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Alcohol Concentration Modeling in the GI Tract and the Bloodstream

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ABSTRACT

We completed a research project on the concentration of alcohol in the GI tract and the bloodstream. We mathematically presented the concentration in the GI tract and the bloodstream, where the models were solved analytically and some pertinent entry parameters were obtained.

Numerical simulation was carried out using Wolfram Mathematica, powerful computational software, and numerical and graphical results were obtained by varying the impact of the relevant parameters on the various concentrations.

The results show that increasing the rate of alcohol movement in the GI tract increases alcohol concentration in the GI tract, increasing the rate of alcohol movement in the GI tract increases alcohol concentration in the bloodstream, and increasing the rate of alcohol movement in the bloodstream increases alcohol concentration in the bloodstream. However, the alcohol concentration in the bloodstream is greater than that in the GI tract, and the alcohol concentration in the bloodstream decreases as the alcohol rate in the bloodstream increases. As alcohol consumption increased, so did alcohol concentrations in the bloodstream and gastrointestinal tract.

Finally, we were able to use mathematics to represent the movement of alcohol in the GI tract and bloodstream, as well as its impact on the human body.

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Study Background

Drinking alcohol raises the risk of developing mental and behavioral disorders, including alcoholism, as well as major non-communicable diseases such as liver cirrhosis, some cancers, and cardiovascular disease. According the fall injuries account for a significant portion of the health burden among the elderly, and they frequently have a negative impact on life quality and impose significant societal costs [1]. Binge drinking is a multi-factorial problem that investigates peer influence in the immediate environment [2]. The research findings enabled us to assess the potential impact of interventions based on the individual and social characteristics of the participants.

Investigated IDU among students as a major global public health issue. Poor academic performance, as well as physical and mental health issues, led to poor development and productivity later in [3].

Alcohol addiction is a phenomenon that has piqued the interest of numerous researchers and academics from a wide range of professions due to the serious consequences it has on all aspects of human life [4]. The study's findings provided useful insights to the government and policymakers for targeting appropriate media awareness programs in the fight against alcoholism. studied the dynamical behavior of the drinking population using a fractional drinking model with Caputo-(CF) Fabrizio's arbitrary order operator and a special non-singular kernel [5]. Using a fixed-point theory and Picard's technique, the proposed system is examined for solution existence, result, and uniqueness. investigated controlled drug release hydrogels [6]. Large polymer-drug conjugate release is more complex than small-soluble drug release with simple diffusion and cannot be predicted by a simple diffusion model. The goal of this research was to develop controlled drug-release hydrogel systems by mathematically modeling polymer-drug conjugate release. developed mathematical models that could be used to explain the distribution of drug administration in the human body after oral and intravenous administration of the drug [7]. The effect of the fractional parameter on drug concentration was graphically depicted. The fractional model provides important and relevant inferences from which new information can be derived.

Substance abuse is known to activate and disrupt neuronal circuits in the brain reward system, according to [8]. To describe the neurobiology of drug addiction, they proposed a simple and easily interpretable dynamical systems model that incorporates the psychiatric concepts of reward prediction error, drug-induced incentive salience, and opponent process theory. developed a mathematical model for alcohol-related health risks that takes into account fuzziness in the uncertainties associated with individual risk behavior and the induced death rate [9]. According to the findings, the most powerful people tend to wield more power. Cancer will account for more than ten million deaths in 2020, who investigated it as one of the leading causes of morbidity worldwide [10]. The findings presented here are promising and have the potential to broaden the scope of this research into other areas, such as the development of effective nutritional supplements capable of inhibiting carcinogenesis.

In this research, we shall formulate the alcohol concentration in the GI tract and in the bloodstream using a mathematical model and solve the problem analytically. After obtaining the analytical solution, we would use Wolfram Mathematica, powerful computational software, to perform the numerical simulation and investigate the impact of all the sensitive entry parameters on the alcohol concentration in the GI tract and in the bloodstream and draw conclusions from the investigation [11].

Formulation and Solution

Consider as the concentration of alcohol (effective BAL) in the GI-tract and is the concentration of alcohol (in BAL) in the bloodstream over time, where is considered as the ingestion rate of alcohol, measured in units of BAL/hour and is the volume of fluid in the blood, measured in 100ml. In addition, let denotes the amount of alcohol taken into the GI-tract in each time step and the constant represents the blood alcohol concentration. We assume that to be the rate of alcohol movement in the GI-tract and in the bloodstream respectively. Based on the considerations presented above, we present the formulated mathematical models as:

$$\frac{dC_1}{dt} = I - k_1 C_1 \qquad C_1(0) = 0 \tag{1}$$

$$\frac{dC_2}{dt} = k_2 C_1 - k_4 C_2 \qquad C_2(0) = 0 \tag{2}$$

Solving for the alcohol concentration, equation (1), we obtained

$$C_1(t) = \frac{I}{k_1} + Ae^{-k_1 t} \tag{3}$$

Applying the initial condition in equation (1), we resolved

$$C_1(t) = \frac{I}{k_1}\left(1 - e^{-k_1 t}\right) \tag{4}$$

We study the impact of alcohol concentration in the bloodstream, we replace equation (4) with equation (2), which is:

$$\frac{dC_2}{dt} = \frac{Ik_2}{k_1}\left(1 - e^{-k_1 t}\right) - k_4 C_2 \tag{5}$$

Resolving equation (5), we have:

$$\frac{dC_2}{dt} + k_4 C_2 = \frac{Ik_2}{k_1} - \frac{Ik_2 e^{-k_1 t}}{k_1} \tag{6}$$

Solving equation (6), we have:

$$C_2(t) = \frac{Ik_2}{k_1 k_4} - \frac{Ik_2}{k_1(k_4 - k_1)} e^{-k_1 t} + Be^{-k_4 t} \tag{7}$$

Solving for the constant in equation (7), we obtain

$$B = \frac{Ik_2}{k_1(k_4 - k_1)} - \frac{Ik_2}{k_1 k_4} \tag{8}$$

Substituting equation (8) into equation (7), we have:

$$C_2(t) = \frac{Ik_2}{k_1 k_4}\left(1 - e^{-k_4 t}\right) + \frac{Ik_2}{k_1(k_4 - k_1)}\left(e^{-k_4 t} - e^{-k_1 t}\right) \tag{9}$$

where $I = \dfrac{i}{V_b}$ is the amount of alcohol consumed per unit time

Results and Discussion

Numerical simulation was carried out using Wolfram Mathematica, version 12, where the results are presented graphical labeled as Figures 1 to 6 and tabular as Tables 1 to 6. The results are presented below:

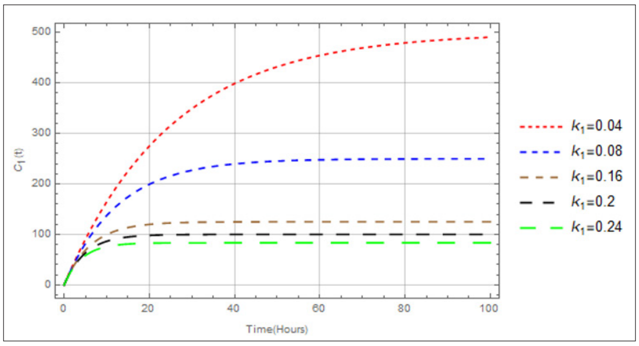

Figure 1: Impact of the Movement of Alcohol in GI-Tract k_1=0.02,0.08,0.16,=0.2 on Alcohol Concentration in the GI-Tract Over Time

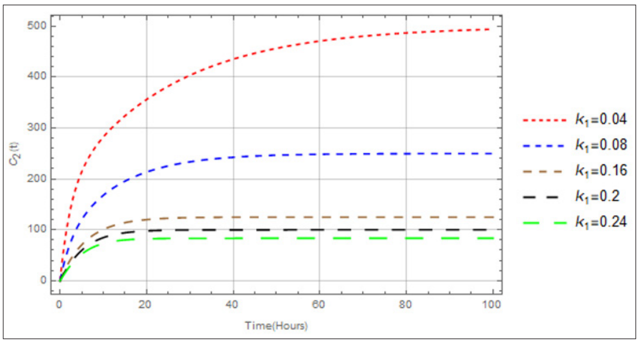

Figure 2: Impact of the Movement of Alcohol in the GI-Tract k_1=0.02,0.08,0.16,=0.2 on Alcohol Concentration in the Bloodstream Over Time

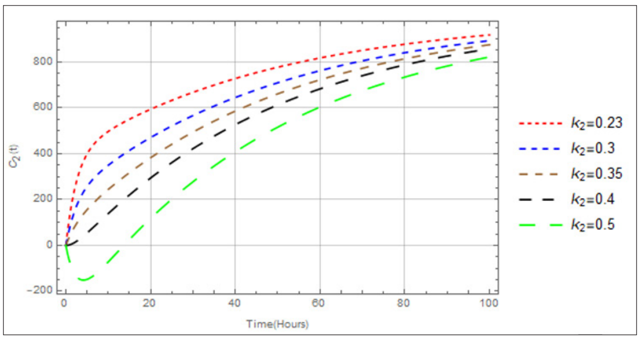

Figure 3: Impact of the Movement of Alcohol in the Bloodstream k_2=0.23,0.3,0.35,0.4,0.5=0.2 on Alcohol Concentration in the GI-Tract Over Time

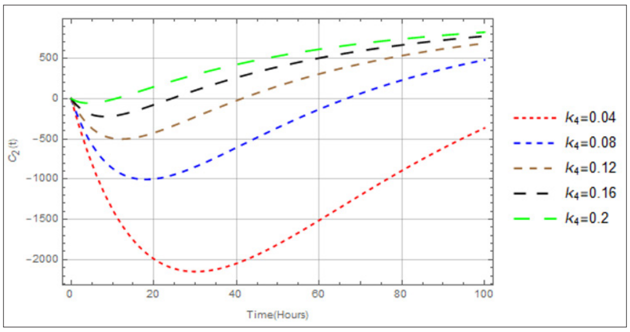

Figure 4: Impact of Alcohol Concentration k_4=0.04,0.08,0.12,0.16,0.2 on Alcohol in the Bloodstream Over Time

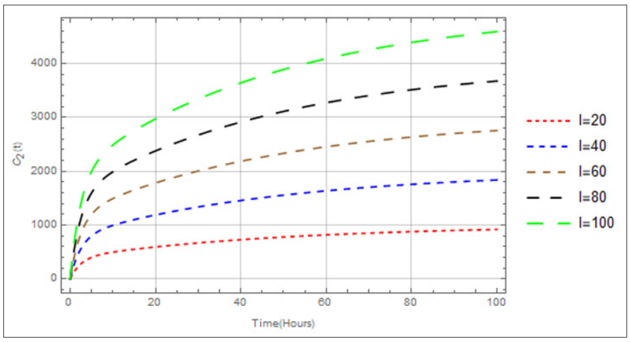

Figure 5: Impact of the Amount of Alcohol Taken I = 20,40,60,80 on Alcohol Concentration in the Bloodstream Over Time

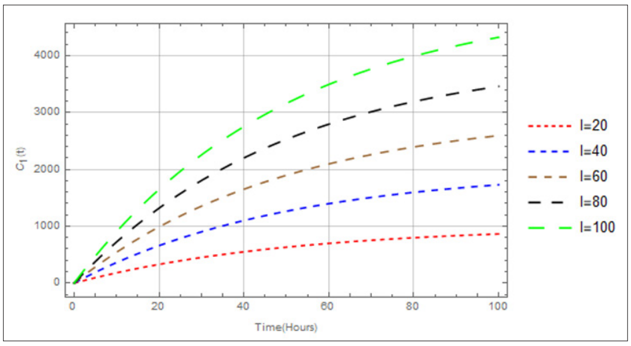

Figure 6: Impact of the Amount of Alcohol Taken I = 20,40,60,80 on Alcohol Concentration in the GI-Tract Over Time

Table 1: Impact of the Movement of Alcohol in GI-Tract k_1 = 0.02,0.04,0.08,0.16, 0.2 on Alcohol Concentration in the GI-Tract Over Time

Time (Hour)	$C_1(t)$	$C_1(t)$	$C_1(t)$	$C_1(t)$	$C_1(t)$
0	0.	0.	0.	0.	0.
20	275.336	199.526	119.905	98.1684	82.6475
40	399.052	239.809	124.792	99.9665	83.3277
60	454.641	247.943	124.992	99.9994	83.3333
80	479.619	249.585	125.	100.	83.3333
100	490.842	249.916	125.	100.	83.3333

Table 2: Impact of the Movement of Alcohol in the GI-Tract k_1 = 0.02,0.04,0.08,0.16, 0.2 on Concentration of Alcohol in the Bloodstream Over Time

Time (Hour)	$C_2(t)$	$C_2(t)$	$C_2(t)$	$C_2(t)$	$C_2(t)$
0	0.	0.	0.	0.	0.
20	356.404	213.698	120.115	97.8987	82.3597
40	435.505	242.676	124.801	99.9614	83.3252
60	471.021	248.521	124.992	99.9993	83.3333
80	486.979	249.701	125.	100.	83.3333
100	494.149	249.94	125.	100.	83.3333

Table 3: Impact of the Movement of Alcohol in the Bloodstream k_2 = 0.23,0.3,0.35,0.4, 0.5 on Concentration of Alcohol in the Bloodstream Over Time

Time (Hour)	$C_2(t)$	$C_2(t)$	$C_2(t)$	$C_2(t)$	$C_2(t)$
0	0.	0.	0.	0.	0.
20	594.148	470.729	382.573	294.418	118.106
40	728.038	645.267	586.144	527.022	408.778
60	817.698	762.215	722.584	682.953	603.692
80	877.799	840.608	814.043	787.477	734.347
100	918.087	893.156	875.349	857.542	821.927

Table 4: Impact of Blood Alcohol Concentration k_4 = 0.04,0.08,0.12,0.16, 0.2 on Alcohol in the Bloodstream Over Time

Time (Hour)	$C_2(t)$	$C_2(t)$	$C_2(t)$	$C_2(t)$	$C_2(t)$
0	0.	0.	0.	0.	0.
20	-1990.73	-997.52	-423.803	-75.0358	148.568
40	-2047.37	-606.935	-22.7579	262.885	425.951
60	-1511.19	-131.26	308.224	505.224	615.142
80	-893.807	230.771	535.726	668.315	742.021
100	-364.042	482.165	688.737	777.664	827.072

Table 5: Impact of the Amount of Alcohol Taken *I*= 20,40,60,80 on Concentration of Alcohol in the Bloodstream Over Time

Time (Hour)	$C_2(t)$	$C_2(t)$	$C_2(t)$	$C_2(t)$	$C_2(t)$
0	0.	0.	0.	0.	0.
20	594.148	1188.3	1782.44	2376.59	2970.74
40	728.038	1456.08	2184.11	2912.15	3640.19
60	817.698	1635.4	2453.09	3270.79	4088.49
80	877.799	1755.6	2633.4	3511.2	4389.
100	918.087	1836.17	2754.26	3672.35	4590.43

Table 6: Impact of the Amount of Alcohol Taken *I*= 20,40,60,80 on Concentration Alcohol in the GI-Tract Over Time

Time (Hour)	$C_2(t)$	$C_2(t)$	$C_2(t)$	$C_2(t)$	$C_2(t)$
0	0.	0.	0.	0.	0.
20	329.68	659.36	989.04	1318.72	1648.4
40	550.671	1101.34	1652.01	2202.68	2753.36
60	698.806	1397.61	2096.42	2795.22	3494.03
80	798.103	1596.21	2394.31	3192.41	3990.52
100	864.665	1729.33	2593.99	3458.66	4323.32

Discussion

Following the numerical simulation, we shall discussion the results as follows:

Figure 1 and Table 1 show that the alcohol concentration increases from zero to 490.842, 249.916, 120, 100, and 83.333 for different values of the rate of alcohol movement in the GI tract. However, for different values of the alcohol movement rate at the GI tract, the alcohol concentration was observed to decrease for a fixed time. Figure 2 and Table 2 depict the alcohol concentration in the bloodstream at different movement rates. The concentration of alcohol in the bloodstream increases from 0 to 494.149, 249.94, 126, 100, and 83.333 for different values of movement rates. In addition, the concentration was observed to have decreased for a fixed time at different levels of the movement at GI-tract. However, we noticed that the alcohol concentration in the bloodstream tends to be more stable in the GI tract at 0.08, 0.16, and 0.3. Figure 3 and Table 3 depict the impact of the movement rate of alcohol in the bloodstream on the concentration of alcohol. The results showed that the alcohol concentration increases from 0 to 918.887, 893.156, 875.344, 857.574, and 821.927 for different values of the movement rate at 0.23, 0.3, 0.35, 0.4, and 0.5; however, the concentration tends to decrease in the bloodstream for different rates of alcohol in the bloodstream at a fixed time and is observed to be faster in the GI tract. Table 4 and Figure 4 illustrate the impact of the blood alcohol rate on the blood alcohol concentration. It is seen that the alcohol concentration in the bloodstream decreases from 0 to -364.042 at the blood alcohol rate of 0.04, 0 to -131.26 for the blood alcohol rate of 0.08, but increases from 0 to 827.072 for the blood alcohol rate of 0.2. However, we observed that the alcohol concentration in the bloodstream tends to increase for a specific time in an hour for different values of the blood alcohol rate of 0.04, 0.08, 0.12, 0.16, and 0.2, respectively. Figures 5 and 6, as well as Tables 5 and 6, demonstrated the effect of alcohol consumption on alcohol concentrations in the bloodstream and GI tract. The figures show that the alcohol concentration in the bloodstream increases from 0 to (329.68, 594.148), (1729.33, 1836.17), (2593.99, 2754.26), (3458.66, 3672.35), and (4323.32, 4590.43).

Summary and Conclusion

In this research article, we have carried out an investigation on alcohol concentration in the bloodstream and GI tract by representing the problem mathematically and solving the models representing alcohol concentration independently. The results were presented in both tables and figures in order to show the numerical information. The obtained results were discussed extensively, and we can conclude that:

- The alcohol concentration in the GI tract increased with the increase in the alcohol movement rate in the GI tract.
- The alcohol concentration in the bloodstream is increased by the increase in the alcohol movement rate in the GI tract.
- For different rates of alcohol movement in the bloodstream, the blood alcohol concentration rises. However, the alcohol concentration in the bloodstream is higher than that in the GI tract.
- The alcohol concentration in the bloodstream decreases with increasing alcohol rate in the bloodstream.
- Alcohol concentrations in the bloodstream and GI tract increased as alcohol consumption increased.

We have been able to present the alcohol concentration problem in mathematical form and the problem solved for the concentration in the GI tract and in the bloodstream. In addition, we have also carried out numerical simulation using high-powered computational software, Wolfram Mathematica, version 12. And the results we obtained all satisfied the objectives of this research.

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