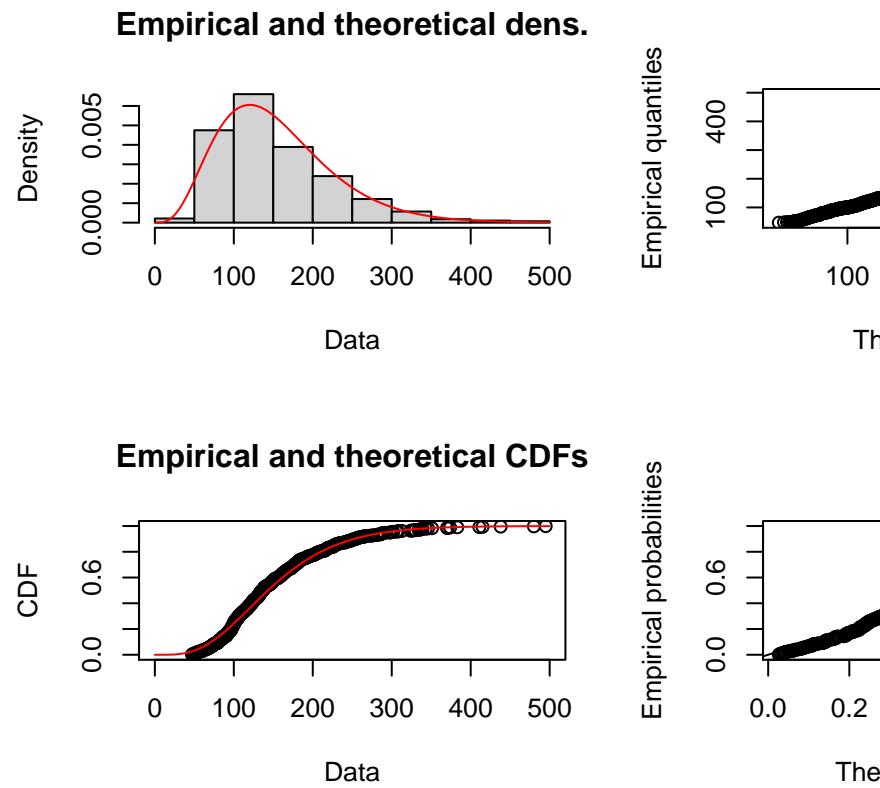
Cullen and Frey graph



5.1.1.3 ASA 3

square of skewness

```
## summary statistics
## -----
## min: 47   max: 495
## median: 137
## mean: 154.6518
## estimated sd: 73.04713
## estimated skewness: 1.272831
## estimated kurtosis: 5.050589
```



5.1.1.3.1 Testing for Gamma Distribution

```

## [[1]]
## Goodness-of-fit statistics
##                               1-mme-gamma
## Kolmogorov-Smirnov statistic 0.05181065
## Cramer-von Mises statistic  0.35534652
## Anderson-Darling statistic  2.48916670
##
## Goodness-of-fit criteria
##                               1-mme-gamma
## Akaike's Information Criterion    6256.461
## Bayesian Information Criterion   6265.117
##
## [[2]]
## Fitting of the distribution ' gamma ' by matching moments
## Parameters :
##     estimate
## shape 4.4903452
## rate 0.0290352
## Loglikelihood: -3126.23 AIC: 6256.461 BIC: 6265.117

```

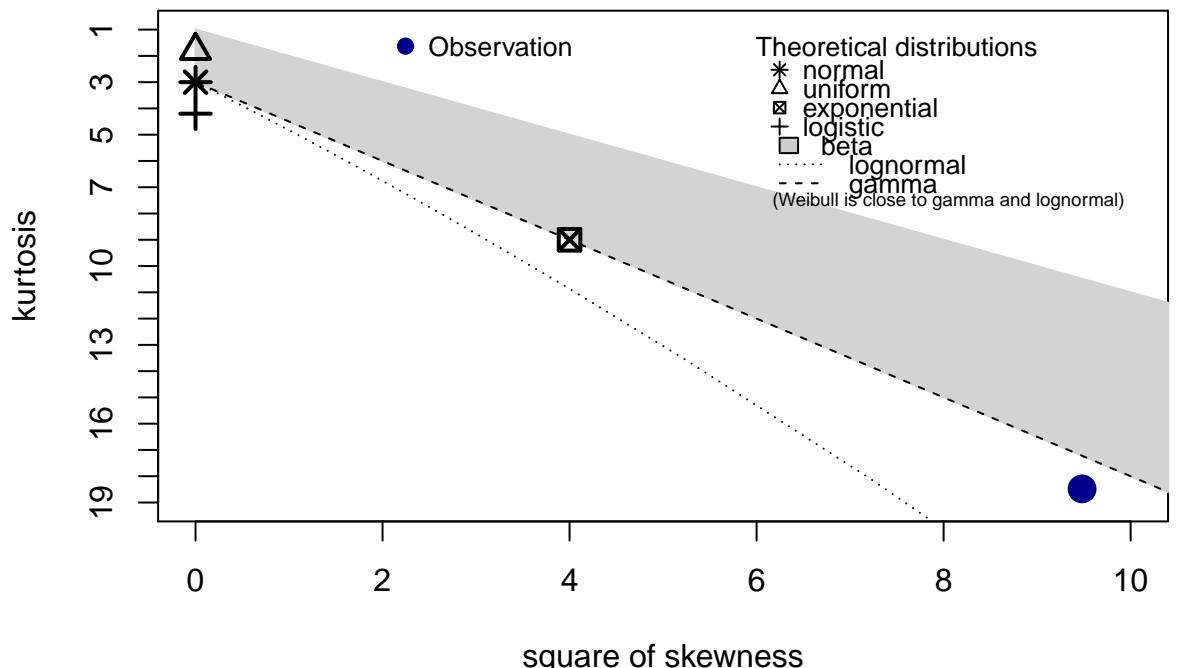
Table 7: Chi-Squared Test for Gamma Distribution with Shape 4.4903452 and Rate 0.0290352

| Pass | Error | Critical Value |
|--------------|----------|----------------|
| Not rejected | 13.37659 | 18.30704 |

5.1.2 Consult Duration

Adjusted version, meaning that the consult duration was shifted by 15 minutes, unless otherwise stated.

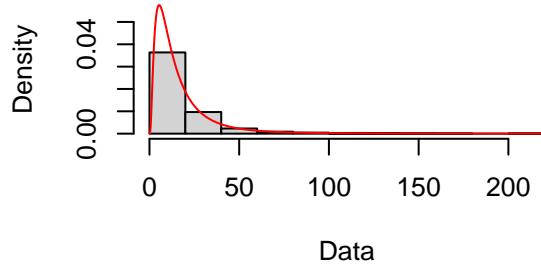
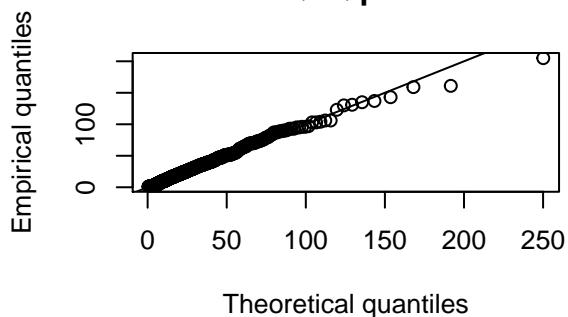
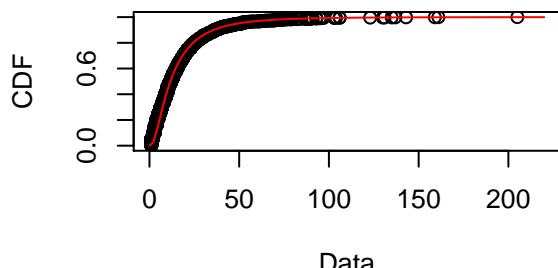
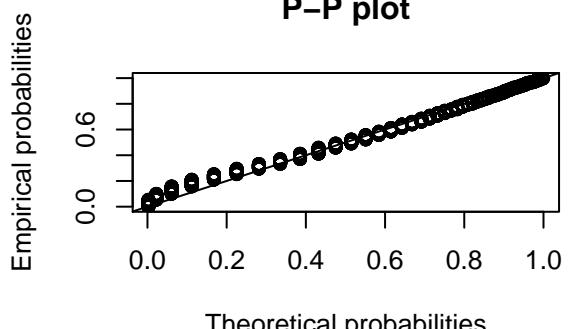
Cullen and Frey graph



5.1.2.1 ASA1

```
## summary statistics
## -----
## min: 0   max: 204
## median: 11
## mean: 16.0456
## estimated sd: 18.30492
## estimated skewness: 3.079084
## estimated kurtosis: 18.48056
```

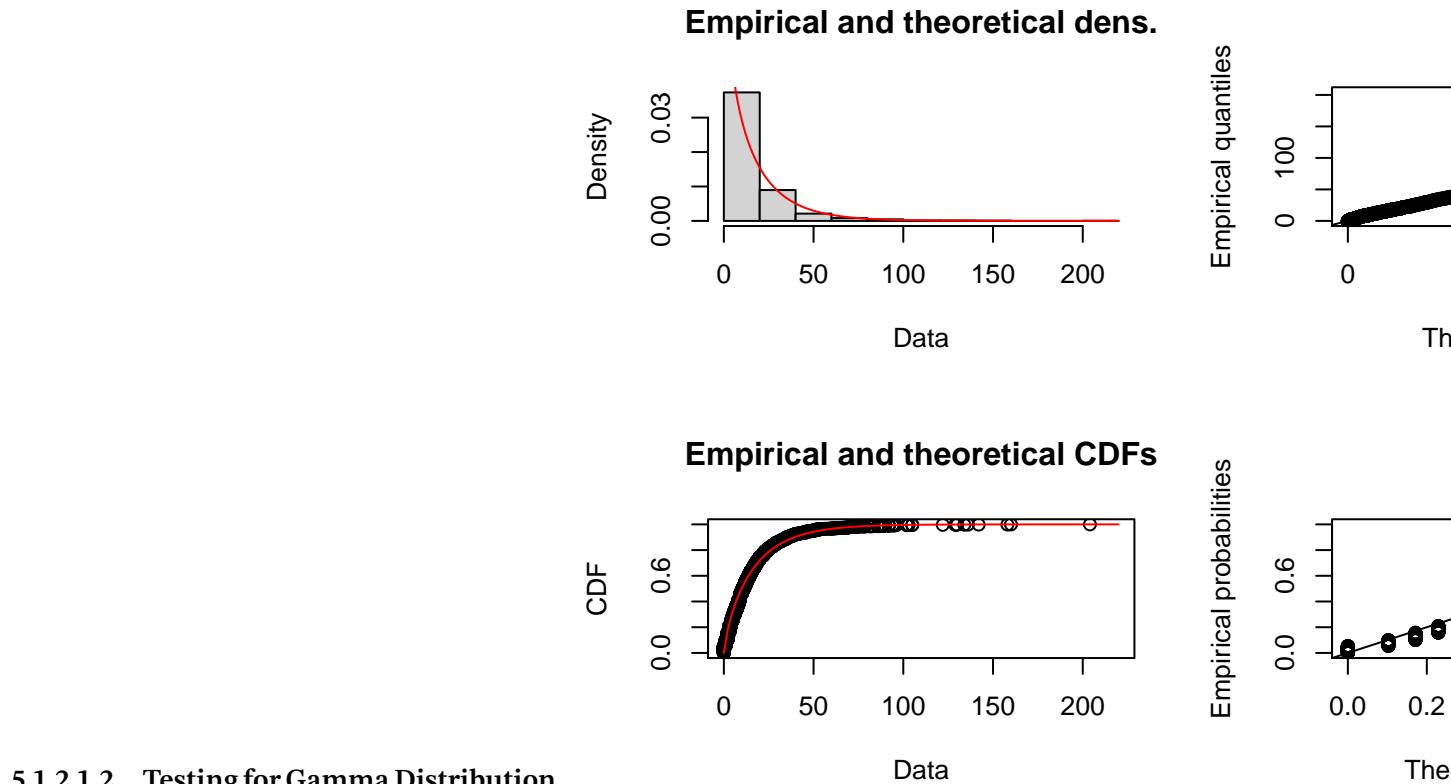
5.1.2.1.1 Testing for Lognormal Distribution The lognormal distribution requires numbers above 0. Hence, the shifting in this case is by 14, such that the minimum is 1.

Empirical and theoretical dens.**Q-Q plot****Empirical and theoretical CDFs****P-P plot**

```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-lnorm
## Kolmogorov-Smirnov statistic 0.09808718
## Cramer-von Mises statistic  2.65276066
## Anderson-Darling statistic 38.40126539
##
## Goodness-of-fit criteria
##                               1-mme-lnorm
## Akaike's Information Criterion 16941.03
## Bayesian Information Criterion 16952.41
##
## [[2]]
## Fitting of the distribution ' lnorm ' by matching moments
## Parameters :
##       estimate
## meanlog 2.4525327
## sdlog   0.8756247
## Loglikelihood: -8468.513 AIC: 16941.03 BIC: 16952.41
```

Table 8: Chi-Squared Test for Lognormal Distribution with
MeanLog 2.4525327 and SdLog 0.8756247

| Pass | Error | Critical Value |
|--------------|----------|----------------|
| Not rejected | 9.605517 | 15.50731 |



5.1.2.1.2 Testing for Gamma Distribution

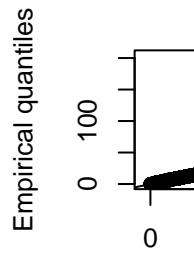
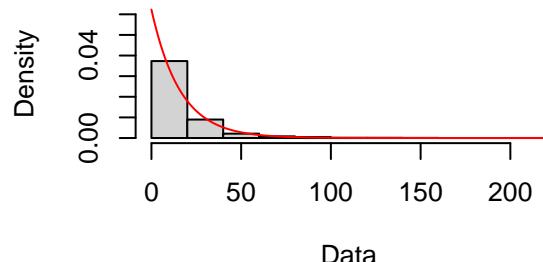
```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-gamma
## Kolmogorov-Smirnov statistic 0.07372338
## Cramer-von Mises statistic  2.59119338
## Anderson-Darling statistic      Inf
##
## Goodness-of-fit criteria
##                               1-mme-gamma
## Akaike's Information Criterion      -Inf
## Bayesian Information Criterion     -Inf
##
## [[2]]
## Fitting of the distribution 'gamma' by matching moments
## Parameters :
##   estimate
## shape 0.76873108
## rate  0.04790915
```

```
## Loglikelihood: Inf AIC: -Inf BIC: -Inf
```

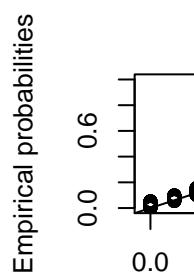
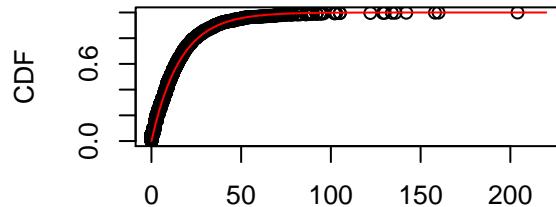
Table 9: Chi-Squared Test for Gamma Distribution with Shape 0.76873108 and Rate 0.04790915

| Pass | Error | Critical Value |
|----------|----------|----------------|
| Rejected | 55.54124 | 14.06714 |

Empirical and theoretical dens.



Empirical and theoretical CDFs



5.1.2.1.3 Testing for Exponential Distribution

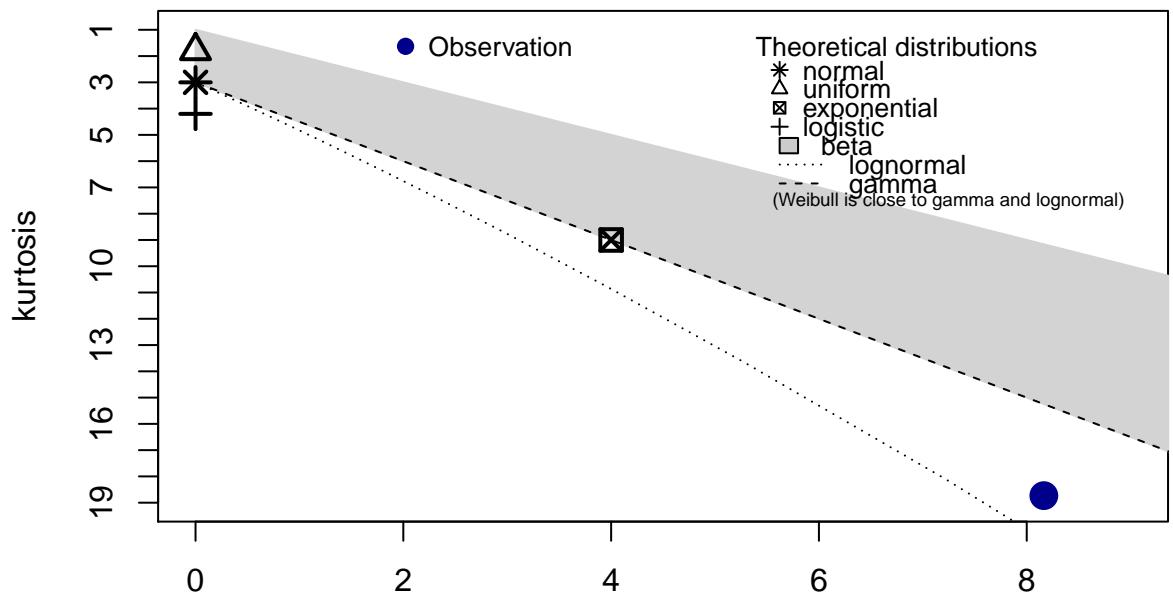
```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-exp
## Kolmogorov-Smirnov statistic 0.05380757
## Cramer-von Mises statistic   0.70027975
## Anderson-Darling statistic    Inf
##
## Goodness-of-fit criteria
##                               1-mme-exp
## Akaike's Information Criterion 16561.06
## Bayesian Information Criterion 16566.75
##
## [[2]]
## Fitting of the distribution 'exp' by matching moments
## Parameters :
##     estimate
##     rate 0.06232238
```

```
## Loglikelihood: -8279.528 AIC: 16561.06 BIC: 16566.75
```

Table 10: Chi-Squared Test for Exponential Distribution with Rate 0.06232238

| Pass | Error | Critical Value |
|----------|----------|----------------|
| Rejected | 42.66968 | 15.50731 |

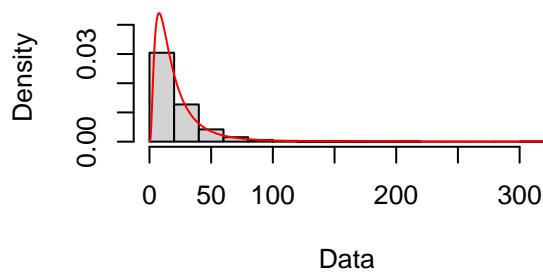
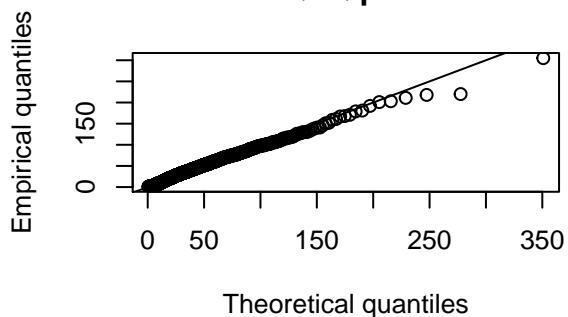
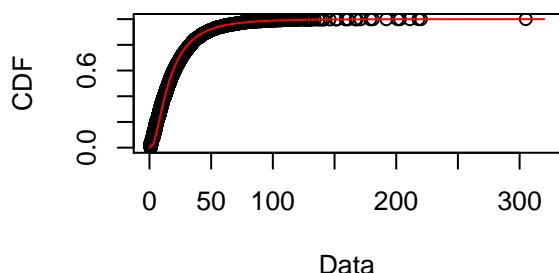
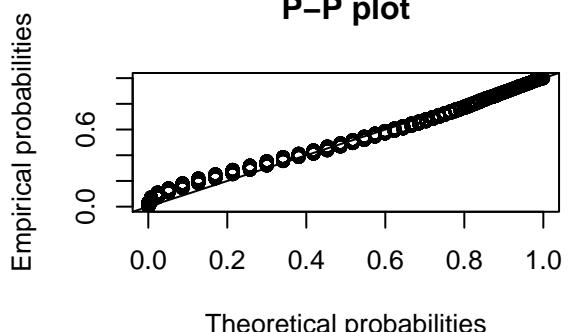
Cullen and Frey graph



5.1.2.2 ASA 2

```
## summary statistics
## -----
## min: 1   max: 305
## median: 16
## mean: 21.73269
## estimated sd: 21.55089
## estimated skewness: 2.857424
## estimated kurtosis: 18.73142
```

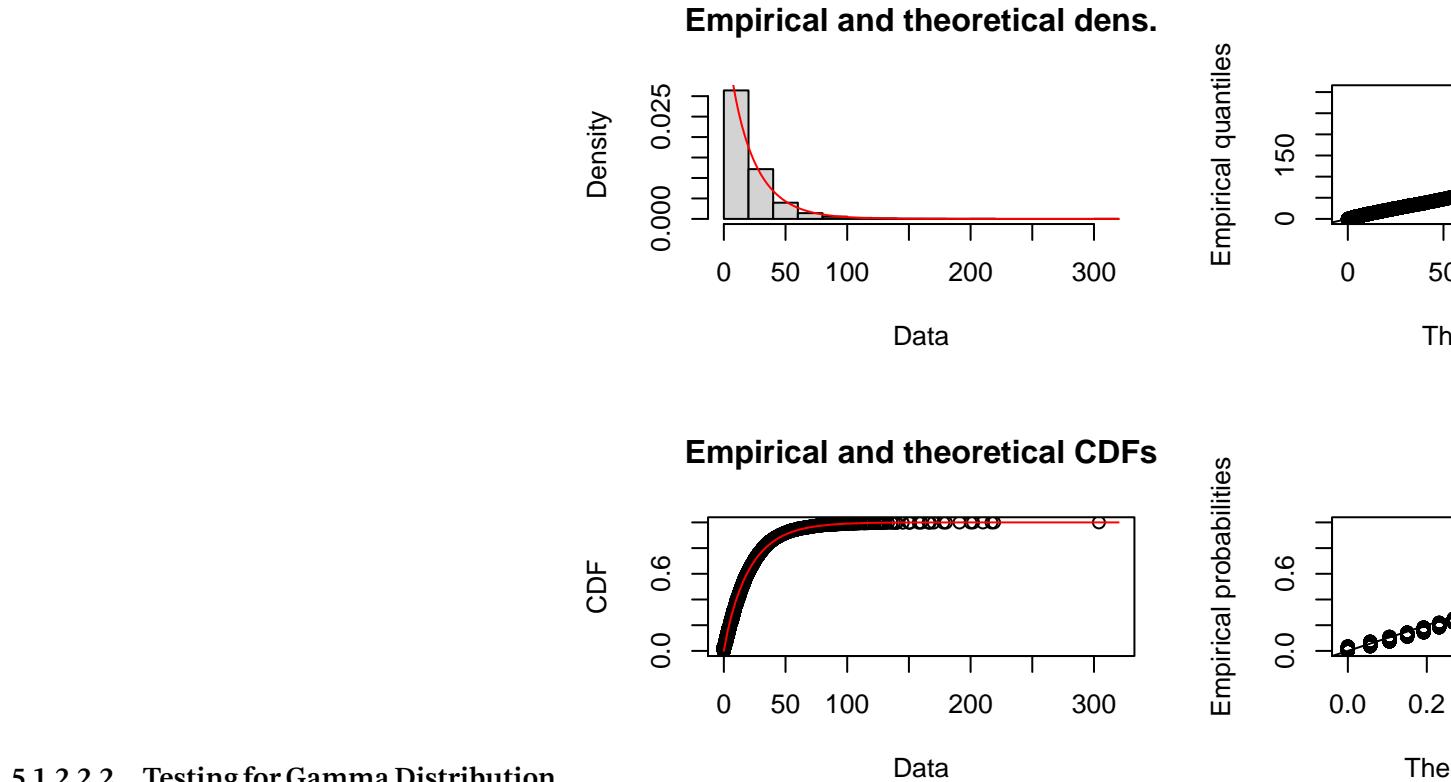
5.1.2.2.1 Testing for Lognormal Distribution The lognormal distribution requires numbers above 0. Hence, the shifting in this case is by 14, such that the minimum is 1.

Empirical and theoretical dens.**Q-Q plot****Empirical and theoretical CDFs****P-P plot**

```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-lnorm
## Kolmogorov-Smirnov statistic   0.09597839
## Cramer-von Mises statistic    9.78075237
## Anderson-Darling statistic   146.12106517
##
## Goodness-of-fit criteria
##                               1-mme-lnorm
## Akaike's Information Criterion 51935.91
## Bayesian Information Criterion 51949.39
##
## [[2]]
## Fitting of the distribution ' lnorm ' by matching moments
## Parameters :
##     estimate
## meanlog 2.7364665
## sdlog   0.8274675
## Loglikelihood: -25965.95 AIC: 51935.91 BIC: 51949.39
```

Table 11: Chi-Squared Test for Lognormal Distribution with
MeanLog 2.7364665 and SdLog 0.8274675

| Pass | Error | Critical Value |
|----------|----------|----------------|
| Rejected | 45.55516 | 5.991465 |



5.1.2.2.2 Testing for Gamma Distribution

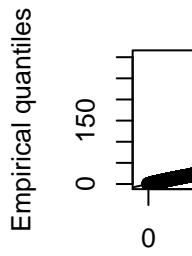
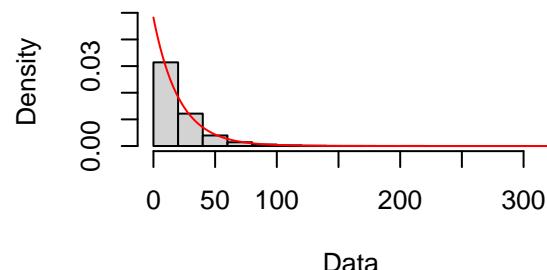
```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-gamma
## Kolmogorov-Smirnov statistic 0.05101785
## Cramer-von Mises statistic   2.85874812
## Anderson-Darling statistic      Inf
##
## Goodness-of-fit criteria
##                               1-mme-gamma
## Akaike's Information Criterion      -Inf
## Bayesian Information Criterion     -Inf
##
## [[2]]
## Fitting of the distribution 'gamma' by matching moments
## Parameters :
##       estimate
## shape 0.92565787
## rate  0.04464725
```

```
## Loglikelihood: Inf AIC: -Inf BIC: -Inf
```

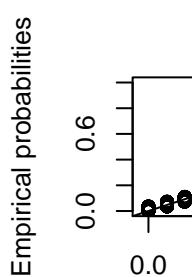
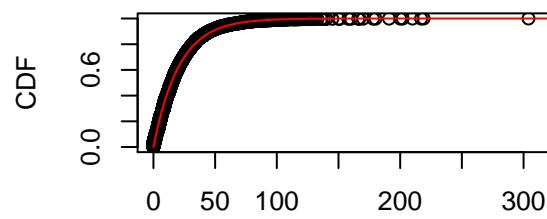
Table 12: Chi-Squared Test for Gamma Distribution with Shape 0.92565787 and Rate 0.04464725

| Pass | Error | Critical Value |
|----------|----------|----------------|
| Rejected | 15.25287 | 3.841459 |

Empirical and theoretical dens.



Empirical and theoretical CDFs



5.1.2.2.3 Testing for Exponential Distribution

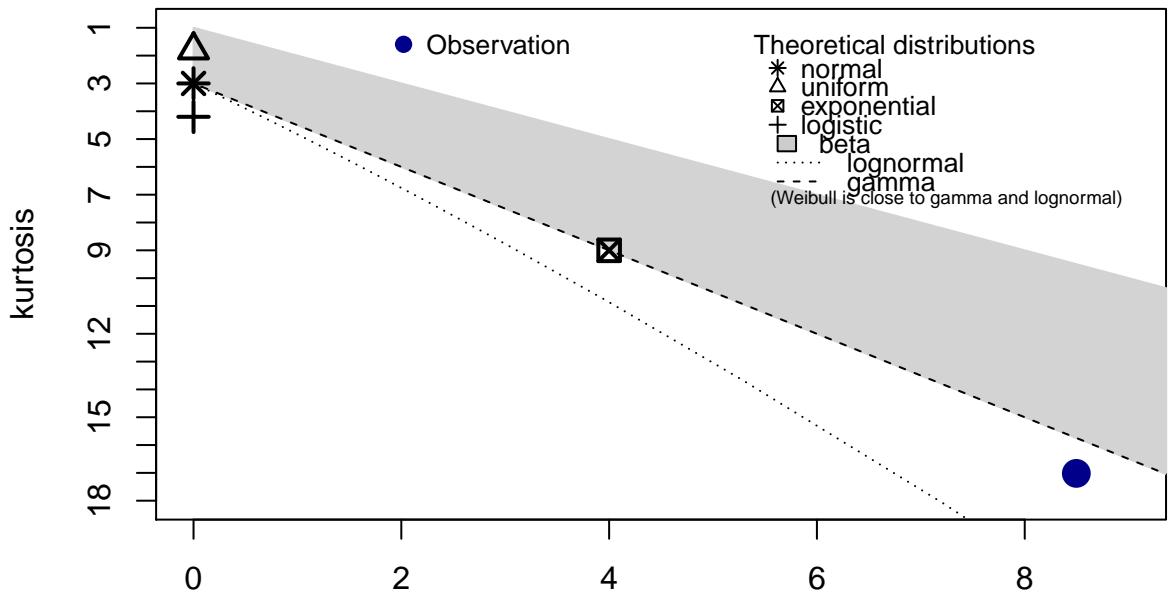
```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-exp
## Kolmogorov-Smirnov statistic 0.03533173
## Cramer-von Mises statistic   1.08195066
## Anderson-Darling statistic      Inf
##
## Goodness-of-fit criteria
##                               1-mme-exp
## Akaike's Information Criterion 50438.72
## Bayesian Information Criterion 50445.46
##
## [[2]]
## Fitting of the distribution 'exp' by matching moments
## Parameters :
##   estimate
##   rate 0.048233
```

```
## Loglikelihood: -25218.36 AIC: 50438.72 BIC: 50445.46
```

Table 13: Chi-Squared Test for Exponential Distribution with Rate 0.048233

| Pass | Error | Critical Value |
|--------------|--------|----------------|
| Not rejected | 5.7713 | 5.991465 |

Cullen and Frey graph

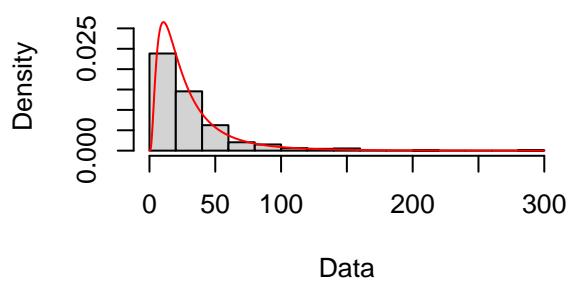
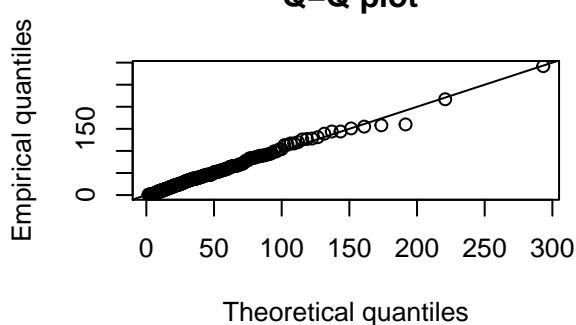
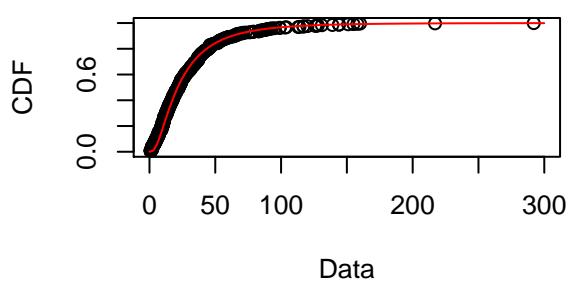
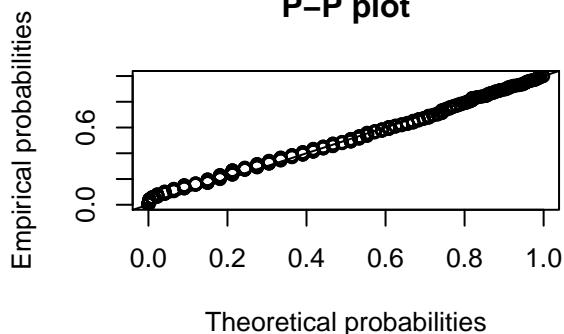


5.1.2.3 ASA 3

square of skewness

```
## summary statistics
## -----
## min: 1   max: 292
## median: 22
## mean: 30.45536
## estimated sd: 30.72181
## estimated skewness: 2.914877
## estimated kurtosis: 17.01842
```

5.1.2.3.1 Testing for Lognormal Distribution The lognormal distribution requires numbers above 0. Hence, the shifting in this case is by 14, such that the minimum is 1.

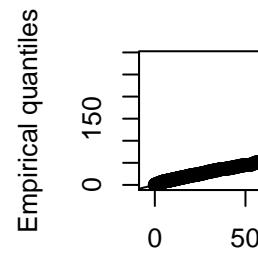
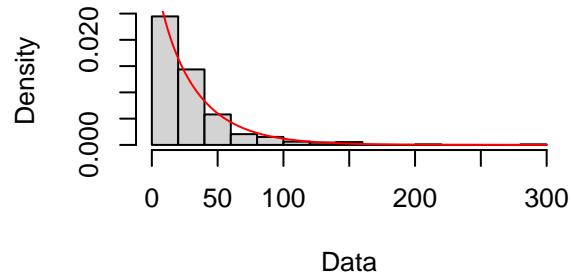
Empirical and theoretical dens.**Q-Q plot****Empirical and theoretical CDFs****P-P plot**

```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-lnorm
## Kolmogorov-Smirnov statistic 0.06304681
## Cramer-von Mises statistic  0.35976253
## Anderson-Darling statistic  6.46302707
##
## Goodness-of-fit criteria
##                               1-mme-lnorm
## Akaike's Information Criterion    4986.764
## Bayesian Information Criterion   4995.420
##
## [[2]]
## Fitting of the distribution ' lnorm ' by matching moments
## Parameters :
##       estimate
## meanlog 3.0657644
## sdlog   0.8372545
## Loglikelihood: -2491.382 AIC: 4986.764 BIC: 4995.42
```

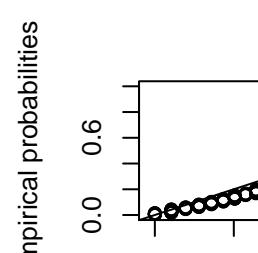
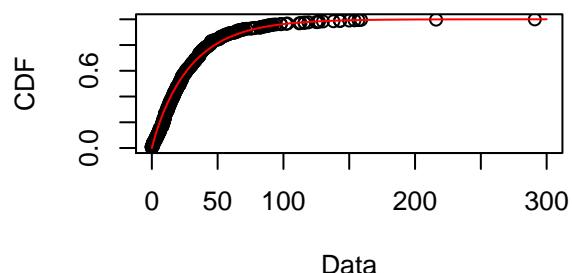
Table 14: Chi-Squared Test for Lognormal Distribution with
MeanLog 3.0657644 and SdLog 0.8372545

| Pass | Error | Critical Value |
|--------------|---------|----------------|
| Not rejected | 5.50356 | 12.59159 |

Empirical and theoretical dens.



Empirical and theoretical CDFs



5.1.2.3.2 Testing for Gamma Distribution

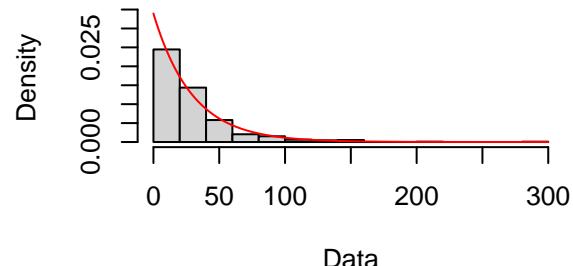
```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-gamma
## Kolmogorov-Smirnov statistic 0.08827393
## Cramer-von Mises statistic  0.73718487
## Anderson-Darling statistic   Inf
##
## Goodness-of-fit criteria
##                               1-mme-gamma
## Akaike's Information Criterion -Inf
## Bayesian Information Criterion -Inf
##
## [[2]]
## Fitting of the distribution ' gamma ' by matching moments
## Parameters :
##       estimate
## shape 0.92089709
## rate  0.03126416
```

```
## Loglikelihood: Inf AIC: -Inf BIC: -Inf
```

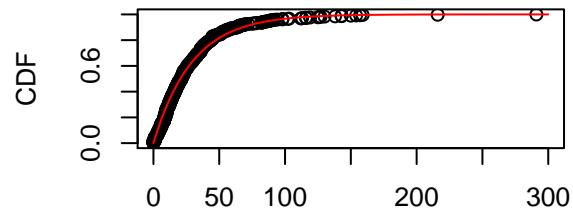
Table 15: Chi-Squared Test for Gamma Distribution with Shape 0.92089709 and Rate 0.03126416

| Pass | Error | Critical Value |
|--------------|----------|----------------|
| Not rejected | 5.842161 | 5.991465 |

Empirical and theoretical dens.

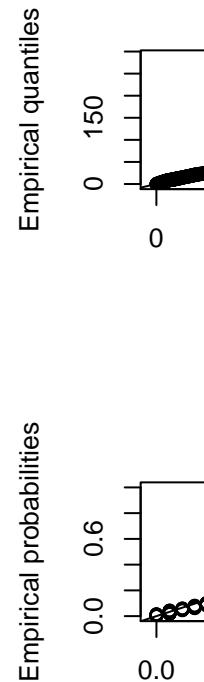


Empirical and theoretical CDFs



5.1.2.3.3 Testing for Exponential Distribution

```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-exp
## Kolmogorov-Smirnov statistic 0.06998185
## Cramer-von Mises statistic   0.40160340
## Anderson-Darling statistic      Inf
##
## Goodness-of-fit criteria
##                               1-mme-exp
## Akaike's Information Criterion 4910.821
## Bayesian Information Criterion 4915.149
##
## [[2]]
## Fitting of the distribution 'exp' by matching moments
## Parameters :
##     estimate
##     rate 0.03394968
```



```
## Loglikelihood: -2454.41 AIC: 4910.821 BIC: 4915.149
```

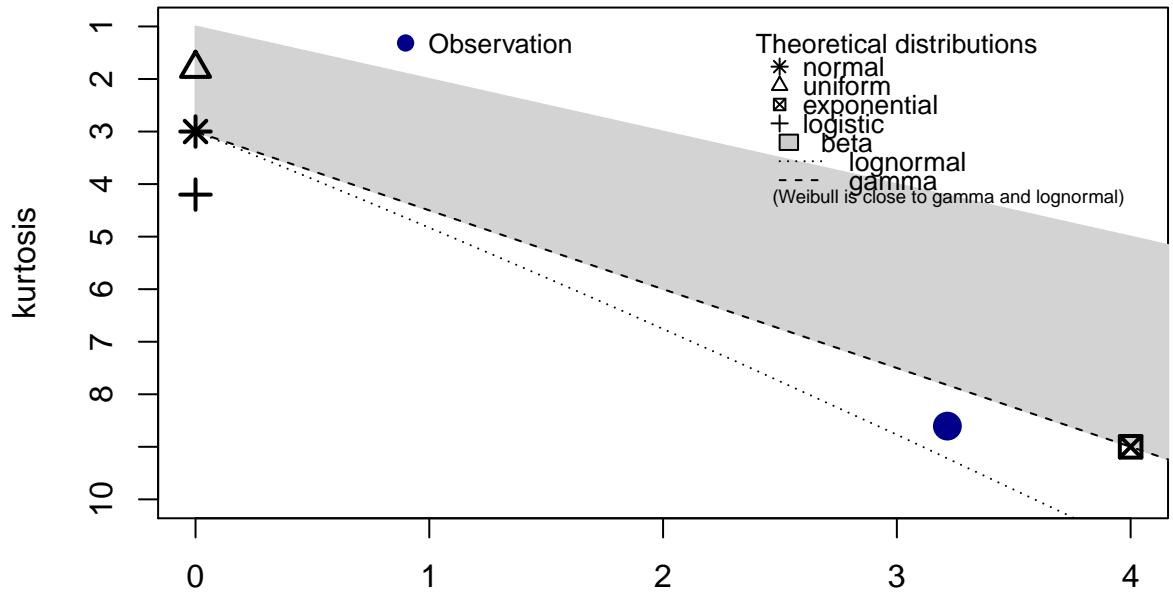
Table 16: Chi-Squared Test for Exponential Distribution with Rate 0.03394968

| Pass | Error | Critical Value |
|--------------|----------|----------------|
| Not rejected | 4.483978 | 7.814728 |

5.2 Planned Appointments

5.2.1 Queue Time

Cullen and Frey graph

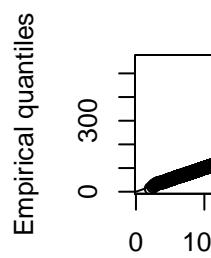
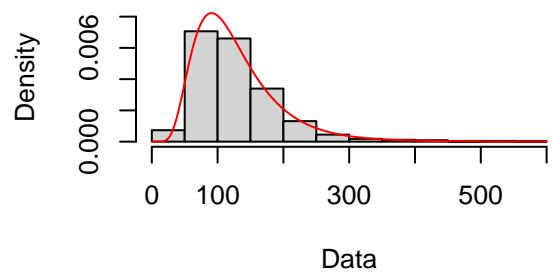


5.2.1.1 ASA1

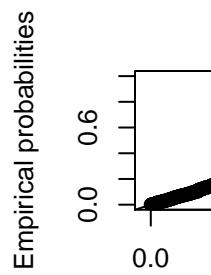
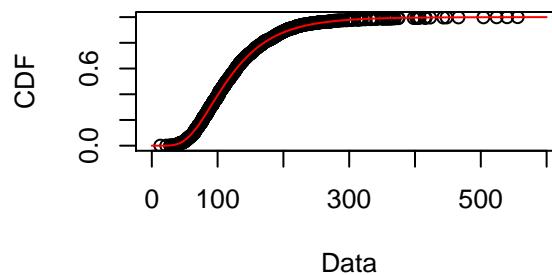
square of skewness

```
## summary statistics
## -----
## min: 13   max: 556
## median: 114
## mean: 127.7265
## estimated sd: 64.52942
## estimated skewness: 1.79333
## estimated kurtosis: 8.60614
```

Empirical and theoretical dens.



Empirical and theoretical CDFs



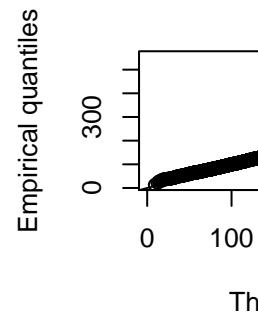
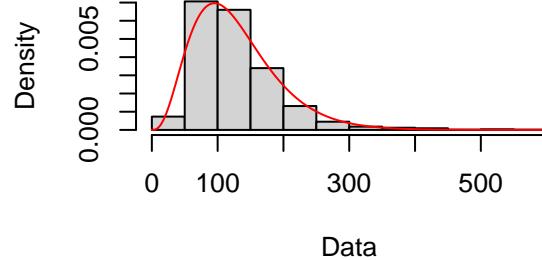
5.2.1.1.1 Testing for Lognormal Distribution

```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-lnorm
## Kolmogorov-Smirnov statistic 0.01654383
## Cramer-von Mises statistic  0.06195682
## Anderson-Darling statistic  0.63112144
##
## Goodness-of-fit criteria
##                               1-mme-lnorm
## Akaike's Information Criterion    21557.21
## Bayesian Information Criterion   21568.41
##
## [[2]]
## Fitting of the distribution ' lnorm ' by matching moments
## Parameters :
##       estimate
## meanlog 4.7362772
## sdlog   0.4766837
## Loglikelihood: -10776.6   AIC: 21557.21   BIC: 21568.41
```

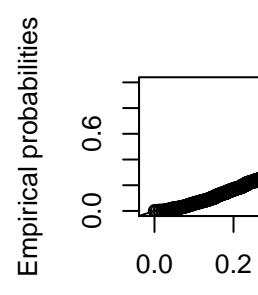
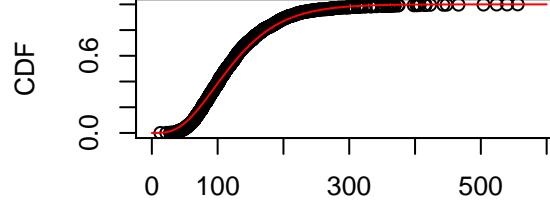
Table 17: Chi-Squared Test for Lognormal Distribution with
MeanLog 4.7362772 and SdLog 0.4766837

| Pass | Error | Critical Value |
|--------------|----------|----------------|
| Not rejected | 5.192523 | 9.487729 |

Empirical and theoretical dens.



Empirical and theoretical CDFs



5.2.1.1.2 Testing for Gamma Distribution

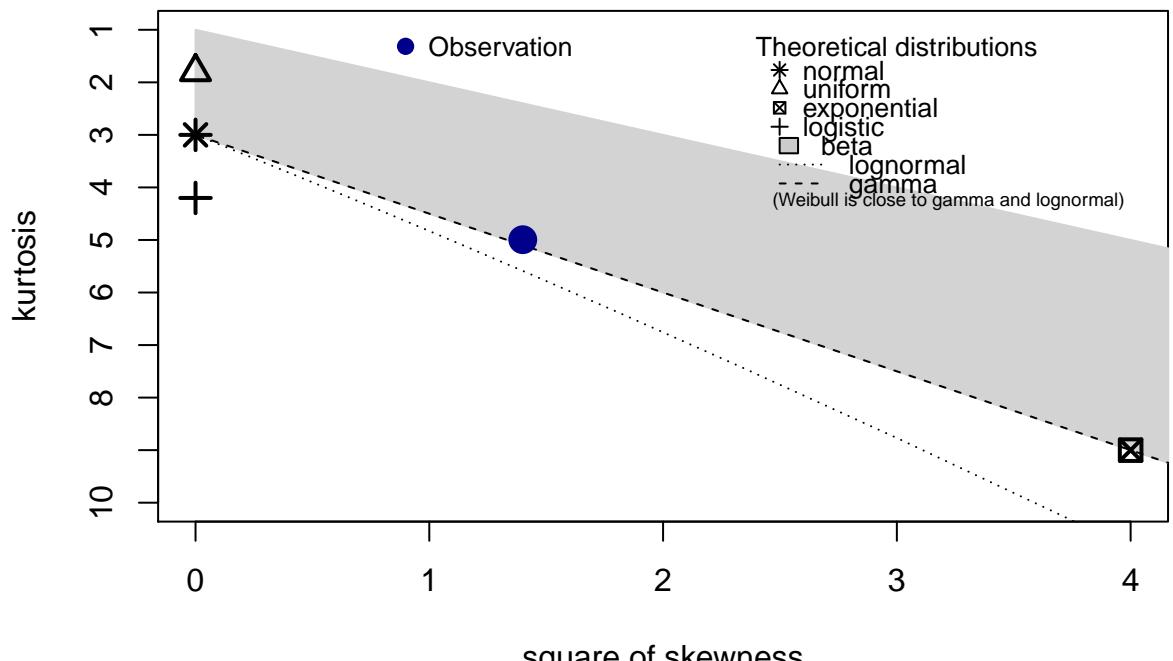
```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-gamma
## Kolmogorov-Smirnov statistic 0.05008021
## Cramer-von Mises statistic  1.31740467
## Anderson-Darling statistic 10.95928126
##
## Goodness-of-fit criteria
##                               1-mme-gamma
## Akaike's Information Criterion    21678.92
## Bayesian Information Criterion   21690.12
##
## [[2]]
## Fitting of the distribution 'gamma' by matching moments
## Parameters :
##       estimate
## shape 3.91979880
## rate  0.03068901
```

```
## Loglikelihood: -10837.46 AIC: 21678.92 BIC: 21690.12
```

Table 18: Chi-Squared Test for Gamma Distribution with Shape 3.9197988 and Rate 0.03068901

| Pass | Error | Critical Value |
|----------|----------|----------------|
| Rejected | 22.16605 | 7.814728 |

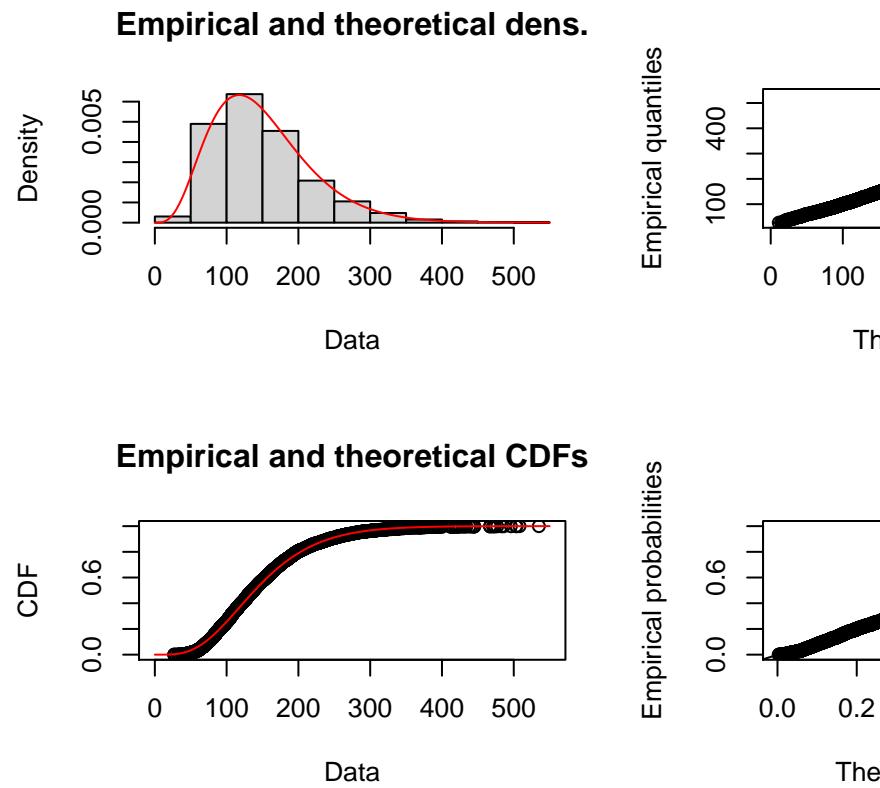
Cullen and Frey graph



5.2.1.2 ASA 2

square of skewness

```
## summary statistics
## -----
## min: 27   max: 535
## median: 137
## mean: 149.8057
## estimated sd: 69.58894
## estimated skewness: 1.183166
## estimated kurtosis: 4.995085
```



5.2.1.2.1 Testing for Gamma Distribution

```

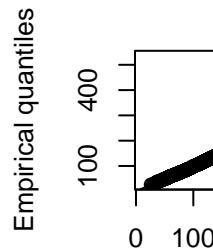
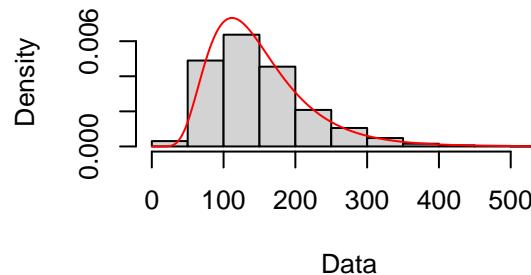
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-gamma
## Kolmogorov-Smirnov statistic 0.02925145
## Cramer-von Mises statistic  0.92462179
## Anderson-Darling statistic  9.11450436
##
## Goodness-of-fit criteria
##                               1-mme-gamma
## Akaike's Information Criterion    64053.78
## Bayesian Information Criterion   64067.10
##
## [[2]]
## Fitting of the distribution ' gamma ' by matching moments
## Parameters :
##     estimate
## shape 4.6350196
## rate 0.0309402
## Loglikelihood: -32024.89 AIC: 64053.78 BIC: 64067.1

```

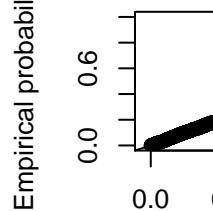
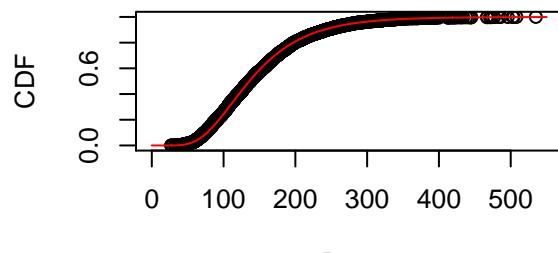
Table 19: Chi-Squared Test for Gamma Distribution with Shape 4.6350196 and Rate 0.0309402

| Pass | Error | Critical Value |
|--------------|----------|----------------|
| Not rejected | 20.84311 | 21.02607 |

Empirical and theoretical dens.



Empirical and theoretical CDFs



5.2.1.2.2 Testing for Lognormal Distribution

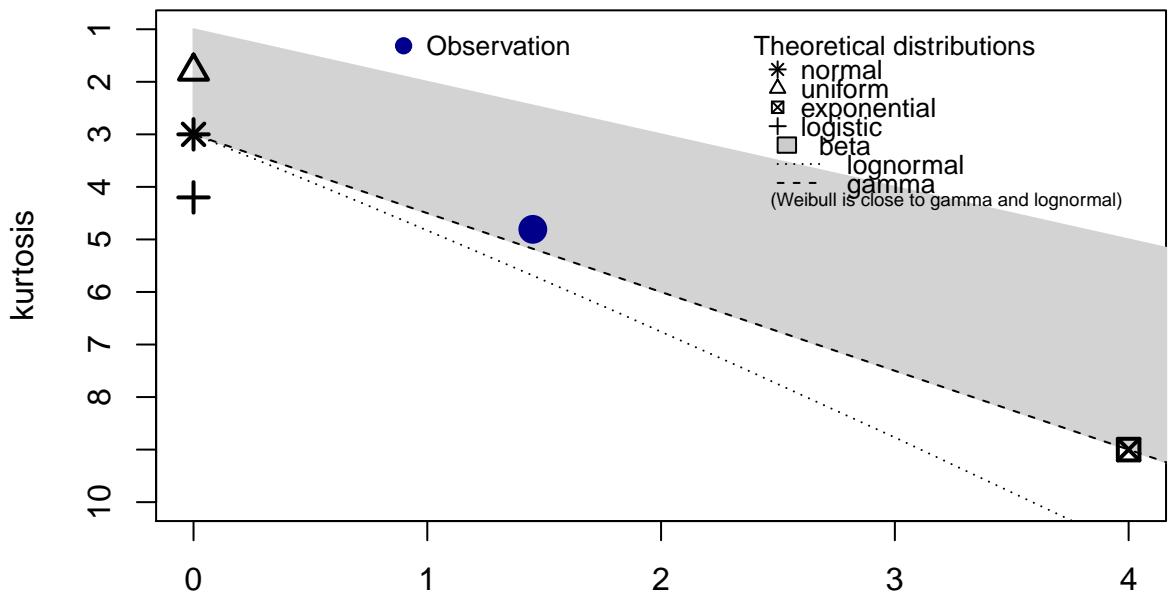
```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-lnorm
## Kolmogorov-Smirnov statistic 0.02588754
## Cramer-von Mises statistic  0.74568786
## Anderson-Darling statistic  5.00402712
##
## Goodness-of-fit criteria
##                               1-mme-lnorm
## Akaike's Information Criterion    63930.79
## Bayesian Information Criterion   63944.11
##
## [[2]]
## Fitting of the distribution ' lnorm ' by matching moments
## Parameters :
##       estimate
## meanlog 4.9116591
## sdlog   0.4419957
```

```
## Loglikelihood: -31963.4 AIC: 63930.79 BIC: 63944.11
```

Table 20: Chi-Squared Test for Lognormal Distribution with MeanLog 4.9116591 and SdLog 0.4419957

| Pass | Error | Critical Value |
|----------|----------|----------------|
| Rejected | 38.91663 | 22.36203 |

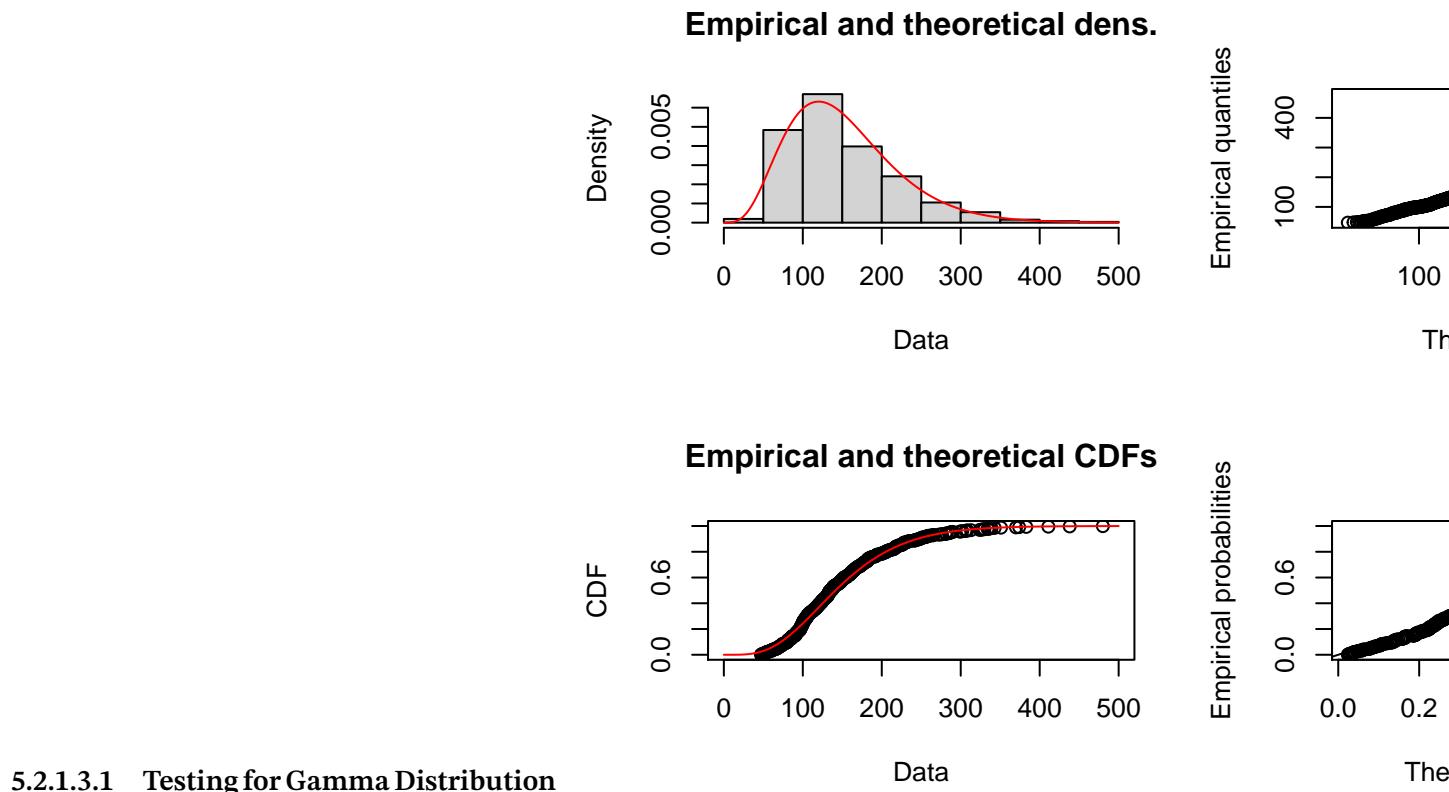
Cullen and Frey graph



5.2.1.3 ASA 3

square of skewness

```
## summary statistics
## -----
## min: 47 max: 480
## median: 136
## mean: 151.883
## estimated sd: 69.55987
## estimated skewness: 1.204725
## estimated kurtosis: 4.808147
```



5.2.1.3.1 Testing for Gamma Distribution

```

## [[1]]
## Goodness-of-fit statistics
##                               1-mme-gamma
## Kolmogorov-Smirnov statistic   0.0467720
## Cramer-von Mises statistic    0.2687312
## Anderson-Darling statistic   1.8789186
##
## Goodness-of-fit criteria
##                               1-mme-gamma
## Akaike's Information Criterion 5691.367
## Bayesian Information Criterion 5699.847
##
## [[2]]
## Fitting of the distribution ' gamma ' by matching moments
## Parameters :
##     estimate
## shape 4.77692467
## rate 0.03145134
## Loglikelihood: -2843.683 AIC: 5691.367 BIC: 5699.847

```

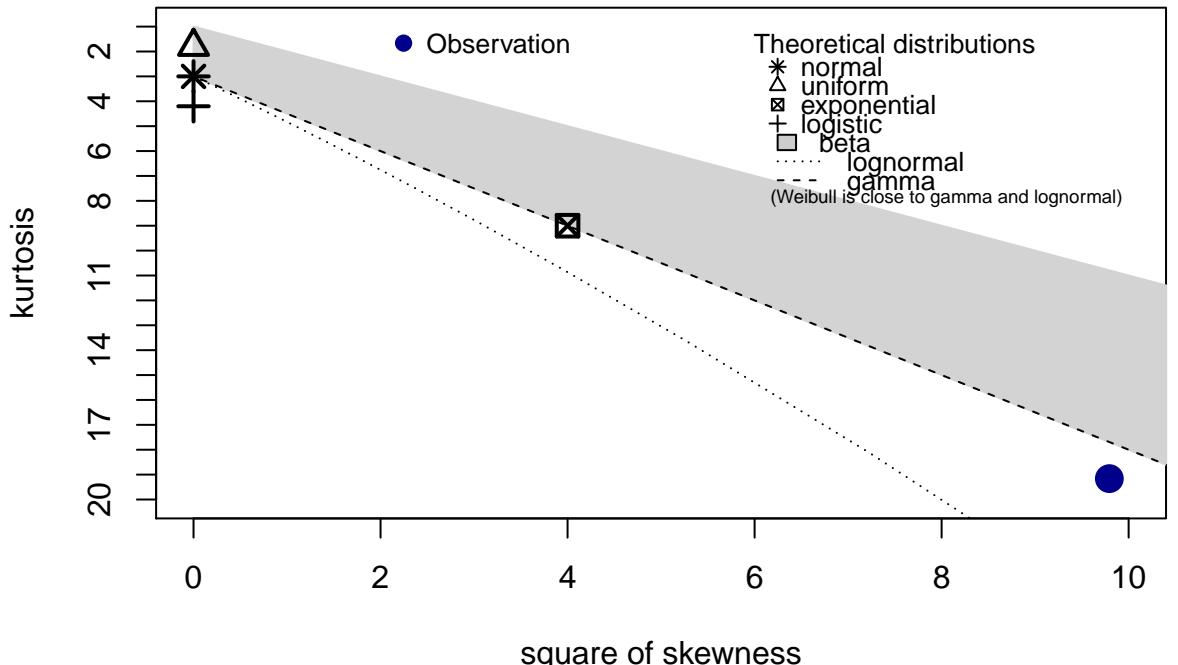
Table 21: Chi-Squared Test for Gamma Distribution with Shape 4.77692467 and Rate 0.03145134

| Pass | Error | Critical Value |
|--------------|----------|----------------|
| Not rejected | 13.61228 | 14.06714 |

5.2.2 Consult Duration

Adjusted version, meaning that the consult duration was shifted by 15 minutes, unless otherwise stated.

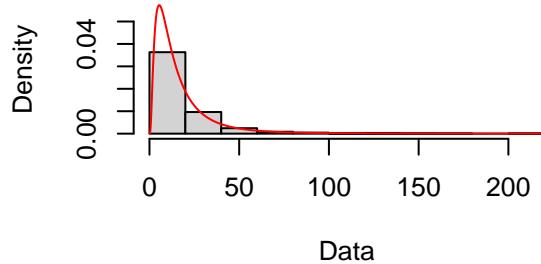
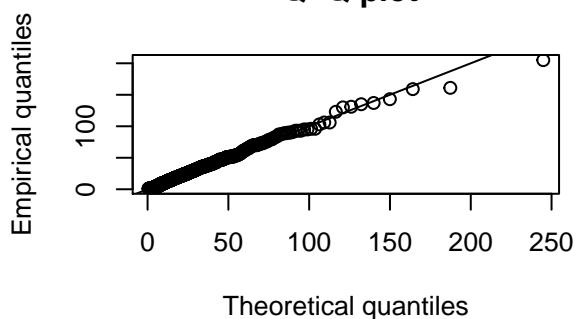
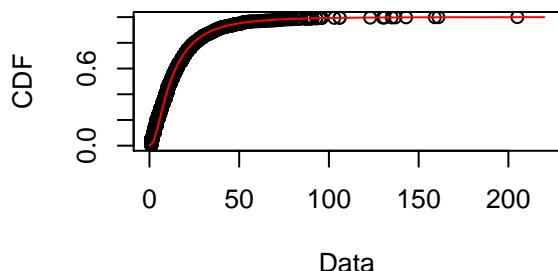
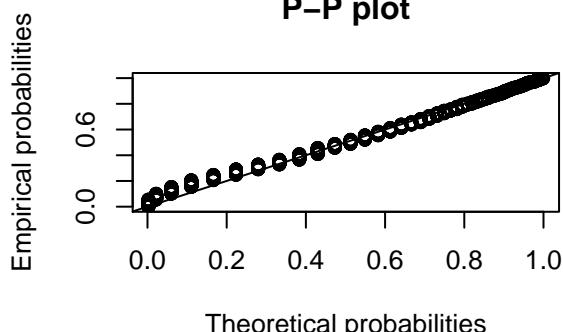
Cullen and Frey graph



5.2.2.1 ASA1

```
## summary statistics
## -----
## min: 0   max: 204
## median: 11
## mean: 16.10571
## estimated sd: 18.33906
## estimated skewness: 3.129485
## estimated kurtosis: 19.16101
```

5.2.2.1.1 Testing for Lognormal Distribution The lognormal distribution requires numbers above 0. Hence, the shifting in this case is by 14, such that the minimum is 1.

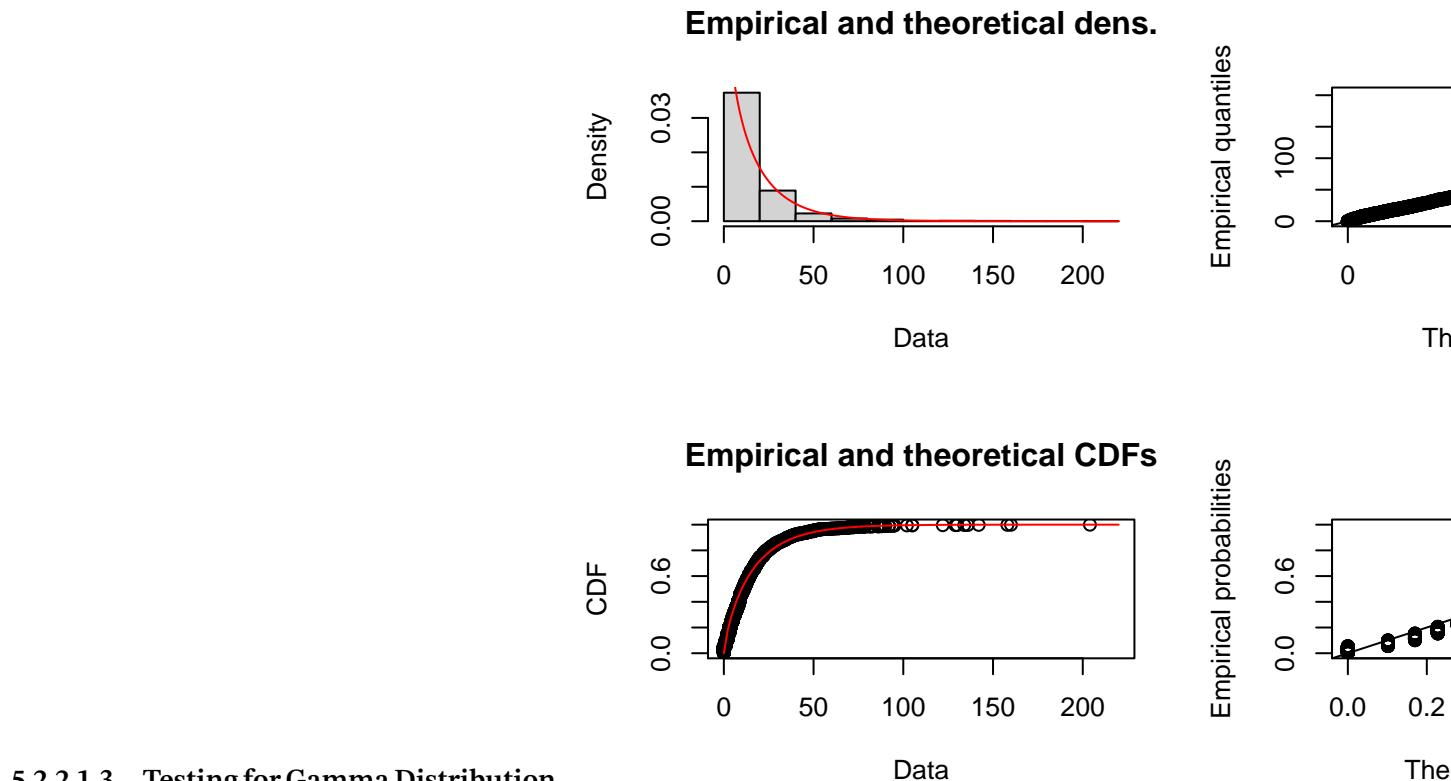
Empirical and theoretical dens.**Q-Q plot****Empirical and theoretical CDFs****P-P plot**

```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-lnorm
## Kolmogorov-Smirnov statistic   0.0954679
## Cramer-von Mises statistic    2.2509975
## Anderson-Darling statistic   34.5996657
##
## Goodness-of-fit criteria
##                               1-mme-lnorm
## Akaike's Information Criterion 15441.94
## Bayesian Information Criterion 15453.14
##
## [[2]]
## Fitting of the distribution ' lnorm ' by matching moments
## Parameters :
##     estimate
## meanlog 2.456952
## sdlog   0.874598
## Loglikelihood: -7718.972 AIC: 15441.94 BIC: 15453.14
```

Table 22: Chi-Squared Test for Lognormal Distribution with
MeanLog 2.456952 and SdLog 0.874598

| Pass | Error | Critical Value |
|--------------|----------|----------------|
| Not rejected | 16.66601 | 16.91898 |

5.2.2.1.2



5.2.2.1.3 Testing for Gamma Distribution

```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-gamma
## Kolmogorov-Smirnov statistic 0.07696044
## Cramer-von Mises statistic  2.50299959
## Anderson-Darling statistic   Inf
## 
## Goodness-of-fit criteria
##                               1-mme-gamma
## Akaike's Information Criterion      -Inf
## Bayesian Information Criterion     -Inf
## 
## [[2]]
## Fitting of the distribution ' gamma ' by matching moments
## Parameters :
##   estimate
```

```

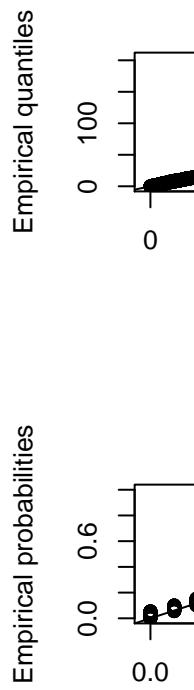
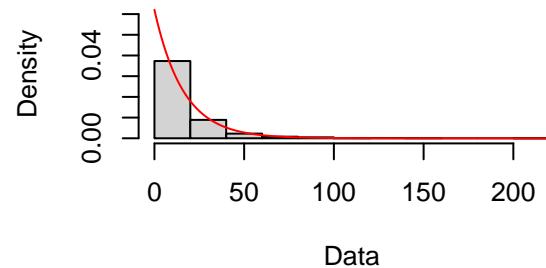
## shape 0.7716552
## rate 0.0479119
## Loglikelihood: Inf AIC: -Inf BIC: -Inf

```

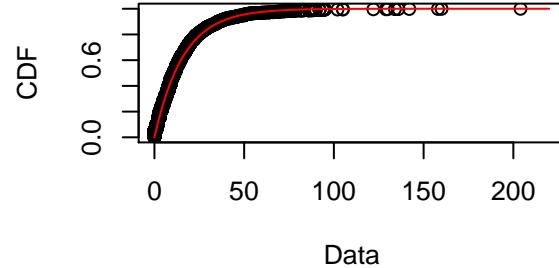
Table 23: Chi-Squared Test for Gamma Distribution with Shape 0.7716552 and Rate 0.0479119

| Pass | Error | Critical Value |
|--------------|----------|----------------|
| Not rejected | 13.26114 | 14.06714 |

Empirical and theoretical dens.



Empirical and theoretical CDFs



5.2.2.1.4 Testing for Exponential Distribution

```

## [[1]]
## Goodness-of-fit statistics
##                               1-mme-exp
## Kolmogorov-Smirnov statistic 0.05511022
## Cramer-von Mises statistic  0.63235091
## Anderson-Darling statistic   Inf
##
## Goodness-of-fit criteria
##                               1-mme-exp
## Akaike's Information Criterion 15088.46
## Bayesian Information Criterion 15094.06
##
## [[2]]
## Fitting of the distribution 'exp' by matching moments
## Parameters :

```

```

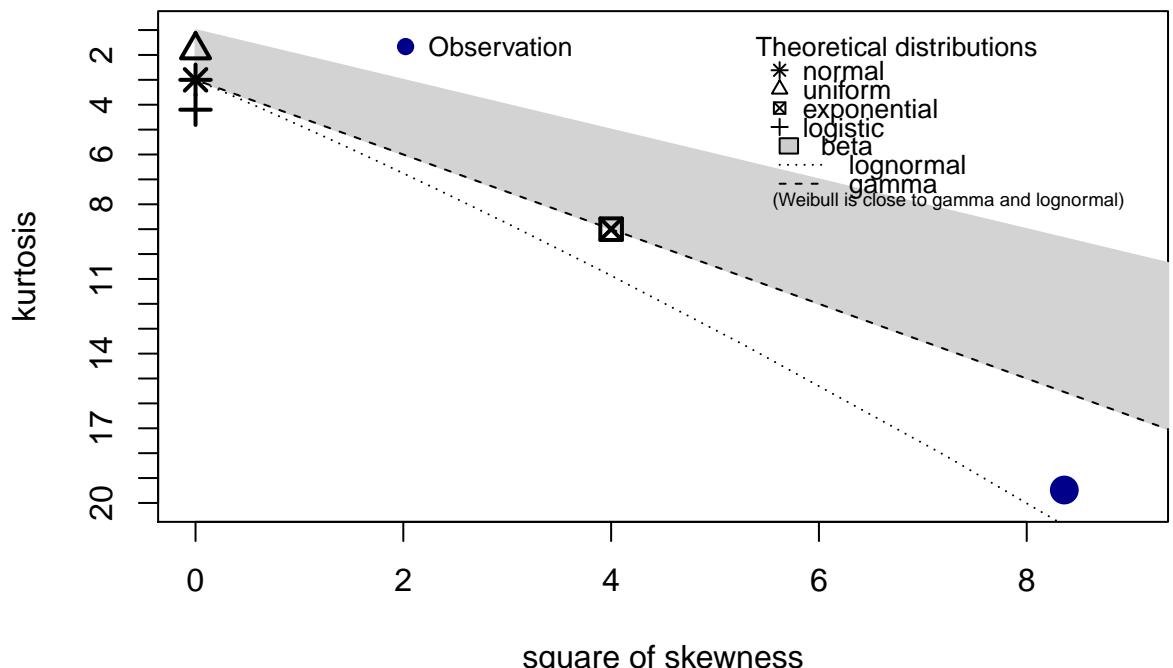
##       estimate
## rate 0.06208978
## Loglikelihood: -7543.231 AIC: 15088.46 BIC: 15094.06

```

Table 24: Chi-Squared Test for Exponential Distribution with Rate 0.06208978

| Pass | Error | Critical Value |
|----------|----------|----------------|
| Rejected | 34.53983 | 16.91898 |

Cullen and Frey graph



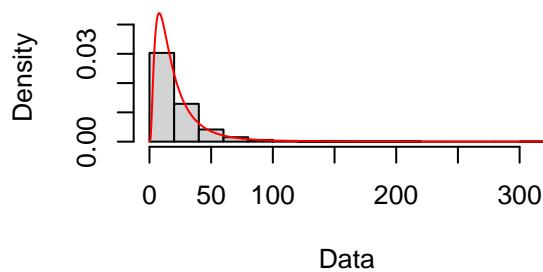
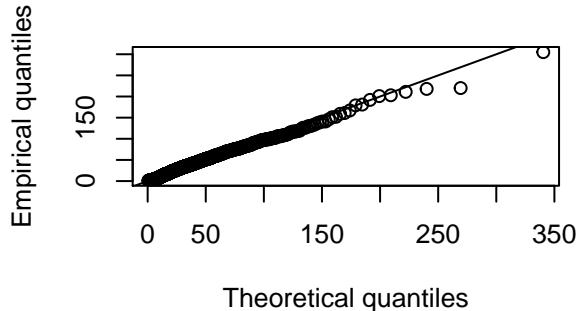
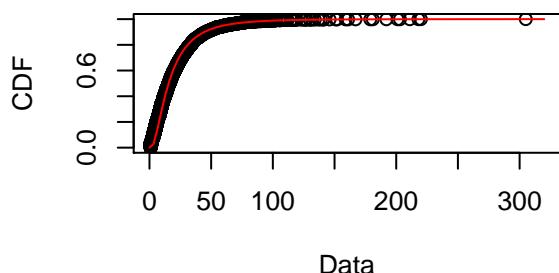
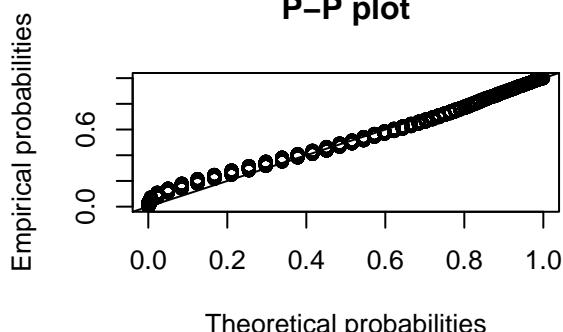
5.2.2.2 ASA 2

```

## summary statistics
## -----
## min: 1   max: 305
## median: 16
## mean: 21.73328
## estimated sd: 21.38637
## estimated skewness: 2.89165
## estimated kurtosis: 19.4802

```

5.2.2.2.1 Testing for Lognormal Distribution The lognormal distribution requires numbers above 0. Hence, the shifting in this case is by 14, such that the minimum is 1.

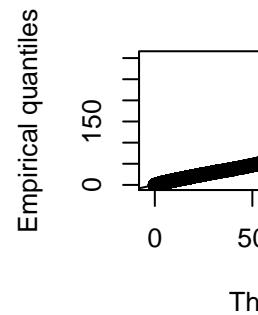
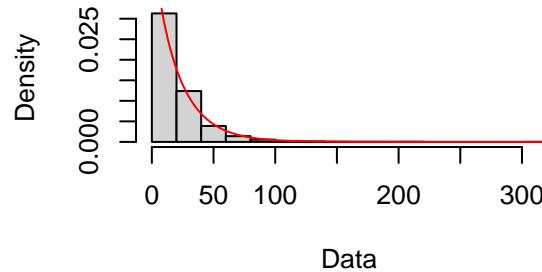
Empirical and theoretical dens.**Q-Q plot****Empirical and theoretical CDFs****P-P plot**

```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-lnorm
## Kolmogorov-Smirnov statistic   0.09452814
## Cramer-von Mises statistic    8.75709084
## Anderson-Darling statistic   133.97976693
##
## Goodness-of-fit criteria
##                               1-mme-lnorm
## Akaike's Information Criterion 47926.62
## Bayesian Information Criterion 47939.94
##
## [[2]]
## Fitting of the distribution ' lnorm ' by matching moments
## Parameters :
##     estimate
## meanlog 2.7402942
## sdlog   0.8228612
## Loglikelihood: -23961.31 AIC: 47926.62 BIC: 47939.94
```

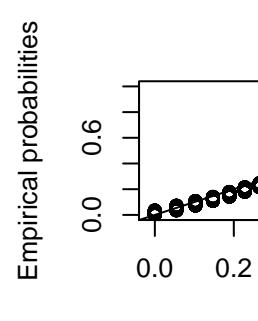
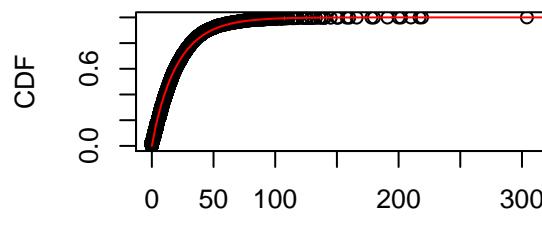
Table 25: Chi-Squared Test for Lognormal Distribution with
MeanLog 2.7402942 and SdLog 0.8228612

| Pass | Error | Critical Value |
|----------|----------|----------------|
| Rejected | 21.42409 | 7.814728 |

Empirical and theoretical dens.



Empirical and theoretical CDFs



5.2.2.2 Testing for Gamma Distribution

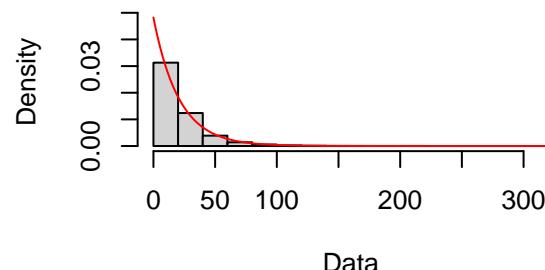
```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-gamma
## Kolmogorov-Smirnov statistic   0.0522794
## Cramer-von Mises statistic    2.6976054
## Anderson-Darling statistic     Inf
##
## Goodness-of-fit criteria
##                               1-mme-gamma
## Akaike's Information Criterion      -Inf
## Bayesian Information Criterion     -Inf
##
## [[2]]
## Fitting of the distribution 'gamma' by matching moments
## Parameters :
##       estimate
## shape 0.9400198
## rate  0.0453387
```

```
## Loglikelihood: Inf AIC: -Inf BIC: -Inf
```

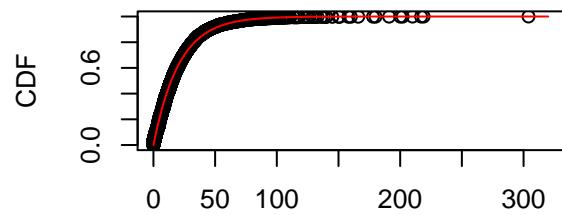
Table 26: Chi-Squared Test for Gamma Distribution with Shape 0.9400198 and Rate 0.0453387

| Pass | Error | Critical Value |
|--------------|---------|----------------|
| Not rejected | 5.40839 | 5.991465 |

Empirical and theoretical dens.

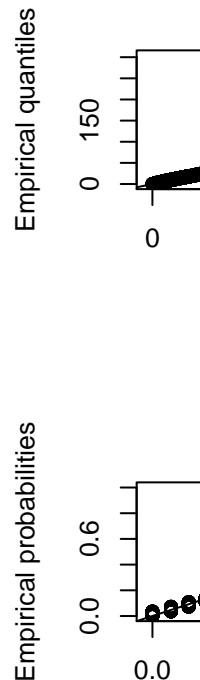


Empirical and theoretical CDFs



5.2.2.2.3 Testing for Exponential Distribution

```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-exp
## Kolmogorov-Smirnov statistic 0.03887442
## Cramer-von Mises statistic  1.26676599
## Anderson-Darling statistic      Inf
##
## Goodness-of-fit criteria
##                               1-mme-exp
## Akaike's Information Criterion 46528.28
## Bayesian Information Criterion 46534.94
##
## [[2]]
## Fitting of the distribution 'exp' by matching moments
## Parameters :
##   estimate
##   rate 0.04823165
```

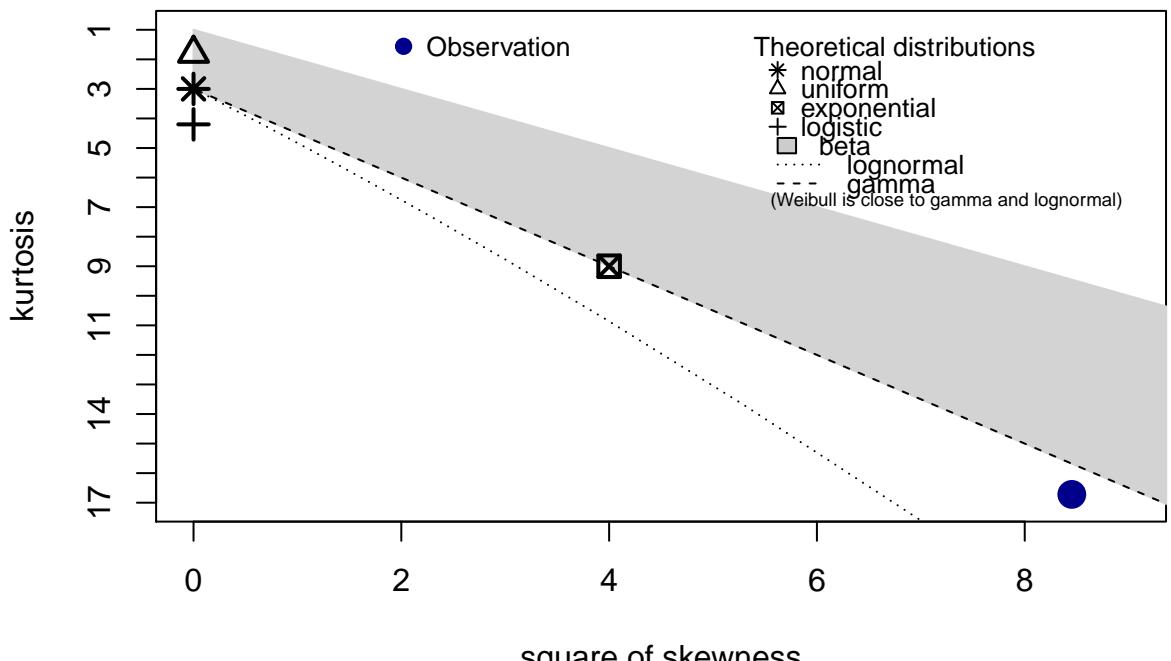


```
## Loglikelihood: -23263.14 AIC: 46528.28 BIC: 46534.94
```

Table 27: Chi-Squared Test for Exponential Distribution with Rate 0.04823165

| Pass | Error | Critical Value |
|--------------|----------|----------------|
| Not rejected | 11.10927 | 12.59159 |

Cullen and Frey graph

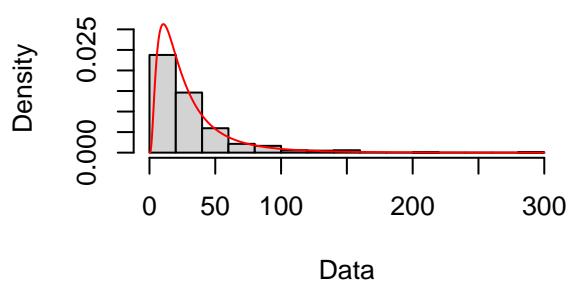
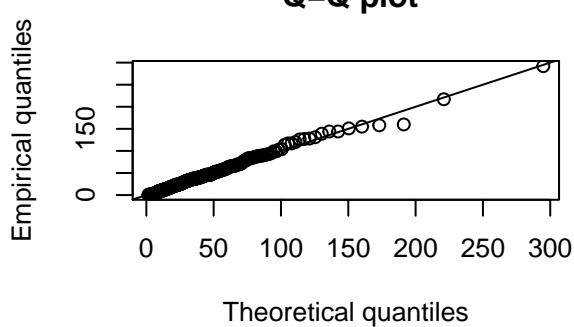
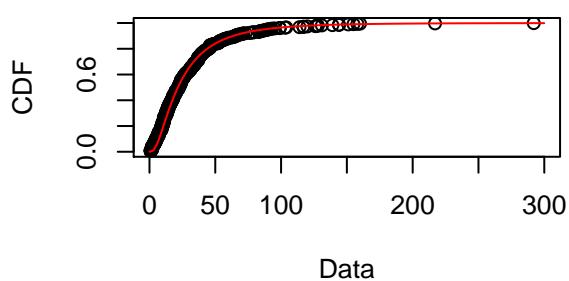
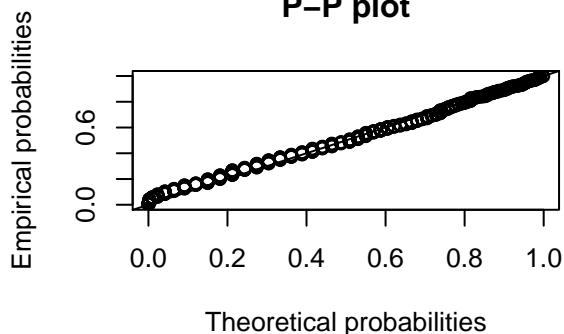


5.2.2.3 ASA 3

square of skewness

```
## summary statistics
## -----
## min: 1   max: 292
## median: 22
## mean: 30.81287
## estimated sd: 31.43551
## estimated skewness: 2.907392
## estimated kurtosis: 16.71943
```

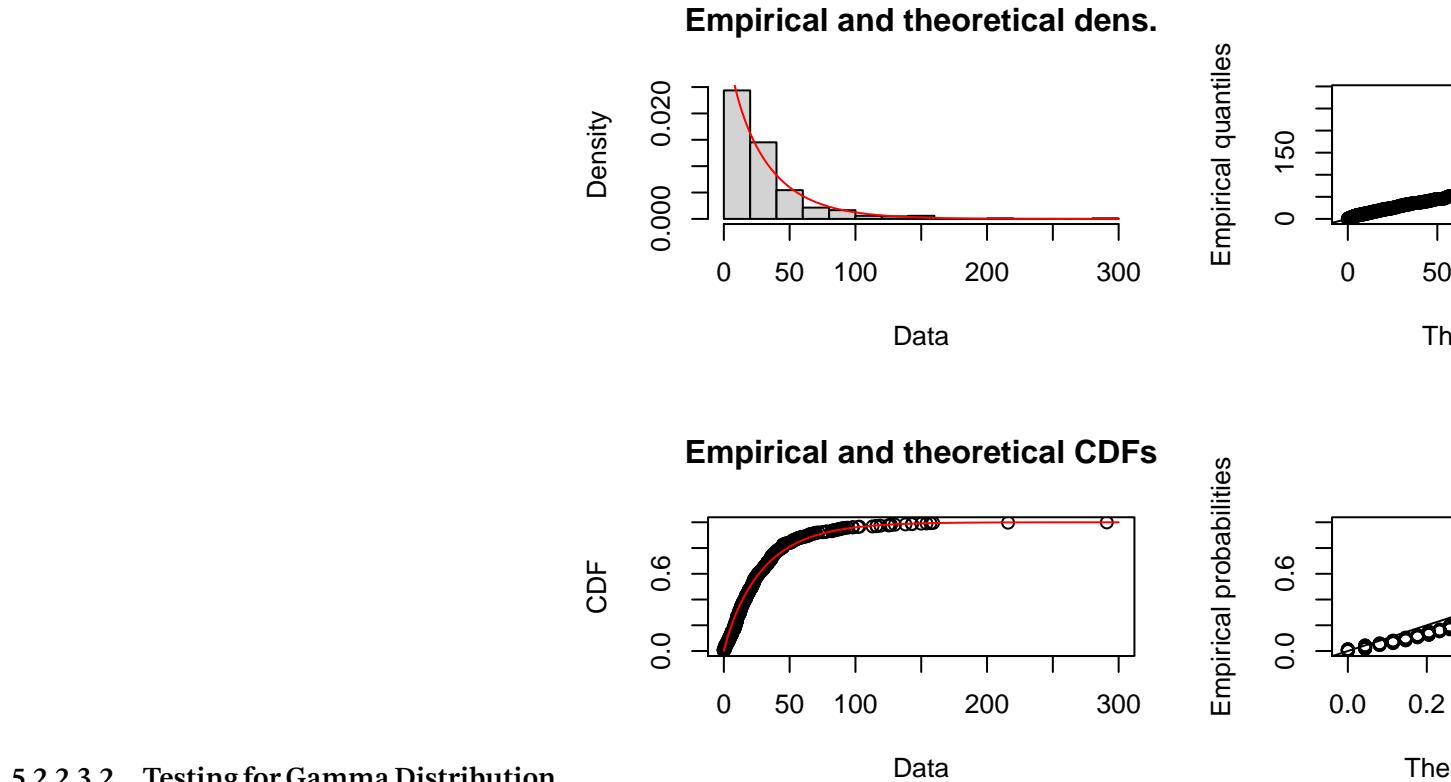
5.2.2.3.1 Testing for Lognormal Distribution The lognormal distribution requires numbers above 0. Hence, the shifting in this case is by 14, such that the minimum is 1.

Empirical and theoretical dens.**Q-Q plot****Empirical and theoretical CDFs****P-P plot**

```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-lnorm
## Kolmogorov-Smirnov statistic   0.0636774
## Cramer-von Mises statistic    0.3279006
## Anderson-Darling statistic    5.7790015
##
## Goodness-of-fit criteria
##                               1-mme-lnorm
## Akaike's Information Criterion 4577.690
## Bayesian Information Criterion 4586.171
##
## [[2]]
## Fitting of the distribution ' lnorm ' by matching moments
## Parameters :
##       estimate
## meanlog 3.0717530
## sdlog   0.8440134
## Loglikelihood: -2286.845 AIC: 4577.69 BIC: 4586.171
```

Table 28: Chi-Squared Test for Lognormal Distribution with
MeanLog 3.071753 and SdLog 0.8440134

| Pass | Error | Critical Value |
|--------------|----------|----------------|
| Not rejected | 4.778335 | 7.814728 |



5.2.2.3.2 Testing for Gamma Distribution

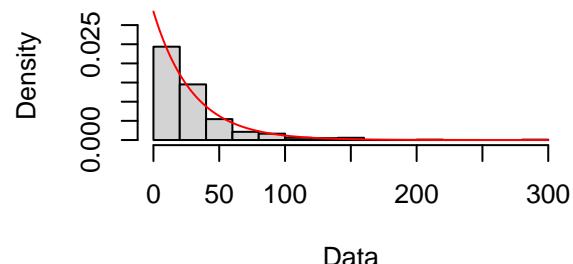
```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-gamma
## Kolmogorov-Smirnov statistic 0.09086619
## Cramer-von Mises statistic  0.72208232
## Anderson-Darling statistic      Inf
##
## Goodness-of-fit criteria
##                               1-mme-gamma
## Akaike's Information Criterion      -Inf
## Bayesian Information Criterion     -Inf
##
## [[2]]
## Fitting of the distribution 'gamma' by matching moments
## Parameters :
##   estimate
## shape 0.90118456
## rate  0.03022804
```

```
## Loglikelihood: Inf AIC: -Inf BIC: -Inf
```

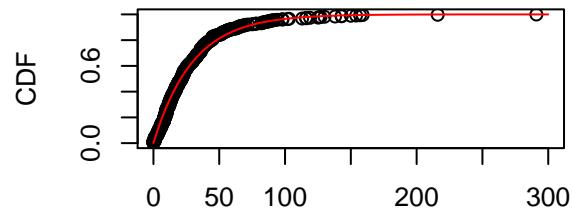
Table 29: Chi-Squared Test for Gamma Distribution with Shape 0.90118456 and Rate 0.03022804

| Pass | Error | Critical Value |
|--------------|----------|----------------|
| Not rejected | 8.379399 | 9.487729 |

Empirical and theoretical dens.

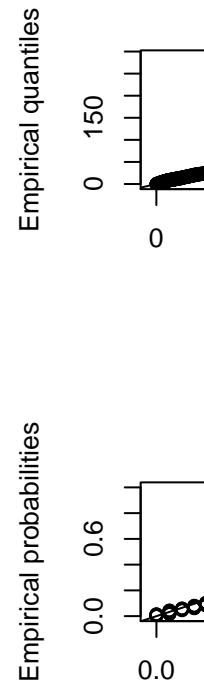


Empirical and theoretical CDFs



5.2.2.3.3 Testing for Exponential Distribution

```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-exp
## Kolmogorov-Smirnov statistic 0.06771132
## Cramer-von Mises statistic   0.34491026
## Anderson-Darling statistic      Inf
##
## Goodness-of-fit criteria
##                               1-mme-exp
## Akaike's Information Criterion 4511.208
## Bayesian Information Criterion 4515.449
##
## [[2]]
## Fitting of the distribution 'exp' by matching moments
## Parameters :
##     estimate
##     rate 0.03354257
```



```
## Loglikelihood: -2254.604 AIC: 4511.208 BIC: 4515.449
```

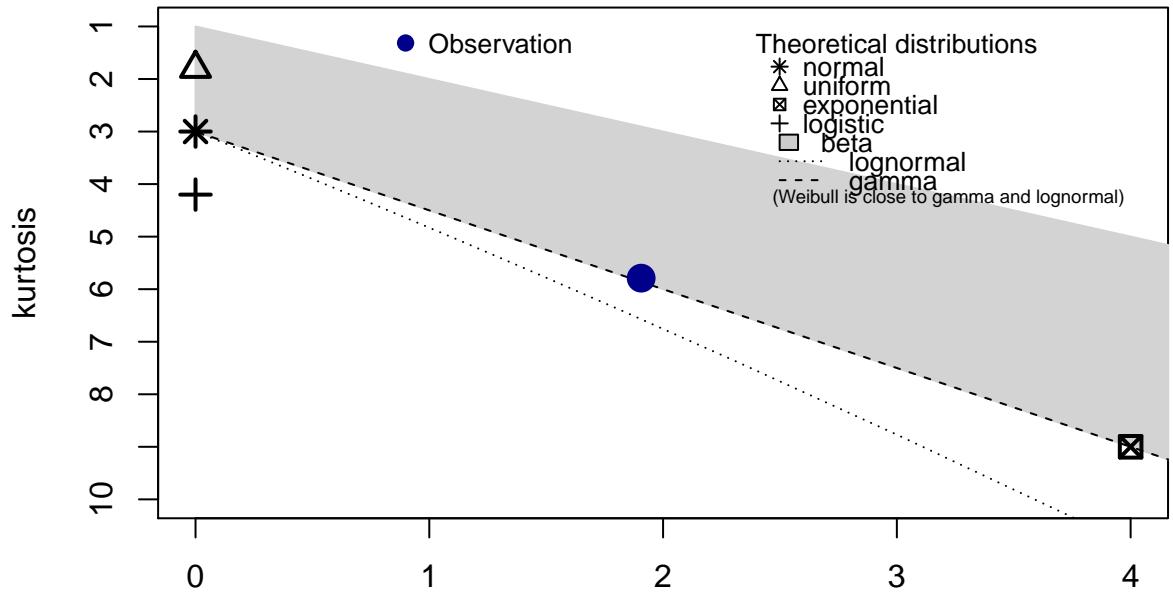
Table 30: Chi-Squared Test for Exponential Distribution with Rate 0.03354257

| Pass | Error | Critical Value |
|--------------|----------|----------------|
| Not rejected | 6.057588 | 11.0705 |

5.3 Walk-In Appointments

5.3.1 Queue Time

Cullen and Frey graph

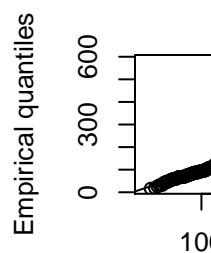
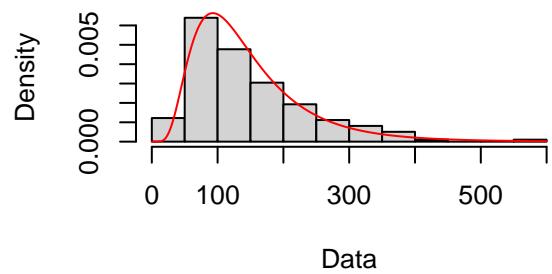


5.3.1.1 ASA1

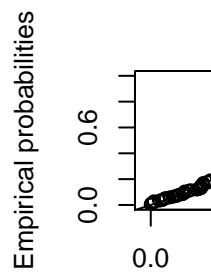
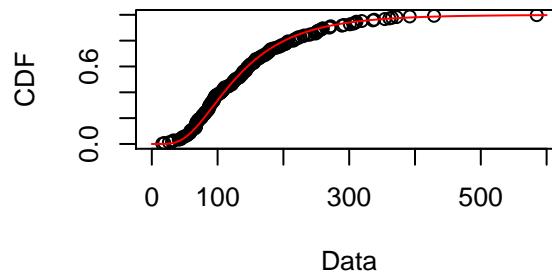
square of skewness

```
## summary statistics
## -----
## min: 16   max: 585
## median: 127
## mean: 147.3503
## estimated sd: 88.83391
## estimated skewness: 1.380647
## estimated kurtosis: 5.790429
```

Empirical and theoretical dens.



Empirical and theoretical CDFs



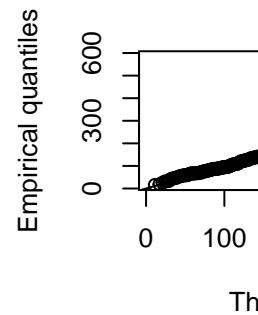
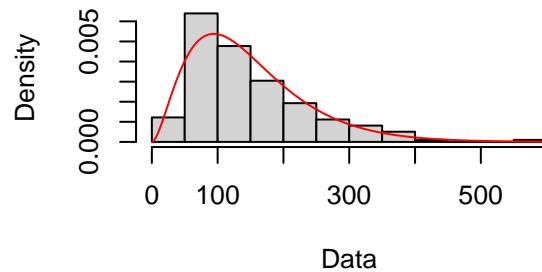
5.3.1.1.1 Testing for Lognormal Distribution

```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-lnorm
## Kolmogorov-Smirnov statistic   0.0596964
## Cramer-von Mises statistic    0.1086712
## Anderson-Darling statistic   0.7974009
##
## Goodness-of-fit criteria
##                               1-mme-lnorm
## Akaike's Information Criterion 2269.386
## Bayesian Information Criterion 2275.953
##
## [[2]]
## Fitting of the distribution ' lnorm ' by matching moments
## Parameters :
##     estimate
## meanlog 4.8384769
## sdlog   0.5555817
## Loglikelihood: -1132.693 AIC: 2269.386 BIC: 2275.953
```

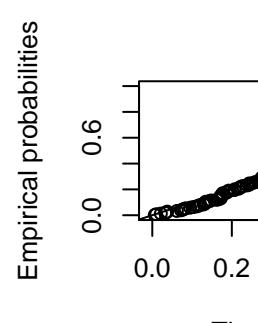
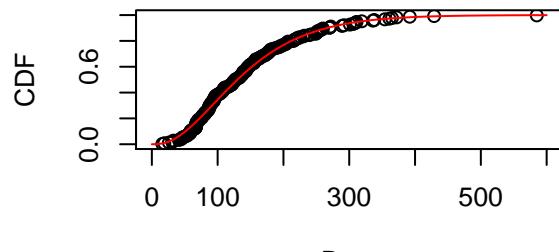
Table 31: Chi-Squared Test for Lognormal Distribution with
MeanLog 4.8384769 and SdLog 0.5555817

| Pass | Error | Critical Value |
|--------------|----------|----------------|
| Not rejected | 5.394277 | 9.487729 |

Empirical and theoretical dens.



Empirical and theoretical CDFs



5.3.1.1.2 Testing for Gamma Distribution

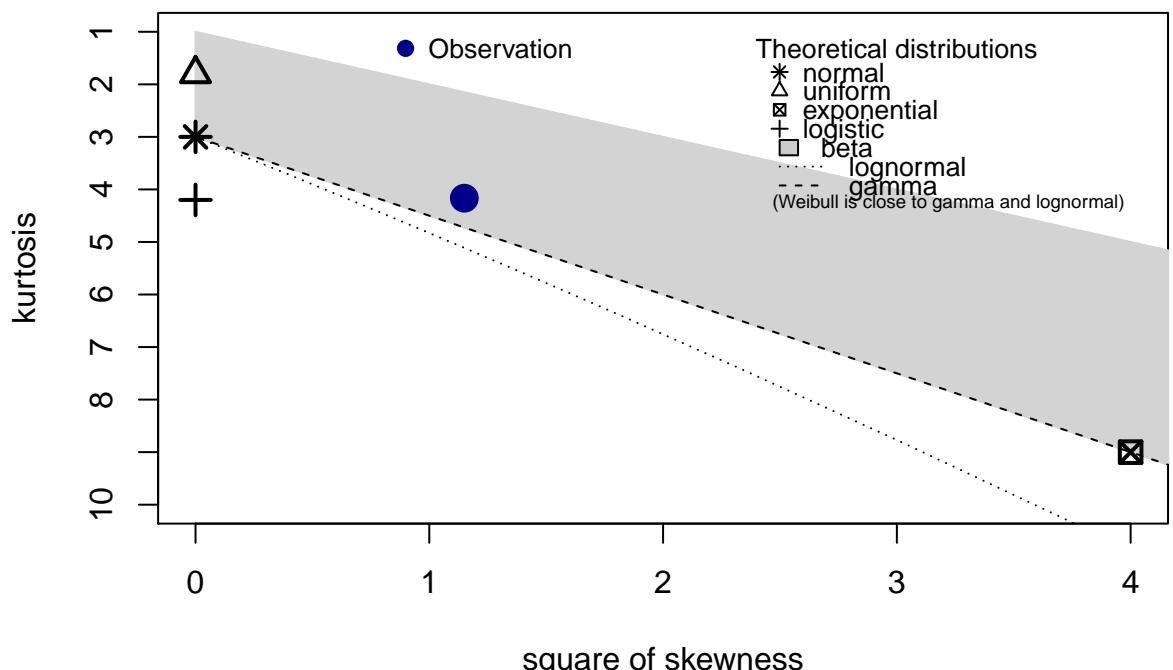
```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-gamma
## Kolmogorov-Smirnov statistic 0.04825587
## Cramer-von Mises statistic  0.08126044
## Anderson-Darling statistic  0.60684980
##
## Goodness-of-fit criteria
##                               1-mme-gamma
## Akaike's Information Criterion    2265.978
## Bayesian Information Criterion   2272.544
##
## [[2]]
## Fitting of the distribution 'gamma' by matching moments
## Parameters :
##       estimate
## shape 2.76537723
## rate  0.01876737
```

```
## Loglikelihood: -1130.989 AIC: 2265.978 BIC: 2272.544
```

Table 32: Chi-Squared Test for Gamma Distribution with Shape 2.76537723 and Rate 0.01876737

| Pass | Error | Critical Value |
|--------------|----------|----------------|
| Not rejected | 2.535864 | 7.814728 |

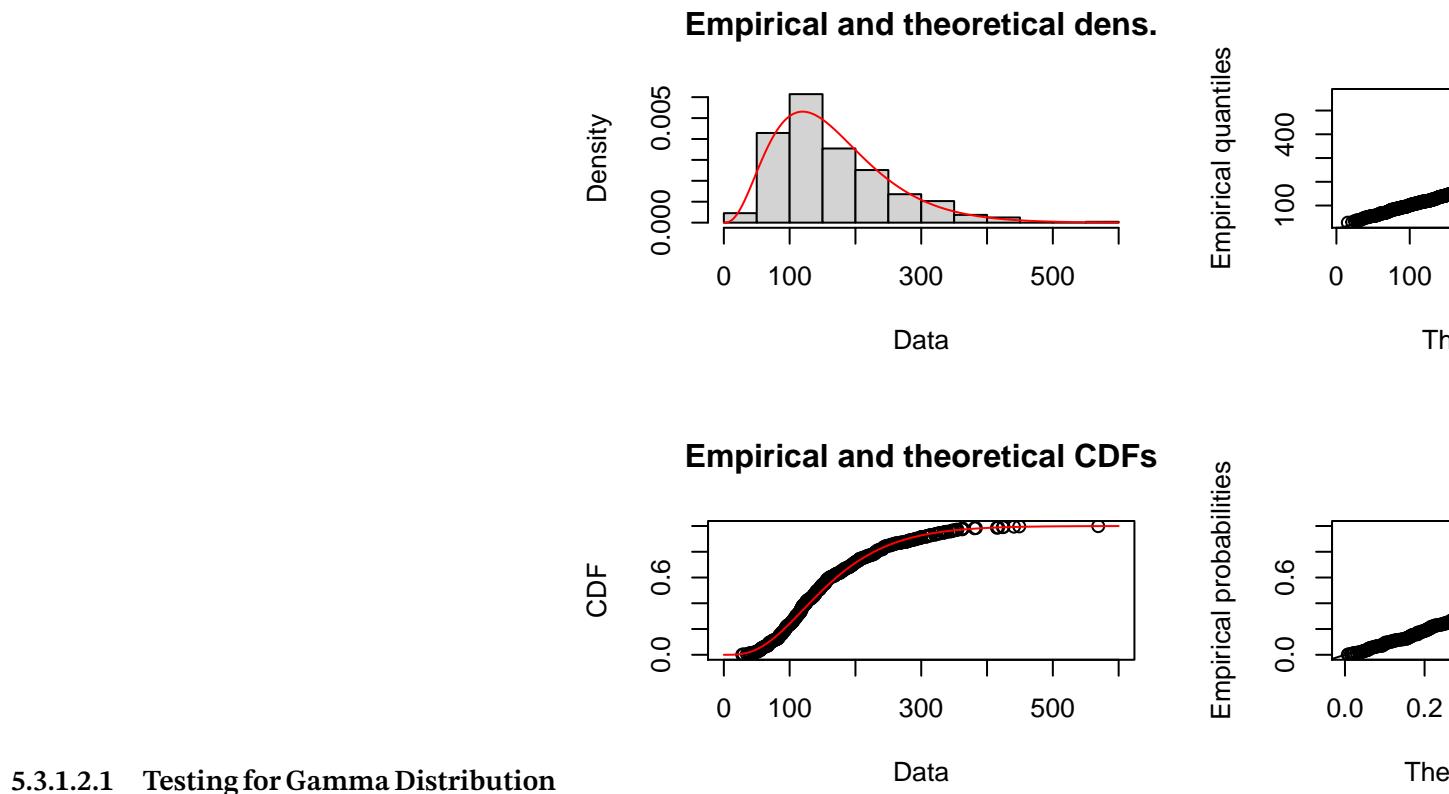
Cullen and Frey graph



5.3.1.2 ASA 2

square of skewness

```
## summary statistics
## -----
## min: 28   max: 569
## median: 143
## mean: 164.1196
## estimated sd: 85.41705
## estimated skewness: 1.072297
## estimated kurtosis: 4.166928
```



5.3.1.2.1 Testing for Gamma Distribution

```

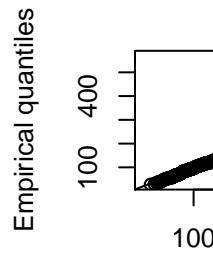
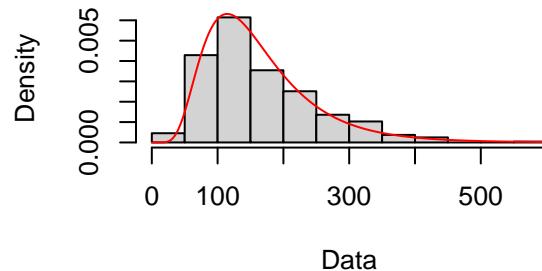
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-gamma
## Kolmogorov-Smirnov statistic 0.04899709
## Cramer-von Mises statistic  0.20490028
## Anderson-Darling statistic  1.22771882
##
## Goodness-of-fit criteria
##                               1-mme-gamma
## Akaike's Information Criterion      5576.171
## Bayesian Information Criterion     5584.539
##
## [[2]]
## Fitting of the distribution ' gamma ' by matching moments
## Parameters :
##   estimate
## shape 3.69937258
## rate 0.02254071
## Loglikelihood: -2786.086 AIC: 5576.171 BIC: 5584.539

```

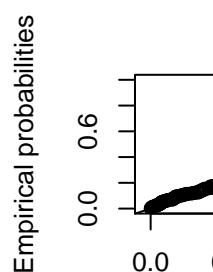
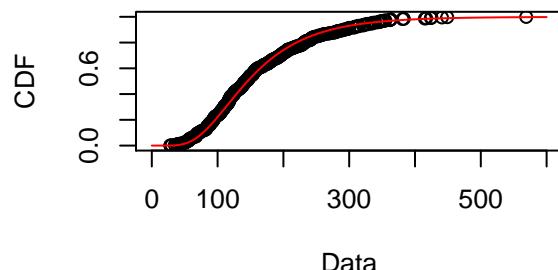
Table 33: Chi-Squared Test for Gamma Distribution with Shape 3.69937258 and Rate 0.02254071

| Pass | Error | Critical Value |
|--------------|----------|----------------|
| Not rejected | 21.08321 | 22.36203 |

Empirical and theoretical dens.



Empirical and theoretical CDFs



5.3.1.2.2 Testing for Lognormal Distribution

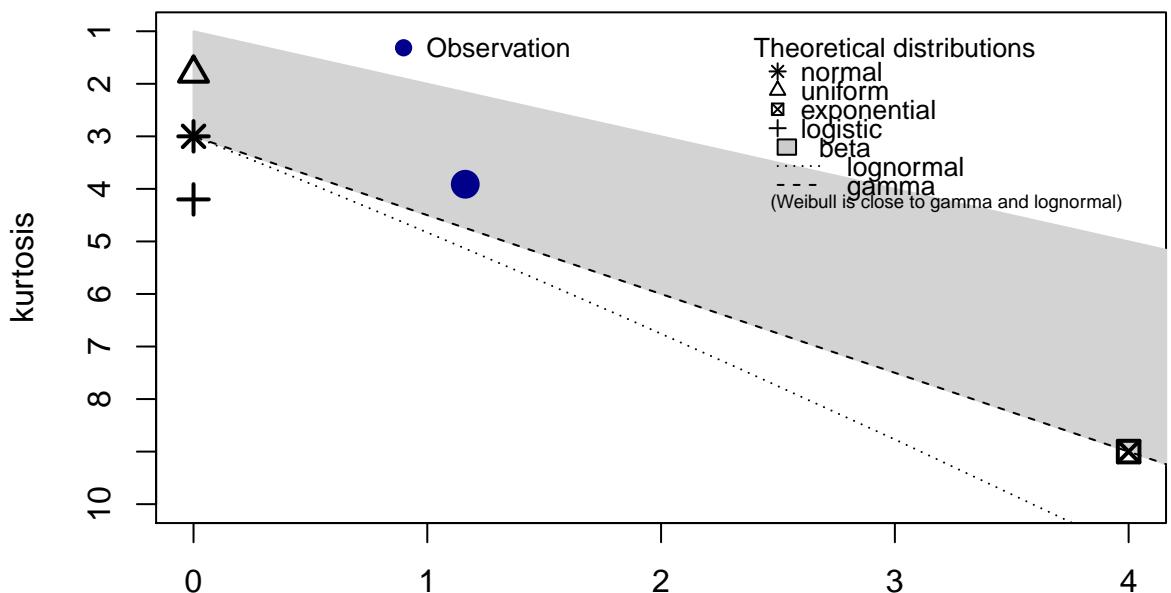
```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-lnorm
## Kolmogorov-Smirnov statistic 0.03889669
## Cramer-von Mises statistic  0.18078797
## Anderson-Darling statistic  1.48333130
##
## Goodness-of-fit criteria
##                               1-mme-lnorm
## Akaike's Information Criterion    5577.235
## Bayesian Information Criterion   5585.603
##
## [[2]]
## Fitting of the distribution 'lnorm' by matching moments
## Parameters :
##     estimate
## meanlog 4.980962
## sdlog   0.489148
```

```
## Loglikelihood: -2786.618 AIC: 5577.235 BIC: 5585.603
```

Table 34: Chi-Squared Test for Lognormal Distribution with MeanLog 4.980962 and SdLog 0.489148

| Pass | Error | Critical Value |
|--------------|----------|----------------|
| Not rejected | 18.26444 | 22.36203 |

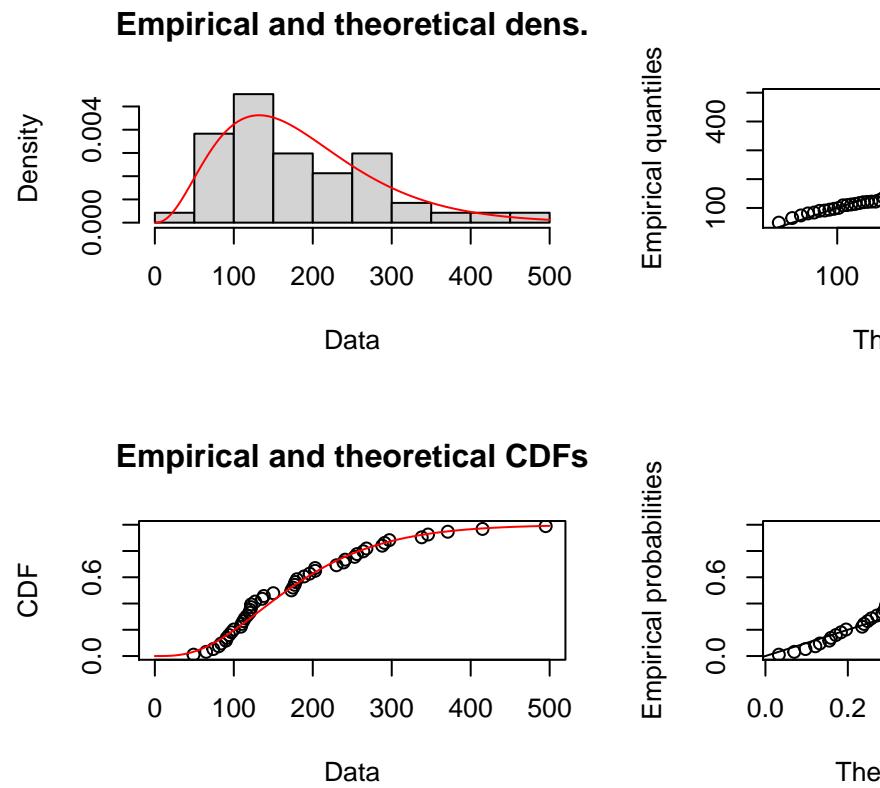
Cullen and Frey graph



5.3.1.3 ASA 3

square of skewness

```
## summary statistics
## -----
## min: 49   max: 495
## median: 173
## mean: 184.8723
## estimated sd: 99.8424
## estimated skewness: 1.078161
## estimated kurtosis: 3.911473
```



5.3.1.3.1 Testing for Gamma Distribution

```

## [[1]]
## Goodness-of-fit statistics
##                               1-mme-gamma
## Kolmogorov-Smirnov statistic 0.11069041
## Cramer-von Mises statistic  0.07231369
## Anderson-Darling statistic  0.42905363
##
## Goodness-of-fit criteria
##                               1-mme-gamma
## Akaike's Information Criterion      556.3347
## Bayesian Information Criterion     560.0350
##
## [[2]]
## Fitting of the distribution ' gamma ' by matching moments
## Parameters :
##   estimate
## shape 3.50311077
## rate 0.01894881
## Loglikelihood: -276.1673 AIC: 556.3347 BIC: 560.035

```

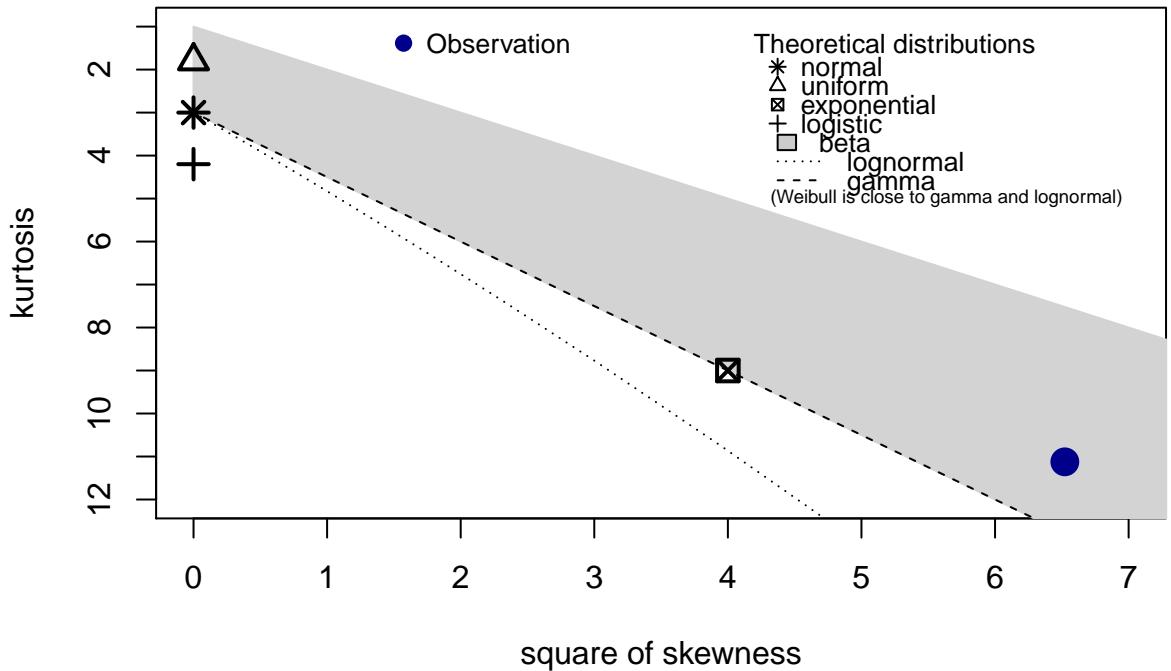
Table 35: Chi-Squared Test for Gamma Distribution with Shape 3.50311077 and Rate 0.01894881

| Pass | Error | Critical Value |
|--------------|----------|----------------|
| Not rejected | 7.495405 | 14.06714 |

5.3.2 Consult Duration

Adjusted version, meaning that the consult duration was shifted by 15 minutes, unless otherwise stated.

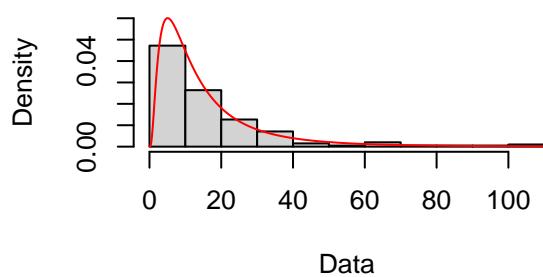
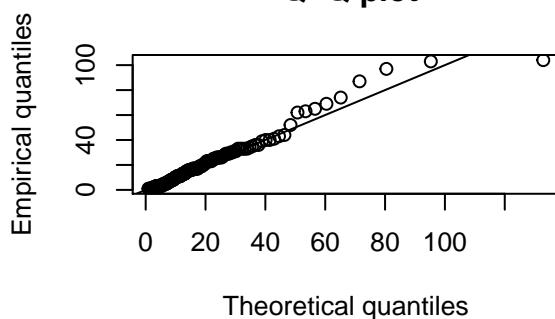
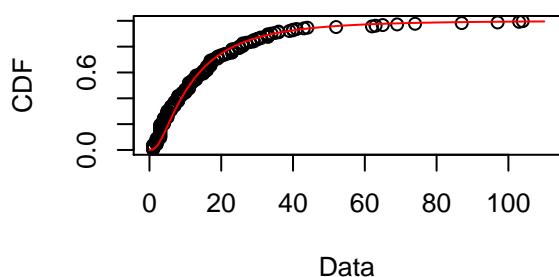
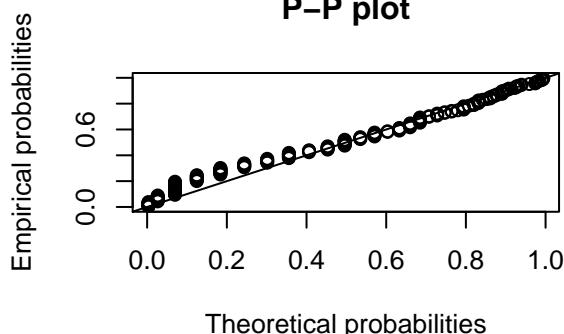
Cullen and Frey graph



5.3.2.1 ASA1

```
## summary statistics
## -----
## min: 0   max: 103
## median: 10
## mean: 15.43655
## estimated sd: 17.98986
## estimated skewness: 2.553924
## estimated kurtosis: 11.12355
```

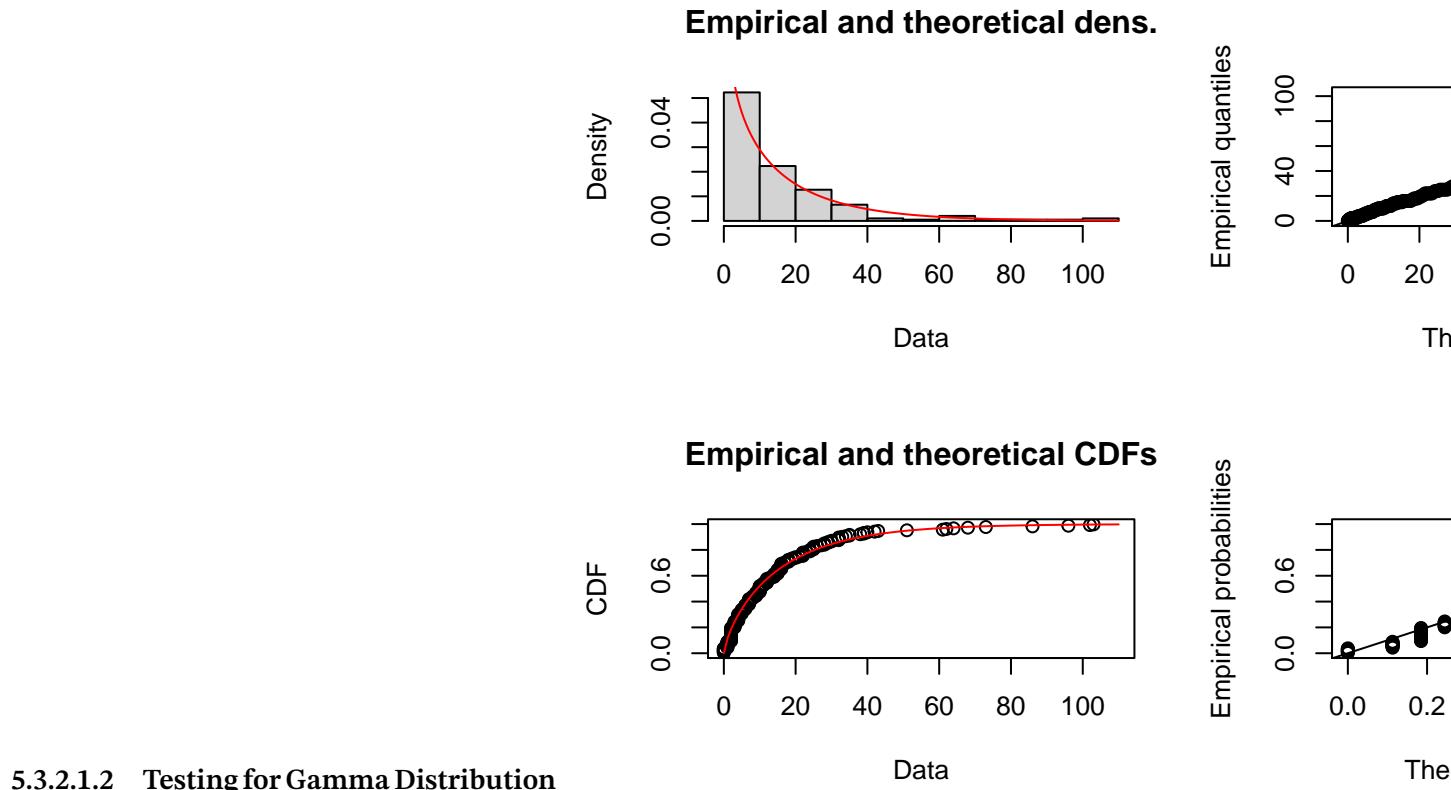
5.3.2.1.1 Testing for Lognormal Distribution The lognormal distribution requires numbers above 0. Hence, the shifting in this case is by 14, such that the minimum is 1.

Empirical and theoretical dens.**Q-Q plot****Empirical and theoretical CDFs****P-P plot**

```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-lnorm
## Kolmogorov-Smirnov statistic   0.1281475
## Cramer-von Mises statistic    0.4791926
## Anderson-Darling statistic   4.4066376
##
## Goodness-of-fit criteria
##                               1-mme-lnorm
## Akaike's Information Criterion 1502.302
## Bayesian Information Criterion 1508.868
##
## [[2]]
## Fitting of the distribution ' lnorm ' by matching moments
## Parameters :
##       estimate
## meanlog 2.4071329
## sdlog   0.8858606
## Loglikelihood: -749.1508 AIC: 1502.302 BIC: 1508.868
```

Table 36: Chi-Squared Test for Lognormal Distribution with
MeanLog 2.4071329 and SdLog 0.8858606

| Pass | Error | Critical Value |
|--------------|-----------|----------------|
| Not rejected | 0.8173222 | 7.814728 |



5.3.2.1.2 Testing for Gamma Distribution

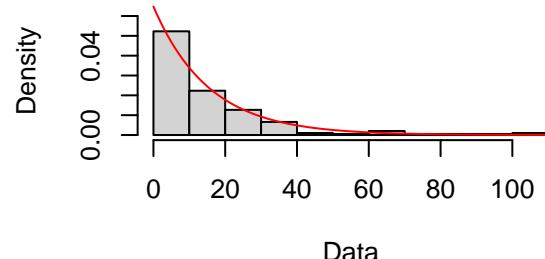
```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-gamma
## Kolmogorov-Smirnov statistic 0.09339454
## Cramer-von Mises statistic   0.16358727
## Anderson-Darling statistic    Inf
##
## Goodness-of-fit criteria
##                               1-mme-gamma
## Akaike's Information Criterion      -Inf
## Bayesian Information Criterion     -Inf
##
## [[2]]
## Fitting of the distribution 'gamma' by matching moments
## Parameters :
##       estimate
## shape 0.74003981
## rate  0.04794076
```

```
## Loglikelihood: Inf AIC: -Inf BIC: -Inf
```

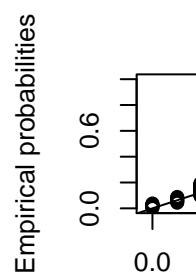
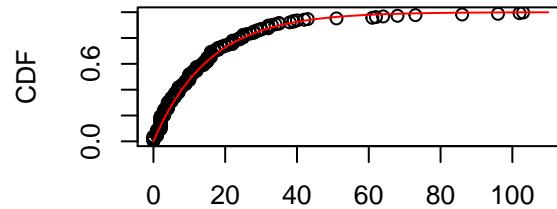
Table 37: Chi-Squared Test for Gamma Distribution with Shape 0.74003981 and Rate 0.04794076

| Pass | Error | Critical Value |
|--------------|----------|----------------|
| Not rejected | 12.19202 | 15.50731 |

Empirical and theoretical dens.



Empirical and theoretical CDFs



5.3.2.1.3 Testing for Exponential Distribution

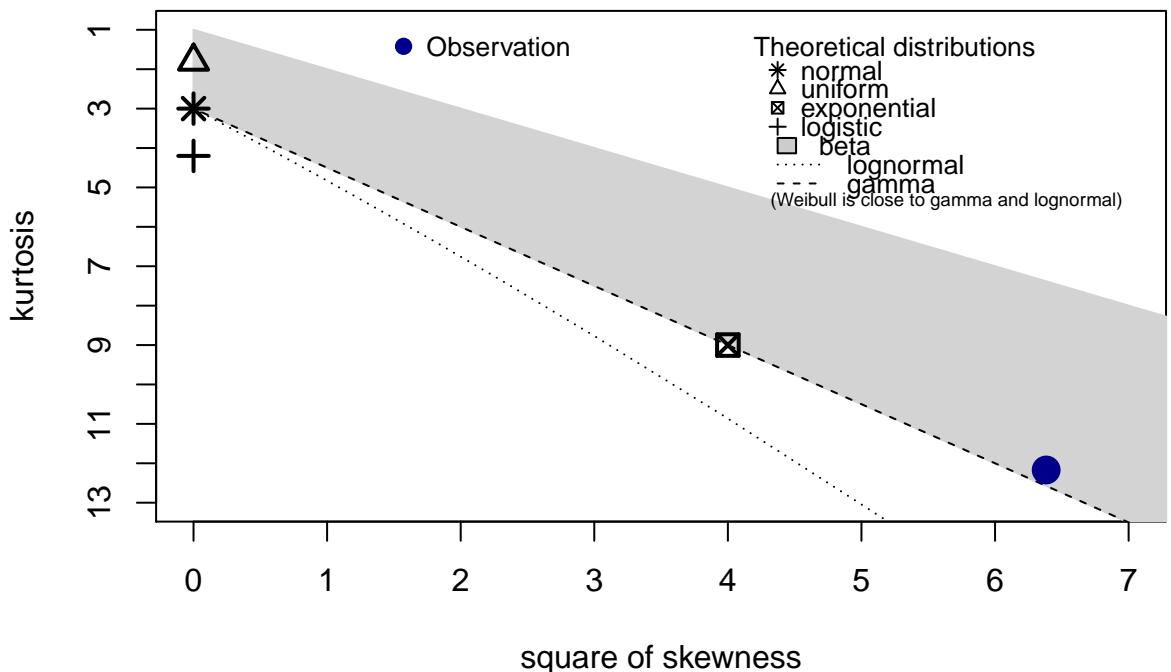
```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-exp
## Kolmogorov-Smirnov statistic 0.0764491
## Cramer-von Mises statistic   0.1701794
## Anderson-Darling statistic      Inf
##
## Goodness-of-fit criteria
##                               1-mme-exp
## Akaike's Information Criterion 1474.275
## Bayesian Information Criterion 1477.558
##
## [[2]]
## Fitting of the distribution 'exp' by matching moments
## Parameters :
##   estimate
##   rate 0.06478132
```

```
## Loglikelihood: -736.1374 AIC: 1474.275 BIC: 1477.558
```

Table 38: Chi-Squared Test for Exponential Distribution with Rate 0.06478132

| Pass | Error | Critical Value |
|--------------|----------|----------------|
| Not rejected | 10.57594 | 11.0705 |

Cullen and Frey graph

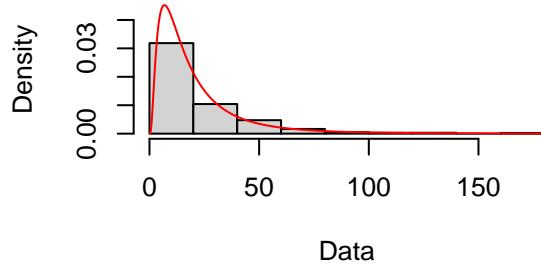
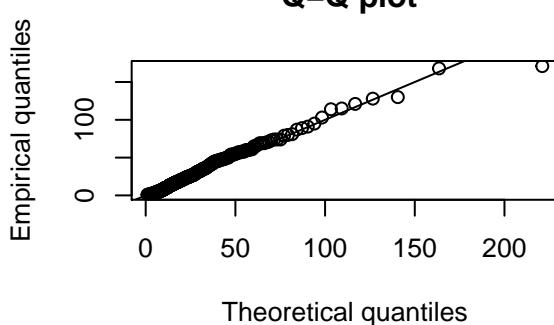
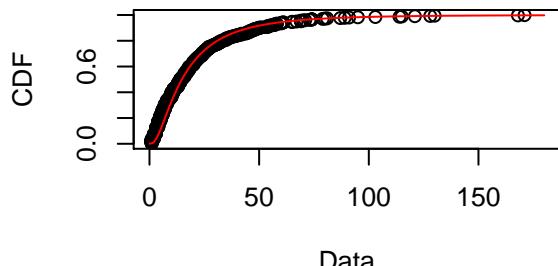
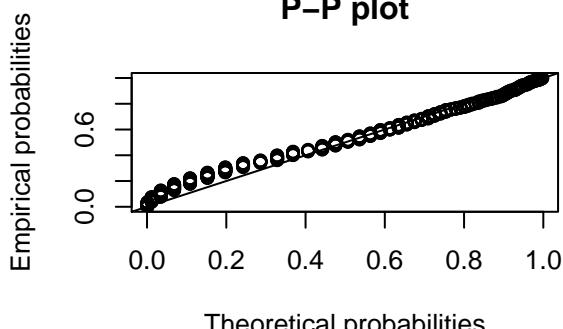


5.3.2.2 ASA 2

square of skewness

```
## summary statistics
## -----
## min: 1   max: 171
## median: 14
## mean: 21.72577
## estimated sd: 23.44355
## estimated skewness: 2.526401
## estimated kurtosis: 12.16981
```

5.3.2.2.1 Testing for Lognormal Distribution The lognormal distribution requires numbers above 0. Hence, the shifting in this case is by 14, such that the minimum is 1.

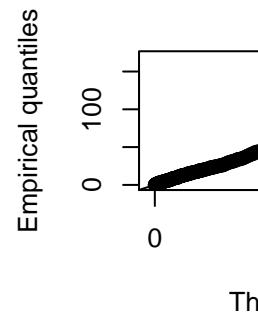
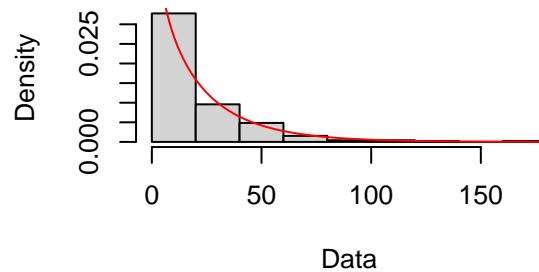
Empirical and theoretical dens.**Q-Q plot****Empirical and theoretical CDFs****P-P plot**

```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-lnorm
## Kolmogorov-Smirnov statistic   0.1140782
## Cramer-von Mises statistic    1.1855089
## Anderson-Darling statistic   13.0342018
##
## Goodness-of-fit criteria
##                               1-mme-lnorm
## Akaike's Information Criterion 4010.304
## Bayesian Information Criterion 4018.673
##
## [[2]]
## Fitting of the distribution ' lnorm ' by matching moments
## Parameters :
##     estimate
## meanlog 2.692986
## sdlog   0.878081
## Loglikelihood: -2003.152 AIC: 4010.304 BIC: 4018.673
```

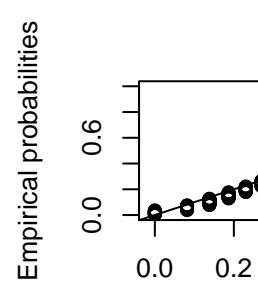
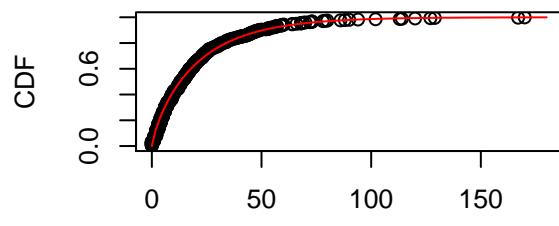
Table 39: Chi-Squared Test for Lognormal Distribution with
MeanLog 2.692986 and SdLog 0.878081

| Pass | Error | Critical Value |
|--------------|----------|----------------|
| Not rejected | 11.18576 | 12.59159 |

Empirical and theoretical dens.



Empirical and theoretical CDFs



5.3.2.2.2 Testing for Gamma Distribution

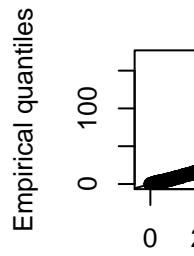
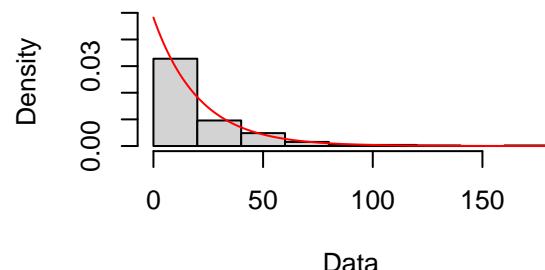
```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-gamma
## Kolmogorov-Smirnov statistic 0.06179999
## Cramer-von Mises statistic  0.21824158
## Anderson-Darling statistic   Inf
##
## Goodness-of-fit criteria
##                               1-mme-gamma
## Akaike's Information Criterion      -Inf
## Bayesian Information Criterion     -Inf
##
## [[2]]
## Fitting of the distribution 'gamma' by matching moments
## Parameters :
##       estimate
## shape 0.78319684
## rate  0.03778855
```

```
## Loglikelihood: Inf AIC: -Inf BIC: -Inf
```

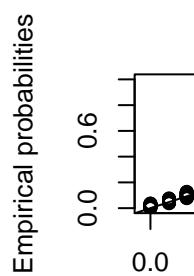
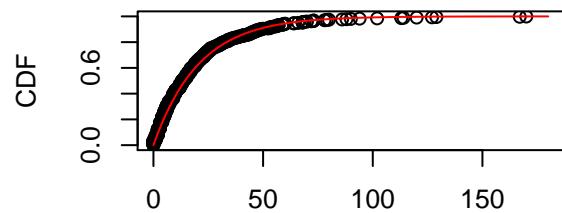
Table 40: Chi-Squared Test for Gamma Distribution with Shape 0.78319684 and Rate 0.03778855

| Pass | Error | Critical Value |
|--------------|----------|----------------|
| Not rejected | 4.265961 | 9.487729 |

Empirical and theoretical dens.



Empirical and theoretical CDFs



5.3.2.2.3 Testing for Exponential Distribution

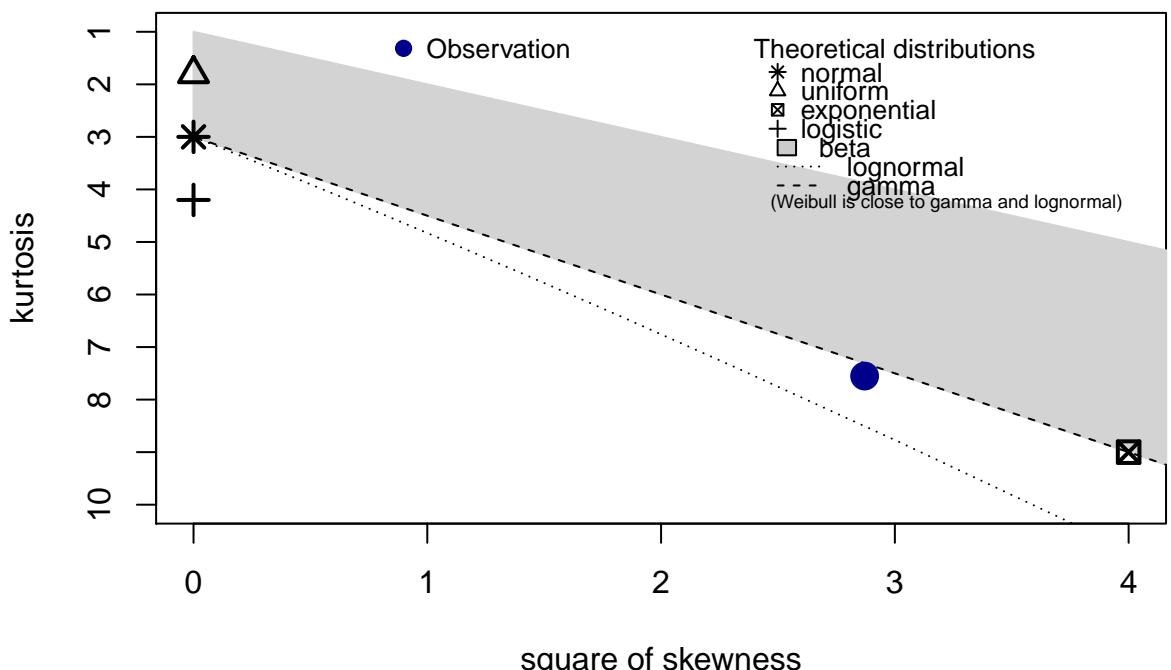
```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-exp
## Kolmogorov-Smirnov statistic 0.05585831
## Cramer-von Mises statistic   0.27792163
## Anderson-Darling statistic    Inf
##
## Goodness-of-fit criteria
##                               1-mme-exp
## Akaike's Information Criterion 3912.437
## Bayesian Information Criterion 3916.621
##
## [[2]]
## Fitting of the distribution 'exp' by matching moments
## Parameters :
##     estimate
##     rate 0.0482491
```

```
## Loglikelihood: -1955.218 AIC: 3912.437 BIC: 3916.621
```

Table 41: Chi-Squared Test for Exponential Distribution with Rate 0.0482491

| Pass | Error | Critical Value |
|--------------|----------|----------------|
| Not rejected | 4.463257 | 12.59159 |

Cullen and Frey graph

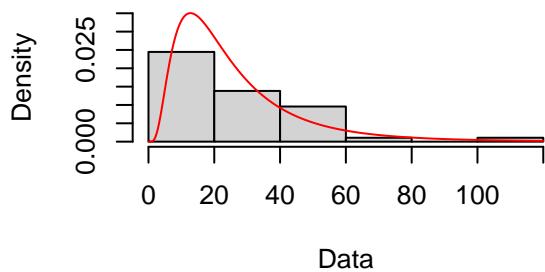
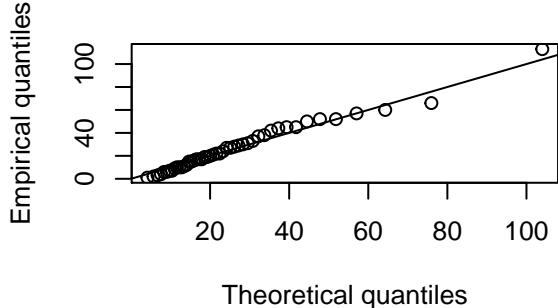
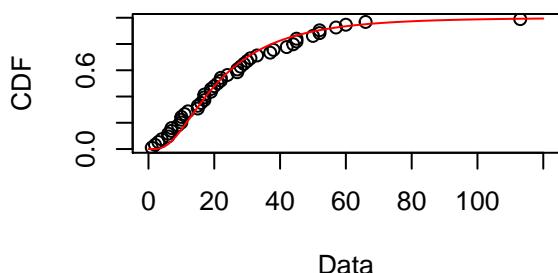
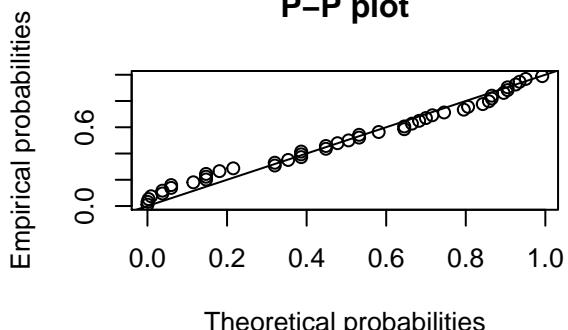


5.3.2.3 ASA 3

square of skewness

```
## summary statistics
## -----
## min: 1   max: 113
## median: 21
## mean: 26.55319
## estimated sd: 21.2979
## estimated skewness: 1.694304
## estimated kurtosis: 7.55201
```

5.3.2.3.1 Testing for Lognormal Distribution The lognormal distribution requires numbers above 0. Hence, the shifting in this case is by 14, such that the minimum is 1.

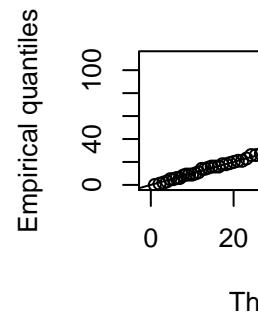
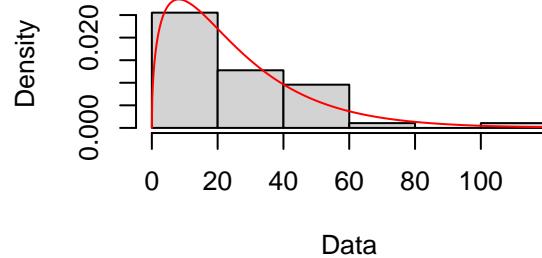
Empirical and theoretical dens.**Q-Q plot****Empirical and theoretical CDFs****P-P plot**

```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-lnorm
## Kolmogorov-Smirnov statistic   0.1106431
## Cramer-von Mises statistic    0.1018993
## Anderson-Darling statistic   1.5959393
##
## Goodness-of-fit criteria
##                               1-mme-lnorm
## Akaike's Information Criterion 419.0401
## Bayesian Information Criterion 422.7404
##
## [[2]]
## Fitting of the distribution ' lnorm ' by matching moments
## Parameters :
##       estimate
## meanlog 3.0349670
## sdlog   0.6988318
## Loglikelihood: -207.52 AIC: 419.0401 BIC: 422.7404
```

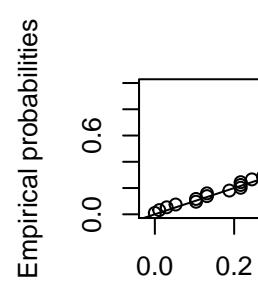
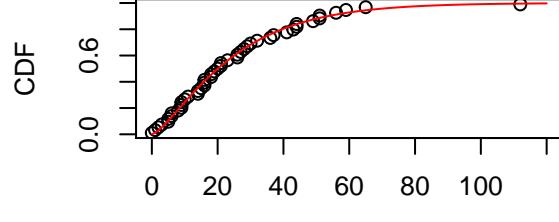
Table 42: Chi-Squared Test for Lognormal Distribution with
MeanLog 3.034967 and SdLog 0.6988318

| Pass | Error | Critical Value |
|--------------|----------|----------------|
| Not rejected | 2.577932 | 7.814728 |

Empirical and theoretical dens.



Empirical and theoretical CDFs



5.3.2.3.2 Testing for Gamma Distribution

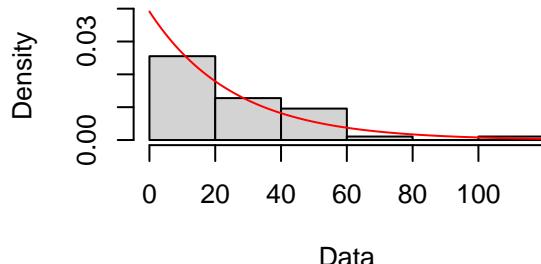
```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-gamma
## Kolmogorov-Smirnov statistic 0.05606922
## Cramer-von Mises statistic  0.01871981
## Anderson-Darling statistic      Inf
##
## Goodness-of-fit criteria
##                               1-mme-gamma
## Akaike's Information Criterion      Inf
## Bayesian Information Criterion      Inf
##
## [[2]]
## Fitting of the distribution 'gamma' by matching moments
## Parameters :
##   estimate
## shape 1.47081119
## rate  0.05755881
```

```
## Loglikelihood: -Inf AIC: Inf BIC: Inf
```

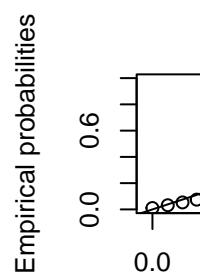
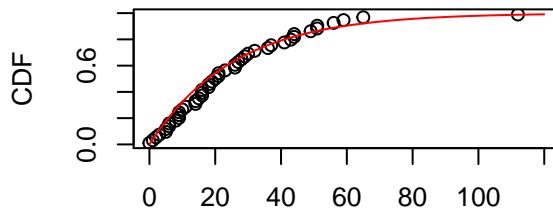
Table 43: Chi-Squared Test for Gamma Distribution with Shape 1.47081119 and Rate 0.05755881

| Pass | Error | Critical Value |
|--------------|----------|----------------|
| Not rejected | 2.209917 | 9.487729 |

Empirical and theoretical dens.



Empirical and theoretical CDFs



5.3.2.3.3 Testing for Exponential Distribution

```
## [[1]]
## Goodness-of-fit statistics
##                               1-mme-exp
## Kolmogorov-Smirnov statistic 0.1239516
## Cramer-von Mises statistic   0.1281206
## Anderson-Darling statistic      Inf
##
## Goodness-of-fit criteria
##                               1-mme-exp
## Akaike's Information Criterion 400.6316
## Bayesian Information Criterion 402.4818
##
## [[2]]
## Fitting of the distribution 'exp' by matching moments
## Parameters :
##     estimate
##     rate 0.03913405
```

```
## Loglikelihood: -199.3158 AIC: 400.6316 BIC: 402.4818
```

Table 44: Chi-Squared Test for Exponential Distribution with Rate 0.03913405

| Pass | Error | Critical Value |
|--------------|----------|----------------|
| Not rejected | 6.167518 | 11.0705 |

6 Summary and Conclusion

6.1 Planned and Walk-In Appointments

6.1.1 Queue Time

Table 45: Distributions for each ASA Score

| ASA Score | Distribution | Error | Critical Values |
|-----------|---------------------------------|----------|-----------------|
| 1 | Lognormal(4.7441447, 0.4887809) | 3.790103 | 9.487729 |
| 2 | Gamma(4.51396193, 0.02991051) | 17.96091 | 18.30704 |
| 3 | Gamma(4.4903452, 0.0290352) | 13.37659 | 18.30704 |

6.1.2 Consult Duration

Table 46: Distributions for each ASA Score

| ASA Score | Distribution | Error | Critical Values |
|-----------|---------------------------------|----------|-----------------|
| 1 | Lognormal(2.4525327, 0.8756247) | 9.605517 | 15.50731 |
| 2 | Exp(0.048233) | 5.7713 | 5.991465 |
| 3 | Lognormal(3.0657644, 0.8372545) | 5.50356 | 12.59159 |
| | Gamma(0.92089709, 0.03126416) | 5.842161 | 5.991465 |
| | Exp(0.03394968) | 4.483978 | 7.814728 |

6.2 Planned Appointments

6.2.1 Queue Time

Table 47: Distributions for each ASA Score

| ASA Score | Distribution | Error | Critical Values |
|-----------|---------------------------------|----------|-----------------|
| 1 | Lognormal(4.7362772, 0.4766837) | 5.192523 | 9.487729 |
| 2 | Gamma(4.6350196, 0.0309402) | 20.84311 | 21.02607 |
| 3 | Gamma(4.77692467, 0.03145134) | 13.61228 | 14.06714 |

6.2.2 Consult Duration

Table 48: Distributions for each ASA Score

| ASA Score | Distribution | Error | Critical Values |
|-----------|---------------------------------|----------|-----------------|
| 1 | Lognormal(2.456952, 0.874598) | 16.66601 | 16.91898 |
| | Gamma(0.7716552, 0.0479119) | 13.26114 | 14.06714 |
| 2 | Gamma(0.9400198, 0.0453387) | 5.40839 | 5.991465 |
| | Exp(0.04823165) | 11.10927 | 12.59159 |
| 3 | Lognormal(3.0717530, 0.8440134) | 4.778335 | 7.814728 |
| | Gamma(0.90118456, 0.03022804) | 8.379399 | 9.487729 |
| | Exp(0.03354257) | 6.057588 | 11.0705 |

6.3 Walk-In Appointments

6.3.1 Queue Time

Table 49: Distributions for each ASA Score

| ASA Score | Distribution | Error | Critical Values |
|-----------|---------------------------------|----------|-----------------|
| 1 | Lognormal(4.8384769, 0.5555817) | 5.394277 | 9.487729 |
| | Gamma(2.76537723, 0.01876737) | 2.535864 | 7.814728 |
| 2 | Gamma(3.69937258, 0.02254071) | 21.08321 | 22.36203 |
| | Lognormal(4.980962, 0.489148) | 18.26444 | 22.36203 |
| 3 | Gamma(3.50311077, 0.01894881) | 7.495405 | 14.06714 |

6.3.2 Consult Duration

Table 50: Distributions for each ASA Score

| ASA Score | Distribution | Error | Critical Values |
|-----------|---------------------------------|-----------|-----------------|
| 1 | Lognormal(2.4071329, 0.8858606) | 0.8173222 | 7.814728 |
| | Gamma(0.74003981, 0.04794076) | 12.19202 | 15.50731 |
| | Exp(0.06478132) | 10.57594 | 11.0705 |
| 2 | Lognormal(2.692986, 0.878081) | 11.18576 | 12.59159 |
| | Gamma(0.78319684, 0.03778855) | 4.265961 | 9.487729 |
| | Exp(0.0482491) | 4.463257 | 12.59159 |
| 3 | Lognormal(3.0349670, 0.6988318) | 2.577932 | 7.814728 |
| | Gamma(1.47081119, 0.05755881) | 2.209917 | 9.487729 |
| | Exp(0.03913405) | 6.167518 | 11.0705 |