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Original Article

Holistic-indicator model for predicting factors that generate visual health affections

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Abstract: This work is based on the General Systems Theory (GST), in that it mentions that the latter offers a better result when all of the parts that interrelate and make up a whole are studied. The objective of modeling a holistic indicator in the field of Optometry is to be able to provide information for evaluating the factors that affect vision, considering the interrelationship between each of these. There are diverse applications that alter visual health, among which the factors taken into consideration in the investigation are the following: cultural; economic; environmental, and technological factors. A mathematical model is designed that integrates the factors in order to provide an indicator in percentage and in global form to predict the state of visual health according to the harm caused by factors found in a population. The importance of the holistic-indicator model is that it comprises elements of the system (factors) that affect visual health.

Keywords: Holistic indicator, factors, prediction, visual health

Introduction

General systems theory

According to the van Gigch a system, is considered as a series of interrelated elements that perform some activity, function, or operation to achieve some objective in common. Thus, this study was based on the General Systems Theory (GST) due to that its approach is systemic. The GST was developed from the need to provide an alternative to conceptual schemes that are known under the name of analytical-mechanical focuses, which are associated with the application of the scientific method. The "mechanical" classification derived from that these were instruments in the development of Newton's Laws, while the instruments are analytical because they proceed by means of analysis, that is, from each of the parts that make them up and that range from the most complex to the simplest. They are also deductive in that they range from the general to the particular [1].

Bunge postulated that: "the systemic focus is an alternative to individualism as well as to "totalism" (holism). Therefore, the holistic focus studies the totality of the system [2].

Figure 1 depicts the interrelationship of the elements comprising the study system, i.e., the cultural, economic, environmental, and technological factors.

Indicator

Gunasekaran defines an indicator as a value in weight, age, stature, amount, and other units of measure that allow to know the magnitude or the size of something in relation to the totality of a given universe. An indicator is expressed in absolute numbers and/or percentages [3].

Jiménez in 2002 suggested that identification of the main indicators can be of aid in the following aspects [4, 5]:

• To identify the principal factors that intervene.

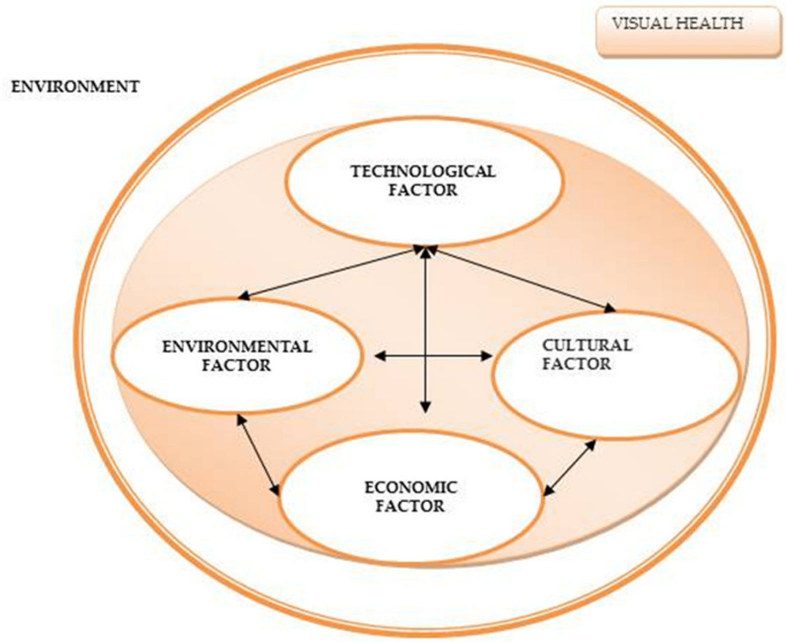

Figure 1. Systemic Representation of Visual Health.

Table 1. Mexican population with visual problems

Age	Total population	Optometry service required	Share of
0 to 4	10, 528, 322	473, 775	4.5
5 to 14	21, 987, 474	5, 716, 743	26
15 to 44	53, 479, 571	16, 043, 871	30
45 onwards	26, 341, 171	26, 341, 171	100
Total	112, 336, 538	48, 575, 560	43.24

Source: INEGI www.inegi.org.mx.

• To detect areas and procedures for improvement.

• To obtain information from the expected results.

• To identify the critical factors for success.

Thus, the indicator model is developed from a systemic form, given that the GTS presents a scientific and systemic manner of approximating and representing reality. At the same time, it plays a very important role in investigation with respect to orienting analyses from an integrative and holistic perspective, in which what is important is the identification of, the relationships among, and the behavior of, the factors affecting visual health.

The Overall Environmental Equipment Effectiveness (OEEE) is employed to analyze the evolution between two identified states of Overall Equipment Effectiveness (OEE) and sustainability taken together, and the references, globally and individually, of production steps and transformation processes in industry [6].

Visual health

Over time, factors arise that alter visual health, some due to their long exposure time, to financial resources, or to access to the health sector. In worldwide terms, uncorrected refractive errors (myopia, hypermetropia, astigmatism, and presbyopia) constitute the most important causes of visual disability. Likewise, the World Health Organization (WHO), in a study carried out in 2012, states that there are 285 million persons with visual disability, among whom 39 million are blind and 246 million present low vision [7].

According to the reports of the Mexican Association of Faculties, Schools, Colleges, and Advisory Boards of Optometry (AMFECCO), 80% of the world's total cases of visual disability could be avoided or cured with a preventive culture involving the arrangement of an appointment for the performance of a clinical vision study on a constant basis. Around 65% of persons with visual disability are >50 years of age. Similarly, it is estimated that the number of children with visual disability worldwide ascends to 19 million, among whom 12 million are affected by refractive errors, which are easily diagnosed and corrected [8].

To be able to visualize the impact of the visual problem in terms of the referred numbers of refractive errors and their null clinical care, the population of Mexico, according to the National Institute of Statistics and Geography (INEGI), an autonomous organism of the Mexican Government, in its most recent census in 2010, establishes the existence of a population of 112,336,538 Mexicans, with 43.24% of the population, this equivalent to 48,575,560 persons, requiring optometric services in Mexico

[8, 9]. One of the possible reasons for these numbers, which are alarming, may be that, according to the WHO, a deficit of 64.40% in Mexico is estimated of professionals with an undergraduate degree in Optometry, and this can also explain the problematic in accessing a visual health service [10]. **Table 1** indicates the number of persons who require optometric services by age in the Mexican Republic.

The most representative factors for evaluating the relationship of the latter with this visual health problem are cultural, economic, environmental, and technological. The impact of the new technologies increases its association with the number of persons who employ visual devices (computers, tablets, mobile phones, and television); for example, the numbers indicate that at least 86% of persons utilize mobile phones, 59% use a Personal Computer (PC), and 54%, a laptop. Individuals come to present ocular tension, headache, double vision, or blurred vision [11]. The latter leads to impeding the nutrition, cleanliness, and hygiene of the cornea, the most superficial layer of the eyeball, while 45% make use of a videogame console or device, 14% a Smartphone, and around 4% are inclined toward electronic tablets [10]. Bansal and Wimalasundera consider that 90% of individuals with a minimal exposure of 3 h in front of a computer, tablet, mobile phone, or laptop begin to experience symptomatology such as headache, ocular hyperemia, blurred vision, double vision, or visual fatigue [12, 13].

In addition, continuous exposure to UltraViolet (UV) rays produces visual alterations [14-16]. On the other hand, the already low economic level, which is declining [17] and lack of access to the visual health sector can generate an increase in injury [18]. Riojas and López in 2013 mentioned that a daily minimal exposure of 5 h is a predisposing factor for the appearance of pinguecula and later, pterygium [19].

On the other hand, the present amount of the daily minimum salary is insufficient to cover the basic needs stipulated by the Mexican Constitution. Additionally, in 2014, according to the Mexican National Council for the Political Evaluation of Social Development (CONEVAL), this amount is even insufficient for covering the purchase of items in the basic food basket [20]. The Mexican Secretariat for Economic Development of the Federal District (SEDECODF) reports that the minimum salary established in Mexico City, Mexico (now denominated CDMX in Mexican Spanish), in 2014 is $2,699.00 Mexican pesos, corresponding the lower-lower social class, this being a possible reason for families sometimes not being able to acquire optical or pharmaceutical treatment [17].

According to a food salary poverty indicator, published by the "México ¿Cómo vamos?" campaign, the population able to acquire the basic food basket on their salary rose from 56.5% in the second trimester pf 2013 to 60.5% for the same period in 2014, in Mexico City (CDMX) [21].

In Mexico, the population prefers to acquire products among those in the basic food basket than to pay out-of-pocket for an appointment with a Visual Health Specialist. Thus, the population does not invest in any type of treatment.

The AMFECCO (Asociación Mexicana de Facultades, Escuelas, Colegios y Consejos de Optometría) recommends requesting regular appointments with the Optometrist to conduct tests in order to maintain visual health, with two visits annually the ideal, or at least one per annum [7]. In Mexico, >21.8 million persons lack access to health services; one reason for this can be the lack of health professionals for covering these services for the Mexican population, and another, the low salary that does not cover basic familial expenses [10].

Therefore, institutions such as the St. Thomas Unit Interdisciplinary Center of Health Sciences CICS UST (Centro Interdisciplinario de Ciencias de la Salud Unidad Santo Tomás) engage in the promotion of programs for patients to have a visual test each year and even better, at no charge [22].

Materials and methods

To generate this holistic indicator, the latter is obtained from the individual indicators of each factor to be evaluated:

1. Establish ranges for the classification of each factor with the general Overall Equipment Effectiveness (OEE) base.

The OEE index is a percentage performance indicator. Its advantage lies in its being the sole indicator that multiplies three percentage ratios: availability, efficiency and quality [23].

Table 2. Classification of OEE

OEE range	Performance
OEE>95%	Excellence. World-class values. Excellent competitiveness.
85%<OEE<95%	Good. Enters World-class Values. Good competitiveness.
75%<OEE<85%	Acceptable. Continue to improve to exceed 85% and move toward World-class values. Slight economic losses. Slightly low competitiveness.
65%<OEE<75%	Regular. Acceptable only if in the process of improvement. Economic losses. Low competitiveness.
OEE<65%	Unacceptable. Significant economic losses. Very low competitiveness.

Source: Domingo [6].

Table 3. Indicator Technology Factor: Visual Devices

Technology factor exposition	Share of
0 to ≤3 hrs	(100%≥90%)
>3 to ≤6 hrs	(≥80 to <90%)
>6 to ≤8 hrs	(≥65 to <80%)
>8 to ≤10 hrs	(≥50 to <65%)
>10 hrs	(<50%)

Source: Bansal, www.ijird.com/index.php/ijird/article/view/55079.

Table 4. Indicator Environmental Factor: UV Rays

Environmental factor exposition	Share of
≤5 hrs	(100%≥90%)
>5 to ≤6 hrs	(≥80 to <90%)
>6 to ≤7 hrs	(≥65 to <80%)
>7 to ≤8 hrs	(≥50 to <65%)
>8 hrs	(<50%)

Source: Rios, revistas.lasalle.edu.co/index.php/sv/article/viewFile/98/54.

Table 2 presents the classification of the ranges of OEE, which classifies a company, for others, and provides an idea of which factors undergo improvement. This classifier is the basis for establishing the ranges of each of the indicator factors. It also provides individual analysis for the formation of holistic predictive-indicator eye care.

The OEE base was assumed to generate the individual indicator as follows: first, each factor would be evaluated according to already established optometric methods, as well as the application of questionnaires for collecting a greater amount of information.

Data for calculations of technological, environmental, economic, and cultural factors are obtained through a structured questionnaire administered by means of interviews with CICS UST patients. This questionnaire analyzes each of the answers to establish the degree of the condition of each factor.

Table 5. Indicator of Economic Factor

Economic factor monthly income	Share of
>15,000	(100%≥90%)
>$11, 600 to ≤$15, 000	(≥80 to <90%)
>$6,800.00 to ≤$11,600	(≥50 to <65%)
>$2700 to ≤$6800	(≥50 to <65%)
$0.00 to ≤$2,700	(<50%)

Source: SEDECODF www.salarioscdmx.sedecodf.gob.mx.

Table 6. Preventive Culture Factor Indicator

Preventive cultural factor	Share of
≤6 meses	(100%≥90%)
>6 to ≤9 meses	(≥80 to <90%)
>9 to ≤12 meses	(≥65 to <80%)
>12 to ≤15 meses	(≥50 to <65%)
>15 meses	(<50%)

Source: AMFECCO www.amfecco.org.

In **Table 3**, the ranges are represented for the classification of visual device factor, which are based on exposure in hours and repercussion on visual health, considering 100% as representing excellent health.

In **Table 4**, ranges are depicted for classification of UltraViolet (UV) rays based on the literature. Exposure is presented in hours, as is repercussion on the patient's visual health, considering 100% as excellent health.

In **Table 5**, the ranges are provided for classification of the economic factor, based on the social-class classification according to salary incomes in Mexico City (CDMX), considering 100% a good economic position.

In **Table 6**, the ranges are revealed for classification of the preventive culture factor for a visual test according to the recommendations

(%Tecnological Factor)X(%Enviromental Factor)X(%Economic Factor)X(Cultural Factor)

= Holistic indicator

Figure 2. Holistic-indicator model of Visual Health Conditions.

in terms of time as suggested by the AMFECCO. These are based on the timeframe in which the visual clinical test (preventive culture) is performed, considering 100% as the adequate range for performing this test, that is, 6 months.

2. Interpret the ranges of each factor in a Table percentage that will form a parameter condition.

This document sets forth the following categories of each of the individual indicators, taking into account the condition of each of the factors considered in the ranges in **Tables 3-6**. The goal is to exceed 90%, which yields excellent visual health; the values do not produce visual impairment. Values between ≥80% and <90% are considered good and can present a minor condition, while ≥65%<80% is considered acceptable only for indicating poor visual health visual prone to deteriorate. A value of 65% should be considered the minimum allowed, considering that the condition is significant.

3. Multiply the percentage of each factor (technological, environmental, economic, and cultural) to engender a total figure that serves to generate the indicator.

With the value of each element already provided, a mathematical design is performed based on established ranges to generate the indicator of each factor. The result is an overall percentage figure intended to render prediction of the visual-health state.

4. Establish the model of the holistic-indicator percentage basis, in order to generate a prognosis of the visual status of a population through a holistic classifier.

5. Perform the holistic-classifier predictive indicator, which determines the damage of the visual condition, established within a specific range according to the final percentage obtained by multiplying the mathematical model to generate the holistic indicator, in order to predict the visual status of a particular population or a patient.

Results and discussion

By means of the mathematical model resulting from the multiplication of each of the individual indicators of each factor, knowledge is obtained of the prognosis of visual health affectations and a holistic indicator is obtained as a result. On obtaining the holistic indicator in the form of a percentage, a prognosis can be performed of the visual state of a patient or of a population based on the affectations of the factors evaluated. Thus, an opening is sought and visual-therapy exercises are offered for the benefit of vision.

Figure 2 represents the mathematical model of a percentage manner of developing the holistic indicator. In this case, this comprises a mathematical multiplication model for each factor evaluated in the study.

This percentage figure is obtained by multiplying each of the individual indicators times the specific visual condition that it causes. Because each factor exerts an impact on vision and damage is cumulative. Thus, it is considered that the interrelationship of each of the factors alters visual health with respect to a holistic approach.

The result obtained by the average form, is greater than that of the holistic indicator. This figure is the sum of the damage of each factor divided by the number of factors assessed.

In **Table 7**, the classifier of the indicator is designated holistically, that is, according to the percentage of injury caused by each individual factor.

Table 7. Classifier holistic indicator

Factor range	Share of
100%≥90%	Excellent. The values do not produce alteration.
≥80% to <90%	Good. They are good values but have little affection.
≥65% to <80%	Acceptable. The values are acceptable but the condition is significant.
≥50% to <65%	Regular. The levels refer to damage present in the visual health from exposure to the factor.
Factor <50%	Unacceptable. The condition for exposure or factors is present and can be further developed.

According to **Table 7**, the final holistic-indicator classifier is presented in percentage form. To generate this, the mathematical model explained in **Figure 2** must be employed, that is, the percentage of injury caused by each factor (cultural, economic, environmental, and technological) is multiplied. The number obtained would be classified according to the range within which it was registered with the aid of the OEE. This in turn predicts the visual state individually or globally, with the results classified as follows: excellent; good; acceptable; fair, and unacceptable.

In prior studies conducted individually, the results are shown of the visual health affections of a direct form, as is the case of Bansal [12] and Wimalasundera [13]. These authors determined that around 90% of users of visual devices present vision symptomatology due to the excessive amount of hours spent in front of these, because the distance at which these devices are employed results as damaging to vision.

On the other hand, Ríos [14] and Sekelj [15] present studies related with direct exposure to UV rays with a minimal time of 5 h daily for at least 5 years and its repercussions on visual health, with the appearance of pathologies such as pinguecula and, later, pterygium. Authors such as García and Lahera [16] carried out a study in which the authors related at least four factors: the social factor, the humanitarian factor, the political factor and the economic factor, as main indicators that affects access to the clinical sector for the population's treatment, due to its lack of financial resources and to demographic aspects such as barriers to transportation to clinical services.

On its part, INEGI [9] and AMFECCO [7], which are autonomous organisms, report numbers on the population requiring optometric care and the time recommended for this. Ministry of Economic Development (SEDECO) [21], a governmental organism, manages the numbers of the salaries earned in Mexico City (CDMX) and, according to these, divides social classes into statuses. These results are not considered, but for the performance of this study, they are taken as a fundamental part in order to be able to generate individual indicators, in that thanks to these data, a better holistic perspective can be obtained.

Within visual health, Carrasco-Font and collaborators [24] consider that in the assessment of glaucoma, the clinical indicators traditionally utilized for monitoring and evaluating the evolution of patients with this problem include values of intraocular pressure, visual acuity, and computerized perimetry (the visual field test). Among these, visual acuity and perimetry can be considered the principle indicators of the patient's daily activity, although other authors, such as Sherwood [25], have mentioned that these measurements can be inadequate as the grade indicator of visual affectation, that is, they are not considered to generate or predict total injury or total functional state.

On the other hand, Pérez in 2013 [26] conducted a study in the health field but with a systemic focus based on GST, interrelating the following factors, including sociodemographic, medical, physio-ergonomic, and safety factors, to design a transdisciplinary method for predictive and preventive evaluation of the risk of accidents and musculoskeletal disorders of the hand and those due to accumulative trauma. This project achieved relating each component comprising this system; therefore, this method aids in presenting the risk of accidents or disorders, due to that the evaluation of various factors generates broader and more complete results compared with a sole factor evaluated separately.

Also, in that same year, Sánchez [27] conducted a study entitled "Design of an integral diagnostic method for diseases derived from the labor risks present in productive processes", with the purpose of explaining the current situation of the diagnosis of workplace diseases in Mexico and of collaborating in the diagnosis of the general pathologic processes in terms of vision-in-workplace risks. The manner for approaching this complex process is that of a transdisciplinary systemic method in which the study of humans is addressed, in addition to the interaction that humans have with their immediate environment, the workplace ambience, and the physiopathologic agents inside the latter.

Solving health problems with a transdisciplinary focus implies involving experts found outside of the scientific disciplines to achieve greater inclusion of the knowledge produced. The knowledge is unified and the vacuums are identified; an attempt is made to discover the non-visible connections among disciplines in order to create a common platform. Both studies deal with the good interaction of each of the elements that comprise their systems, thus obtaining a more complete result, in that they encompass more components than that produced by a single affectation. The results obtained achieve a better panorama for finding a solution to the problem and in a more rapid manner.

According to what has been described here previously, we decided to perform this work with a systemic focus, the latter the study of the open visual health system, because the exchange of information of each element or factor among themselves permitted obtaining more complete results, due to this system's scientific focus and to its approximation to reality. Therefore, this work takes the initiative, to our knowledge, and proposes studying visual health disorders systemically, interrelating four factors that have proven to possess some degree of repercussion on vision, basing this not only on previous works, but also on information from institutions and associations for greater data sustainability. The functional part of the study is to generate individual indicators previously, such as the following: exposure time; socioeconomic level, and preventive culture, to generate a holistic indicator subsequently that aids in classifying the visual state of the patient or of a population.

Conclusions

The importance of applying the General Systems Theory (GST) is because the integration of each of the elements composing a system reflects a better approximation to the reality of a scientific form. In this manner, modeling individual indicators for each factor aids in perceiving the injury that this represents, thus being able, in the end, to classify the magnitude-of-injury in the holistic indicator. This possesses greater relevance in the field of Optometry due to its being presented in a multifactorial form, in that it achieves interrelating the factors that best represent visual health affections.

Therefore, a mathematical model that multiplies the injury range for each factor helps to predict a diagnosis of the visual state over time of the population of Mexico City (CDMX) or of an individual. The latter could aid in reforming our health system in Mexico, because the indicator would allow knowing the magnitude-of-injury caused by the study factor or factors. In order to generate an opening of preventive awareness, investment must be made in schools with preparation at the undergraduate level to care for more patients, not only in Mexico City, but also throughout the country.

On knowing the visual health affectations, alterations can be prevented or diminished in refractive problems, preserving a good proportion of tear production and preventing the appearance of some pathology due to exposure to UV radiation. Thus, on integrating in this systemic fashion all of the visual injuries caused by the previously mentioned factors, and likewise predicting the visual state of the population or of the individual, pharmacologic, optical, or therapeutic treatment can be recommended to improve visual quality, even in those with daily exposure to factors that alter vision, and to avoid frequent symptomatology.

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