Breakout Exercise

REM Latency in Depressed Patients

The data for this problem comes from a study comparing REM (rapid eye movement) latency times, in minutes, for 19 depressed patients with those for 20 healthy patients. The goal is to determine whether REM latency is a good indicator of depression.

The REM latency times (in minutes) for depressed patients were

```
Pat. no.:  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19
REM lat.: 87  2 39  5 81 81 47  6 10 25 65 48 15 21 52 17 48 19 48
```

and for healthy patients they were

```
Pat. no.:  1  2  3  4  5  6  7  8  9 10 11  12 13 14 15 16  17 18 19 20
REM lat.: 47 90 95 51 87 60 69 51 19 54 66 138 64 66 60 84 137 60 69 63
```

Look over the next several pages of summary information about this data, and on the last page,

- Write down any conclusions or impressions you get from these summaries.
- Answer the question: Is REM Latency a good predicttor of depression? Justify your answer.

We have the following graphical information:

```
  Depr    -
          -    *
          -
        80+               *  *
          -
          -
          -
          -                                *
        60+
          -
          -                                            *
          -                     *             *              *    *
          -
        40+          *
          -
          -
          -
          -                              *
        20+                                         *          *
          -                                      *        *
          -                           *
          -                        *
          -       *    *
         0+
            +---------+---------+---------+---------+---------+------PatNo
          0.0       3.5       7.0      10.5      14.0      17.5
```

Depressed patients’ REM latencies (min) vs. patient number.

```
        -
Hlth    -                                 *              *
        -
        -
     120+
        -
        -
        -
        -        *
      90+     *       *
        -                                             *
        -
        -                   *                                 *
        -                              *     *  *                *
      60+                *                         *       *
        -          *           *     *
        -  *
        -
        -
      30+
        -
        -                         *
        -
        -
          --------+---------+---------+---------+---------+--------PatNo
                3.5       7.0      10.5      14.0      17.5
```

Healthy patients’ REM latencies (min) vs. patient number.

```
Stem-and-leaf of Depr      N  = 19
Leaf Unit = 1.0

    3    0 256
    7    1 0579
    9    2 15
   (1)   3 9
    9    4 7888
    5    5 2
    4    6 5
    3    7
    3    8 117
```

```
Stem-and-leaf of Hlth      N  = 20
Leaf Unit = 1.0

    1    1 9
    1    2
    1    3
    2    4 7
    5    5 114
   (9)   6 000346699
    6    7
    6    8 47
    4    9 05
    2   10
    2   11
    2   12
    2   13 78
```

Distribution of patients’ REM latency times.

```
 REM latency times

                ---------------
 Depr      -----I         +   I---------------
                ---------------

                                 ------------
 Hlth             ---------------I  +       I----                *
                                 ------------
          +---------+---------+---------+---------+---------+------Latency
          0        25        50        75       100       125

Comparison of depressed and healthy patients---Parallel Box Plots.
```

Group	Min	QL	Median	QH	Max
Depr	2.00	15.00	39.00	52.00	87.00
Hlth	19.00	55.50	65.00	86.25	138.00

Put your answers here:

1 REM Latency in Depressed Patients: A Good Solution

The data for this problem comes from a study comparing REM (rapid eye movement) latency times, in minutes, for 19 depressed patients with those for 20 healthy patients. The goal is to determine whether REM latency is a good indicator of depression.

A scatter plot of the REM latency time vs. patient number for depressed patients (Figure 1) shows that the middle of the distribution of times is around 40 minutes, but there are large changes in the variability as a function of patient number—the times are much more variable for the first few patients than for later patients.

```
Depr    -
        -    *
        -
      80+               *  *
        -
        -
        -
        -                                *
      60+
        -
        -                                             *
        -                     *             *               *    *
        -
      40+          *
        -
        -
        -
        -                              *
      20+                                          *          *
        -                                      *         *
        -                           *
        -                        *
        -       *    *
       0+
          +---------+---------+---------+---------+---------+------PatNo
         0.0       3.5       7.0      10.5      14.0      17.5
```

Figure 1: Depressed patients' REM latencies (min) vs. patient number.

One possible reason for this change in variability is "learning" by the medical technician recording the times. If this is the case, then perhaps in future experiments the technician should be trained on a few patients to begin with, and then record "live" data for the experiment, to get more consistent readings.

Note that in Figure 1 the depressed patients' REM latency times can also be separated into two groups—one group with REM latencies around 20 minutes, and another group around 50 minutes. This suggests that perhaps there are two types of depressed patient—a low-REM-latency group and a high-REM-latency group.

A plot of REM latency time vs. healthy patient number (Figure 2) shows that the middle of the distribution of times is around 60 or 70, and that there is less change in variability across patients. However, three observations, with times 19, 137 and 138, do not group well with the others and may represent outliers.

Back-to-back stem and leaf diagrams of the two groups of patients are shown in Figure 3.

The distribution of depressed patients' REM latencies appears to be bimodal, with a mode in the the upper 10–20

```
        -
Hlth    -                                 *              *
        -
        -
     120+
        -
        -
        -
        -        *
      90+     *       *
        -                                             *
        -
        -                   *                                 *
        -                              *     *  *                *
      60+                *                         *       *
        -          *           *     *
        -  *
        -
        -
      30+
        -
        -                         *
        -
        -
          --------+---------+---------+---------+---------+--------PatNo
                3.5       7.0      10.5      14.0      17.5
```

Figure 2: Healthy patients' REM latencies (min) vs. patient number.

minute range and another in the upper 40–50 minute range. This distribution also appears to be somewhat skewed to the right (long tail to the right). Again, there are no really clear outliers among depressed patients.

The distribution of healthy patients appears to be unimodal (mode in the high 60's) and symmetric or again slighltly skewed to the right. Again the latency times 19, 137 and 138 may be outliers, with 137 and 138 looking more extreme than 19. Note that if the two suspected outliers 137 and 138 were removed, the distribution would look skewed to the left (longer tail to the left).

The two modes in the stem and leaf plot for the depressed patients show again that it may be possible to separate depressed patients into two groups: a low-REM-latency group with latencies of around 20 minutes; and a high-REM-latency group with latencies nearer to 60 minutes, which is more like the healthy REM latencies. This should be brought to the attention of the medical researchers: perhaps these two groups will respond to different types of treatment for depression. This also suggests that a test for depression based on REM latency alone may not catch all depressed patients—the high-REM-latency group will be missed.

The mean REM latency for depressed patients is 37.68 and the standard deviation is 27.27. The mean for heathy patients is 71.50 and the standard deviation is 28.20. The difference in means also suggests that the two groups are different, but the two possible outliers 137 and 138 are inflating the mean (and the standard deviation too) of the healthy patients, so the evidence of the means alone is not very convincing.

The back to back stem and leaf plots in Figure 3 give a better comparison of the two distributions of REM latencies. REM latency times for depressed patients are generally much lower than for healthy patients, although there is definitely some overlap. Dotplots for the two groups (not shown) give the same impression.

```
  652| 0|
 9750| 1|9
   51| 2|
    9| 3|
 8887| 4|7
    2| 5|114
    5| 6|000346699
     | 7|
  711| 8|47
     | 9|05
     |10|
     |11|
     |12|
     |13|78
-----+--+-----
Depr |  | Hlth
```

Figure 3: Comparison of depressed and healthy patients—Back-to-back Stem and Leaf Diagrams.

Now let's consider boxplots for the two groups, graphed on the same latency (time) scale (Figure 4). The boxplot

```
REM latency times

                ---------------
Depr       -----I         +    I---------------
                ---------------

                                 ------------
Hlth              ---------------I  +       I----                *
                                 ------------
          +---------+---------+---------+---------+---------+------Latency
          0        25        50        75       100       125
```

Figure 4: Comparison of depressed and healthy patients—Parallel Box Plots.

for depressed patients' latencies has a longer tail to the right (skewed right), suggesting that the distribution is overall skewed right. The boxplot for healthy patients shows that the two observations 137 and 138 (represented by the `*`) are outliers according to the "`1.5*IQR`" rule, and if they are omitted the distribution has a longer tail to the left (skewed left). These observations are consistent with the stem and leaf diagrams in Figure 3.

The outlying observations 137 and 138 should be brought to the attention of the medical researchers, and investigated. They may represent some other sleeping disorder not related to depression. Or they may simply be mis-coded data: could the correct observations have been 37 and 38, which would be more consistent with the rest of the healthy patients' REM latencies?

The impression that the two groups are separate is even stronger with the boxplots in Figure 4 than with the back-to-back stem and leaf plot in Figure 3. The 5 number summaries for the two distributions are:

Group	Min	QL	Median	QH	Max
Depr	2.00	15.00	39.00	52.00	87.00
Hlth	19.00	55.50	65.00	86.25	138.00

Note, from the numbers or from Figure 4, that the *lower* quartile Q_L for healthy patients is above the *upper* quartile Q_H for the depressed patients. Thus, 75% of the healthy REM latencies are above 75% of the depressed REM latencies. A reasonable guess as to who is depressed and who is healthy might come from separating patients according to a REM latency time of about 53 minutes. Note that this would not be perfect however: 25% of each group would be mis-classified according to this rule; and remember that the depressed patients seem to belong to two separate groups, one of which looks much more like healthy patients. So some other test will be needed as well, to distinguish depressed and healthy patients.

2 REM Latency in Depressed Patients: A Bad Solution

Group 1: mean=37.68, standard deviation=30.75. Distribution skewed right.
Group 2: mean=71.50, standard deviation=28.20. Distribution slightly skewed right.
71.50>37.68, so there's a difference. MINITAB output attached[1] on separate pages.

[1] (Raw computer output omitted from this example to save paper! –BJ)

3 Comparison of the Two Solutions

3.1 The good solution

Your solutions to data analysis exercises may only be 1/2 or 1/3 as long as this idealized "good solution". But you should still use this as a model of the style and rough content for homework problems. Try to include the following features in your writeups.

- Subject matter (REM latency times in depressed and healthy patient) clearly stated. *Subject matter plays an important role* throughout the writeup and interpretation of results. This is absolutely crucial.
- The analysis uses *multiple views of the data*:
  - Time series plots (REM latency vs. patient number)
  - Stem and leaf diagrams
  - Boxplots
  - Numerical summaries

  The different views confirm some patterns which don't show up well in just one view. They also reveal things (unusual REM latencies that might be data recording errors, more than one group of depressed patients, changing variability of REM latencies for depressed patients) that can't be seen with numerical summaries alone.
- *The problem is discussed in clear English* sentences and paragraphs.
- *Patterns and outliers are identified, if present*; possible interpretations are given for them, and actions are suggested.
- *All statements about the data are justified* by referring to MINITAB output. All graphs shown have a clear purpose, are used in the discussion, and are explained.
- *Conclusions are based on all the evidence*, not just one thing.

3.2 The bad solution

This solution is too brief, and is totally disconnected from the process or problem from which we got the data. It would probably get a zero on a homework assignment.

- No statement of what the data are, why we are looking at them, or how many observations there are.
- No mention of outliers (or lack of outliers), or patterns in the data (or lack of patterns). No discussion of how outliers or patterns might affect the results.
- Insufficient statements about variability.
- No justification for the statements about skewness.
- No reference to or interpretation of computer output.
- No statement about the meaning or relevance of the results.