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A Walk through the Time Tunnel:

An Approach to the Death Formula

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Abstract

The human being has always tried to play at being a fortune teller, he has always wanted to know what was going to happen before time, and one of the questions that puzzles him the most and at the same time worries him at present, is to know the date of his death. In this article we try to answer this question in a very general way, obviously making many hypotheses and getting an initial formula through the Classical Dimensional Analysis.

Keywords: dimensional analysis, causes of death, cardiovascular diseases, tobacco, prediction

1. Introduction

One of the greatest longings of the human being is immortality. Since this is impossible today, unless one is Count Dracula, at least it seems that one of the questions that trouble, and even obsess, mankind is that of the date/age of his death, can be solved in an approximate way? Death' is always surrounded by a mysterious halo. Is there anything after it appears? Is there anything that can be done to avoid it? Is it destiny that marks when each person's time comes, or is it determined by the actions of each person? The answers vary according to one's beliefs. However, when science comes into play, everything makes sense, because calculations do not lie and there is no room for mysticism.
The question that we can ask ourselves a lot or not, depending on how we are, is whether the date/year of our death can be predicted. In 1754, the French mathematician Abraham de Moivre predicted the date of his own death. Accustomed, perhaps obsessed with calculus and statistics, he realized that he slept 15 minutes longer each day, and that this was not insignificant. As he grew older, Abraham de Moivre, began to feel and to see that he needed more hours of sleep. So he began to make exact calculations about the time he spent in bed sleeping.

Moivre perceived an increase of 15 minutes of sleep every night, when he woke up at dawn, from the moment he fell into the arms of Morpheus. And, like a good mathematician, using an inference that only he could explain, he calculated the date of his death on the day when his sleep time reached the sum of 24 hours. Thus, in his calculations, he dated his demise, which was November 27, 1754. The prediction was made just 73 days before, and without any counter-prognosis, HE WAS RIGHT. He died blind and without his mathematical achievements being recognized by the scientific community. It is said that the doctor who certified his death alleged 'drowsiness' as the official cause, although perhaps the doctor was a condescending friend. That escapes the tremulous hulls of history. What we wonder is whether Abraham de Moivre was right?

Peris has created a calculator that is based on the test-like answers to forty questions related to a person's behaviors and habits, such as the type of food or the amount of coffee consumed per day, to decipher how likely he or she is to extend his or her life. Although it is true, it seems impossible to know exactly how long we will live, more and more is known about the factors that are most important for a long and healthy life, so that a trend can be established by comparing our habits.

This paper aims to highlight by means of classical statistical analysis (4,12) a simple formula for approximating the determination of the date of death of people based mainly on statistical data obtained from diseases that lead us to death or demise. The factors obtained will be discussed by taking them to borderline situations and appropriate conclusions will be drawn.

1.1. Leading causes of death in the world.

Globally, 7 of the 10 leading causes of death in 2019 were noncommunicable diseases. These 7 causes accounted for 44% of all deaths, or 80% of the total of the 10 leading causes. However, noncommunicable diseases as a whole accounted for 74% of deaths worldwide in 2019.

The world's leading cause of death is ischemic heart disease, responsible for 16% of all deaths worldwide. Since 2000, the largest increase in deaths corresponds to this disease, which has risen from more than 2 million deaths in 2000 to 8.9 million in 2019. Stroke and chronic obstructive pulmonary disease (COPD) (7,17,2) are the second and third leading causes of death, accounting for approximately 11% and 6% of total deaths, respectively. These three leading causes of death account for one third of deaths worldwide (11).

2. Methods and materials

It is important to know why people die in order to improve their way of life. Measuring how many people die each year helps to assess the effectiveness of health systems and to direct resources to where they are most needed. For example, mortality data can help focus activities and resource allocation between sectors such as transportation, food and agriculture, and environment and health.

In order to prevent or address these types of problems, mathematical models are found (8,12). A mathematical model is a description of any system using mathematical language and concepts. The great advantage of mathematical models is that they can help to study the original system, explain the effects of the different components of the system and predict its future behavior, in the short or long term. All this at a low economic cost and, in the case of a medical model, without the need for experiments on humans or animals.
The development of a mathematical model within the scope of the most important diseases of causes of death will naturally be a causal model of the most important risk factors within the identified diseases. In order to build the model some considerations need to be made about many of the factors that have already been explained. There are other risk factors involved but they have not been considered so as not to complicate the simplicity of the model sought by the author. Naturally, this will affect the accuracy of the model, but it is assumed with the objective of achieving a model that is easy to apply (14,18).
The mathematical model in this study has been carried out using Classical Dimensional Analysis (CDA) since it allows the study of certain complex problems within the field of Sciences. It could be said that it is an analysis technique that allows, in a minimum time, to estimate a first solution to a given problem. The ADC reduces to a minimum the degrees of freedom of a problem, suggesting the most economical and immediate scaling laws. The result obtained is independent of the system of units chosen to express them (1).
The ADC is closely related to the Pi-Buckingham theorem, the theorem used in the elaboration of the mathematical model presented in this study, this theorem allows obtaining dimensionless numbers from a set of variables associated with a particular problem (5,6).
In order to define the variables to be used in the mathematical model, we must know the most important risk factors that are present in the three diseases that cause the greatest number of deaths in the world population, so we will analyze them.

2.1. Definition of variables

Based on the previous study and in order to create the mathematical model to determine the patient's age at death (time of life, Tv), it is necessary to define the most important variables for this model based on the previous data.
Regarding the cause of death due to ischemic heart disease, it has been indicated that the fundamental variable to be able to evaluate coronary microvascular dysfunction is the measurement of coronary flow reserve (Qc) (9,10).
The cause of death by cardiovascular accident depends on the following variables many risk factors:

- Non-modifiable: these include age (E), sex, heredity, race, geography and climate. Age is considered to be the most important of the above factors for the purpose of this study compared to the other factors.

- Well-established modifiable factors: the main long-lasting factor for stroke is arterial hypertension (AHT). As indicated above, 35-60% of strokes can be attributable to HT. It has been observed that there is a linear relationship between blood pressure (BP) values, both diastolic (DBP) and systolic (SBP), and cardiovascular morbidity and mortality, specifically cerebral vascular morbidity and mortality, influenced by potential modifiable factors (19,15).

- Potential modifiable: dyslipidemia, smoking, alcoholism, obesity and sedentary lifestyle are among the main factors. There are discrepancies between the relationship between cholesterol level and stroke risk has been controversial with respect to dyslipidemia, something similar has occurred with alcoholism where some epidemiological studies suggest that moderate alcohol consumption (< 30 g/day) may have a protective effect on the risk of ischemic stroke (16). However, smoking, obesity (Ob) and sedentary lifestyle, which in the end would lead to overweight (already considered), are factors to be taken into account. Questionnaires are the most widely used method to monitor the prevalence of smoking and the number of cigarettes smoked in the general population. To study the consequences of smoking, it may be useful to know the form of use. Therefore, the questionnaire used should contain questions that collect information on the forms of tobacco used (cigarettes, cigars, pipe tobacco, roll-your-own tobacco). In identifying the pattern of tobacco use, the most common indicators are frequency (f) and quantity consumed (Ct) (3,13).

Some hypotheses have been considered for the simplification of the model:

The equation will be as well as it has been commented an approximation to the final equation, since women and men have been considered together, and it has been commented that women live on average, longer than men, 85 years compared to 89 years respectively.

Not all the causes of death in the world have been included in the model; only the three main causes of death, which account for 33% of deaths worldwide, have been selected so as not to complicate the model.

A mathematical model has been made with a linear and non-exponential approximation for simplification and visibility of the model by decreasing the coefficient of determination R^2. The R^2 is the percentage of variation of the response variable (Tv) that explains its relationship with one or more predictor variables (Qc, E, f, Ct, Ob and Pa). Generally, the higher the R2, the better the fit of the model to its data.

Within these causes of death, not all risk factors have been considered either, but only the most important ones.

With these simplifications, the mathematical model has been reduced considerably, which is what was sought for the development of this study.

Based on the variables indicated above, we will proceed to perform a classical dimensional analysis using the Pi-Buckingham method and observe the influence of these variables and be able to determine, approximately, the life span of a person.

3. Discussion

Considering the variables of the system formed by the set of eight variables in their fundamental or basic dimensions: length (L), mass (M) and time (T), the following table is obtained:

Nº	Variable	Description	Fundamental dimensions
1	Tv	Life time (years)	T
2	Qc	Coronary flow (m3/s)	L^3T^{-1}
3	E	Age (years)	T
4	Pa	Blood pressure (N/m2 or Kg/m.s2)	$ML^{-1}T^{-2}$
5	Ob	Obesity (kg)	M
6	f	Smoking frequency (No. cigarettes per day)	T^{-1}
7	Ct	Amount of tobacco consumed (kg)	M

Table.-1 System variables vs. fundamental dimensions

From Table 1, eight homogeneous variables (m) with three basic dimensions (L, T and M) are identified and will be referred to as n.

$$f(x_1, x_2 \ldots\ldots x_n) = 0$$

which is a representative law of a physical phenomenon, can be represented as:

$$F(\pi_1, \pi_2 \ldots\ldots \pi_n) = 0$$

Where the π_i are the independent monomials of dimension zero, which can be formed with the quantities considered in the physical law.

The number of monomials is π_i = m - n, where m is the number of homogeneous variables and n is the number of basic dimensions.
It is intended to form dimensionless monomial groups of the form:

$$\pi = \prod_{i=1}^{n} X_i^{ei} \quad que\ cumplan\ [\pi] = 1$$

Particularizing for the defined system of variables we will have that:

$$\pi i = m - n = 7 - 3 = 4 \text{ (dimensionless groups)}$$

this indicates that 4 groups of dimensionless numbers will be needed to solve the system.
Next, the matrix of the coefficients of the identified homogeneous variables with respect to the fundamental magnitudes of each one of them is presented.

Variables:	**M**	**L**	**T**
Tv	0	0	1
Qc	0	3	-1
E	0	0	1
Pa	1	-1	-2
Ob	1	0	0
f	0	0	-1
Ct	1	0	0

Table.-2 Coefficient matrix of the variables

The following were taken as reference variables: coronary flow (Qc), age (E) and obesity (Ob). To verify that they are independent, it is verified that the determinant of the coefficients of the fundamental dimensions is different from zero; this ensures that one variable is not a combination of the others selected.

$$\det\begin{bmatrix} 0 & 3 & -1 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \end{bmatrix} = 3 \neq 0$$

Thus, the following four dimensional equations are posed:

$$\pi_1 = T_v \cdot Qc^a \cdot E^b \cdot O_b^c \quad (1)$$
$$\pi_2 = P_a \cdot Qc^a \cdot E^b \cdot O_b^c \quad (2)$$
$$\pi_3 = f \cdot Qc^a \cdot E^b \cdot O_b^c \quad (3)$$
$$\pi_4 = C_t \cdot Qc^a \cdot E^b \cdot O_b^c \quad (4)$$

where the exponents a, b and c must be obtained in such a way that their contribution cancels all the dimensions involved in the system.
We proceed to determine the dimensionless numbers π_1, π_2, π_3 and π_4 of the system of dimensional equations posed.

- Determination of the dimensionless number π_1:

$$\pi_1 = T_v \cdot Qc^a \cdot E^b \cdot O_b^c \quad (1)$$

Dimensionally it can be written that:

$$M^0.L^0.T^0 = (T).\ (L^3T^{-1})^a\ .\ (T)^b\ (M)^c$$

By identifying the values for the three fundamental quantities we arrive at the following system of equations:

Dimension	Equation
M	c=0
L	0=3a
T	0=1-a+b

Table.-3 Equations to determine the parameter π_1.

So the values obtained from solving the above system are: a=0, b=-1 and c=0, which by substituting in equation (1) determines the first dimensionless number:

$$\Pi_1 = \frac{T_v}{E} \quad (5)$$

- Determination of the dimensionless number π_2:

$$\pi_2 = P_a \cdot Qc^a \cdot E^b \cdot O_b^c \quad (2)$$

Dimensionally it can be written that:

$$M^0.L^0.T^0 = ML^{-1}T^{-2}.\ (L^3T^{-1})^a\ .\ (T)^b\ (M)^c$$

By identifying the values for the three fundamental quantities we arrive at the following system of equations:

Dimension	Equation
M	0=1+c
L	0=-1+3a
T	0=-2-a+b

Tabla.-4 Equations to determine the parameter π_2.

So the values obtained from solving the above system are: a=1/3, b=7/3and c=-1, which by substituting in equation (2) determines the second dimensionless number:

$$\Pi_2 = \frac{P_a}{O_b}.E^2.\sqrt[3]{Q_c.E} \quad (6)$$

- Determination of the dimensionless number π_3:

$$\pi_3 = f \cdot Qc^a \cdot E^b \cdot O_b^c \quad (3)$$

Dimensionally it can be written that:

$$M^0.L^0.T^0 = T^{-1}.\,(L^3T^{-1})^a\ .\,(T)^b\,(M)^c$$

By identifying the values for the three fundamental quantities we arrive at the following system of equations:

Dimension	Equation
M	c=0
L	3a=0
T	0=-1-a+b

Tabla.-5 Equations to determine the parameter π_3.

So the values obtained from solving the above system are: a=0, b=1 and c=0, which by substituting in equation (3) determines the third dimensionless number:

$$\Pi_3 = f.E \quad (7)$$

- Determination of the dimensionless number π_4:

$$\pi_4 = C_t \cdot Qc^a \cdot E^b \cdot O_b^c \quad (4)$$

Dimensionally it can be written that:

$$M^0.L^0.T^0 = M.\,(L^3T^{-1})^a\ .\,(T)^b\,(M)^c$$

By identifying the values for the three fundamental quantities we arrive at the following system of equations:

Dimension	Equation
M	0=1+c
L	0=a
T	0=-a+b

Tabla.-6 Equations to determine the parameter π_4.

So the values obtained from solving the above system are: a=0, b=0 and c=-1, which by substituting in equation (4) determines the fourth dimensionless number:

$$\Pi_4 = \frac{Ct}{O_b} \quad (8)$$

3.1. Mathematical Model

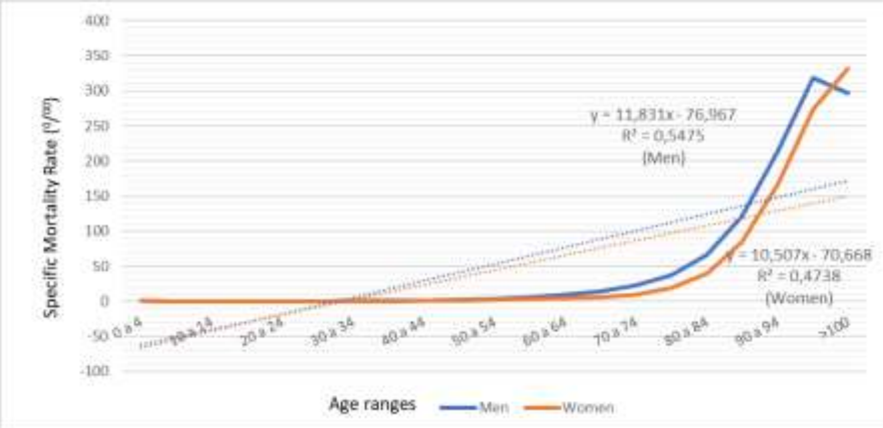
To determine the mathematical model that would give the speed of virus propagation as a function of the remaining homogeneous variables, to be put as:

$$\Pi_1 = f\,(\pi_2, \pi_3, \pi_4)$$

This assumes that the mathematical model could be set as:

$$\frac{T_v}{E} = f\ (\frac{P_a}{O_b}.E^2.\sqrt[3]{Q_c.E}, f.E, \frac{Ct}{O_b}) \qquad (9)$$

The function f appearing in the relation of dimensionless parameters should be determined experimentally.
It is observed from formula 9 that the estimate of a person's life span (Tv) is directly proportional to the parameters E, Pa, Qc, f and Ct, and inversely proportional to Ob.



Graph.-1 Specific mortality rate of men and women worldwide for different age ranges (2016). Linear trend curves with R^2 value.
Based on the data represented in graph 1, it is going to be assumed that the life time estimation has a linear relationship with the product of each of the dimensionless numbers π2, π3 and π4. This assumption has been made to simplify the model by fleeing from second and third degree polynomial adjustments that would have been more accurate but would also have complicated the simplicity of the mathematical model intended to be developed in this study.

Thus, the new expression of the model would be as follows:

$$\frac{T_v}{E} = a - b\ (\frac{P_a}{O_b^2}.E^3.\sqrt[3]{Q_c.E}.f.C_t)\ \text{(years)} \qquad (10)$$

The new parameters a and b appearing in equation 10 must be determined experimentally.

By subtracting the estimated life time (Tv) in equation 10 we will have:

$$T_v = a.E - b\ (\frac{P_a}{O_b^2}.E^4.\sqrt[3]{Q_c.E}.f.C_t)\ \text{(years)} \qquad (11)$$

3.2. Model Validation

Next, it will be verified that the mathematical model obtained by equation (11) fits the real experience of life expectancy time expressed in years.

- Condition that the age of the person is very high, for this purpose, E tends to infinity, such that:

$$Tv \mid E \to \infty = \lim(E \to \infty)\left(a.E\ -\ b\ (\frac{P_a}{O_b^2}.E^4.\sqrt[3]{Q_c.E}.f.C_t)\ \right) = -\infty$$

This indicates that for very old ages, for both men and women, the estimated lifespan decreases dramatically.

- Condition of very high blood pressure, Pa is made to tend to infinity, such that:

$$Tv \mid Pa \to \infty = \lim(Pa \to \infty)\left(a.E\ -\ b\ (\frac{P_a}{O_b^2}.E^4.\sqrt[3]{Q_c.E^2}.f.C_t)\ \right) = -\infty$$

It follows that when blood pressure is very high, life span decreases significantly. If, on the other hand, the blood pressure were within normal limits, the individual's life span would be close to that marked for the average age of the individual.

- High coronary Flow, in this case Qc tends to infinity:

$$Tv \mid Qc \to \infty = \lim(Qc \to \infty)\left(a.E\ -\ b\ (\frac{P_a}{O_b^2}.E^4.\sqrt[3]{Q_c.E^2}.f.C_t)\ \right) = -\infty$$

It’s observed that high coronary flows cause the person's life span to decrease.

- Frequency of smoking, in this case if f tends to infinity, i.e. the person smokes very frequently:

$$Tv \mid f \to \infty = \lim(f \to \infty)\left(a.E\ -\ b\ (\frac{P_a}{O_b^2}.E^4.\sqrt[3]{Q_c.E^2}.f.C_t)\ \right) = -\infty$$

This indicates that if the person smokes very often, it will have a direct and negative impact on the expected life span.

- Tobacco consumption, in this case if Ct tends to infinity, that is, if the person consumes a lot of tobacco:

$$Tv \mid Ct \to \infty = \lim(Ct \to \infty)\left(a.E\ -\ b\ (\frac{P_a}{O_b^2}.E^4.\sqrt[3]{Q_c.E^2}.f.C_t)\ \right) = -\infty$$

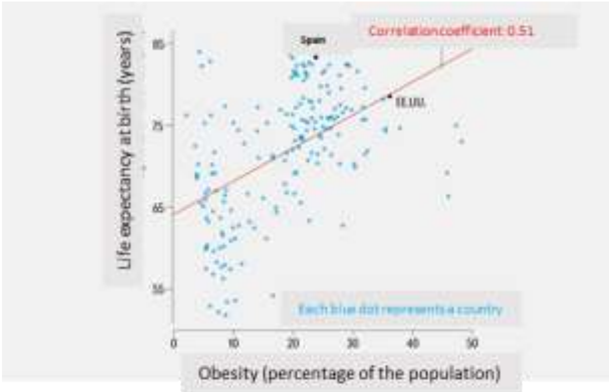
This indicates that if the person consumes a lot of tobacco, it will also have a direct and negative impact on the expected life span.

- Obesity, in this case if Ob tends to infinity, i.e. the person is overweight:

$$Tv \mid Ob \to \infty = \lim(Ob \to \infty)\left(a.E\ -\ b\ (\frac{P_a}{O_b^2}.E^4.\sqrt[3]{Q_c.E^2}.f.C_t)\ \right) = a.E$$

This indicates that life span will not be negatively affected because the person is obese, which seems to be in contradiction with current medical advice. To define overweight and obesity, the BMI or body mass index is commonly used. It is calculated by dividing weight in kg by height in meters squared. Life expectancy is shortened by 5-7 years with BMI between 30 and 40 and 10 years with a BMI over 40.

Looking at the following graph, a person may feel relieved because in general terms, the more obese the population of a country is, the longer the life expectancy. A priori, one might think that the proposed model works if we think globally, which is how the study was carried out. After all, the correlation (red line) is quite clear.



Graph.-2.- Alberto Cairo; Asesor: Heather Krause Datassist; Source: Association between class II obesity (BMI of 40-59 Kg/m^2) and mortality: a pooled analysis of 20 prospective studies.

Graph 2 itself is not incorrect, but it does not really reflect that the more obese a population is, the longer it lives. If a more accurate depiction is made on a national scale, country by country, there is a direct relationship between obesity and life expectancy at birth, and vice-versa. Even so, that does not mean that such a relationship holds at the local or individual level, as other approaches come into play. The first is that a trend in the overall data may disappear or even reverse if the data are examined in detail. If countries are separated by income level, the close direct correlation becomes much looser as wealth increases. In more affluent countries (bottom right), the relationship is reversed: the higher the incidence of obesity, the lower the life expectancy. Other factors, such as access to health care and physical exercise, are also linked to life expectancy, as is income. But this study is far from the pretensions of this work, which seeks an approximate model of life expectancy based on the factors that cause the greatest number of deaths.

4. Conclusion

It has been proven that by means of classical dimensional analysis, a simple mathematical model can be developed that confirms the data observed in daily life or by experience with respect to the estimated time of life expectancy.
The parameters selected for the study have been considered as the most important due to their influence on the cause of death of the person. With respect to smoking, it is true that one of the two parameters selected could have been eliminated, but it was considered that the frequency and quantity of tobacco consumed by the person should be taken into account because it is a decisive and very important factor in a society that, through tobacco consumption, tries to distract itself from the ever-

increasing political, health, social, etc. problems that the current population faces every day.

The obesity parameter has been treated at a global level, so that the incidence obtained in the mathematical model could be thought to be contrary to what the experts indicate. If this parameter is treated in a more personal way, an incidence in the expected order is observed as indicated in the discussion part of this work.

It should be pointed out that the parameters collected, which represent the three main diseases from which people die, only cover 33% of the deaths in the population; other important diseases as causes of death such as lower respiratory tract infections, neonatal conditions, cancer of the trachea, bronchus or lung, Alzheimer's disease and others derived from it, diarrheal diseases, nephropathies, etc., have not been taken into account.

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