Monte Carlo Simulation for Prediction of Worsening Conditions of Type-2 Diabetes Patients at Peri-Urban Zones of Lima City

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***Abstract*—From a sample of 1K type-2 diabetes cases, using Monte Carlo simulation and real data, we have estimated that a 2.5% might be potential candidates in being in the highest levels of progress of type-2 diabetes as manifested in nephropathy or necrosis, In addition, a 1% of the sample might be highly sensitive to cardiovascular attack. The pattern of the sample is characterized by having low incomes per month, poor education to improve lifestyle, as well as the lack of contact with health specialist, among others. The results of this simulation might serve to reconfigure ongoing schemes of public health aiming to reduce diabetes complications and extend minimally the lifetime of those type-2 diabetes patients belonging to vulnerable groups.**

Keywords*—Monte Carlo method, type-2 diabetes, mathematical modeling.

I. Introduction

The rapid growth of number of diagnosticians of type-2 diabetes at urban and Peri-urban cities of developing countries is nowadays considered priority in their modern frameworks of programs of public health by which one expects that new medical methodologies to be applied are capable to tackle the expansion of this disease in the short term [1]. For instance in Latin American countries like Peru, reports have indicated that diagnosticians of type-2 diabetes in Lima city are massively given in young people population around the thirties which means that this human group might reduce drastically their quality of life in long term [2][3][4]. Clearly the reduction of the life expectancy of diabetes patients involves serious social and economic consequences, and novel designs of diabetes treatment are required to be urgently applied in a coherent manner between the health policy and the stability of diabetes patient. This paper has paid attention on diabetic patients of human groups featured by having lowest incomes and minimal interaction with medical specialists.

It is believed that these patients are candidates to acquire diabetes complications in their main forms: (i) retina degradation, (ii) necropsy and (iii) renal insufficiency, among others. In addition, upper levels of complication might be understood as unexpected apparition of strokes and cardiovascular events. Although pharmacological actions and patients care are usually taken by health specialists inside classical schemes, computer-based medical studies seen as the conjunction of the medical analysis and computer technologies application appears to be an interesting option to mitigate and tackle complications of advanced states of diseases [6]. In effect, these initiatives might be crucial to improve the quality of life of patients with metabolic disorder such as type-2 diabetes. Recently in Ref. [7], it was seen that Telemedicine oriented to diabetes, targets to compute critical parameters of patients inside mathematical schemes of the computational simulation such as the Monte Carlo method which is used to simulate data for diabetes analysis. The purpose for using Monte Carlo technologies is that of extending the real acquired data from patients to a large number of cases which should be needed to make predictions within reasonable statistical errors [8][9].

This paper has paid attention to those patients that for different reasons are changing their quality of life and expecting the apparition of complications due to the progress of disease such as depression, high systole blood pressure, glucose above the normal values and overweight [10][11][12]. The confluence of these factors can be perceived as the imminent complication of diabetes patient With the information of the results of a survey applied to 25 patients belonging to a Peri-urban of Lima city, up to 975 samples have been simulated with the method of Monte Carlo. Simulated data have served inside a scheme of discrimination based on algorithms that would allows us to calculate the number of patients with the highest probabilities for acquiring nephropathy and necrosis which would reduce the lifetime of diabetes patient substantially. In this manner, attention is paid to the different combinations of levels of complications by which the patient might acquire due to the abandon of prescriptions (metformin, for example) and careful lifetime. For example, mood disorder can be the cause to trigger the rapid growth of the values of glucose as well as states of overweight [11]. In fact, aspects of incorrect nutrition can be driven by the psychology of patient by which would require of a concrete prescription to defeat the depression and recover the willing to continue the treatment.

The paper is structured as follows: second part gives details about the initial sample and the Monte Carlo simulation to reproduce 975 cases. Third part provides the mathematical machinery that serve as basis in these studies. Here is presented all normalized probability density functions corresponding to the (i) depression, (ii) weight, (iii) glucose, (iv) blood pressure, and (v) diabetes complications that involves: nephropathy or kidney disease and necrosis. In fourth part, the algorithm used to filter and select data is described. The acceptance or rejections follows the mathematical treatment given in third part. In fifth part, we interpreted the results of the application of algorithm in order to make statistical predictions about the fraction of patients which would reduce their life expectancy substantially in the middle and long term. Finally, conclusion

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of this study is given.

II. Collected and Generated Data

A. Patient Characteristics

The present study has its starting point in the identification of diabetes patient that belong to a Peri-urban zone at Lima (this study was approved by the ethical committee of Universidad de Ciencias y Humanidades 2015). The disease of type-2 diabetes in these patients was confirmed through glycated hemoglobin Hb_{1C} test. This project has started with 37 patients (which have provided consent for these studies), by the which 12 of them decided do not continue for private reasons. In this manner we have considered up to 25 patients with signs of having started to develop diabetes complications. This diabetes group resides 18 km south away from Lima city. It is known that patients have manifested depression, fact that underlines to this sample. Health specialists have monitored all patients through medical consults, interviews and visits during 6 months. The choice of these patients has followed these criteria: (i) income below 75 USD per month, (ii) depression triggered by economic and social factors, (iii) depression triggered by the progress of diabetes disease, (iv) abandoning the metformin (or other anti-diabetic) treatment, (v) low level of self-care, and (vi) lack of a nutritional rigid control. In addition, systole blood pressure was taken during the sessions with health specialists.

B. Measurements and Worsening Levels

Each diabetes patient has received (attended) in average up to 6 visits (phone consults). In most cases patients at worse status have had more visits (attentions). In Table I, is shown the register of 25 patients whose ages are ranging between 32 and 80 years old. Patients are in the regime of obesity and presenting high values of systole blood pressure (SBP measured in mmHg). Also, depressive episodes was perceived and corroborated through the usage of the Zung's questionnaire. Although depress was not quantified in this study, it was a criterion to study the patients whose data is listed in Table I. In second column the difference between the first and last glucose measurement, is presented. Third column gives the number of cardiovascular events by which in some cases are 2 per month, approximately. Fourth column gives the level of nephropathy. Here, the high level denoted the case where the diabetes patients have started to use dialysis procedure. In last column the necrosis level, with the high level denotes the cases of amputation of foot or leg, or nearly to these events.

C. Monte Carlo Simulation

From the real samples shown in the Table I, we applied the Monte Carlo technology to increase the initial sample up to 975 samples. Roughly speaking the simulation involves the following criteria: (i) variation of glucose of order of 20%, (ii) variation of cardiovascular events of order of ± 1, (iii) nephropathy level is equal or greater than the level medium when glucose is above 240 mg/dL, and (iv) necrosis level increases only if ΔG is greater than 220 mg/dL. Algorithm 1 briefly describes the structure of the Monte Carlo step, where is seen that each one of the 25 real samples are used to generate

TABLE I. Collected data for 7 relevant variables of 25 type-2 diabetes patients.

Age/Weight/SBP (y.o./kg/mmHg)	Initial Glucose Value (mg/dL)	Cardiov. Events/month (average)	Nephro level	Necrosis level
32/95/125	280	2	low	medium
35/93/133	340	2	low	medium
38/81/131	265	2	low	medium
42/87/137	205	2	low	medium
46/82/128	240	2	low	medium
47/78/141	300	2	low	medium
49/77/143	290	3	low	null
53/65 /152	275	2	low	null
55/92/167	280	1	medium	low
55/88/180	290	2	medium	null
58/75/155	330	3	low	low
59/72/128	400	1	medium	null
61/66/129	358	2	medium	null
61/72/136	200	2	medium	low
61/79/125	180	2	low	low
62/91/155	160	2	medium	medium
66/98/179	225	2	low	high
67/94/144	180	2	medium	high
67/106/141	170	2	low	high
69/86/173	180	3	medium	high
71/65/130	320	1	high	medium
72/74/140	250	1	high	low
75/70/119	235	1	high	low
77/97/146	290	1	medium	medium
80/69/138	180	1	medium	low

Algorithm 1: Monte Carlo Generation

1 **for** β = 1 to 25 real patients
2   **for** i = 1 to 39 simulated patients
3   **for** α = 1 to 7 variables (see Table I)
4   call random ξ
5   **if** $\mathcal{N}(\mu_i^{\alpha,\beta}) > \xi$ **then**
6        $\mathcal{S}(\beta, i, \alpha)$ = $\mu_i^{\alpha,\beta}$ + $\delta_i^{\alpha,\beta}$
7   **end if**
8   **end for**
9   **end for**
10 **end for**

39 additional samples. Also, per each generated sample we must simulate the values corresponding to 7 variables (see Table I), thus the task of algorithm 1 is the simulation of 39×25×7=6825 quantities. The algorithm has required of 10000 Monte Carlo tries, having discarded around 30% of them. Lines 1-3 run over the number of patients, simulated patients and variables. Line 4 calls a random number which is generated by aleatory numbers generator. Line 5 performs the Monte Carlo acceptance together with the error $\delta_i^{\alpha,\beta}$ (line 6). The realization of the Monte Carlo acceptance is supported by the function $\mathcal{N}(\delta_i^{\alpha,\beta})$ that is denoted by a Gaussian profile normalized to 1. Only for those accepted values which passed the Monte Carlo acceptance, $\mathcal{S}(\beta, i, \alpha)$ is saved, and therefore the sample is obtained. The statistical error of simulation was of order of 8%.

III. The Mathematical Model

From the resulting statistics obtained by the Monte Carlo technique, it was possible to recognize in a qualitative manner the morphologies of the curves of (i) depression, (ii) weight, (iii) glucose, (iv) blood pressure, and (v) diabetes complications that involves: nephropathy (or kidney disease) and necrosis. Experience tells us that (v) might be a critical phase of diabetes patients degrading substantially their quality of life, so that this variable is crucial to calculate the fraction of patients with very low life expectancy. Thus below is present the normalized (to 1) curves of variables but interpreted as probability curves as function of age of patient:

a) Depression: This this variable turns out be a factor relevant for triggering other diabetes complications in patients. It is modeled by a Lorentzian function composed by three free parameters and written explicitly as

$$\mathcal{D}(z) = \frac{\chi_{1,1}^2}{\chi_{1,2}^2 + \left(\frac{z-\chi_{1,3}}{\chi_{1,4}}\right)^2} \tag{1}$$

where $\chi_{1,j}$ the free parameters of curve. In Fig. 1 top panel, blue line denotes the curve of probability for this case, and $\chi_{1,1}$=$\chi_{1,2}$=10.0, $\chi_{1,3}$=70.0 and $\chi_{1,4}$=2.0. The curved is peaked around 70, under the hypothesis that the population around this age is quite vulnerable to experiment depressive episodes. It is actually congruent with survey results obtained from the past where it was identified adults above 60 y.o, with a defined unstable social and economic state and more probably to abandon diabetes therapy.

b) Weight: The modeling is given by a Gaussian function centered around 55 y.o. We postulate that the accumulation of overweight cases is over the filthies and extended by a minor decreasing beyond sixties. Thus one can write down as

$$\mathcal{W}(z) = \chi_{2,1}\mathrm{Exp}\left[-\left(\frac{z-\chi_{2,2}}{\chi_{2,3}}\right)^2\right] \tag{2}$$

with $\chi_{2,j}$ defines the morphology of curve. In this case, $\chi_{2,1}$= 100.0, $\chi_{2,2}$=55.0, $\chi_{2,3}$=40.0. For the present case, the highest value is around 100 kg. According to the curve behavior one can estimate in a straightforward manner the cases of overweight for ages ranging between 30 and 80 y.o patients resulting in 70 kg in average.

c) Glucose: This variable uses a random parameter ζ and has dependence of $\frac{z-30}{0.05}$ which rescales the independent variable for ages between 30 and 80 y.o. In addition, the modeling reads as

$$\mathcal{G}(z) = \frac{\chi_{3,1} + \zeta\left(\frac{z-30}{0.05}\right)\chi_{3,2}}{\chi_{3,3}}. \tag{3}$$

Glucose is actually one of the main variables of importance in this study. In Fig. 1 top panel, one can see the oscillating curve denoting glucose concentration but expressed in terms of probability, and reaching value 1 for oldest patients. However, low values of glucose is also found for patients beyond 60 y.o, fact that can be translated as a successful control of glucose independently of patient age. For plotting of Fig. 1 top panel the set of values given by $\chi_{3,1}$=150.0, $\chi_{3,2}$=0.3, and $\chi_{3,3}$=440.0 were used.

d) Blood Pressure: The modeling has considered the ratio systole and diastole pressure, with their minimal values 110 and 70 mmHg, but the normal value around 120/80 mmHg. The modeling takes into account up to 4 free parameters, and reads as

$$\mathcal{P}(z) = \chi_{4,1}\frac{110.0 + \chi_{4,2}\left(\frac{z-30}{0.05}\right)}{70.0 + \chi_{4,3}\left(\frac{z-30}{0.05}\right)} + \chi_{4,4}\left[2\zeta - 1\right] \tag{4}$$

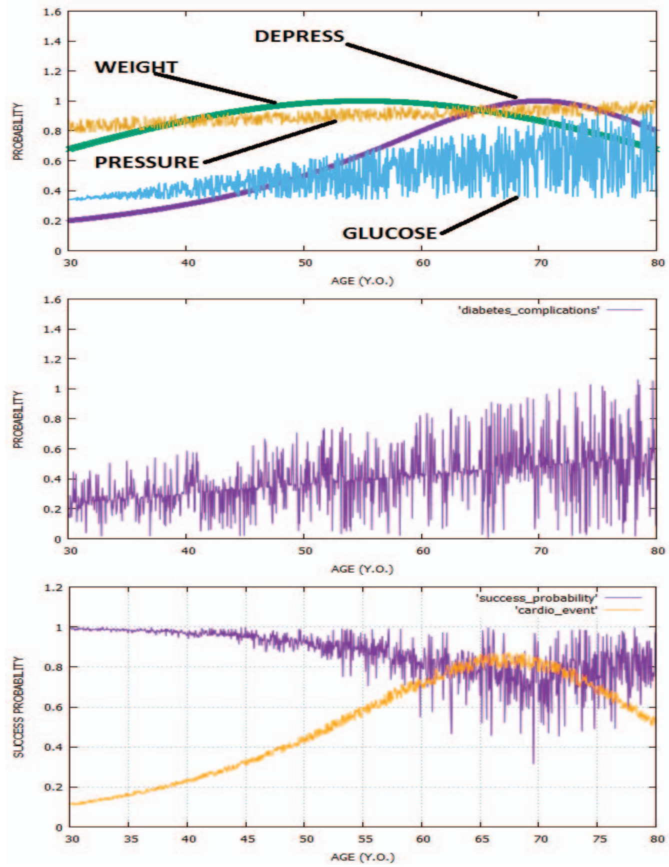

Fig. 1. Top: normalized probability curves of depress, weight, glucose concentration and systole blood pressure, for a range between 30 and 80 y.o. Middle: normalized probability curve for diabetes complication. Bottom: normalized probabilities of success (blue line) and cardiovascular event (orange line) against age of diabetes patient.

where ζ is a number random. For plotting Fig. 1 top panel, one gets $\chi_{4,1}$=1.9, $\chi_{4,2}$=0.09, $\chi_{4,3}$=0.04, and $\chi_{4,4}$=0.05. The curve is normalized to 1 through the factor $\chi_{4,1}$. It should be noted that the curve shows that $\mathcal{P}(z)$ increases with age. The random number provides the stochastic character to the curve, within a window of order of less than 5%.

e) Diabetes Complications: The modeling of this variable is seen in Fig. 1 middle panel. For the present study we have incorporated up to three stages for diabetes worsening (i) first level moderate given by depress, (ii) middle level of worsening manifested by necrosis diabetes, and (ii) high level given by nephropathy or kidney disease. In terms of probability it is interpreted in the following manner

$$\mathcal{C}(z) = \frac{1}{\chi_{5,1}}\left[\chi_{5,2} + \chi_{5,3}\left(\frac{z-30}{0.05}\right)\right]\left[1 + (2\zeta-1)^{\chi_{5,4}}\right] \tag{5}$$

$$= \begin{cases} \text{depress} & 0 < \mathcal{C} \leq 0.33 \\ \text{necrosis} & 0.33 < \mathcal{C} \leq 0.66 \\ \text{nephropathy} & 0.66 < \mathcal{C} \leq 1.00 \end{cases}$$

for any value of z. In Fig. 1 middle panel, is shown the behavior of $\mathcal{C}(z)$ against ages with the input values $\chi_{5,1}$=2.1, $\chi_{5,2}$=0.5, $\chi_{5,3}$=0.00066, and $\chi_{5,4}$=3.0. Again, ζ a random number. The curve shows an intense aleatory behavior since the level of worsening should not be deterministic but also random, in the sense that the age of diabetes patient does not determines the grade of complication. For example, we take the case of a 60 y.o. patient, and his probability is calculated to be of order of 48% that means that the worsening is in the level of necrosis, in according to values above. Aside, another case of a 48 y.o. patient is seen from Fig. 1 middle panel that its probability is more than 66% belonging to the upper level of worsening or nephropathy.

f) Collapse of the Probability of Success: As expressed in [8] the probability of a diabetes patient following his treatment can be written as $P(z) = P_S(z) + P_F(z)$ =1, where P_S and P_F denotes the success and fail, respectively. The success probability can be immediately written as $P_S(z) = 1 - P_F(z)$ as the form more general. From all presented previously, we concluded that the fail probability can be written as the product of all quantities which are against the stability or recovery of diabetes patient. Under this view,

$$P_S(z) = 1 - \mathcal{D}(z) \otimes \mathcal{W}(z) \otimes \mathcal{G}(z) \otimes \mathcal{P}(z) \otimes \mathcal{C}(z) \tag{6}$$

and the total success probability reads

$$P_S = \int_{z_A}^{z_B} P_S(z)dz = 1 - \int_{z_A}^{z_B} \mathcal{D}(z) \otimes \mathcal{W}(z) \otimes \mathcal{G}(z) \otimes \mathcal{P}(z) \otimes \mathcal{C}(z)dz \tag{7}$$

with $z_B - z_A = T_W$ the time of worsening due to diabetes complication. P_S is plotted in Fig. 1 bottom panel and it is not difficult to interpret that the ages between 65 and 75 years old would denote the range for the collapse of the probability of success. Over this range we can model the possible events with the lowest values of P_S which can be translated as the irreversible deterioration of diabetic patient health and under constant thread of cardiovascular assault (or strokes) due to the concurrence of the highest values of depression, overweight, glucose and systole blood pressure. It reads

$$P_{CV} = \int_{z_B}^{z_A} \mathcal{D}(z) \otimes \mathcal{W}(z) \otimes \mathcal{G}(z) \otimes \mathcal{P}(z)dz \tag{8}$$

where the difference $z_B - z_A$ denotes the range where P_{CV} acquires a non negligible value. It actually is understood as the range of age of diabetes patients where become sensitive to experiment complications or similarities. Integration of (8) is done by using numerical methods, in particular for this exercise we have employed the method of Romberg, with an attained error of 0.15% [13]. The resulting integration has numerically converged since the functions to be integrated are dominated by numerators. Exceptionally, $\mathcal{P}(z)$ has a singularity when $70.0 + \chi_{4,3}\left(\frac{z-30}{0.05}\right)$ = 0, that means $z \approx -40$, far from the range of integration. For instance Fig. 1 bottom panel was calculated with Eq. 8, and can be interpreted as the probability of cardiovascular event (or stroke), and having the shape of a Gaussian-like function and peaked between 65 and 75 years old. In addition, P_{CV} can also be interpreted as some event of high risk to mortality.

IV. Algorithm for Identification of Critic Patients

In order to identify those critic patients close to acquire complications reflected in the apparition of necrosis or

Algorithm 2: Identification of Critic Patients

```
for 1 to M patients, M = 1000
Random selection N_j-patient and age ⊂ [30,80]
——searching cases of necrosis——
Necrosis due to glucose and depression
    if D_j(z_k) > 0.5 then
        if G_j(z_k) > 0.5 then
            if C_j(z_k) > 0.66 then
            p_1 = p_1 + 1
            Fill 2D histogram
            end if
        end if
 Necrosis due to depression, overweight and glucose
    else if D_j(z_k) > 0.3 then
        if W_j(z_k) > 0.2 then
            if G_j(z_k) > 0.4 then
                if C_j(z_k) > 0.66 then
                p_2 = p_2 + 1
                Fill 2D histogram
                end if
            end if
        end if
 Necrosis due to overweight and SBP
    else if W_j(z_k) > 0.9 then
        if P_j(z_k) > 0.9 then
            if C_j(z_k) > 0.66 then
            p_3 = p_3 + 1
            Fill 2D histogram
            end if
        end if
    end if
    if P_S < 0.65 then
    Fill 3D histogram (Fig. 3 up)
    end if
——searching cases of nephropathy——
Nephropathy due to overweight and glucose
    if W_j(z_k) > 0.8 then
        if G_j(z_k) > 0.5 then
            if 0.33 < C_j(z_k) < 0.66 then
            p_4 = p_4 + 1
            Fill 2D histogram
            end if
        end if
 Nephropathy due to glucose and SBP
    else if G_j(z_k) > 0.5 then
        if P_j(z_k) > 0.9 then
            if 0.33 < C_j(z_k) < 0.66 then
            p_5 = p_5 + 1
            Fill 2D histogram
            end if
        end if
    end if
    if P_S < 0.65 then
    Fill 3D histogram (Fig. 3 down)
    end if
end for
```

nephropathy, we use a stochastic-based algorithm that uses the resulting statistics of the Monte Carlo simulation. Thus, algorithm 2 consists of 53 lines and runs over 1K patients (line 1) already generated by the Monte Carlo as described by the algorithm 1. The election of each patient is given in an aleatory manner together with its age (lines 2-3). The first criterion of selection considers that necrosis is triggered by glucose and depression. Thus, patients with high probability of having various depressive episodes and glucose greater than 50% (lines 4-5), and diabetes complication manifested by necrosis above 66% passed the filter (line 6). Once it is achieved, the histogram is filled (line 8), otherwise we pass to the second criterion consisting in the events of necrosis is triggered by depression, overweight and glucose. In this case, depression and overweight are required to be greater than 0.3 and 0.2 (lines 12-13), respectively, whereas glucose 0.4 (line 14). With these requirements, the complication should be greater than 0.66 in order that the cases are accepted (line 15), implicating that the histogram be filled (line 17). A third criterion considers that necrosis can be triggered due to overweight and systole blood pressure (SBP), with the requirement of having overweight and SBP both above 0.9 (lines 22-23). This acceptance is achieved only if complication is above 0.66 (line 24). To calculate P_S Eq. 7 is used (line 30), and those patients that pass this criterion are stored in 3D histograms (line 31) [14]. Here are stored the cases which have passed the cuts (or criterion of discrimination of cases) already described in algorithm 2. The selected cases are interpreted as those potential patients that might develop necrosis. On the other hand, the analysis of nephropathy is initialized due to overweight and glucose, above of 0.8 and 0.5 (lines 34-35), respectively. It should be noted that the acceptance of nephropathy in patients are guaranteed by the requirement of complication ranging between 0.33 and 0.66 (line 36). The last criterion demands that glucose and SBP are above 0.5 and 0.9 (lines 42-43), respectively. All nephropathy counts are stored in 2D histograms. Finally, P_S is again used to calculate the total success probability and fill the 3D histograms (line 51).

V. Results

A. Interpretation of 2D Histograms

In Fig. 2, 2D histograms that denote number of critic patients versus age and generated by the algorithm 2, are shown. Fig. 2 (A) corresponds to the case where necrosis is pushed out by depressive episodes and uncontrolled glucose, resulting that 15 critic patients belong to the range given by 54 and 62 years old. Fig. 2 (B) shows also the cases of necrosis as consequence of having assumed that patients are under depression, overweight and uncontrolled glucose [15][16], and the histogram shows two peaks just on 55 and 59 years old, and yielding a total of 17 patients. The why one can see here more cases is because the filter for glucose is lower than the previous case. In Fig. 2 (C) depicts the cases of necrosis but with the filters of overweight and SBP, displaying a certain accumulation of cases at the range whose ages are limited by 46 and 54 years old. The rest of histograms are the cases of nephropathy due to overweight and glucose (D), and glucose and SBP (E) being both histograms that show their morphologies peaked to the right side of plots. It is interesting to note that the complications due to nephropathy contains more cases than necrosis.

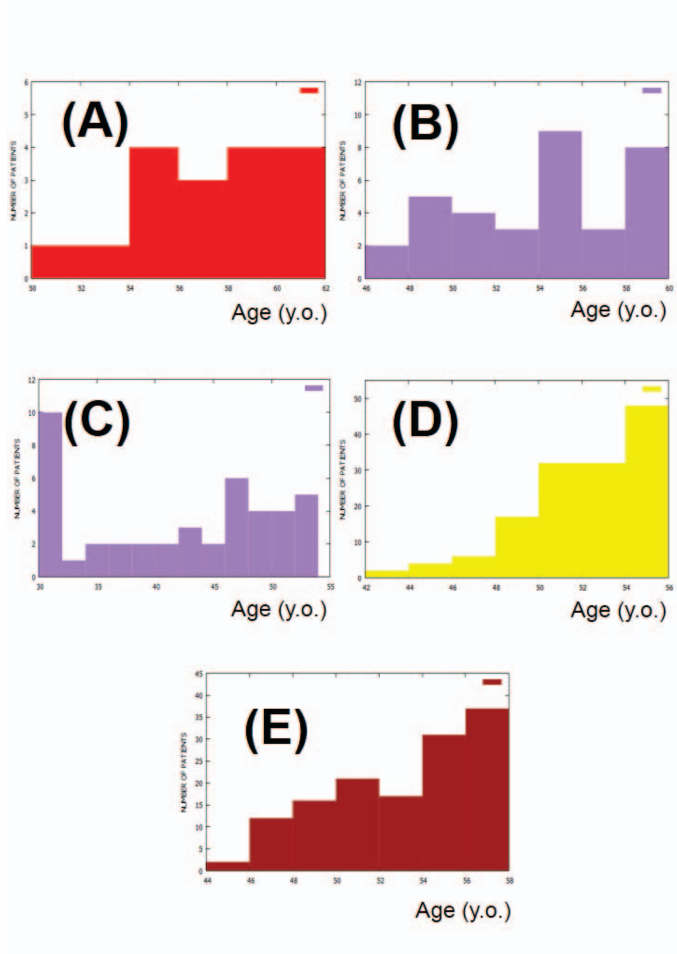

Fig. 2. Resulting histograms from the acceptance of algorithm of identification of critic patients for the cases of necrosis due to glucose and depression (A), necrosis due to depression, overweight and glucose (B), necrosis due to overweight and SBP (C), nephropathy due to overweight and glucose (D), and nephropathy due to glucose and SBP (E).

B. Interpretation of 3D Histograms

In Fig. 3 top panel, 3D histogram of number of critic patients versus age and necrosis level is plotted. It is not difficult to identity up to N_{NC} = 13 patients between 56 and 64 years old with necrosis already is manifested on them. In according to Eq. 7, the total success probability was calculated for these cases. Because line 30 is demanding to accept only cases below 0.65, the resulting 13 patients is translated as the ones that might be in vulnerable situation against a worse state of necrosis. For this range then $P_{CV} = \int_{56}^{64} \mathcal{G}(z)\mathcal{D}(z)\mathcal{P}(z)\mathcal{W}(z)dz \approx 0.31$ which means that $N_{\mathrm{NC}} \times P_{CV} = 0.31 \times 13 \approx 4$ patients are sensitive to cardiovascular attacks [17] in conjunction to the worse status presented by the apparition of necrosis. On the other hand, in the bottom panel the case of nephropathy is presented. One can see that up to 12 cases were identified. Furthermore, 3D histogram is substantially filled over the range of ages between 56 and 72 years old in accordance to the histogram. It would also indicate the range with the lowest values of success probability. In this way, $P_{CV} = \int_{56}^{72} \mathcal{G}(z)\mathcal{D}(z)\mathcal{P}(z)\mathcal{W}(z)dz = 0.53$. Again $0.53 \times 12 \approx 6$ patients might be sensitive to cardiovascular

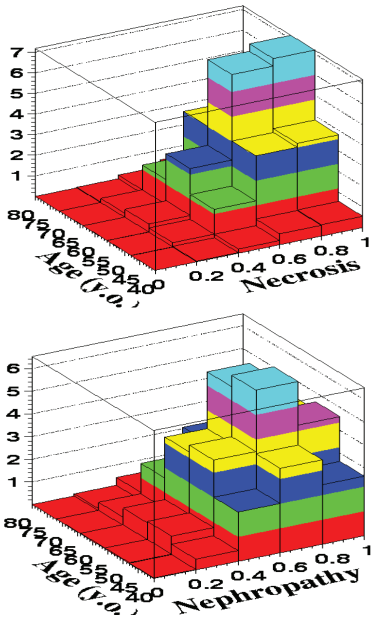

Fig. 3. 3D histograms of number of critic patients versus age and level of necrosis (up) and nephropathy (down).

attacks due to the concurrence of highest values of glucose [18], high levels of depress, high SBP and overweight. In more simple words, 6 diabetic patients might to be near of using processes of dialysis. In addition, from both 3D histograms up to 25 diabetes patients have been identified of having started necrosis and nephropathy complications, which is translated as a 2.5% of the total data (25 real data plus 975 Monte Carlo data), whereas 10 patients might be sensitive to cardiovascular assault, representing 1% of total data [17][19].

VI. Conclusion

In this paper, a computational methodology to estimate the fraction of patients which would have imminent complications due to advanced states of diabetes such as necrosis and nephropathy was presented. Our methodology has consisted in the selection of 25 diabetes patients with symptomatology of exhibiting progress in diabetes. In this way, we have used the Monte Carlo algorithm to extend the sample to reach 1K cases. With this statistics, we have built various curves of probability to identify the ranges of ages of patients where they are sensitive to depression, overweight, high values of glucose and high SBP. All this formulation has served to propose the probability of success and their lowest values which can be interpreted as the fault of the diabetes patient to continue firmly its treatment. Also, this mathematical machinery represents the basis to the application of algorithm 2 whose role is that of filtering only those cases for obtaining the number of advanced cases of diabetes complications commonly known as kidney disease (nephropathy) and necrosis in legs and foots. From a sample of 1000 diabetes patients, the simulation has yielded that 25 of them are already started to develop either necrosis or nephropathy. It should be noted that this study has been applied to a sample of diabetes patients belonging to a Peri-urban zone of Lima city and featured by having incomes of order of 75 USD per month. Clearly this study shows that this group is quite sensitive to a substantial degradation of their quality of life with a serious risk to collapse. The results of this paper would suggest reconfigure the public health schemes in the sense of provide specific medic attention and improve the quality of life of type-2 diabetes patients belonging to social and economic vulnerable groups, in particular of those patients which would need to be accommodated in hospitals and health center for dialysis sessions daily.

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