

# Ubiquity of Fractals in Gerontology

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## **Abstract**

*This study compares the fractal dimensions of certain characteristics of the aging population which exhibited irregularity in patterns such as population distribution, life expectancy and living arrangements in developed and developing countries. Data were gathered from on-line data base of United Nations organization. Findings revealed that the fractal dimension of living arrangement is 1.11 which is greater than that of life expectancy at 1.07. Fractal dimension of older population is 1.07, while the fractal dimension of living arrangement is 1.04. It is concluded that demographic distributions in older adults are better predicted at a higher fractal dimension. It is concluded further that living arrangement and older population can reduce variability of distribution in life expectancy and living arrangement respectively.*

*Keywords: fractals, gerontology, older adults, older population, life expectancy, living arrangement*

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## **1.0 Introduction**

Gerontology is a multidisciplinary field that studies the aging processes and individuals as they grow from middle age through later life. Aging is a complex and dynamic process that includes biopsychosocial changes and its demographics which presumed to affect society in general (The Association of Gerontology in Higher Education, 2011). Based on statistical reports, distributions of older adults' characteristics across countries vary from one country to another (World Health Organization, 2012). The diversity of these characteristics of elderly such as population, life expectancy, and living arrangements presents a dynamic pattern of the older adults across the globe.

Knowing the irregularity (fractals) of these patterns determines the uniqueness of the aging phenomenon necessary for policy determination in developed and developing countries. Gerontology studies provide wide latitude on fractal dimensions

which clearly created a picture of the aging population. As gleaned from literatures, studies on older adult distribution across countries focused mainly on their mean or percentage distribution or changes across the years and countries (Pallonia, et al., 2002; Rajeshwar, D., Shambunath Singh, Pankaj Mala and Meena Dhyani., 2008; United Nations, 2010). However, the evaluation of only mean changes in aging characteristics ignores the dynamic nature of aging phenomenon across the globe.

A different approach in exploring the characteristics of older population characteristics is through fractal analysis. Fractal is a structural concept that applies to a wide class of complex shapes that are irregular, but their irregularity has an underlying pattern. The key feature to the fractal pattern is called self-similarity and the extent of the ruggedness of the distribution of older population characteristics based on the category of countries as developed and developing countries. It is on

this premise that patterns of aging characteristics particularly older population, living arrangement and life expectancy were closely studied in developed and developing countries. Furthermore, the fractal correlations of the distribution of older adults' living arrangement and life expectancy as well as older population across countries were investigated.

**2.0 Conceptual Framework**

Fractal dimension analysis was used in this study. Fractal is a concept that was discovered by Benoit Mandelbrot in 1975. Fractals are characterized by self – similarity, ruggedness, irregularity and fractal dimension ( Forex Academy, 2012). Fractals aim to describe the inherent

ruggedness of objects from smaller to larger scale.

In this study, gerontology concepts and data are variable in nature and has shown fractal patterns. Some of these are the older population, living arrangement and life expectancy across countries. The older population distribution shows the extreme variability from the highest at 29.7% to the lowest at 1.9%. Living arrangement ranges from living alone to living with distant and expanded family members, while life expectancy varies from 83 as the highest to 47 years old.

In this study, distribution of older adults' population, living arrangement and life expectancy fractal patterns were determined. The graphs that follows show that these variables are indeed fractals.

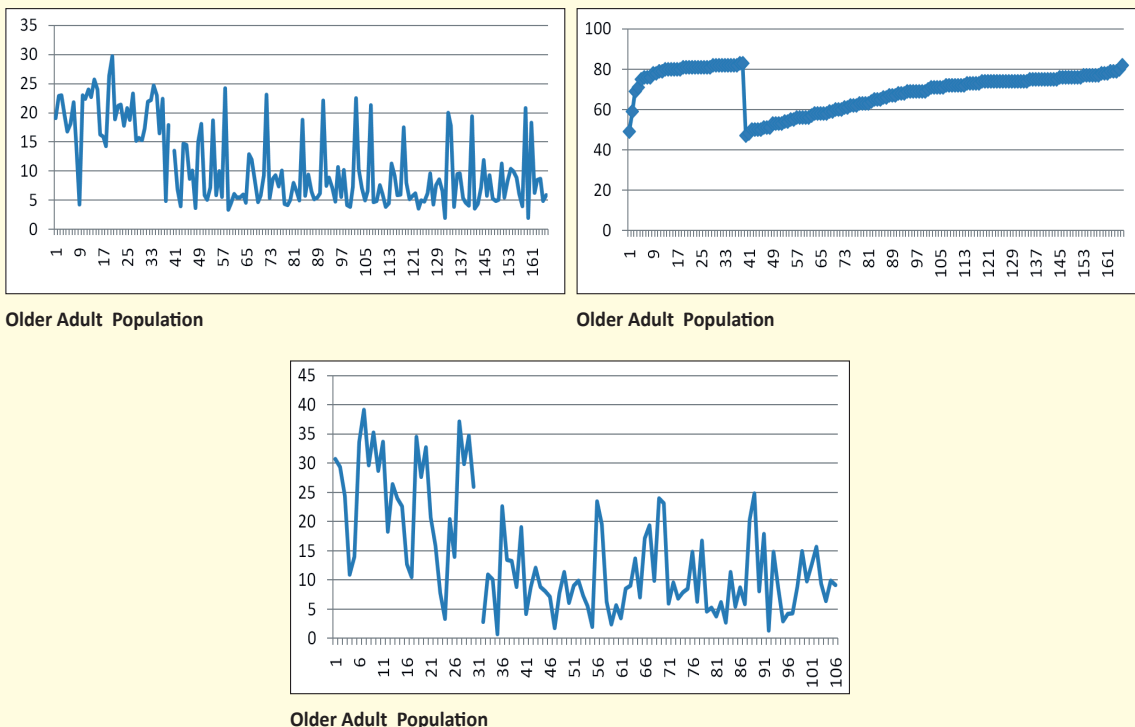


Figure 1. Graphical tracing of population distribution, life expectancy and Living arrangement showing irregular patterns of distribution (United Nations, 2013)

Mandelbrot (1075) further explains that fractal dimensions ( $\lambda$ ) describe how fractal objects fill the spaces they live in. The higher the fractal dimension, the more space is occupied by the fractal object. The more space the fractal object occupies, the more information it contains about the space it lives in. The amount of information (about the space) is best expressed in terms of statistical fractals. In fractal observations, "roughness" of the data is described through fractal dimension ( $\lambda$ ).

In this study, the characteristics of the older populations in different countries were retrieved through the on-line sources of the United Nation (UN) published in 2013. The population of older adults over 60 years old was retrieved from the same source as that of life expectancy and living arrangements. Thirty nine developed countries

and 128 developing countries were included in the study (Appendix A). The percentage distribution of elderly in developed and developing countries were used in measuring population variations. In acquiring data for life expectancy, the age at which an elderly survived was analyzed. In the living arrangement, the number of elderly living alone was analyzed and those living otherwise are those living with spouse or family members.

**3.0 Results and Discussions**

**The Older Adults' Characteristics in Developed and Developing Countries**

The figures below present the fractal dimensions of older population, living arrangement and life expectancy in comparison with developed and developing countries.

**Elderly Population**

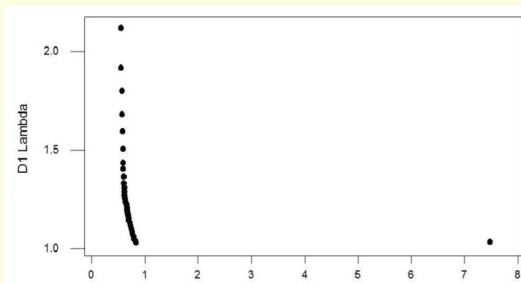


Figure 2A. Older Adult Population in Developed Countries

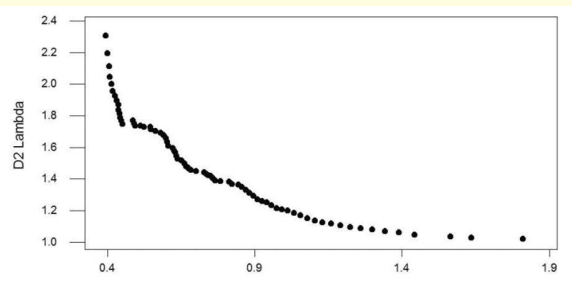


Figure 2B. Older Adult Population in Developing Countries

**Living Arrangement**

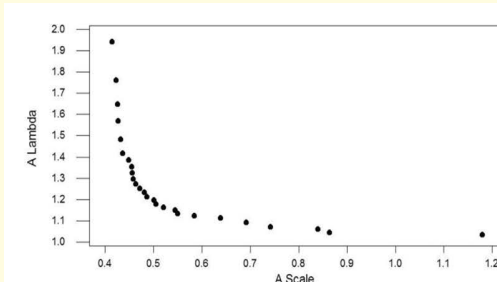


Figure 3A. Older Adult Living Arrangement in Developed Countries

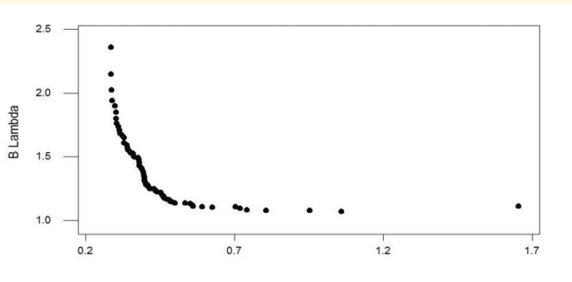


Figure 3B. Older Adult Living Arrangement in Developing Countries

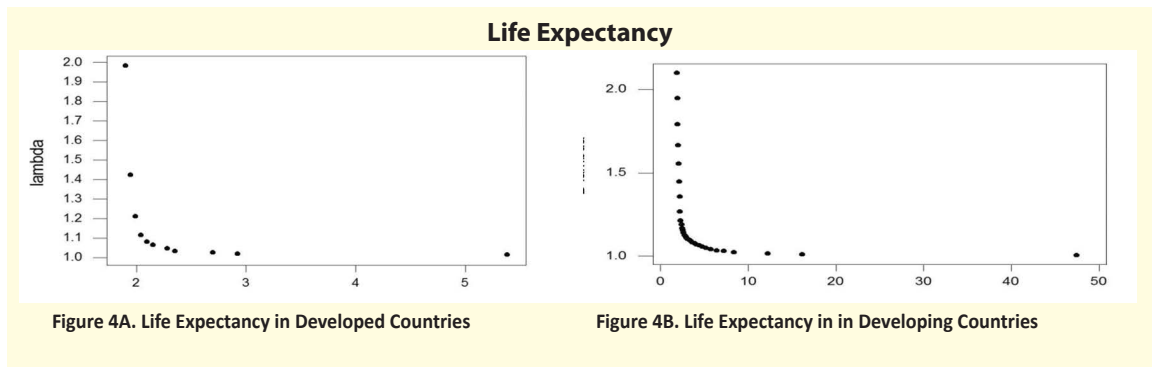


Figure 2A- 4B. Fractal Spectrum of elderly population, life expectancy and Living arrangement in developed and developing countries (United Nations, 2013)

The older adult population in both developed and developing countries are rugged or dispersed in distribution particularly in those countries with high older population. However, in developing countries, the dispersion or ruggedness of population are distributed less in medium and large scale population. This finding indicates a more stable and predictable pattern in countries with existing high older adult population. It is therefore the high population of older adults that led to the ruggedness of the population and more fractal the dimensions will be observed. Japan, Italy and Germany have high elderly population and they are characterized by their universal practices of population control and the strong health care policies for elderly thereby increasing the life expectancy which indirectly contributes to increase in elderly population (Vanhuysse, 2012). Developed countries have more aging population which is a consequence of their respective country policies for population control most commonly Japan. The citizens of the aforementioned countries also focused more on career and social orientation. On the other hand, developing countries like Bahrain has strong Islamic religious orientation practicing polygamy and early marriages among women which contribute to the increase in the population of the younger generations (n.a., 2012).

Other developing countries like Niger have strong orientation on expanding their family size (IRIN, 2007).

Figures 3A and 3B present the number of older adults living alone in developed and developing countries in fractal spectrum. The ruggedness of the distribution of the older adults' living arrangement is highlighted in developed and developing countries with high number of older adults living alone. Developed countries commonly practices elderly independent living in as much as most of them were career oriented in their younger days rather than having a family of their own. Developed countries' living arrangement can be driven by the high number of elderly population and their economic conditions (Velkoff, n.d.).

Life expectancy of elderly in developed countries show a highly dispersed distribution in countries with high life expectancies like Japan which is 80 for men and 86 for women (Kyodo, 2013) in both developed and developing countries. Developed countries show a more stable life expectancy distribution compared to developing countries indicating a high survival rates of the elderly population. The economic status of the country is an important consideration in lengthening life expectancy (Palloni, 2000). As life expectancy increases, there is a reduction of

living alone as observed in developed countries because of the increased tendency for couples to become widows or widower (Iacovou, 2000). Moreover, higher income and urbanization are expected to associate with living separately. Developing countries like Africa and Asia have reduced life expectancy due to diseases and low economic capabilities for improving health services (Rosenberg, 2007).

#### 4.0 Fractal Correlations

Further analysis was done to determine the correlation of the extent of the distribution of demographics of older persons in developed and developing countries.

As seen in Tables 1 and 2, living arrangement is correlated with both life expectancy and older population distribution. As fractogram measure, the researchers determined the fractal dimensions of X (independent variable) and Y (dependent variable). A Pearson "r" correlation of the fractal dimensions was computed to generate the

correlation coefficient. Accordingly, the "thinner" the area, the more closely associated are the roughness measures of X and Y.

The fractal correlation between living arrangement (x) and life expectancy of older adults was computed. In table 1, the fractal dimension of living arrangement is 1.11 which is greater than that of life expectancy at 1.07. These findings show that the increased in the dimension of living arrangement induces a reduction of the variability of the life expectancy in older adults. Hence, when taken together both variables generate a dimension of 1.30 accounting for 0.61 or 61% of the ruggedness of life expectancy. This implies that the more older adults living alone, the life expectancy of older adults become more uniform. According to Velkoff (n.d.), living arrangement among older adults affect life satisfaction, health and well-being. This further explains that the better the life satisfaction, health and well-being of older adults, the longer is the life expectancy. In similar cases, there is a strong predictive pattern

Table 1. Fractal Correlations Between Living Arrangement and Life Expectancy

| Variables                              | Fractal Dimension | Fractal Correlation |
|--|-------------------|---------------------|
| Living arrangement (x)                 | 1.11              | 0.61                |
| Life Expectancy (y)                    | 1.07              |                     |
| Living arrangement and Life Expectancy | 1.30              |                     |

Table 2. Fractal Correlations Between Older Population and Living Arrangement

| Variables                                 | Fractal Dimension | Fractal Correlation |
|---|-------------------|---------------------|
| Older Population (x)                      | 1.07              | 0.44                |
| Living Arrangement (y)                    | 1.04              |                     |
| Elderly Population and Living Arrangement | 1.46              |                     |

that living arrangement predicts life expectancy of older adults.

It can be gleaned from table 2 that the fractal dimension of older population is 1.07, while the fractal dimension of living arrangement is 1.04. These findings explain that older population reduces the variability of living arrangement. When taken together, the fractal dimension of 1.46 resulted to a fractal correlation of 0.44. Hence, 44% of the composite effect of the older population and living arrangement accounts for the variability of living arrangement. Hence, the increase in the older adult population will result to a more predictable living arrangement. IRIN (2007) states that the number of older population influence the distribution of the living arrangement across countries. Depending on the culture and economic profile of countries, older adults are either living independently or co-residing with their family or distant relatives.

## 6.0 Conclusion

Demographic distributions in older adults are better predicted at a higher fractal dimension. It is concluded further that living arrangement and older population can reduce variability of distribution in life expectancy and living arrangement respectively. Policy recommendation is focused on providing appropriate living arrangements for the older adults so as to increase their life expectancy. Policies in controlling the gap in population age distribution may be implemented to ensure suitable living arrangements.

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**Appendix A**

## LIST OF DEVELOPED COUNTRIES

Australia  
Austria  
Belgium  
Canada  
Cuba  
Cyprus  
Czech Republic  
Democratic People's Republic of Korea  
Democratic Republic of the Congo  
Denmark  
Estonia  
Finland  
France  
Germany  
Greece  
Iceland  
Ireland  
Israel  
Italy  
Japan  
Luxembourg  
Malta  
Netherlands  
New Zealand  
Norway  
Poland  
Portugal  
Republic of Korea  
Republic of Moldova  
Singapore  
Slovakia  
Slovenia  
Spain  
Sweden  
Switzerland  
The former Yugoslav Republic of Macedonia  
United Kingdom  
United Republic of Tanzania  
United States of America



**Appendix B**

## LIST OF DEVELOPING COUNTRIES

|                                  |                                  |                                    |
|----------------------------------|----------------------------------|------------------------------------|
| Albania                          | Georgia                          | Panama                             |
| Algeria                          | Ghana                            | Papua New Guinea                   |
| Angola                           | Grenada                          | Paraguay                           |
| Argentina                        | Guatemala                        | Peru                               |
| Armenia                          | Guinea                           | Philippines                        |
| Azerbaijan                       | Guinea-Bissau                    | Qatar                              |
| Bahamas                          | Honduras                         | Romania                            |
| Bahrain                          | Hungary                          | Russian Federation                 |
| Barbados                         | India                            | Rwanda                             |
| Belarus                          | Indonesia                        | Saint Lucia                        |
| Belize                           | Iran (Islamic Republic of)       | Saint Vincent and the Grenadines   |
| Benin                            | Iraq                             | Sao Tome and Principe              |
| Bolivia (Plurinational State of) | Jamaica                          | Saudi Arabia                       |
| Bosnia and Herzegovina           | Jordan                           | Senegal                            |
| Botswana                         | Kazakhstan                       | Serbia                             |
| Brazil                           | Kenya                            | Sierra Leone                       |
| Brunei Darussalam                | Kuwait                           | Somalia                            |
| Bulgaria                         | Kyrgyzstan                       | South Africa                       |
| Burkina Faso                     | Latvia                           | Sri Lanka                          |
| Burundi                          | Lebanon                          | Sudan                              |
| Cote d'Ivoire                    | Lesotho                          | Suriname                           |
| Cameroon                         | Liberia                          | Swaziland                          |
| Cape Verde                       | Libya                            | Syrian Arab Republic               |
| Central African Republic         | Lithuania                        | Tajikistan                         |
| Chad                             | Madagascar                       | Thailand                           |
| Chile                            | Malawi                           | Togo                               |
| China                            | Malaysia                         | Tonga                              |
| Colombia                         | Maldives                         | Trinidad and Tobago                |
| Comoros                          | Mali                             | Tunisia                            |
| Congo                            | Mauritania                       | Turkey                             |
| Costa Rica                       | Mauritius                        | Turkmenistan                       |
| Croatia                          | Mexico                           | Uganda                             |
| Djibouti                         | Micronesia (Federated States of) | Ukraine                            |
| Dominican Republic               | Mongolia                         | United Arab Emirates               |
| Ecuador                          | Montenegro                       | Uruguay                            |
| Egypt                            | Morocco                          | Uzbekistan                         |
| El Salvador                      | Mozambique                       | Venezuela (Bolivarian Republic of) |
| Equatorial Guinea                | Namibia                          | Viet Nam                           |
| Eritrea                          | Nicaragua                        | Zambia                             |
| Ethiopia                         | Niger                            | Zimbabwe                           |
| Fiji                             | Nigeria                          |                                    |
| Gabon                            | Oman                             |                                    |
| Gambia                           | Pakistan                         |                                    |