Self-Medication: A Bayesian Approach Proposal

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Abstract
The article examines self-medication from a multidisciplinary perspective, specifically through the lens of Bayesian statistics, a data analysis and parameter estimation method grounded in Bayes' theorem. It develops a general equation proposal based on this theorem. The text highlights how human judgments can be interpreted through a probabilistic model, leveraging theoretical approaches to Bayesian models of cognition (Griffiths, Chater, and Tenenbaum, 2024). It underscores the complexity of the self-medication phenomenon, which has been studied through diverse theoretical frameworks, including economic paradigms, process-based approaches, and transgression models. The ability to predict medication effects in relation to current symptoms is pivotal, as it allows for risk anticipation and outcome forecasting, emphasizing the significance of disciplinary and methodological pluralism in the realm of pharmacovigilance. The article advocates for the necessity of real-time monitoring to identify emerging concerns about drug safety. Furthermore, it offers an epistemological framework and an approach that integrates probabilistic inference with the practice of self-medication, underscoring the critical roles of education and vigilance in this domain.

Keywords: Bayesian Model, Self-Medication, Pharmacovigilance, Cognition, Equation.

About statistics and Bayesian inference

To approach the study of self-medication from a Bayesian perspective it will be necessary to first have an understanding of said approach. Although there is not an exhaustive analysis of the Bayesian theorem, it is necessary to highlight that a Bayesian approach is a statistic method based — on the Bayesian theorem —, that allows updating the probability of a hypothesis as new evidence is incorporated (Heider y Simmel, 1944). This approach interprets probability not only as a frequency measure but also as a confidence interval (or belief in an event) (Liu, Ullman, Tenenbaum y Spelke, 2017).

The key components in this approach include: i) a priori probability: this measure represents the initial belief in a hypothesis before obtaining evidence, reflects previous knowledge or suppositions on the subject matter whether it is based on previous experiences, empirical evidence or contextual factors; ii) verosimilitude: it refers to the probability of observing evidence under the presented hypothesis, likewise, degrees in which the hypothesis explains the observed data and evaluates its coherence with empirical reality must be quantified; iii) *a posteriori* probability: after considering the new evidence, this reviewed probability represents the adjusted belief in the hypothesis, this value is obtained through the integration of *a priori* probability and verosimilitude, applying the Bayesian theorem (Liu, Ullman, Tenenbaum y Spelke, 2017).

Mathematically the Bayesian theorem is expressed as:

$$P(H \mid E) = \frac{P(E \mid H) \cdot P(H)}{P(E)}$$

And can be understood as follows:
P (H|E) a posteriori probability (the probability of hypothesis *H* given evidence *E*),
P (E|H) is verosimilitude (the probability of observing evidence *E* given *H* is true),
P (H) a priori probability of the hypothesis,
P (E) total probability of evidence.
Within the social reasoning, a Bayesian approach allows individuals to make inferences about beliefs, wishes and intentions of others based on their actions, which results in a more nuanced understanding of social interactions (Liu, Ullman, Tenenbaum y Spelke, 2017; Heider y Simmel, 1944). This theoretical framework provides a solid foundation to explain how people can infer mental states from observable behaviors, thus making social interactions and learning in group contexts uncomplicated.

The relevance of Bayesian inference

Understanding Bayesian inference is essential, since it renders a homogenized framework for statistical practices by combining multiple sources of information under probability standards, which makes drawing conclusions easier with observed data (Etz y Vandekerckhove, 2018). Besides, authors express that it also allows them to integrate previous knowledge and subjective beliefs, especially useful in disciplines as psychology, where hypothesis can vary among researchers, simplifying communication of results despite differences in initial beliefs (Etz y Vandekerckhove, 2018; Lindley, 1980; Royall, 1997).

According to Etz y Vandekerckhove (2018), Bayesian inference allows to "make clear probabilistic statements on a given hypothesis, granting more enriching information than with traditional methods, which often offer binary results" (p.30). Its flexibility and adaptability make it useful to solve diverse statistical problems, such as parameter estimation, hypothesis testing and model comparison, also allowing the incorporation of new data to update beliefs undergoing dynamic research (Etz y Vandekerckhove, 2018). Altogether, a solid understanding of Bayesian inference contributes to the rigor and clarity of statistical analysis, placing it as a key tool to scientists and professionals alike.

In the words of Edwards et al. (1963) quoted in Etz y Vandekerckhove, (2018): "The Bayesian approach is a common sense approach. It is simply a set of techniques for orderly expression and revision of your opinions with due regard for internal consistency among their various aspects and for the data" (p.30)
According to Smith et al., (2024, a Bayesian approach has the ability to contribute in different areas, among them, in Intuitive Physics modeling, the management of uncertainty, within the Causal Inference and of course, within the Probabilistic Modeling. Authors examine how Bayesian inference and approach is also understood as a theory of the mind and could cover Intuitive Psychology, thus linking psychological and physical reasoning (Smith et al., 2024).

The study highlights that understanding the world implies that agents must estimate the probabilities of transition among states, depending on the actions taken; this probability estimation is an essential aspect in Bayesian reasoning, granting a link between intuitive mental processes and the underlying principals of everyday physics (Smith et al., 2024). About the management of uncertainty (Intuitive Physics), it is emphasized that many physical processes are intrinsically complex and are not bound to simple analytical answers; however, Bayesian methods ease approximations that help individuals understand uncertain situations, which afterwards would be applied to develop a proposal around understanding self-medication, resulting especially pertinent within perceptual uncertainty management within physical reasoning's scope, where people must integrate several sources of information to generate predictions and, in this context, the Bayesian reasoning allows a cognitive adaptation that considers the inherent uncertainty in physical perceptions (Smith et al., 2024).

On Causal Inference, Smith et al. (2024), mention that the Bayesian approach supports the causal reasoning by allowing individuals to infer non-observable variables (such as mass), from observed variables (such as trajectories). This aligns with Bayes theorem, which is fundamental to make inferences on causes according to the available evidence. When integrating observable and non-observable data, the approach allows a better understanding on how people attribute causality to physical events intuitively (Smith et al., 2024)

Finally, about Probabilistic Modeling, the Intuitive Physical Engine (IPE) is introduced as a probabilistic model that explains how people predict physical results (Smith et al., 2024). The IPE, for example, employs basic Bayesian principles to simulate different scenarios and combine predictions, which depicts how human judgement could be interpreted through a probabilistic lens. This model offers a detailed perspective on how Bayesian

principles underlie the intuitive assessment of physical events, simplifying a deeper understanding of human cognition in situations that involve physical predictions (Smith et al., 2024).

Next off, self-medication is approached in this context as a social phenomenon, characterized by its high complexity and the diversity of its theoretical approaches. This phenomenon has been explored from different perspectives, including even etiological angles, which bestows comprehension of its origins and manifestation in terms of behavior. Despite a wide array of approaches , there is a consensus in fundamentally considering self-medication as a behavior. This agreement highlights self-medication as not being an isolated practice, but fed by a series of underlying mechanisms that contribute to its emergence and steadiness within a myriad of contexts, among them it can be found social, cultural, historical, political, economic, environmental, physical, biological, and more, without dismissing a series of social, territorial and local determinants (Braveman, Egerter y Williams, 2011).

Apprehending these structures permits the analysis of, on one side, self-medication as an adaptive response to diverse needs or conditions, integrating biological and contextual factors in its understanding; and on the other, it permits developing the basis and an epistemic framework to build the terms that reflect probabilistic relations among events linked to self-medication.

Self-medication: a social phenomenon

Self-medication is defined as the act of acquiring and consuming medication without direct intervention, supervision, or prescription by a qualified healthcare professional, such as a doctor (Lobo y Carvalho, 2020 citados en Molina Aguilar 2021). This phenomenon takes multiple forms, from taking free sale medication to the self-modification of doses in prescribed treatments previously prescribed; and, its origin, answers to a complex individual, social and economic factors network, which includes the search for quick solutions to health matters as well as the accessibility to non-prescription drugs in certain regions (Molina Aguilar, 2021).

This self-medication phenomenon is able to carry on detrimental effects on health, such as the unnecessary lengthening or abrupt interruption of drugs, as well as risking adverse effects due to misuse of drugs (Calderón Soler y Pérez-Acosta, 2020). In certain contexts, the leniency of health systems on free sale drugs makes these practices easier, hence contributing to their prevalence in different sectors (Oviedo, Cortina, Osorio y Romero, 2020).

However the social sciences perspective has shown that self-medication must be understood within a series of paradigms, and on that note, it is possible to mention the following:

"There are different ways to conceive self-care as self-medication. As said before, its conceptual approach, depends in great measure on the models and paradigms whether these are medical, economic and social at heart. According to the World Health Organization, more than half of drugs are prescribed and distributed (sale and dispensation) inappropriately and half of the consumers do it inadequately (Fajardo-Zapata, et al., 2013). This brings us to the realization that, from public health, self-medication can be a serious problem, since it creates harmful risks and effects to those under this practice. It even mentions that it can generate and foster 'antimicrobial resistance from the germs' (Fajardo-Zapata et al., 2013, p. 232).

According to Pardo (1984), from an economic point of view, especially from healthcare, people choose those alternatives that provide greater satisfaction or usefulness. This outlook assumes that the usefulness people experience will depend on the consumption of goods and the result on their well being. In this case, self-medication (result of self-care and self-prescription), is simply one more alternative among a myriad of possibilities in the healthcare field, this is linked to personal or individual factors that might as well be cultural, demographic, socioeconomic, and these, at the same time, could be related to the peculiarities of the medical healthcare provider (Pardo, 1984). Human expectation to immediately solve medical and healthcare problems themselves, makes it easier and strengthens self-care and self-medication practices" (Molina Aguilar, 2021, p.116).

Self-medication, from transgression

On this matter, self-medication could be understood from different paradigms, each of which provides "unique perspectives on the causes and consequences" (Molina Aguilar, 2021, 2023). From the transgression paradigm, Cárdenas (1998), states that this vision assumes self-medication in the line of misbehavior, and, would not necessarily be compatible with dominant biomedical modelings, since self-medication will be seen as "something negative and rescinded from the possibility of a cure or well-being" (Menéndez, 2018, citado en Molina Aguilar, 2021).

Summarizing, this transgression paradigm, conceives self-medication as a negative practice that implies health risks due to the lack of medical supervision, and, drug misuse, within this paradigm some elements are linked to the well-being of who has the probability to self-medicate, as well as, a comprehension about the ailment (a personal way to experience and live a disease), the illness or the pathogen agent, with a formal diagnosis or treatment, to which (disease), it is an overstatement, it does not necessarily match illness and drug availability, meaning, the ability to acquire it.

Self-medication, a process

In the case of process paradigm, self-medication is understood as a phenomenon that implies knowledge on people's interactions, their relationship dynamics on self-medication, their previous knowledge, their community, their routine, and their home, the latter will be understood as a space where knowledge is produced, a space with the probability of descentralizing the pharmaceutical/medical knowledge (Molina Aguilar, 2021).

Thus, home constitutes a space where "laical practices are developed" on autonomous medication, out of the supervision of healthcare professionals (Menéndez, 2016; Molina Aguilar, 2021). In this environment (home), medical products are individualized and adapt according to perceptions and experiences of the ill and the significant people in their lives (who produce and reproduce a kind of knowledge related to self-medication practices), combining prescriptions and diagnosis with daily knowledge. This often makes drugs be reinterpreted, reused and even disposed of, which can evolve into a misuse and a poor adherence to treatment (Tilley, 2006, como se cita en Dew et al., 2014). Likewise, in the home context, knowledge is generated about self-care and self-medication that comes from scientific sources and popular knowledge (Molina Aguilar, 2021; Molina Aguilar, Deleón Castro y Pérez-Acosta, 2024). Although these perspectives may seem different, they are linked to daily practice, influencing their health, well-being and treatment effectiveness (Cárdenas, 1998; Dew et al., 2014).

The process paradigm may offer one of the main lenses on the understanding of a series of key events, among these, the self conception of their body and the way knowledge is assimilated around itself (Good, Brodwin, Good, y Kleinman 1994; Ohnuki-Tierney, 2000). Along the same line, perception, from the patient or potential patient, about healthcare matters, between a wide and complex amount of cartographies, depending on their trust or mistrust about the indications in the pharmaceutical treatments, and even, the possible adherence or withdrawal of it (Molina Aguilar, Deleón Castro y Pérez-Acosta, 2024; Singer y Baer, 2007). At home it will always be possible to obtain true information about drug availability, as well as other personal and/or family cures, and to adopt strategies for health care (Cockerham, 2016; Kleinman, 1980; Willey y Allen, 2021).

From consumerism paradigm to the understanding of temporality

In this case, self-medication is framed mostly in a decision oriented to maximize the person's satisfaction and is linked to personal factors, drug availability and even attention in the healthcare system (Molina Aguilar, 2021). Without pretending a lineal or abrupt explanation, a classic example in this sense turns on the people who prefer self-medication, since apparently it is "low cost". To consider the consumerism paradigm, it will be important to know the phenomenon of self-medication is within an economic system, in some cases, capitalist and neoliberal, where the phenomenon is promoted and fostered in a consumerist culture, which is the strategic foundation to develop marketing strategies that have their origin in the mercantilism of healthcare (Fajardo-Zapata et al., 2013; Molina Aguilar, 2022a, 2022b).

Even if some definitions have been described about the spatiality of the self-medication phenomenon (place and availability), about temporality it will be necessary to make an epistemic definition of self-medication, also from the consumerism perspective, since it is here where two moments are highlighted: pre-consumption and post-consumption (Ruiz-Sternberg y Pérez-Acosta, 2011; Sunder Rajan, 2017). Both will be key elements that represent different probabilities and information within a probabilistic reasoning framework. Temporality is understood in the concept of understanding how objects and events change through time, a crucial aspect to ponder over physical interactions (Braveman, Egerter y Williams, 2011).

As a depiction, in the pre-consumption stage, there will be a series of potential forces as, for example, drug availability, communication whether they are in the market as advertising, public or technical relations and strategies in sale points (merchandising), as well as, personal and family

economy, recommendations or influence of close people at home, among others. In case of post-consumerism, change will be present in time as a result of human and not human interactions, since the drug will get back to the environment and in some cases said interactions and potential behaviors will get to impact the body, even of those who have never consumed the medicine, for instance: antimicrobial resistance (Molina Aguilar, Deleón Castro y Pérez Acosta, 2024).

Key points on temporality and self-medication
According to Smith et al., (2024), some key points about temporality in the probabilistic inference framework are: brain simulation, and spatial reasoning, probabilistic inference, IPE, and causal inference. In the case of brain simulation and spatial reasoning, these are based on mental representations that can transform with time, said representations are "analog" to changes in real-world objects, this is evident in cases to determine whether two figures are the same through mental rotation, which implies a temporal dimension to manipulate shapes within the mind, self-medication is in this case, linked to decisions on the use of drugs, which usually depend on mental representations about the expected effects with time (Smith et al., 2024). For example, when evaluating if a dose will alleviate symptoms, the individual mentally simulates the course of the disease and the treatment's impact, implying a temporal dimension similar to the mental rotation of shapes in thoughts.

About Probabilistic Inference, this is linked to the way of reasoning in the world, in this case, "individuals must consider a series of future outcomes, which inevitably involves temporality" (Smith et al., 2024, p.2). So, the ability to foresee how a scene can unfold through time is an essential aspect of intuitive physics, since it allows anticipating events based on current states (Smith et al., 2024). In a self-medication context, this implies anticipating medication effects according to the current symptoms, and also, project possible and probable outcomes of its use or misuse, here comes into play a series of constructions and representations that emerge daily and are, in great measure, a result of the potential forces mentioned above, therefore, the ability of foreseeing how the body's response could evolve with time is fundamental, since it lets anticipate risks and effects of treatment based on the current well-being (or even the perceived well-being). All of this, highlights the importance of pedagogy and didactics, as potential strengths in both moments, pre and post consumerism, and, as a result, its analysis on a surveillance matter becomes even more important, because it will be a probabilistic factor with the ability to lean in on an important decision in this case, about self-medication.

About Intuitive Physics Engine, this imitates how the world could evolve using dynamics that incorporate temporal changes (Smith et al., 2024). This engine is rooted on "understanding how objects collide, fluids pour, or things fly through the air – and discuss how a simulator that includes physical principles accounts well for human judgments about these scenarios." (Smith et al., 2024, p.5). Similarly to probabilistic inference, in self-medication, people mentally emulate how their bodies could respond to different medications, considering time and evolution of symptoms, in this specific case, the "engine" in question is based on the continuous comprehension of drugs dynamic effects on the body, such as it occurs with moving objects in space, becoming essential to make predictions about future health conditions (or diseases) and possible side effects.
Finally, Smith, et al., (2024), point out that causal reasoning requires comparing the expected result of hypothetical worlds without the causal agent to actual observations" (p.8). Within a self-medication context, predicting its results after certain drugs implies knowing how this action will affect their health through time, considering benefits and possible side effects alike. ALso, planning in this context is about selecting actions that would produce the desired effect, which highlights the importance of temporality in the assessment of health decision making (Smith et al., 2024, p.5).

Pharmacovigilance
With the documented benefits provided by drug and vaccine trials, there is also a series of analysis (and meta analysis), where medications and vaccines can cause adverse effects, some of them are unpredictable or unwanted (World Health Organization [WHO], 2023, 2010; Iessa et al., 2021). Thus, making Pharmacovigilance the science and activities relating to the detection, assessment, understanding and prevention of adverse effects or any other drug-related problem (WHO, 2023).

Even though pharmaceutical and immunological products, undergo strict safety and efficacy tests in controlled clinical trials before their approval, this process usually implies relatively small groups, carefully selected, and short study times, case studies are relatively few, and even fewer are the longitudinal studies (WHO, 2010, 2023; Iessa et al., 2021). Hence, some side effects can be revealed once these products are distributed to a wider and more diverse population, which includes individuals with chronic illnesses and

use them for long periods of time (WHO, 2023. International Society of Pharmacovigilance, 2023. Iessa et al., 2021).

Due to the aforementioned, pharmacovigilance systems are established to comply with the legal and ethical obligations in each country or region in relation to drug safety. These systems monitor the risk-benefit profile for authorized medicinal products, protecting public health through the early identification of adverse effects and an effective communication of findings (WHO, 2010).

However, the framework for pharmacovigilance varies significantly among countries and in this context, there are also challenges, e.g., in low income countries and with vulnerable normative frameworks. Before this discrepancy, the World Health Organization (2010, 2023), next to the Global Fund, have started a Pharmacovigilance Strategy, which established the minimal requirements to assist countries to develop solid frameworks. This strategy also looks to improve the safe use of complementary drugs, herbal remedies, vaccines, and biological substances, guaranteeing to surveil a wide variety of health products (WHO, 2023).

The pharmacovigilance process

The pharmacovigilance process has multiple stages that include: i) detection of adverse effects; ii) notification and report through standardized tools; iii) research of causes; and, iv) feedback to the health system agents (WHO, 2010, 2023). The gathered information in this process withstands a detailed analysis to reevaluate the potential risks patterns, with communication as a fundamental element throughout the whole process. The WHO has developed valuable tools and methodologies for each stage in this process, perfecting them constantly to align them with health needs in continuous evolution (WHO, 2023; Uppsala Monitoring Centre, 2024). As a result, on the surveillance system, pharmacovigilance contributes to a safer global health environment, ensuring safety and efficacy in the long term for herbal products while interacting with complex and diverse populations (WHO, 2010, 2023; Rademaker, 2001).

Currently, pharmacovigilance implements innovative solutions and tools to identify and manage adverse events related to drugs and vaccines, said strategies cover from standardized data collection to real-time monitoring. The WHO, in conjunction with its State Parties and global committees such as the Global Advisory Committee on Vaccine Safety (GACVS), have established 25 new fundamental variables to the adverse event following immunization (AEFI), or as it is used in the latin american region: event allegedly caused by immunization (ESAVI for its acronym in Spanish) (Panamerican Health Organization [PAHO], 2021), thus ensuring, data standardization at a global level (WHO, 2010, 2023. Uppsala Monitoring Centre, 2024). Using technology such as VigiFlow and VigiMobile, designed to simplify the notification process by health care providers and patients, these systems allow a real-time report from mobile devices, even without internet access, and guarantee data flow efficiently from local levels to the WHO global database (WHO, 2010, 2023. Uppsala Monitoring Centre, 2024).

This way, through advanced monitoring systems such as VigiLyze and support tools for causality assessment by the WHO, it is possible to quickly identify safety problems related to drugs, for instance, the systematic research of severe ESAVI cases.

The organization also fosters training for healthcare professionals and patients through innovative courses and pedagogical, didactic and innovative educational tools, to gradually improve a notification culture that is proactive and patient-focused (WHO, 2010, 2023. Uppsala Monitoring Centre, 2024). This global collaboration, involves regulatory agencies, healthcare providers, industry and patient advocates, and it has the goal to strengthen the safety in treatments through a balance between the pharmacovigilance practices and the constant improvement in report and analysis (WHO, 2010, 2023. Uppsala Monitoring Centre, 2024).

Pharmacovigilance system and self-medication: a systemic relationship

The relationship between pharmacovigilance and self.medication has a set of variables, one of the most important among them is around safety. In this context, several important studies come up due to pharmacological safety concerns, something that brings a significant widening in the pharmacovigilance area, since there is an increase in pharmaceutical products' diversity and availability (Jeetu y Anusha, 2010). This growth requires a deeper understanding of drugs safety beyond detection and adverse reaction analysis (ADRs), under standardized conditions and controlled doses (Jeetu y Anusha, 2010). And of course, the

understanding of causative motives and mechanisms which increase the possibility and probability of self-medication.

Along this line, pharmaceutical safety intertwines complexly with social and cultural patterns of drug consumption, and these change according to the social, economic, historical, political and cultural contexts in which individuals engage (Jeetu y Anusha, 2010. Baracaldo-Santamaría et al., 2022). From this, other phenomena derive, among them, the problems as drug misuse, polydrug policy, drug interactions with others and overdose, the growing demand for traditional and herbal medicine next to conventional pharmaceuticals, illegal trade of drugs (through different means), the proliferation of questionable quality and of course, self-medication. These problems conform fundamental elements in the pharmacovigilance field and the circumstances for the risks widen their scope, thus making noticeable that the current pharmacovigilance system must evolve and adapt to respond efficiently to this range of challenges, from a technical and a social perspective (Jeetu y Anusha, 2010).

From the previous information, it can be said that the relationship between pharmacovigilance and self-medication can only be seen as systemic. The evolution of this relationship implies, then, not only overseeing adverse reactions to drugs, but also adopting a focus on prevention and a systemic approach, which considers the socio-cultural context in which the drug consumption takes place, since as mentioned above, self-medication can be understood from a series of paradigms, and these keep a continuous interaction.

General Bayesian equation to study self-medication

The following proposal emerges from a literary review and an epistemic framework about self-medication and pharmacovigilance, its objective is not to provide lineal relations, but to develop a general proposal (general equation in this case), from the Bayes theorem to understand variables around self-medication probabilities.

It is clear that pharmacovigilance needs to incorporate advanced methods, interdisciplinary perspectives and a methodological pluralism that allows an efficient management of information flow and strongly analyse the emerging patterns among diverse and complex populations. To this it is advisable to keep monitoring systems, and, as mentioned by the WHO (2023), about the need of a real-time monitoring system, these come up to "identify and quickly assess emerging safety concerns".

The aforementioned is crucial to understand how social, cultural and economic factors mold the drug consumption which at the same time informs and strengthens the updating and formulating of normative frameworks, health policies and pharmacovigilance safety practices (Jeetu y Anusha, 2010). Even if the following general equation proposal is focused on strengthening the technical aspect in phzarmacovigilance matters, the need to strengthen its epistemic framework also comes from widening the understanding about the systemic vision that drug safety must have.

Hence, medicine safety must be understood beyond a medical-technical issue since that is also an integral dimension of public healthcare and the social management of pharmaceutical products, this means, a holistic approach considering the interactions among individuals, drugs and contexts.

To this extent, from a Bayesian approach, it is proposed to build a general probabilistic equation that considers a series of factors. From this approach, according to Griffiths, Chater y Tenenbaum (2024), the probability of an event, in this case, self-medication, can be updated as information is collected from different sources, for instance, the human body, the social context, drug availability, pharmacovigilance context among others. Based on this, a general equation is proposed which, by not depending on fixed values for each constant, acquires a flexible quality which is applicable to different contexts. The general equation is different from a specific values for constants, whereas the general equation allows modeling different circumstances and contexts, under this perspective the inclusive nature of the general equation is highlighted, which allows taking in a whole series of solutions within a determined ensemble (Hoang y Ehrhardt, 2024).

From this, it is possible to think, from a cognitive Bayesian cognition, within the probability *(P)*, that a person could self-medicate *(A)* as follows: *P(A)* as depending on different functions, seen as mathematical expressions that have variables and influence this behavior. In this sense, the structure that integrates said functions for a general Bayesian equation would be as follows:

$$P(A \mid B, P, E, S, D, AT, IT, CS, FV) = \frac{P(B, P, E, S, D, AT, IT, CS, FV \mid A) \cdot P(A)}{P(B, P, E, S, D, AT, IT, CS, FV)}$$

Where *A* would be understood as self-medication, *B* as the human body state, *P* as the ailment or the way each person lives the disease, *E* refers to the underlying illness, if it has already been diagnosed and this may or may not match the perceived ailment; *S*, in this case is the healthcare attention system, including the access to medical services, waiting time, and the system's perceived quality, *D* refers to availability (access, ease of acquisition, price, advertising, among others), *AT,* understood as self-attention, meaning the strategies a person uses to care for personal health that could influence the decision to self-medicate or not. At the same time, *IT*, seen as routine diagnostic tests, *CS*, refers to the social context, including cultural, family, or community norms on drug use and self-medication; and, *FV*, meaning the pharmacovigilance system, in which influences the risk or safety perception about the use of certain free sale medication, and the standards under which a country is regulated in matters of safety around drugs.

To depict the application of the proposed formula to calculate the probability of a person self-medicates, data collection, in some cases, could improve first by the National Integrated Health System (SNIS for its acronym in Spanish), thus knowing about their ailment or disease, prescribed medication, social context, type of healthcare attention used, if there are self-attention efforts out of the consulted system, meaning at home; and, second, it would be necessary to obtain linked data to a strong pharmacovigilance system *(FV)*, such as reactions and adverse events, alerts, pattern use, regulatory compliance, among others.

About the previous example there is missing information that would be important for the future and it is maybe the most complex within the salvadoran context, such as the body's state, precisely with molecular phylogenetics. From programs as "Mr Bayes" (a specialized software that applies bayesian statistical methods to infer phylogenetic trees and analyse evolutionary data, using Markov Chain Monte Carlo, MCMC algorithms), it would be possible to explore evolutionary relations and estimate parameters, among them, mutation rates and nucleotid substitution models (Huelsenbeck y Ronquist, 2001). This would complement the equation, which if possible, its main strength lies in generating probability distributions on phylogenetic trees, which allows assessing inference uncertainty, thus getting to know deeply (Huelsenbeck y Ronquist, 2001). This way, some activities become easier such as modeling, risk analysis, behaviors and patterns associated with self-medication, using Bayesian statistical principles to manage uncertainty and update the probabilities as new evidence is obtained.

From the preceding information, among a myriad of probabilities, there are four mentioned, being these: i) the probability of a person deciding to self-medicate given a set of variables that describe their biological stated, social and healthcare context, and their access to medication, which would be represented as follows:

P(A | B, P, E,S ,D, AT, IT, CS, FV); ii) it is the probability to observe variables under the hypothesis that the person is self-medicating, represented like this: *P(B, P, E, S, D, AT, IT, CS, FV | A)*; iii) it is the probability of observing the variables without knowing if the person self-medicates represented as: *P(B, P, E, S, D, AT, IT, CS, FV)*; and, iv) the probability that a person self-medicates without knowing the antecedent variables, meaning: *P(A).*

Final reflections

When considering the presented proposal, it is important to analyse how different variables intertwine, which are mostly of different nature, some involve socio-cultural or socio-historical variables, others refer to the biological state of the human body. To intertwine variables of different nature, for example, sociocultural, sociohistorical and biological in the analysis of human phenomena such as self-medication implying a series of challenges, from an epistemic framework to a multidisciplinary that considers interdependence among other factors. The sociocultural and sociohistorical variables, that include the social norms, cultural beliefs and the inconsistent access to healthcare services, influence in individual decision making, like adoption of self-medication. At the same time, the state of the human body, determined by factors as genetics, and preexisting health conditions, could moderate the impact of these decisions, setting in place a complex system of interactions that must be understood completely. A conceptual approach to consider to develop the previous idea is the exposome, this refers to the aggregate of environmental exposures throughout an individual's life that could influence their health. The exposome brings a holistic concept to study the genetics-environment interaction, and

also widen the genome approach by considering environmental factors as determining in ailments (Wild, 2005).
Nonetheless, this dynamic interaction among variables strengthens the need to acknowledge the limitations in analytical modelings, given that the relations among the factors are contextual and variable. Just as in physics, where complex systems require flexible modelings that adapt universal laws to specific conditions, the social analysis must consider the individual and group variability. Rigid approaches that do not contemplate these interactions can be inaccurate, which stresses the importance of integrating multiple perspectives to accurately comprehend the complexity of self-medication and other related phenomena.

This has to reinforce two aspects, first, the need to grasp the limitations of the equation, since as El Salvador progresses in its SNIS, it will be necessary to emphasize the urgency to strengthen research (multidisciplinary), mainly if it is in a country that lacks population studies in genetic matters, as mentioned before, and, second, that said limitations can be overcome as long as there is a strengthening of research. However, the study of variables in this case represents a starting point, mostly ontological and epistemological, data collection will be possible by enhancing the SNIS and other social actors that build the research in related fields.

The implications of the general equation in self-medication matters, have the potential to intertwine with different realities and study contexts, ideally, these contexts have the potential to reinforce the pharmacovigilance system, especially if this system aspires to science based decision making. Along this line, as long as this equation's new functions are explored, more than conclusive or omnicomprehensive elements, a series of questions surface, potentially for future research and reflection around the study subjects in pharmacovigilance matters, especially when this is seen from different disciplines.

Despite the equation having a few limitations, it can be updated as new information on the variables is added. For example, if there is more information on the social context or availability of medications, and the pharmacovigilance system, the probability of self-medication can be adjusted according to how the variables affect the individual decision to self-medicate, the latter was stated in the document from a cognitive Bayesian modeling framework. Yet, other research documents may even develop algebraic expressions and different epistemic perspectives, and not necessarily exclude the proposal in this document.
Finally, the discussion on self-medication implies a critical assessment, since it is a historical phenomenon that states a series of dilemmas, it is not only an observable individual behavior, but a series of underlying mental processes. At the same time, self-medication is a social, historical, political, and even environmental phenomenon, and, if the aspiration is to comprehend deeply and within different populations (especially those considered vulnerable), the disciplinary and methodological pluralism will not only be expressions and necessary figures or approaches to aesthetics, they will be ethical expressions that surface as a result of a pharmacovigilance system that moves towards a vision that is critical, integral, systematic, and just as important: socially engaged.

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