Consequences and Lessons from 2020 Pandemic Disaster: Game-Theoretic Recalibration of COVID-19 to Mobilize and Vaccinate by Rectifying False Negatives and False Positives

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Abstract—**The main purpose of this applied research paper is to optimize the probabilities of the false negative (*FN*) error, *β*, and the false positive (*FP*) error, α in a pandemic healthcare setting. The overall objective is to estimate the number of those patients falsely declared uninfected, and those falsely declared infected, aiming to recalibrate the overall count of cases aligned with the world's mobilization and vaccination efforts. Incomplete *FN* results can have devastating impacts on current efforts to contain the *SARS-CoV-2* (*COVID*-19) outbreak as infected patients are mistakenly given the go-ahead to return to normal life, likely infecting others. The whole world experienced in 2020 that the number of deaths were undercounted due to existence of false negatives or asymptomatic carriers. But there did not exist universally unbiased scientific methods other than controversial comparisons with the past seasonal death records. This game-theoretic research effort fills a void to replace guesswork and judgment-calls by employing data-scientific health informatics. This article reasons by citing real-data examples why von Neumann's mixed-strategy game-theoretic feasible solutions to predict the *FN* cases are noteworthy to prevent more fatalities by facilitating timely pandemic mobilization. *FP* counts are however not so critical other than causing panic and waste of resources. In the wake of vaccination relief efforts, this research topic is still valid and invaluable for the future unprecedented pandemics such as a hypothetical *COVID*-35. A fringe benefit of the article is to transform hypothesis testing from subjective to objective for scientific, medical and engineering decisions. Evolutionary game theory may be incorporated for evolving and mutating pandemic variants e.g. *OMICRON* and *DELTA* for further research tips.**

Index Terms—**Cross-products of errors and non-errors, game theory, minimax-maximin rule, false negatives, false positives.**

I. Introduction and Motivation

Since the 0.1μ(micron)-diameter-sized new coronavirus was confirmed at Wuhan of Central China on 11/19/2019, the infectious respiratory disease *COVID*-19 has rampantly spread with deaths exceeding 6.3M globally, and 1*M* (≈twice the U.S. recorded *WWII* deaths) in the U.S. by 6/1/2022. The first confirmed coronavirus cases outside China occurred on 1/20/2020 in Japan, Thailand, and South Korea. The first *COVID*-19-afflicted death in the USA was identified in Washington State on 1/21/2020. On 3/11/2020, the World Health Organization (*WHO*) declared the outbreak a pandemic, the first time since *H1N1* in 2009. Since the globe was stricken with the new coronavirus as the culprit of an unprecedented pandemic of vast dimensions akin to the 1918 Spanish Flu, this topic deserved urgent and focused attention. One aims to estimate the number of those patients falsely declared uninfected to avoid a wider spread of the virus, and those falsely declared infected to avoid unnecessary waste of life-saving health workers. This article plans to examine von Neumann's game-theoretic framework to formulate the hitherto unresolved Type I and II error optimization impasse. This particular virus, officially known as *SARS-CoV-2*, is only the third strain of coronavirus known to frequently cause severe symptoms in humans. The other two strains had caused the Severe Acute Respiratory Syndrome (*SARS*) and the Middle East Respiratory Syndrome (*MERS*). There have been two types of tests worldwide floating in circulation to execute coronavirus testing: 1) *PCR* in biology stands for *polymerase chain reaction*, which refers to a process of multiplying or amplifying a small sample of biological or viral of *RNA* in a short amount of time, expediting more conclusive research or data analysis. Whether you have symptoms or not, it can detect if you have an active *COVID*-19 infection. 2) Antibody testing, instead of searching for the virus, checks for protective blood proteins called antibodies which the body produces days after fighting a viral infection.

Currently, though almost all testing in hospital clinics and drive-thru sites use the *PCR* method to help doctors detect and treat patients with active *COVID*-19, one can test negative threefold in a sequence and then positive the next. One or more *FN* test results will not rule out the possibility of *COVID*-19 infection in any tested patient by Weaver [1]. What are some of the *PCR* limitations per Fig. 1?

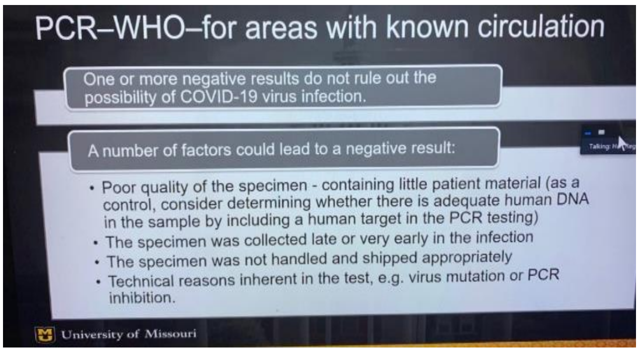

Fig. 1. PCR has issues in the screenshot by the University of Missouri link.

One must answer several key questions: How accurate are the tests? What antibody level is needed for immunity? How long does that immunity last? Not only were antibody tests likely to report false negatives early on, why also miss infections among people who are immunocompromised, and

Manuscript received January 11, 2022; revised June 13, 2022.

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DOI: 10.7763/IJCTE.2022.V14.1318

who do not produce antibodies? Molecular or nucleic acid–based (*PCR*) testing is still going to be the preferred method for diagnosis of *COVID*-19 in symptomatic patients. The only appropriate use of antibody testing for active infection may be for patients with symptoms for over a week but were *PCR*-negative. Fig. 2 emphasizes antibody tests to be flawed.

Fig. 2. The antibody test has issues as in this screenshot by a U.S. unnamed lab. The issue is the fast-tracked coronavirus tests, but are they accurate?

Section I introduces the history of pandemics, research goals and remedial healthcare motivations. Section II studies the classic definitions (Table I), figures and tables to achieve the game-theoretic goals via the cross-products of errors and non-errors model (Table II) with the subsequent *COVID*-19 cases in April, May and December of 2020. One recalibrates #Deaths and #Recoveries, and verifies the proposed optimal method with multiple software, plots, Venn Diagrams and simple algebraic-roots along a literature survey and input data management. Section III concludes with further research tips.

II. Game-Theoretic Framework: Decision Tables, Risks, Errors and Case Studies

Proactively, the entire testing process may boil down to the testing analysts' experiencing an erroneous decision-making analysis, which ought to be rectified and calibrated to reach trustworthy results. One needs to calculate accurate estimates of Type-I (*alpha*) and Type-II (*beta*) error probabilities. As conventionally exercised, if the *alpha*=.05 goes assumed, then 1 out of 20 decisions of false positives (*FP*) is incorrectly decided to be false. This implies that the critical or red region of falsely rejecting the true (e.g. uninfected with *COVID*-19 virus) for H_0: *No COVID-19* is 5%. If the *beta*=.1 is assumed, 1 out of 10 decisions of false negatives (*FN*) is incorrectly decided to be true. This implies that falsely accepting (failing to reject) the untrue H_0 is 10%. So how can one authentically compute the Type-I and Type-II error probabilities to recalibrate the possibly erroneous *COVID*-19 test results and reach dependable test decisions worldwide?

Tests' performance can also produce a potentially significant proportion of false positives in populations far less likely to have the disease. Consider a scenario with *COVID*-19 testing in an asymptomatic or mildly infected population with 1 in 50 people infected. Assume the test is falsely positive with α=10% and falsely negative with $\beta\approx$17% of the time. As in Fig. 3, the chance that someone with a positive test result be actually infected is under 20% (1 in 6, or ≈17%). The actual #episodes of the false negative and false positive patients remain unclear when the pandemics strike. The motivation here is to compare the pre-specification of *alpha* and *beta* in Fig. 3 to their post-specification via game theoretic solutions of the errors' and non-errors' cross-products model in Table II ahead, reframed after the classical Table I. The elements of Table I are swapped in the Truth (columns) and the Test (rows) for convenient reading.

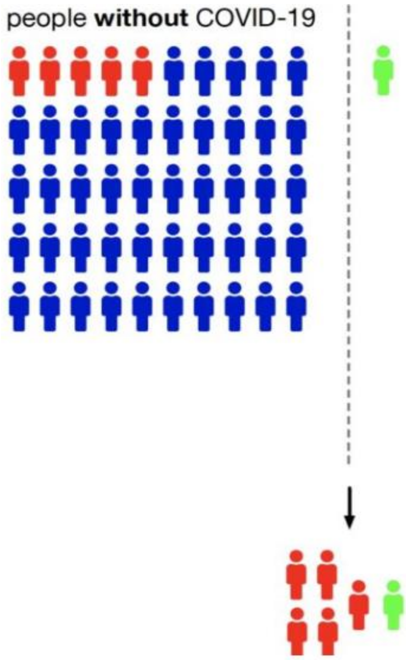
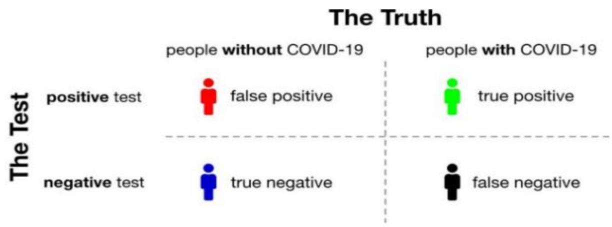


Fig. 3. 50 NFL players tested false positives (*FP*) with α=5/50=10%, i.e. Specifity=1-α=0.90=90% or true negatives (*TN*), and the same lot tested one true-positive, namely, β≈16.7% (=1/6) to represent false negatives (*FN*), which suggests Sensitivity=1-*β*=5/6≈16.7%≈83.3%. The more the sample size, the more sensitive the hypothesis test and the more the power of the test.

TABLE I: Classical Truth (Reality) vs Test (Decision) Elements

	Test	
Truth	Reject Ho	Accept Ho
True Ho	Producer's Risk=α error=*FP*	No Error=*Confidence*=1-*α*=*TN*
False Ho	No Error=*Power*=1-*β*=*TP*	Consumer's Risk=*β* error=*FN*



The problem is that tests almost never have perfect sensitivity and specificity scores. In medical diagnosis jargon, Fig. 3's test sensitivity (1-β=5/6) is the ability of a test to correctly identify those with the coronavirus disease, whereas test specificity (1-α=45/50) is the ability of the test to correctly identify those without the coronavirus disease. See Sharma *et al*. [2]. The Test and the Truth in Table I together create four possibilities: true positives (1- β), true negatives (1- α), false positives (α), and false negatives (β). See Manrai and Mandl [3] for Fig. 3. The Reality and the Decision of Table I cannot be falsely mistaken neither as players nor intelligent decision-making agents in the game-theoretic algorithms.

Failing to isolate someone who actually has *COVID*-19 and sending him back to an infectious disease ward means placing lots of people at stake. But if the criterion for calling a test positive is set too low, then a number of patients who lack *COVID*-19 will test positive, thereby causing an unwarranted and debilitating panic. The purpose of this article therefore lies beyond optimizing a procedure to estimate efficiently, the sensitivity and specificity of a *COVID*-affiliated hypothesis testing in the chaotic albeit pandemic-conscious world. The goal is to reset the magnitude of the undercounted *#FN* cases due testing errors, or else, prior/posterior to vaccination by recalibrating the world's *COVID*-19 cases, which reached a peak in 2020 and stubbornly continued decimating all people.

Aside from the usual rule-of-thumb or best-guess or judgment-call-based choices such as 1-out-of-20, etc., there have been alternative attempts to compute α (Type-I error probability) by deriving the first and second derivatives of the standard normal distribution curve. One can determine the second derivative to reach maximum at $z = \pm 1.732$ which corresponds to a *p*-value of 0.083. The calculus-based algebraic approaches were studied by Grant [4] and Kelley [5] who remarked, "No one therefore has come up with an objective statistically based reasoning behind choosing the now ubiquitous 5% level." In this research, the authors will implement game theory to optimize test sensitivity and test specificity provided the supporting data. Game theory is considered a branch of mathematical sciences devoted to the logic of decision-making in social, engineering or managerial interactions, and concerns the behavior of decision-makers whose decisions cross-influence each other by Sahinoglu *et al*. [6], and Blackwell and Girschik [7]. Each decision maker has only partial limited control.

Game theory is a generalization of decision theory where two or more decision makers compete by selecting each of the several optimal strategies, while decision theory is a one-person *game theory*.

A. Game-Theoretic Errors' Cross-Products Model for COVID-19, Example 1, Roots, and Venn Diagrams

Schlag [8] employed Nash-induced game theory to establish the minimal Type-II error (β: beta) whereby the associated randomized test was characterized as part of Nash [9] equilibrium, as stated in Osborne and Rubinstein [10]. However, these attempts did not lead to a relatively simple and a practical formulation usable by the practicing statistician. Sahinoglu *et al*. [11]-[14] followed up with a pragmatic approach, respectively, along an *ASA*'15 proceedings paper and a Wiley-published textbook in 2016, and an *ISI*'17 proceedings paper and a published monogram by *LAMBERT* (German book publisher) in 2018. Game theory can also be used to solve problems in statistics by Savage [15]. The underlying idea is to solve the worst-case problems by invoking the mini-max and maxi-min rules' gaming algorithms developed by Neumann [16] who was inspired by poker games, and who further improved with the contributions of Neumann and Morgenstern [17]. Game theoretical methods have not been used in hypothesis testing curriculum e.g. regarding medical diagnoses to a considerable extent. The author deals with an application implementing von Neumann's game theoretic two-player, zero-sum, mixed strategy-equilibrium approach. The proposed approach differing from the traditional one based on pre-specifying α and β errors is data-driven. It is customary to compare different analytical (math-statistical and operations-research based) approaches leading to a proposed algorithm. To determine whether to reject a null hypothesis based on a sample data, statistical hypothesis testing with various steps is outlined in the statistical literature by Ostle and Mensing [18]. For the hypothesis testing: H_o: *COVID-19 uninfected* vs. H_a: *COVID-19 infected*; two types of errors exist: Type-I or α-error (*FP* risk) occurs when the analyst rejects a true null hypothesisby mistakenly over-counting the false patients. Type-II or β-error (*FN* risk) occurs when one rejects a true alternative hypothesis by falsely under-counting the infected patients:

$$\alpha = P\{\text{Type-I error}\} = P\{\text{reject } H_0 \mid H_0 \text{ true}\} \quad (1)$$

$$\beta = P\{\text{Type-II error}\} = P\{\text{fail to reject } H_0 \mid H_0 \text{ false}\} \quad (2)$$

In pandemics, specifity and sensitivity metrics are never exactly known but they can be at best estimated. The *beta* error becomes critical in dealing with infection-based tests while an untrue H_0: *COVID-19 uninfected* vs. true H_a: *COVID-19 infected* is falsely not rejected. Then, it follows:

$$\text{Sensitivity=Power=}(1\text{-}\beta)\text{=P}\{\text{reject } H_0 \mid H_0 \text{ false}\} \quad (3)$$

$$\text{Specificity=Confidence=}(1\text{-}\ \alpha)\text{=P}\{\text{accept } H_0 \mid H_0 \text{ true}) \quad (4)$$

TABLE II: THE ASSOCIATED CONSTANTS OR COEFFICIENTS (C_{11}, C_{12}, C_{21}, C_{22}) FOR CROSS-PRODUCTS OF ERRORS AND NON-ERRORS

	β↓	(1-β)↓
α →	*C11*	*C12*
(1-α) →	*C21*	*C22*

It follows from Table II such that valid for $0< \alpha, \beta <1$:

$$\alpha\,\beta + \alpha \times (1\text{-}\beta) + (1\text{-}\alpha) \times \beta\ + (1\text{-}\alpha) \times (1\text{-}\beta) = 1.0; \quad (5)$$

$$\Pi(\alpha,\beta,Cij)=\alpha\times\beta\times C_{11}+\alpha\times(1\text{-}\beta)\times C_{12}+(1\text{-}\alpha)\times\beta\times C_{21}+(1\text{-}\alpha)\times(1\text{-}\beta)\times C_2 \quad (6)$$

where, $\Pi(\alpha, \beta, Cij)$ is the (negative) expected count (*EC*) denoting #Recoveries. Let $P_{11}=\alpha\times\beta$, $P_{12}=\alpha\times(1\text{-}\beta)$, $P_{21}=(1\text{-}\alpha)\times\beta$, $P_{22}=(1\text{-}\alpha)\times(1\text{-}\beta)$ where C_{11}, C_{12}, C_{21} are erroneous (positive) counts respectively due to products of errors, and C_{22} a utility (negative) non-erroneous count due to product of non-errors from Table II. Let $\alpha=P_{11}+P_{12}$ and $\beta=P_{11}+P_{21}$. See similarly by Sahinoglu and Capar [19] where the counts $C_{ij,}$ are in terms of cost and utility currency, not humans as here. Singpurwalla and Wilson [20] examined utility concepts, which date back to 18th century's Nicholas Bernoulli. Let *LOSS* denote patients lost by the defender while minimizing *LOSS* against the offender, i.e., Patient vs. Coronavirus. In the two-player, zero-sum, optimal mixed-strategy in Anderson *et al*. [21]'s Ch. 5.4: Game Theory, pp. 236-248, two players compete against each other. Zero-sum means that the *LOSS* (or *GAIN*) for player1, i.e. virus, is equal to the *GAIN* (or

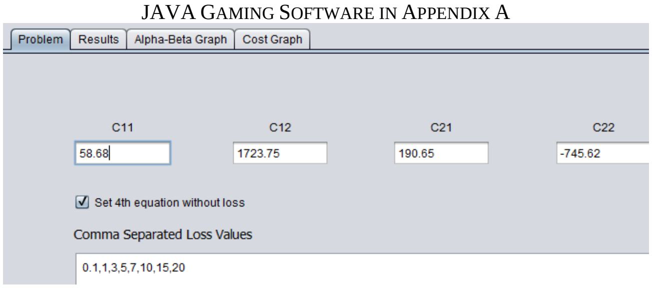
LOSS) for the player2, i.e. patient. Unlike dead patients, virus gets eradicated. The *GAIN* and *LOSS* balance out resulting in a zero-sum game. Each player selects a strategy unaware of another. Virus therapy (e.g. vaccination) is the game.

Example 1: On *COVID*-19 confirmed cases of 4/24/2020 by Johns Hopkins [31]. See Tables III to VIII, and Figs. 4 and 5.

TABLE III: WORLD'S *COVID*-19 #CASES ON APRIL 24, 2020 1:57 GMT WHERE TOTAL#CASES ≈ 2,719K AND #DEATHS ≈ 191K; #RECOVERIES ≈ 746K, ACTIVE#CASES ≈ 1,783K AND CLOSED#CASES ≈ 936K

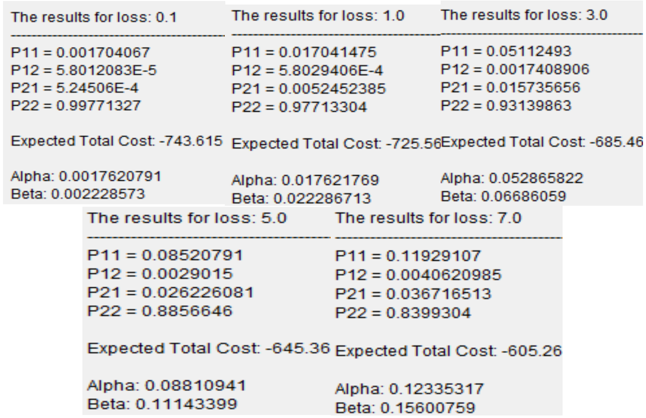
Let in Table III, C_{11}: High-Risk, i.e. Critical Condition counts due to the intersection of *FP*s (by over-counting uninfected patients) and *FN*s (by under-counting infected patients) be ~3% of actives where C_{11}≈59*K*. Let C_{12}: Resource-Risk (Mild Condition) counts due to *FP*s while ~97% of actives yielded C_{12}≈1724*K* and C_{21}: Death counts due to *TP*s (true-positive). Note, #Deaths from Closed#Cases are nation-specific with C_{21}≈191*K*, and C_{22}≈ -746*K* denotes #Recoveries due to count of *TN*s (true-negative) from Closed#Cases where C_{22} is a utility constant, i.e. a negative count denoting human #Recoveries. All |*Cij*| sum up to the TotalConfirmed#Cases≈2,719*K* in Table III. Recall, Table II's disjoint elements' probabilities' cross-products sum to unity as indicated in equation (5).

TABLE IV: INPUT FOR *COVID*-19 WORLD #CASES FROM TABLE III FOR JAVA GAMING SOFTWARE IN APPENDIX A



Captured on 4/24/2020, WORLD-wide *COVID*-19 #Cases follow from Tables III to VIII where 20% of the Closed#Cases died and 3% of the Active#Cases were critical. To brief, out of 1,783*K* of Active#Cases; critically Infected#Cases≈59*K* and Mild#Cases≈1,724K. Given the *COVID*-19 counts; C_{11} ≈ +58.68K, C_{12} ≈ +1,723.75*K*, C_{21} ≈ +190.65*K* and C_{22} ≈ -745.62*K* are the three error constants and one non-error constant, respectively, where the negative count, C_{22} implies #Recoveries. The proposed game-theoretic algorithm minimizes *LOSS* variable as a tolerated (slack) quota of false negatives (*FN*) or false positives (*FP*) or intersection of both, *FN*∩*FP*, by *LP* constraints (13) to (23).

TABLE V: $P_{ij} = [P_{11}, P_{12}, P_{21}, P_{22}]$ FOR *LOSS*=0.1, 1, 3, 5, 7 PER TABLE IV'S JAVA GAMING SOFTWARE IN APPENDIX A



To recapitulate from Section II, Aggregate Composite Riskiness, Disjoint Partial Riskiness due to Type-I error probability, Disjoint Partial Riskiness due to Type-II error probability and Aggregate Composite Non-Riskiness due to non-errors can be formulated, respectively, as follow:

$$P_{11} = \alpha \times \beta \tag{7}$$

$$P_{12} = \alpha \times (1- \beta) \tag{8}$$

$$P_{21} = (1- \alpha) \times \beta \tag{9}$$

$$P_{22} = (1-\alpha) \times (1-\beta) \tag{10}$$

Table VI displays the action-loss based game-theoretic *LP* formulation of the *COVID*-19 problem as follows:

TABLE VI. EXPECTED LOSSES (*EL*) FOR ACTIONS TAKEN BY PLAYER1 (*COVID-19*) INCURRED UPON PLAYER2 (*PATIENT*)

ACTIONS TAKEN (OR CAUSED) BY PLAYER1: *COVID*-19 VIRUS	*EL* FOR TAKING a_i GIVEN C_{ij} ACTED ON PLAYER2: *PATIENT*
a_1 (Action 1: Serious Critical)	$EL(a_1) = P_{11}C_{11} \le LOSS$
a_2 (Action 2: Mild Condition)	$EL(a_2) = P_{12}C_{12} \le LOSS$
a_3 (Action 3: Deceased)	$EL(a_3) = P_{21}C_{21} \le LOSS$
a_4 (Action 4: Recovered)	$EL(a_4) = P_{22}C_{22} \le LOSS$

Table VI shows how Player2 vs Player1 can utilize *LP* to find its optimal mixed strategy through following constraints of (13) to (23). The goal here is to calculate probabilities, *Pij*, to minimize the expected *LOSS* caused by Player1 (*COVID*-19) incurred upon Player2 (Patient), regardless of the strategy executed by Player1. In essence, Player2 will protect itself from any strategy selected by Player1 by making sure Player1's expected gain is as small as possible even if Player1 selected its own optimal strategy. Given the probabilities, *Pij* for *i*, *j* = 1,2 and the expected losses in Table VI, the game theory assumes that Player1 will select a strategy that causes the maximum expected human loss incurred upon Player2 based on equation (11):

$$Max \{ EL(a_1), EL(a_2), EL(a_3), EL(a_4) \} \tag{11}$$

TABLE VII: EXAMPLE 1 FOR $C_{ij,}$ i,j=1,2; $LOSS \geq 3$ WITH *EXCEL* SOLVER *LP*

					C11	58.68
MIN	3				C21	190.65
					C12	1723.75
P11	P21	P12	P22	LOSS	C22	-745.62
0.051124743	0.015735641	0.00174	0.931399	3		
P11	0.05112		<	1		
P21	0.01574		<	1		
P12	0.00174		<	1		
P22	0.93140		<	1		
Constraint 1	-685.4698895		<	0		
Constraint 2	1		equal	1		
Constraint 3	-5.49201E-08		<	0		
Constraint 4	-2.41483E-08		<	0		
Constraint 5	-7.12225E-08		<	0		
Constraint 6	-697.4698893		<	0		
Constraint 7	3		>	3		
Constraint 8	0.051124743		<	0.931399		
Constraint 9	0.015735641		<	0.931399		
Constraint 10	0.001740392		<	0.931399		

TABLE VIII: EXAMPLE 1 FOR $C_{ij,}$ i, j=1,2; LOSS≥5 WITH *EXCEL SOLVER LP*

					C11	58.68
MIN	5				C21	190.65
					C12	1723.75
P11	P21	P12	P22	LOSS	C22	-745.62
0.085207909	0.026226077	0.0029	0.88567	5		
P11	0.08521		<	1		
P21	0.02623		<	1		
P12	0.00290		<	1		
P22	0.88567		<	1		
Constraint 1	-645.369805		<	0		
Constraint 2	1		equal	1		
Constraint 3	1.04312E-07		<	0		
Constraint 4	1.57683E-06		<	0		
Constraint 5	-5.77316E-14		<	0		
Constraint 6	-665.3698067		<	0		
Constraint 7	5		>	5		
Constraint 8	0.085207909		<	0.88567		
Constraint 9	0.026226077		<	0.88567		
Constraint 10	0.002900653		<	0.88567		

However, when Player1 (*COVID*-19) selects its strategy, the value of the game will be the maximum expected gain to maximize Player2's expected human loss. On the other hand, Player2 (Patient) will select its optimal minimax strategy to minimize the maximum expected human loss, so to maximize expected humans saved via (12). Therefore, the mini-max rule by von Neumann [16] is presented as follows:

$$Min\ [\ Max\ \{\ EL(a_1), EL(a_2), EL(a_3), EL(a_4)\}\ ] \qquad (12)$$

Finally, (12) identifies the Neumann's mini-max rule revisited by Anderson *et al*. [21]. In case the players are reversed, and *GAIN* replaces *LOSS*; then the maxi-min rule will replace the mini-max rule. The *LP* system of equations governed by an objective function *Min LOSS* subject to constraints of (13) to (23) with solution vector, $P_{ij} = [P_{11}, P_{12}, P_{21}, P_{22}]$, *LOSS* variable, and $C_{ij} = [C_{11}, C_{12}, C_{21}, C_{22}]$ follow.

It remains to optimize Type-I (α) and Type-II (β) error probabilities with a game theoretic mixed-strategy solution by Sahinoglu *et al*. [11]-[14]. One formulates the two-player, optimally mixed strategy zero-sum game von Neumann *et al.* [16], [17] with the objective function: *Min LOSS*. Defensive gamer patient's objective function transforms to *Max GAIN* along the rivalling virus' offensive gamer perspective if the inequality signs become reversed. *Min LOSS* is s.t. constraints from (13) to (23), where the $\Pi(Pij, Cij)$ reveals #Recoveries:

$$P_{11} \times C_{11} - LOSS \leq 0 \qquad (13)$$

$$P_{12} \times C_{12} - LOSS \leq 0 \qquad (14)$$

$$P_{21} \times C_{21} - LOSS \leq 0 \qquad (15)$$

$$P_{22} \times C_{22} - LOSS \leq 0 \qquad (16)$$

$$0 \leq P_{11} < 1 \qquad (17)$$

$$0 \leq P_{12} < 1 \qquad (18)$$

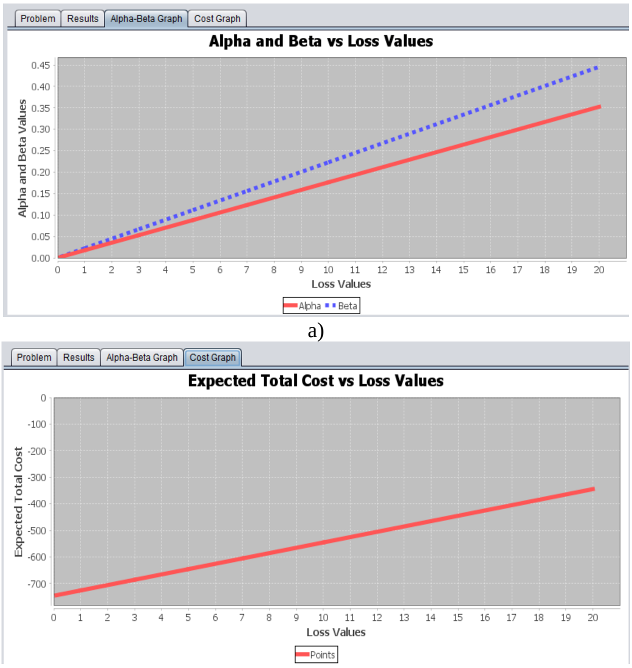
$$0 \leq P_{21} < 1 \qquad (19)$$

$$0 \leq P_{22} < 1 \qquad (20)$$

$$LOSS \geq LOSSmin \qquad (21)$$

$$P_{11} + P_{12} + P_{21} + P_{22} = 1 \qquad (22)$$

$$\Pi(Pij, Cij) = P_{11} \times C_{11} + P_{21} \times C_{21} + P_{12} \times C_{12} + P_{22} \times C_{22} \leq 0 \qquad (23)$$



a)

b)

Fig. 4. Game-theoretic $\alpha \approx .088$, $\beta \approx .111$ vs *LOSS*=5*K* of Fig. 4.a. and Table V; Expected Count (#Recovered): $|EC| \approx 646$K vs *LOSS*=5*K* of Fig. 4. b. and Table V to yield $|EC| \approx 744K$ vs *LOSS*=.1, $|EC(.)| \approx |20 \times LOSS\text{-}746|$.

Tables VII and VIII for *LOSS*=3*K* and *LOSS*=5*K*, respectively, reveal a favorable simple shortcut technique to serve as an optimality verification tool without using the *NLP* (Non-linear Programming) software programs, so to validate the game-theoretic feasible solution vector, *Pij*, given C_{ij} and *LOSS* variable. *LOSS* variable constraint plays a crucial role. Once the *LOSS* variable is accurately constrained by the financial analyst in equations (13) to (23), it becomes a simple algebraic task to compute the $\hat{P}_{ij}$ roots. That is, $\hat{P}_{ij} = LOSS/C_{ij}$ given the constant C_{ij} for all *i* and *j* excluding *i*=2, *j*=2. Once $\hat{P}_{11}$, $\hat{P}_{12}$ and $\hat{P}_{21}$ are calculated, one finds $\hat{P}_{22}$ = 1 - $\hat{P}_{11}$ - $\hat{P}_{12}$ - $\hat{P}_{21}$ by subtraction per equation (22), i.e. $\hat{P}_{11}+\hat{P}_{12}+\hat{P}_{21}+\hat{P}_{22}=1$. Results invariably concur with the software solution vectors in Table V by the *JAVA* software from the input Table IV, and by the Microsoft's *EXCEL* Solver algorithm per Table VIII referring to *LOSS*=5*K*. Therefore, $\hat{P}_{11}=5/58.68 \approx .0852$, $\hat{P}_{12}=5/1723 \approx .0029$, $\hat{P}_{21}=5/190.65 \approx .0262$ and $\hat{P}_{22}$ = 1- $\hat{P}_{11}$ - $\hat{P}_{12}$ - $\hat{P}_{21} \approx .88567$.

A similar algorithmic example was adopted in a textbook by Sahinoglu [12] on p.232 while minimizing *COLLOSS* (Column Loss) in the Eco-Risk article by Sahinoglu *et al*. [22]. Next comes what lies behind the *LP* problem by Dantzig [23]. The forward and backward proofs of a general representation theorem (*GRT*) are given by Lewis [24] on pp. 17-22. An introduction of game theory applied to risk analysis is given by Cox [25]. The preceding *EXCEL* spreadsheets in Table VII and Table VIII show the input and output with an *NLP* algorithm. If the *LOSS* variable is assumed to be, e.g. $LOSS \geq 5K$ by (13) to (23), one then completes the *NLP* system of equations given the constraints so as to minimize the objective function: Min *LOSS*. Nonlinear implies not necessarily linear but includes such *NL* functions by Rapcsak [26] for a smooth optimization. Observing input Table IV and output Table V of 4/24/2020's *COVID*-19 #Cases, the rules follow: The more the *LOSS* constraints are, often the higher become the $FP(=\alpha)$ and $FN(=\beta)$ error rates. The game-theoretic Expected (negative) Count $|EC|$ of the human loss for the entire WORLD shows that as the *LOSS* increases from 1K to 5K, $|EC|$ falls (#Recoveries diminish) since *FN* errors rise. But the rise of #*FP* errors may reverse due to saturation. Only if $LOSS=0$, $C_{22}=|EC|$. Elapsed time yields less deaths due to vaccination.

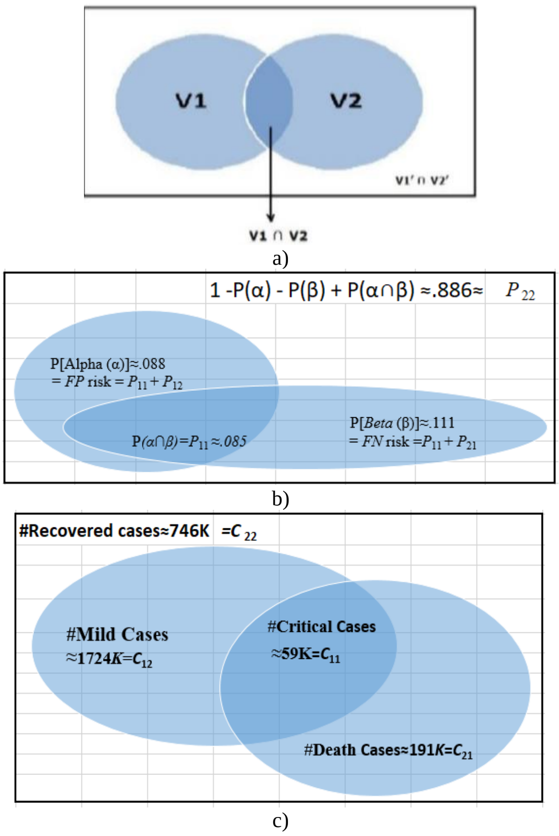


Fig. 5. Venn diagrams for Table III input data: a) All Vulnerabilities (V). b) For Table V's $LOSS=5K$, dependent errors α and β intersected: $P(\alpha\cap\beta)=P(FP\cap FN)=P_{11}\approx.085\neq0$. Aggregate $P(\alpha)=P_{12}+P_{11}\approx.088$ denotes #Actives=$C_{11}+C_{12}$. Aggregate $P(\beta)=P_{21}+P_{11}=.111$ is #Closed= #Deaths+ #Recoveries=$C_{21}+C_{22}$. Disjoint $P(\beta')=P_{21}$ gives #Deaths=C_{21}=191K. Disjoint $P(\alpha')=P_{12}$ yields #Milds=C_{12}=1724K. $P(1-\alpha-\beta+\alpha\cap\beta)$) gives #Recoveries= C_{22}=746K. c) 5.b replaced by Example 1's Cij's in Table IV → ΣDisjoints≈1724K+59K+191K+746K≈2719K verify Table III's inputs.

Venn diagrams in Fig. 5 will clarify that $P(V_1 U V_2)$ + $P(V_1'\cap V_2')$=1 is identical to $P(V_1) + P(V_2) - P(V_1\cap V_2\}$ + $P(V_1'\cap V_2')\}$=1 or by equation (22), $P_{12}+P_{21}+P_{11}+P_{22}=1$ or $\{\alpha\beta\}+\{\alpha(1-\beta)\}+\{(1-\alpha)\beta\}+\{(1-\alpha)(1-\beta)\}=1$. Let the middle dark-blue ($V_1\cap V_2$) intersection of *FP* and *FN* risks where $P(V_1\cap V_2)\approx .085 = P_{11}$, which refers to the Critical (Serious) #Cases of Table III. The aggregate α in Fig. 5.b. refers to the Active#Cases in Table III where $P(\alpha) = P(V_1)\approx.088$. The aggregate β in Fig. 5.b. refers to the sum of Critical#Cases + #Deaths in the input Table III where $P(\beta)=P(V_2)\approx .111$ Let the blank $V_1'\cap V_2'$= error-free region with none of *FP* and *FN* risks. Let $P\{(1-\alpha)(1-\beta)\} = P(V_1'\cap V_2')\approx .886 = P_{22}$ in Fig. 5.b refer to #Recoveries in Fig. 5.c.

One observes the Constituent#Cases of Tables III and IV add up to Total#Cases in Fig. 5.c. as explained in Fig. 5's caption. Following, observe the related Venn Diagrams, which serve to clarify valid sample spaces in a summary format regarding Example 1. Note, α' and β' denote disjointed α and β without $\alpha\cap\beta$ intersections of Fig. 5.

B. Applications to COVID-19 Cases: Example 2 and How to Recalibrate for Unaccounted #FNs and #FPs

Example 2: *COVID*-19 World Nations' Confirmed#Cases of Table IX by Johns Hopkins University [31] of 5/3/2020. See related Tables X to XVI and Figs. 6-8.

TABLE IX: WORLD NATIONS *COVID*-19 TOTAL # CASES ON MAY 3, 2020

Populations	*#Cases*	*#Deaths*	*#Recovered*
WORLD	3,494,671	246,475	1,114,898
USA	1,180,366	68,049	153,005
Spain	247,122	25,264	118,902
Italy	210,797	28,884	81,654
Germany	165,565	6,848	126,153
Russia	134,687	1,280	16,639
France	131,287	24,895	50,784
Turkey	126,045	3,397	63,151
Brazil	101,147	7,025	40,973

TABLE X: INPUT FOR *COVID*-19 WORLD #CASES OF TABLE IX FOR *JAVA* GAMING SOFTWARE IN APPENDIX A

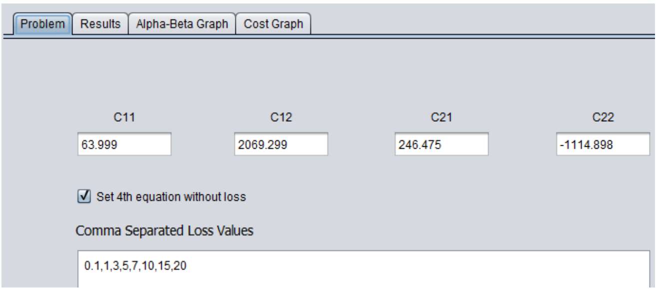
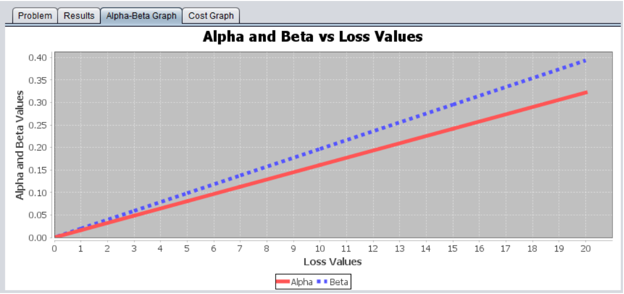


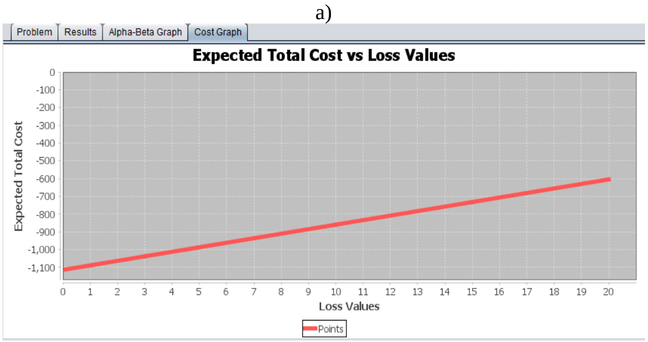
TABLE XI: WORLD SOLUTION $P_{ij} = [P_{11}, P_{12}, P_{21}, P_{22}]$ FOR $LOSS$ = .1, 5, 10, 15, 20 BY TABLES IX, X WITH GAMING SOFTWARE IN APPENDIX A

The results for loss: 0.1	The results for loss: 5.0	The results for loss: 10.0
P11 = 0.0015630424	P11 = 0.07812634	P11 = 0.15625244
P12 = 4.8344955E-5	P12 = 0.0024162773	P12 = 0.00483256
P21 = 4.0596724E-4	P21 = 0.020286076	P21 = 0.04057213
P22 = 0.99798286	P22 = 0.8991711	P22 = 0.7983426
Expected Total Cost: -1112.3469	Expected Total Cost: -987.48	Expected Total Cost: -860.07
Alpha: 0.0016113874	Alpha: 0.08054262	Alpha: 0.16108501
Beta: 0.0019690096	Beta: 0.09841242	Beta: 0.19682458

The results for loss: 15.0	The results for loss: 20.0
P11 = 0.23437873	P11 = 0.31250486
P12 = 0.0072488366	P12 = 0.009665113
P21 = 0.060858123	P21 = 0.081144154
P22 = 0.6975141	P22 = 0.5966855
Expected Total Cost: -732.65	Expected Total Cost: -605.24
Alpha: 0.24162756	Alpha: 0.32216996
Beta: 0.29523686	Beta: 0.395649



a)



b)

Fig. 6. a. b. WORLD's $\alpha\approx.08$, $\beta\approx.098$ and Negative Expected Count (#Recoveries), $|EC|\approx987K$ vs $LOSS=5K$ of Table XI to yield $|EC|\approx1{,}112K \approx|C_{22}|$ vs $LOSS=.1K$; $EC(.)\approx|25.5\times LOSS\text{-}1{,}115|$, $LOSS>0$; $|EC(0)| = 1{,}115K$.

TABLE XII: INPUT FOR *COVID*-19 FOR USA #CASES OF TABLE VII FOR JAVA GAMING SOFTWARE IN APPENDIX A

Problem | Results | Alpha-Beta Graph | Cost Graph

C11	C12	C21	C22
28.779	930.533	68.049	-153.005

☑ Set 4th equation without loss

Comma Separated Loss Values

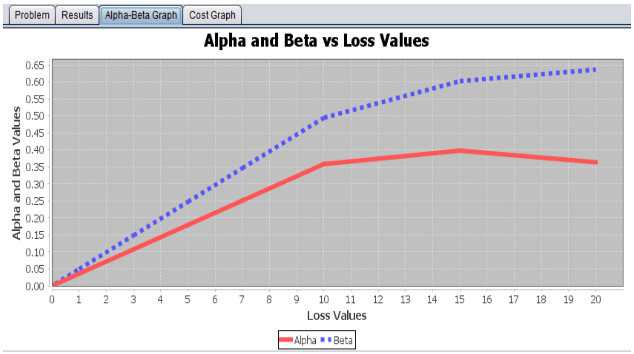
0.1,1,3,5,7,10,15,20

In WORLD's Tables IX to XI and Fig. 6, $|EC|\approx1{,}112K$ vs errors negligible due to minimal *LOSS* constraint≈0, i.e. $|EC| \approx P_{22}|C_{22}| \approx |C_{22}|$=#Recoveries. The α and β errors, and cross products vanish leaving $P_{22}=1$. The same argument is valid for USA's Tables XII, XIII and Fig. 7 where $|EC|\approx153K$ vs $LOSS\approx0$. In Tables XIV, XV and Fig. 8, Germany is studied. WORLD's Table X's Active#Cases=Total#Cases - #Deaths - #Recoveries≈3,494,671–246,475–1,114,898≈2,133,298. So, $C_{11}\approx3\%$ of 2,133,298≈63,999(Critical#Cases), $C_{12}\approx97\%$ of 2,133,298≈2,069,299(Mild#Cases), $C_{21}\approx$246,475(#Deaths) and $|C_{22}|\approx$1,114,898(#Recoveries). Thus, $|\Sigma\Sigma C_{ij}| \approx 63{,}999 + 2{,}069{,}299 + 246{,}475 + 1{,}114{,}898 = 3{,}494{,}671$ as confirmed in the original input Tables IX and X of the Example 2 in II.B.

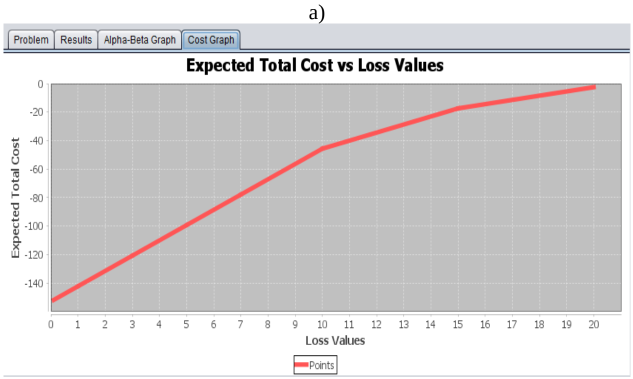
TABLE XIII: USA SOLUTION $P_{ij} = [P_{11}, P_{12}, P_{21}, P_{22}]$ FOR *LOSS* = .01, 1, 5, 10, 15, 20 BY TABLE IX WITH GAMING SOFTWARE IN APPENDIX A

The results for loss: 0.01	The results for loss: 1.0	The results for loss: 5.0
P11 = 3.4746528E-4	P11 = 0.03474754	P11 = 0.17373778
P12 = 1.07456E-5	P12 = 0.001074654	P12 = 0.0053732665
P21 = 1.4697015E-4	P21 = 0.014695302	P21 = 0.07347645
P22 = 0.9994947	P22 = 0.9494823	P22 = 0.74741244
Expected Total Cost: -152.89	Expected Total Cost: -142.27	Expected Total Cost: -99.35
Alpha: 3.5821088E-4	Alpha: 0.035822194	Alpha: 0.17911105
Beta: 4.9443543E-4	Beta: 0.049442843	Beta: 0.24721423

The results for loss: 10.0	The results for loss: 15.0
P11 = 0.3474756	P11 = 0.38172543
P12 = 0.010746529	P12 = 0.016119793
P21 = 0.14695293	P21 = 0.22042938
P22 = 0.4948249	P22 = 0.38172537
Expected Total Cost: -45.71	Expected Total Cost: -17.42
Alpha: 0.35822213	Alpha: 0.3978452
Beta: 0.49442852	Beta: 0.6021548



a)



b)

Fig. 7. a, b. USA's $\alpha\approx.358$, $\beta\approx.494$; Expected Count (#Recoveries): $|EC|\approx46K$ vs $LOSS=10K$ of Table XIII; $|EC|\approx153K\approx|C_{22}|$ vs $LOSS=.01K$. $|EC(.)|\approx|10.7\times LOSS\text{-}153K|$ for $LOSS\leq10K$ when $|EC(0)|\approx153K$.

TABLE XIV: INPUT FOR *COVID*-19 GERMANY #CASES OF TABLE IX FOR JAVA GAMING SOFTWARE IN APPENDIX A

Problem | Results | Alpha-Beta Graph | Cost Graph

C11	C12	C21	C22
.977	31.587	6.848	-126.153

☑ Set 4th equation without loss

Comma Separated Loss Values

0.01, 0.1, 0.5, 1, 1.5, 2, 3, 4, 5

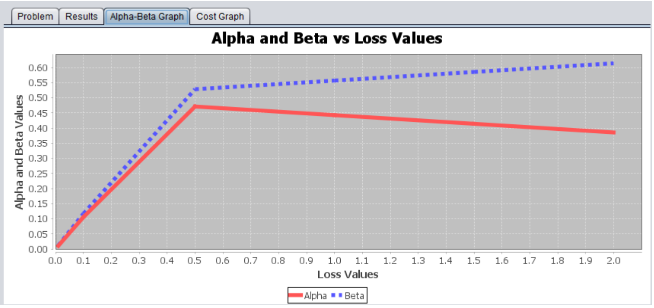
TABLE XV: GERMANY'S SOLUTION $Pij = [P_{11}, P_{12}, P_{21}, P_{22}]$ FOR *LOSS* = .01, .5, 1, 1.5, 2 BY TABLE XIV WITH GAMING SOFTWARE IN APPENDIX A

The results for loss: 0.01	The results for loss: 0.5	The results for loss: 1.0
P11 = 0.010234803	P11 = 0.45557833	P11 = 0.41115665
P12 = 3.1663757E-4	P12 = 0.015829299	P12 = 0.031658597
P21 = 0.0014605299	P21 = 0.07301402	P21 = 0.14602804
P22 = 0.9879895	P22 = 0.45557833	P22 = 0.41115665
Expected Total Cost: -124.607	Expected Total Cost: -56.02	Expected Total Cost: -49.46
Alpha: 0.0105514405	Alpha: 0.47140762	Alpha: 0.44281524
Beta: 0.011695333	Beta: 0.52859235	Beta: 0.5571847

The results for loss: 1.5	The results for loss: 2.0
P11 = 0.366735	P11 = 0.32231337
P12 = 0.047487896	P12 = 0.063317195
P21 = 0.21904206	P21 = 0.29205608
P22 = 0.366735	P22 = 0.32231337
Expected Total Cost: -42.90	Expected Total Cost: -36.34
Alpha: 0.4142229	Alpha: 0.38563055
Beta: 0.58577704	Beta: 0.61436945

For USA and Germany, Figs. 7 and 8 visibly are piece-wise linear with elbow points. β never falls but α may vs more *LOSS*. Simple clarification and interpretation of Table XVI: Bracket (1) implies $LOSS=1K$ and bracket (2) implies $LOSS=2K$ for all nations below USA, i.e. Spain etc. For USA's bracket (1) implies $LOSS=5K$ and bracket (2) implies

LOSS=10*K*. For WORLD, (1) and (2) imply *LOSS*=15K and *LOSS*=20*K*. Regarding false positive (*FP*), α=[#*FP*/(#*FP*+ #*TN*)]=1-Specificity. Regarding false negative (*FN*), β= [#*FN*/(#*FN*+#*TP*)]=1-Sensitivity. So #*FP*=*TN*×[α/(1-α)] and #*FN*=#*TP*×[β/(1-β)]. *FN*'s Recalibration Constant $(RC)_\beta$ is β/(1-β). *FP*'s Recalibration Constant $(RC)_\alpha$ is α/(1-α). C_{12}'(= Recalibrated Mild#Cases Over-counted)=C_{12}-C_{12}×$(RC)_\alpha$= C_{12}-C_{12}×[α/(1-α)]. C_{21}'(=Recalibrated #Deaths Under-counted)=C_{21}+$C_{21}(RC)_\beta$=C_{21}+C_{21}×[β/(1-β)], all in Table XVI.



a)

b)

Fig. 8. a, b. Germany's $\alpha\approx.386$, $\beta\approx.614$; Table XV's Expected Count: #Recoveries=|*EC*|≈36K vs *LOSS*=2*K*; |*EC*| ≈ 125*K* ≈ |C22| vs *LOSS*=.01*K*; |*EC*(.)| ≈ 140×LOSS-126*K* vs *LOSS*≤0.5*K* and *EC*(.) ≈ |13.5×*LOSS*-63K| vs 0.5K<*LOSS*≤2K approximately governs #Recoveries.

By April 2020, experts claimed that 1 out of 3 patients infected with *SARS-CoV-2* or *COVID*-19 tested false negative with the *PCR* method by Weaver [1]. In certain countries, this ratio climbed to 66% (i.e. $\beta\approx$2/3 for Germany, Russia, Turkey and Brazil in the final column of Table XVI) due to testing false negative, or positive carriers unreported. This further was appended to the pool of existing asymptomatic *COVID*-19 patients. With less deaths reported, the error probabilities of *FN* risk (=β) and *FP* risk (=α) fell. As the game theoretic *LOSS* variable constraint rose in the equations from 1*K* to 2*K* (Spain's south in Table XVI) and 5*K* to 10*K* (for USA) and 15*K* to 20*K* (for WORLD), so did the *FN* (=β) errors rise, but *FP*(=α) fell for USA and Germany evident in Figs. 7 and 8.

Referring to Table IX's May 3, 2020 *COVID*-19 data, of the WORLD's ~3.495M cases reported, ~7% of which ~246*K*(≈#*TP*:True Positives) died, and ~32% of which ~1,115K(≈#*TN*:True Negatives) recovered totaling to ~1.361*M* closed cases (~39%). Out of the remaining actives i.e. ~61% of the total, ~2,134*M* Active#Cases for (α=*FP*), and by the rule of thumb ~3% to be ~64*K* for $\alpha\cap\beta$=*FP*∩*FN* was critically serious although not known-to-be dying but leaning both ways. The rest of the #active cases to be ~%97 was ~2,069M (≈C_{12}) being Mild#Cases. Example 2's Tables IX to XV, and Figs. 6 to 8 outputs are tabulated in Table XVI. Since β=#*FN*/(#*TP*+#*FN*), one derives #*FN*(2) in (24) using β(2). Bracket (1) and (2) denote the lesser and higher *LOSS* values.

$$\widehat{\#FN}(2) = \beta(\#TP)/(1\text{-}\beta) = .396(246{,}475)/1\text{-}.396) \approx 162K \quad (24)$$

Take #*TP*=246,475 deaths from Table IX. $\widehat{\#FN}(2)$ in (24) need to be recalibrated appending onto the WORLD, i.e. the missing #FalseNegatives assuming *LOSS*=20*K* in column 5 of Table XVI. By United Nations [27], USA in 2019 recorded ~2.9M deaths for non-*COVID*-19 cases while the entire world witnessed ~58M in 2019 to die. Also, Spain: ~428*K*, Italy: ~642K, France: ~609*K*, Germany: ~944*K*, Russia: ~1,858*K*, Turkey: ~451*K*, and Brazil: ~1,377*K*. WORLD's *COVID*-19 #cases were nearly 3-fold relative to that of the USA. This implies in Table XVI via (24), there exist ~162*K* more infected patients with #*FN*s missed to vanish with respect to the prior death ratios varying for the WORLD, USA and Germany. *FN*(=β) errors are in Figs. 6 to 8, and Table XVI for select countries. Note, *RTC*: RecalibratedTotal#Cases. "Imprecise data muddy virus death forecasts…" reported U.S. academic models projected from 70*K* to 170*K* deaths until mid-May 2020 by Abbott and Overberg [28]. Table XVI shows maximum #*FN*(2)=66,435 missing *COVID*-19 deaths by the USA to recalibrate, which lifts the #deaths to ~70*K* <C_{21}(2) ≈ 68*K*(Table IX) + 66*K*(≈ #*FN*(2)) ≈ 134*K* < 170*K* in the projected range by mid-2020. II.B's Input Table IX elicits Tables XVI and XXV (APPENDIX D):

1) WORLD: Min. #*FN*(1)≈103*K* for *LOSS*=15*K* to max. #*FN*(2)≈162*K* for LOSS=20*K* unaccounted deaths (or false negatives) calculated in Table XVI appended to C_{21}≈246*K* to form C_{21}(1)≈350*K* and C_{21}(2)≈408*K*. Next, min. #*FP*(1)≈660*K* to max. #*FP*(2)≈983*K* excess false positives in Table XVI are deleted from C_{12}≈2,069*K* (Mild#Cases) to form C_{12}(1)≈1,409*K* and C_{12}(2)≈1,087*K*. Also, the same deleted from #Actives≈2,133*K* to form #Actives(1)≈1,473*K* and #Actives(2)≈1,151*K*. #*FN*(1)/C_{21}≈103/246≈.41 when 41% more died for *LOSS*=15*K*. Next, #*FN*(2)/C_{21}≈162/246≈.66 i.e. $(RC)_\beta$=β(2)/(1-β(2))≈.396/(1-.396)≈.66 when 66% more died for *LOSS*=20*K*. |*FP*(1)-*FN*(1)|≈|661*K*-103*K*|≈558*K*; 3495*K*(original)-558*K* (surplus)≈2937*K*(*RTC*) for *LOSS*=15*K*. |*FP*(2)-*FN*(2)|≈|983*K*-162*K*|≈821*K*; 3495*K* (original)-821*K*(surplus)≈2674K(*RTC*) for *LOSS*= 20*K*. Let's recall, *RTC*: RecalibratedTotal#Cases.

2) USA: Min. 22*K* for *LOSS*=5*K* to max. 66*K* for *LOSS*=10*K* missing #deaths appended to C_{21}≈68*K* from Table IX to form C_{21}(1)≈90*K* and C_{21}(2)≈134*K* in Table XVI. Also, min. 203*K* to max. 519*K* false positives subtracted in Table XVI from C_{12}≈931*K* to form C_{12}(1)≈728*K* and C_{12}(2)≈412*K*. Also to be subtracted from #Actives≈959*K* to form #Actives(1)≈756*K*, #Actives(2)≈440*K*. #*FN*(1)/C_{21}≈22/68 ≈.32 when 32% more died for *LOSS*=5*K*. #*FN*(2)/C_{21}≈ 66/68≈.97; i.e. $(RC)_\beta$≈β(2)/ (1-β(2))≈.49/(1-.49)≈.97 when 97% more died for *LOSS*=10*K*. Then, |*FP*(1)-*FN*(1)|≈|203*K*-22*K*|≈181*K*; 1180*K* (original)-181*K*(surplus)≈999*K*(*RTC*) for *LOSS*=5K. |*FP*(2)-*FN*(2)|≈|519*K*-66K|≈453*K*; 1180*K* (original)-453*K*(surplus)≈727K(*RTC*) for *LOSS*=10*K*.

TABLE XVI: CALCULATION OF FALSE NEGATIVES & FALSE POSITIVES: #*FN*(1)=β(1)(#*TP*)/[(1-β(1)] AND #FP(1)=α(1)(#*TN*)/[1-α(1)] SIMILAR to #*FN*(2) AND #*FP*(2); RECALIBRATING *COVID* #CASES FOR MAY 3, 2020 [31]. SEE APPENDIX D'S TABLE XXV FOR A COMPARISONS' TABLE REGARDING THE WORLD AND ALL COUNTRIES. THE FOLLOWING TABLE ESTIMATES RECALIBRATEDTOTAL#CASES (*RTC*) IN BRACKET (1) FOR CONSERVATIVE ≈ ORIGINAL TOTAL#CASES - |#*FN*(1) – #*FP*(1)| OR IN BRACKET(2) FOR LIBERAL ≈ ORIGINAL TOTAL#CASES - |#*FN*(2) – #*FP*(2)|

LEGEND	#CASES	#RCV'RD	#FN(1)	#FN(2)	#FP(1)	#FP(2)	#ACTV(1)	#ACTV(2)	C11	C12(1)	C12(2)	C21(1)	C21(2)	C22	α(1)	β(1)	α(2)	β(2)
WORLD(15,20)	3494671	1114898	103135	161596	660647	982764	1472651	1150534	63999	1408652	1086535	349610	408071	1114898	0.242	0.295	0.322	0.396
USA(5,10)	1180366	153005	22322	66435	202881	518895	756431	440417	28779	727652	411637	90371	134484	153005	0.179	0.247	0.358	0.494
SPAIN(1,2)	247122	118902	14397	28489	49859	88562	53097	14394	3089	50009	11306	39661	53753	118902	0.333	0.363	0.470	0.530
ITALY(1,2)	210717	81654	16746	31797	50731	87919	49448	12260	3005	46442	9255	45630	60681	81654	0.343	0.367	0.475	0.524
GERMANY(1,2)	165565	126153	8610	10893	25122	19858	7442	12706	977	6465	11729	15458	17741	126153	0.443	0.557	0.386	0.614
RUSSIA(1,2)	134687	16639	2256	2419	47167	59659	69601	57109	3503	66098	53606	3536	3699	16639	0.294	0.638	0.345	0.654
FRANCE(1,2)	131287	50784	25911	27078	49393	51618	6215	3990	1668	4547	2322	50806	51973	50784	0.478	0.510	0.489	0.521
TURKEY(1,2)	126045	63151	5987	6118	31903	32604	27594	26893	1785	25809	25108	9384	9515	63151	0.356	0.638	0.361	0.643
BRAZIL(1,2)	101147	40793	8977	11609	31170	40316	22159	13013	1600	20559	11414	16002	18634	40793	0.376	0.561	0.438	0.623

3) *SPAIN*: Min. 14,397 for *LOSS*=1*K* to max. 28,489 for *LOSS*=2*K* missing #deaths appended to C_{21}=25,264 to form C_{21}(1)=39,661 and C_{21}(2)=53,753. Also, 49,859 (min.) to 88,562 (max.) false positives subtracted in Table XVI from C_{12}=99867 to form C_{12}(1)=50,009 and C_{12}(2)=11,306. Also to be subtracted from #Actives=102,956 to form #Actives(1) =53,097 and #Actives(2)=14,394. #*FN*(1)/C_{21}≈14/25≈.56 when 56% more died for *LOSS*=1*K*. #*FN*(2)/C_{21}≈ 28/25≈1.13; i.e. $(RC)_\beta$ =β(2)/(1-β(2))=.53/(1-.53)≈1.13 when 113% more died for *LOSS*=2*K*. Then, |*FP*(1)-*FN*(1)| ≈|50*K*-14*K*|≈36*K*; 247*K*(original)-36*K*(surplus)≈211*K*(*RTC*) for *LOSS*=1*K*. |*FP*(2)-*FN*(2)|≈|89*K*-28*K*|≈61*K*. 247*K*(original)-61*K*(surplus)≈186K(*RTC*) for *LOSS*=2*K*.

4) *ITALY*: Min. 16,746 for *LOSS*=1*K* to max. 31,797 for *LOSS*=2*K* missing #deaths by mid-2020 appended to C_{21}- =28,884 to form C_{21}(1)=45,630 and C_{21}(2)=60,681. Also, min. 50,731 to max. 87,919 false positives deleted in Table XVI from C_{12}=97,174 to form C_{12}(1)=46,442 and C_{12}(2)=9,255. Also deleted from #Actives= 100,179 to form #Actives(1)=49,448 and #Actives(2)=12,260. #*FN*(1)/C_{21}≈ 17/29≈.59 when 59% more died for *LOSS*=1*K*. #*FN*(2)/C_{21}≈32/29≈1.1, i.e. $(RC)_\beta$=β(2)/(1-β(2))=.52/(1-.52) ≈1.1 when 110% more died for *LOSS*=2K. Then, |*FP*(1)-*FN*(1)|≈|51*K*-18*K*|≈33*K*; So, 211*K*(original)-33*K*(surplus)≈ 178K(*RTC*) for *LOSS*=1*K*. |*FP*(2)-*FN*(2)|≈|88*K*-32*K*|≈58*K*; 211*K*(original)-58*K*(surplus)≈153K(*RTC*) for *LOSS*=2*K*.

5) *GERMANY*: Min. 8,610 for *LOSS*=1*K* to max. 10,893 for *LOSS*=2*K* missing #deaths appended to C_{21}=6,848 to form C_{21}(1)=15,458 and C_{21}(2)=17,741. Also min. 19,858 to max. 25,021 false positives deleted in Table XVI from C_{12}=31,587 to form C_{12}(1)=6,465 and C_{12}(2)=11,729. Also to be deleted from #Actives=32,564 to form Actives(1)=7,442 and Actives(2)=12,706. #*FN*(1)/C_{21}≈8.6/6.85≈1.25 when 125% more died for *LOSS*=1*K*. #*FN*(2)/C_{21}≈10.89/6.85≈1.59; i.e. (RC_β)=β(2)/(1-β(2)) =.61/(1-.61)≈1.59 when 159% more died for *LOSS*=2*K*. Then, |*FP*(1)-*FN*(1)|≈|25*K*-9*K*|≈16*K*; 166*K* (original)-16*K*(surplus)≈150K(*RTC*) for *LOSS*=1*K*. |*FP*(2)-*FN*(2)|≈|20K-11*K*|≈9K; 166*K*(original)-9*K*(surplus)≈157*K* (*RTC*) for *LOSS*=2*K*.

6) *RUSSIA*: Min. 2,256 for *LOSS*=1*K* to max. 2,419 for *LOSS*=2*K* missing #deaths appended to C_{21}=1,280 to form C_{21}(1)=3,536 and C_{21}(2)=3,699. Also, min. 47,167 to max. 59,659 false positives deleted in Table XVI from C_{12}=113,265 to form C_{12}(1)=66,098 and C_{12}(2)=53,606. Also deleted from #Actives=116,768 to form Actives(1)=69,601 and Actives(2)=57,109. #*FN*(1)/C_{21}≈2.26/1.28≈1.77 when 177% more died for *LOSS*=1*K*. #*FN*(2)/C_{21}≈2.42/1.28≈1.89; i.e. $(RC)_\beta$=β(2)/(1-β(2))=.65/(1-.65)≈1.89 when 189% times more died for *LOSS*=2*K*. |*FP*(1)-*FN*(1)|≈|47*K*-2*K*|≈45*K*; 135K(original)-45*K*(surplus)≈90*K*(*RTC*) for *LOSS*=1*K*. |*FP*(2)-*FN*(2)|≈|60*K*-2*K*|≈58*K*; 135*K*(original)-58*K* (surplus) ≈77*K*(*RTC*) for *LOSS*=2*K*.

7) *FRANCE*: Min. 26*K* for *LOSS*=1*K* to max. 27*K* for *LOSS*=2*K* missing #deaths appended to C_{21}≈25*K* to form C_{21}(1)≈51*K* and C_{21}(2)≈52*K*. Also, min. 49*K* to max. 52*K* false positives deleted in Table XVI from C_{12}≈54*K* to form C_{12}(1)≈4.5*K* and C_{12}(2)≈2.3*K*. Also to be deleted from #Actives≈56*K* to form Actives(1)≈6*K* and Actives(2)≈4*K*. #*FN*(1)/C_{21}≈26/25≈1.04 when 104% more died for *LOSS*=1*K*. #*FN*(2)/C_{21}≈27/24.9≈1.08 or $(RC)_\beta$≈ β(2)/(1-β(2) =.52/(1-.52)≈1.08 when 108% more died for *LOSS*=2*K*. |*FP*(1)-*FN*(1)|≈|49*K*-26*K*|≈13*K*; 131*K*(original)-13*K*(surplus) ≈118*K*(*RTC*) for *LOSS*=1*K*. |*FP*(2)-*FN*(2)|≈|52*K*-27*K*|≈25*K* (surplus); 131*K*(original)-25*K*(surplus)≈106*K*(*RTC*) for *LOSS*=2*K*.

8) *TURKEY*: Min. 5,987 for *LOSS*=1*K* to max. 6,118 for *LOSS*=2*K* missing deaths appended to C_{21}=3,397 to form C_{21}(1)=9,384, C_{21}(2)=9,515. Next, min. 31,903 to max. 32,604 false positives deleted in Table XVI from C_{12}=57,712 to form C_{12}(1)=25,809 and C_{12}(2)=25,108. Also deleted from #Actives=59,497 to form Actives(1)=27,594 and Actives(2) =26,893. #*FN*(1)/C_{21} ≈6/3.4≈1.76 when 176% more died for *LOSS*=1*K*. #*FN*(2)/C_{21}≈6.11/3.4≈1.8 or (RC_β)= β(2)/(1- β(2) =6434/(1-.6434)≈1.8 when 180% more died for *LOSS*=2*K*. |*FP*(1)-*FN*(1)|≈|32*K*-6*K*|≈26*K*; 126*K*(original)-26*K*(surplus) ≈100*K*(*RTC*) for *LOSS*=1*K*. |*FP*(2)- *FN*(2)|≈|33*K*-6*K*|≈27*K*; 126*K*(original)-27*K*(surplus)≈99*K*(*RTC*) for *LOSS*=2*K*.

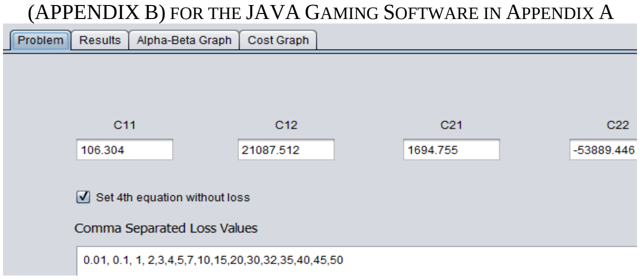
9) *BRAZIL:* Min. 8,977 for *LOSS*=1*K* to max. 11,609 for *LOSS*=2*K* missing #deaths appended to C_{21}=7,025 to form C_{21}(1)=16,002 and C_{21}(2)=18,634. Also, min. 31,170 to max. 40,316 false positives deleted in Table XVI from C_{12}=51,729 to form C_{12}(1)=20,559 and C_{12}(2)=11,414. Also deleted from #Actives=53,329 to form Actives(1)=22,159 and Actives(2) =13,013. #*FN*(1)/C_{21}≈9/7≈1.28 when 128% more died for *LOSS*=1*K*. Therefore, #*FN*(2)/C_{21}≈11.6/7.03≈1.65; i.e. $(RC)_\beta$ =β(2)/(1-β(2))=.623/(1-.623)≈1.65 when 165% more died or *LOSS*=2*K*. |*FP*(1)-*FN*(1)|≈|31*K*-9*K*≈22*K*|; 101*K*(original)-22*K*(surplus)≈79*K*(*RTC*) for *LOSS*=1*K*. |*FP*(2)-*FN*(2)|≈|40*K* -12*K*|≈28*K*; 101*K*(original)-28*K*(surplus)≈73*K*(*RTC*) for *LOSS*=2*K*.

At least globally 46,000 more people supposedly died during the coronavirus pandemic over the month of April 2020 than the official *COVID*-19 death counts reported. A review of mortality data in 14 countries so shows [27]. The totals include deaths from *COVID*-19 as well as those from other respiratory causes, likely including people who could not be treated as hospitals became overcrowded. In New York City, the number in April 2020 was four times the normal amount published by NY Times article titled “Coronavirus – missing - deaths” in its World section accessed 04/21/2020 (NY Times website link removed).

C. Applications to COVID-19 Cases: Example 3 and How to Recalibrate for Unaccounted #FNs and #FPs

Example 3: *COVID*-19 WORLD’s Confirmed#Cases in Tables XVII (APPENDIX B) and related Tables XVIII, XIX (APPENDIX C), XX, XXI, XXII, XXIII, XXIV and XXV (APPENDIX D), and Figs. 9 – 11 of 12/20/2020.

TABLE XVIII: INPUT FOR *COVID*-19 WORLD #CASES FROM TABLE XVII (APPENDIX B) FOR THE JAVA GAMING SOFTWARE IN APPENDIX A



Problem | Results | Alpha-Beta Graph | Cost Graph

C11	C12	C21	C22
106.304	21087.512	1694.755	-53889.446

☑ Set 4th equation without loss

Comma Separated Loss Values

0.01, 0.1, 1, 2,3,4,5,7,10,15,20,30,32,35,40,45,50

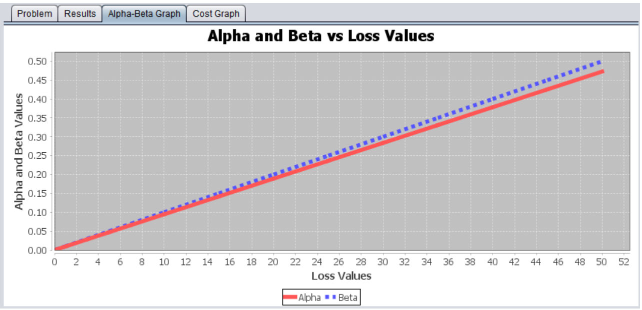


Fig. 9. WORLD game-theoretic α≈.378, β≈.399 vs. *LOSS*=40K; Expected #Recoveries vs *LOSS*=40*K* from APPENDIX C’s Table XIX has $|C_{22}|$≈32*K*.

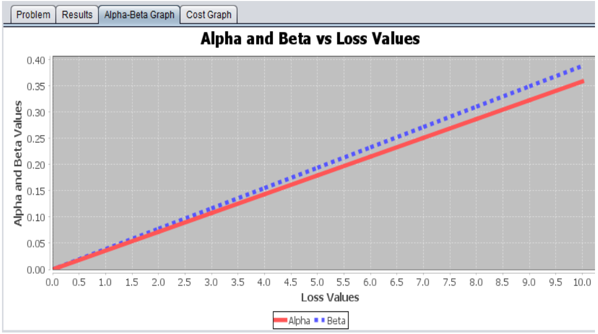


Fig. 10. USA game-theoretic α≈.359, β≈.388 vs *LOSS*=10*K* as in Table XXI i.e. (Negative) Expected Count, |*EC*|≈6.4*K* vs *LOSS*=10*K*; $|C_{22}|$ ≈10,547*K* for *LOSS*=0 in Table XX.

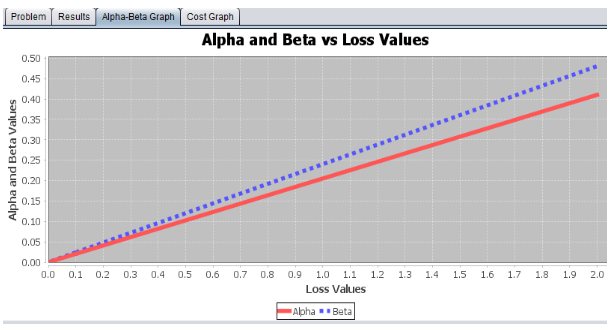
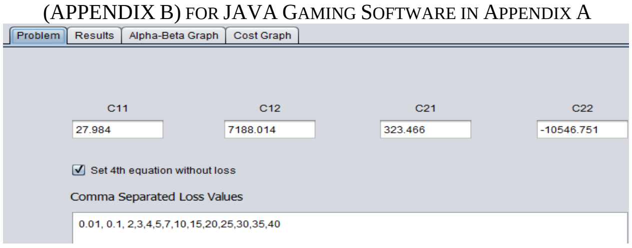


Fig. 11. Germany’s game-theoretic *α*≈.41, *β*≈.48 vs *LOSS*=2*K* in Table XXIII, Expected Count(#Recoveries) |*EC*|≈552*K* and $|C_{22}|$≈1085.5*K* for *LOSS*=0 in Table XXII.

In WORLD’s P_{ij} vector solutions vs *LOSS* variable in Table XIX (APPENDIX C), |*EC*|≈53,884K vs *LOSS*=.01*K* when $P_{ij}=[P_{11}\approx P_{12}\approx P_{21}\approx 0,\ P_{22}\approx 1]$, i.e. *α* and *β* errors are negligibly small due to minimal *LOSS* constraint ~0. The same argument is valid for USA’s Tables XX and XXI where |*EC*|≈10,542*K* vs *LOSS*=0.01*K*. For Tables XXII and XXIII, Germany’s |*EC*|=$|C_{22}|$≈1083*K* vs. *LOSS*=.01*K*. With *α* and *β* errors ~0, only P_{22}≈1.0 remains. WORLD’s Table XVII’s #Actives = Total#Cases - #Recoveries - #Deaths ≈ 76,778*K* – 53,889*K* - 1,695*K* = 21,194*K*. Table XVIII shows C_{11} (≈Critical#Actives’0.5%)≈106*K*, C_{21}(≈Mild#Actives’99.5%)≈21,088*K*, C_{12}(#Died)≈1695*K*, C_{22}(#Recoveries)≈53,889*K* ΣΣ$|C_{ij}|$ ≈ 106*K* + 1,695*K* + 21,088*K* + 53,889*K* ≈ 76,778*K* is verifiable in Table XVII.

TABLE XX: INPUT FOR *COVID*-19 USA CASES OF TABLE XVII (APPENDIX B) FOR JAVA GAMING SOFTWARE IN APPENDIX A



Problem | Results | Alpha-Beta Graph | Cost Graph

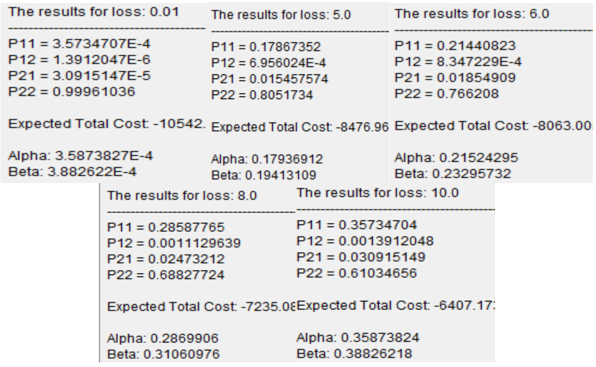
C11	C12	C21	C22
27.984	7188.014	323.466	-10546.751

☑ Set 4th equation without loss

Comma Separated Loss Values

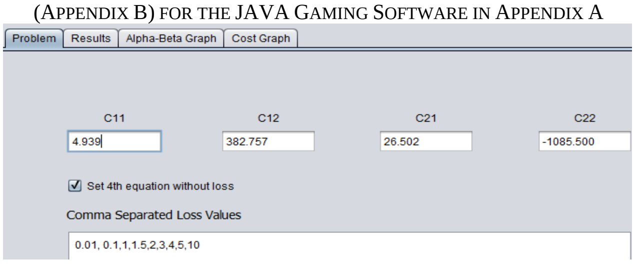
0.01, 0.1, 2,3,4,5,7,10,15,20,25,30,35,40

TABLE XXI: $P_{ij} = [P_{11}, P_{12}, P_{21}, P_{22}]$ FOR *LOSS* = .01, 5, 6, 8, 10 BY INPUT TABLE XX FOR USA WITH GAMING SOFTWARE IN APPENDIX A



The results for loss: 0.01	The results for loss: 5.0	The results for loss: 6.0	The results for loss: 8.0	The results for loss: 10.0
P11 = 3.5734707E-4	P11 = 0.17867352	P11 = 0.21440823	P11 = 0.28587765	P11 = 0.35734704
P12 = 1.3912047E-6	P12 = 6.956024E-4	P12 = 8.347229E-4	P12 = 0.0011129639	P12 = 0.0013912048
P21 = 3.0915147E-5	P21 = 0.015457574	P21 = 0.01854909	P21 = 0.02473212	P21 = 0.030915149
P22 = 0.99961036	P22 = 0.8051734	P22 = 0.766208	P22 = 0.68827724	P22 = 0.61034656
Expected Total Cost: -10542.	Expected Total Cost: -8476.96	Expected Total Cost: -8063.00	Expected Total Cost: -7235.0	Expected Total Cost: -6407.17
Alpha: 3.5873827E-4	Alpha: 0.17936912	Alpha: 0.21524295	Alpha: 0.2869906	Alpha: 0.35873824
Beta: 3.882622E-4	Beta: 0.19413109	Beta: 0.23295732	Beta: 0.31060976	Beta: 0.38826218

TABLE XXII: INPUT FOR *COVID*-19 GERMANY #CASES OF TABLE XVII (APPENDIX B) FOR THE JAVA GAMING SOFTWARE IN APPENDIX A



Problem | Results | Alpha-Beta Graph | Cost Graph

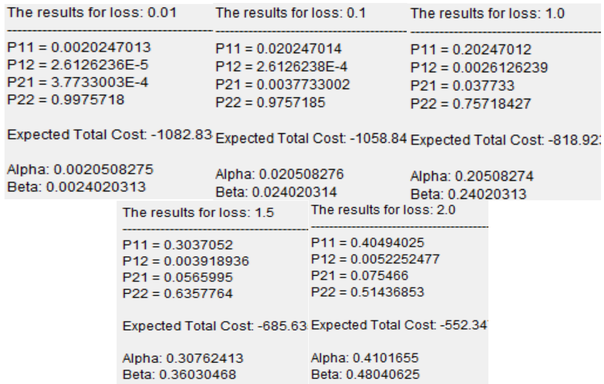
C11	C12	C21	C22
4.939	382.757	26.502	-1085.500

☑ Set 4th equation without loss

Comma Separated Loss Values

0.01, 0.1,1,1.5,2,3,4,5,10

TABLE XXIII: $P_{ij} = [P_{11}, P_{12}, P_{21}, P_{22}]$ FOR *LOSS* =.01, .5, 1, 1.5, 2 BY INPUT TABLE XXII FOR GERMANY WITH GAMING SOFTWARE IN APPENDIX A



The results for loss: 0.01	The results for loss: 0.1	The results for loss: 1.0	The results for loss: 1.5	The results for loss: 2.0
P11 = 0.0020247013	P11 = 0.020247014	P11 = 0.20247012	P11 = 0.3037052	P11 = 0.40494025
P12 = 2.6126236E-5	P12 = 2.6126238E-4	P12 = 0.0026126239	P12 = 0.003918936	P12 = 0.0052252477
P21 = 3.7733003E-4	P21 = 0.0037733002	P21 = 0.037733	P21 = 0.0565995	P21 = 0.075466
P22 = 0.9975718	P22 = 0.9757185	P22 = 0.75718427	P22 = 0.6357764	P22 = 0.51436853
Expected Total Cost: -1082.83	Expected Total Cost: -1058.84	Expected Total Cost: -818.92	Expected Total Cost: -685.63	Expected Total Cost: -552.34
Alpha: 0.0020508275	Alpha: 0.020508276	Alpha: 0.20508274	Alpha: 0.30762413	Alpha: 0.4101655
Beta: 0.0024020313	Beta: 0.024020314	Beta: 0.24020313	Beta: 0.36030468	Beta: 0.48040625

TABLE XXIV. CALCULATION OF FALSE NEGATIVES & FALSE POSITIVES: #*FN*(1)=*β*(1)(#*TP*)/[(1-*β*(1)] AND #*FP*(1)=*α*(1)(#*TN*)/[1-*α*(1)] SIMILAR TO #*FN*(2) AND #*FP*(2); RECALIBRATING *COVID* CASES FOR DECEMBER 20, 2020 [31]. SEE APPENDIX D'S TABLE XXV FOR A COMPARISONS' SUMMARY REGARDING THE WORLD AND ALL COUNTRIES. THE FOLLOWING TABLE ESTIMATES RECALIBRATEDTOTAL#CASES (*RTC*) IN BRACKET (1) FOR CONSERVATIVE ≈ ORIGINALTOTAL#CASES-|#*FN*(1)–#*FP*(1)| OR IN BRACKET (2) FOR LIBERAL≈ ORIGINALTOTAL#CASES - |#*FN*(2)–#*FP*(2)|

LEGEND	#CASES	#RCV'RD	#FN(1)	#FN(2)	#FP(1)	#FP(2)	#ACTV(1)	#ACTV(2)	C11	C12(1)	C12(2)	C21(1)	C21(2)	C22	α(1)	β(1)	α(2)	β(2)
WORLD(35,40)	76778017	53889446	912159	1125137	10428722	12815240	10765094	8378576	106304	10658790	8272272	2606914	2819892	53889446	0.331	0.350	0.378	0.399
USA(5,10)	18086215	10546751	77857	205073	1567180	4020491	5648818	3195507	27984	5620834	3167523	401323	528539	10546751	0.179	0.194	0.359	0.388
BRAZIL(3,6)	7213155	6222764	112771	195521	455410	757205	348625	46830	8318	340307	38512	299127	381877	6222764	0.364	0.377	0.488	0.512
RUSSIA(1,2)	2848377	2275657	31557	54199	301243	487165	220639	34717	2300	218339	32417	82395	105037	2275657	0.367	0.383	0.484	0.516
FRANCE(1,2)	2460555	183571	37504	64413	1283537	2075715	933029	140851	2727	930302	138124	97922	124831	183571	0.367	0.383	0.484	0.516
TURKEY(1,2)	2004285	1779068	5569	16190	46340	120294	161026	87072	5501	155525	81571	23420	34041	1779068	0.187	0.238	0.373	0.476
ITALY(1,2)	1938083	1249470	40858	72072	348485	586092	271681	34074	2784	268897	31290	109305	140519	1249470	0.361	0.374	0.487	0.513
GERMANY(1,2)	1499698	1085500	8369	24463	98698	265984	288998	121712	4939	284059	116773	34871	50965	1085500	0.205	0.240	0.410	0.480

Table XXIV bracket (1) denotes *LOSS*=1*K* and bracket (2) denotes *LOSS*=2K for many nations such as Russia etc. below Brazil, whose bracket (1) denotes *LOSS*=3*K* and bracket (2) denotes *LOSS*=6*K* due to sudden rise of cases by 2020's end. Brackets (1) and (2) show *LOSS*=35*K and* 40*K* for WORLD. Also brackets (1) and (2) denote *LOSS*=5*K and* 10*K* for USA.


Covid-19 Death Toll Is Even Worse Than It Looks

Global deaths are running far past what would have been expected

The recorded death count from the Covid-19 pandemic as of Thursday is nearing 2 million. The true extent is far worse.

By Paul Overberg, Jon Kamp and Daniel Michaels

More than 2.8 million people have lost their lives due to the pandemic, according to a Wall Street Journal analysis of data from 59 countries and jurisdictions. This tally offers the most comprehensive view yet of the pandemic's global impact. Deaths in these places last year surged more than 12% above average levels. Less than two-thirds of

People who have died in 2020 in selected countries above the average of previous years

ALL EXCESS DEATHS 1,904,127

KNOWN COVID DEATHS IN SELECTED COUNTRIES 1,082,442

Source: a Wall Street Journal analysis of data from 59 countries and jurisdictions. For additional methodology and sources, see A9.

Public-health experts believe that many, if not most, of the additional deaths were directly linked to the dis

was sparse. Some of those excess deaths came from direct fallout, from heal

Fig. 12. The WSJ article, on 1/15/2021 less than a month after 12/20/2020's Table XVII, globally discovered 1,904,127–1,082,442= 821,685 additional deaths unaccounted. This agrees with $FN(1) \approx 912K < FN(2) \approx 1{,}125K$, since WSJ reflected only ¾ of the WORLD's death count. For USA, known COVID deaths: 281*K*, all excess deaths: 475*K*, and missing: 194*K*.

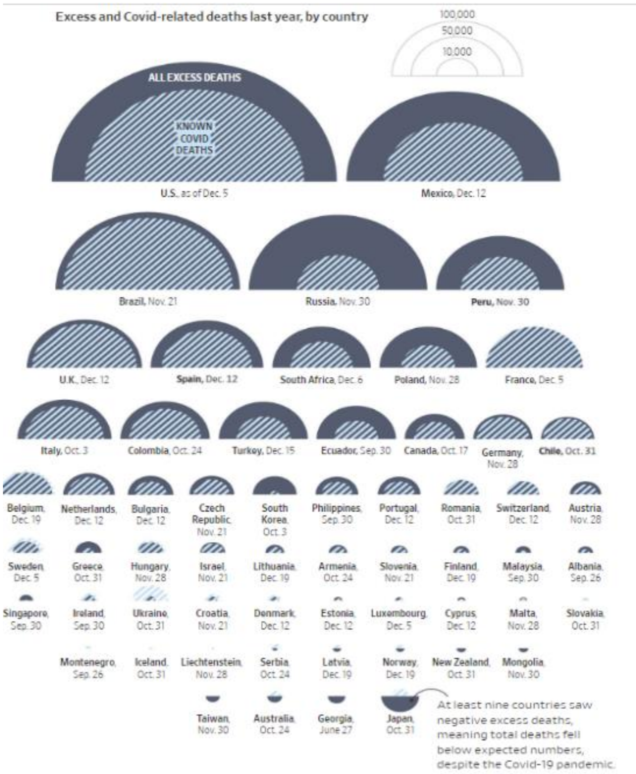


Fig. 13. Excess and COVID-related deaths in 2020 by country [29] where for the WORLD, the dark blue belt(*dbb*) ≈ 822*K* and for USA, *dbb* ≈ 194*K*.

Let's glance at the most recent summary Table XXIV. derived from Table XVII (APPENDIX B) to Table XXIII and Figs. 9 to 11 on the *COVID*-19 #Cases of December 20, 2020. If the reported deaths are multiplied by their associated recalibration constants, $(RC)_\beta=(\beta/(1-\beta)$, while assuming a feasible *LOSS* variable; the more the #*FN* number of unaccounted for virus infections will be generated as shown in equation (24) of Section II.B for each case. Overberg *et al*. [29] in 2021 reported in WSJ.com on 1/15/2021 a month after the 12/20/2020 tabulations of Table XVII: "… *To better understand the pandemic's global toll, the WSJ compiled the most recent available data on deaths from those countries with available records. These countries together account for roughly one-quarter of the world's population but about the three-quarters of all reported deaths from Covid-19 through late last year. The tally found more than 821K additional deaths that aren't accounted for in governments' official Covid-19 counts. In the U.S. alone, CDC data show more than 475K unaccounted for in governments' official Covid-19 death counts through early December in 2020, a time frame that also included about 281,000 deaths linked to Covid-19 according to John Hopkins University*." The WSJ article by Overberg et al. (2021) reported those in Fig. 12 with excess and COVID-related deaths shown in Fig. 13.

The U.S. discrepancy by WSJ [29] indicates in 01/2021 that 475K–281K=194K #deaths missing. Table XXIV roughly agrees with WSJ since $FN(1) \approx$ 78K<194K<$FN(2) \approx$ 205K for U.S. Details on the clarification of Table XXIV:

1) <u>*WORLD*</u>: Min. #*FN*(1)≈912,159 for *LOSS*=35*K* to max. #*FN*(2)≈ 1,125,137 for *LOSS*=40*K* are unaccounted deaths in Table XXIV and appended to C_{21}=1,694,755 to form $C_{21}(1)$=2,606,914 and $C_{21}(2)$=2,819,892 respectively in Table XXIV by 2020's end. Fig. 12's WSJ declares unaccounted for as ~822K. Table XXIV's unaccounted for #deaths, #*FN*(1)≈912K refers to the entire globe while WSJ's ~822K is conservative for globe's 75% data records only. Min. #*FP*(1)≈10,428,722 to max. #*FP*(2)≈12,815,240 excess false positives in Table XXIV are deleted from C_{12}=21,087,512 to form $C_{12}(1)$=10,658,790 and $C_{12}(2)$=8,272,272. Also deleted from #Actives=21,193,816 to form #Actives(1)=10,765,094 and #Actives(2)=8,378,576 in Table XXIV. #$FN(1)/C_{21}$ ≈912/1,695≈.54 when 54% more died for *LOSS*=35*K*; #$FN(2)/C_{21}$≈1,125/1,695≈.664 or $(RC)_\beta$ =*β*(2)/(1-*β*(2)=.399 /(1-.399)≈.664 when 66.4% more died for *LOSS*=40K. |*FP*(1)-*FN*(1)|≈|10,429K–912*K*|≈9,517*K*; 76,778K(original)-9,517K(surplus)≈67,261K(*RTC*) for *LOSS*=35*K*. |*FP*(2)-*FN*(2)|≈|12,815K–1,125*K*|≈11,690*K*. 76,778K(original)-11, 690K(surplus)≈65,088K(*RTC*) for *LOSS*=40*K*.

2) USA: Min. #*FN*(1)≈77,857 for *LOSS*=5*K* to max. #*FN*(2)≈205,073 for *LOSS*=10*K* are missing #deaths and appended to C_{21}=323,466 to form $C_{21}(1)$=401,323 and $C_{21}(2)$=528,539 respectively in Table XXIV. Fig. 12's WSJ report declares 194*K*≈475*K*(excess#deaths)-281*K*(known COVID-19 #deaths) unaccounted for within the *FN*'s range 78*K*<194*K*<205*K* as cited. Min. #*FP*(1)≈1,567,180 to max. #*FP*(2)≈4,020,491 false positives in Table XXIV are deleted from C_{12}=7,188,014 to form $C_{12}(1)$=5,620,834 and $C_{12}(2)$=3,167,523. Also deleted from #Actives=7,215,998 to form #Actives(1)=5,648,818, #Actives(2)=3,195,507. #*FN*(1)/C_{21}≈78/323≈.24 when 24% more died for *LOSS*=5K. #*FN*(2)/C_{21}≈205/323≈0.63; i.e. $(RC)_\beta=\beta(2)/(1-\beta(2))$=.388/(1-.388)≈.63 when 63% more died for *LOSS*=10K. |*FP*(1)-*FN*(1)|≈|1,567*K*-78*K*|≈1,409*K*; 18,086*K* (original)-1,409*K* (surplus)≈16,677K(*RTC*) for *LOSS*=5*K*. |*FP*(2)-*FN*(2)|≈ |4,021*K*-205*K*|≈3,816*K*; 18,086*K*(original)–3,816*K* (surplus) =14,270K(*RTC*) for *LOSS* =10*K*.

3) BRAZIL: Min. #*FN*(1)≈112,771 for *LOSS*=3*K* to max. #*FN*(2)≈195,521 for *LOSS*=6*K* missing #deaths in Table XXIV and appended to C_{21}=186,356 to form $C_{21}(1)$=299,127 and $C_{21}(2)$=381,877 respectively. Min. #*FP*(1)≈ 1,567,180 to max. #*FP*(2)≈4,020,491 false positives deleted from C_{12}=795,717 to form $C_{12}(1)$=340,307 and $C_{12}(2)$=38,512. Also deleted from #Actives=804,035 to form #Actives(1)=348,625 and #Actives(2)=46,830 in Table XXIV. #*FN*(1)/C_{21}≈113/186≈.61 when 61% more died for *LOSS*=3*K*. #*FN*(2)/C_{21}≈196/186≈1.05; i.e. $(RC)_\beta=\beta(2)/(1-\beta(2))$=.512/(1-.512)≈1.05 when 105% more died for *LOSS*=6*K*. |*FP*(1)-*FN*(1)|≈|455*K*-113*K*|≈342*K*; 7,213 (original)-342*K*(surplus)=6,871K(*RTC*) for *LOSS*=3*K*. |*FP*(2) -*FN*(2)|≈|757*K*-196*K*|≈561*K*; 7,213(original)-561*K* (surplus)≈ 6,652*K*(*RTC*) for *LOSS*=6*K*.

4) RUSSIA: Min. #*FN*(1)≈31,557 for *LOSS*=1*K* to max. #*FN*(2)≈54,199 for *LOSS*=2*K* missing #deaths in Table XXIV and appended to C_{21}=50,838 to form $C_{21}(1)$=82,395 and $C_{21}(2)$=105,037 respectively. Min. #*FP*(1)≈301,243 to max. #*FP*(2)≈487,165 false positives in Table XXIV deleted from C_{12}=519,582 to form $C_{12}(1)$=218,339, $C_{12}(2)$=32,417. Also deleted from #Actives=521,882 to form #Actives(1)=220,639 and #Actives(2)=34,717 in Table XXIV. #*FN*(1)/C_{21}≈32/51≈.63 when 63% more died for *LOSS* =1*K*. #*FN*(2)/C_{21}≈54/51≈1.07; i.e. $(RC)_\beta=\beta(2)/(1-\beta(2))$ =.516/(1-.516)≈1.07 when 107% more died for *LOSS*=2*K*. |*FP*(1)-*FN*(1)|≈|301*K*-32*K*|≈269*K*; 2,848*K*(original)-269*K* (surplus)≈2,579K(*RTC*) for *LOSS*=1*K*. |*FP*(2)-*FN*(2)| ≈|487*K*-54*K*|≈433*K*; 2,848*K*(original)-433*K*(surplus)≈2,415 K(*RTC)* for *LOSS*=2*K*.

5) FRANCE: Min. #*FN*(1)≈37,504 for *LOSS*=1*K* to max. #*FN*(2)≈64,413 for *LOSS*=2*K* missing #deaths in Table XXIV and appended to C_{21}=60,418 to form $C_{21}(1)$=97,922 and $C_{21}(2)$=124,831 respectively. Similarly min. #*FP*(1)≈1,283,537 to max. #*FP*(2)≈2,075,715 false positives in Table XXIV deleted from C_{12}=2,213,839 to form $C_{12}(1)$=930,302 and $C_{12}(2)$=138,124. Also deleted from #Actives=2,216,566 to form #Actives(1)=933,029 and #Actives(2)=140,851. #*FN*(1)/C_{21} ≈38/60≈.63 when 63% more died for *LOSS*=1*K*. |*FP*(1)-*FN*(1)|≈|1,284*K*-37.5*K*| ≈1246.5*K*; 2,461*K*(original)-1246.5*K*(surplus)≈1214.5K(*RTC*) for *LOSS* =1*K*. Thus, #*FN*(2)/C_{21} ≈64/60≈1.07; i.e. $(RC)_\beta=\beta(2)/(1-\beta(2))$ =.51/(1-.51)≈1.07 when 107% more died for *LOSS*=2*K*. |*FP*(2)-*FN*(2)|≈|2,076*K*-64*K*|≈2,012*K*; 2,461*K* (original)–2,012*K*(surplus)≈449K(*RTC*) for *LOSS*=2*K* is infeasible due to disproportionately overcounted false #Actives in Table XVII (APPENDIX B), i.e. 2,216,566.

6) TURKEY: Min. #*FN*(1)≈5,569 for *LOSS*=1*K* to max. #*FN*(2)≈16,190 for *LOSS*=2*K* missing #deaths in Table XXIV and appended to C_{21}=17,851 to form $C_{21}(1)$=23,420 and $C_{21}(2)$=34,041, respectively. Min. #*FP*(1)≈46,340 to max. #*FP*(2)≈120,294 false positives in Table XXIV deleted from C_{12}=201,865 to form $C_{12}(1)$=155,525 and $C_{12}(2)$=81,571. Also deleted from #Actives=207,366 to form #Actives(1)=161,026 and #Actives(2)=87,072 in Table XXIV. #*FN*(1)/C_{21} ≈5.56/17.85≈.31=31% more died for *LOSS*=1*K*. Thus, #*FN*(2)/C_{21} ≈16.2/17.85≈ 0.908; i.e. $(RC)_\beta=\beta(2)/(1-\beta(2))$=.47/(1-.47)≈0.908 when 90.8% more died for *LOSS*=2*K*. |*FP*(1)-*FN*(1)|≈|46*K*-6*K*|≈40*K*; 2,004*K* (original)-40*K*(surplus)≈1,964K(*RTC*) for LOSS=1*K*. |*FP*(2)-*FN*(2)|≈|120*K*-16*K*|≈104*K*; 2,004*K*(original)-104*K*(surplus)= 1,900K(*RTC*) for *LOSS*=2*K*.

7) ITALY: Min. #*FN*(1)≈40,858 for *LOSS*=1*K* to max. #*FN*(2)≈72,072 for *LOSS*=2*K* unaccounted deaths in Table XXIV and appended to C_{21}=68,447 to form $C_{21}(1)$=109,305 and $C_{21}(2)$=140,519 respectively. Min. #*FP*(1)≈348,485 to max. #*FP*(2)≈586,092 false positives in Table XXIV deleted from C_{12}=617,382 to form $C_{12}(1)$=268,897 and $C_{12}(2)$ =31,290. Also deleted from #Actives=620,166 to form #Actives(1)=271,681 and #Actives(2)=334074 in Table XXIV. #*FN*(1)/C_{21}≈41/68≈.6=60% more died for *LOSS*=1*K*. Therefore, #*FN*(2)/C_{21}≈72/68≈1.06, i.e. $(RC)_\beta=\beta(2)/(1-\beta(2))$ =.513/(1-.513)≈1.05 when 105% more died for LOSS=2*K*. |*FP*(1)-*FN*(1)|≈|348*K*-41*K*|≈307*K*; 1,938*K*(original)-307*K* (surplus)≈1,631K(*RTC*) for LOSS=1*K*. |*FP*(2)-*FN*(2)|≈|586 *K*-72*K*|≈514*K*; 1,938*K*(original)-514*K*(surplus)≈1,421K(*RTC*) for *LOSS*=2*K*.

8) GERMANY: Min. #*FN*(1)≈8,369 for *LOSS*=1*K* to max. #*FN*(2)≈24,463 for *LOSS*=2*K* missing #deaths in Table XXIV and appended to C_{21}=26,502 to form $C_{21}(1)$=34,871 and $C_{21}(2)$=50,965 respectively. Min. #*FP*(1)≈98,698 to max. #*FP*(2)≈265,984 false positives in Table XXIV deleted from C_{12}=382,757 to form $C_{12}(1)$=284059 and $C_{12}(2)$=116733. Also deleted from #Actives=387,696 to form #Actives(1)=288,998 and #Actives(2)=121,712 in Table XXIV. #*FN*(1)/C_{21}≈8.4/26.5≈.32=32% more died for *LOSS*=1*K*. Thus, #*FN*(2)/C_{21}≈24.46/26.5≈.92; i.e. (RC_β) $=\beta(2)/(1-\beta(2))$=.48/(1-.48)≈.92 when 92% more died for *LOSS*=2*K*. |*FP*(1)-*FN*(1)|=|99*K*-8*K*|≈91*K*; 1,500*K*(original)-91*K*(surplus)≈1,409K(*RTC*) for *LOSS*=1*K*. |*FP*(2)-*FN*(2)| =|266*K*-24*K*|≈242*K*; 1,500*K*(original)-242*K*(surplus)≈1,258 (*RTC*) for *LOSS* =2*K*.

9) SPAIN: Not applicable for #Recoveries and #Actives in Table XVII APPENDIX B unavailable to process.

Findings are summarized in Table XXV for comparisons.

III. Conclusions and Further Research

A novel conceptual game-theoretic quantitative model using a JAVA-coded software, namely, game-testing (see APPENDIX A), and/or Microsoft's *EXCEL*'s Solver (Tables VII and VIII), both verified by algebraic-root solutions and Venn Diagrams in section II.A regarding *COVID*-19 diagnosis-savvy hypothesis testing, generates an innovative and objective (vs. subjective) optimal solution algorithm for Type-I (*FP*) and Type-II (*FN*) error probabilities in healthcare informatics. The *alpha*(α) and *beta*(β) errors are best estimated in contrast to haphazardly hand-picking these inputs through traditional guess-work procedures devoid of apriori data-driven facts. Grant [4] and Kelley [5] similarly remarked the need for an objective solution to α and β instead of using the traditional textbooks' error guesstimates to run the hypothesis testing process to prove or disprove *Ho* vs H_a.

The core aim is to compare between i) flatly pre-specifying alpha and beta in the usual truth/decision model of Table I, and ii) data-centric post-specifying alpha and beta using the game-theory algorithm feasibly verified by simple algebraic roots depending on the probability model of the cross-product of the errors' and non-errors' paradigm in Table II.

It falls upon the authors to further state that the most challenging task in this game-theoretic proposition is to employ the new *COVID*-19-related WORLD's and various nations' dependable input death and recovery statistics from which the *Cij* constants and *LOSS* variable-related constraints are elicited. The analysts are free to assign calculated and mindful *LOSS* constraints to their different countries as each possesses different dynamics per Tables XVI and XXIV. The authors extensively discussed about how and why such a novel method was indispensable in section II for recalibrations after section I's introductory medical testing jargon. In this approach, the authors follow a game-theoretic algorithm (von Neumann's two-player, optimal mixed strategy, zero-sum game) where the *Cij* and *LOSS* must be empirical and data-driven by the analyst. For more details, see Sahinoglu *et al*. [11]-[14], [19]. The algorithmic solutions for the world's three chronologically reported cases as of 4/24/2020, 5/3/2020 and 12/20/2020 are illustrated in examples 1, 2 and 3 of subsections II.A, II-B and II.C with pertinent software outcomes, plots and diagrams to clarify feasible solutions. As a result of which, the *WHO's* or countries' or States' (in USA) primary healthcare departments can invest timely and smarter for pandemic mobilization and vaccination toward securing remedial actions such as in the case of *CON* (Certificate of Need) laws, masks, intubators, test-kits and vaccines as opposed to practicing inutile and old-fashioned conventional habits without remedial precautions for an imminent threat. The authors' proposed empirical, data-centric and user-friendly predictive technique makes appropriate sense for pandemic-related diagnoses-savvy estimation. This article therefore examines a game-theoretic optimization of the novel coronavirus-related hypothesis testing parameters (α=*FP* error, β=*FN* error) by utilizing the errors' and non-errors' cross-products classification schematic paradigm of Table II. Foremost crucial and critical is recalibrating the countries' floatingly unknown and asymptomatic false negatives. These #*FN*s can be likened to potential land mines due to the extremely infectious nature of the coronavirus. Lastly, it would be surprising if any statistical theory could address such an enormous range of games. There is no single game theory for all by Davis [30]. Venn Diagram's light blue vulnerability set V_1 of Fig. 5. a. without the dark blue intersection namely, $V_1 \cap V_2$, i.e. to recapitulate $V_1 \cap V_2'$ in Fig. 5. c. does represent patients to be mildly declared risky due to a given % of Active#Cases. Similarly, the counter-opposite light blue vulnerability set $V_2 \cap V_1'$ without the intersection of $V_1 \cap V_2$ will represent patients who died of COVID-19 from Closed#Cases. The dark blue intersection $V_1 \cap V_2$ is due to a critical % of the #Actives from both sets of V_1 and V_2. The blank area shows Recovered#Cases from Closed#Cases. Tables III, IX and XVII (APPENDIX B) recorded: Fatal#Deaths(C_{21})+Recovered#Cases(C_{22})=Closed#Cases(C) and #Milds(C_{12}) + # Criticals(C_{11}) = #Actives(A). So #*C* + #*A* =TotalConfirmed#Cases check for Tables of III, IX, XVII.

Further research ought to dictate that non-postponed pandemic testing data should be consistently and accurately supplied by *WHO* to be vested by sound check-mechanisms. Scientific methods to estimate the undesirable #*FN*s are of prime nature. Authentic number of cases from each country must be known by the positive scientists accurately in order to lead a trustworthy testing, and vaccine-discovery process. Hence while testing new vaccine discoveries prevail, the reliable statistical error-estimation methods will support such remedial preventions by discarding an information deluge-based guesswork. The *LOSS* variable constraints are critically important. Next to USA, India, Brazil and Russia with more than ~2.5*M* *COVID*-19 cases as of 12/2/2020, one moves from the reference point of adopting *LOSS*=1*K* or *LOSS*=2*K* constraint for lesser infected nations of less than ~2*M* #cases each, such as France, Germany, Italy, Spain, Turkey etc. as listed in Table XXIV as of 12/20/2020. The article's research findings may prove to be a reminder benchmark to warn that the actual results shall appear in the spotlight sooner or later. Objective game-theoretic hypothesis testing proposed is why the optimized coronavirus-related *alpha*(=*FP*) and *beta*(=*FN*) errors computed are data-centric, non-judgmental and objective. One considers more complicated situations, such as non-zero-sum games, to model the interaction between the rival players. Since the virus spread may evolve by natural selection and mutation such as variants (e.g. *OMICRON*, *DELTA*), classical gaming may not be rational. Evolutionary game theory may be needed by Orlando *et al*. [32].

Last but not the least, one should examine APPENDIX D's Table XXV for a comparison of missing % of #*FN*s regarding the world and various countries, and their relative % of (+) or (-) change over the most critical 7-month period from 5/2020 to 12/2020 until vaccines were invented. This certainly hints how many false negative patients (i.e. #*FN*) or asymptomatic virus carriers were accidentally, or otherwise, ignored, besides the *RTC* (RecalibratedTotal#Cases) excesses that dictated from 5/2020 to 12/2020. Results: ***A***) For the WORLD, 41% more died in 5/2020 for *LOSS*(1)=15*K* while 54% more died in 12/2020 for *LOSS*(2)=35*K*. For the WORLD, %66 more in 5/2020 for *LOSS*(1)=20*K* while %66.4 more died in 12/2020 for LOSS(2)=40*K*. The WORLD's original(0) 3,495*K* was recalibrated to *RTC*: 2,937*K* for *LOSS*(1)=15*K*, and to *RTC*: 2,674*K* both for *LOSS*(2)=20*K* in May 2020. The WORLD's original (0) 76,778*K* was recalibrated to *RTC*: 67,261*K* for *LOSS*(1) =35*K*, and to *RTC*: 65,088*K* for *LOSS*(2)=40*K*, both in December 2020. ***B***) For USA, 32% more died unaccounted in 5/2020 compared to 24% in 12/2020 at the minimum *LOSS*(1)=5*K* assumption with 8% less. Then, 97% more died unaccounted for in 5/2020 compared to 63% more deaths in 12/2020 at the maximum *LOSS*(2)=10*K* assumption with 34% less. Table XXV reveals the RecalibratedTotal#Cases (*RTC*) over the

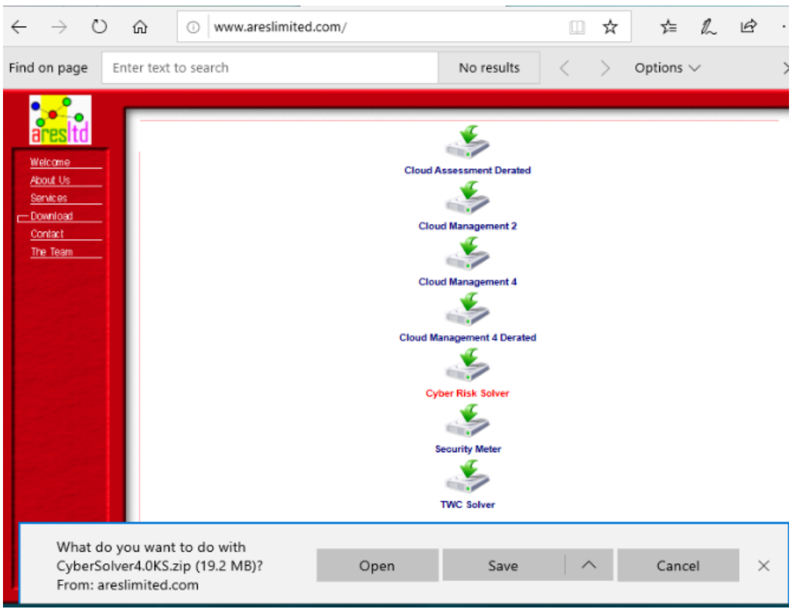
Original#Cases in Tables IX and XVII where (0) shows the original in Table XXV. Total 1,180K for USA was recalibrated down to between *RTC*: 999*K* and *RTC*: 727*K* in 5/2020, and total 18,086K was recalibrated down to between 16,677K and 14,270K in 12/2020 for minimum *LOSS*(1)=5*K* and maximum *LOSS*(2)=10*K*, both respectively. ***C***) For Brazil, 128% more died in 5/2020 for *LOSS*(1)=1*K*, and 61% more in 12/2020 for LOSS(2)=3*K*. For Brazil, %165 more died in 5/2020 for *LOSS*(1)=2*K* while %105 more died in 12/2020 for LOSS(2)=6*K*. ***D***) For Russia, 177% more died in 5/2020, and 63% more in 12/2020 for LOSS(1)=1K. For Russia, %189 in 5/2020 to %107 more died in 12/2020 for LOSS(2)=2K. ***E***) For France, 104% more died in 5/2020, and 63% more in 12/2020 for LOSS(1)=1*K*. For France, %108 more in 5/2020 while %107 more died in 12/2020 for LOSS(2)=2*K*. **F**) For Turkey, 176% more died in 5/2020, and 31% more in 12/2020 for *LOSS*(1)=1*K*. For Turkey, %180 more in 5/2020 whereas %91 more died in 12/2020 for LOSS(2)=2K. ***G***) For Italy, 59% more died in 5/2020, and 60% more in 12/2020 for LOSS(1)=1*K*. For Italy, %110 more in 5/2020 whereas %105 more died in 12/2020 for *LOSS*(2)=2*K*. ***H***) For Germany, 125% more died in 5/2020 (and 166K Total#Cases were recalibrated from a range of *RTC*: 150*K* to *RTC*: 57*K*) for *LOSS*(1)=1*K*. 32% more died in 12/2020 (and 1500*K* Total#Cases were recalibrated from a range of *RTC*: 1409*K* to *RTC*: 1258*K*) for *LOSS*(2)=2*K*. For Germany, 159% more died in 5/2020 for *LOSS*(1)=1*K*; 92% more died in 12/2020 for *LOSS*(2)=2*K*.

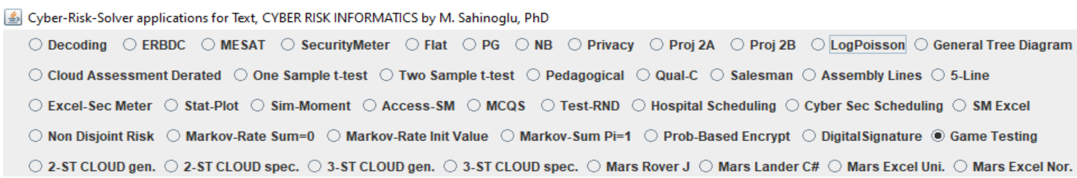
Otherwise, an elsewhere systematic review by Pecoraro *et al*. [33] showed that among 32 studies enrolling more than 18,000 patients by *SARS—CoV*-2 up to 58% of *COVID*-19 patients undercounted may have initial false-negative *PCR* results, suggesting the need to implement a correct diagnostic strategy to correctly identify suspected cases, thereby reducing false-negative results and decreasing the disease burden among the population. The cited nearly ~60% estimate is apparently close to this article's quantitative results per Table XXIV (12/2020) for comparisons of Table XXV where for the WORLD, 54% more died in 12/2020 for *LOSS*(1)=35*K* and %66.4 more died in 12/2020 for *LOSS*(2)=40*K*. Not to forget, these authors' data-centric *LOSS* constraint assumption can be accurately leveraged to reach a sensible consensus. In another 34 studies enrolling 12,057 *COVID*-19 confirmed cases by Arevalo-Rodriguez *et al*. [34], up to 54% of the patients may have an initial false-negative *PCR* current up to July 2020 after which the cases escalated until 12/2020. Despite blockchain's recent mushrooming advantages, it's not fully adaptable to combat the *COVID*-19 pandemic due to limited business incentives, lack of laws for its governance, lack of confidence of the users on the evolving technology and finally, high energy consumption rate and complexity of mining by Chamola *et al*. [35]. Miller's [36] MiPasa tested blockchain to verify data.

APPENDIX A

How to install Cyber-Risk-Solver's game testing application:

1. Click www.areslimited.com. Type in the user name: mehmetsuna, password: Mehpareanne, click OK.
2. Go to DOWNLOAD on www.areslimited.com for l.h.s. menu's 4th choice.
3. Click on the Cyber Risk Solver in red and download the application which a ZIP file. Unzip or extract the downloaded application into C:\myapp folder. See C:\myapp\dist. Open a Command Prompt and go to C:\myapp\dist folder and run the following command: //For Cyber Risk Solver, java –jar twcSolver.jar. Use license code: EFE28SEP1986 for twcSolver.jar.
4. Click on the game-testing app installer OPEN. Enter the input per Tables IV, X, XII, XIV, XVIII, XX and XXII in the article.





APPENDIX B

TABLE XVII: WORLD'S COVID-19 #CASES ON DECEMBER 20, 2020 BY JOHNS HOPKINS UNIVERSITY [31]

#	Country, Other	Total Cases	New Cases	Total Deaths	New Deaths	Total Recovered	Active Cases	Serious, Critical	Tot Cases/ 1M pop	Deaths/ 1M pop	Total Tests	Tests/ 1M pop	Population
	World	76,778,017	+172,194	1,694,755	+3,600	53,889,446	21,193,816	106,304	9,850	217.4			
1	USA	18,086,215	+8,206	323,466	+62	10,546,751	7,215,998	27,984	54,491	975	232,660,262	700,968	331,912,730
2	India	10,047,131	+15,472	145,669	+156	9,595,711	305,751	8,944	7,247	105	161,198,195	116,276	1,386,345,438
3	Brazil	7,213,155		186,356		6,222,764	804,035	8,318	33,822	874	25,700,000	120,506	213,267,162
4	Russia	2,848,377	+28,948	50,858	+511	2,275,657	521,862	2,300	19,514	348	85,900,000	588,502	145,963,926
5	France	2,460,555		60,418		183,571	2,216,566	2,727	37,657	925	30,346,777	464,434	65,341,427
6	Turkey	2,004,285		17,851		1,779,068	207,366	5,501	23,646	211	22,280,635	262,858	84,762,888
7	UK	2,004,219		67,075		N/A	N/A	1,364	29,451	986	49,579,548	728,540	68,053,296
8	Italy	1,938,083		68,447		1,249,470	620,166	2,784	32,077	1,133	24,991,705	413,634	60,419,904
9	Spain	1,817,448		48,926		N/A	N/A	1,920	38,865	1,046	24,918,644	532,867	46,763,305
10	Argentina	1,537,169		41,763		1,362,617	132,789	3,452	33,866	920	4,464,725	98,364	45,389,708
11	Germany	1,499,698	+5,737	26,502	+88	1,085,500	387,696	4,939	17,873	316	31,974,158	381,054	83,909,818

APPENDIX C

TABLE XIX: $P_{IJ} = [P_{11}, P_{12}, P_{21}, P_{22}]$ FOR *LOSS* =.01K, 30K, 32K, 35K, 40K FROM TABLE XVII (*APPENDIX* B) AND TABLE XVIII INPUTS

The results for loss: 0.01	The results for loss: 30.0	The results for loss: 32.0	The results for loss: 35.0	The results for loss: 40.0
P11 = 9.4072E-5	P11 = 0.282216	P11 = 0.3010304	P11 = 0.32925197	P11 = 0.37628794
P12 = 4.7422517E-7	P12 = 0.0014226756	P12 = 0.0015175208	P12 = 0.0016597882	P12 = 0.0018969008
P21 = 5.9006934E-6	P21 = 0.01770208	P21 = 0.01888222	P21 = 0.020652426	P21 = 0.023602773
P22 = 0.9998995	P22 = 0.6986592	P22 = 0.6785699	P22 = 0.6484358	P22 = 0.59821236
Expected Total Cost: -53884	Expected Total Cost: -37560.35	Expected Total Cost: -36471.75	Expected Total Cost: -34838.84	Expected Total Cost: -32117.33
Alpha: 9.454622E-5	Alpha: 0.2836387	Alpha: 0.30254793	Alpha: 0.33091176	Alpha: 0.37818483
Beta: 9.997269E-5	Beta: 0.2999181	Beta: 0.3199126	Beta: 0.3499044	Beta: 0.39989072

APPENDIX D

TABLE XXV: TOTALRECALIBRATED#CASES (TRC) AND % FOR EXTRA #DEATHS (1) & (2)

(1), (2) → BRACKETS WITH LOWER AND HIGHER LOSS CONSTRAINTS IN TABLE XVI AND XXIV OF NATION COLUMNS E.G. USA (5K, 10K)

ORIGINAL #CASES: (0) % Δ SHOWS (+) OR (-) CHANGES FROM MAY 2020 UNTIL DECEMBER 2020 FOR LOSS VARIABLES (1) AND (2)

TIME	*WORLD*	*USA*	*BRAZIL*	*RUSSIA*	*FRANCE*	*TURKEY*	*ITALY*	*GERMANY*	*CODE*
MAY'20→	3,495K	1,180K	101K	135K	131K	126K	211K	166K	(0)
MAY'20→	2937K	999K	79K	90K	118K	100K	178K	150K	(1)
MAY'20→	2674K	727K	73K	77K	106K	99K	153K	57K	(2)
DEC'20→	76,778K	18,086K	7,213K	2,848K	N/A	2,004K	1,938K	1,500K	(0)
DEC'20→	67,261K	16,677K	6,871K	2,579K	N/A	1,964K	1,631K	1,409K	(1)
DEC'20→	65,088K	14,270K	6,652K	2,415K	N/A	1,900K	1,421K	1,258K	(2)
MAY'20→	41%	32%	128%	177%	104%	176%	59%	125%	(1)
DEC'20→	54%	24%	61%	63%	63%	31%	60%	32%	(1)
MAY'20→	66%	97%	165%	189%	108%	180%	110%	159%	(2)
DEC'20→	66.4%	63%	105%	107%	107%	91%	105%	92%	(2)
~% Δ→	+13%	-8%	-67%	-114%	-41%	-145%	+1%	+93%	(1)
~% Δ→	+0.4%	-34%	-60%	-82%	-1%	-89%	-5%	-67%	(2)

CONFLICT OF INTEREST

The authors declare no conflict of interest in this work.

AUTHORS' CONTRIBUTIONS

The principal author, Prof. MS applied the original theory with innovative findings in 2020 based on Johns Hopkins University's universally-trusted *COVID*-19 data bank. This effort was followed by justifying the software solutions with the actual national and world field results. The article was mainly supported by MS's game-theoretic research following pandemic's resurgence. Dr. HS, co-author, now an Emergency Medicine (*ER*) Physician and an *ER* Resident at Piedmont Hospital in Macon, GA, contributed to the authenticity of the medical and epidemiological terminology that he, out of tested clinical experience, justified in addition to his professional insights to bridge the IJCTE readers with medicinal and life sciences of pandemic-speak and infodemic nomenclature.

ACKNOWLEDGMENT

The authors thank the three anonymous reviewers for pointing out to, respectively, 1) Elbow points in Figs. 7 and 8 owing to their piece-wise and definitely, the nonlinear nature often common to the life-sciences, and 2) Source and relative importance for the NFL data size in Fig. 3 which was referenced by [3] on p. 2 column 2, and 3) Corrections of minor points with no major alterations executed.

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M. Sahinoglu served as a distinguished professor in the position of founding director of the Informatics Institute and the founder head of the Cybersystems and Information Security Graduate Program (2008-2018) in Auburn University at Montgomery. Formerly, the Eminent Scholar and Chair-Professor at Troy University's Computer Science Department (1999-2008), he holds a *BSEE* from *METU*, Ankara, Turkey (1969-73), and *MSEE* from

University of Manchester, UK as a British Council scholar (1974-75). He completed a joint Ph.D. from Statistics and ECE at Texas A&M University (*TAMU*) in College Station, TX (1977-81). Full Prof. (1990) by the *ABET*-accredited *METU* at 39; he was the founder Dean of the College of Arts & Sciences at Izmir's *DEU* (1992-97). He was invited to June 1990's First Kickoff Workshop on Software Reliability Engineering in Washington, *DC*. He published software-centric class-notes: *Applied Stochastic Processes* (*ISBN*: 975-95363-1-5, *METU*-Ankara, 1992) two years later. In 1993-94, Dr. Sahinoglu founded the Statistics Department to recently have celebrated its 25th anniversary in 2019. Dr. Sahinoglu currently conducts research on Multi-Themed Quantitative Risk Assessment and Management. He authored *Trustworthy Computing: Analytical and Quantitative Engineering Evaluation* (2007), *ISBN*: 978-0-470-08512-7 and *Cyber-Risk Informatics: Engineering Evaluation with Data Science* (2016), *ISBN*: 9781119087519 by *WILEY* Inc. Dr. Sahinoglu, who retired from Auburn University System as of June, 2018, has since instructed Cybersecurity curriculum at Troy University's CS Dept. in Troy, AL. Dr. Sahinoglu is an ASA Senior (1980-), *ISI* Elected (1995-), *IEEE* Senior Life (1978-) and *SDPS*: Society of Design & Process Science Fellow Member (2003-). He taught at *METU* (1977-92), *TAMU* (1978-81), *DEU* (1992-97), Purdue (1989-90 Fulbright and 1997-98 *NATO*) and *CWRU*, Cleveland, *OH* (1998-99). One of the world's 14 *Microsoft Trustworthy Computing* Awardees (2006) with a $50,000+ grant budget to build an original cybersecurity-lab, and twice silver medallist for the U.S.-*DAU* (Defence Acquisition University)'s Hirsch Paper Competition on Software Assurance (2015) and Digital Forensics (2016); Mehmet was the 2009 recipient of the *SDPS*' Software Eng. Society's Excellence in Leadership Award. Dr. Sahinoglu's life-time findings: i) S&L (Sahinoglu-Libby) statistical pdf jointly with Dr. D. Libby, PhD from the Univ. of Iowa on repairable hardware (1981), ii) *CPSRM*: Compound Poisson Software Reliability Prediction Model (1992), iii) *MESAT*: Cost-Optimal Stopping-Rule in Reliability/Security Testing (2002), iv) *SM*: Security and Privacy Risk Meter (2005), v) Coding & Decoding of large complex networks using Polish Algorithms (2006), vi) *OVERLAP* ingress-egress solution for large Complex Block Diagrams jointly with B. Rice (2007), vii) Sahinoglu's 3-State Monte Carlo Simulation Model (2008), viii) *CLOURAM*: Cloud Computing Risk Assessor & Manager (2017), and most recently, ix) Data-Based (Empirical) Optimization of Type I and Type II Errors in Hypothesis Testing (2022). He published 160 proceedings, 70+ peer-reviewed journal articles and managed 20 (inter)national grants. He delivered 60+ keynotes, invited seminars and Public Radio talks (also invited at *TRT*: Turkish Radio & Television in 1980s and 1990s for Turkish college youth) at Troy *WTSU* in *AL* on Cybersecurity for public awareness covering South-eastern USA.

H. Sahinoglu graduated Summa Cum Laude (GPA: 4.0) as Chancellor's Scholar, the University's highest level of distinction conferred, from Auburn University at Montgomery with a B.S. in Biology/Pre-Health (2013-2017). Among many notable awards, he was a member of the Phi Kappa Phi Honor Society, Tri-Beta Biology Club & Honor Society, Alpha Epsilon Delta Pre-Health Club & Honor Society, and the National Society of Leadership and Success, also a school ambassador. Hakan graduated from the Edward Via College of Osteopathic Medicine (VCOM), Auburn, Alabama (2017-2021). While there, he continued to demonstrate scholastic achievement and excellence and received acceptance into Sigma Phi, the National Osteopathic Honor Society. Hakan's interests were in emergency medicine, medicine management, and global (epidemics) healthcare improvement. He has participated in many Emergency Medicine Club activities as well as helped contribute to the design of two research projects. The activities included MedWars, Rescue Race, and Disaster Day. MedWars and Rescue Race were medical scenario-based races where students incorporated teamwork and orienteering skills into recognizing medical situations and how to triage and intervene in them with limited resources, all while practicing useful medical skills like splinting, suturing, water purification, and other general improvisations. Disaster Day was a multifaceted and original training opportunity created by VCOM, where students partnered with Auburn University Nursing, Pharmacy, and Social Work, along with local EMS, to simulate day-long mass-casualty scenarios to train participants in the proper response and intervention needed in these types of events. Hakan has also attended VCOM's Annual Student Osteopathic Surgical Association Conference each year (2018-2020), where he furthered his procedural skills training and attended lectures from some of the finest surgeons in the region. Other conferences attended were the Association of Southeastern Biologists Meeting (2017), VCOM Wilderness Medicine Mountain Medicine Conference (2019), and the Southeastern Student Wilderness Conference (2020). He has two undergraduate abstracts (*Evaluation of Lake Martin Water Samples and Treated Water for Indicator Bacteria*, April 2016 and *Screening of Soil Bacteria for Production of Thermostable Amylase*, April 2017), one medical school abstract (*Field Amputations: A Scenario-Based Workshop For First Responders, A Pilot Project*, Feb. 2020), one authored undergraduate Top Research Award paper (*Selection and Molecular Characterization of Antibiotic Producing Microbial Isolates from Soil*, April 2017), and one medical school poster presentation (*Bleeding Control for the Medical Student*, April 2019). Hakan was a member of the Student Osteopathic Medical Association (2017–2021), American College of Osteopathic Emergency Physicians, American College of Emergency Physicians, and the Emergency Medicine Residency Association (2019–). His certifications included Basic Life Support, Advanced Cardiovascular Life Support, and Basic Disaster Life Support. During the *COVID*-19's high-season when the coronavirus risk was fast escalating and proving lethal, Hakan fulfilled his Med-School's senior-away summer Emergency Medicine rotation at Henry Ford Wyandotte Hospital upon invitation at Wyandotte, MI 48192 near Detroit. He worked as a voluntary *COVID*-19 front-liner (July 1-31, 2020) in tandem with the assigned hospital staff and under his attending's supervision. Hakan experienced first-hand up-to-then unforeseen pandemic exposure problems of *COVID*-19-infected and thus intubated patients, risking his own health collaborating with Wyandotte personnel for a humane cause. Upon graduation from Med-School in May 2021 as a physician, Hakan began his Emergency Medicine first-year internship having successfully matched at the Piedmont (formerly Coliseum) Hospital in Macon, GA 31210 as of June 2021 following a dozen of competitive *ZOOM* interviews and written clocked-tests.