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FUZZY MATHEMATICAL MODEL RELATIVE ANALYSIS FOR THE EFFECT OF OXYTOCIN IN PPH

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Abstract:

In this study we discussed relative analysis for the various fuzzy mathematical models based on generalized gamma distribution, log-logistic distribution, generalized Rayleigh distribution and Rayleigh distribution for the effect of oxytocin.Testing of hypothesis between the expected values of cardiac output changes after the administration of oxytocinfor different distribution models.

Key Words: Hypothesis Testing & Oxytocin.

1. Introduction:

The significance of the methods used in a statistical study rest on tremendously on the assumed probability model or distribution.The persistence of statistical explanation is to inducementresultsaround a population on the basis of recordsattained from a sample of that population. Hypothesis testing is the route used to evaluate the strength of confirmation from the sample and offers a origin for constructionof choicescorrelated to the population, i.e., it offers a system for understanding how dependably one can take a broad viewexperiential findings in a sample under study to the higher population from which the sample was taken.Gholamreza et al. [3] offered aprocessfor fuzzy random variables using parametric testing statistical hypotheses. Buckley [2] produced a fuzzy test statistic by apply a fuzzy estimator in hypothesis testing.

Oxytocin is a mammalian neurohypophysial nonapeptide hormone secreted by the posterior pituitary gland. Oxytocin is a nine amion acid long peptide. The amino acid structure of oxytocin is: cysteine-tyrosine-isoleucine-glutamine-asparagine-cysteine-proline-leucine-glycine-amide(Cys-Tyr-Ile-Gln-Asn-Cys-Pro-Leu-Gly) and its molecular formula is C43H66N12O12S2. The molecular mass of oxytocin is 1007.187 Da. Oxytocin plays vital parts in several regulatory tasks. For example, oxytocin performs as a neuromodulator, and has been revealed to be involved in stress, anxiety, belief, empathy, social recognition, orgasm, parturition, lactation, maternal behaviors, mother-child and pair bonding with these functions altered by variations in both oxytocin and oxytocin receptor concentrations.

World Health Organization (WHO) defines primary postpartum hemorrhage (PPH) as blood loss of greater than or equal to 1000 ml following cesarean section (CS) [5]. It accounts for one-quarter of the major direct causes of maternal deaths nearly one-third of mortalities in Africa and Asia [6]. The risk of postpartum complications in women who received a CS was higher than that in women who underwent a vaginal delivery (VD) and vaginal birth after cesarean section (VBAC) [3,7]. The incidence of PPH has been reported to be 3.9% in women delivered vaginally and reaches 7.9% after CS [8].Ahmed [1] discussed prevention of postpartum hemorrhage (PPH) after cesarean section by administrating the study drug oxytocin.

In this paper organized as follows, in section 2 we presented the notations involved in this paper. In section 3 we introduced the different kinds of fuzzy mathematical model using the generalized gamma distribution (GGD), log-logistic distribution (LLD), generalized Rayleigh distirbution(GRD) and Rayleigh distribution (RD). In section 4 we were using the above mentioned models in an application to find the effect of oxytocin by finding the mean and variance values. In section 5 using testing of hypothesis we compare the mean and varaince values of the various models. In section 6 a breif conclusion is delivered.

2. Notations:

λ	– Scale parameter of GGD
μ, φ	– Shape parameter of GGD
η	– Scale Parameter LLD
ψ	– Shape Parameter LLD
β	– Scale parameter of RD and GRD
χ	– Shape parameter GRD
$E(X)$	– Mean value of X
$V(X)$	– Variance value of X
$\overline{E}(X)$	– Fuzzy mean value of X
$\overline{V}(X)$	– Fuzzy variance value of X

3. Fuzzy Mathematical Models:

A r.v. X follows Fuzzy Generalized Gamma distribution (FGGD) with fuzzy parameter $\overline{\lambda},\overline{\mu},\overline{\varphi}$ is symbolized by $X \sim FGGD\left(x;\overline{\lambda},\overline{\mu},\overline{\varphi}\right)$. The expected value of $X \sim FGGD\left(x;\overline{\lambda},\overline{\mu},\overline{\varphi}\right)$ is given by

$$\overline{E}[X]=\frac{\overline{\mu}\Gamma\left(\overline{\varphi}+\frac{1}{\overline{\lambda}}\right)}{\Gamma\overline{\varphi}},\quad \lambda\in\overline{\lambda}(\alpha),\mu\in\overline{\mu}(\alpha),\varphi\in\overline{\varphi}(\alpha).$$

The variance value of $X \sim FGGD\left(x;\overline{\lambda},\overline{\mu},\overline{\varphi}\right)$ is given by

$$V[X]=\overline{\mu}^{2}\left(\frac{\Gamma\left(\overline{\varphi}+\frac{2}{\overline{\lambda}}\right)}{\Gamma\overline{\varphi}}-\left(\frac{\Gamma\left(\overline{\varphi}+\frac{1}{\overline{\lambda}}\right)}{\Gamma\overline{\varphi}}\right)^{2}\right)$$

Fuzzy Log-Logistic Distribution Model:

A r.v. X follows log-logistic distribution with scale and shape parameter η , ψ respectively is denoted by $X \sim LLD(\eta,\psi)$. The p.d.f. of $X \sim LLD(\eta,\psi)$ is

A r.v. X follows fuzzy log-logistic distribution (FLLD) with the fuzzy numbers $\overline{\eta},\overline{\psi}$ is indicated by $X \sim FLLD(\overline{\eta},\overline{\psi})$. The expected value for $X \sim FLLD(\overline{\eta},\overline{\psi})$ is

$$\overline{E}(X)=\frac{\overline{\eta}\left(\frac{\pi}{\overline{\psi}}\right)}{\sin\left(\frac{\pi}{\overline{\psi}}\right)},\ \eta\in\overline{\eta}(\alpha),\ \ \overline{\psi}\in\overline{\psi}(\alpha)\cdot$$

The variance values of $X \sim FLLD(\overline{\eta},\overline{\psi})$ is

$$\overline{V}[X]=\frac{\overline{\eta}^{2}\left(\left(\frac{2\pi}{\overline{\psi}}\right)\sin 2\left(\frac{\pi}{\overline{\psi}}\right)-\left(\frac{\pi}{\overline{\psi}}\right)^{2}\right)}{\sin^{2}\left(\frac{\pi}{\overline{\psi}}\right)},\ \eta\in\overline{\eta}(\alpha),\ \ \overline{\psi}\in\overline{\psi}(\alpha)\cdot$$

Fuzzy Rayleigh Distribution Model:

A r.v. X follows Fuzzy Rayleigh distribution is denoted by $X \sim FRD\left(x;\overline{\beta}\right)$ with fuzzy parameter $\overline{\beta}$. The Mean of FRD distribution is given by $\overline{E}(X)=\overline{\beta}\sqrt{\frac{\pi}{2}},\ \overline{\beta}\in\overline{\beta}(\alpha)$.The fuzzy variance is defined as follows $\overline{V}(X)=\left(\overline{\beta}\right)^{2}\left(2-\frac{\pi}{2}\right)$

Fuzzy Generalized Rayleigh Distribution:

If a r.v. X follows fuzzy generalized Rayleigh Distribution is denoted by $X \sim FGRD\left(x:\overline{\chi},\overline{\beta}\right)$ where $\overline{\beta},\overline{\chi}$ are fuzzy parameters. The expected value of $X \sim FGRD\left(x;\overline{\beta},\overline{\chi}\right)$ is given by $\overline{E}[X]=\frac{\Gamma\left(\overline{\chi}+\frac{3}{2}\right)}{\Gamma\left(\overline{\chi}+1\right)}\sqrt{\overline{\beta}},\ \ \overline{\chi}\in\overline{\chi}(\alpha),\overline{\beta}\in\overline{\beta}(\alpha)$. The variance value of $X \sim FGRD\left(x;\overline{\lambda},\overline{\mu},\overline{\varphi}\right)$ is given by

$$\overline{V}[X]=\left(\left(\overline{\chi}+1\right)-\left(\frac{\Gamma\left(\overline{\chi}+\frac{3}{2}\right)}{\Gamma\left(\overline{\chi}+1\right)}\right)^{2}\right)\overline{\beta},\quad \overline{\chi}\in\overline{\chi}(\alpha),\overline{\beta}\in\overline{\beta}(\alpha).$$

4. Results and Application:

Consider a trail conducted by Pinder A J [9] for prevention of postpartum hemorrhage (PPH) after cesarean section by administrating the study drug oxytocin. The study was conducted on 34patients after fetal extraction. The heart rate changes were shown in the figure4.1. after administration of oxytocin.Based on the heart rate changes after 5u dose the parameters of GGD are 1.0196, 82.5130, 1.3830, the LLD parameters are 14.45, 102.01, the parameters of GRD are 18.19, 81.796 and the parameter of RD is 83.633. The fuzzy triangular numbers of the GGD parameters are $\overline{\lambda}=$ [0.9525, 1.0196, 1.1042], $\overline{\mu}=$[81.2311, 82.5130, 83.8875], $\overline{\varphi}=$[1.3803, 1.3830, 1.3875] and the corresponding α–cuts are $\overline{\lambda}(\alpha)=$[0.9525+0.0671α, 1.0196, 1.1042-0.0846α], $\overline{\mu}(\alpha)=$[81.2311+1.2819α, 82.5130, 83.8875-1.3745α], and $\overline{\varphi}(\alpha)=$. [1.3803+0.0027α, 1.3830, 1.3875-0.0045α]. The fuzzy triangular numbers of the LLD parameters are $\overline{\eta}=$[13.4263, 14.4500, 15.4923], $\overline{\psi}=$[100.7358, 102.0100, 103.3782] and the corresponding α–cuts are $\overline{\eta}(\alpha)=$[13.4263+1.0237α, 14.4500, 15.4923-1.0423α], $\overline{\psi}(\alpha)=$[100.7358+1.2742α, 102.0100, 103.3782-1.3681α]. The fuzzy triangular numbers of the GRD parameters are $\overline{\beta}=$[17.2480, 18.1900, 19.0631], $\overline{\chi}=$[80.7663, 81.7960, 82.8446].and the corresponding α–cuts are $\overline{\beta}(\alpha)=$[17.2477+0.9423α, 18.1900, 19.0630-0.8731α], $\overline{\chi}(\alpha)=$[80.7663+1.0297α, 81.7960, 82.8446-1.0486α]. The fuzzy triangular number for RD parameter is $\overline{\beta}=$[82.8284, 83.6330, 84.3782] and the corresponding α–cut is $\overline{\beta}(\alpha)=$[82.8284+0.8046α, 83.6330, 84.3782-0.7452α].

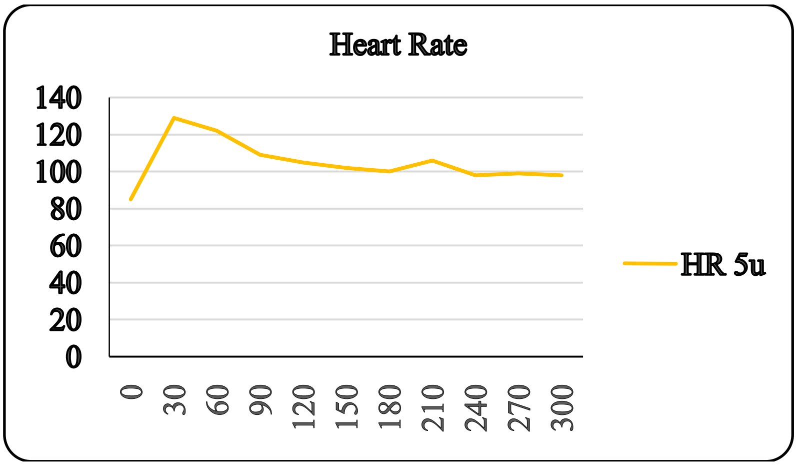

Figure 4.1: Heart rate after administration of oxytocin

The Fuzzy mean values and variance for FLLD, FGGD, FGRD and FRD are presented in the tables 4.1. and 4.2. for lower and upper alpha cuts respectively.

Table 4.1: Fuzzy mean values for the lower and upper alpha cut for the effect of 5u does of oxytocin in HR

Alpha	$E_L(X)[\alpha]$				$E_U(X)[\alpha]$			
	FLLD	**FGGD**	**FGRD**	**FRD**	**FLLD**	**FGGD**	**FGRD**	**FRD**
0	13.4285	115.849	37.4963	103.81	15.4947	109.763	39.9197	105.752
0.1	13.5309	115.489	37.6224	103.911	15.3904	110.009	39.8032	105.659
0.2	13.6332	115.14	37.7482	104.012	15.2862	110.265	39.6865	105.566
0.3	13.7356	114.802	37.8739	104.113	15.182	110.532	39.5698	105.472
0.4	13.838	114.475	37.9995	104.213	15.0777	110.809	39.453	105.379
0.5	13.9404	114.159	38.1249	104.314	14.9735	111.097	39.336	105.285
0.6	14.0428	113.852	38.2501	104.415	14.8692	111.397	39.2189	105.192
0.7	14.1451	113.556	38.3751	104.516	14.765	111.709	39.1017	105.099
0.8	14.2475	113.269	38.5001	104.617	14.6608	112.034	38.9844	105.005
0.9	14.3499	112.991	38.6248	104.718	14.5565	112.371	38.867	104.912
1	14.4523	112.722	38.7494	104.818	14.4523	112.722	38.7494	104.818

Table 4.2: Fuzzy variance for the lower and upper alpha cut for the effect of 5u does of oxytocin in HR

Alpha	$E_L(X)[\alpha]$				$E_U(X)[\alpha]$			
	FLLD	**FGGD**	**FGRD**	**FRD**	**FLLD**	**FGGD**	**FGRD**	**FRD**
0	13.4285	115.849	37.4963	103.81	15.4947	109.763	39.9197	105.752
0.1	13.5309	115.489	37.6224	103.911	15.3904	110.009	39.8032	105.659
0.2	13.6332	115.14	37.7482	104.012	15.2862	110.265	39.6865	105.566
0.3	13.7356	114.802	37.8739	104.113	15.182	110.532	39.5698	105.472

0.4	13.838	114.475	37.9995	104.213	15.0777	110.809	39.453	105.379
0.5	13.9404	114.159	38.1249	104.314	14.9735	111.097	39.336	105.285
0.6	14.0428	113.852	38.2501	104.415	14.8692	111.397	39.2189	105.192
0.7	14.1451	113.556	38.3751	104.516	14.765	111.709	39.1017	105.099
0.8	14.2475	113.269	38.5001	104.617	14.6608	112.034	38.9844	105.005
0.9	14.3499	112.991	38.6248	104.718	14.5565	112.371	38.867	104.912
1	14.4523	112.722	38.7494	104.818	14.4523	112.722	38.7494	104.818

5. Testing of Hypothesis:

Hypothesis testing is the process used to extent the strength of validation from the trial and offers a plan for making decisions related to the population, i.e., it conveys a technique for accepting how consistently one can deduce experimental findings in a sample under study to the greater population from which the sample was drawn. We first define a hypothesis – a certain declaration of the population parameters. Such a hypothesis denoted by H_0. Here we define the as H_0 follows, H_0: $\overline{\mu_1} - \overline{\mu_2} > 0$ there is significant difference in μ_1 than μ_2, H_1: $\overline{\mu_1} \leq \overline{\mu_2}$.

Test statistic for lower alpha values is defined by

$$t_l = \left[\frac{\overline{\mu_l}\sqrt{n}}{S_l}\right] \text{ and } S_l^2 = \left[\frac{\sum\left(\mu_l - \overline{\mu_l}\right)^2}{n-1}\right] \text{ and } S_l = \sqrt{S_l^2}\ .$$

Test statistic for upper alpha values is defined by

$$t_u = \left[\frac{\overline{\mu_u}\sqrt{n}}{S_u}\right] \text{ and } S_u^2 = \left[\frac{\sum\left(\mu_u - \overline{\mu_u}\right)^2}{n-1}\right] \text{ and } S_u = \sqrt{S_u^2}\ .$$

a) For FLLD and FGRD $\overline{\mu_l} = \overline{E}_{L(FLLD)} - \overline{E}_{L(FGRD)}$ and $\overline{\mu_u} = \overline{E}_{U(FLLD)} - \overline{E}_{U(FGRD)}$

b) For FGGD and FGRD $\overline{\mu_l} = \overline{E}_{L(FGGD)} - \overline{E}_{L(FGRD)}$ and $\overline{\mu_u} = \overline{E}_{U(FGGD)} - \overline{E}_{U(FGRD)}$

c) For FRD and FGRD $\overline{\mu_l} = \overline{E}_{L(FRD)} - \overline{E}_{L(FGRD)}$ and $\overline{\mu_u} = \overline{E}_{U(FRD)} - \overline{E}_{U(FGRD)}$

d) For FGGD and FLLD $\overline{\mu_l} = \overline{E}_{L(FGGD)} - \overline{E}_{L(FLLD)}$ and $\overline{\mu_{\max}} = \overline{E}_{U(FGGD)} - \overline{E}_{U(FLLD)}$

e) For FRD and FLLD $\overline{\mu_l} = \overline{E}_{L(FRD)} - \overline{E}_{L(FLLD)}$ and $\overline{\mu_u} = \overline{E}_{U(FRD)} - \overline{E}_{U(FLLD)}$

f) For FGGD and FRD $\overline{\mu_l} = \overline{E}_{L(FGGD)} - \overline{E}_{L(FRD)}$ and $\overline{\mu_u} = \overline{E}_{U(FGGD)} - \overline{E}_{U(FRD)}$

Now we applying the paired sample t-test for the values in table 4.1.

Table 4.3: Paired sample t-Test for fuzzy mean values for the effect of 5u dose of oxytocin in HR

Paired Samples t-Test									
S.No	**Paired Distributions**	**Paired Differences**					**t**	**df**	**Sig.**
		Mean	**Std. Deviation**	**Std. Error Mean**	**95% Confidence Interval of the Difference**				
					Lower	**Upper**			
1	FLLD Lower – FGRD Lower	100.269	1.376	0.415	99.345	101.194	241.631	10	0
2	FGGD Lower – FGRD Lower	24.184	0.076	0.023	24.133	24.235	1054.706	10	0
3	FRD Lower – FGRD Lower	90.374	0.005	0.002	90.370	90.377	58821.348	10	0
4	FGGD Lower – FLLD Lower	76.085	1.452	0.438	75.110	77.061	173.754	10	0
5	FRD Lower – FLLD Lower	66.190	0.081	0.024	66.136	66.245	2705.442	10	0
6	FGGD Lower – FRD Lower	9.895	1.371	0.413	8.974	10.817	23.935	10	0
7	FLLD Upper – FGRD Upper	96.182	1.327	0.400	95.291	97.073	240.473	10	0

8	FGGD Upper – FGRD Upper	24.362	0.042	0.013	24.333	24.390	1905.018	10	0
9	FRD Upper – FGRD Upper	90.312	0.036	0.011	90.288	90.336	8332.054	10	0
10	FGGD Upper – FLLD Upper	71.820	1.369	0.413	70.900	72.740	174.002	10	0
11	FRD Upper – FLLD Upper	65.950	0.078	0.024	65.897	66.003	2791.308	10	0
12	FGGD Upper – FRD Upper	5.870	1.291	0.389	5.003	6.737	15.085	10	0

From the sig. value in the table 4.16., there was a significant difference in

- ✓ FGGD than FRD [t(10)=23.935, p<0.05], [t(10)=15.085, p<0.05],
- ✓ FGGD than FLLD [t(10)=173.754, p<0.05], [t(10)=174.002, p<0.05],
- ✓ FGGD than FGRD [t(10)=1054.706, p<0.05], [t(10)=1905.018, p<0.05] for lower and upper α-cuts respectively.

6. Conclusion:

Here we successfully established the fuzzy models to calculated the effect of oxytocin by estimate the mean and variance of FGGD, FLLD, FRD, FGRD. The mean values are increased for lower alpha cuts and decreased for upper alpha cuts. The testing of hypothesis shows that there is a significant difference in FGGD than FLLD, FGRD, FRD. FGGD fits well for measuring the effect of oxytocin in PPH.

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