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Health-related Quality of Life among Children/Adolescent Living with HIV/AIDS in Lagos State Using Analysis of Variance (ANOVA) Approach

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ABSTRACT

Health- Related Quality of Life (HRQoL) is a notion that is commonly used to examine the impact of health status on quality of life. HRQoL is measured by the physical and psychosocial health quality of life of children and adolescent in this study. These two measures were used to provide a better picture of overall HRQoL of children and adolescent as individual measure may not capture the HRQoL as expected. To tackle this problem, this study developed a method for combining these two measures into a summary score called absolute HRQoL of children for ease of investigating the impact of drugs (first and second line ART) on the HRQoL of children/adolescents living with HIV/AIDS in Lagos State. The HRQoL data were verified to know whether the assumptions of normally distributed data and equality of standard deviations in the two groups were reasonably satisfied. These assumptions were not met due to skewness, orthogonal array-based Latin hypercube designs [OA (121,3) LHD and OA (16, 8) LHD] were adopted and the data was scaled to normally distributed data using a universally accepted mathematical formula. The standard deviations also showed that the largest standard deviation (20.53) is not more than twice as large as the smallest (15.91) and thus the assumption of equality of variances has been satisfactorily met which allowed the use of analysis of variance (ANOVA) approach on HRQoL among children and adolescent in Lagos State. The aim of this study is to determine the influence of the ART based on the first and second line drugs on the health related quality of life of children/adolescent living with HIV in Lagos State and determine the reliability of the result obtained in this respect. Y (Health Related Quality of Life) denotes the response variable and X represents the independent variable (first and second line drugs). The *p*-value obtained is greater than 0.05 indicating that there is sufficient evidence that the mean of the health related quality of life of children and adolescent on first line ART and those on second line ART do not differ significantly as shown in Table 6. Conclusively, children and adolescent in both groups are doing fine in terms of their health related quality of life. The rationale behind this may be attributed to their level of adherence to taking drugs at regular times and as prescribed.

Introduction

Human immunodeficiency virus (HIV) remains a major public health problem in low- and middle-income countries including Nigeria. There was an estimated 36.9 million people that were living with HIV as at 2014 out of which about 2.6 million were children giving a global HIV prevalence of 0.8% [UNAIDS. How AIDS Changed Everything. Available from: http://www.unaids.org/sites/default/files/media_asset/MDG, Last cited on2016 Jan 13]. Even though, the burden of HIV in Nigeria has been revised downward with the national prevalence of 1.4% but the burden of new infections and mortality remains high among adolescents and young adults. There is a growing concern about quality of life among people living with HIV/AIDS (Geocze et al., 2010; O'Connell et al. 2003 and Jelsma et al., 2005). The quality of life simply refers to health status when taking into consideration multiple dimensions including social, psychological, physical and functional well-being. The World Health Organization (WHO) defines quality of life as "individuals' perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns" (WHO, 1995).

Several authors have reported the effect of HIV/AIDS on the quality of life of adolescents. Some authors reported the negative impact of the disease on the quality of life of adolescents while other researchers have shown positive effects of HIV/AIDS on adolescent life**.** The differences in their studies could be attributed to a myriad of reasons including but not limited to the degree of available, accessible comprehensive adolescent-friendly health care services, HIV/AIDS care and support centres, the stage of HIV/AIDS among affected adolescents, long-term disorders associated

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with AIDS (cardio-metabolic syndromes, cancers) as well as the challenges peculiar to lifestyle/habits (WHO, 2019; UNICEF, 2019).

A dramatic decline in mortality and morbidity has been recorded among HIV-infected individuals (Zhang, et al., 2009). HIV/AIDS infection is more often a chronic manageable disease rather than a terminal illness (Nakagawa et al., 2012). The focus of HIV/AIDS care has been shifting from increasing life expectancy to improving health-related quality of life (HRQoL) (Carpenter, et al., 2000). Besides, HRQoL is a concept that could change at different time points (Degroote, et al., 2014). Thus, regularly assessing HRQoL among HIV-positive children/adolescents can help us discover potential problems that influence health and provide important information to help healthcare providers and policymakers improve HRQoL. The orthogonal array-based Latin hypercube designs (OALHD) used a standardised input between 0 and 1 having ensured the space-filling properties of the design. The orthogonal array-based Latin hypercube designs adopted [OA (121,3) LHD and OA (16, 8) LHD] were developed by Osuolale, et al. (2014b) and Osuolale, et al. (2017) using Hadamard matrices and Latin square of order *s* where *s* is a prime number. The big advantage of these designs is that each of the input variables is sampled at n levels which implies that when OALHD is collapsed into a single dimension, n distinct levels are obtained. This study investigates the impact of drugs (first and second line ART) on the health related quality of life of children/adolescents living with HIV/AIDS in Lagos State by verifying the difference in mean of the health related quality of life in relation to the independent variable under study using one-way ANOVA and also determine the reliability of the result obtained in this respect..

Methodology

Prior to applying the ANOVA approach, OA (16, 8) LHD and OA (121,3) LHD were used on the HRQL data to ensure that assumptions for using one – way ANOVA approach are met. The designs as explained earlier are provided in Table 1 and Table 2, respectively.

The above design points were scaled accordingly with the minimum and maximum value in the respective HQOL data using:

$$y_{OALHD} = \frac{y_{data} - y_{data(min)}}{y_{data(max)} - y_{data(min)}}$$

$$y_{dataHQOL} = y_{OALHD}\left(y_{data(max)} - y_{data(min)}\right) + y_{data(min)} \quad (1)$$

The aov () function in R-software was used to analyse the scaled data on health related quality of life. It might be indicated that Health Related Quality of Life is affected by the drugs, either first line ART or second line ART and this is expressed by the following mathematical model (Berger et al., 2018):

$$Y = f(X, \epsilon)$$

Where Y represents the response and X is the independent variable, f is the functional form of the relationship and ϵ is a random error component, representing all factors other than *X* having an influence on the Health Related Quality of Life. This model is usually a solution to a set of equations, which can be linear or nonlinear in nature. The analytical solution to equation (2) is often impossible due to the complex nature of f (X) for many real life cases and therefore the need to study the relationship between the independent variable *X* and outputs *Y* by varying the values of the independent variable and observe how the response is being affected (Osuolale et al., 2014a). The relationship between the dependent and independent variable can be further investigated by developing the appropriate statistical model.

Every element, Y_{ij}, in the array corresponds to HQoL data for participant *i* (*i* indexes rows) whose line of drugs is *j* (*j* indexes columns, and a column represents a specific line of drugs). Y_{ij} is an individual HQoL data value at one specific "treatment" or level and it is also called the dependent variable while the independent variable is *X*. The statistical model we desire to fit to the data is given as:

$$Y_{ij} = \mu + \tau_j + \varepsilon_{ij} \quad (3)$$

where

$i = 1, \dots, R; j = 1, \dots, C$

$R = number\ of\ rows\ or\ replicates\ in\ each\ factor$

$C = number\ of\ columns\ or\ factors$

$\mu = overall\ mean$

$\tau_j =$ differential effect connected with jth level of X

$\varepsilon_{ij} = error\ associated\ with\ the\ ijth\ data\ value$

Estimation of Model Parameters

There is need to compute the column means using the theoretical data layout provided in Table 1 to proceed with the estimation process. The notation for the column means is $\bar{Y}_{.j} = \sum_{i=1}^{R} Y_{ij}/R$ for the mean of column *j* and we have $\bar{Y}_{.1}, \bar{Y}_{.2}, \bar{Y}_{.3}, \cdots, \bar{Y}_{.j}, \cdots, \bar{Y}_{.C}$ are the means for the first, second, third, . . ., *jth*, . . ., and *Cth* columns, respectively and

Table 1. OA (16, 8) LHD for Hadamard Matrix of Order 8λ

x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8
0.5313	0.5313	0.5313	0.5313	0.5313	0.5313	0.5313	0.5313
0.5938	0.0313	0.5938	0.0313	0.5938	0.0313	0.5938	0.0313
0.6563	0.5938	0.0313	0.0938	0.6563	0.5938	0.0313	0.0938
0.7188	0.0938	0.0938	0.5938	0.7188	0.0938	0.0938	0.5938
0.7813	0.6563	0.6563	0.6563	0.0313	0.1563	0.1563	0.1563
0.8438	0.1563	0.7188	0.1563	0.0938	0.6563	0.2188	0.6563
0.9063	0.7188	0.1563	0.2188	0.1563	0.2188	0.6563	0.7188
0.9688	0.2188	0.2188	0.7188	0.2188	0.7188	0.7188	0.2188
0.0313	0.2813	0.2813	0.2813	0.2813	0.2813	0.2813	0.2813
0.0938	0.7813	0.3438	0.7813	0.3438	0.7813	0.3438	0.7813
0.1563	0.3438	0.7813	0.8438	0.4063	0.3438	0.7813	0.8438
0.2188	0.8438	0.8438	0.3438	0.4688	0.8438	0.8438	0.3438
0.2813	0.4063	0.4063	0.4063	0.7813	0.9063	0.9063	0.9063
0.3438	0.9063	0.4688	0.9063	0.8438	0.4063	0.9688	0.4063
0.4063	0.4688	0.9063	0.9688	0.9063	0.9688	0.4063	0.4688
0.4688	0.9688	0.9688	0.4688	0.9688	0.4688	0.4688	0.9688

Table 2. OA (121, 3) LHD using Latin Square of Order 11

N	Design Points (L)						
No	x_1	x_2	x_3		x_1	x_2	x_3
1	0.0041	0.0041	0.0041	18	0.1446	0.5579	0.6488
2	0.0124	0.0950	0.0950	19	0.1529	0.6488	0.7397
3	0.0207	0.1860	0.1860	20	0.1612	0.7397	0.8306
4	0.0289	0.2769	0.2769	21	0.1694	0.8306	0.9215
5	0.0372	0.3678	0.3678	22	0.1777	0.9215	0.0124
6	0.0455	0.4587	0.4587	23	0.1860	0.0207	0.2025
7	0.0537	0.5496	0.5496	24	0.1942	0.1116	0.2934
8	0.0620	0.6405	0.6405	25	0.2025	0.2025	0.3843
9	0.0702	0.7314	0.7314	26	0.2107	0.2934	0.4752
10	0.0785	0.8223	0.8223	27	0.2190	0.3843	0.5661
11	0.0868	0.9132	0.9132	28	0.2273	0.4752	0.6570
12	0.0950	0.0124	0.1033	29	0.2355	0.5661	0.7479
13	0.1033	0.1033	0.1942	30	0.2438	0.6570	0.8388
14	0.1116	0.1942	0.2851	31	0.2521	0.7479	0.9298
15	0.1198	0.2851	0.3760	32	0.2603	0.8388	0.0207
16	0.1281	0.3760	0.4669	33	0.2686	0.9298	0.1116
17	0.1364	0.4669	0.5579	34	0.2769	0.0289	0.3017
35	0.2851	0.1198	0.3926	52	0.4256	0.6736	0.0372
36	0.2934	0.2107	0.4835	53	0.4339	0.7645	0.1281
37	0.3017	0.3017	0.5744	54	0.4421	0.8554	0.2190
38	0.3099	0.3926	0.6653	55	0.4504	0.9463	0.3099
39	0.3182	0.4835	0.7562	56	0.4587	0.0455	0.5000
40	0.3264	0.5744	0.8471	57	0.4669	0.1364	0.5909
41	0.3347	0.6653	0.9380	58	0.4752	0.2273	0.6818
42	0.3430	0.7562	0.0289	59	0.4835	0.3182	0.7727
43	0.3512	0.8471	0.1198	60	0.4917	0.4091	0.8636
44	0.3595	0.9380	0.2107	61	0.5000	0.5000	0.9545
45	0.3678	0.0372	0.4008	62	0.5083	0.5909	0.0455
46	0.3760	0.1281	0.4917	63	0.5165	0.6818	0.1364
47	0.3843	0.2190	0.5826	64	0.5248	0.7727	0.2273
48	0.3926	0.3099	0.6736	65	0.5331	0.8636	0.3182
49	0.4008	0.4008	0.7645	66	0.5413	0.9545	0.4091
50	0.4091	0.4917	0.8554	67	0.5496	0.0537	0.5992
51	0.4174	0.5826	0.9463	68	0.5579	0.1446	0.6901
69	0.5661	0.2355	0.7810	89	0.7314	0.0702	0.7975
70	0.5744	0.3264	0.8719	90	0.7397	0.1612	0.8884
71	0.5826	0.4174	0.9628	91	0.7479	0.2521	0.9793
72	0.5909	0.5083	0.0537	92	0.7562	0.3430	0.0702
73	0.5992	0.5992	0.1446	93	0.7645	0.4339	0.1612
74	0.6074	0.6901	0.2355	94	0.7727	0.5248	0.2521
75	0.6157	0.7810	0.3264	95	0.7810	0.6157	0.3430
76	0.6240	0.8719	0.4174	96	0.7893	0.7066	0.4339
77	0.6322	0.9628	0.5083	97	0.7975	0.7975	0.5248
78	0.6405	0.0620	0.6983	98	0.8058	0.8884	0.6157
79	0.6488	0.1529	0.7893	99	0.8140	0.9793	0.7066
80	0.6570	0.2438	0.8802	100	0.8223	0.0785	0.8967
81	0.6653	0.3347	0.9711	101	0.8306	0.1694	0.9876
82	0.6736	0.4256	0.0620	102	0.8388	0.2603	0.0785
83	0.6818	0.5165	0.1529	103	0.8471	0.3512	0.1694
84	0.6901	0.6074	0.2438	104	0.8554	0.4421	0.2603
85	0.6983	0.6983	0.3347	105	0.8636	0.5331	0.3512
86	0.7066	0.7893	0.4256	106	0.8719	0.6240	0.4421
87	0.7149	0.8802	0.5165	107	0.8802	0.7149	0.5331
88	0.7231	0.9711	0.6074	108	0.8884	0.8058	0.6240
109	0.8967	0.8967	0.7149	116	0.9545	0.5413	0.4504
110	0.9050	0.9876	0.8058	117	0.9628	0.6322	0.5413
111	0.9132	0.0868	0.9959	118	0.9711	0.7231	0.6322
112	0.9215	0.1777	0.0868	119	0.9793	0.8140	0.7231
113	0.9298	0.2686	0.1777	120	0.9876	0.9050	0.8140
114	0.9380	0.3595	0.2686	121	0.9959	0.9959	0.9050
115	0.9463	0.4504	0.3595				

$\bar{Y}$ refer to the overall sample mean. Other notations are Total Sum of Squares (TSS), Sum of Squares between Columns (SSBc) and Sum of Squares within Columns (SSW). Sum of Squares within Columns are equivalent to the error sum of squares, SSE. The analysis of variance table is given in Table 4.

$$TSS = SSBc + SSW \quad (4)$$

Table 3. Theoretical Data Layout for One-Way Analysis of Variance

	1	2	3	J	C
1	Y_{11}	Y_{12}	Y_{13}		Y_{1C}
2	Y_{21}	Y_{22}	Y_{23}		Y_{2C}
3	Y_{31}	Y_{32}	Y_{33}		Y_{3C}
i	Y_{i1}	Y_{i2}	Y_{i3}		Y_{iC}
R	Y_{R1}	Y_{R2}	Y_{R3}		Y_{RC}

Table 4. Analysis of Variance showing the partitioning of Total Sum of Squares.

Source of variability	Df	Sum Sq	Mean Sq	F value
Between columns (due to region of residence)	C-1	SSBc	MSBc	MSBc/ MSW
Within columns (due to error)	(R-1)C	SSW	MSW	
Total	**TSS**	**RC-1**		

Results and Discussion

The design points in yellow as shown in Table 1 and Table 2 were extracted and used on the health related quality of life data. Histograms with a normal curve over them as shown in Figure 1 and Figure 2 show that the normality assumptions were satisfied.

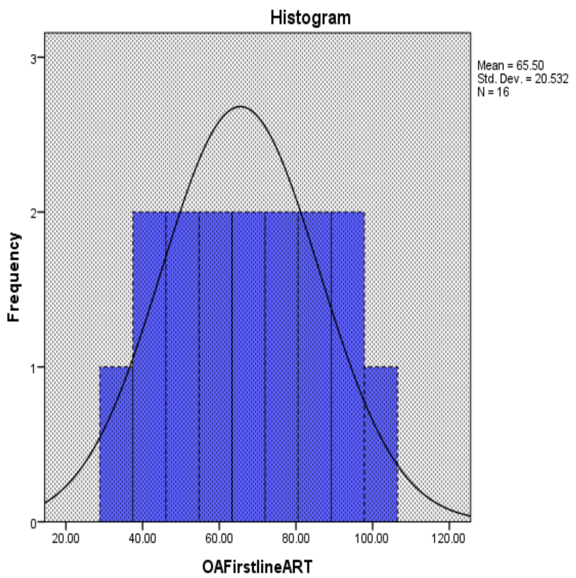

Figure 1. Normal distribution curve for the HRQL of Children and adolescent on First Line ART.

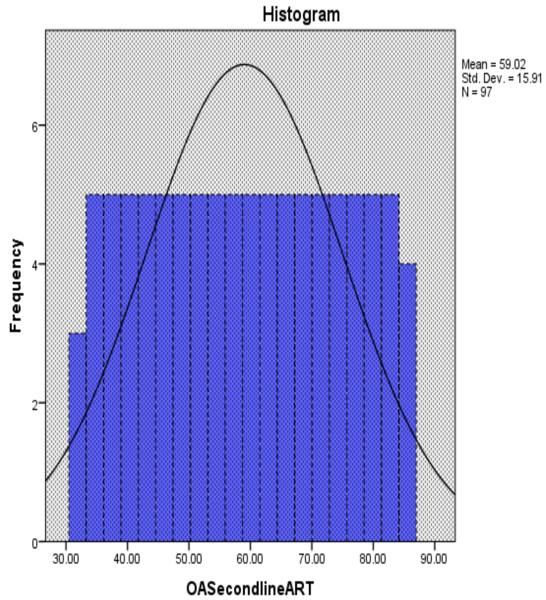

Figure 2. Normal distribution curve for the HRQL of Children and adolescent on Second Line ART.

The descriptive statistics results obtained are given in Table 5 and the standard deviations shows that the largest standard deviation (20.53) is not more than twice as large as the smallest (15.91) indicating that assumption of equality of variances has been satisfactorily met following the rule of thumb.

The HQOL data of children and adolescent on first line and second line ART were stacked on each other into a single column. Beside each column, place the number 1 beside the first 16 entries and label that as HQOL of children and adolescent on first line ART and HQOL of children and adolescent on second line ART was also stacked with 2 beside 97 entries until we have only two columns.

The *p*-value (0.151) is greater than 0.05 implies that there is sufficient evidence that the mean of the health related quality of life of children and adolescent on first line ART and those on second line ART do not differ significantly as a non-significant result was obtained in Table 6. The children and adolescent are doing fine in both groups in terms of their health related quality of life, which may be attributed to their adherence to taking drugs at regular times and as prescribed.

Conclusion

The OA (121, 3) LHD and OA (16, 8) LHD have been adopted in this study to guarantee the use of ANOVA model on the health related quality of life of children and adolescent in Lagos State, Nigeria. The standard deviations also showed that the largest standard deviation (20.53) is not more than twice as large as the smallest (15.91) and thus the assumption of equality of variances was satisfactorily met which allowed the use of analysis of variance (ANOVA) approach on HRQoL among children and adolescent in Lagos State. The *p*-value obtained is greater than 0.05 indicating that there is sufficient evidence that the mean of the health related quality

Table 5. Description of the Health Related Quality of Life Data based on First and Second Line ART.

HQOL of children and adolescent on ART	N	Minimum	Maximum	Mean	Std. Deviation
1	16	33.16	97.84	65.5	20.53
2	97	31.88	86.15	59.02	15.91
Total	113				

Table 6. Description of the Health Related Quality of Life Data based on First and Second Line ART.

Source of variability	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Line	1	577	577.4	2.093	0.151
Residuals	111	30625	275.9		
Signif. Codes	0 ‘***’	0.001 ‘**’	0.01 ‘*’	0.05	0.1

of life of among children and adolescent on first line ART and those on second line ART do not differ significantly as shown in Table 6. Conclusively, children and adolescent in both groups are doing fine in terms of their health related quality of life. The rationale behind this may be attributed to their level of adherence to taking drugs at regular times and as prescribed. The data were originally skewed until the designs adopted to ensure normality assumption was met. health-related quality of life among children/adolescent living with HIV/AIDS in Lagos State using a non–parametric statistical method will be considered for future research. This is a novel approach as the study used orthogonal array-based Latin hypercube designs to ensure that certain statistical assumptions were satisfied to guarantee the use of parametric statistical method.

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