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A MATHEMATICAL MODEL FOR THE SECRETION OF THYROXINE AND THYROID STIMULATING HORMONE IN IODINE-DEFICIENT PREGNANT WOMEN BY FUZZY APPROACH

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Abstract:

The fuzzy survivor and fuzzy Weibull hazard rate functions were developed and is used to analyze the relationships between serum thyroxine and thyroid stimulating hormone concentrations in iodine-deficient pregnant women. We show that, if the fuzzy survivor function decreases, then the fuzzy hazard rate increases in the lower alpha cut values, whereas in upper alpha cut values is the fuzzy survivor function increase then the fuzzy hazard rate function is decreased.

Key Words: Fuzzy Survivor & Fuzzy Weibull Hazard Rate Function
2010 Mathematics Subject Classification: 97Mxx, 93A30, 60A86

1. Introduction:

A mathematical model is a description of a system using mathematical concepts and language. The process of developing a mathematical model is termed mathematical modeling.

The survival function, also known as a survivor function or reliability, function, is a property of any random variable that maps a set of events, usually associated with mortality or failure of some system, onto time [7].

The hazard function $h(x)$ is the ratio of the probability density function $P(x)$ to the survivor function, and is given by

$$h(x) = \frac{p(x)}{s(x)} = \frac{P(x)}{1-D(x)}$$ where $D(x)$ is the distribution function.

Thyroxine test measures the blood level of the hormone T4, also known as thyroxine, which is produced by the thyroid gland and it helps to control metabolism and growth. The T4 test is performed as part of an evaluation of thyroid function [1], [8].

Thyroid stimulating hormone (TSH) promotes the growth of the thyroid gland in the neck and stimulates it to produce more thyroid hormones. When there is an excessive amount of thyroid hormones, the pituitary gland stops producing TSH, reducing thyroid hormone production. This mechanism maintains a relatively constant level of thyroid hormones circulating in the blood and TSH is also known as thyrotrophic [9].

An adaptation of iodine deficiency (ID) requires changes in thyroid and pituitary function that have been well characterized in animals also [9].

Iodine deficiency (ID) is known to cause alterations in plasma thyroid hormone levels. It was of interest to us to see whether moderate or mild iodine deficiency and a detectable influence on serum thyroid hormone and TSH concentrations. We were particularly interested in the role of serum T4 in TSH regulation [10].

2. Materials & Methods:

2.1 Fuzzy Survivors and Fuzzy Weibull Hazard Rate Function:

Hazard rate functions address [11], [12], [13] the problem of varying life spans for certain types of annuities. The hazard rate function attempts to assess the expected lifetime of an individual. If 't' measures the age of a randomly chosen individual (including deceased individuals), then the hazard rate function $h(t)$ is given by

$$h(t) = \lim_{\Delta t \to 0} \frac{1}{\Delta t} prob\ \{A \mid B\}$$

where A is the event that the individual will die within the time period (t, $t+\Delta t$), B is the event that the individual is alive at time t, Δt represents a time increment. The probability that an individual is alive at time is called the survivor function, denoted as $s(t)$, such that $s(t+\Delta t)$ = $Prob${individual is alive at $t+\Delta t$ }which is equivalent to $s(t+\Delta t) = Prob\{\bar{A}$ and B}. where we denote by $\bar{A}$, the event that the individual is alive at $t+\Delta t$. Consequently, by the definition of conditional probabilities the above equation becomes

$$s(t+\Delta t) = Prob\{\bar{A} \mid B\}\ Prob\{B\}$$

The Weibull hazard rate function is defined as $h(t) = \alpha\beta t^{\beta-1}$ for $\alpha > 0$ and $\beta > 0$. The $h(t)$ is unbounded when β >1and from this distribution survivor rate becomes $s(t) = e^{-\alpha t^{\beta}}$. On simplification we get, the Weibull survivor function as $s(t) = e^{-\alpha t^{\beta}}$ and hazard rate function as $h(t) = \alpha\beta t^{\beta-1}$. Thus the total damage Weibull function at time 't' is

$$s_l(t) = min\{e^{-\alpha t^{\beta}}\} \text{ and } s_u(t) = max\{e^{-\alpha t^{\beta}}\}$$
$$h_l(t) = min\{\alpha\beta t^{\beta-1}\} \text{ and } h_u(t) = max\{\alpha\beta t^{\beta-1}\}$$

The alpha cut of the fuzzy Weibull survivor and the hazard function at time 't' is

$$\bar{s}_l(t) = min\{e^{-\bar{\alpha} t^{\bar{\beta}}}\} \text{ and } \bar{s}_u(t) = max\{e^{-\bar{\alpha} t^{\bar{\beta}}}\}$$
$$\bar{h}_l(t) = min\{\bar{\alpha}\bar{\beta} t^{\bar{\beta}-1}\} \text{ and } \bar{h}_u(t) = max\{\bar{\alpha}\bar{\beta} t^{\bar{\beta}-1}\}$$

2.2 Application:

Blood samples were obtained at different gestational ages, pregnant women. These women came from various suburban and rural areas so that there were some differences in iodine intake due to factors such as iodine content in the water, seafood consumption, and access to iodized salt.

Then the whole pattern of thyroid hormones and TSH found in these studies is similar to that in many earlier reports of ID. When serum T_4 is low, the serum TSH is increased. Fewer studies have dealt with these parameters in pregnancy, but the trend is the same as that in nonpregnant adults. Since iodine requirements are expected to increase during pregnancy, iodine-deficient women might not be expected to increase their total T_4 normally in response to the pregnancy-induced increase in thyroxine-binding globulin [2].

Figure 2.1 suggested that decreasing iodine supply was associated with a progressive increase in serum TSH, whereas at higher iodine intake, the serum TSH level didn't influence by further increases in iodine supply.

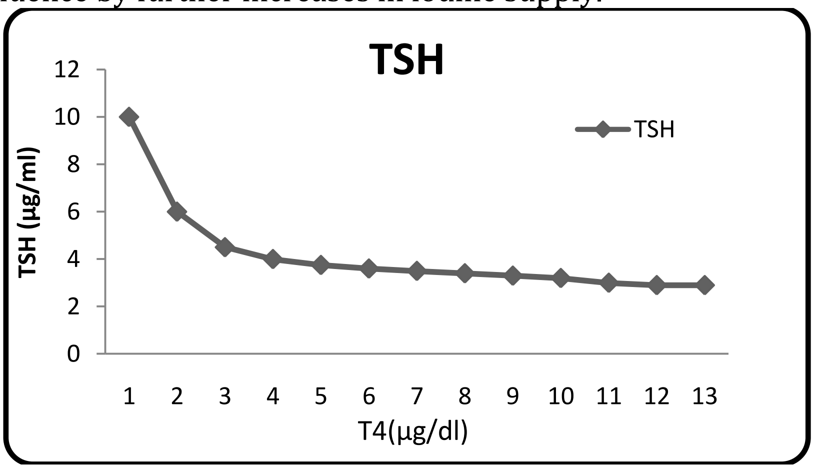


Figure: 2.1

An inverse relationship between T_4 and TSH concentrations is suggested, but the relationship does not seem to be a simple linear one.

A steep increase in TSH would be expected in pregnant women when serum T_4 decrease below 6μg/dl, while as the serum T_4 concentrations approaches normal, TSH would not decrease greatly [2], [3], [4], [5], [6]. [7].

3. Discussions:

In general, when the serum T_4 is low the serum TSH is increased in pregnancy, but the trend is the same as that in non-Pregnant adults.

Since iodine requirements are expected to increase during pregnancy, iodine deficient women might not be expected to increase their total T_4 normally in response to the pregnancy-induced increase in thyroxin-binding globulin.

The triangular fuzzy numbers on the scale and location parameters are:

$$\bar{\alpha} = [0.0, 0.276, 3.202]$$
$$\bar{\beta} = [2.0, 2.430, 5.508]$$

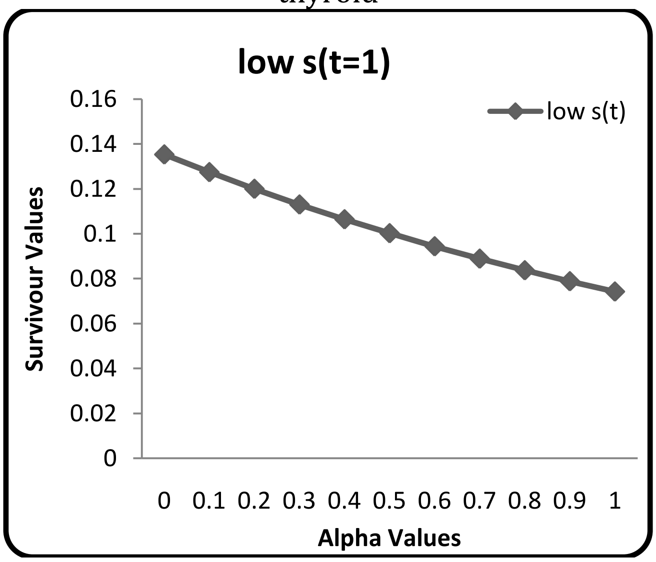
The corresponding alpha cut for the scale and location parameters are

$$\bar{\alpha} = [2 + 0.601\alpha, 3.202 - 0.601\alpha]$$
$$\bar{\beta} = [4 + 0.754\alpha, 5.508 - 0.754\alpha]$$

Under the alpha cut zero, the fuzzy survivor values of the autoimmune thyroid response to the higher day for t = 1 is calculated from $\bar{s}\{\bar{z}(t)\} = [\bar{s}_l(t), \bar{s}_u(t)]$ and the fuzzy hazard rate values of the autoimmune thyroidits response to the higher day for t = 1 is calculated from $\bar{h}\{\bar{z}(t)\} = [\bar{h}_l(t), \bar{h}_u(t)]$ is shown in the following table 3.1.

α	$\bar{s}_l(t)$	$\bar{s}_u(t)$	$\bar{h}_l(t)$	$\bar{h}_u(t)$
0	0.13534	0.040681	8	17.636616
0.1	0.12744	0.043201	8.39573	17.0686859
0.2	0.12001	0.045877	8.80053	16.509819
0.3	0.11301	0.048718	9.21438	15.9600151
0.4	0.10642	0.051736	9.6373	15.4192742
0.5	0.10021	0.054941	10.0693	14.8875965
0.6	0.09436	0.058344	10.5103	14.3649818
0.7	0.08886	0.061958	10.9604	13.8514303
0.8	0.08368	0.065796	11.4196	13.3469418
0.9	0.0788	0.069871	11.8879	12.8515163
1	0.0742	0.074199	12.3652	12.365154

Table: 3.1 Fuzzy survivors and fuzzy Weibull hazard rate values for lower and upper thyroid



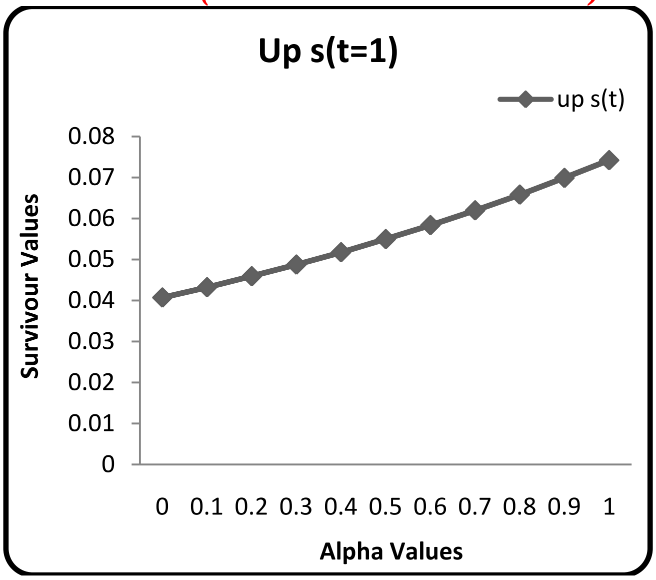


Figure: 3.1 Lower and upper alpha cut for the fuzzy survivor values

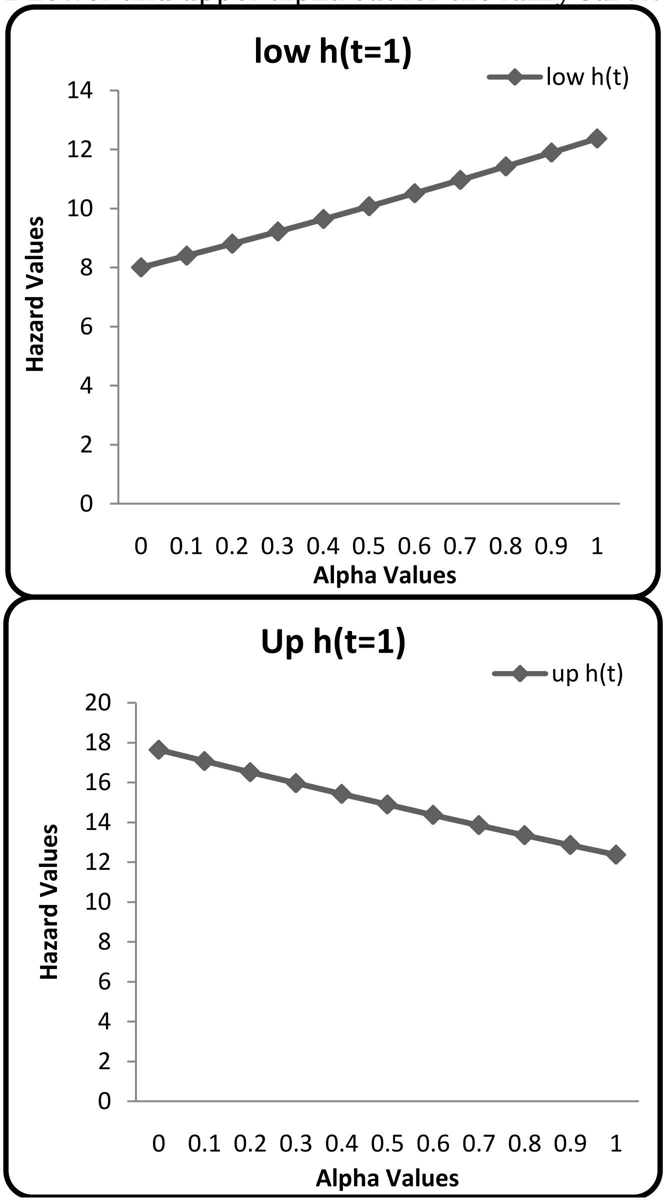


Figure: 3.2 Lower and upper alpha cut for the fuzzy Weibull hazard rate values

4. Conclusion:

This shows that, if the fuzzy survivor function decreases, then the fuzzy hazard rate increases in the lower alpha cut values, and in upper alpha cut values if the fuzzy survivor function, increase then the fuzzy hazard rate function decreases and when the Serum T_4 is low, then the serum TSH is increased and we have dealt with these parameters in pregnancy, but the trend is the same as that in non-pregnant adult's mothers and newborns. It may also reflect the participation of compensatory mechanisms that partially protect the fetus from the low maternal iodine intake.

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