International Journal of Mathematical Archive-10(3), 2019, 6-13
Available online through www.ijma.info ISSN 2229 – 5046

DETECTION OF ERRORS IN AGE DATA OF NATIONAL HEALTH INSURANCE SCHEME REGISTRANTS IN GHANA: DEMOGRAPHIC INDEXES APPROACH.

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(Received On: 22-01-19; Revised & Accepted On: 04-03-19)

ABSTRACT

The most significant errors found in demographic data have been widely known to occur in age reporting. This study sought to assess the precision of age reporting by registrants of National Health Insurance Scheme (NHIS) of the Sekondi District of Ghana for the month of June, 2018 by employing demographic indexes. Myer's index found about 16% of male and 24% of female registrants to have respectively misreported their ages with wrong terminal digit. For both female and male ages reported, there was a terminal digit preference for 0 and 5 with percentages of about 14% and 17% respectively for females and about 16% and 20% respectively for male registrants. The most avoided terminal digit for male and female registrants were 3 and 2 respectively. Additionally, the UN Joint score with an index of 138.14 qualified the data as highly inaccurate. By comparing the absolute sum of deviations from 100 of both male and female ages, it was evident that there were more inaccuracies in the age data of females than males. Again, the Whipple's index qualified the data as approximate and rough for terminal digit of 5 for male and female ages respectively. However, Whipple's index qualified the data as highly accurate for both male and female registrants with terminal digit of 0. The greatest fluctuation for both male and female age ratios occurred at higher age intervals of 45-49 and 60-64years; an indication of large differences of populations in adjacent groups. Mandatory birth registration was recommended to be enforced in Ghana.

***Keywords**: Whipple's Index, Myer's Index, UN Index, Health Insurance, Ghana.*

1. INTRODUCTION

Demographic indexes (such as Whipple's index, Myer's blended index, and joint score) give one way of detecting errors in single years of age. Other methods include post enumeration survey and record matching. Digit preference may be defined as the tendency of one to report certain ages at the expense of other ages. Age heaping is a major error recorded when ages are recorded in single years although other errors such as misreporting, non-reporting of age may also be realized in single years. Age errors due to misreporting or digit preference have been extensively examined in many studies including population census, surveys, as well as epidemiological studies (i.e including Pardeshi (2010), Shirley *et al.*, (2004), and Denic *et. al*, 2003).

Bello (2012) used demographic indexes on ages reported by outpatients in General Hospital Dutsin-ma of Nigeria, in January 2012.From the results, Myer's index indicated that 86% of male and 88% of female outpatients were inaccurate in reported ages with wrong terminal digits. The study reported the terminal digits of 5 and 0 as the most preferred. However, the most avoided digit was 1. In addition, the Whipple's index indicated a rough data and identified age heaping at terminal digits of 0 and 5.Again, the Joint score indicated the data as highly inaccurate. Female age data showed more inaccuracy which was almost twice that of the male age data.

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Another study by Barua (2015) in Bangladesh sought to compare the quality of age data from two sources; Chittagong Medical College (CMC) and the population of Health Demographic Surveillance System (HDSS) in Matlab. According to the results of the study, the Whipple's index qualified the data as very rough for both male and female CMC Hospital outpatients. However, Matlab HDSS data for both male and female was found to be accurate. With the Myer's index, it was found out that 64% (male) and 72% (female) outpatients misreported their ages with incorrect terminal digits in CMC Hospital. The most avoided digits were 9 and 1 whilst the most preferred digits were 0 and 5. On the contrast, the Matlab HDSS showed no digit preference for both male and female. Again, the joint score for CMC Hospital outpatients which qualified the data as highly inaccurate was found to be approximately 4 times higher than the Matlab HDSS. The study identified fluctuations in the age interval of 15-19 to 35-39 for male age ratios and higher fluctuations age interval of 35-39 to 60-64 years for female age ratios.

A good planning of a country's development depends on the accurate data on sex and age. Again, there is the need to evaluate or assess age data since: (a) illiterate population are highly likely to misreport correct age (b) enumerators may be careless in recording age (c) there is a tendency for people to report ages ending in 0 or 5 (d) older folks tend to exaggerate length of life (e) some people tend to have the sub-conscious aversion to some numbers (f) due to some political, economic, social or personal reasons some people mis-place their age.

2. METHODOLOGY

The age and sex data of new registrants was collected from the Sekondi District of the National Health Insurance Scheme for the period spanning 1st to 30th June of the year 2018.

2.1 Method of Data Analysis

The demographic methods such as Whipple's index and Myers' blended index were used for measuring the degree of age heaping and digit preference or avoidance. United Nation Index or Joint Score was also calculated.

2.2 Whipple's Index

Whipple's Index measures age heaping or digit preference. It also reflects digit avoidance. Based on rectangularity assumption for 5- year age range, heaping on terminal digit 0 and 5 combined in the age range 23-62 may measured by comparing the sum of the population at ages in this range ending in zero and five with 1/5 of the total population in the age range. This is computed as:

$$\text{Whipple's Index} = \frac{P_{25}+P_{30}+P_{35}+P_{40}+P_{45}+\cdots+P_{60}}{\frac{1}{5}(P_{23}+P_{24}+P_{25}+\ldots+P_{60}+P_{61}+P_{62})} \times 100.$$

For a 10 year age range based on the assumption of rectangularity or of linearity, age heaping in the age range of 23-62 years may be calculated by comparing the sum of the populations at the ages ending in zero in this age range 23-62 with 1/5th of the total population in the age range. This is computed as:

$$\text{Whipple's Index} = \frac{P_{30}+P_{40}+P_{50}+P_{60}}{\frac{1}{5}(P_{23}+P_{24}+P_{25}+\ldots+P_{60}+P_{61}+P_{62})} \times 100.$$

For a 5 year age range based on the assumption of rectangularity or of linearity, age heaping in the age range of 23-62 years may be calculated by comparing the sum of the populations at the ages ending in 5 in this age range 23-62 with 1/5th of the total population in the age range. This is computed as:

$$\text{Whipple's Index} = \frac{P_{25}+P_{35}+P_{45}+P_{55}}{\frac{1}{5}(P_{23}+P_{24}+P_{25}+\ldots+P_{60}+P_{61}+P_{62})} \times 100.$$

Whipple's index measures the heaping of digit ending only in zero or five. Whipple's index calculated value of 100 can be interpreted as zero preference for digit with terminal in zero or five. Whipple's index calculated value of 500 means only terminal digits of zero or five were reported (Kpedekpo, 1982). The scale of reliability of Whipple's index is as follows:

Quality of the data	Whipple's Index
Highly Accurate	less than 105
Fairly Accurate	105 -109.9
Approximate	110 -124.9
Rough	125 – 174.9
Very Rough	175+

2.3 Myers Blended index

Myers index which only applies to age data in single years measures the preference or avoidance for ten digits of 0, 1, 2, 3, 4, 5, 6, 7, 8 and 9. It is also referred to as a blended method since it takes care of the flaw of bias in the computation of the indexes and avoids the assumption in the case of Whipple's index that ages of childhood and extreme old age more affected by other types of errors than by preference for specific terminal digit. It requires data within the ages of 10-69, or 10-79 or 10-89.

Myer's Blended Index is computed as:

$$\text{Myers Blended} = \sum_{i=0}^{9} Bi \left| \left[\frac{Bi}{\sum_{i=0}^{9} Bi} x100 \right] \right| - 10\%$$

$$\text{Magnitude of Preference} = \left[\frac{Bi}{\sum_{i=0}^{9} Bi} \times 100 \right]_{-10}$$

Bi = Blended Population i range from 0-9,

$\sum_{i=0}^{9} Bi$ = Grand Blended Population

3. WHIPPLE'S INDEX

Table -1: Age Distribution of Male Registrants of Sekondi District Branch of NHIS in the month of June, 2018 in Ghana

The digit preference with ages with terminal digits of 0 and 5 is computed as $\frac{561}{1/5(1241)} \times 100 = 226.0$.

Age	Number of NHIS Registrants	Age	Number of NHIS Registrants
23	98	25	98
24	104	30	63
25-29	240	35	70
30-34	104	40	60
35-39	128	45	38
40-44	114	50	96
45-49	84	55	104
50-54	156	60	32
55-59	169	**TOTAL**	**561**
60	19		
61	2		
62	23		
TOTAL	**1241**		

The value 226.0 is interpreted by the UN standards to mean that the data is of a very rough quality.

The Whipple's index for male ages ending with 5 is $\frac{310}{1/5(1241)} \times 100 = 124.9$.

Whereas the Whipples index for male ages ending with 0 is $\frac{251}{1/5(1241)} \times 100 = 101.1$.

This shows that the age reporting of male registrants with ages which have terminal digit of 0 can be deemed as Highly accurate (i.e Whipple's index of 101) under the scale of reliability of whipple's index. However, ages reported with terminal digits of 5 with Whipple's index of 124.9 is considered approximate under the scale of reliability of Whipple's index.

Table-2: Age Distribution of Female Registrants of Sekondi District Branch of NHIS in the month of June, 2018 in Ghana

Age	Number of NHIS Registrants	Age	Number of NHIS Registrants
23	112	25	328
24	128	30	113
25-29	440	35	115
30-34	220	40	118
35-39	228	45	47
40-44	172	50	87
45-49	62	55	92
50-54	152	60	29
55-59	160	**TOTAL**	**929**
60	22		
61	5		
62	10		
TOTAL	**1711**		

The digit preference with ages with terminal digits of 0 and 5 is computed as $\frac{929}{\frac{1}{5}(1711)} \times 100 = 271.5$.

The value 271.5 or 272 is interpreted by the UN standards to mean that the data is of a very rough quality.

The Whipples index for female ages ending with 5 is $\frac{582}{\frac{1}{5}(1711)} \times 100 = 170.1$.

Whereas the Whipples index for female ages ending with 0 is $\frac{310}{\frac{1}{5}(1711)} \times 100 = 90.6$.

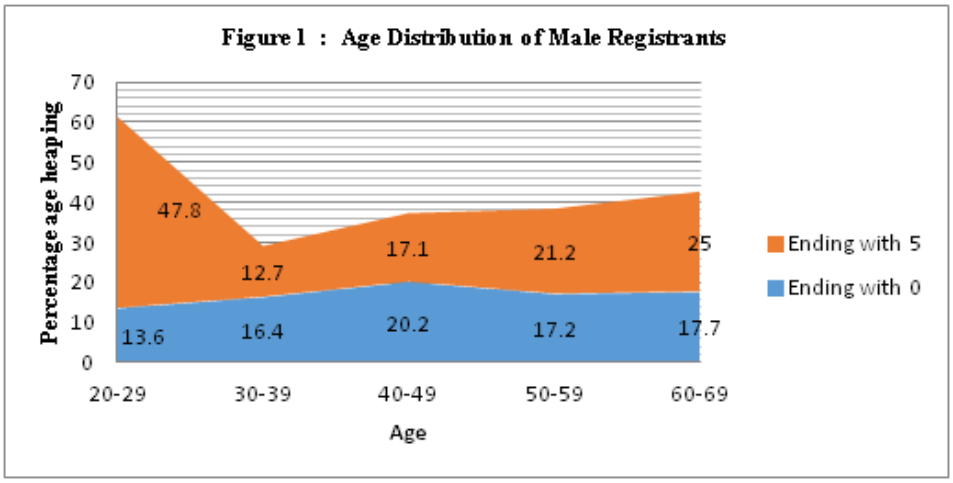
This shows that the age reporting of females with ages which have terminal digit of 0 can be deemed as Highly accurate (i.e whipple's index of 90.6) under the scale of reliability of whipple's index. However, ages reported with terminal digits of 5 with whipple's index of 170.1 is considered rough under the scale of reliability of whipple's index.

3.1 Combined Discussions on Tables 1 And 2

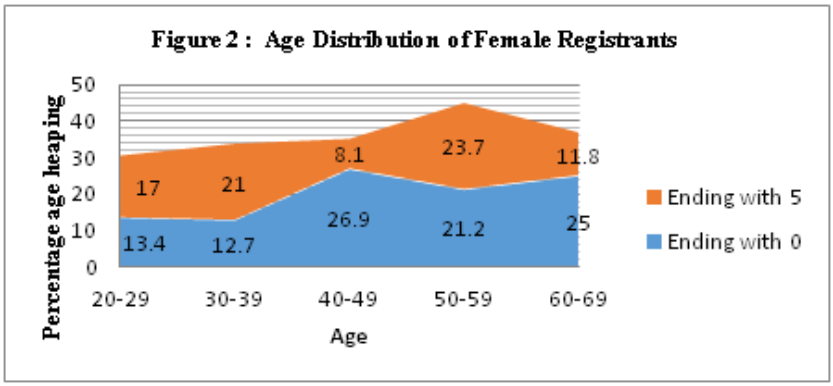
The Whipple's Index computed for male and female NHIS membership registration was respectively 226 and 272. These indices show that females have a higher tendency to prefer ages ending in 0 and 5 than males. This tendency may be due to a number of factors including: high illiteracy rate among females, that they have lower interest in age particularly in traditional set up; and males in most cases report the age of females on their behalf and there is a tendency to use rounded figures for females.

Female and male digit preference for ages with terminal digits of 0 were respectively 90.6 and 101.1 .Although all these indices are of a highly accurate data quality, females can be interpreted to have less preference for terminal digits of 0 than males ($90.6 < 101.1$).

Similarly, female and male digit preference for ages with terminal digits of 5 were respectively 170.1 (very rough data quality) and 124.9 (rough data quality).Male registrants can be interpreted to have less preference for terminal digits of 0 than males ($124.9 < 170.1$).



The percentage of age heaping for the ages with terminal digits of 5 increased with increasing age except for the ages 20-29 and 30-39. Similarly, the percentage of age heaping for the ages with terminal digits of 0 increased with increasing age except for the age interval of 50-59.The highest terminal age digit preference for the terminal digit of 0 was found in the age group of 60-69.However, the highest terminal age digit preference for the terminal digit of 5 occurred in the age bracket of 20-29.This may be due to fewer ages reported in the other higher age bracket for the period used for the study.



Again, the percentage of age heaping for the ages with terminal digits of 5 increased with increasing age except for the ages 40-49 and 60-69. Similarly, the percentage of age heaping for the ages with terminal digits of 0 increased with increasing age except for the age intervals of 50-59 and 60-69.The highest terminal age digit preference for the terminal digit of 0 was found in the age group of 40-49.However, the highest terminal age digit preference for the terminal digit of 5 occurred in the age bracket of 50-59. This sporadic trend might be due to the inability of the scheme to register more people in the higher age brackets of 50-59 and 60-69 for the month under consideration.

4. MYER'S BLENDED INDEX

Table-3: Myer's Blended Index for Male NHIS Registrants

Terminal Digits	Sum of age 10-89	Coefficient	Ages 10-89 coefficient product	Sum of age 20-89	Coefficient	Ages 10-89 coefficient product	Blended Sum	% Distribution	Deviation from 10
0	351	1	351	252	9	2268	2619	15.63	5.63
1	186	2	372	134	8	1072	1444	8.62	-1.38
2	173	3	519	131	7	917	1436	8.57	-1.43
3	118	4	472	87	6	522	994	5.93	-4.07
4	152	5	760	113	5	565	1325	7.91	-2.09
5	370	6	2220	279	4	1116	3336	19.91	9.91
6	200	7	1400	139	3	417	1817	10.85	0.85
7	105	8	840	90	2	180	1020	6.09	-3.91
8	144	9	1296	97	1	97	1393	8.31	-1.69

9	137	10	1370	119	0	0	1370	8.18	-1.82
Sum	**1936**						**16754**	**100.00**	**32.78**
Summary Index of age preference	$\frac{Total\ Inde}{2}$								**16.39**

Table 3 makes evident the persistent preference of terminal digits of 0 (15.6%) and 5 (19.9%) in age reporting during NHIS registration among male registrants. However the ages ending with terminal digits of 3 recorded the highest avoidance (5.9%) followed by terminal digit of 7 (6.1%). Ages reported which had terminal digits of 5 were 4.3% more than those ages ending with terminal digit of 0. Ages reported which had terminal digits of 5 among male registrants had the most preference (19.9%). About 16 % of the male registrants reported their ages with incorrect terminal digits.

Table-4: Myer's Blended Index for Female NHIS Registrants

Terminal Digits	Sum of age 10-89	Coefficient	Ages 10-89 coefficient product	Sum of age 20-89	Coefficient	Ages 10-89 coefficient product	Blended Sum	% Distribution	Deviation from 10
0	428	1	428	330	9	2970	3398	14.14	4.14
1	285	2	570	234	8	1872	2442	10.16	0.16
2	199	3	597	155	7	1085	1682	7.00	-3.00
3	254	4	1016	136	6	816	1832	7.62	-2.38
4	217	5	1085	179	5	895	1980	8.24	-1.76
5	468	6	2808	354	4	1416	4224	17.58	7.58
6	227	7	1589	152	3	456	2045	8.51	-1.49
7	231	8	1848	150	2	300	2148	8.94	-1.06
8	186	9	1674	125	1	125	1799	7.49	-2.51
9	248	10	2480	154	0	0	2480	10.32	0.32
Sum	**9935**						**24030**	**100.00**	**24.4**
Summary Index of age preference	$\frac{Total\ Index}{2}$								**12.2**

Inferring from Table 4, ages reported which had terminal digits of 5 among female registrants had the most preference (17.6%) followed by ages with terminal digit of 0 (14.4%). However, the ages ending with terminal digits of 2 recorded the highest avoidance (7.0%) followed by terminal digit of 8 (7.5%). Ages reported which had terminal digits of 5 were 3.5% more than those ages ending with terminal digit of 0. Ages reported which had terminal digits of 5 among female registrants had the most preference (17.6%). About 24 % of the female registrants reported their ages with incorrect terminal digits.

5. AGE-SEX ACCURACY INDEX OR UNITED NATIONS INDEX

The joint score of 138.14 from table 5 qualifies the data as highly inaccurate by United Nations interpretation standards. The inaccuracy in the age reporting of female NHIS registrants was higher than that of the male registrants (evident from the absolute deviation sum 380.07 > 339.25).

Table-5: Age-Sex Accuracy Index or United Nations Index of NHIS registrants

Terminal Digits	Male Registrant Population	Age Ratio	Deviation from 100	Female Registrant Population	Age Ratio	Deviation from 100	Sex Ratio	Successive Difference
0-4	428			416			102.89	
5-9	376	108.83	8.83	342	101.18	1.18	109.94	-7.06
10-14	263	77.58	-22.42	260	67.8	-32.2	101.15	8.79
15-19	302	122.02	22.02	425	123.19	23.19	71.06	30.10
20-24	232	85.61	-14.39	430	99.42	-0.58	53.95	17.11
25-29	240	142.86	42.86	440	135.38	35.38	54.55	-0.59
30-34	104	56.52	-43.48	220	65.87	-34.13	47.2	7.27
35-39	128	117.43	17.43	228	116.33	16.33	56.14	-8.87
40-44	114	107.55	7.55	172	118.62	18.62	66.28	-10.14
45-49	84	62.22	-37.78	62	38.27	-61.73	135.48	-69.20
50-54	156	123.32	23.32	152	136.94	36.94	102.63	32.85
55-59	169	153.64	53.64	160	164.95	64.95	105.63	-2.99
60-64	64	54.47	-45.53	42	45.16	-54.84	152.38	-46.76
65-69	66	88	-12	26	65	-35	253.85	-101.47
70+	86			416				
Absolute Total			**339.25**			**380.07**		**343.2**
Mean			**28.27**			**31.67**		**26.4**
Joint Score			**138.14**					

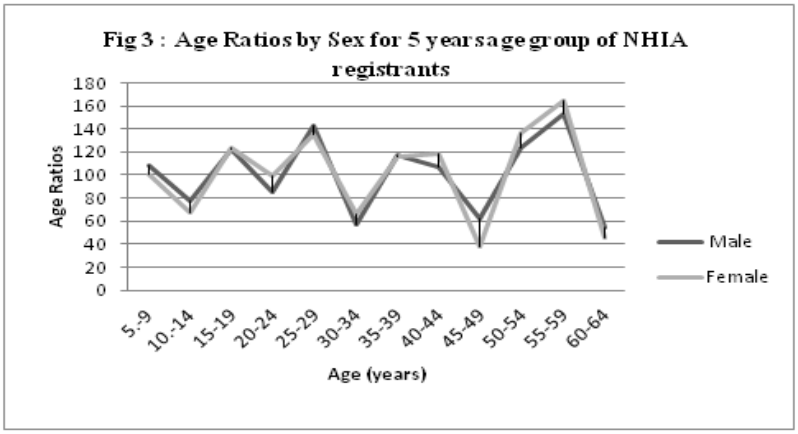


Fig. 3 shows fluctuations in the age groups from 5-9 to 60-64 for both male and female age ratios. Both male and female age ratios recorded very high fluctuations between 20-24 and 30-34 and massive fluctuations were detected at upper age group for both male and female age ratios ;thus 45-49 to 60-64 years. These fluctuations are indication of large differences of populations in adjacent groups.

6. CONCLUSIONS

This paper applied Whipple's Index, Myer's Blended Index and Age-sex Accuracy Index to evaluate the age and sex data collected from National Health Insurance Scheme of the Sekondi District of Ghana on registrants for the month of June, 2018. The data was found to be of very rough quality for both male and female registrants by the method of Whipple's Index. However, male and female registrants with ages which have terminal digit of 0 were found to be highly accurate. The quality of male and female reported ages with terminal digits of 5 was found to be approximate and rough respectively.

The Summary Index of age preference by the method of Myer's index was found to be 16.39 for male registrants and 12.2 for female registrants. Male ages reported by registrants who had terminal digits of 5 had the most preference (19.9%) followed by ages with terminal digit of 0 (15.6%).In the case of female registrants, ages reported which had terminal digits of 5 had the most preference (17.6%) followed by ages with terminal digit of 0 (14.4%). The evaluation of the ages reported by NHIS registrants by use of demographic techniques has eventually qualified the data inaccurate due to systematic age heaping and digit preference. Again, United Nations Index of NHIS was 138.14 which qualify the data as highly inaccurate by United Nations interpretation standards. The inaccuracy in the age reporting of female NHIS registrants was higher than that of the male registrants.

7. RECOMMENDATIONS

The study recommended the following:

a. Mandatory birth registration is recommended to be enforced in Ghana.
b. Ghanaian citizens should be educated on the need to report correct age.
c. Where respondents or registrants find it difficult to state their ages, calendar of historical event technique should be encouraged.

8. REFERENCES

1. G.S. Pardeshi, Age heaping and accuracy of age data collected during a community survey in the Yavatmal district, Maharashtra, *Indian J Community Med*, 35(3) (2010), 391-395.
2. L. Shirley, V. Ravi and M. Margaret, An evaluation of the age and sex data from the census population of Canada, provinces and territories, 1971 to 2001, *Canadian Population Society Annual Meeting*, Winnipeg, Manitoba, (2004). http://web.uvic.ca/~canpop/2004/Loh-Verma-Michalowski-CPS04.ppt.
3. S. Denic, F. Khatib and H. Saadi, Quality of age data in patients from developing countries, *Journal of Public Health*, 26(2) (2003), 168–171.
4. Bello Y., (2012). Error Detection in Outpatients' Age Data Using Demographic Techniques. *International Journal of Pure and Applied Sciences and Technology***.** *Int. J. Pure Appl. Sci. Technol*., 10(1) (2012), 27-36.. *ISSN 2229 – 6107***.** *Available online at* ***www.ijopaasat.in.***
5. Barua, R.K (2015). Detection of Digit Preference and Age Misreporting by using Demographic Techniques. A thesis submitted in partial fulfillment of the requirements for the degree of Master of Population, Reproductive Health, Gender and Development
(MPRHGD) at East West University, Dhaka, Bangladesh.
6. Kpedekpo G.M.K. (1982). *Essentials of Demographic Analysis for Africa.* Hernerman Educational Books Inc., ew Hemisphere.

Source of support: Nil, Conflict of interest: None Declared.