

Beverly Martinez and Donna Brogan, Emory University

INTRODUCTION

This paper uses the results of a 1983 complex sample survey in rural Georgia to empirically compare two methods of estimating the intraclass correlation (ROH) of blood pressure. One method estimates ROH from the design effect (DEFF). The other method estimates ROH from the analysis of variance (ANOVA) of a nested design. We found that the two methods give approximately equivalent estimates when the sample sizes are not too small. Sampling variability is one possible explanation for some discrepancies we observed when the sample sizes are small.

METHODS

The complex sample survey conducted in six counties in south Georgia was designed with the counties as strata and segments of 16 to 73 housing units (HU's) as the primary sampling units (PSU's). Within each selected PSU, 6 to 18 HU's were selected, and all adults (18 years or older) in the selected HU's were interviewed. This paper estimates the intraclass correlation of diastolic blood pressure within ultimate clusters. An ultimate cluster consists of all adults belonging to the same PSU. We have estimated ROH for each stratum separately, and for some age, race and sex domains in each stratum. All analyses were unweighted. (Probabilities of HU selection within a stratum were planned to be equal.)

The first method uses the formula suggested by Kish (1965)

$$roh = \frac{Deff-1}{\bar{b} - 1}$$

where  $\bar{b}$  = the average size of the clusters

Deff = the design effect, computed by SESUDAAN, a computer program developed at the Research Triangle Institute (RTI).

The second method uses the formula suggested by Ebel (1951)

$$roh = \frac{MSC - MSE}{MSC + (b^* - 1) MSE}$$

where MSC, MSE and  $b^*$  are obtained from the following ANOVA table of an unbalanced nested design:

| Source          | d.f.  | SS  | MS  | E(MS)                         |
|-----------------|-------|---|-----|-------------------------------|
| Among clusters  | $a-1$ | $\sum_{i=1}^a b_i (\bar{y}_{i.} - \bar{y}_{..})^2$        | MSC | $b^* \sigma_c^2 + \sigma_e^2$ |
| Within clusters | $n-a$ | $\sum_{i=1}^a \sum_{j=1}^{b_i} (y_{ij} - \bar{y}_{i.})^2$ | MSE | $\sigma_e^2$                  |

The coefficient  $b^*$  is given by

$$b^* = (n - \sum_{i=1}^a b_i^2 / n) / (a - 1)$$

where

$a$  = the number of clusters  
 $b_i$  = the number of adults in the  $i$ th cluster,  $i=1, \dots, a$   
 $n$  = the total sample size,  $\sum_{i=1}^a b_i$

RESULTS

Tables 1 to 6 give the results for the six counties or strata. Rounded to the first decimal place, the difference between estimates of ROH from the two methods is approximately zero for 58 out of 66 instances (88%). This we consider as a relatively high degree of agreement.

The two methods produce estimates which differ considerably from each other only for those domains with small sample sizes. For example, black men in Crawford County were selected in only four PSU's with an average cluster size of 5, for a total sample size of 20 adults. The estimate of ROH from DEFF is -0.07 while that from the ANOVA is 0.48, giving a difference of -0.55. In contrast, the two estimates of ROH for the total population in each stratum did not differ from each other by more than 0.02. The sample sizes for these strata range from 134 to 370. Hence, the sample size seems to affect the magnitude of the difference between the two estimates. A small sample size produces more sampling variability of estimates and therefore increases the likelihood of getting different estimates from the two methods.

Both sets of estimates were computed using the Statistical Analysis System (SAS) in conjunction with complex sample survey software developed at the Research Triangle Institute (RTI). Within this statistical package, estimating ROH from DEFF for all domains in all counties used up a total of approximately 9 CPU seconds. The same number of estimates obtained from the ANOVA used up a total of approximately 5 CPU seconds. It was noted that the first method uses the procedure SESUDAAN which took about the same amount of time (4.39 CPU seconds) as the procedure NESTED (4.49 CPU seconds) used by the second method. The total amount of time used in computing ROH was greater for the first method because the average cluster size ( $b$ ) had to be computed separately first, while the coefficient  $b^*$  was already outputted by the NESTED procedure.

CONCLUSION

Except for domains with very small sample sizes, estimates of the intraclass correlation obtained from the design effect are approximately equivalent to estimates obtained from the analysis of variance.

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Table 1  
Estimates of Intraclass Correlation (roh)  
of Blood Pressure Among Adults in  
Crawford County, Georgia, 1983

| Domain             | n <sup>1</sup> | a <sup>2</sup> | b <sup>3</sup> | roh <sub>1</sub> <sup>4</sup> | roh <sub>2</sub> <sup>5</sup> | diff <sup>6</sup> |
|--------------------|----------------|----------------|----------------|-------------------------------|-------------------------------|-------------------|
| Total Popn         | 134            | 8              | 17             | 0.06                          | 0.06                          | 0.00              |
| Old <sup>7</sup>   | 13             | 7              | 2              | 0.11                          | -0.02                         | 0.13              |
| Young <sup>8</sup> | 121            | 8              | 15             | 0.05                          | 0.04                          | 0.01              |
| Blacks             | 42             | 4              | 10             | 0.01                          | 0.13                          | -0.12             |
| Whites             | 92             | 8              | 12             | 0.04                          | -0.02                         | 0.06              |
| Women              | 69             | 8              | 9              | 0.05                          | 0.05                          | 0.00              |
| Men                | 65             | 8              | 8              | 0.07                          | 0.07                          | 0.00              |
| Black Women        | 22             | 4              | 6              | -0.07                         | -0.01                         | -0.06             |
| Black Men          | 20             | 4              | 5              | -0.07                         | 0.48                          | -0.55             |
| White Women        | 47             | 7              | 7              | 0.16                          | 0.04                          | 0.12              |
| White Men          | 45             | 8              | 6              | -0.07                         | -0.12                         | 0.05              |

Table 3  
Estimates of Intraclass Correlation (roh)  
of Blood Pressure Among Adults in  
Peach County, Georgia, 1983

| Domain             | n <sup>1</sup> | a <sup>2</sup> | b <sup>3</sup> | roh <sub>1</sub> <sup>4</sup> | roh <sub>2</sub> <sup>5</sup> | diff <sup>6</sup> |
|--------------------|----------------|----------------|----------------|-------------------------------|-------------------------------|-------------------|
| Total Popn         | 370            | 20             | 18             | 0.03                          | 0.04                          | -0.01             |
| Old <sup>7</sup>   | 49             | 17             | 3              | 0.64                          | 0.29                          | 0.35              |
| Young <sup>8</sup> | 321            | 20             | 16             | 0.02                          | 0.01                          | 0.01              |
| Blacks             | 147            | 11             | 13             | 0.03                          | 0.01                          | 0.02              |
| Whites             | 223            | 14             | 16             | 0.05                          | 0.05                          | 0.00              |
| Women              | 213            | 20             | 11             | 0.07                          | 0.07                          | 0.00              |
| Men                | 157            | 20             | 8              | 0.01                          | -0.02                         | 0.03              |
| Black Women        | 91             | 11             | 8              | 0.01                          | 0.00                          | 0.01              |
| Black Men          | 56             | 10             | 6              | -0.07                         | -0.08                         | 0.01              |
| White Women        | 122            | 14             | 9              | 0.21                          | 0.16                          | 0.05              |
| White Men          | 101            | 14             | 7              | 0.02                          | -0.02                         | 0.04              |

Table 2  
Estimates of Intraclass Correlation (roh) of  
Blood Pressure Among Adults in  
Macon County, Georgia, 1983

| Domain             | n <sup>1</sup> | a <sup>2</sup> | b <sup>3</sup> | roh <sub>1</sub> <sup>4</sup> | roh <sub>2</sub> <sup>5</sup> | diff <sup>6</sup> |
|--------------------|----------------|----------------|----------------|-------------------------------|-------------------------------|-------------------|
| Total Popn         | 292            | 12             | 24             | 0.02                          | 0.04                          | -0.02             |
| Old <sup>7</sup>   | 54             | 12             | 4              | -0.06                         | -0.07                         | 0.01              |
| Young <sup>8</sup> | 238            | 12             | 20             | 0.01                          | 0.04                          | -0.03             |
| Blacks             | 176            | 11             | 16             | -0.02                         | 0.00                          | -0.02             |
| Whites             | 116            | 8              | 14             | 0.10                          | 0.14                          | -0.04             |
| Women              | 163            | 12             | 14             | 0.00                          | 0.00                          | 0.00              |
| Men                | 129            | 12             | 11             | 0.04                          | 0.08                          | -0.04             |
| Black Women        | 100            | 11             | 9              | -0.07                         | -0.06                         | -0.01             |
| Black Men          | 76             | 10             | 8              | -0.06                         | -0.03                         | -0.03             |
| Black Women        | 63             | 8              | 8              | 0.18                          | 0.20                          | -0.02             |
| White Men          | 53             | 8              | 7              | 0.20                          | 0.19                          | 0.01              |

Table 4  
Estimates of Intraclass Correlation (roh) of  
Blood Pressure Among Adults in  
Taylor County, Georgia, 1983

| Domain             | n <sup>1</sup> | a <sup>2</sup> | b <sup>3</sup> | roh <sub>1</sub> <sup>4</sup> | roh <sub>2</sub> <sup>5</sup> | diff <sup>6</sup> |
|--------------------|----------------|----------------|----------------|-------------------------------|-------------------------------|-------------------|
| Total Popn         | 157            | 8              | 20             | 0.11                          | 0.10                          | 0.01              |
| Old <sup>7</sup>   | 31             | 8              | 4              | 0.23                          | 0.14                          | 0.09              |
| Young <sup>8</sup> | 126            | 8              | 16             | 0.12                          | 0.11                          | 0.01              |
| Blacks             | 101            | 6              | 17             | 0.11                          | 0.15                          | -0.04             |
| Whites             | 56             | 6              | 9              | 0.02                          | 0.00                          | 0.02              |
| Women              | 95             | 8              | 12             | 0.08                          | 0.06                          | 0.02              |
| Men                | 62             | 7              | 9              | 0.12                          | 0.19                          | -0.07             |
| Black Women        | 66             | 6              | 11             | 0.10                          | 0.12                          | -0.02             |
| Black Men          | 35             | 5              | 7              | 0.21                          | 0.27                          | -0.06             |
| White Women        | 29             | 6              | 5              | -0.11                         | -0.10                         | -0.01             |
| White Men          | 27             | 5              | 5              | 0.08                          | 0.11                          | -0.03             |

See Table 7 for footnotes.

Table 5  
Estimates of Intraclass Correlation (roh)  
of Blood Pressure Among Adults in  
Twiggs County, Georgia, 1983

| Domain             | n <sup>1</sup> | a <sup>2</sup> | b <sup>3</sup> | roh <sub>1</sub> <sup>4</sup> | roh <sub>2</sub> <sup>5</sup> | diff <sup>6</sup> |
|--------------------|----------------|----------------|----------------|-------------------------------|-------------------------------|-------------------|
| Total Popn         | 342            | 16             | 21             | 0.06                          | 0.05                          | 0.01              |
| Old <sup>7</sup>   | 42             | 13             | 3              | 0.21                          | 0.11                          | 0.10              |
| Young <sup>8</sup> | 300            | 16             | 19             | 0.03                          | 0.03                          | 0.00              |
| Blacks             | 215            | 13             | 17             | 0.09                          | 0.08                          | 0.01              |
| Whites             | 127            | 14             | 9              | -0.06                         | -0.04                         | -0.02             |
| Women              | 197            | 16             | 12             | 0.04                          | 0.03                          | 0.01              |
| Men                | 145            | 16             | 9              | 0.08                          | 0.06                          | 0.02              |
| Black Women        | 126            | 13             | 10             | 0.03                          | 0.05                          | -0.02             |
| Black Men          | 89             | 13             | 7              | 0.16                          | 0.05                          | 0.11              |
| White Women        | 71             | 14             | 5              | -0.13                         | -0.11                         | -0.02             |
| White Men          | 56             | 13             | 4              | -0.16                         | -0.10                         | -0.06             |

Table 6  
Estimates of Intraclass Correlation (roh)  
of Blood Pressure Among Adults in  
Wilkinson County, Georgia, 1983

| Domain             | n <sup>1</sup> | a <sup>2</sup> | b <sup>3</sup> | roh <sub>1</sub> <sup>4</sup> | roh <sub>2</sub> <sup>5</sup> | diff <sup>6</sup> |
|--------------------|----------------|----------------|----------------|-------------------------------|-------------------------------|-------------------|
| Total Popn         | 281            | 16             | 18             | 0.08                          | 0.08                          | 0.00              |
| Old <sup>7</sup>   | 72             | 15             | 5              | -0.09                         | -0.08                         | -0.01             |
| Young <sup>8</sup> | 209            | 16             | 13             | 0.11                          | 0.12                          | -0.01             |
| Blacks             | 69             | 10             | 7              | -0.05                         | -0.01                         | -0.04             |
| Whites             | 212            | 16             | 13             | 0.04                          | 0.05                          | -0.01             |
| Women              | 154            | 16             | 10             | 0.04                          | 0.06                          | -0.02             |
| Men                | 127            | 16             | 8              | 0.08                          | 0.08                          | 0.00              |
| Black Women        | 37             | 10             | 4              | -0.15                         | -0.06                         | -0.09             |
| Black Men          | 32             | 8              | 4              | -0.22                         | -0.10                         | -0.12             |
| White Women        | 117            | 16             | 7              | 0.00                          | 0.03                          | -0.03             |
| White Men          | 95             | 16             | 6              | 0.02                          | 0.01                          | 0.01              |

Table 7  
Footnotes to Tables 1 to 6

1. n = total number of adults interviewed in the domain
2. a = number of primary sampling units in - which domain members are present
3. b = average cluster size for PSU's where domain members are present
4. roh<sub>1</sub> = estimate for ROH from the Design Effect (DEFF) computed by SESUDAAN, a program for computing standard errors for complex surveys
5. roh<sub>2</sub> = estimate of ROH from the analysis of variance (ANOVA) computed by the SAS procedure NESTED
6. diff = roh<sub>1</sub> - roh<sub>2</sub>
7. old = age ≥ 65 years
8. young = age ≥ 18 years and age < 65 years

References

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