2019

A Conflictive Triuvirate Consruct of Epidemiologic Systems Failure

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Walden University
2019

Abstract

A Conflictive Triumvirate Construct of Epidemiologic Systems Failure

by

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Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

Public Health, Epidemiology

Walden University

November 2019

Abstract

Epidemiologic systems failure (ESF) is a major hurdle in minimizing the spread of infectious diseases during outbreaks. The reasons for ESF include the technical limitation of personnel handling epidemic crises, strictly defined health policies that limit the actions of epidemiologists, and personal perspective's reservations towards the intentions of health agencies. The purpose of this triumvirate mixed-methods case study was to examine factors of infectious disease control mechanisms useful for determining ESF. Three juxtaposed pre-emptive factors (technical [T], organizational [O], and personal [P] perspectives were used to determine how the multiple perspectives inquiring systems and fuzzy logic revealed factors causing ESF so that remedial tools may be constructed. The juxtaposed ESF-TOP model formed the research theoretical framework and allowed for clustering the ESF factors. Data sources were direct quotations from TOP based secondary data of 4 well-publicized participants; who had Ebola, HIV-AIDS, Tuberculosis, or Typhoid disease; and randomized quantitative TOP hypothetical data sets were created with Microsoft Excel software and used to model an Ebola outbreak of 10 theoretical subjects. Data were analyzed using TOP guidelines from which T, O, and P perspective themes emerged. The findings indicated that a disjointed TOP perspective specifies a serious ESF, a strictly overlapped TOP indicates an effective containment of ESF, and the overall fuzzy set with T given O and P indicates the actual ESF. The findings may result in positive social change by helping epidemiologists identify critical outbreak control factors which may minimize the outbreak impact.

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Dedication

According to the book of Ecclesiastes chapter 3 everything under the heaven happens in its season and in its time of purpose. Intrinsically, the time for this dissertation is right and rightfully dedicated to God the creator, the center of my existence. Should, I exist without recognizing and embracing his presence, the owner of the universe, my life would be meaningless and monotonous. Imperatively, this dissertation is to honor the almighty God, the ultimate power, the Omni potent, Omni present and Omni science through whose guidance this dissertation manifested.

Also, in dedication, is my unrivaled spouse, (Chief) V. C. Ifeanyichukwu Ulinwa, (Ph.D.) whose interminable support and altruism are unimaginable. In the same token, is late, Mrs. Ezidigwu C. Ulinwa, aka. Madam Gold, my mother in-law, whose endurance and sacrifices made possible the earliest foundation of this dissertation; regrettable you did not witness the completion of this research work. Also, in dedication is late Madam Abigail Nwagwo Okaforanyanwu, once a great worrier and a wonderful inspiration.

To late Elder Paul Nwanpka, my father, you taught me the wonderful ways of the almighty God, and also embraced my accomplishments. Also, in dedication, is late Ihunna, your display of sweet sisterly love will remain cherished in my heart always Finally, my uncle late Wereucheye Nwadike, whose heroic effort perpetuated my birth and today, made possible the completion of this scientific accomplishment.

Acknowledgments

I acknowledge the profound interest of Dr. Ji Shen, and his acceptance to serve as my committee chairperson. I recognize my URR team: Dr. Dana Chad Moretz, my initial URR member whose swift approval of my proposal made it possible for the dissertation to move forward; and Dr. David Segal, my second URR member whose review focused that I conduct and provide a scholarly study. Also, in acknowledgement is Dr. Kachgal the Walden University editor with an extensive and detailed edition of this study.

Every scholarly dissertation has a beginning: I warmly acknowledge Dr. Morton Wagenfeld for accommodating the first appointment to serve as my dissertation committee chairperson but retired in the process. Your commitment, impeccable advisement, feedbacks, and comments in the initial stage were set toward completing this research and your endless sense of humor was an addition. I acknowledge Dr. Marilyn K. Simon. Your unweaving willingness to support this dissertation and to serve as the second committee member is unmeasurable. An educator like you is encountered only once in a scholar's life. Because you humbly and graciously dispensed your knowledge toward guiding the completion of this dissertation, your character toward learning and to scholars questing for such knowledge is unequivocal. You provided support by reading, evaluating, commenting and offering outstanding feedbacks through all stages of this dissertation. Remaining from the beginning of the dissertation process to the end speaks volume of your dedication to scholars I thank you.

Also in acknowledgement, is Ms. Janel Jones, my academic advisor, every time, I email you to ask for one thing or another you were willing to assist promptly. I acknowledge also Dr. Nancy Rea, for taking the time to look through my IAP forms and approving an extension each quarter that I appeal. I acknowledge also Mary Magadalean Trout, my good friend at Head Start for all your kind support and words of encouragement during my time there.

Also, in appreciation is my brilliant and exceptional husband, (Chief) Dr. V.C. Ifeanyichukwu Ulinwa, it is impossible to express or describe your endless supportive roles, understanding, guidance and encouragement to keep moving forward. My best friend, words are never enough to express your goodness as you propagate the stars and twinkles in my eyes. To my children, I thank God almighty that my life is full and fulfilled with all of you in it and you have made me proud in managing every aspect of your affairs and the home in my absence. As you each strive toward reaching your academic goals, earnestly I am, encouraged that with this giant academic achievement, you will each be inspired to endeavor toward reaching your academic milestones.

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Chapter 1: Introduction to the Study

Epidemiologists use scientific methods to determine, prevent, control, and report infectious disease outbreaks (Gordis, 2004). For example, in a given population, epidemiologists use etiology, which is an epidemiology practice, to examine the determinants and effects of disease spread and distribution (Brownson et al., 2015; Lake, Ambrose, Lipman, & Lowe, 2016; Simpson, Taylor, & Mei, 2015; see, also, Bracken, 2014; Morabia, 2015; Rogawski, Gray, & Poole, 2016). In this study, I examined and categorized factors that hinder the effectiveness of epidemiologic systems during any disease infectivity.

This chapter consists of the background of the study, the problem statement, and the purpose of the study. It also includes the research questions, theoretical framework, nature of the study, and definitions of key terms. The definitions are followed by sections on the assumptions, delimitations, limitations, and significance of the study and a summary of key points made in the chapter.

Background of the Study

Plagues have a long history and are notable for their adverse impacts on human populations. The first recorded bubonic plague, the Plague of Justinian, is attributed by scholars to issues with grain imported from Egypt to Constantinople (Turkey) in A.D. 541–542 (El-Bahnaswy et al., 2012; Mitchell, 2016; Ranscombe, 2016). The plague was a result of massive public granaries that nurtured the populations of rats and fleas in the transporting ships. It was estimated that 40% of the residents and a quarter of the eastern Mediterranean population died because of the infection (El-Bahnaswy et al., 2012;

Mitchell, 2016; Ranscombe, 2016). According to the Bible, a similar plague caused by ravaging mice infected the Philistines of Ashdod as a consequence of stealing the Ark of the Covenant from the Israelites (Harris, 2006; IBS, 1984).

In 2006, a Phoenix, Arizona, an extreme drug-resistant tuberculosis (XDR-TB) patient was jailed for not wearing a prescribed protective mask in public (Wagner, 2007). In another case, a Mexican national with XDR-TB crossed the U.S. border 76 times undetected in spite of U.S. officials' knowledge of the traveler's health condition (Callahan, 2009). In January 2007, staff at the U.S. Centers for Disease Control and Prevention (CDC) informed TB patient Andrew Speaker that he had a strain of tuberculosis or multidrug resistant tuberculosis (MDR-TB (Callahan, 2009). Speaker still boarded a commercial plane back to the United States after his wedding in Europe (Chrysler, 2012). A U.S. border control officer had failed to screen Speaker at the Canada-U.S. border (Callahan, 2009). Noticeably, 100 years before Speaker's case, Mary Mallon (Typhoid Mary) infected about 22 people with typhoid fever of which three of those infected died (Parachin, 2006). According to Parachin (2006), Mallon adamantly believed she was well and ignored New York public health officials' recommendations and their conclusion that she was a typhoid carrier. She died in isolation at North Brother Island. In both the Speaker and Mallon cases, health officials, health institutions, and the disease hosts disagreed among themselves.

Problem Statement

All infectious diseases outbreaks have a certain degree of epidemiologic systems failure (ESF). Typhoid Mary and Andrew Speaker TB are specific cases. Other cases include 49 extensively drug resistant tuberculosis (XDR-TB) patients who used their diseases as a threat in South Africa (News24, 2008). In their research, Centner and Ferrira (2012) considered one perspective of ESF. However, as Rogawski, Gray, and Poole (2016) and Bracken (2014) noted, researchers using conventional research methods need to entertain multiple perspectives to fully understand ESF.

None of the vast number of epidemiology techniques is appropriate for studying ESF. The theories and analysis presented by conventional researchers such as Ho (2014), Tongkaw (2013), and Syafar and Gao (2013**)** are inadequate for understanding the depth of an ESF. In studies conducted using conventional methods, Wilson, Sharma, Dy, Waldfogel, and Robinson (2017) discovered lapses in epidemiologic reporting while Hemkens et al. (2017) noted inadequate considerations of confounding. Ballantyne, Edmond, and Found (2017) suggested combining empirical evidence and peer review methods for accuracy and validity of an epidemiologic technique of any particular case.

In reviewing the literature, I found no literature that addressed the need for ESF analytic tools identified by Mesnard and Seabright (2009), Sim, Chan, Chong, Chua, and Soon (2010), Wang, Xu, Zhao, Cao, He, and Fu (2011), and Marienau et al. (2010). Each of these works provides support for the need for this study. As noted by Morabia (2015), scientific and applied methods for infectious disease outbreaks seem to be daunting tasks for epidemiologists. To reduce this gap in the literature, the specific problem for this study was how to construct, calibrate, and use the technical, organizational, and personal (TOP); (Linstone, (2011) standard for an ESF tool. In my study, I emphasized that the perspectives of epidemiologists (T), public health policy makers (O), and infectious disease hosts (P) oftentimes conflict.

Purpose of the Study

The purpose of this triumvirate mixed-methods case study was to document factors suitable for constructing, calibrating, reporting, and controlling an ESF for epidemiologists and allied scientists. The term *triumvirate* refers to a set of three perspectives suggested by Linstone (2011). I used the three perspectives-based guidelines in this study. First are technical or professional epidemiologic systems (T) consisting of technical personnel (i.e., those who study or treat infectious diseases) in private or public settings. Second are the regulatory institutions or policy systems (O) for mandating health policies through legislation and administrative laws. The third is the host system (P) for determining the personal perspective of individuals (disease carriers). Cross-cuing the perspective factors as suggested by Linstone (1984) would enable epidemiologists to design versatile epidemic control methods, as demonstrated by other researchers (see Dale et al., 2012; Ho, 2014; Kuang, 2012; Yoo, Hawryszkiewycz, & Kang, 2012).

In accord with Pijnenborg (2011), who recommended using the three perspectives to study an ill-defined system, I documented each aspect of an ESF using synthetic fuzzy sets and the method set forth by Zadeh (2015). The fuzzy set axioms aided in explaining and describing ESF and satisfied Yin’s (2013) recommendations for a case study. Finally, I constructed a model to discover and explain a solution set to minimize ESF. Relying on the guideline suggested by Linstone (2011) and Ulinwa (2009), I used triumvirate-selected secondary (synthetic) data to model the infectious disease control mechanism.

The discovered tools could aid epidemiologists and allied scientists in discovering factors that cause ESF.

Research Questions

RQ1. How could the multiple perspectives inquiring systems (technical, organizational, and personal perspectives) and fuzzy logic be used to discover the factors causing or influencing epidemiologic systems failure?

RQ2. How should an efficient and effective ESF monitoring tool be constructed from the synthesized perspectives?

Theoretical Framework

As suggested in Ulinwa (2008), I used the Singerian framework by deriving solutions from three sets of sources. The Singerian used in this study was the multiple perspective analysis (TOP) method of Linstone (1984). I conceptualized ESF as a TOP framework as conceived by Linstone (2011). TOP is a pragmatic triumvirate observation stance and a research method (Linstone, 2011).

The T perspective quantifies the science of research solutions as Musgrove-Chavez (2011), Pijnenborg (2011), Wei (2012), and Adams et al. (2011) noted. Ulinwa (2009) observed that the O filter is about the fairness process in compromising solutions and routines. From Linden (2010), the P perspective is an intuitive tool that is useful for scrutinizing human decisions in cases such as ESF. Succinctly, the T quantifies findings; the O seeks rules and routines (as research findings) that define the problematic system; and the P gauges human reactions towards and about the problematic system (Linstone, (2011). ESF as a system problem is suitable for TOP and should be analyzed with the

TOP framework. Yoo et al. (2012), Tongkaw (2013), Lee and Ho (2013), and Linstone (1984) examined similar problems. Therefore, public health research community would appreciate TOP framework.

Underpinning this study were two theoretical factors. The first was systems failure. Chatha and Weston (2005) suggested that researchers studying systems failure in an ESF study should focus on two broad types of activities: problem identification and searching, evaluating, and choosing an alternative solution to remedy the failure. To identify a solution, I considered the classification of, structure of, and strategy for minimizing ESF. Hall and Fagen (1968) clarified that a system like ESF is structured by the relationship among its properties, functions, and attributes.

Fuzzy set was the second guiding theory. According to Zadeh (1965), Zadeh (2015), Zimmermann (2010), and Molinari (2016), the theory is useful for representing, analyzing, and reporting study findings and can be used for any scientific research. Osuna-Gómez, Chalco-Cano, Rufián-Lizana, and Hernández-Jiménez (2016) used fuzzy sets to study necessary and sufficient conditions. Massad, Ortega, Struchiner, and Burattinia (2003) recommended the use of fuzzy set theory, specifically a linguistic (numeral) fuzzy measure and models, to study an epidemiologic phenomenon. The work of these researchers shows that fuzzy set theory could be considered an epidemiologic toolkit because fuzzy numbers could be defined as linguistic (numeral) variables. In this study, I used a linguistic (numeral) variable (usually in the form of laced labels) to specify a focal point of a measurement (i.e., fuzzy sets).

Nature of the Study

This study was a triumvirate mixed-methods case study. Unlike Pearce (2012) who studied aspects of epidemiology with cross-sectional design, I used a multiple perspective inquiring systems (TOP) design encompassing qualitative and quantitative methods. The TOP model (Linstone,2011) is an ideal approach to investigate, construct, and report the associations among the extremely volatile factors causing ESF failure. Moreover, the explanatory outcome of the study was focused on the conflict among the perspectives. Ulinwa (2009), Phillips and Linstone (2016), and Kuang (2012), Lee (2013), and Tongkaw (2013) are the most recent researchers who have used TOP. Linstone (1984), Sapp (1987) and Tarr (1990) were the earliest.

In this study, I used linguistic (numeral) fuzzy set (possibility mathematics) theory. Use of fuzzy set theory was necessary because the linguistic (numeral) meaning of ESF is imprecise, yet important. I concluded that TOP and fuzzy systems theories were sufficient to characterize and analyze the qualitative and quantitative ESF. In the study, I considered the belief systems of the infectious diseases hosts, health policy related to the diseases, and the medical practice for the diseases. Following Ricci’s (2009) and Parachin’s (2006) approach to using secondary data, I derived the research population from a number of reported infectious disease types.

Definitions

Brucellosis: An infectious disease caused by the genus *Brucella* (Gram-negative) bacteria (Trangadia, Rana, Nagmani, & Srinivasan, 2012).

Etiology: The study of how diseases spread in a given population and the causes that account for the distribution (Sundel, 2009).

Fuzzy logic: A computational model of human-like reasoning (Zimmermann, 2010).

Mean time to failure (*MTTF*): The mean life time a system is expected to fail without maintenance or repair (Kumar and Ram, 2018).

Prognosis: The quantification of disease historic-baseline (Gordis, 2004).

Triumvirate: A set of three perspectives (Linstone, 2011).

Assumptions

First, I assumed that all infectious diseases have a certain degree of ESF. There are conflicts among public health professionals, legislators, and health consumers regarding such failures. Schools of public health need a reliable framework to monitor and resolve ESF and related conflicts. This is necessary because recent cases such as Andrew Speaker's TB case revealed the conflict of TOP views about infectious diseases (Afolabi, 2018). The conflict is also noticeable in the Typhoid Mary saga. Resolving such conflicts was the focus of this study. Second, based on the cases of Andrew Speaker and Mary Mallon, I assumed that current methods to check and control infectious diseases were ineffective. The Mary Mallon case was the earliest sign of the conflictive perspectives or ESF (Parachin, 2006). Andrew Speaker's TB case also demonstrated ESF. A third assumption was that the triumvirate method with fuzzy set approach should help infectious diseases researchers dynamically monitor ESF. I assumed that ESF will continue to be an extremely volatile infectious diseases (EVID) reservoir if ESF is not eliminated or controlled. I presupposed that the more ESF there is the more EVID will continue to increase unless ESF and EVID professionals understand the ramification of ESF-EVID.

Scope and Delimitations

The findings of this study could be generalized to a class of ESF involving hosts, epidemiologists, and public health officials. Findings should not be applied in cases where legislation or administrative law is used to ban isolation facilities or quarantine. Furthermore, the results may not apply to authoritarian public health sectors. Last, the findings should not be generalized to implicit or explicit cases that are based on one (T, O, or P) perspective.

Limitations

This study should interest public policy, epidemiology, and medical professionals even though epidemiologic studies emphasize public health. The study would not apply to noninfectious diseases or chronic diseases. Furthermore, this study should not be applied to nonfuzzy data or interpreted as a Boolean case study. Another limitation of this study is its reliance on the secondary authors' data and the triumvirate method guideline as stated by Linstone (1984). In any case, researchers have used fuzzy set theory in cases that required validity and reliability (Ulinwa, 2009).

Significance

From Afolabi (2018), it seemed that the most EVID are Ebola, HIV-AIDs, SARS, TB, and Typhoid, among others. This study is significant because ESF remains a major hurdle in minimizing the spread of any infectious diseases. By examining factors of ESF, providing baseline data, and describing the susceptibility, I sought to provide insight that health professionals can use to address the study problem. The results may provide epidemiologists information and methods to characterize ESF. In addition, the tools may be resourceful to local, state, and national (if not international) health agencies for the prevention and control of ESF. The ESF tool would aid public health workforce in understanding the different risks between conventional methods and the TOP ESF tools. TOP ESF tools are generalizable to all perspectives for monitoring and controlling any infectivity. For example, Biostatistics does not consider the importance of the O perspective.

The ultimate implication for positive social change could help minimize ESF and EVID. With a fuzzy linguistic (numeral) calibrated ESF monitoring tool, the social change of this study is three fold. First, epidemiologists would be able to determine if their instruments are efficient and adequate for any giving infectivity such as Ebola, Zika, or TB spread. As a remedial method it would be useful when gauging the spread of any infectivity. Second, the tool would identify any of the perspectives that hinder the full application of epidemiologic tools. Third, calibrating the ESF monitor would stimulate ideas for public health policies. It would aid in reducing public health resources waste. Succinctly, this study recommended to ESF and EVID professionals possible ways to minimize ESF. These recommendations could indirectly affect EVID control in addition to medical treatment.

Summary

This chapter explains the problem statement, purpose of the study, theoretical and conceptual frameworks, the research questions, nature and significance of the study, social change, and definition of terms, delimitation, and limitations of the study. The outlined sections serve as the foundation of this study: outcome of epidemiologic systems failure. Pertinent literatures supporting this study are documented in chapter 2; and are reflective of the problem under research. The chapter also contains the underpinning ESF theories; such as multiple perspective inquiring system and other works that shaped the study. The methodology, chapter 3, focused on the research design, structure of the research, analysis, validation and interpretation of the method. Chapter 4 explained and presented the analysis or the research findings. Finally, chapter 5 summarized, concluded, and provided recommendations.

Chapter 2: Literature Review

The purpose of this triumvirate-based, mixed-methods case study was to examine factors undermining infectious disease control or prevention. In this chapter, I discuss the body of theories related to ESF and which constituted the theoretical framework of this study. These concepts and theories include general systems theory, selected epidemiologic systems, and facets of epidemiologic systems and problem solving. In the chapter, I highlight three levels: the micro (human) level, the macro (societal) level, and the meso (interaction between humans and societies) level. I also document the foundation for modeling the interactions among humans, contexts, and relations. This chapter provides researchers with a frame of reference for interpreting this study's findings and those of future studies.

Literature Search Strategy

I obtained literature about relevant concepts from books, dissertations, and peer-reviewed journals. The databases I accessed from Walden University Library included Academic Search Premier, Business Source Premier, Computer and Applied Science Complete, EBSCOhost, ProQuest Central, ProQuest Dissertations, Opposing Viewpoint Resource, Sage, and SocINDEX. In addition, I performed a general search using Google Scholar, Yahoo!, and Bing Internet search engines. The sources used in the review are not exhaustive of epidemic studies for I excluded microbiology, biochemistry, or virology specific studies. This literature review concerns ESF. Table B1 includes a summary of the literature used in the study.

Theoretical Framework

The theories examined in this chapter underpin the systems framework. Intuitively, an observable and solvable problem constitutes a scientific system. Such a system (with their properties, functions, and attributes) is relational (A. D Hall & Fagen, 1968). It is a unit with subunits operating together and manifesting perceived attributes (Lendaris, 1986). The percept is relative to its external environment and has the quality of containing subunits operating together to manifest the perceived attributes of the unit. The subunits are also systems (A. D Hall & Fagen, 1968; Lendaris, 1986). The unit is either explicit or implicit. An observable system is explicit whereas an implicit system is unobservable. An abstract system takes a conceptual form such that x_1, x_2 ,and x_3 form a linear equation: $a_1x_1 + a_2x_2 + a_3x_3 = C_1 \text{ or } b_1x_1 + b_2x_2 + b_3x_3 = C_2$ (Ulinwa, 2008).

According to A. D. Hall and Fagen (1968), there is a derivable set of macroscopic behaviors. A. D. Hall and Fagen (1968) noted that wholeness is one and implies that every part of a system relates to every other part and a change in each part changes the rest, causing the system to behave coherently. Progressive segregation, another macroscopic behavior, is decay or growth behavior process relative to time and noticeable from a system’s physics (A. D Hall & Fagen, 1968). The authors stated that a system gains experience or decays as time passes. Another is progressive systematization. A system undergoes progressive systematization when the whole changes. The behavior strengthens the existing relationships among the subsystems or develops a new relationship among parts that never related. Von Bertalanffy (1968) noted that

A system can be a complex interacting element; interaction means that elements, p stand in relations, R, so that the behavior of an element p in R is different from the behavior in another relation R'. If the behaviors in R and R' are not different, there is no interaction, and the elements behave independently with respect to the relations R and R'. (pp. 55-56).

To deduce from the foregoing discussion, certain rudiments must be satisfied. One, a system must be corporeal with an environment (its upper and outer levels). The outer level according to Lendaris (1986) is the relevant environment or the immediate surrounding because it specifies other objects that affect and are affected by the system. An environment that is irrelevant to the system does not change the system's attributes, nor does the system change the attributes of the environment. This aspect is consistent with Von Bertalanffy's (1968) assertion that "the whole is more than the sum of parts" (p. 55). The reason is that a system's behavior cannot be characterized or explainable from the characteristics of isolated parts.

Consequently, a system that maintains identity and individuality and is distinguishable due to its properties is a unique one (Ulinwa, 2008). Even if there is a similarity among systems, bundling differentiates the systems, noted Sanderson (1999). Given these criteria, a table of presence, a table of absence, and a table of comparison prevent two systems from maintaining the same spatio-temporal bundles (Sanderson. 1999). A table of presence implies that a system is physically or conceptually present to an observer. The system should exhibit a set of attributes that attract observation (Sanderson. 1999). Objects in the universe of discourse (other than the system) make up a table of absence because they do not satisfy the table of presence criteria; they do not contain the same spatio-temporal bundle with the identified system (Sanderson. 1999). A table of comparison (the degree to which a set of bundle is present or absent in a system) is for comparing a system with other objects in the universe (Sanderson. 1999).

Sanderson (1999) continued that centralization, openness and caginess, adaptability, and feedback clarify behavioral requisite meanings of a system. Centralization occurs when one subsystem dominates others in such a way that a little change causes change in the system. An open system exchanges information with its relevant environment whereas a caged one does not; however, each depends to the degree the universe is included in the system and the environment. An adaptable system adjusts to environmental changes and operates continuously in its normal state. Feedback characterizes the process of rerouting back a certain or a portion of a system's output along with new input. Feedback affects succeeding outputs and the system's stability or instability. Stability occurs when certain or all system's variables behave within a specified behavioral limit.

These behaviors are evident in epidemiologic systems because of the ability, tools, psychology, sociology, and ethics of epidemiologists. Generally, the system is a purposive human creation; and the behavior is for continuity of the system. This view is in accord with Kurth-Schai's (1984) understanding of a system.

When one thinks of epidemics, one could also think of meme. Meme is a thoughtful action, a virus or an imitation of actionable information that infects. It spreads and leaps in and between humans (Gatherer, 2002). It suffices that attitude, beliefs, and behaviors are communicable. With software agents, Gatherer (2002) explained that institutional and human behaviors are transmittable. As with Bajarneskans, Gronnevik, and Sandberg (1999) findings, epidemiologic discoveries spread among epidemiologists and health community like contagions. Succinctly, meme is a transmissible cognitive phenomenon that infects quite easily (Langrish, 1999). Once developed, it becomes real among the hosts and identical to the source. It followed that Boardman, Sauser, and Verma (2009) referred to the proceedings as systems DNA.

Living Systems Theory

An argument could be that a collection of diseases, for example, is not a system, but a set. However, if the set is rearranged according to symptoms, or regions of disease occurrence, the arrangements form systems. This establishes 'systemhood'; and meaning could be attached to it. Thus, one could distinguish objects that are systems from those that are not (Klir, 1991). Although discipline centric, (thinghood) the scope of epidemiologic system is more than thinghood because:

> Studying the ways in which [the systems] can be, or can become, organized equally meaningful and may, under some circumstances, be even more significant than studying the [thing] themselves. (p. 6)

For having such a broader meaning, epidemiologic systems could be examined with living systems theory (a particular general systems theory).

To ground living systems theory (LST), Miller (1978), Miller (1990), and Miller (1995) defined a set of interacting units having relationships as a system. The concrete system consists of a hierarchy of levels of differentiable small types (subsystems). In all, there are eight levels. Each of the levels has an interface (boundaries and deciders for independence, and reproducers for perpetuating themselves) (Jaros, 2000). Boundary is the subsystem at a system's perimeter holding the system's components and protecting them from adverse environment (Swanson, 1992). It serves two main purposes. For free flow of information, it filters data flows between the system and its environment. It also enables a system to maintain a steady state differentiable from the surrounding environment.

For each of the level there are nineteen subsystems: see Table 2 and Table 3. There are twenty subsystems including a timer subsystem: see Table 4. Each subsystem (a process) performs a specific function. See also Figure 1.

Jaros (2000) posited 'real' and 'imaginary' systems. Real systems are similar to the ones Miller (1978) conceived as concrete systems. Imaginary systems are those humans conceptualized in their minds. For example, cells are real or concrete systems with regard to a cell, the process of energy production from nutrients is imaginary. Such process is older than human societies and as old as a cell. Organized information such as types of epidemics and their host are concrete systems, but groups of such hosts or societies are concepts.

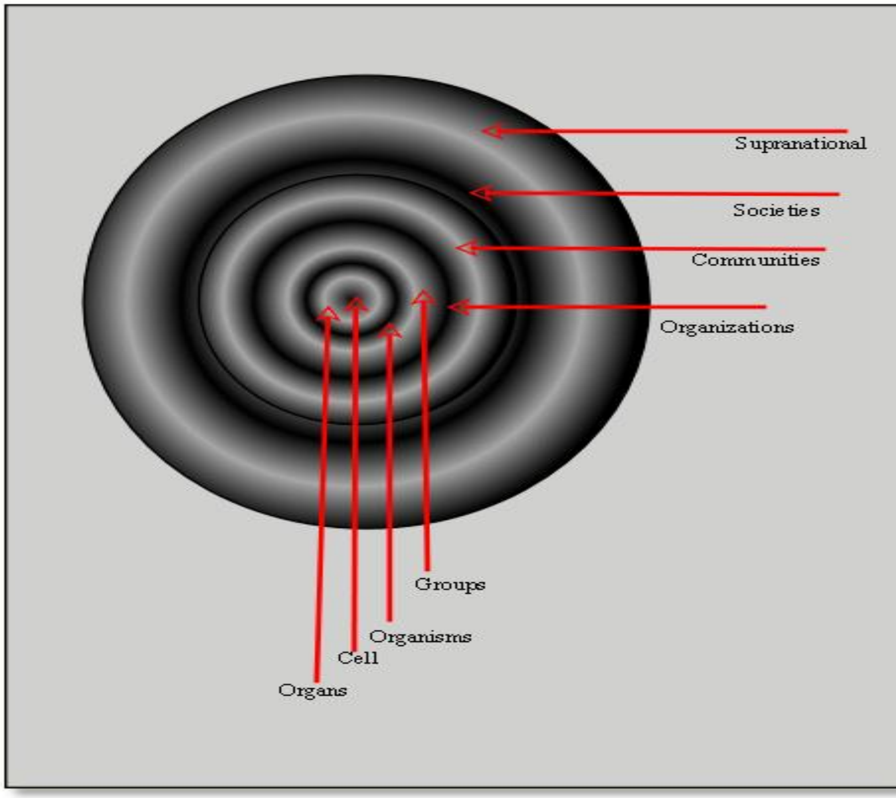


Figure 1. The eight levels of living systems theory.

Systems Failure

Chatha and Weston (2005) suggested systems failure enables researchers such as epidemiologists to focus on two broad types of activity: problem identification; and searching, evaluating, and choosing an alternative solution to remedy the failure. To realize the alternative, epidemiologists must consider the classification of, structure of, and strategy for solving the problem. Chatha and Weston (2005) clarified that the classification is about routine, computational and programmable nature of the decision. It has to be generic. In other words, the structure of the problem is procedural, predictable, and well-defined. The authors seemed to suggest that epidemiologists must rely on rules and computation. The classification, structure, and strategy are what Chatha and Weston (2005) termed category I of system decision. For category II, Chatha and Weston (2005) stated that the classification is about non-programmability, the uniqueness, and innovative nature of the decision. The structure is novel, unstructured, and incomplete (channel) of information. This category II is also about reliance on principles and judgment (a general problem-solving method).

As with this study, Toscano (2006) related systems thinking and grounded theory. Grounded theory is a research methodology. See chapter three. The method enables researchers (such as epidemiologists) to analyze the mutability of the constantly shifting patterns of epidemics and the hosts behaviors irrespective of (and respect to) the dynamic environment of overlapping cultures, languages, religions, and belief. Toscano (2006) acknowledged that systems' thinking is about reorganizing factors constituting a system of patterns for discovering positive modifications. Systems thinking invert analysis and reorganize systems by focusing on the problematic system components and methods to re-integrate them for efficient and effective functionality. Systems thinking transform a system. According to Toscano (2006) and Chatha and Weston (2005), it is not only about repairing the system.

Referencing Von Bertalanffy (1968), Hung (2008) explained systems thinking as an essential cognitive skill (although not an innate skill) enabling researchers develop a relative understanding of a given problem at a conceptual and systemic level. Hung (2008) integrated systems thinking and scientific modeling. The integration takes into account the interconnectedness and interdependency distinct characteristic of the system parts as the focus of systems thinking. Of importance are the emergent properties of a system. The emergencies are determined or characterized by individual parts; their inter-causal relationships and effects among the parts and the system. Succinctly, the effects on the whole are determinable by the emergent properties.

Besides the emergent properties, Hung (2008) acknowledged closed or feedback loop and dynamics (time delay effect) as two critical dimensions of the interrelationships. Feedback loop is about nonlinearity, multiple-directional, and effects of the feedback nature caused by a given system. A system component relates to how it and other parts affect its functionalities. It follows that functionality of a system is a result of each part acting on itself and its own, among other parts, feedback effects on each part, and time effects. Hung (2008) also emphasized the consideration of complexity when applying or using systems thinking as a research tool. The focus is how to represent the complex inter-causal relationships. The basic view of complexity as Hung (2008) explained rested on the relationships, such as systems nonlinearity, feedback loops, and time delay. Diaz (2008) added that systems thinking (for hard systems and soft systems) require completeness. Soft systems thinking recognize socio-technical nature of systems caused by human involvement. According to Elizalde-Medrano, Tejeida-Padilla, Morales-Matamoros, and Mendez-Díaz (2010) Diaz (2008) and Diaz (2002), soft systems thinking is important to hard science like engineering and soft science like epidemiology; both thinking rely on sociological considerations of decision-making.

Relating to systems thinking with futures thinking and macro-systems, Marien (2009) focused on maladaptive, nonadaptive, and semi-adaptive systems. Marien (2009) learned four things. The first knowledge is that futures thinking and systems thinking somewhat drifted apart. The reason was that a cluster of systems thinking ideas is considered as evolutionary theoretic stage during the late 1960s and early 1970s futures vogue. The second knowledge is that futures thinking and systems thinking lack a core and a strong academic base for both can be traced to hard and soft sciences. Third, Marien (2009) learned futures thinking and systems thinking fragmentally continued with a wide variety of theoretic styles in futures thinking and system thinking. Future thinking is implicitly futurism and systems' thinking is implicitly systems-related. The fourth knowledge is the strong correlation between systems thinking (in forms and values); being Utopianism and merely progressive. Systems' thinking is holistic and allows new ideas. It helps professionals like epidemiologists to see the present and future through new observatory tools.

In spite of Marien's (2009) knowledgeable concerns, John, Boardman, and Sauser (2009) focused on using systems thinking to discover wisdom. The authors believed that those developing systems benefit and appreciate paradox in a given system because they leverage paradox for solving problems that could otherwise be intractable. John, Boardman, and Sauser (2009) seemed to agree that policy makers (certain public health professionals) will benefit from systems thinking. Their idea rested on two fundamental systems thinking constructs. With the constructs, John, Boardman, and Sauser (2009) postulated a three-step approach to leverage paradox in problem solving.

Leveraging the implications of the paradox involves the use of Ashby's (1956) requisite variety to keep the system operational. The understanding according to John, Boardman, and Sauser (2009) is to take two major types of paradoxes (qubit and photon) into account. For example, a qubit paradox is similar to an infectious disease with multiple states (stages) at once whereas a photon is similar to an infectious disease that can infect multiple individual simultaneously. The authors seemed to suggest that epidemiologists (those focusing on infectious diseases) operate in similar realm and paradoxes; and the professionals seemingly tackle paradoxical on a daily basis. Obviously, such paradoxes arise whenever professional interests conflict with other interest groups (private or public sector).

Relating to the concepts of hard and soft systems thinking John, Boardman, and Sauser (2009) asserted the development of effective and efficacious systems in service of the public good such as public health) is a function a true communion of the policy and technology (not necessarily electronic) sector. Rather the function focuses on discovering the root causes of the paradoxes and how to develop professional, policy, and socio-psychological mechanism to handle paradoxes. The constructs of interest are systems boundary and control. John, Boardman, and Sauser (2009) believed these concepts lead to the awareness of the implications of paradox (even soft systems like epidemiological systems). John, Boardman, and Sauser (2009) suggest the need to focus on the relationships between the health policy, epidemiology and technology profession, and infectious diseases communities because the communities must use effective and efficient framework to understand the problems and solutions.

Boundary and system are inseparable. Boundary separates parts and relationships from those outside the system. Those inside are controlled to benefit the system; and those outside are influenced to better the system. The expectation is that those inside at least be good enough to ensure the system solves the targeted problem. It follows health policy, epidemiology and technology profession, and infectious diseases communities (as epidemiological system designers) ought to perpetually be mindful of the system boundary. Concerning system boundary, John, Boardman, and Sauser (2009) stated

> Medical experts know that as much as the human body prefers not to be invaded by unwanted bacteria, immunization (letting a specified amount of bad guys in) provides the body a distinct benefit – it enables the good guys that make up the immune system to get better at dealing with the bad guys so when large numbers of the latter try to invade, the body's defenses have significantly improved. There are those who argue passionately that children who lead lives that never involve getting dirty end up with weaker, less experienced immune systems. While we are not attempting to imply an immunizing effect, there are also those who argue quite passionately, and the histories of many countries confirm, that permitting controlled immigration can deliver benefits to the host nation. How limiting should parental policies and borders be? And what does this mean in terms of the definition of the concept a "healthy childhood" or "a secure border?" (p.365)

Given systems paradoxes, John, Boardman, and Sauser (2009) asserted the need to recognize the systemic problem. The idea is about the contextual circumstance or a problem statement clarifying the context. The better one understands the context, the better one appreciates the actual problem statement. Systemic arises when systems thinkers identify a problem (need) if the original problem (requirement) statement relates to events, circumstances, situations or affects the context. The authors advocated the necessity to adopt a frame of reference covering the systemic problem. The frame of reference is the use of systemic models to represent the problem space and create a high-level view of the paradoxes. The view reveals the initial problem and things affecting it or its affects.

Last is to leverage the paradox to develop systemic solutions. This is achievable by generating ideas that define the requirements for the ideal state (solution); or approximate it. Finally is to determine the proximity to the ideal in the real world, which is attainable through feedback (control) mechanism (Senge, 1990).

Although Goh, Brown, and Spickett's (2010) work focused on major incident and safety cultures, the study seemly used systems thinking to relate to this study. Their focus was on the circular nature of most systems. The circular relationships are mostly represented in the form of causal loop diagrams mapping the cause and effect. The circular nature demonstrates aspects of the system over time. Succinctly, systems' thinking has three basic processes: reinforcing feedback, balancing feedback, and delays.

To Senge (1990), systems' thinking has five disciplines. One of the disciplines is personal mastery. Personal mastery occurs because of continuous individual growth and development. This is necessary for the systems growth and development. Another discipline is shared vision. Systems paradoxes trigger shared vision because it is commonly expressed in the systems vision statement (mission statement). It clarifies the visions of the stakeholders. Among the disciplines is mental model. The model is generalizations shaping individual perceptions and actions influencing the dynamics of the systems. Mental models also strongly affect other organizational activities behavior. Senge (1990) also included team learning. Senge (1990) seemed to suggest that requisite variety for solving system failure is greater than the sum of all the varieties. Ashby

(1956) held the same view. Obviously, the understanding is that the disciplines are for problem solvers such as epidemiologists.

Because complexity is paradox build-ups, Lamb and Rhodes (2008) described ongoing research exploring systems thinking at human systems team level. To this effect, Wirsbinski (2008) examined if paradoxical thinking epitomizes systems thinking. The collaborative systems thinking (a concept of higher level systems thinking) study by Lamb and Rhodes (2008) envisioned a workforce competency for dealing with system complexity at an organization higher level. Lamb and Rhodes (2008) aimed to provide empirical knowledge to support workforce development interventions for developing systems thinking. The study in reference to Rhodes, Lamb, and Nightgale (2008) incorporated organizational culture as a factor for enabling collaborative systems thinking. Lamb and Rhodes' (2008) study is important because Valerdi and Rouse (2010) asserted that systems thinking competencies are not as prevalent among professionals such as epidemiologists. Valerdi and Rouse (2010) posited that systems' thinking is not a natural act.

Vansupaa, Rogers, and Chen (2008) reminded there is sparse data on how to nurture systems thinking cognitive development. The authors encouraged expressing and connecting realities in terms of images such as pictures with appreciative inquiry strategy hypothesizing the learning. To demonstrate the use of systems thinking, Mkandawire, Ijumba, and Whitehead (2011) used systems thinking to evaluate causes of systems failure. Sasaki, Sugimoto, Yajima, Masuda, et. al (2011) used systems thinking to study social consensus formation in situation where a measure reduced one risk increases another in multiple risks context.

Of importance to this study are systems failures or systems archetypes. According to Kim (2000a), Kim (2000b), Kim (1994), Kim (1999), and Anderson and Johnson (1997) the science of systems thinking has eight systems failure (archetypes). Not necessarily according to this sequence or order, but the first is drifting goals. This archetype arises when there is gap between a system objectives and reality. The second type is escalation. Escalation occurs when a component of a system takes action that negatively affects other components causing others to react the same. This escalates the adverse behavior of the system. The third is fixes that fail. This type of failure occurs when a solution is quickly applied to a system problem disturbing the symptoms causing the unintended consequences. Notwithstanding, the unintended consequences, the original problem reoccur and becomes worse. The growth and underinvestment is the fourth archetype. The failure occurs when solution reaches its limit or when solution standards are lowered to justify under investment.

Another set of four archetypes (failure) are limit to success, shifting the burden/addiction, success to the successful, and tragedy of the common. In the case of limit to success, a system encounters or reaches a limit causing its performance to slow or decline. Whereas in shifting the burden/addiction, a solution that distracts the application of more effective and efficient solution is applied to resolve a systems failure. This side effect gains more attention than the original problem. Success to the successful archetype occurs when more and more resources are available or applied to a solution component to another solution with the same effect. The last is tragedy of the common. In this type of failure, each system components acts on action that benefits it. If the action becomes too large, each of the components, benefit declines. Systems thinking is a broad field to the extent that Mildeová, Dalihod, Exnarová (2012) applied it to computer science. The application seemed to suggest the possibility of applying it to ESF.

Selected Epidemic Systems

Infectivity of a disease is due to its itinerancies. There are three *raison d'être*. First examines the similarities of infectious diseases; two identifies the earliest contagions to infect humans; and three refutes or supports the most primitive contagion in the literature relative to the first and second underlying principles. The justifications require an exploratory rather than a prescriptive definition of disease.

First, Random House Unabridged Dictionary, second edition, defined disease, among others, as “a disordered or incorrectly functioning organ, part, structure…resulting from the effect of …developmental error, infection…or unfavorable environmental factors”. The American Heritage Stedman's medical dictionary articulated it as a pathological condition characterized by a set of symptoms resulting from various causes. In addition, Boorse (1997) noted it as an impaired or a limited functional internal state below a typical efficiency due to environmental agents. Further, Dorland’s medical dictionary inferred it as any departure from a state of health having a characteristic stream of symptoms affecting part or whole body where the etiology, pathology, and prognosis may be known or unknown.

Boorse (1997) seems to suggest disease as a fluid thought having objective and subjective notions. Objectivists posit that there is an underlying pathological etiology definable by a set of essential symptoms for every disease. This is to say that disease is a state statistically below a certain biological function, quantity; and it is unaffected by external human values. Subjectivists, on the other hand, use labeling to differentiate one disease type to another without the underlying etiological explanation. Disease is thus a prescriptive experiential norm and value judgments based. Experts decide what it is.

The following benchmarks define and classify disease: the presence of a specified etiological agent; an evidence of an effect; the combination of clinical signs and symptoms; any combination of the above alternatives; and specific symptom (or combination of symptoms or clinical signs) caused by a specific etiological agent. Classification of a new disease is a result of peer review, and acceptance. Turnock (2001) noted the importance of defining disease base on standardized protocol and medical guidelines. Example is The Food and Drug Administration definition of disease. It is an institutional definition and concern when a part of or the population is at risk, of being sick. Take national vaccination program as an example. The purposeful process of immunization is to control that which the state defines as disease. Thus, it is that which is of national concern relative to illness in correlation with sample of the population.

Burnet and White (1979) and Dinstin (2005) inferred disease is usually felt as one end of a pole of a continuum, wellness and illness. Only the carrier knows what it is; and stating the exact meaning is much harder. Thus, disease is an obstruct manifesting from active live data. It advances if and only if it changes the carrier's state. Dinstine (2005) ignored technical definitions of individual symptoms despite the inclusion of the carrier, be it the environment, or human. As a construct, the medical professionals can better provide health service by understanding the etiology of the active obstruct; public health legislators can regulate health service by understanding disease as active object rather than a concluded manifest; and the carrier (a host) can explain the experiential feelings of the obstruct more meaningfully. Affixing "obstruct" to the definition implies to that which stops a system's original purpose and deviates it to a favorable or an unfavorable state. Depending on the implications, a disease can be thought as a favorable or unfavorable manifest of a system state.

With the understanding of living systems theory, Lilienfeld and Stolley (1998) seemed to suggest infectious disease as that which transmits from a system to another. It is obstructive because it changes a host's state. Three factors clarify this derivative. First, the obstruct in a host usually is identical, not necessarily at the same precise processing level and effect, to the source; two, the disease is capable of altering a host's state similar to others infected from the same or different carrier; and three, each host is capable to establish new carriers. It is the itinerancy of a given disease among humans or living systems that is referred as infectivity.

Contagions also share common characteristics (Lilienfeld & Stolley, 1998). Environmental persistence is one; and it implies to the persistence of a contagion in an environment. This can be determined by how long one can expect to recognize the disease in the environment. First, is environmental susceptibility, it means that the health of a host determines the vulnerability of the contagion or infectious disease. Social and environmental conditions also affect vulnerability. Second, some contagions infect instantly and some require time to develop. Third is the ability to develop in a vector. The vector or temporary host acts as an incubator from which the contagion matures for a transmission. A fourth factor is invasiveness. By invasiveness one means that a host's contagion results from an attack from a carrier. The communicability arises when a host or a carrier is a risk to a population; when a host or a carrier is a risk to service providers; and when contaminated service providers are a risk to others. Susceptibility of a host is also a factor. Other factors are curability, preventability, and reducibility.

Notwithstanding the definition, characteristics, and similitude of contagions as summarized, this sectional brings to bear the earliest contagion to infect humans. The first recorded and known bubonic plague is the plague of Justinian. Bubonic, an infectious disease, characterized by swollen, tender; and inflamed lymph glands are the most common plague (Barnard, 2005; Burnet & White, 1979; Drancourt et al., 2004; Khan, 2004; Kupferschmidt, 1993). It is a disease of rodents: marmots. It infects humans when bitten by rats or flea that ate infected rodent. When hosts and the infected flea make contact with humans, blood is regurgitated along with the bacillus into the hosts' bloodstream.

The plague of Justinian occurred in A.D. 541–542. An estimated 40% of the resident and a quarter of the eastern Mediterranean population died as a result. The plague is attributed to grain mostly from Egypt to Constantinople, Turkey. The cargo ships might have been the source of the contagion because of the massive public granaries that nurtured rats and flea population. This account is recently validated by archaeological evidence. A similar but a biblical account also occurred when the Philistines of Ashdod were infected with a similar plague for stealing the Ark of the Covenant from the Israelites (Harris, 2006; IBS, 1984). Their cities and territory were besieged with ravage of mice, causing death to a large section of the population.

Given the emerging and vast number of infectious disease, four contagions are examined below. Each is briefly explained; not as a medical reference, but as epidemic systems. In addition, an attempt is made to avoid medical elucidation of their symptoms. The listed epidemic systems are arbitrarily and alphabetically selected and presented; and the degree of the severity of each was not considered.

Human Immunodeficiency Virus and Acquired Immunodeficiency Syndrome. Human immunodeficiency virus (HIV) causes acquired immunodeficiency syndrome (AIDS) (Stevens, 2008). Although there is no cure for HIV infection, present medications are for prolonging patients' lives and making them feel better. AIDS (with a variety of symptoms) is a serious life-threatening illness. There is also no cure for AIDS at present.

A medical fact is that HIV infections are not possible from sharing water fountain and toilet seats with infected persons; nor is one at risk by touching an infected person. Evidence shows HIV infection is not transmittable through saliva. However, one is at risk through bodily fluids (semen and vaginal secretions usually during sexual contact with an infected person) and blood (Fox & Fidler, 2009; Stevens, 2008). HIV infection is also possible through sharing contaminated (with infected blood) drug injection needles or accidentally in contact with such needle stick. HIV transmission is also possible through blood transfusion, breast milk, and pregnancy and delivery (Csete, Pearshouse, & Symingtonc, 2009).

Singh, Kaur, Sharma, and Mehra (2008) and Stevens (2008) seemed to note HIV infection has a variety of symptoms, depending on the period of the infectivity. Because the system similarities in comparison to human immune system functions, infected persons usually develop illness that immune system could previously prevent (Singh, Kaur, Sharma, & Mehra, 2008). The medical fact is that the number of symptoms and severity increase as long as the person is not treated (Stevens, 2008). The symptoms include swollen lymph nodes, fever, chills, night sweats, diarrhea, weight loss, coughing, and shortness of breath, persistent tiredness, skin sores, blurred vision and headaches, and other infections such as tuberculosis and certain pneumonia (Stevens, 2008; Sulkowski, 2008). In any case, an estimated 33 million people are HIV positive worldwide.

Swine Flu. There are three influenza genera: A, B, and C viruses that can infect (Watts, 2009). Type A is the most common with serious epidemics. Type A or H1N1 is new; and originated from pigs in Mexico and the United States (Blake, Stevenson, & England, 2009). It probably resulted from an abrupt structural change in the virus (Chang, 2009). Because of respiratory organs, transmission of H1N1 among humans, even ducks, chickens, and pigs are possible. It transmits by droplets through cough, sneeze, or touching a flu contaminated surface; and people in crowded environment are at greatest risk.

Watt (2009) explained hemagglutinin (Park, 2009) (H) as a molecule that attaches the virus to any targeted cell; and neuraminidase (N) as an enzyme that helps the viruses to digest through mucous secretions of the host cell. It also assists in releasing the newly synthesized virus. The ‘symptomic’ similarities between H1N1 and the seasonal variety (flu) make it harder to differentiate both. The symptoms include fever, cough, sore throat, runny or stuffy nose, body aches, headache, chills, fatigue, diarrhea, and vomiting (Park, 2009). See Table 5.

Similar swine flu spread (at a military installation in New Jersey, USA) among children and young adults in late 1970 and early 1980s (Blake et al., 2009). Davey (2009) noted that H1N1 is a novel human influenza that spread because novel influenza viruses easily transmit among humans. It is a pandemic for spreading globally and host population has little or no immunity against it. Pandemic is not strictly implying to the severity effects of the flu, although the novel subtypes of influenza could cause more severe illness and death in younger people.

Tuberculosis. Tuberculosis (TB) is very challenging (Shah et al., 2008). Banerjee et al (2008) and Schweon (2009) had the same concern. Worldwide, TB causes the main infectious disease death among adults. With an estimated 489 000 new cases in 2006, drug resistant TB, a type of bacterium, is emerging as a major threat to public health; and the treatment of multidrug-resistant TB (MDR-TB) is 100 times costly compare to treatment of drug-susceptible TB. It requires intensive treatment up to two years with more toxic treatment (Ferguson & Rhoads, 2009). In any case, MDR-TB resists or cannot be cured with standard antibiotics. MDR-TB as resistance to rifampicin and isoniazid was clinically recognized in the early 1990s (Dheda, 2009). The World Health Organization (WHO) and participating international reference laboratories define XDR-TB as

Mycobacterium tuberculosis resistant to isoniazid, rifampin, any fluoroquinolone, and at least one of three injectable second-line drugs: aminoglycosides, polypeptides, fluoroquinolone, thioamides, cycloserine, and paraaminosalicyclic acid (Sharma et al., 2009). It suffices that an estimated 10 million total cases of tuberculosis in 2007, about 5% had MDR-TB whereas 40 000 or 7% had XDR-TB.

TB is mycobacterium tuberculosis infection (Ringold, 2008). It typically occurs after a prolonged exposure of uninfected person to an actively infected person who also coughs. TB can attack any human organ especially the lungs. During latent stages, those with the bacteria may not have the signs of active infection. The symptoms depend on patient's age and the infected organs. Common symptoms are fever and sweating at night), unexplainable weight loss, and loss of appetite. It also includes fatigue, persistent cough associated with bloody sputum, and breathing difficulty or chest pain while breathing.

Reiling (2008) hinted statistically that pulmonary tuberculosis favor the presumption of heredity as the leading (if not) the dominant factor of the TB. However, literature also supports that persons with human immunodeficiency virus (HIV) infection are more at risk for TB. Li, et al (2007) found most drug-resistant tuberculosis among patients undergoing treatment for the disease could reflect new infections. Roth (2009) hinted the possibility that TB during past centuries evolved and generated selective force intensifying the metabolic syndrome and inflammatory processes that associate obesity. Roth views that innate immune system (IIS) consisting of an array of cells, cytokines, and other antimicrobial peptides forms the initial defense against the microbes. IIS is for preventing or controlling infection until pathogen specific responses could be forged by adaptive immune system (AIS). IIS and AIS with B cells, T cells, and macrophages have the capacity to forestall infection and reinfection.

Wanjari, Baradkar, Nataraj and Kumar (2009) articulated that tubercular brain abscess and tubercular cerebellar abscess are rarely reported. Both occur in immune compromised patients. It was noted that the central nervous system (CNS) tuberculosis is the most dangerous form of TB.

Typhoid. Typhoid (an enteric fever) is one of the most serious infectious diseases that concern epidemiologists. Mweu and English (2008) posited Gram-negative bacterium *Salmonella enterica* serovar Typhi causes typhoid fever; and it is attributed to low socio-economic condition and poor hygiene. The literatures support that humans are the most possible known natural hosts and reservoir. There are approximately 21.5 million typhoid cases with 200,000 deaths globally each year.

With statistical data and mapping of disease patterns, Dr. William Budd showed typhoid could transmit through water contaminated by feces (Pierce, 2007). A paradox is that some people could carry the disease without experiencing it. The declines of typhoid associated mortality rate in United States of America (USA) is due to sanitary improvement of municipal water and sewage treatment systems starting from the first half of the 20th century (Lynch et al., 2009). Typhoid fever is usually explained as an acute illness with fever and abdominal softness; the symptoms could be insidious and nonspecific from the beginning (Colomba, Saporito, Infurnari, Tumminia, & Titone, 2006).

In summary, literatures seem to suggest that typhoid fever, tuberculosis, HIV, and swine flu are systemic infections. The diseases qualify as special case of epidemic systems. Each of the diseases has symptoms as attributes and interactions among the attributes produce effect that is more than the summation of the effect of each attribute. Mweu and English's (2008) study revealed the systemness. The systemness seems to arise when the components of each of the perspectives used in this study interact (partially or in whole) to manifest ESF. Parachin (2006) documented Typhoid Mary as an example of typhoid case.

Literature Review Related to Key Variables and/or Concepts

Epidemiologic Systems as Complex General Systems and the Research

Epidemiologic systems are complex systems (Galea, Hall, & Kaplan, 2009). This presupposition seemed to originate from the entanglement within the philosophical sciences (Zexian, 2007). According to Zexian (2007) generalization encompassed complex systems with self-organization and evolution. The work was an implementation of an interactive system. Forrester (2007) emphasized the importance of systems dynamics. Lane and Husemann (2008), and Semetsky (2008) outlined some future characteristics and trend of dynamic and complex systems. Considering complex systems as goal satisfying systems, Nechansky (2009) modeled elements of a cybernetic epistemology.

On the other hand and relating general systems theory with scientific research (Philippe, 2010), Hmelo-Silver and Azevedo (2006) outlined certain primary challenges researchers could confront while studying complex systems such as epidemiologic systems. The outlined factors were cognitive, metacognitive, and self-regulatory processes. The authors emphasized

> [Epidemiologists] needs generic knowledge about the nature of models (physical, formulas, three-dimensional, etc.), domain knowledge, general skills (including cognitive and metacognitive skills and motivational strategies), and scientific reasoning skills, such as hypothesis generation, experimentation, data collection, data analysis, and communication of results. (p. 55)

The complexity includes focusing on disease instead of health; relating risk factors of diseases per a time; disregarding the communities in which individuals live (Fleischer et al., 2006). Zhao, Calder´on, Xu, Hui, and Johnson (2008) discovered even community dynamics could generate complex epidemiology through self-induced amplification and suppression. To solve the problem, the authors' framework (individual and community) encompassing the dynamics of context and population vulnerability and resilience (Fleischer et al., 2006). The authors viewed health as a dynamic process not as a set of risk factors and diseases. Although this study used fuzzy set mathematics, AbouZahr, Adjei, and Kanchanachitra (2007) articulated good researchable evidence grounds on statistical laws. The authors supposed institutional, political, and practices complicate use of data for epidemiologic policies.

It follows that any general systems theory ground research should root on Churchman (1971) five philosophized inquiring systems (as noted earlier). From the assumptions Linden, et al. (2007) discovered four propositions. Given their views, a priori law predominate a posteriori fact; a priori law does *not* predominate a posteriori fact; a posteriori fact predominates a priori law; and a posteriori fact does not predominate a priori law.

Epidemiologic system is also an information system because it generates health data for decision-making (Armenian, 2008). The author acknowledged epidemiologic systems in of complex systems environment. It was strongly recommended that the etiologic factors should be examined with systems analysis tools (methods). For mathematical modeling of epidemiologic systems, see Ulrich, Nijhout, and Reed (2006).

Takahara (2005) examined mathematical general systems theory. To determine the relevance of general system theory, Drack and Apfalter (2007) examined if Paul A. Weiss' and Ludwig von Bertalanffy's system thinking is still valid. The work of Pouvreau and Drack (2007) on Ludwig von Bertalanffy's "general Systemology" seemed to relate epidemiologic systems to cybernetics or systems control. It follows that the authors seemed to agree to the objectives of this study; to seek a dynamic systems control to minimize ESF. This encompasses Ricci's (2009) global implications on health governance.

Forensic Epidemiology: The Selected Toolkits

In the previous section, HIV/AIDS, swine flu, tuberculosis, and typhoid fever were qualified as special cases of epidemic systems. Each of the diseases with associated symptoms and subsystems (diseases) constitute the documented systems. The consideration in this section is to examine selected epidemiologic toolkits. The list is not exhaustive for it excluded microbiology, biochemistry, or virology specific tools that could apply to the examination of epidemic systems. The emphasis however is on biostatistics approach, the emerging theoretical postulations, and a few hypothesized mechanisms.

One begins with a general understanding of forensic epidemiology as a general toolkit. With causation and causal inferences (using measures of disease frequency, measures of association, measures of impact, and their interpretations), Loue (1999) strictly related epidemiology to certain criminal investigations. Loue (1999) considered such epidemiological works of forensic epidemiology; and Koehler and Brown (2010) had the same view. Thus, forensic epidemiology is one of the emerging branches within the field of epidemiology. Koehler and Brown (2010) listed eleven branches of epidemiology and emphasized forensic epidemiology (in relationship to forensic science) is a new field. See Table 6.

Irrespective of various assumptions about forensic epidemiology Goodman, Manson, Dammers, Lazzarian, and Barkley (2003) speculated that Dr. Ken Alibek referred any investigative epidemiology as forensic epidemiology. Dr. Ken Alibek included both natural occurring epidemiological and manmade epidemiological happenings. Thus, forensic epidemiology encompasses criminal and noncriminal investigation of disease outbreak. Using systems approach, Duncan (1988), Gordis (2004), Koehler and Brown (2010) related forensic science to epidemiology. Duncan (1988) narrated how epidemiologists investigated the 1976 mysterious disease outbreak in Philadelphia. A general understanding Koehler and Brown, (2010) posited that forensic epidemiology is an interdisciplinary science: epidemiology and forensic science.

A very restricted (narrow) definition according to Koehler and Brown (2010) is that forensic epidemiology is the application of epidemiologic science to law.

Den et al. (2007) related an investigation of infectious disease outbreak to a forensic science method. Using an approach similar to a forensic method, Briese, Glass, and Lipkin (2000) established a sensitive and specific real-time method for detecting West Nile virus. The 1999 New York outbreak analysis showed the presence of viral sequences in cerebrospinal fluid. The case involved four hosts with fatal outcomes of which one survived. In another study, Lewis, et al. (2002) considering nonintentional disease spread and seemed to suggest forensic method could apply to noncriminal (infectious) disease outbreak cases. Robertson, Nelson, MacNab, and Lawson (2010) had a similar assumption when reviewing some methods of analyzing space–time disease surveillance data. In practice, Robertson, Nelson, MacNab, and Lawson (2010) suggested many factors determine appropriate methods for disease surveillance. Using contextual factors such as scale, scope, surveillance objective, characteristics of disease, and technical issues, Robertson, Nelson, MacNab, and Lawson (2010) quantified forensic science (in relation to commonly used approaches to surveillance) without legal consequences or application. See Figure 2 for clarification.

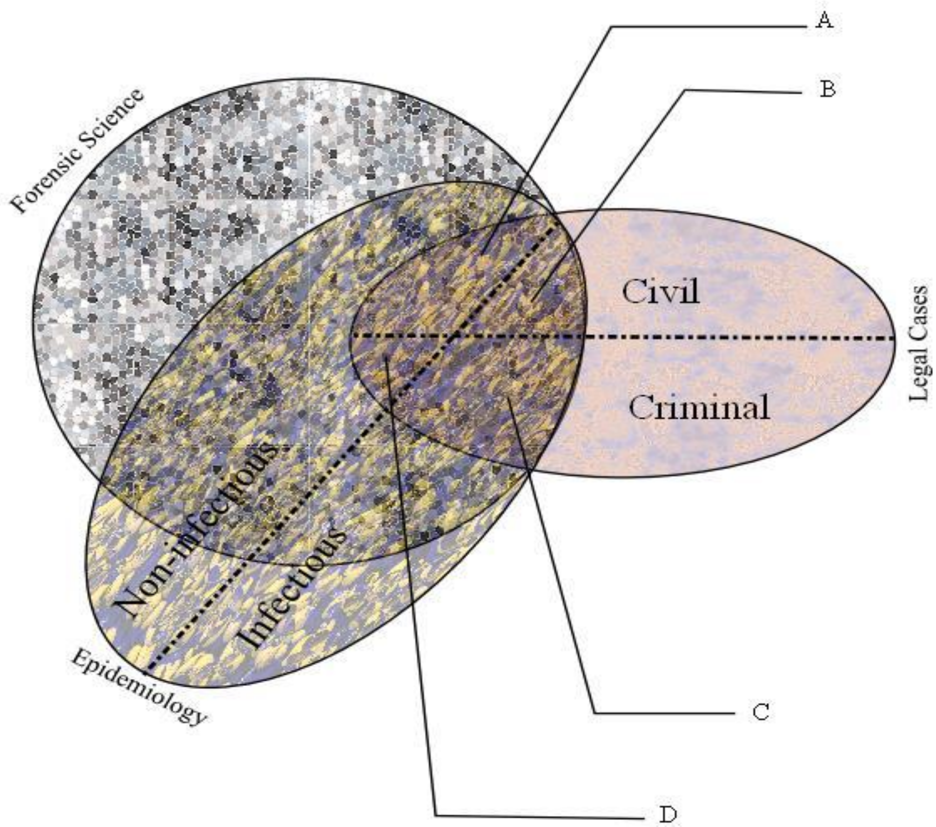


*Figure 2.*Determination of forensic epidemiology

Based on the aforementioned literatures in this section, figure 2 is deducible to forensic science, law and epidemiology. The figure helps classify and clarify forensic epidemiology, a field that is conflictive or ambiguously defined in various literatures. Den, et al. (2007), Robertson, Nelson, MacNab, and Lawson (2010), Duncan (1988), Koehler and Brown (2010), and Goodman, Manson, Dammers, Lazzarian, and Barkley (2003) held different definitions. The figure shows the three primary forensic science, law (criminal and civil), and epidemiology (infectious and noninfectious disease) discipline. It is clear that the three fields intercept and form A, B, C, and D regions as shown in the figure.

Region A represents noninfectious disease epidemiology that has civil case over tone; region B is infectious disease epidemiology that has civil implications. Region C has criminal implication within the application of infectious disease epidemiology whereas D region has criminal implications within the field of noninfectious disease epidemiology. Regions A, B, C, and D (usually assumed as forensic epidemiology because of legal application) generally is legal medicine. It is obvious that Beran (2010) considered this interception as legal medicine. It is however clear from the figure and the literature, forensic epidemiology is the regions where forensic science intercepts epidemiology.

A careful review of Restif's (2009) work elucidated that forensic epidemiology includes nonlegal investigation of infectious diseases. To this end, Yan, Zhoub, Weia, and Zhang (2008) used a qualitative investigative method to study the difficulties of early detection of infectious disease outbreak in China. Wagner, Dato, Dowling, and Allswede (2003) inferred that forensic epidemiology could relate to criminal investigations (cases) involving biological (bioterroristic) agents or biological agents caused by nature. Ihekweazu, et al. (2010) are also in support of the generalized view about forensic epidemiology, Freeman and Kohles (2010) used a Bayesian perspective to relate forensic biomechanics to forensic epidemiology. Furthermore, Freeman, Rossignol, and Hand (2008) demonstrated the reliance of forensic science and epidemiology on biostatistics or probabilistic (statistical) theories. Conceivably, forensic is a methodical science of data collection and analysis. See Table 7 for other fields of forensic science.

Biostatistics

In determining disease outbreak, epidemiologists consider when disease occurred, when it began, and the incubation period. Barnett (1994), Coughlin (1998), Philips (1973), and Runyon (1981) inferred that the analysis includes the use of attack rate or (incident rate), $AR = \frac{n}{N}(100)$ where n is the number of people at risk and have the disease, and N represents all persons at risk. The analysis considers who is infected, when the infection occurred, and where the infection took place. There are also morbidity (Incident and prevalence) and mortality (case-fatality rate and proportional mortality) measures among others. Incident rate $IR = \frac{x}{Y}(1000)$, where x is new cases of a disease at a specified period; and Y is people at risk at the period. Prevalence or $PR = \frac{p}{P}(1000)$, where p is cases of people with the disease in a population at a period; and P is the population at the time. Case fatality rate or $CFR = \frac{d}{D}(100)$, where d is the number of infected persons who died during diagnosis; and D is the number of persons who have the disease. Proportional mortality is determined with $CFR = \frac{d}{P}(100)$, where d is the number of deaths due to a particular disease in a given period; and P is the total death in the period.

Fuzzy Sets

Therefore, any mathematical assertion could be formatted with set theory. From the works of Massad, Ortega, de Barros, and Struxhiner (2008) and Helgason, and Jobe (2003) among others, fuzzy set theory could be considered an epidemiologic toolkit. A set contains elements; and a set of all sets is usually called the universal set X or U (Clark, Larson, Mordesen, Potter, & Wierman, 2008). A typical U consists of real numbers. With the theory, one could determine elements that are or are not in a given set; and in the case of fuzzy set, that partially belong in it. To specify a set, one could use the explicit listing of the elements; specification of the required properties; or characteristic function method.

The characteristic function of fuzzy sets is useful for this study. An example of a standard set having values greater than or equal to ten is $X_A(x) = \begin{cases} 1 \text{ if } x \geq 10 \\ 0 \text{ otherwise} \end{cases}$. Such a fuzzy set of unlike a standard set, a fuzzy set could assign membership values $f(\bullet) \mapsto [0,1]$ assigns numbers between zero and one to any U subset (Buckley and Eslami, 2002). Bojadziev (1995) emphasized the degree of membership such that each element could belong partially to another such set or the universal set by complementation. Let $f_\mu(A)$ be the value of an element μ belonging to A (Ulinwa, 2008); and $f_\mu(0) = 0$ and $f_\mu(1) = 1$ are boundaries where fuzzy set A could be written as $A = \sum_{i=1}^{n} x_i / \mu_i = \{x_1 / \mu_1 + x_2 / \mu_2 ... x_n / \mu_n\}$. The plus sign separates the elements. The "/"separates an element and its value. The x_1 / μ_1 indicates that x_1 value belongs to μ_1 element of U .

Fuzzy numbers could be defined with linguistic (numeral) variables (Zadeh, 2015). A quintuple (x, T(x), U, G, and M) makes a linguistic (numeral) variable. In this case, x is a variable; $T(x)$ is a variable set in the universe U; whereas G is the rule generating the linguistic (numeral) values; and M conveys the meanings of the values (Moses, Degani, Teodorescu, Fiedman, & Kandel, 1999). A linguistic (numeral) variable (usually in form of laced labels) specifies a focal point of a measurement or fuzzy sets. See Figure 3, where N represents normal state; SN means somewhat normal; SF means somewhat failed; and F means failed ES.

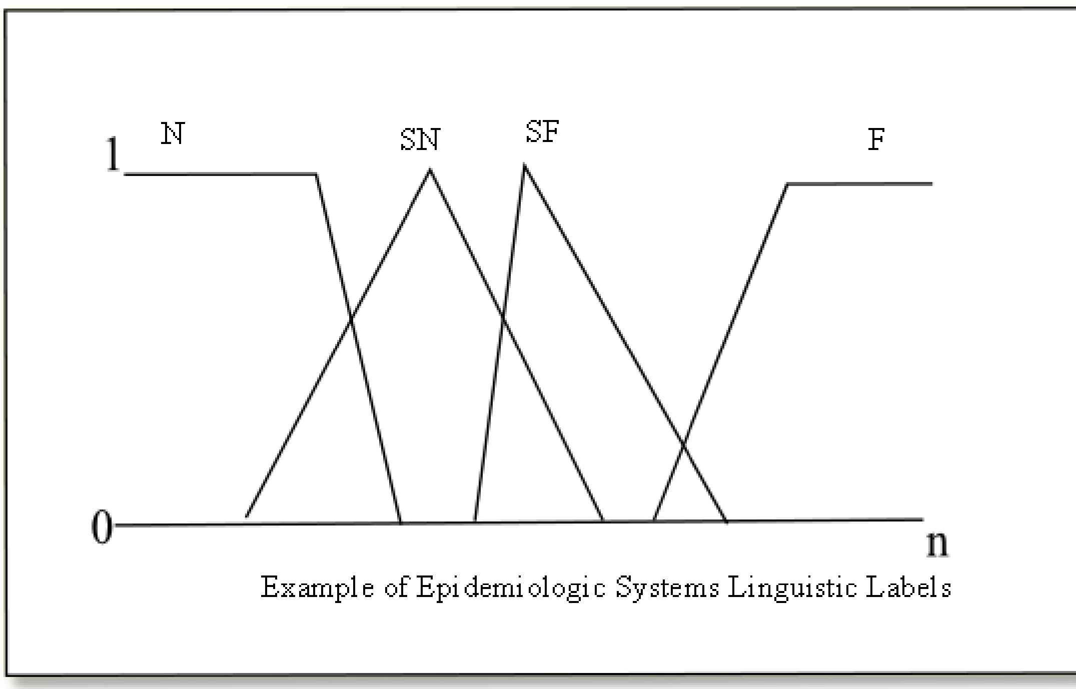


Figure 3. Epidemiologic systems fuzzy linguistic (numeral) variable

$$A(x) = \left\{ z \begin{cases} 1 - \dfrac{|x-a|}{s} & \mathrm{a - s \le x \le a + s} \\ 0 & \text{otherwise} \end{cases} \right.$$

forms a triangular fuzzy set (as shown in Figure 2. The left and right trapezoidal sets are from trapezoidal membership functions. See Tanaka (1996).

The parameters are *z*, *x*, *a*, and *s*. A normal fuzzy set has an element having a unit grade or $\max_{x \in X} \mu_A(x) = 1$ (Kandel, 1986). Fundamentally, the number of elements of the set is $|A| = \sum_{x \in X} \mu_A(x)$. According to Tanaka (1996), and Ulinwa (2008), two fuzzy sets (A and B) $\mu_{A \cup B}(x) = \mu_A(x) \vee \mu_B(x) = \begin{cases} \mu_A(x) & \text{if } \mu_A(x) \geq \mu_B(x) \\ \mu_B(x) & \text{if } \mu_A(x) < \mu_B(x) \end{cases}$ is the union operation. Their interception $\mu_{A \cap B}(x) = \mu_A(x) \wedge \mu_B(x) = \begin{cases} \mu_A(x) & \text{if } \mu_A(x) \leq \mu_B(x) \\ \mu_B(x) & \text{if } \mu_A(x) > \mu_B(x) \end{cases}$ and their complements $\mu_{\bar{A}} = 1 - \mu_A(x)$ and B or $\mu_{\ddot{B}} = 1 - \mu_B(x)$ are equal if i^{th} corresponding membership degree of one set is equal to the i^{th} membership degree of the other. $A_i \leq B_i$ imply A is a subset of B.

Massad, Ortega, Struchiner, and Burattinia (2003) reviewed the application of fuzzy set theory in epidemiology using possibility linguistic (numeral) fuzzy measure and models. The applications to epidemic research seemed promising. For example, fuzzy risk ratio $FRR \propto poss \dfrac{D \mid E}{D \mid \bar{E}}$ (where *poss.* is a possibility measure) is equivalent to a standard risk ratio $RR = \dfrac{D \mid E}{D \mid \bar{E}}$. Given that Greenland (1987) considered four possible theoretical individuals, Massad, Ortega, Struchiner, and Burattinia (2003) and Massad, Ortega, Barros, and Struchiner (2008) provided the equivalents. One is the doomed or an individual who would independently develop (whether exposed or not) certain disease. The second type, the resistant or individual who would never develop (whether exposed or not) the disease. The third is the protected. This individual develops the disease even if not exposed to the cause. The fourth is the 'at risk' individual, who develops the disease because of exposure. The heterogeneity of the classification assumed a high degree of several uncertainties because of the class definitions. The following fuzzy possibility individuals and their respective risk categories are useful for determining fuzzy odd ratio estimator $FOR = \frac{poss(\overline{D} \mid \overline{E}) \wedge Poss(D \mid E)}{poss(D \mid E) \wedge Poss(D \mid E)}$ that is comparable to a standard odd ratio estimator $OR = \frac{(\overline{D} \mid \overline{E})(D \mid E)}{(D \mid E)(D \mid E)}$.

Massad, Ortega, Barros, and Struchiner (2008), Nguyen and Wu (2006), and Manton, Woodbury, and Tolley (1994) demonstrated how fuzzy statistics could be applied to disciplines like epidemiology and public health. Buckley (2004) exemplified how such statistics could be simulated and modeled. One of the demonstrations showed that fuzzy mean of a normal probability density is a triangular fuzzy number. For fuzzy set methods applicable to epidemiologic systems see the works of Buckley and Eslamni (2002), Nguyen and Wu (2006), Clark, Larson, Mordeson, Potter, and Wierman (2008), Buckley (2004), Manton, Woodbury, and Tolley (1994), and especially Massad, Ortega, de Barros, and Struchiner (2008).

The Multiple Perspective (TOP) Filters

The multiple perspective inquiring method is one of the contemporary research toolkits. Multiple perspective inquiring method is a Singerian approach with technical (T), organizational (O), and personal (P) filter (Linstone, 1984). The T-filter is quantitative and the science quantifies epidemiologic systems failure (ESF) if the problem is mathematically measurable. Because there are sets of health policies that guide contagion control such as quarantine policies, O-filter focuses on legislations that contribute to ESF. O-filter reveals legislated compromise and routine between technocrats and interest groups.

The P-Filter is very subtle. The subtlety is because of perceptual, political, economic, and social outlooks of ESF. These factors are inseparable from the mental models for designing this study. Hall (1989) and Linstone (1984) noted similar observations when studying complex systems similar to ESF. Therefore, P-Filter is the human persona for understanding ESF. This method is known as TOP model.

In summary, literatures suggested that biostatistics are good in the world where a person is either ill or well; whereas fuzzy set statistics are for real world where a person could be partially well and ill due to uncertainties. GIS makes it possible to embed fuzzy set theory or biostatistics when mapping spatial data about disease. TOP is the interface for communication and analysis. It brings the three foci of research tools for this study.

2010 to 2016 Selected Literatures

The intent to select the following literatures was not to close the gap in the literature, but to examine the advancement made since 2010 to 2016 to support this study. Therefore, from Adams, Hester, Bradley, Meyers, and Keating (2014) it could be deduced that the purpose of systems theory is to examine from various scientific fields of the isomorphic of laws, concepts, and models. Thus, science theory helps develop theoretical models in fields lacking them and interchanges ideas among the fields. Moreover, the science eliminates the duplications of models among the fields. In addition, science theory advances scientific unity and communications among experts in the various fields. The authors furthered that

> Systems theory is a unified group of specific propositions which are brought together to aid in understanding systems, thereby invoking improved explanatory power and interpretation with major implications for systems practitioners. It is precisely this group of propositions that enables thinking and action with respect to systems. However, there is no one specialized field of endeavor titled *systems* from which systems theory may be derived. Rather, the propositions available for inclusion into a theory of systems come from a variety of disciplines, thereby making its underlying theoretical basis inherently multidisciplinary. (p.113).

Adams, Hester, Bradley, Meyers, and Keating (2014) therefore conceived a definition of systems theory as

> a population of propositions that ... explains a [real system in terms of a] large set of observations or findings. Those constituent findings are the product of scientific research and experimentation, those findings, in other words, already have been verified, often many times over, and are as close to being 'facts' as science cares to characterize them. (p.115).

Agreed with Adams, Hester, Bradley, Meyers, and Keating (2014), Chan (2015) stated that the theory of systems thinking enables systems thinkers to understand how the whole is greater than the sum of the parts. Therefore, the derived holistic solutions simultaneously address many scientific problems.

The field of public health is included among the field of systems science. Frerichs, Lich, Dave, and Corbie-Smith (2016) linked the idea by stating that the existing gaps in health outcomes, despite researches addressing health disparities, because of epidemiologists ignoring systems science or the theory. The authors pointed the interactions among biopsychological sciences, socioeconomic status, and environments. The interactions give rise to health disparities not easily examined by any of the reductionist methods such as biostatistics, regression, and randomized controlled trials. Frerichs, Lich, Dave, and Corbie-Smith (2016) therefore strongly suggested to link systems thinking with systems theory such as living system theory. Thus such linkage could improve the knowledge about factors that shape health disparities.

Jeanquartier, Jean-Quartier, and Holzinger (2015) posited that appreciating living systems theory is important for preventing and curing infectious diseases. The acceptance, Dubois and Holmberg (2010) argued, should stem from the fact that as living system theory a comprehensive theory about all living systems: their structural, interactive, behavioral development. Miller (1995) therefore enhanced the science of public health by advancing relevant living systems research knowledge into a general framework.

Forrest (2014) used the idea to advance a new proposition. The author used a new theoretical perspective of living systems to differentiate and delineate health construct. Forrest (2014) started by assuming that health enables and helps human capacity to thrive and survive in physical and social environments. According to the author, health is a collection of assets. The assets (interacting at the whole of a person) are the scopes of energetics, restoration, mind, reproduction, and capabilities. It is the assets of living things that help them adapt to environmental challenges, needs satisfaction, life gal attainment, or survival. Considering living systems as complex adaptive systems, Banerjee (2016) emphasized that physical space also plays an important role in their being alive.

Unsatisfied with the foregoing approach to living systems theory, Beer (2015) hinted that what are differentiating a living system from those that are not are the organizational processes supporting the structure. Beer (2015) called it autopoietic or self-producing. According to Sayin (2016), the whole is greater than the sum of the parts is one of the axioms or postulation of systems theory because

> Constructing a System Theory (ST) is a method to establish a logical, mathematical, self-consistent, self-existing, coherent model to explain the interactions of the elements, functions and development of a closed or open system. *System Theory* (ST) is very important to define, organize, evaluate, control, regulate the systems and form mathematical models in a set of elements of that particular system. (p.126).

Therefore, Beer (2015) and Laflamme (2014) would assert that autopoiesis is a well-known method of defining living systems that satisfies whole is greater than the sum or list of the parts. Bellomo and Soler (2012) pointed out that abstracting and modeling the dynamics of a living system is challenging. The research objective requires mathematical endeavor that could capture the figural and featured complexity of these systems. The research method should describe or narrate how the living system develops specific interactions with other systems.

Systems do fail sometimes. It could be deduced from Mair (2012) that epidemiologists in comparison to other health professionals are versed in need of systems tools that would avoid (human or nonhuman) mishaps. Failure to identify process mishaps could lead to a total systems failure. Mair (2012) illustrated this with a hospital setting. The author imagined performing a wrong limb or organ or giving the wrong medications to a wrong patient. Healthcare institutions are well aware of the possibilities of these mishaps. Thus, it is possible that different factual circumstances could lead to societal action as seen in Ebola crises where residents of parts of Monrovia in Liberia revolted for housing Ebola patients in their neighborhood.

Carney and Weber (2015) acknowledged that health crises such as infectious diseases could expose systems process, policy, or response failure. The authors summed that the underlying failures “is deficiencies in actionable intelligence that inform process, policy, and responsiveness” (p.9). Williamson, Bathiany, and Lenton (2016) termed such failure a complex system tipping point. The tipping point requires serious monitoring because according to the authors

> Abrupt change in a system can occur due to a bifurcation – that is, a small smooth change in parameter values can result in a sudden or topological change in the system’s attractors. (p.313).

To somewhat actualize Carney and Weber’s (2015) concerns, Malilay, et al. (2014) listed some of the roles of “applied epidemiology methods in the disaster management cycle” (p.11).

In a verge of new epidemiological challenges for epidemiologic research methods, Tong, Neale, Shen, and Olsen (2011) highlighted the increase interest in advancing public health from a risk factors-based discipline. The authors suggested the advancement as a discipline concerned with complex causal patterns. Such patterns operate in “different levels in time and space (e.g., from the molecular to the population, from the past to the future, and from the distal to the proximal)” (p.689). Despite the methodology needs continuous refinement and improvement, the authors maintained that the method is necessary because the state of health status of any given population changes over time. Thus epidemiology needs to evolve as the state changes. Moreover, certain biomedical researches are observational in nature in comparison to experimental ones that are often impracticable because of ethical reasons.

To summarize, Zubillaga, et al., (2014) it very important to consider means to reduce thermodynamic entropy. To maintain themselves, living systems requires the reduction in order to satisfy the axiom or concept of self-organization. Thus measuring systems complexity or dynamics requires reconciling (balancing) two opposing views: order and chaos.

Gap in the Literatures

There are gap in the literature because some authors (as examined in this section as well as in the entire literature review) focused on the technical or organization aspect of epidemiologic systems. Others sampled the personal perspective to test the effectiveness of the technical (pharmaceutical effect). It is necessary to include the personal perspective to determine an effective epidemiologic system.

Ebola crises remind the school of Epidemiology the need to minimize ESF. The crises were mind boggling to the extent House (2014), Farmer and Mukherjee (2014), and Gate (2015) implicitly reasoned about ESF. House (2014) explained and described the epidemiological dynamics of the Ebola outbreaks. Given the crises, Gate’s (2015) presupposed that health system be comprehensive and ready for future epidemic system. The author argued that emerging epidemic systems will spread effectively when compared to the Ebola.

No sooner did Gate (2015) posit some concerns about emerging infectious diseases that Zika virus began to threaten human health. Fonseca, et al., (2014) reported about a Canada traveler who contracted Zika virus (ZV) in Thailand. The authors noted that the Canadian was wrongly categorized as having a case of dengue fever based on an established clinical and epidemiologic history, and preliminary laboratory investigations. It was urine samples indicated she had ZV despite measles, malaria, and dengue tests were conducted. Gourinat, O'Connor, Calvez, Goarant, and Dupont-Rouzeyrol (2016) noticed that during an acute (viremic) phase ZV can be misdiagnosed because of nonspecific influenza like symptoms.

Roth, et al., (2014) historically stated that Zika (the mosquito-borne disease epidemic) is becoming frequent and diverse. There was the possibility that 2012 was the earliest stage of the continuous wave. To minimize the wave the authors urged for improved surveillance and response measures. Such quick response would mitigate future spread to other countries.

Buathong, et al., (2015) categorized that Zika virus (ZV) is a serious emerging pathogen explanatorily described in 1952. It was isolated in 1947 from a controlled rhesus macaque monkey in 1947 and in 1948 in a pool of *Aedes africanus* mosquitoes in Uganda Zika forest. A few cases noted in Africa and Asia before 2007. Later there was a major outbreak in Yap Island in the Federated States of Micronesia. French Polynesia had laboratory-confirmed 396 cases in 2013 with about 29,000 individuals seeking health care for ZV like illness. Suggestively, humans are the primary amplification hosts in nonhuman primate environments.

Enfissi, Codrington, Roosblad, Kazanji, and Rousset (2016) catalogued about a hospitalized 52-year-old man with exanthema and conjunctivitis in Paramaribo, Suriname. In few days later four patients were admitted with similar mild symptoms that included exanthema. All the patients were ZV positive. Gourinat, et al., (2016) gave similar account to the authors and Buathong, et al. (2015).

Jessica Glenza (2016) reminded that there were no vaccines for ZV and methods of eradicate mosquito are inadequate. Shocking is the learning that ZV (despite being a mosquito-borne virus similar to West Nile virus) is also sexually transmittable diseases. Jacob (2016**)** announced that the CDC travelers to ZK infected areas to use condoms and refrain from having sexes with pregnant partners. McNeil (2016) amplified that the World Health Organization warned that people in ZV infected should delay being pregnant.

Samarasekera and Triunfol (2016) hinted that a number of people with ZV will not show clear symptoms. Symptoms usually lasts a week for those (one in five) individuals that could show symptoms. The authors concurred that the most symptoms are conjunctivitis, fever, joint pain, and rashes. Severe disease requiring admission to hospital is uncommon. The authors noted that standard methods used by the government of Brazil seemed not to work. One of the methods was through education. The Brazil Government through the military forces visited and educated households on how to control the vector. The Health Minister (Marcelo Castro) and the Brazil President Dilma Rousseff admitted that the country could not stop the vector: he mosquito. Some Brazil health experts noted that Brazilians were not doing enough to stop mosquitoes breeding in stagnant water. The others experts suggested that the government should instead fund mosquito eradication research projects.

McNeil (2016) examined the new findings. The author observed that new evidences are emerging, and the recent findings are rigorously disputed. Although experts acknowledged ZV is mosquitoes borne disease, two reports now suggest that women in Latin America were likely infected more than men. In addition to mosquito bites, a new worry is the emerging transmission vector: sex. In spite that United States health officials want all pregnant women who visited countries affected with ZV to be tested, Santora (2016) documented that many who live in New York City were not tested.

Jacob (2016) and Glenza (2016) acknowledged that the US president Obama requested about a billion dollars fund for ZV. However, the congress did not work on it before taking a break. The failure of the bill was the inclusion of partisan amendments. The failure might have an international impact. Given non passage of the bill, Siddiqui (2016) reported an official of the US government saying such actions cause people to hate the US Congress. The administration sounded the seriousness to get the fund. The CDC director stressed the congressional approach to funding ZV is not sound method of handling the communicable disease. Herszenhorn (2016) however noted that the Senate Democrats blocked the spending bill because Republicans sabotaged the bill with partisan charged provisions. Therefore the fund would not be available 2016 summer break.

In any case, Gate (2015) scantly emphasized the critical need for reinforcing basic public health care facilities, laboratories, and surveillance systems. Gate (2015) noted the lack of trained medical technocrats knowledgeable about Ebola during the crises. For example, it took about three months for countries that had experts to respond for what would have taken three days. To solve such dilemma, Gate (2015) suggested that there is a need for global health warning and response system including research and development, fast decision making system, and clarification of regulatory method for developing new tools and approaches. Therefore, such daily scalable health system (expandable during epidemic crises) should encompass early warning and detection subsystems. The technocrats should include reserve trained personnel and volunteers.

Gate (2015) echoed Farmer and Mukherjee's (2014) concerns. Farmer and Mukherjee (2014) worried that countries affected by the crises needed ''staff, stuff, and systems" (p.1). In the identified West Africa countries, Ebola cases exceeded 2,200 with about 1,200 deaths. As the Ebola crises raged, Sturchio (2014) articulated that Ebola epidemic system had exposed the underlying ESF.

Pitman, et al., (2012) reminded that it is the transmissibility of infectious diseases differentiates them from other diseases. With the reminder, Garner and Hamilton (2011) suggested that epidemiological modeling (which vary from deterministic mathematical models to complex spatially and explicit decision support systems) is useful for developing health policies and disease control. However, the authors acknowledged that models could vary based on the used research approach, the purpose of the study, how the epidemic system is well- understood, and the data quality. In addition to these variations, the authors noted that the technical and scientific background and experience of the modeler are very important. To this concern and notification, Galea, Riddle, and Kaplan (2009) agreed that epidemiologists

> Remain concerned with looking for individual causes of individual diseases, and noting the mismatch between our methods, our outlook and the hunt for individual cause–disease relations, the chorus of epidemiological voices expressing concern is rising. (p.102).

The authors furthered that complex systems models integrate knowledge about multilevel causes of health patterns and the associating feedbacks to inform epidemiologists' knowledge about policy interventions. While compartmental models are very artistic and scientific inquiry into epidemiologic science, they are not necessarily the panacea or solutions to all the epidemiologic challenges facing epidemiologists who are grappling with causal thinking.

Auchincloss and Diez-Roux (2012) agreed because traditional epidemiologic designs and biostatistical approaches are unsuitable for examining the dynamic processes of epidemic systems. The limitations of the traditional epidemiologic including biostatistical designs constrained the research questions asked, the received answers, and the hypotheses (assumptions) or the developed theoretical explanations. The authors alternatively suggested agent-based models and other systems-dynamics models. They argued that these alternative approaches might help address some of the challenges.

From the foregoing, complex epidemic systems abound. Luke and Stamatakis (2012) categorically stated that such complex systems are characterized by interactive heterogeneous elements. Moreover, such systems persist over time and adapt to circumstantial changes. In any case, identifying or understanding each of the elements is insufficient for explaining the systems emergent properties. Compounding the interactivity of the elements is the possibility and the risk probability an individual being infected at any point in time. This force of infection relates to the individuals infected in the population, which change over time, and the effect (feedback) for future infectivity force. These nonlinear interactions are necessary for modeling communicable diseases. Rasmussen (2014) combined Markov chain Monte Carlo and Bayesian inference method to illustrate the idea.

With a compartmental (delayed SIR epidemic) model satisfying a logistic equation, Rihan and Anwar (2012) investigated the qualitative behavior of the model guarantying an asymptotic stability with matching steady states. The delayed differential equation model was stable and illustrated with numeral simulations. The illustrated analysis addressed the theoretical and behavioral results of the system.

Not using a breadth and depth method as I used in this study poses danger on monitoring epidemic systems. Roach, Gostin, Hougendobler, and Friedman (2014) cautioned that the West African Ebola crisis was an international public health peace and security threat. The threat was a result of ESF. However, Ebola system was not the only health crisis that manifested ESF. The earliest was Typhoid crisis labeled Typhoid Mary. The most recent and remarkable one is the tuberculosis involving Andrew Speaker. Each of these crises had qualitative and vague uncertainties; and these qualitative parameters require a robust modeling technique. Most of the literatures I examined did not account for uncertainties or vague data. I used fuzzy sets to represent all types of data.

Among the research methods I reviewed, the fuzzy methodology is the most appropriate and relevant for this study. The methodology had been used to study diseases. Pizzi (2013) noted that infectious disease modeling is an interdisciplinary tool and activity within the school of public health. Fuzzy set method along with artificial genetics algorithms and artificial neural network consist soft computing. Fuzzy set suite is a set of techniques and strategies that effectively handle imprecise, approximate, and vague or uncertainties scenarios.

The following are summaries of fuzzy soft computing techniques applied in infectious disease modeling. Pizzi (2013) encouraged public health community to fully accept soft computing. First, Barros, Oliveira, Leite, and Bassanezi (2014) considered environmental and demographic fuzziness. The varying environmental and demographic uncertainties as parameters were modeled by fuzzy set method with differential equations. Each of the state variables and associating variation rates were linguistic (numeral) relating with fuzzy rules. The authors posited that given their results it is possible to obtain relevant information in any given study. They encouraged public health community to apply fuzzy method to more complex epidemiology.

Second, Jafelice, Silva, Barros, and Bassanezi (2015) studied the evolution of CD4+ T lymphocytes infected with HIV-seropositive individuals under antiretroviral treatment. The model consisted of system of delay-differential equations such that the delay was represented by a fuzzy number. Pharmacological and intracellular delays influenced the uncertainty. The authors seemed to suggest that their results were qualitatively equivalent with an ideal or realistic solution.

Third, Ntaganda and Gahamanyi (2015) solved a hepatitis B virus problem with fuzzy sets. The authors tested the efficiency of their method through a numerical comparison. They took the values of determinant parameters of the disease for people administrating the drugs. The comparison showed that the final results of the numerical methods matched the experimental data.

Four, Bhatia and Kumar (2015) implemented a version of soft computing technique called fuzzy cognitive maps (FCM) for detecting the presence or absence of diabetes mellitus. The idea was based on the input sign or symptoms recorded at three fuzzy levels that were developed by the domain experts. With 50 cases the software tool was 96% accurate.

Five, Silveira and Barros (2015) examined dengue disease with a fuzzy model. Dengue is an infectious disease transmitted through the bite of the *Aedes aegypti* mosquito. Dengue is common in tropical and subtropical areas such as Brazil. Like other authors, Silveira and Barros (2015) used a variation of soft computing. Using the Takagi–Sugeno model a partial differential equation represented the consequence of each fuzzy rule. Furthermore, the uncertainty parameters given as κ_i, represented the risk of spread of the dengue. The parameters were concomitant to the mosquito population behavior and depended on the population of humans' blood. Period simulations of December, January, and February results showed that dengue reduced.

Lastly, Emokhare and Igbape (2015) researched that the Ebola Hemorrhagic Fever (EHF) had up to 90% mortality rate given the affected. The authors emphasized urgent necessity for effective diagnostic procedures. The authors tested their idea with fuzzy logic. EHF symptoms (muscle pain, temperature, bleeding, vomiting, and diarrhea) from those with the Ebola virus were represented with fuzzy in linguistic (numeral) terms. The author noted the quick approach of fuzzy system compare to manual laboratory diagnosis that takes long. The system also reduced quarantining a healthy persons or falsely subjecting wrong people to laboratory processes. As an Ebola virus early detection system, Emokhare and Igbape (2015) concluded that the fuzzy system reduced is useful in reducing the virus spread.

Emerging technology would be enhancing how data about epidemic systems are collected, analyzed, and reported. In this regard, Lamb, Paul, and Dredze (2013) noted that Twitter has proven to be a quick and reliable means to monitor and collect data about diseases. With Twitter, the authors demonstrated the significant improvement in influenza disease surveillances.

Given any of the outlined infectious diseases in this study, there are noticeable degrees of ESF. With this study I succinctly considered and used the technical, organization, and personal aspects of epidemiologic system to close the gap in the literature. The usage is in chapter four and chapter five.

Summary

This chapter documented the body of theories for epidemiologic systems failure. The scope covers the general systems theory, selected epidemiologic systems, and the facets of epidemiologic systems and problem solving. The chapter highlights three frameworks by examining micro (human) level, macro (societal) level, and meso (interaction between humans and societies) levels. It also documents the foundation for modeling the interactions among humans, contexts, and the relations. It provides the researcher a frame of reference for the research findings and future studies.

HIV/AIDS, TB, Typhoid fever, and swine flu are summarized as examples of epidemic system. In addition, selected epidemiologic tools such as fuzzy set, GIS, biostatistics, and TOP are summarized with the understanding of Ashby's (1956) law of requisite variety. The law implied what to look for such that a toolkit should have as much variety as the problem it tends to solve. The examined literatures (peer-reviewed journals and books) are obtained from Walden University and Portland State University, and Oregon Health Science University. In addition to the primary search engines such as Sage, Academic Search Premier, or Science Direct among others, Google Scholar and Bing Internet search engines were used. It is still possible that unknown findings could emerge from literature not included in this review. See Table 8 for the main searched terms.

Chapter 3: Research Method

The purpose of this triumvirate mixed-methods case study was to examine factors undermining infectious disease control or prevention. Since William Farr used biostatistics to study cholera (Gordis, 2004), epidemiologists have relied on basic science as the tool for discovering solutions to epidemiological phenomena (Gordis, 2004). Conversely, Gordis (2004) noted that John Snow used an observational method to exemplify an alternative research method. I avoided the common typicality of biostatistics because the factors characterizing ESF may show the inadequacy of biostatistics.

This chapter consists of the research design and rationale, methodology, research questions, instrumentation, data collection and analysis processes, and research reliability and validity. The design and methodology sections depict how the research was conducted. Following this section, I present the research questions. In the subsequent section, I describe how the data were collected, processed, and analyzed. I explain the method used to validate the data in the validity and reliability section.

Research Design and Rationale

There are several research tools available for qualitative and quantitative studies. Massad, Ortega, de Barros, and Struchiner (2008) seemed to suggest that the nature (the data representation) of ESF may require a dynamic fuzzy set data structure. The fuzzy set data calibration techniques I used in this study are suitable within the framework of multiple perspectives for representing, analyzing, and reporting the research findings. According to Angelov (2010) and Massad, Ortega, de Barros, and Struchiner (2008), a dynamic fuzzy set data structure is a graded scale suitable for qualitative and quantitative studies, making it appropriate for this ESF research. My expectation was to have a reliable and valid study.

In addition, I used pictorial and secondary data motivated by Glaser and Strauss's (1967) grounded theory in building a theoretic model. The theory is a set of relational concepts or themes that explain a given phenomenon. Additionally, researchers use the multiple perspective method to focus on a single perspective while holding other perspectives constant (Glaser & Strauss, 1967). Use of multiple perspectives helped in explaining ESF according to different assumptions. The fuzzy set theorem is used to articulate the characterization of ESF. The assumption, according to Zadeh (2015) and Zimmerman (2010), is that most phenomena are characterized by qualitative and quantitative data. In such cases, yes or no are not adequate, but conflictive. By using fuzzy sets, I was able in this study to describe and explain ESF in a better manner than had I used standard biostatistical methods.

To bridge how epidemiologists and other biological professionals examine ESF, I considered the scholarly and expert opinions of authors of scholarly journal and professional proceedings articles on contagious diseases. For example, the works of Leavitt (1996) with media documentaries on the topic served as germinal studies. Specifically, I accessed public health, epidemiology, and medical articles in Sage, ProQuest, Lancet, and databases for related proceedings. Libraries at Walden University, Portland State University, and University of Minnesota served as data collection centers.

Research Questions

I sought to answer two research questions in this study. The first question focused on discovering of the extremely volatile factors causing or influencing ESF. Based on the synthesized perspectives in the second question, I developed a usable ESF monitoring instrument for epidemiologists. Succinctly, the second question was, How should a usable (efficient and effective) ESF monitoring tool be constructed from the synthesized perspectives? Addressing the significances of the influencing factors, I determined that the implications of T and P given O (compliance to health policies) and P given T and O. In the first premise, the T and P were independently examined given O or governmental health policies for a particular contagion. For the second premise I probed the conditional reactions of P given T and O. To test the premises, I used fuzzy set possibility theory.

The first research question was, as follows: How could the multiple perspectives inquiring systems (technical, organizational, and personal perspectives) and fuzzy logic be used to discover the factors causing or influencing epidemiologic systems failure? The solution to this research question rested on the answer to the first question. If there is a significant influencing factor among the ESF theories, there could exist a synthesis instrument (fuzzy set theoretic) for constructing ESF solutions. A proposition is that outliers emerged within each perspective and among conditional perspectives.

Instrumentation

I developed the instrumentation based on the multiple perspective inquiring system, grounded theory, forensic epidemiology analysis, and fuzzy possibility theory. I used the five inquiring methods identified by Churchman (1971) for selecting the reliable and valid instrument. The examination helped in selecting the multiple perspective analysis. According to Courtney, Croasdell, and Paradice (1998), Hasan (1998), and Kienholz (1999), the five possible approaches to epidemiological scientific inquiry are Leibnizian, Lockean, Kantian, Hegelian, and Singerian. The name of each approach is that of a philosopher or persona.

The following according to Mitroff and Slivers (2010) are the basic philosophical beliefs of each approach. Proponents of the Leibnizian strongly believe in models and data over theory and methods (Mitroff & Slivers, 2010). The Leibnizian presupposes that truth is analytical and that external world data are not useful such that any epidemiological problem should be mathematically reducible. In reality, not all ESF factors are mathematically reducible. Proponents of the Lockean approach, which is more realists, posits that truth is inductive through experiential and empirical hypotheses (Mitroff & Slivers, 2010). Because peer consensus is very important, a Lockean would consult peer experts to seek a scientific opinion. Delphi method is an example. This approach would not guarantee a reliable research results and forces the acceptance of whatever a group of epidemiologists says the epidemiological result is.

Kantian is an idealist who believes that truth is synthetic. Kantians combined the Lockean and Leibnizian methods. Kantian would develop two complementary models: null and alternative hypotheses for accepting or rejecting an ESF. This methodology is suitable for ill-structured problems that are difficult for Lockean or the Leibnizian approach. According to Mitroff and Silvers (2010) *Hegelians* are synthesists who believe that truth is conflictive. Hegelians posit dialectical arguments from data interpretation. An antithetical representation of any phenomenon is usually formulated.

Singerians are pragmatists. According to them, truth is pragmatic and relative to the general purpose and objective of a study. Thus the psychology, ethics, and sociology of the researcher are inseparable from the epidemiological issue or its model representation (Arthur D. Hall, 1989; Linstone, 1984).

The Multiple Perspective (T-O-P) Filters

Linstone (1984) posited the multiple perspective inquiring method as a practical Singerian approach. There are three perspectives: technical (T-filter), organizational (O-filter), and personal (P-Filter). These filters are known as TOP. Linstone specified that the T-filter quantitatively abstracts, idealizes, isolates, and simplifies problems into solutions. The science is for quantifying ESF if and only if aspects of the problem are mathematically measurable. Because there are sets of health policy that guide contagion control such as quarantine policies, O-filter is useful for considering lapses in legislative remedies that contribute to ESF. According to Linstone (1984), O-filter often reveals legislated compromise and routine between technocrats and interest groups.

The P-Filter is very subtle. The subtlety is because of perceptual, political, economical, and social outlooks of ESF. These factors are inseparable from the mental models for designing this study. Hall (1989) and Linstone (1984) noted similar observations when studying complex systems such as ESF. Therefore, P-Filter is the human persona for understanding ESF.

TOP is chosen over the other research methods because of the pragmatism and useful guides by Linstone (1984) to validate research finding. It is also, for explaining differential and similitude of phenomenon such as ESF. It decomposes the unit of analysis into technical, organizational, and personal perspectives.

As with grounded theory TOP framework encourages intellectual imagination and theory creativity is used within. For grounded theory, see Glaser and Strauss (1967). T, O, P could be a recursive research process. Four principles guide the use of the theory in this study. It also reveals methods of developing theories. Furthermore, it explains criteria for valuating emergent themes. The last principle is its means for expressions that balance verification language in literature (Locke, 1996).

TOP method has two analytical characteristics. One is constant comparative method. It begins with the formation of provisional categories from data. Locke (1996) stated that "data and theory be constantly compared and contrasted during data collection and analysis" (p.240). During this phase, each datum was compared with earlier data for a category for generating axiomatic properties for each perspective.

Recursively, the comparison shifted to each datum and properties in each perspective. This simultaneously created new theme through "an ongoing data collection" (p.240), Linstone (1984) like Glaser and Strauss (1967) stipulated that the comparison and data sampling are recursive until an assumptive saturation point. The expectation is that grounded theory emerged at this point.

This study used seven phases within each perspective. Categorization was used to group instances that share common features. Identification was for categorizing the data and theme in each perspective. To differentiate and group properties of each perspective, comparative analysis was used. Negative case analysis is used to ensure constant generation of theories. To ask questions, compare and differentiate opposite features of ESF, theoretical sensitivity analysis were performed. To check new theories against reality from sample cases (to support or discredit emerging categories), theoretical sampling was performed. A saturation phase (a phase in which no new theory or finding exists) is used to terminate the recursive process.

Fuzzy Set Method

The most enduring thinking in this ESF study is causality (factors of cause and effect). Legewie (2013) examined the use of qualitative comparative analysis in research. The author acknowledged that Boolean theory for representing cases as configurations of conditions (truth table) is problematic. Depending on the theoretical and practical knowledge of a researcher, simplified Boolean assumptions about a research could be misleading and insufficient to answer the problem. Pappas, Giannakos, and Sampson (2016) reminded that focusing on Boolean symmetry may mislead researchers because relational variables in life are not symmetrical. Therefore, I opted for fuzzy set given that all cases in a dataset are not symmetrical.

From Lee (2014) it is obvious that the use of fuzzy set extends the underlying logic of Boolean set method into a research process. From Tamasino (2015) and Roig-Tierno, Huarng, and Ribeiro-Soriano (2016) it is well-known that fuzzy set qualitative comparative analysis (FSQCA) is a social science research method. Basurto and Speer (2012) provided a method to structure and calibrate qualitative data as sets for the analysis. Leischnig, Henneberg, and Thornton (2014) focused that FSQCA is a powerful method suitable for building causal theories. Thus, fuzzy set theory is suitable for this study. As with Pustovrh and Jaklič (2014) this study analyzed necessary and sufficient conditions.

A quantitative reader should understand the numerals and a qualitative reader should appreciate the fuzzy linguistic interpretations of the numerals. The goodness of fit is that the fuzzy linguistic approach combines case and variable oriented quantitative analyses for a comprehensive understanding of a problem. FSQCA could begin from either qualitative comparative or quantitative comparative spectrum.

Mendel and Korjani (2013) posited that FSQCA is also useful for obtaining linguistic variables from case associated data set. To achieve this Mendel and Korjani (2012) provided a six step fast FSQCA. See also Thiem and Dusa (2013). In any case, the authors' method did not include TOP as used in this study. It seemed that the momentum for FSQCA compelled Mello (2013) to report that researchers using FSQCA for social scientific inquiry are increasing. For the school of public health, Warren, Wistow, and Bambra (2013) acknowledged the demands for more appropriate methods for complex interventions evaluation. For the basic principles of fuzzy sets see Appendix C. Succinctly and according to Mendel and Korjani (2013), fuzzy sets are not derived from mathematics even though the sets use mathematics

Fuzzy set theory (also documented in chapter 2) could be considered a research instrument. The theory was integrated with the data acquisition, representation, analysis, and reporting phases of this study. It is recommended that the section in chapter 2 be read carefully in order to understand the findings and reporting of the study.

Each category is discovered with grounded theory within the TOP framework represented as fuzzy sets. Each set is made of membership functions. A membership function could be, triangular, or trapezoidal shape. However, this study used triangular and trapezoidal functions for their convenience in data analysis. An epidemiologic system (ES) could be represented as shown in Figure 4. The N represents normal state; SN means somewhat normal; SF means somewhat failed; and F means failed ES. Golden mean ratio is used to standardize the set (Ulinwa, 2009). The purpose is to harmonize the various sets and their integrations.

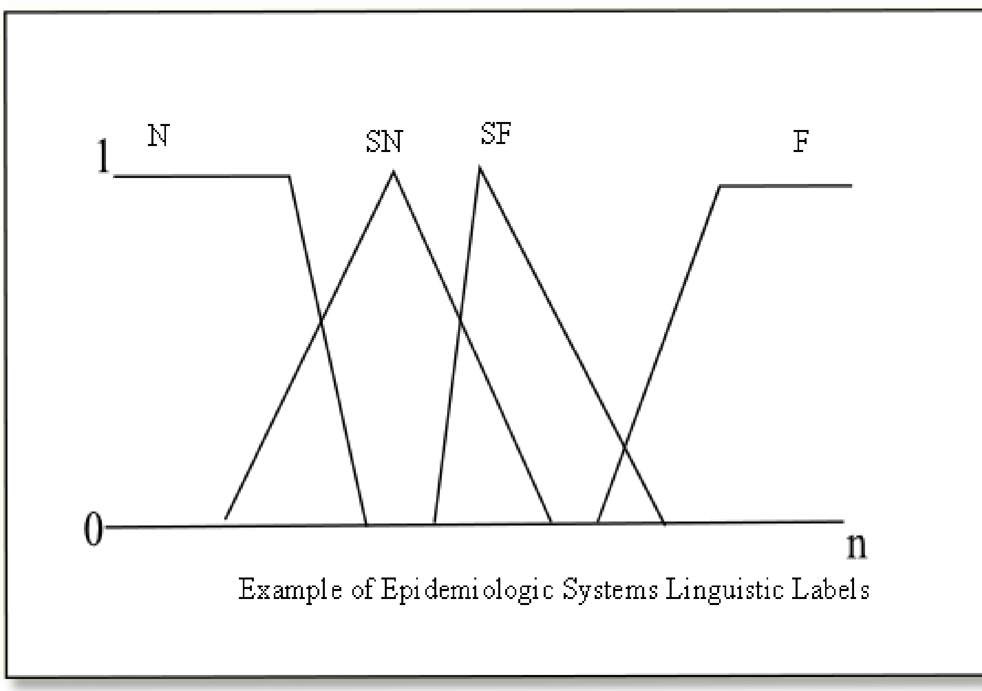


Figure 4. Epidemiologic systems fuzzy linguistic (numeral) variable.

Forensic Epidemiology Analysis

Pictorial research method as a forensic epidemiology analysis is a form of naturalistic observation in which events could be replayed as if they are reoccurring. This study used video documentaries. This gives the opportunity to infer what those observed in the documentaries are doing. The advantage of this analysis is that events are real. It also provides opportunity to observe behavioral cases and effects among the documented individuals. Video documentaries acted as live laboratories. The reliability and validity of the analysis rely on the fact that observations cannot be distorted nor can the pictorial method result change because of the observations. Moreover, the pictorial method makes it possible to observe independent and dependent subjects at action.

The purpose of using pictorial analysis is to discover reactions of those who have different and conflicting perspectives that created ESF. The pictures may include still photographs and static video frames. It was expected that video documentary of categories would elucidate factors not interpretable in the literature. The assumption for pictorial analysis is to clarify what is in the literature and discover what is not in the literature. This approach is within the utilities of perception research framework. Video documentary can be classified as a surrogate for reliability. Gibson (1954) considered visual arts as a means to represent and interpret problems.

This study used three stages of pictorial analysis. See Table 9. The pretest stage involved casual viewing of all the obtained video documentaries without focusing on any particular perspective or actors. Two pretest viewing were conducted per video documentary. There were three tests per a perspective. Two of the tests were used to take notes and recheck the accuracy of the previous observations. The last of the three was to ensure that what is needed is observed. The third stage is the analysis. This involved the transformation of the observations into fuzzy sets.

The Sample and Ethical Considerations

Sample Size and Justification

The multiple perspectives inquiring research instrument guided the study sample size. Succinctly, sample size is necessary for this research work to avoid information over load. With the understanding from Thomson (2011), Marshall (1996), Sandelowski (1995), and Onwuegbuzie and Leech (2007), the unit of analysis of this study was derived using the phenomenal variation sampling method. The unit (variation) is the set of world views (perspectives) that led to ESF. Figure 5 shows a generalized unit of analysis and the subunits. From Ulinwa (2009) in reference to Linstone (1984), the world view could be exhausted as A, B, and C subunits. The theoretic observation showed that subunit B is the same as the generalized unit of analysis which is TOP. Subunits A and B are rejected because of their extremely world views. A careful observation shows that subunit B is similar to the generalized unit of analysis.

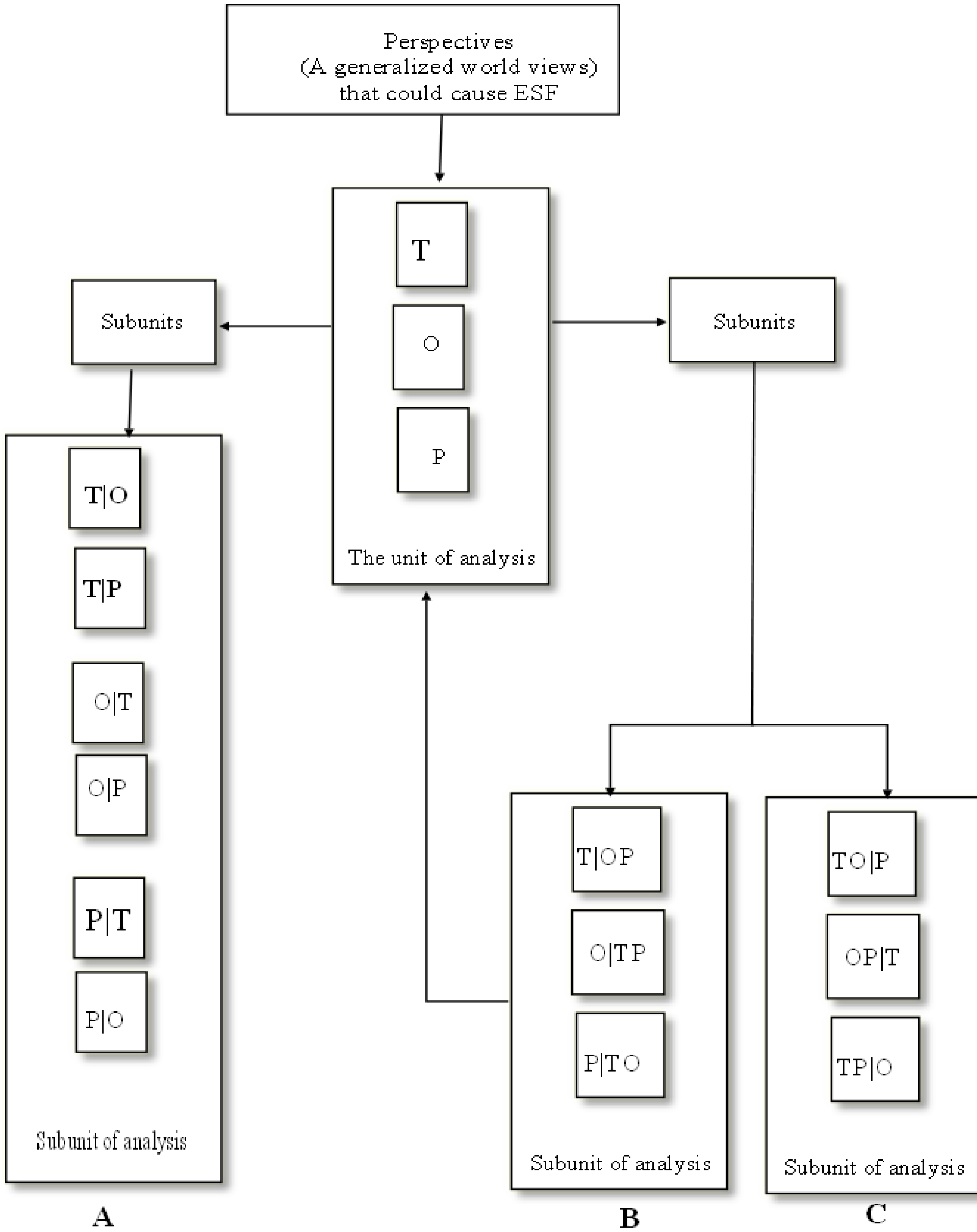


Figure 5: The selected unit of analysis.

Of the three subunits, subunit C is theoretically expected to be more meaningful and informative. For example, T and O given P (that is holding P constant while observing the interaction between T and O) could be considered a probability or possibility conditional statement. Following this reasoning, subunit C is selected as the appropriate set of unit of analysis for this study.

In general, the selected unit of analysis rested on and satisfied the theory-based sampling, critical-case sampling, or homogenous sampling method. As shown in Figure 6, the selected unit of analysis is the intersection among the theory-based sampling, critical-case sampling, and homogenous sampling methods. It follows that the consideration and use of subunit B world view (perspectives) as the unit of analysis is in accord with Thomson's (2011), Marshall's (1996), Sandelowski's (1995), and Onwuegbuzie and Leech's (2007) acknowledgement that a theme could be a unit of analysis.

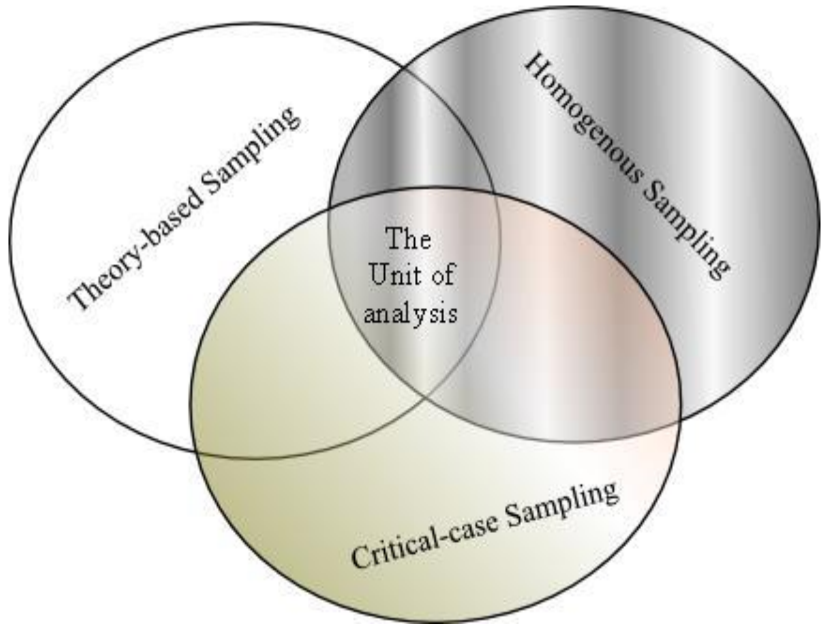


Figure 6: Bases for the unit of analysis.

This exploratory-explanation study of ESF used TOP guideline to determine an adequate data size. This includes available ESF documentary and ESF outliers reported in the media. A media documentary, for instance, could have several participants in an event. Such is also about printed media of most epidemics. Therefore, the sample for this study was based on deadly contagions. Table 10 presents the sample according to the three perspectives where T are quantitative sample, O are legislative sample, and P sample (human subtlety about contagions).

Ethical Considerations

Given the United States of America (USA) Code of Federal Regulations, Title 34 Department of Education PART 97 that guides the use of children (humans) in research studies or institutional review board (IRB) that is a special case of the policy, this study posed no risk to humans. The study is strictly a secondary data research. The research investigator collected and analyzed data from selected secondary data. Most of (if not all) are in public domains. Participants in the media documentary are assumed to be volunteers. As such, participants' confidentiality remains within those protections stipulated in the documentary sources. In most cases, the consent of participants was not possible because of death such as in the case of Mary Mallon. This is the case of some of the documentary participants for this study. To ensure research integrity, the research used an IRB approval.

Data Collection

The nature of this study required secondary data. One primary advantage of secondary data is the availability. Data collection centers such as libraries and private holdings, and commercial databases served as scientific data sources. Information found on the World Wide Web supplemented the data sources. In respect to the research questions, data were collected based on the perspectives. This enabled reliable categorization. It brings to bear, that the nature of this study and researcher's view determined the availability of data size.

This is reflected in Sandelowski's (1995) explanation. Thus, this data collection approach may not support some aspects of the perspectives. However, this study is not limited to the theoretical foundation nor the limitation of large data detoured this study.

The imperative issue is to use technical, (T), organizational, (O), and personal (P), perspectives instruments to represent the in-depth explanatory analysis. The technical perspective sources focused on quantitative epidemiological journal articles. The organizational perspective sources focused on ethical and governmental health action with respect to infectious diseases. The personal perspective instrument was used to filter data that are patient centric views. Generally, the instruments are researcher dependent data collection, analysis, and reporting protocol.

Three data types (T, O, and P) guided the data collection and University of Minneapolis, Walden University, and Portland State University libraries served as collection sites for peer-review articles. Television and video documentaries obtained through commercial data centers. The pictorial of observational (evidence-based) research method used to examine media documentary of contagions and helped determine if there would be emergent results beyond the scope of standard qualitative and quantitative methods. The Pictorial analysis focused on the T, O, and P perspectives data. The intent is to demystify factors (perspective conflicts) that cause ESF. News media such as newspapers also served as means to obtain the P-perspective data.

Data Analysis

To demystify ESF, this study used the simultaneous process of data collection and analysis common to TOP, grounded theory, fuzzy sets, and pictorial research methods (quantitative and qualitative research).This uniformity of the evidenced -based TOP model uncovered the nature of the data, the collection, analysis, and reporting.

The TOP process is similar to grounded theory. Creswell (1998) and Creswell (2011) explained four stages common to the grounded theory research methods. See Figure 7. These stages were used within each of the perspectives. The grounded theory as shown in figure 7 indicates categorization, coding comparison analysis negative case, theoretic sensitivity, theoretical sampling, and theoretic saturation.

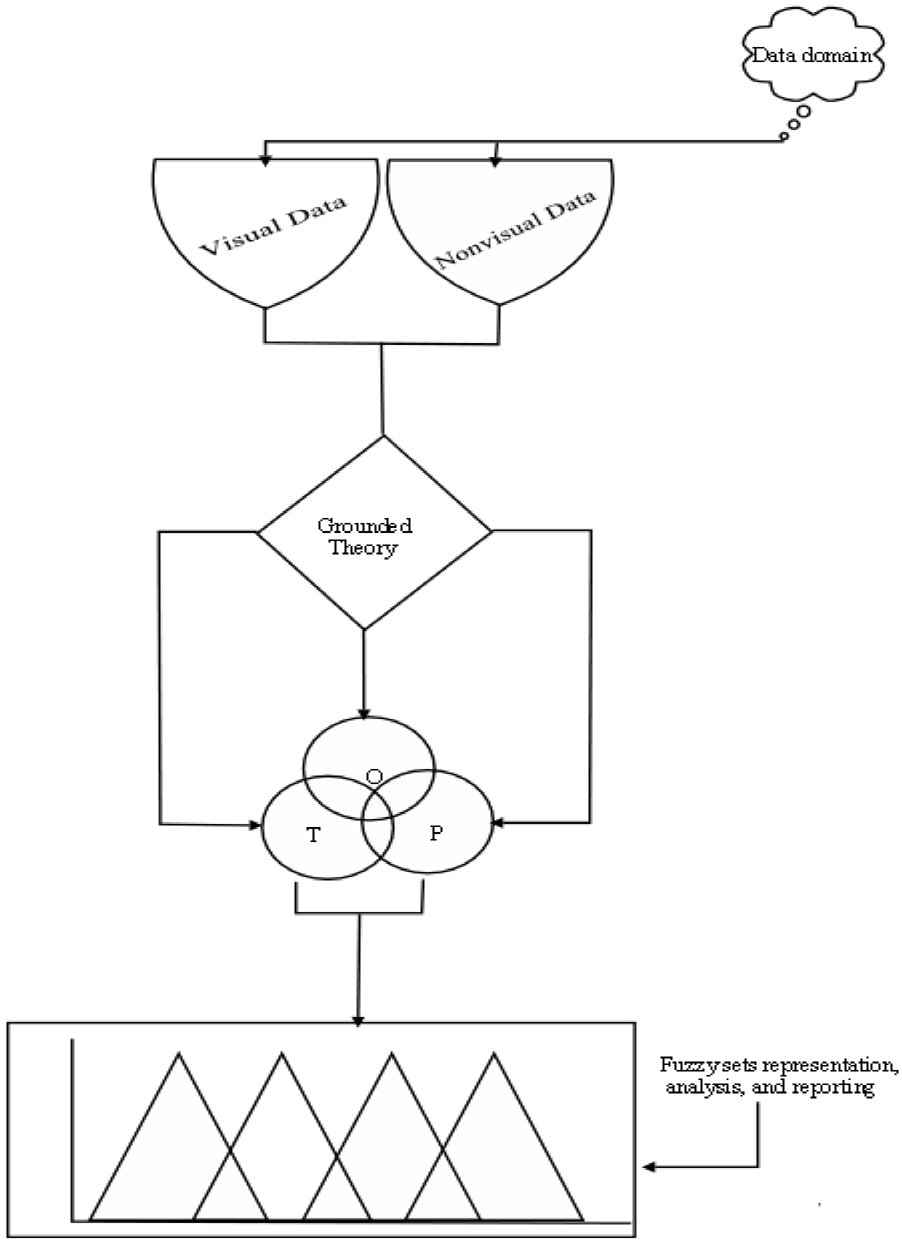


Figure 7: The research process.

For example, the research (using the T-perspective) focused on reviewing the data to seek relevant quantitative themes or concepts. During this open coding stage in reference to Glensne and Peshkin (1992), new data were collected until no new themes or categories emerge. Second, emphasis shifted to axial coding for relational analysis among the discovered categories. The purpose is to discover a common concept and how the categories relate to the core-concept. Third, selective coding was used to discover relational characteristics of the categories for the emerging theoretical constructs.

Creswell (1998) and Creswell (2010) explained that the characterizations unify the core-phenomenon and how the problem occurs. Finally, the proposition stage was used to report the uniqueness of the phenomenon as characterized by the relations among the categories and between the core-concepts and the categories. Figure 7 shows this research process.

The epidemiologic data domain, the acquisition, analysis, and reporting as shown in Figure 7.were grouped as pictorial and non-pictorial domain. The pictorial data are primarily video documentaries of selected dangerous contagions. Non-pictorial data consisted of literature about the same contagions. The consistency is to ensure reliable analysis. The selected data were then classified into TOP categories using Linstone (1984) guidelines. For the analysis to be valid and reliable, it is expected that each literature be read six times using or focusing on each of the perspectives. Each video documentary was also viewed six times.

A modified grounded theory was applied to each stages of the reading or viewing of the data. Notes were taken in various stages of the data examinations after the saturation phase, and the discovered categories were transformed to fuzzy sets. The sets of fuzzy linguistic (numeral) variables that are suitable for reporting ESF were analyzed as conditional possibility solutions.

Research Reliability and Validity

Miles and Huberman (1994) identified four validation approaches necessary in studies pertaining to the TOP model. In this case, outliers were carefully examined. Outliers as data do not fit or satisfy the findings of a particular scope of perspective. This study considered the informational outliers and explained the contrasting perspectives.

Moreover, critiques and recommendations from the dissertation committee members provided additional validation. The study reliability was achieved through a pilot study based on current literatures for this study. A small study, of (thirty pieces) of literature collected from reliable and effective sources served (as the population) base on the research questions. The intent is to ensure that the research questions measured its intended purpose. Further expectation is to link each question with a particular set of findings.

The validation and reliability rested on Ashby's cybernetics control tool: requisite variety. Requisite variety states that a research tool should have the same number or amount of variety as the phenomenon it is analyzing or solving. This study therefore used a holistic methodology that meets the same variety a researcher will observe or see in any ESF phenomenon. It brings to bear a systems approach for understanding ESF.

Each of the research tools (the grounded theory, multiple perspective tool (TOP), pictorial, or fuzzy set method) was not sufficient by itself, but the combination strengthened the reliability and validity of the study. The tool streamlined information by excluding irrelevant data.

To improve the external validity, data were collected, sorted, examined, and reported using the TOP guidelines. This approach minimizes information overload (Kohn, 1997). The validity and reliability approach addressed Yin (2003) concern regarding threat to external validity. The concern focused on generalizing the research findings to a broader theory of infectious diseases.

Fuzzy set method of analyzing data is closer to human reasoning because most data are not strictly characterized with a yes or no response. To strengthen the research validity fuzzy set method effectively, efficiently, and naturally reports data as humans interpret them. In addition to the instruments, direct quotes from peer-reviewed and collaborated works of leading academic journals and renowned epidemic historians validated the study. The validity and reliability increased given the virtual reality (as video) of the actual events as in the case of Mary Mallon or (Typhoid May).

Justification

The documentary (document and videos) analysis component consisted of qualitative and quantitative aspects. It is expected that some of the qualitative literatures contain quantitative data. The reason is that it is not uncommon to encounter quantitative data in qualitative research. As such, the use of mixed research method overcomes any disadvantage of quantitative or qualitative approach. The weakness of each is reduced with the advantages of the other.

Foremost, the multiple perspective method reduced information overload and forced the research on the specific needs of the perspectives. The grounded theory enabled thorough means to discover emergent theories. In addition, these standard methods, the pictorial analysis exposed factors of ESF which may be hidden from textural analysis. To represent the facts as humans would, fuzzy set theory allowed a clear data representation, analysis and reporting. Therefore, the justification of this study was based on the data, the qualitative research method, and the research assumptions.

Summary

This chapter presented the study plans methodology, the study design, data collection, process, and analysis. It briefly outlined the research questions that guided the research. Each of the mixed methods, grounded theory, multiple perspective method, pictorial analysis, and fuzzy set theory is summarized; and each examined and relationally explained for the study. The purpose is to present an interactive process that revealed relevant factors characterizing ESF. The subsequent chapter therefore, presented the research findings according to the research questions with respect to the mixed methods. The findings were reported in form of conclusive fuzzy sets, which includes tables and graphs.

Chapter 4: Results

The purpose of this triumvirate mixed-methods case study was to examine factors undermining infectious disease control or prevention. In this chapter I present the triumvirate conflict construct that lead to ESF. Prior to this study, there was no documentation about ESF based on all the perspectives, according to my review of the literature. In conducting this study, I sought to address this gap by determining and examining mechanisms useful for preventing, monitoring, controlling, and reporting infectious diseases. I differentiated three epidemic control mechanisms: the regulatory systems or legislated laws and health policies, technical systems or epidemiology in public and private sector settings or those who study or treat infectious diseases, and the compliance system or infectious disease hosts and influential individuals. I used lack of synergy among these mechanisms to identify ESF. The conflictive synergy eludes conventional field or clinical epidemiologists.

Drawing from fuzzy set theory and embedded multiple perspective research methods, I queried how the multiple perspectives inquiring systems by Linstone (1984) and fuzzy logic by Zadeh (1965) could be used to discover the factors causing or influencing ESF. I also queried how a usable (efficient and effective) ESF monitoring tool should be constructed from the synthesized perspectives. Research findings provide ESF and EVID professionals information and methods to characterize ESF. The tools may be resourceful to local, state, national and possible international health professionals in their efforts to prevent and control ESF. In this chapter, I detail participants' profiles and discuss how they were selected; how their interviews were simulated; and how the discovered themes were recorded, analyzed, and reported. The verified reliability, data analysis, and research findings are methodologically presented. Tables, the fuzzy mathematical procedure, and participants' statements are included in the appendixes.

To understand how fuzzy set theory is used in this study, see the "Fuzzy Set" subsection in the "Forensic Epidemiology: The Selected Toolkits" section of Chapter 2 and the "Fuzzy Possibility Set Method" subsection in the "Instrumentation" section in Chapter 3. A brief introduction of fuzzy set theory as the basis for this research is presented in Appendix C.

Demographics

I used a primary sources method to identify the research participants based on their direct statements, concerns, or assertions in the data about four epidemiologic systems. There are no risks, barriers, or biases involved in using proximate participation (Grahan & Jackson, 1993). Use of this approach shielded me from deadly infectious diseases to which I might have been exposed had I interviewed live participants. Moreover, it would be impossible to contact the late Mary Mallon or late Patrick Sawyer for live interviews. Table 11 shows the demographic of the TOP participants.

I divided the participants into two groups: primary and supporting participants. I used the assertion of each primary participant to seek the supporting participants. In addition to the two participatory categories, each participant was categorized according to the three perspectives used in this research. The perspectives were technical (T), organizational (O), and personal (P).

T participants were epidemiology technocrats who, through literature such as papers or pictorial data, quantitated epidemic systems without jettisoning fallacies in biostatistics. The actualized T assertions quantified the characterized ESF and the effects. The O participants were government or private establishments' representatives who through laws (regulations, ethics, public health policies, and politics) suggest means to qualify and quantify epidemic treatment without jettisoning legal fallacies. The U.S.-based CDC as well as WHO are examples of O participants. The P participants were disease hosts or their advocates who have been identified in the literature has been critical to the establishments or technocrats. An example of a P participant is Andrew Speaker who was diagnosed as a tuberculosis carrier or Mary Mallon who was a typhoid carrier.

Primary Participants' Profiles

Participant 1 was 40-year old Patrick Oliver Sawyer, a Liberian and U.S. national and lawyer), who worked for the Liberian Ministry of Finance for ArcelorMittal, a mining company, as a national manager for public health and had Ebola. Sawyer reported to ArcelorMittal on July 9th, 2014, about the death of his sister who died of Ebola on the previous day. Sawyer had a minimum contact with the sister who lived in a state where Ebola cases were more prevalent. Upon reporting his sister's death, Sawyer was given sick leave and placed under daily monitor for 21 days; Sawyer was to resume work after 28 days.

Sawyer could not endure attending an Economic Community of West African States (ECOWAS) meeting at Calabar in Nigeria at the time. Sawyer sought and received approval from the Liberian Finance Ministry to attend the conference. In addition, the

Liberia government did not list Sawyer's name at the airport. Sawyer left for Nigeria and became Nigeria Ebola index host (case) for transmitting the infectious disease in Nigeria. Nigeria health officials’ rapid and intense health care response minimized Ebola the number of deaths due to Ebola. The hospital, First Consultant Hospital in Lagos Nigeria, where Patrick was hospitalized and died revealed that Liberia diplomats pressured it to discharge Patrick for he had an important role at the Calabar conference (PMNews, 2014).

Participant 2 was Russell Lee Willis. Willis’ case was one of the preludes of ESF of HIV/AIDS. The ESF began when the Office of Kalamazoo County Prosecution dismissed Willis’ case the same day Willis should have faced trial. Willis, who was HIV positive, had unprotected sex with an uninformed partner. The victim declined to testify against Willis in an open court about her exposure to HIV. The sexual encounter became known when the victim confronted Willis after her friend saw him outside her home. The friend warned the victim that Willis had served a 4-year prison time for failing to disclose he was HIV-positive to his former sex partner (Hall Jr., 2014 and Hall Jr.,2015).

Number Three Participant, (Tuberculosis) Andrew Speaker (a 31 year old Atlanta Georgia native and personal injury attorney) in 2007 was classified an international risk. The international concern was that (Andrew Speaker who was diagnosed multidrug-resistant tuberculosis positive in the first quarter of the year) travelled to Santorini, Greece in Europe for a personal wedding. It was assumed then that Andrew Speaker might have exposed other passengers to tuberculosis.

For public safety, CDC ordered Andrew Speaker to either be admitted to an Italian hospital or charter a private airplane costing about $100,000.00 if considering returning to US (Fellow, 2008). Avoiding the possibility of dying in Europe, Andrew Speaker boarded a commercial flight from the Czech Republic to Montreal, Canada. With a rented vehicle, Andrew Speaker returned to the United States through Champlain, New York. Upon entry Andrew Speaker was served a federal order through the Department of Health and Human Services/Centers for Disease Control and flown to Atlanta Georgia. He was later transported to the National Jewish Medical and Research Center in Denver, Colorado for treatment. At Denver, Andrew Speaker's physician, Dr. Gwen Huitt, assured TB was at a low communicability level and was not a threat to the fellow passengers during the trip to Europe. In any case, Andrew Speaker received an extensive treatment at the hospital.

Unlike Mary Mallon, who denied having typhoid, Speaker was aware of having tuberculosis. Concerning continuous employment, everyday activities, interactions with family members, the public, and the travel, Andrew Speaker claimed that doctors advised that the public was not at risk. A conflicting account from Dr. Steven Katkowsky of Fulton County Department of Health and Wellness (in Georgia) was that Andrew Speaker should have not traveled because a standard medical advice is not to travel. Therefore, the form of the TB was not as severe as CDC and federal officials thought.

Number Four Participant, (Typhoid Fever) Mary Mallon immigrated to the Oyster Bay, Long Island, New York USA from Cookstown, Ireland in 1884 at the age of fifteen (Marineli, Tsoucalas, Karamanou, & Androutsos, 2013). In 1906 Charles Henry Warren family employed Mary Mallon as a cook. In the cause of her service with the Warrens, six of the family's eleven residents developed typhoid. In any case, the owner of the property, George Thompson, hired investigators who unsuccessfully traced the source of the epidemic system before retaining George Soper. George Soper was a civil engineer acclaimed to have experience in typhoid fever outbreaks. Mary Mallon left the Warrens as soon as Mr. Soper began investigating the source of the outbreak. Soper discovered that from 1900 to 1907 there were cases of typhoid at each of the seven families Mary Mallon had worked. Satisfied that Mary Mallon was the carrier, Soper persuasively convinced Hermann Biggs of the New York City Health Department with the findings. The department commenced further investigation through Dr. S. Josephine Baker. Mary Mallon was then detained at the New York Willard Parker Hospital from where her stool was determined to contain typhoid bacilli. Mary Mallon died in 1938 after suffering a six-year stroke during her detention at North Brother Island.

Data Collection

Data Collection and Storage

I used two data types totaling 350 as shown in Table 12. The dataset included videos and printed data formats. Google, Yahoo, Duckduckgo, Bing, and Start page, the most popular Internet search engines, were used to determine the most deadly infectious disease of 2013 to 2015. After the identification, I selected Ebola, HIV/AIDS, tuberculosis, typhoid infectious diseases. Given the four diseases, I looked for primary participants who were readily available as primary data sources. The participants were also considered based on the multiple perspectives (TOP).

The data were collected through the Walden University and Portland State University centers. Video documentaries and pictorial (evidence- based) observations were collected through Youtube.com and commercial data centers (such as Amazon.com). The pictorial data were used to support the media documentaries. The extensive online searches were conducted with combinatory keywords: infectious, communicable, contagion, and epidemiologic paired with disease(s), contagion(s), and epidemic(s). Additional peer- reviewed articles (from the above data centers) supported this researcher's assumption. The conjecture reflected Delphi data representation method (the consensus of the writers and the article reviewers). The data were grouped as technical (T), organizational (O), or personal (P) perspective based —245 (70%) had a T-perspective, 17 (5%) had an organizational perspective (O), and 88 (25%) had a P-perspective as shown in Table 12.

The participants answered the research questions in the form of primary data and the responses were recorded or published statements that corresponded to answers they would have given if live interviews were conducted. The procedures were detailed in chapter 3. Because the records are in the public domain, the participants' consents were not necessary for this study. The primary sources were saved on compact disk format and secured in a private safe.

Data Analysis and Verification

Four deadly epidemic systems (Ebola, HIV/AIDS, Tuberculosis, and Typhoid, as classified by health experts) were used to identify and understand the factors causing or influencing epidemiologic systems failure (ESF). Two research questions were studied:

1. How could the multiple perspectives inquiring systems (technical, organizational, and personal perspectives) by Linstone (1984) and fuzzy logic by Zadeh (1965) be used to discover the factors causing or influencing epidemiologic systems failure?

2. How should a usable (efficient and effective) ESF monitoring tool be constructed from the synthesized perspectives?

To answer the research questions, I developed and used three guidelines in accordance with Linstone (1984) and Churchman (1968). With the three guidelines, fuzzy sets and pictorial research methods (quantitative and qualitative research) were fused into TOP approach. To harmonize various methodological scaling (which may vary among experts within a perspective or among perspectives) themes, Ulinwa (2009) recommended discovering such variations through research assumptions, conventional readings, and study. Without such, conventional, qualitative or quantitative approaches could fail to explain or describe ESF.

With the developed guidelines, I took the following content analysis steps. First, I read each document and viewed each video. I then took some notes that summarized or described on the margin what the data was about. During a second reading, if the participant's perspective statement is clear, I then marked the data as a T, O, P, or TOP participant. I also ensured that the perspective linked ESF. For each type of data, I repeated these processes five times. Finally, I scanned each data to ensure that the marked perspective and the participant's statement are relatively informative by using Linstone's (2011) guideline. Second, I merged likely perspectives accordingly with respect to each infectious disease. Moreover, statements by the participants are cited in the appropriate section of this study. I used direct quotes from the primary data sources to validate this study. For the second research question, the data themes were transformed into fuzzy sets (fuzzy linguistic (numeral) variables).

Results

Systemic Observation for Research Question 1

To ensure reliability and validity, each ES primary data was read or viewed five times. Research question one was reframed to how could a researcher use T, O, and P mindsets to discover factors causing ESF. Figure 8 depicts the typical analytic approach.

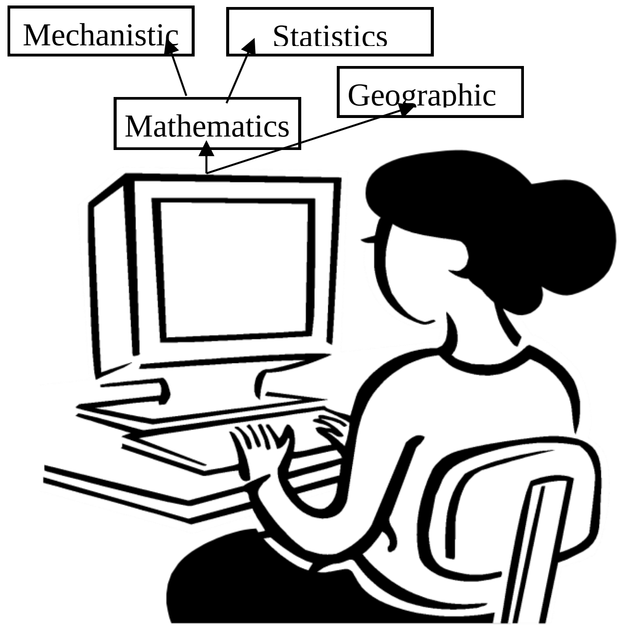


Figure 8: The TOP investigation

The T Perspective Contribution to ESF. The desired and standard guideline (as assumptions and validations) was created for the T perspective. The researcher considered the T perspective as a filter (a lens). The guideline was used to discover how epidemiologic tools cause ESF. A number of factors were discovered. Assumption and validation: Assumption and validation: Based on Linston's (2011) guideline, I assumed that primary source data that used quantitative or mathematical and statistics tools to examine on epidemic systems satisfied the science of the technical perspective. The actualized T assumption quantified characteristics and the effects of ESF. Linstone (1984) validated this conjecture by saying that T perspective quantifies everything.

Findings: The T perspective was applied to answer how could the multiple perspectives inquiring systems by Linstone (1984) and fuzzy logic by Zadeh (1965) be used to discover the factors causing or influencing epidemiologic systems failure. The examinations of the 300 datasets about ESF marked T perspective indicated two broad fields: mathematic tools and geographic tools. The question was rephrased to how could mathematic tools or geographic tools cause ESF.

Linstone's (2011) guideline and Ulinwa (2009) classified technical perspective to include mathematical and graphic theoretic tools. Based on this, rephrasing the question differentiated the mechanistic from the statistic within the mathematic theoretic toolset; and from the web-based method versus the nonweb-based method within the geographic theoretic toolset. This discovery is shown in Figure 9.

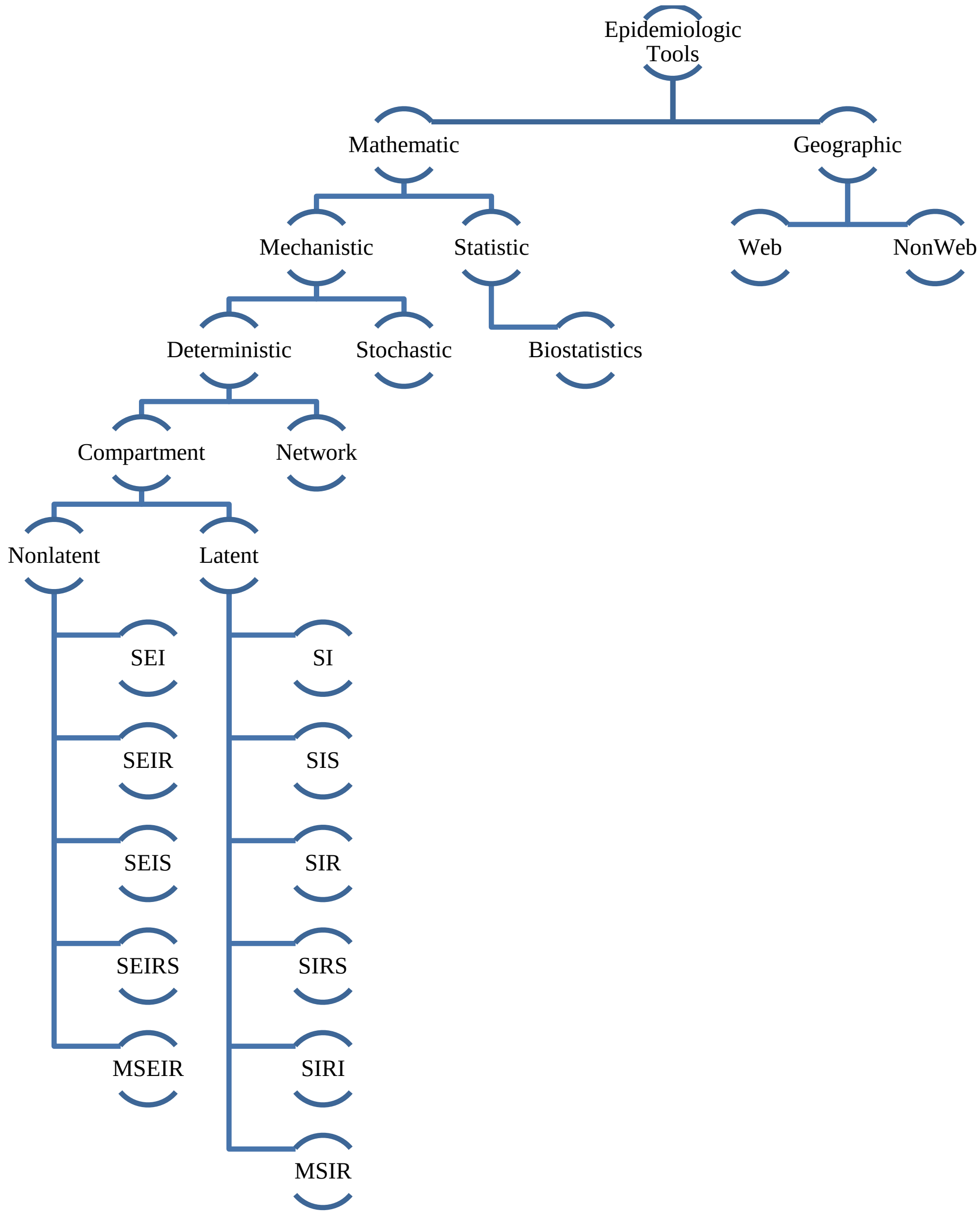


Figure 9: The epidemiologic tools

Attention of this researcher was on the last nodes (toolset) of the figure. For example, the five (nonlatent) and six (latent) nodes within the compartment thematic tool were of interest as much as the network node. Compartmental tools are mathematical or abstract model of disease spread. These tools are insufficient for suggesting means of preventing, controlling, or stopping infectious disease spread when applied without the O, and P perspectives. The compartment and network formed the deterministic toolset. For generality, the last nodes of the figure are the sub-thematic measurements. The upper most thematic types were mathematic and geographic-theoretic measures. The mechanistic and statistic are the mathematical tools epidemiologists use to seek quantitative truth about epidemic systems. The geographic toolset complementarily maps, visually characterizes the environment of the epidemic systems. The geographic tools complement the mathematic tools. For this reason this researcher focused on the mathematical toolset. The T filtered toolsets are quantitatively calibrated. See Appendix C.

Monahan (1969) subsumed limitations of quantitative (a considerable contributor to ESF) into three. First, predictability is seldom finite because consequences are somewhat axiomatic. There is a consequence requirement that an analyst must use an existing set of consequences of other antecedent decisions and be satisfied with an optimal solution—the best solution under the circumstances. Second, there is limitation due to applicability. Monahan (1969) commented that bad epidemiologic decisions are not going to have predicted consequences if the applicability is misjudged. Epidemiologists work in a fluid mathematical environment, but the problem set is probabilistically specified. Obviously, the consequences will be unintended. There is a limitation of expertise. For the third, Monahan (1969) emphasized limitations of expertise.

> In this context, there is always the limitation of know-how. If [biostatistics] is the only technique one knows then the utility of the service rendered is substantially reduced. Moreover, that lack of sophistication can be compounded many times over if one knows only this one technique but tries to apply it to all kinds of problems. (pp. 4-7).

Compartmental models contribution: Mathematical (compartmental) models with a few mathematical equations are used in epidemiology to represent a disease transmission dynamics. Fung (2014) mentioned three leading challenges contributing to ESF: model misspecification and parameter uncertainty, modeling intervention, and model structure. First is model misspecification and parameter uncertainty. For example, Fung (2014) said that in most epidemiologic contexts disease concentration and contact rate are unknown. That

> The rate at which susceptible individuals become infected is determined by many variables in reality, most of which cannot be easily measured. As the 'contact rate' (β) can rarely be measured directly from experimental studies, it is usually estimated by fitting models to time series data. (pp. 1-3).

Second is misspecification of model. Misspecification occurs if realistic problem of interest differs from the actual models. On misspecification, Fung (2014) clarified that in such an empirical experiment, data represent number of bacteria, instead of the environmental water bacteria concentration data. Dimitrov and Meyers (2010) said that

> Although compartmental SIR models have proven to be quite useful in modeling epidemics, they do not properly model some important aspects of disease spread. (pp. 7).

To support Dimitrov and Meyers (2010), Willie (2009) added that

> While [compartments] are powerful tools for predicting the behavior of diseases within a population … they are drastic simplifications of reality. Disease dynamics in real life are not deterministic –human behavior can affect outcomes for any set of initial conditions. These models are merely approximations of what should happen for sufficiently large populations. They assume constant total population (although they account for births and deaths at an equal rate) and they assume that the population will mix homogeneously (that each individual will come into contact with the same constant number of other individuals).

Obtaining perfect information about a given disease is impossible including constant characterizing of the model. Worsening the impact of mathematical models on ESF, Willie (2009) explained:

> Chaos and sensitive dependence further complicate this dynamic. Epidemiologists can only approximate initial conditions, and the possibility that two very similar sets of initial conditions could have results that diverge at an exponential rate has serious ramifications for the accuracy of their models. [For example], the production of vaccines takes a significant amount of time, and which diseases or strains of a virus the mathematical models predict will be most prevalent in the future and will be most affected by mass vaccinations govern their production. (p. 2).

Fung (2014), Grad, Miller, and Lipsitch (2012), and Blomhøj, Kjeldsen, and Ottesen (2014) narrated cases of T contribution to ESF. Fung (2014) began by staying that cholera life span in water reservoir ($1/\delta$) depends on the local environment because

> While it is largely unmeasured in many endemic or epidemic contexts, modelers can use historical experimental data from the literature and therefore this parameter is also relatively certain. The rate of water contamination by infectious people shedding V. cholera into the water reservoir (ξ) depends on both bacteria

> shedding of the infected individuals (a biological quantity) and the level of sanitation in the environment (an environmental assessment). This is largely unknown in most contexts. These problems are that of parameter uncertainty. (p. 3).

Fung (2014) added that

> Probably the weakest link in modeling…interventions is the dearth of data that link the programmatic variables (e.g. implementation coverage) to the reduction of the transmission coefficient. (p. 6).

Grad, Miller, and Lipsitch (2012) cautioned epidemiologists to be cautious on models with high parameter value variability. The reason, according to Fung (2014) is that interpreting a model with such parametric outputs would include (unnoticed) great uncertainty in the model output and the interpreted result.

Another challenge impeding epidemiologic tool is building the correct model structure; including the essential (necessary and sufficient) components of replicating the observed dynamics. It ties to understanding relative importance of certain features in the biologic disease and its epidemiology. Thus Grad, Miller, and Lipsitch (2012) and Fung (2014) seemed to suggest that modeling a disease with a wrong model structure amounts to ESF. Describing epidemic system as a number of compartments and deriving (writing) mass-balance equations for each compartment does not guarantee good compartment models will result from the endeavor.

First, epidemiologists assume to work in closed environment and therefore exclude unaccounted sources in models of epidemic system. The second assumption is that. Blomhøj, Kjeldsen, and Ottesen (2014) narrated that how epidemiologists accept that homogeneity is a reasonable hypothesis.

> In 1950 a compartment model was used to mark rabbits as the biggest thread for survival of the grass-land in Australia. The model was based on observations, that rabbits could eat all grass on an entire field. These observations overestimated the number of rabbits and the amount of damage they could make. The reason for this was that all grass-land was lumped into one compartment independent of their location. As a result the Australian state started to poison rabbits by exposing them to the deadly virus myxomatois, which killed 90% of all rabbits. Today, rabbits are no threat to Australia, and the original study has been criticized for being too crude. (p. 15).

It is also well known that all initial conditions are not known precisely and included in a compartment model. Further, model parameters and initial conditions change model solutions. Supporting the deficiency of compartment models, Sorkat and Kaufman (2015) authenticated that some compartment models and equations are finite difference equations. The author continued that

> In a finite difference equation, the time step is fixed (e.g., one day, one hour) and the value at the current time step is used to predict the value at the next time step. Computationally efficient, this approach is fast and lends itself to simple solutions. Unfortunately, it is also inaccurate. In reality, time is a continuous variable. Trying to predict the number of people that will be infectious one day from now based on the number infectious now will give a different answer than trying to predict the number of people infectious one hour from now, given the number infectious now, and repeating that calculation every hour. (p. 13).

Even if all mechanisms are known and programmed, Keeling (2005) said that there are things models cannot do due to limited available data.

Concerned T perspective conflicting personas, Keeling (2005) said that

> During the 2001 epidemic, there was considerable tension between some members of the veterinary profession (who implemented the control strategies) and the modelling community. This can be partially attributed to issues of scale and emphasis. Even the most ardent modeler would agree that, on a farm-by-farm basis, veterinary judgment was (and still is) the best available. Veterinary opinion will use a host of subtle details and local information that models could not hope to replicate. At the most local of scales, veterinary judgment is always more accurate than even the most sophisticated model. However, the power of models comes from their ability to compound the approximate behavior of thousands, if not millions, of individual elements. (p. 1196).

In studying the effects of contact-related parametric dependence in model epidemics, Schaffer and Bronikova (2007) said compartment models to chaos theory in that " chaotic attractors, strange invariant sets are topologically transitive with the consequence that in the limit of infinite time, trajectories based at any point on a SIS pass arbitrarily close to every other point" (p. 188).

In using a static, deterministic, and age-compartment model to study vaccines, Wals, Black, Borrow, and Pearce (2009) pointed out that designing any epidemiologic model is complicated. The lack of large-scale efficacy data contributed to the experienced ESF. They explained that using assumptions of a particular epidemic system in another causes ESF; and ESF also arises if similar assumptions of an epidemic system is applied in different environment. In T contribution to ESF, Regan, Hocking, and Wilson (2009) noticed that any solution obtained from mathematical model of epidemic system cannot better the underlying data. The Regan, Hocking, and Wilson (2009) averred that

> The first is the inability of compartmental models to explicitly capture the duration of long term sexual partnerships and, hence, to account for reinfection of index case patients (i.e., those who are screened and treated). We agree that accurate simulation of reinfection to capture the complex nature of immunity and susceptibility to future infections is a limitation of the type of model we developed. However, the biological literature is also inconclusive about how to inform detailed agent-based models that would attempt to address such issues. (p. 769).

The statistical contribution to ESF: Among popular epidemiologic measures (such as relational strength between an exposure factor and a disease and attributable risk (AR)) that are of interest to epidemiologists, the quantification of AR has flaws (Rämsch, Pfahlberg, and Gefeller, 2009). Hanf, Guégan, Ahmed, and Nacher (2014) said

> Most epidemiologists now acknowledge that most human infectious diseases are likely to have complex dynamics. However, this knowledge still percolates with difficulty in their statistical 'modus operandi'. Indeed, for the study of complex systems, the traditional first-line statistical toolbox of epidemiologists (mainly built around the Generalized Linear Model family), despite its undeniable practicality and robustness, has structural limitations deprecating its usefulness. (p.497)

Hanf, Guégan, Ahmed, and Nacher (2014) said further

> Most epidemiological studies in infectious diseases have taken into account only individual-level risk factors for disease. This approach has led to the intensive use of statistical models developed on a 'one level data' spirit…[yet] epidemiologists acknowledging the hierarchical organization of data were often inhibited from applying the 'multilevel perspective' by a lack of understanding of how to analyze

> such data and by the lack of dedicated statistical tools leading to utilize traditional one-level statistical tools, even when their data and hypotheses were multilevel in nature. (p. 498).

Given that T perspective statistical tools have hidden flaws, Hanf, Guégan, Ahmed, and Nacher (2014) mentioned that

> Three major sources of complexity neglected or not taken into account by this first-line statistical toolbox[s] and having deep statistical implications are the multi-level organization of data, the non-linear relationships between variables, and the complex interactions between variables. (p.497)

Hanf, Guégan, Ahmed, and Nacher (2014) seemed to suggest two factors contributing ESF by saying that

> First, all the contextual and statistical information ends up pooled into the single individual error term of the model. This is problematic because individuals belonging to the same context will presumably have correlated errors, which violates one of the basic assumptions of classical regression models. The second problem is that by ignoring the context under investigation, the model assumes that the regression coefficients apply equally to all contexts, thus propagating the notion that processes work out in the same way in different contexts. (p. 498).

Livingston (2004b) stated further that

> With today's computer technology, any investigator has access to the most powerful statistical analytic tools. However, without understanding the basic assumptions that statistical analyses use in deriving their results, erroneous conclusions regarding significance may be made. Several good textbooks present these concepts in relatively simple terms, yet many investigators have a limited understanding of the tests they use. Exclusive of the few texts oriented for biologists, most statistical treatments present the underpinnings of statistical concepts in mathematical terms that are difficult for [epidemiologists] to

> understand. Worse yet, the terminology used replete with double negatives, such as disproving the null hypothesis. (p. 117).

On using statistics such as biostatistics, Greenstein (2003) said that

> The limitations of statistical significance testing related to identifying clinically significant changes include failure to indicate if the detected differences between variables in test and control groups are large or important. (p. 583).

Referencing the result of their statistical (standard correlation or regression analytic) study, Tu, Maddick, Griffiths, and Gilthorpe (2004) said that they discovered that mathematical coupling could cause spurious correlations among baseline disease severities and treatment effects. Tu, Maddick, Griffiths, and Gilthorpe (2004) furthered that

> The use of ratio variables in correlation and regression analysis can give rise to spurious results due to inappropriate model specification and mathematical coupling, leading to serious misinterpretation of data and consequently to in correct study conclusions. (p. 143).

Galgut (2003) had similar findings and said that

> Results of clinical trials are reported in terms of statistical significance, but interpretation of statistical significance in relation to clinical benefits is limited. Furthermore, the compromises inherent in the design of clinical trials and in the statistical analysis techniques themselves cast doubts on the soundness of the inferences drawn from data from clinical trials. (p. 92).

See Table 13. Kaplan (1997) metaphorically illustrated misuses of epidemiology and the associated T perspective tool, biostatistics, by saying that

> It brings to mind the observations of an English economist in the last century that the use of statistics resembles that of a drunk leaning against a lamp post -- more for support than for illumination. (p. 4).

It seems that Kaplan's (1997) metaphor was vivid in a number of court cases Heafey (1988-1989) used to explain ESF. Heafey (1988-1989) began by saying that

> One of the most significant issues in litigation involving drugs or chemicals is the use of statistical evidence to "prove" a causal link between the drug or chemical use and an individual's disease or injury…Epidemiologic computations are usually accurate, but the conclusions are far from certain. Even an effective cross examination that exposes the vagaries in the correlations made by experts may not be enough to breach the wall of certainty which appears to surround evidence presented as statistical fact. (pp. 19-20).

On retrospective studies, Heafey (1988-1989) a typical retrospective case-control study should not be used as cause of a disease for court cases. Heafey said that

> The fact that epidemiologists perform retrospective studies, that these studies contain mathematical equations, and that the authors of these studies reach conclusions reported in the medical literature does not mean that retrospective studies should be admissible as evidence in a court of law. (p. 20).

Heafey (1988-1989) said that statistical hypothesis of a causal association is imaginary comprising numerical abstractions lacking fact. That hypothesis is arguably invalid and speculative such that

> An association is merely a correlation and does not prove a causal fact…While epidemiological statistics produce hypotheses or reasonable inferences that will guide scientific researchers toward areas which should be experimentally

> investigated, they are merely population searches. Therefore, these statistics do not constitute a scientific certainty of fact. (pp. 24-29).

To typify the limitations of biostatistics, Heafey (1988-1989) cited a Miller versus National Cabinet Company (a court case) on which the judge ruled that

> So long as the causes of a disease-like cancer-are unknown to science, everyone contracting the disease could secure medical testimony that it is "possible" that the disease is contracted from a wide variety of causes, choosing in each instance the particular possibility having the greatest promise of holding liable some responsible defendant. Any cancer expert could readily state that cancer could be caused by virus infection or by exposure to automobile exhaust fumes, sunlight, radiation, smog, smoking, hormone imbalance or according to any other theory which has been entertained by researchers or specialists as a possibility...This is a perversion of the normal rule that the disease must have resulted from the occupation and that the burden of proving causation is upon the party asserting it. The law does not intend that the less that is known about a disease the greater shall be the opportunity of recovery in court. (p. 30).

Heafey (1988-1989, p .38) finally said that “[a] statistical evidence should be excluded as proof of what in fact caused a…disease.

Freeman, Rossignol, and Hand (2008) added that risk of an occurrence or condition (as a proportion or percentage) is the most abused epidemiologic concept by saying that

> Risk may be expressed in absolute terms, e.g. the risk of dying in a motor vehicle crash in a given year is approximately 1 in 6500 or as a relative risk (typically presented as a ratio, but also as a difference), such as the lifetime risk of dying in a car crash is more than 23,000 times greater than dying from a snake bite. Misunderstanding is rife in such claims, however. For example, while it is reasonable to conclude that one is significantly less likely to die from a snake bite

> than in a traffic collision, this does not mean that handling a venomous snake is safer than driving a car. The average person's exposure to a venomous snake, in terms of duration, may be more than 23,000 times less than their exposure to a motor vehicle; thus the incidence of snake bite death may be significantly higher per unit of time of exposure than that of motor vehicle death per exposure for the same unit of time. Opinions involving risk often rely upon probabilistic language, and this in turn may lead to a lack of specificity. (p. 3).

The findings showed that the use of T perspective tools weakens the effectiveness and efficiency of epidemiologic systems. Table 13 listed the most well-known statistical limitations that could contribute to ESF. Where modeling approach was used, Fung (2014) listed model misspecification, parameter uncertainty, modeling intervention, and model structure as factors of T that could lead to ESF. Generally, compartmental models are an overly abstract of reality because factors that are certain in compartmental models are not in real life.

The O Perspective Contribution to ESF. The standardized O-guideline was used to discover how public (health) policy, politics, ethics, laws, and economics of public health undermine epidemiologic system. With the O-guideline (assumptions and validations), a number of O impediment thematic were discovered. Assumption and validation: Epidemiologic papers or pictorial data that used ethics, laws, or public (health) policies and politics (qualitative tools) to comment about epidemic systems without jettisoning the inherited fallacies in qualitative methods satisfied the science of organizational perspective. The actualized assumption is to use the O lens to qualify characteristics that imped the full application of epidemiologic systems. This conjecture is validated by the following:

Findings: The examinations of sixty papers marked O perspective and five video documentaries (data) marked TOP indicated two broad fields. The first sub-O lens focused on the viewpoint and actions of formal organizations irrespective of the infectious disease. The second sub-O lens focused on the belief and actions of informal organizations about (irrespective of the contextual) infectious disease. Focused on two structural type—–formal and informal organizations—–the question was rephrased to how could formal organizations' and or informal organizations' behavioral assessments of infectious disease cause ESF. See Figure 10. This restatement differentiated formal and informal organizations' reaction about epidemiologic systems.

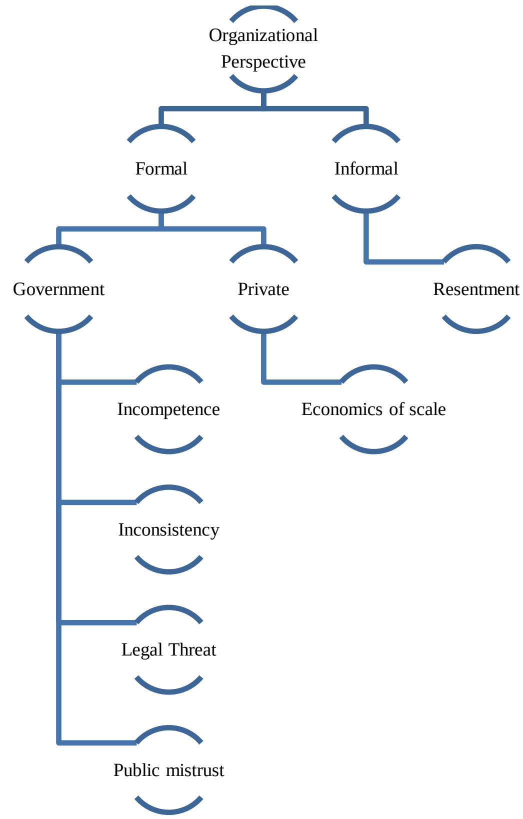


Figure 10: The organizational perspective.

Using Figure 10, the first lens focused on formal organizations such as government (health) institutions and agencies deriving functions and power from them. These agencies were World Health Organization (WHO), Center for Disease Control and Prevention (CDC), state public health, congressional committee, or a Nigeria Ministry of Health. Private organizations were nongovernment organizations (establishments) and pharmaceutical industrial groups having interest in infectious disease control and prevention. The O lens correlated the infectious disease, the actions and behavior of the concerned establishments. The second lens focused on informal organizations public health insurrectionaries: protesters. Four well-known and scientific documented epidemic systems (Ebola, Human immunodeficiency virus and AID, Tuberculosis, and Typhoid) were used to show how the O characteristics elucidated ESF.

The Formal Organization Contribution: The O examined data revealed a two-tier approach. The first-tier was a subjective evaluation. Within this tier is a legalized threat, sub-theoretic thematic. Opar (2008) validated that

> The use of mandatory isolation to keep [an infectious] disease…in check is a centuries-old practice. Isolating people with confirmed or suspected infection has helped protect the public from diseases…[and] physical barriers work better than drugs at preventing the spread of respiratory viruses…[And] if a person refuses treatment, health officials may turn to quarantine. (p. 109).

The primary objective is to enforce treatment. The first-tier is summarily depicted as government on the left branch of Figure 11. The second-tier was an objective evaluation. The second-tier is private (with respect to IDS) on the left branch of the Figure. The economics of scale was tiered with IDS and epidemiologic systems (quarantine, prevention, and treatment). The formal organization class is summarily depicted as the left branch of Figure 11. Given the identified IDS paired with epidemiologic systems, this researcher assumed that the most cardinal is quarantine. The assumption was that quarantine encompasses isolation (surveillance), infectious disease prevention to the uninfected public, and treatment.

When each of the assumed quarantine segments was examined with respect to the second-tier and given each of the first-tier, the O lens discovered public institution and private organization subclasses with respect to IDS. They included government health agencies; and drug companies and other private interest group are clustered as private organization.

Public Institution: As validated previously, epidemiologists believe that to protect lives, public health trumps individual rights. One such an outstanding epidemiologic tool is isolation. Isolation prevents spread of infectious disease (making it possible to treat the infected (hosts)) and protect the public. Notwithstanding the effectiveness of quarantine and isolation, the O lens revealed government (public health) actions that seem to impede the effectiveness of legislated health mechanism. The characterized impediments (public health actions) are incompetence, inconsistence, legal threat, and distrust.

Incompetency: The data suggested that ESF sometimes occur when public health and allied agents are incompetent in handling a given epidemic system. This discovery is validated by the following cases. According to Johnson (2013), the World Health Organization's (WHO) admitted a false claim. An article from the Washington Post validated that:

> This part is not in dispute: Greece has seen a worrisome spike in HIV cases, with the number up 52% in 2011 from 2010. But in a report last month, the World Health Organization made a jaw-dropping assertion, that about half of the new cases were the result of people deliberately infecting themselves so they could collect about $1,000 a month in benefits. Today, WHO published what Sky News calls a "humiliating" correction: Turns out, that claim is utterly untrue. (p. 1).

Another contribution to SF is government ESF actions that heighten public mistrust**.** In a letter to deans of 13 prominent public health schools, President Obama's top counterterrorism adviser, Lisa Monaco, said that the CIA agreed it would stop using vaccination programs, workers for intelligence purposes, and genetic materials obtained through the programs. Prior to the stoppage, the deans who said "public health programs should not be used as cover for covert operations," warned the CIA that the vaccination program caused the shootings of several health workers in Pakistan during the targeting of Osama bin Laden in 2011.

The O perspective focused on the ethics and regulation of health by the governments. The application the O perspective revealed that governments are usually incompetent, inconsistent, and uses legal threat to mandate health treatment. As such public mistrust becomes one of the factors that impede the application of epidemiologic tools from the O perspectives. The resentment of Liberians during the 2014 Ebola crisis, or the 2014 kidnapping and killings of health officials in Guinea during the Ebola crisis showed the extent mistrusting governments led to the ESF in both countries.

The P Perspective Contribution to ESF. As with the T and O perspectives, the P guideline was created. The guideline (as assumptions and validations) was developed to examine an individual's actions towards epidemiologic systems. The P perspective guideline focused on how individuals (disease hosts and influential individuals) could cause aspects of ESF. Epidemiologic papers or pictorial data in which infectious disease hosts blame the technocrats or the establishment without jettisoning the inherited fallacies in human psychology satisfied the science of the personal perspective. When the guideline was applied, a number of P types were discovered.

Assumption and validation: To the P, ESF is a result of T incompetence and uncompassionate O. To this perspective, epidemiologic system should not have any blemish. P was about morality of disease hosts.

Finding: The P perspective was applied to answer how could the multiple perspectives inquiring systems by Linstone (1984) and fuzzy logic by Zadeh (1965) be used to discover the factors causing or influencing ESF. The examinations of 50 papers marked P perspective and five video documentaries (data) marked TOP indicated two broad fields. The first sub-P lens focused on the viewpoint and actions of an infectious disease host irrespective of the infectious disease. The second sub-P lens focused on the belief and actions of influential individuals about (irrespective of the contextual) infectious disease. Focused on the two broad fields—–host and influence—–the question was rephrased to how could hosts' and or influential individuals' behavioral assessments of infectious disease cause ESF. This restatement differentiated the host's and or influential individual's reaction about epidemiologic systems.

The discovery is shown in Figure 11. Using Figure 11, the first P lens focused on the hosts of an infectious disease, but correlated the diseases and the actions and behaviors of the disease hosts. The second lens focused on influential individuals' implicit or explicit actions, but correlated the hosts and the health establishment. The resentment targets establishment including drug companies and or public health system. Four well-known and scientific documented epidemic systems (Ebola, Human immunodeficiency virus and AID, Tuberculosis, and Typhoid) were selected to determine if disease hosts or influential individuals elucidated ESF.

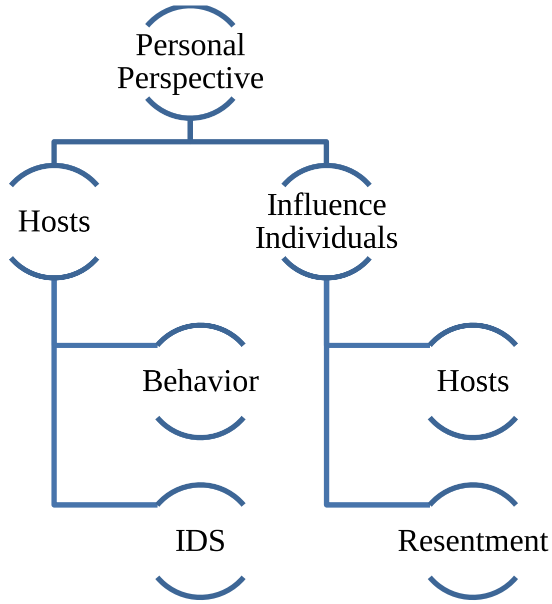


Figure 11: The personal perspective

The examined literature using P filter or lens showed a two-tier host approach. With the tier I discovered displaced aggression, unethical behavior, and unreasonable freedom. This tier is summarily depicted as behavior on the left branch of the figure.

Conditioned Perspectives Contributions to ESF. To understand how T, O, and P could cause ESF, this researcher conditioned the three perspectives into six. Each perspective was acclimatized to the others such that T given O (for instance) gave T/O with O/T as the complement. These are likened to mathematical expressions. The others with similar associating complements are T/P with P/T; P/O and O/P. Then each of the conditioned was applied in consideration of Ebola, HIV/AIDS, Tuberculosis, and Typhoid.

Ebola: Ebola began raging in West Africa (Guinea, Liberia, Nigeria, Senegal, and Sierra Leone) countries in 2014. To understand each perspective with respect to ESF, this researcher applied the conditioned expressions. The following were said and understood with the application of P/O (where P is an influential individual and O is the organizational stance). On the Ebola ESF, Boyle said

> It seems to me, that what we are dealing with here is a biological warfare work that was conducted at the bio-warfare laboratories set up by the USA on the west coast of Africa. And if you look at a map produced by the Center for Disease Control you can see where these laboratories are located. And they are across the heart of Ebola epidemic, at the west coast of Africa. So, I think these laboratories, one or more of them, are the origins of the Ebola epidemic. I have absolute proof from a Pentagon document that the Center for Disease Control was doing bio-warfare work for the Pentagon in Sierra Leone, the heart of the outbreak, as early as 1988.

On trusting Public Health or the O, Boyle continued

> So, again, I don't believe you can trust anything the WHO or the CDC [is] telling you. And I really don't know about the European Health Agency… If they‘re believing the WHO and the CDC then, in my opinion, they‘re not properly protecting the health of the European people…These people are trying to distract public opinion from the fact. My opinion is that the origins of the current pandemic came out of the USA bio-warfare labs in West Africa.

When Patrick Sawyer, a Liberian infected Nigeria health official, a former Nigeria's president Obasanjo derided the unethical behavior of the Liberian **(**Patrick Sawyer) and the Liberian minister (Sebastian Omar) who approved the travel by saying:

> It is devilish enough that Patrick Sawyer had to spread this [Ebola virus disease, EVD], and, indeed, spread it to Nigeria in connivance with some authorities from his country [Liberia]. Because they knew he had it before he came to Nigeria. The EVD has started to take its toll on the country [Nigeria] and the West African sub-

> region. The toll is not only on the number of those that are ill or dead but on the economy of communities, countries, region and the sub-region.

Concerned about possible ESF, Nigeria's President (Goodluck Jonathan) said

> It is unfortunate that one mad man brought Ebola to us, but we have to contain it. As a government, we promise that we will do everything humanly possible to contain the Ebola virus.

In like manner, a former Nigeria Minister of Aviation **(**Femi Fani-Kayode**)** added that

> I disagree with those who have described Patrick Sawyer as a madman. He was not mad at all but just evil. He was a man that was on a mission. That mission was to spread the Ebola virus to Nigeria and to infect and kill as many people as possible with it. He was an evil man with an evil intention and purpose. Worst still he was not working alone. Some people, and I mean rich, powerful and well-connected people, were working with him. As a matter of fact they sent him on the mission. They cultivated him, took care of him, paid him, brainwashed him, gave him all that he wanted in life and finally asked him to go on a suicide mission to destroy the lives of others and spread the deadly disease. This was a clear case of bio-terrorism and Sawyer was simply a pawn in a bigger game and a wider picture.

On P/T (P (Kayode) as an influential individual and T as drug industry) Femi Fani-Kayode continued

> The motive of those who sent him was to spread fear and panic, to kill as many people as possible, to create a need for a solution to the problem, to prepare the ground for a new wonder drug that could cure [Ebola], to create a massive market for that drug and to ensure that there would be massive profits from it's sale. As usual it is the unbelieving, unprepared, undiscerning and naive Africans that have been used as the prime guinea pigs. When will they stop destroying us and

> treating us with such contempt? When will they begin to see and treat us as human beings?

With an O/P expression where O is a representative of a government (Liberian Minister of Information, Lewis Brown) and P (as a disease host: Mr. Sawyer), Mr. Brown concerned with Mr. Sawyer's moral standard and ethics said:

> I can confirm to you that he was advised by the Chief Medical Officer at the Ministry of Health not to leave the country because he was under observation… It was regrettable that he left the country while being observed. [That] we [the government of Liberia] felt he had a duty to his colleagues to tell them that he was under observation for the disease. We also felt he had a duty to our country and yours (Nigeria) not to leave Liberia so as not to endanger the lives of others."

Substituting Mr. Brown with Mr. Omar as representing the O and P as Mr. Sawyer, Mr. Omar said

> A friend [Patrick Sawyer] is dead; I do not owe you any explanation. POS (Patrick Sawyer) was a public health practitioner if you must know. The Ugandan doctor was a medical doctor if you again must know. They are no longer. So the freaking issue is not why he lied or didn't lie to travel. If you don't have jack to say in that direction then frankly shut up on the subject. Sebastian Omar doesn't have time today frankly for your rants. Someone must have frustrated the hell out of you in Liberia...Take me to the international court since I am guilty of approving a travel.

When this researcher applied O/T where O is the Liberia government and T is application of epidemiologic instrument and the discovery of Ebola infectivity in the country, Mr. Brown said that O (the government given the T in reference to Mr. Sawyer)

> It's possible the health ministry was monitoring him (Mr. Sawyer) but the finance ministry did not know. It was a slip and we have learned from it regrettably. Before the Patrick Sawyer incidence, we did not have that kind of cooperation. We were not locking people under observation down. We were only bringing them to the isolation center after they show signs of the disease.

Another T/O occurred during the Ebola epidemic system happening in the USA. It involved the initial poor handling of the disease (minimizing or preventing) the spread in the USA. In the case, the executive vice president of Texas Health Resources (referring to a Liberian who visited relatives in Texas in September 2014 from Liberia) said a medical team “felt clinically [the visitor’s viral disease] was a low-grade common viral disease”. The visitor who later died of Ebola initially checked in to the hospital, but was sent home. The hospital claimed the Liberian’s initial symptoms were “low-grade fever and abdominal pain,” and would not warrant admission. Texas public health however tracked and quarantined those that had contact with the visitor. The hospital later admitted that “[the visitor] volunteered [haven] traveled from [Liberia] in response to the nurse operating the checklist and asking that question…Regretfully, that information was not fully communicated throughout the full team”. Considering the hospital staff as T and the Hospital and Texas Public Health as O, ESF was evident because the nurse failed to disclose or report that the visitor came from Ebola raging country and could infect others. Also the T misdiagnosed the host. The T failed to follow health policy or guideline.

HIV/AIDS: As one of the preludes to explain HIV/AIDS ESF, the Office of Kalamazoo County Prosecution dismissed one Russell Lee Willis case the same day Mr. Willis should have faced trial. Mr. Willis (a HIV positive) had unprotected sex with an uninformed partner. Surprisingly, the victim declined to testify against Mr. Willis in an open court about her exposure to HIV. The sexual encounter became known when the victim confronted Mr. Willis after her friend saw Mr. Willis outside her home. The friend warned the victim that Willis served a four year prison time for failing to disclose he was HIV-positive to his former sex partner.

In another case, one Mr. David Dean Smith (estimated slept with 3,000 men and women) was charged with two counts of AIDS-sexual penetration after turning himself to the police. According the investigating officer, "[Mr. Smith] says he intentionally attempted to spread the disease to kill people [and Mr. Smith's] latest fantasy is strangling a woman and having sex with her dead body". It was widely accepted in epidemiology that deadly disease hosts should be isolated or quarantined as it was in the case of Mary Mallon. However and from the onset of HIV/AIDS disease, the hosts were never isolated or quarantined.

This in mind, this researcher tested ESF with respect to isolation (disease control and prevention) on HIV/AIDS. With isolation and treatment as the epidemiologic policy (as the O) and the actions of health experts given the O (as the T), the researcher conditioned the three perspectives to T/O and P/O. P was considered an influential individual. The P/O revealed Huckabee complained

> If the federal government is truly serious about doing something with the AIDS virus, we need to take steps that would isolate the carriers of this plague…It is difficult to understand the public policy towards AIDS. It is the first time in the history of civilization in which the carriers of a genuine plague have not been isolated from the general population, and in which this deadly disease for which

> there is no cure is being treated as a civil rights issue instead of the true health crisis it represents… I feel homosexuality is an aberrant, unnatural, and sinful lifestyle, and we now know it can pose a dangerous public health risk

Huckabee seemed to suggest that the sudden policy change (jettisoning isolation, a sound health policy) for human right policy (not isolating or quarantining those with HIV and AID diseases) caused the wide spread of HIV/AID and associated deaths. The policy failure is an ESF.

Michael L. Johnson's 2014 case seemed to validate Huckabee's assumption. Michael L. Johnson of Missouri deceptively infected people with HIV and video-taped the callousness. Missouri police noted about 31 individual had unprotected sex with Mr. Johnson who knew he had HIV. Johnson was thereafter charged with (possible life imprisonment) recklessly infecting others with HIV. Another influential P, Troy Mader (1989), recommended a mandatory testing for everyone:

> If not, it would be well to enroll your children in a private school that does test for AIDS, or take other actions you, the parent, deem necessary in protecting your children from the AIDS virus infection…There is no a constitutional right to practice homosexuality…Many homosexuals demand the right to kill themselves with the AIDS virus and to kill others by infecting them. (p. 180).

When the T/O and P/T were applied, Lang (a HIV/AIDS expert) worried about the reluctance of drug industries in treating IDH by saying that

> If we can get Coca-Cola and beer to every remote corner of Africa, it should not be impossible to do the same with drugs…South Africa, Botswana and Swaziland will be potential basket cases if they don't act, and in the case of Botswana, if it

doesn’t act, it will cease to exist.

Lange was seen as P (an influential person) and T (a health expert). When Lange was seen as the T the drug industries were considered as market regulatory body or O. When Lange was seen as an influential person P, the drug industry was considered as health medical experts or T. The drug industry was considered T in the sense that they manufacture drugs for infectious diseases; and as O, they regulate, monopolize the making, supply, and marketing.

Relied on social stigma theory to understand the continuity of HIV related stigma, Jurgwnsen, Tuba, Fylkesnes, and Blystad (2012) seemed to suggest that the burden of one knowing being HIV positive and IDHs’ personified irreconcilable memories of suffering and death among non-curable AIDS patients over the last decades cause ESF. The ESF resulted from the reluctance of some percentage of the targeted population to take HIV tests. The reluctance was due to avoid being labeled HIV-positive. Jurgwnsen, Tuba, Fylkesnes, and Blystad (2012) validated that

> To know your status was found to be a highly charged concept yielding strong barriers against HIV testing. [Voluntary counselling and testing] (VCT) was perceived as a diagnostic device and a gate way to treatment for the severely ill. Known benefits of prevention and early treatment were outweighed by a perceived burden of knowing your HIV status related to stigma and fear. The manner in which the VCT services were organized added to this burden. (p).

Supported Jurgwnsen, Tuba, Fylkesnes, and Blystad (2012), Dlamini, Kohi, Uys, Phetlhu, and et.al (2007) identified ESF when noting P/T that

> Participant reports documented extensive verbal and physical abuse and neglect or negating (disallowing of access to services and opportunities) experienced by [people living with HIV/AIDS] (PLWA) and observed by nurses caring for them, and identified negative consequences experienced by PLWA whose HIV-positive status was disclosed to family friends, or community members. (p. 389).

Dlamini, Kohi, Uys, Phetlhu, and et.al (2007) explored the P/T experiences of HIV/AIDS stigma of people living with HIV/AIDS in Lesotho, Malawi, South Africa, Swaziland, and Tanzania. Daftary and Padayatchi (2012) substantiated in a TB/HIV co-infected patients in South Africa study that

> Fears of having to face the stigma associated with HIV affected many patients' adherence to co-treatment. They hid their medications, delayed or skipped a dose to avoid being labeled as sick. In the context of their communities, patients feared any illness would be perceived as HIV/AIDS. Stigma also affected patients' retention in HIV care. The fear of being discriminated and consequent inability to openly share their status when first diagnosed with HIV, pushed several patients to remain secretive and neglect accessing healthcare, particularly when asymptomatic. Now acutely ill with TB, patients believed they had compromised their health worrying about how others would perceive them. The negative social consequences of being identified at HIV clinics accelerated some patients' decisions to "quit" attending, particularly when ineligible for [antiretroviral treatment] ART. Conversely, the stigma associated with overt EPTB symptoms (e.g., enlarged glands) encouraged others to adhere. Adherence would assure them quicker recovery from physical symptoms – symptoms they perceived were more indicative of HIV. (p. 1483).

In a P/T and P/O study about introducing HIV testing among tuberculosis patients in Jogjakarta, Indonesia, Mahendradhata, Ahmad, Lefvre, Boelaeert, and Van (2008) found out that

Patients' and providers' knowledge regarding HIV was poor. The main barriers perceived by patients were: burden for accessing VCT and fear of knowing the test results. Stigma caused concerns among providers, but did not play much role in patients' attitude towards VCT. The main barriers perceived by providers were communication, patients feeling offended, stigmatization and additional burden.

Tuberculosis: Tuberculosis is one of the dreaded infectious diseases**.** With isolation and treatment as the epidemiologic policy (as the O) and the actions of health experts given the O (as the T) on TB, the researcher conditioned the three perspectives to T/O, P/O, and P/T. In a P/O or P/T condition, Daniels (a Russia national whose wife and child reside in Russia, is jailed in Arizona over tuberculosis). Daniels (as the P) hinted an instance of ESF by saying

> I'm slowly dying in this room…I didn't realize how serious this was, and I regret that, but nothing justifies the kind of treatment I've received in here. The solitary confinement starts to mess with your head and it has taken a serious toll on my body.

To substantiate the ESF, an ACLU attorney Linda Cosme clarified that

> It's psychologically damaging to exist in a vacuum without meaningful activities or opportunities to interact with others…By placing Robert Daniels in these deplorable conditions, the county clearly has no intention of helping him get better. For years, they've been aware of the need to create an adequate quarantine area for extremely ill patients, yet they've chose to ignore the needs of some of

> the most vulnerable people in Maricopa County in favor of harsh, jail-like conditions for people who are sick and accused of no crimes

However, ACLU in a court case on behalf of Daniels did not request Daniels release, but to treat Daniels humanely. The reason was that

> For most of the 10 months, he has not been allowed a TV or a telephone, and he has absolutely no activities during the day. It is taking, predictably, a terrible toll on his psyche. I believe it is not helpful for the physical treatments as well…He's not seen the horizon, seen a tree, from his locked room for 10 months…He has a light on 24 hours. There's a video camera in the corner of the room that takes pictures of his every activity in that room 24/7. His mail is opened routinely.

According to ACLU, there seemed no assurance when or if Daniel will ever be treated. Until that occurs, Daniel will remain locked up. The Daniels' case indicated how isolation causes ESF because of additional physical and mental hardships to the host. No assurance of treatment was an indication of a total ESF. It seemed therefore that strict isolation could be attributed to one of the factors of ESF.

In January 2007, the USA Center for Disease Control and Prevention (CDC) claimed that one Andrew (TB Andrew) knew of hosting a strain of tuberculosis or Multidrug resistant tuberculosis (MDR-TB) before traveling to Europe via commercial plane. The CDC furthered that Andrew still boarded commercial plane. Incongruous as it seemed, a US border control officer gave TB Andrew a free passage. TB Andrews' responses revealed P contribution to ESF. TB Andrew argued that

> No one ever gave the impression that I was a threat to anyone…No one ever told me that any one in my family was at risk…If they' re [the CDC] going to say now

> that I was a threat, then they should have said that a long time ago so I can protect my wife and my child.

TB Andrew continued

> I hope they [the public] understand, based on what I was told didn't think I was making that gamble…I truly believe that there is a misunderstanding of how we entered into all of this. I hope they understand that at every turn it was conveyed to me that my family, my wife, my daughter, no one was at risk. And that I was not contagious. And that I never would have put my family at risk and my daughter at risk…Everyone knew. The CDC knew, doctors knew, Kaiser knew. [CDC] said we would prefer you not go on the trip…And that's when my father sad, 'OK, are you saying because he's a risk to anybody or are you simply saying it to cover yourself?' And they said, 'We have to tell you that to cover ourselves, but he's not a risk.'

To further contribute to ESF, during a phone call, Ted [TB Andrew's father] replied Dr. David Kim of the CDC: 'I can't do that. I don't know where he [TB Andrew] is ... I appreciate your call'. Dr. Kim had asked on May 22, 2007: 'I need your assistance to reach out to Andrew "to get him back to U.S. quickly and safely.

Typhoid: One of the earliest cases of typhoid occurred in New York in early part of 1900s. The noticeable case was Mary Mallon (Typhoid Mary). Ms. Mallon was a healthy carrier for she was typhoid positive without the symptoms. P/O or P/T condition with respect to typhoid was applied. The application revealed Mary Mallon complaining about her isolation saying

> Why should I be banished like a leper and compelled to live in solitary confinement with only a dog for a companion? ... I have committed no crime and

> I am treated like an outcast -- a criminal. It is unjust, outrageous, uncivilized. (Leavitt, 1996, p. 180)

Where Mary Mallon was the P (the disease host), New York public health agency as the O, and the epidemiologists or the agency staff as the T. Mary Mallon continued

> I never had typhoid in my life, and have always been healthy. Why should I be banished like a leper and compelled to live in solitary confinement with only a dog for a companion? ...This contention that I am a perpetual menace in the spread of typhoid germs is not true. My own doctors say I have no typhoid germs. I am an innocent human being. I have committed no crime and I am treated like an outcast -- a criminal. It is unjust, outrageous, uncivilized. It seems incredible that in a Christian community a defenseless woman can be treated in this manner. (p. 180).

To understand the action of the health specialists, this researcher applied the T/P. The application discovered Dr. Baker saying

> I had my first talk with Mary in the kitchen of this house. . . . I was as diplomatic as possible, but I had to say I suspected her of making people sick and that I wanted specimens of her urine, feces and blood. It did not take Mary long to react to this suggestion. She seized a carving fork and advanced in my direction. I passed rapidly down the long narrow hall, through the tall Iron Gate . . . and so to the sidewalk. I felt rather lucky to escape.

Dr. Baker furthered

> Mary was on the lookout and peered out, a long kitchen fork in her hand like a rapier. As she lunged at me with the fork, I stepped back, recoiled on the policeman and so confused matters that, by the time we got through the door, Mary had disappeared. 'Disappear' is too matter-of-fact a word; she had completely vanished.

With P/O expression where O was the health agency and P been Mary Mallon, the latter complained

> This contention that I am a perpetual menace in the spread of typhoid germs is not true. My own doctors say I have no typhoid germs. I am an innocent human being. I have committed no crime and I am treated like an outcast -- a criminal. It is unjust, outrageous, uncivilized. It seems incredible that in a Christian community a defenseless woman can be treated in this manner.

With P as an influential person (in the case of Judith Walzer Leavitt and O been the public health and the New York government, Dr. Leavitt pointed the existence of ESF by pointing out that

> The conflict between competing priorities of civil liberties [P] and public health [O] will not disappear, but we can work toward developing public health guidelines that recognize and respect the situation and point of view of individual sufferers. People who can endanger the health of others would be more likely to cooperate with officials trying to stem the spread of disease if their economic security were maintained and if they could be convinced that health policies would treat them fairly. Equitable policies applied with the knowledge of history should produce very few captives to the public's health.

ESF occurred when disease hosts begin to believe that the application of isolation inserted fear of imprisonment to them.

In addition to the conditioned P perspective with T and O, Two groups (disease host and influential individuals) consisted the P-perspective that contributing to ESF. The disease hosts uses displaced aggression, unethical behavior, or unreasonable desire of freedom at the risk of the general public. The factors are listed in Table 14, Table 15, and

Table 16. On another hand, influential individuals contribute to ESF through public encouragement to ignore public health policy. It follows that the P perspective showed how an individual or influential persons could impede the application or the effectiveness or efficiency of epidemiologic instrument during health crisis. This was evident in Liberia where a number of Liberia officials defended Mr. Sawyer's visit to Nigeria with Ebola disease or virus.

Research Question 1 Summary

To answer this research question, I developed TOP guidelines. Each article was exhaustively read and notes taken. Abstract and summary (conclusion) of each article were read first. After the fourth reading of full text or watching each datum, it was marked and placed into the appropriate perspectival group. The articles and notes taken from the pictorial data were grouped according to the perspectives. The stages are listed in Table 17.

Systemic Observation for Research Question 2

To ensure research reliability and validity, each ES primary document and video documentary was scrutinized five times and comments or direct quotes from the participants were used. Research question two was reframed and likened to asking how one could develop a TOP fuzzy set theoretic and scientific instrument to monitor ESF. From the findings of research question one, the necessary T, O, and P factors for monitoring ESF were identified.

The procedure for answering research question two is detailed in Appendix C. To measure the actual resilience level, the epidemiologic instrument is likened to a set of remote sensors (similar to thermometers), but with linguistic (numeral) calibrations. After identifying and selecting the individualities, three timeframes—pre-event, event, and post-event—as fuzzy sets were considered as the ideal patterns. The timeframes were non-severe, severe, or very severe. For example, the Nigeria pre-event (the Ebola index case) could be mapped as severe or very severe. A timeframe was defined as a fuzzy set. See Appendix C.

Ebola TOP Epidemiologic Systems Failure Case Study

The Democratic Republic of Congo Yambuku village (near River Ebola) and Nzara Sudan were the first recorded Ebola infectious disease (EID) cases in 1976. EID transmits through contact with a host's blood, secretions, organs, or other bodily fluids. In a given human population, the disease is expected to pose a major health hazard. With the foreknowledge and the 2014 West Africa countries (Guinea, Liberia, Nigeria, and Sierra Leone) EID happenings, this case study demonstrated how to simulate if there were ESF or the lack thereof during those cases.

The first Nigeria Ebola case was introduced by Patrick Sawyer—–a Liberian. According to Mrs. Sawyer, Patrick sought treatment in Nigeria after contact with late EID ailing sister in Liberia. Although aware of the serious implications of the contacts, and having signs of some EID symptoms, Patrick never disclosed the facts to the Nigeria health officials at Nigeria port of entry. Belligerently, Patrick exposed a number of staff to the virus at a Lagos hospital. To worsen the situation, one of the nurses who had a direct contact with Patrick escaped surveillance to Eastern Nigeria thereby sharply increased Nigeria's epidemiologic systems workload with about twenty cases. In addition to that but for an Ebola treatment, a non-Nigeria diplomat of Economic of West Africans (ECOWAS) escaped surveillance to Southeastern Nigeria. The diplomat also had contact with Patrick. The physician and the assistant who treated the diplomat later died of EID. The physician's family members were among those quarantined. In all, about 198 individuals were under surveillances.

With synthetic data as shown in Table 18, this researcher simulated the event with TOP model using Microsoft Excel software (Murray, 2010).. For clarity, imagine placing T, O, and P data sensors in Nigeria before, during, and after the Ebola crisis. The T lens filtered technical data; The O lens filtered organizational data; and the P lens collected personal perspective data. The filters were assumed to be specialized web crawlers (collecting data from news outlets) or humans.

For possible implications, the following assumptions were brought to bear. The T lens on filtering technical data sought to determine if the health officials are knowledgeable about combating infectious disease and methods of applying the necessary health policies, regulations, and health technologies. The O lens sought to know if there exist necessary and sufficient public health policies and regulations about infectious diseases with respect to EID. The policies and regulations were assumed to minimize the spread of EID. The core regulations and policies are expected to be independent of the disease. Examples are surveillance, isolation, quarantine, and enforcing public awareness of the disease. The Nigeria public health officials (knowledgeable about Ebola, state health policies and regulations) are considered the O assessors. It is also assumed that the infected and uninfected persons (from the P perspective standpoint) are expected to obey public policies and regulations (minimizing the spread of the disease). They should not be belligerent and unethical.

With Serial and parallel configurations (formations) this researcher considered ten T perspective observers, ten O perspective observers, and ten P perspective observers. Each observer is subscripted according to the assigned perspective. For example, T_1 is the number one T perspective observer. See Table 18. Also ten unspecified variables (listed under the *V* in Table 18) are used in this demonstration.

Given any V_i, each of the perspective observers assigned a linguistic (numeral) variable L_i (from the six labeled linguistic (numeral) variables from Figure 12) to $V_{i.}$ For instance, T_3 assigned 1 as L_i to V_7. Tables 19, 20, and 21 show the completed assignments. Using the numeric values of each of the linguistic (numeral) variables from Figure 12 or Figure 29, each of the L_i is then converted to an appropriated fuzzy possibility set.

The ESF mathematics and figures are explained in Appendix C. The first consideration was on the mean survival time in a state. The elapsed time ES is in an ineffective state before being in an effective and efficient state). The state is the time it takes ES to perform as expected after a failure or nonperformance.

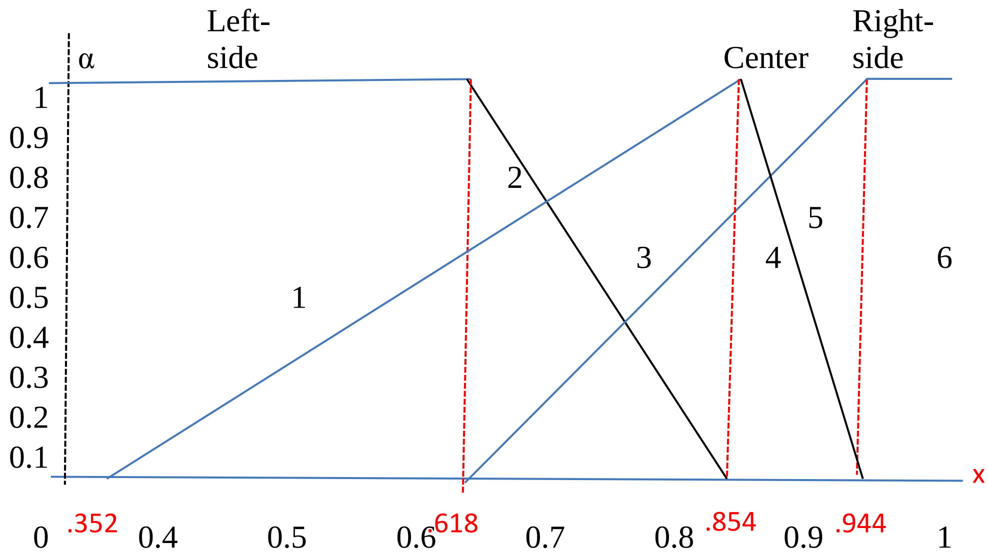


Figure 12. Golden rule linguistic (numeral) variables

For example, the T_3 assignment is $T_3(7) = 1 = V_7(3) = \left[\overset{a}{0}, \overset{b}{0}, \overset{c}{.618}, \overset{d}{.618}\right]$ as shown in Table 19. In furtherance of the calculation, all the fuzzy possibility sets of each variable were added with the ordinary arithmetic addition-operation. This addition gave $V_7 = \left[\overset{a}{5.802}, \overset{b}{7.574}, \overset{c}{8.810}, \overset{d}{8.810}\right]$ and divided by the number of each perspective observers. For example, the quotient of 5.802 into ten observers gave 0.5802. See in Table 19 that $V_7 = \left[\overset{a}{.5802}, \overset{b}{.7574}, \overset{c}{.8810}, \overset{d}{.8810}\right]$ along with the other V_i calculations. See Table 20 for the O perspective and Table 21 for the P perspective calculations. The TOP configuration data is also shown in Table 22.

Using fuzzy min-operator the possibility of O given T (O/T) was obtained as shown in the T/O section of Table 23 for each V_i as L_i. For example, the minimum value of $T_1(a)$ and $O_1(a)$ is 0.0506. The operation was applied to T_1 (a) and O_1 (a), T_1 (b) and O_1 (b), $T_1(c)$ and $O_1(c)$, and T_1 (d) and O_1 (d) similar to the $T_n = [a, b, c, d]$. The max-operator was applied to obtain the maximum value for a, b, c, and d columns of the O/T such that the a value is 0.609, b is 0.819, c is 0.887, and d is 0.887. Similar fuzzy possibility set calculations was performed for the P/O and P/T conditions. For the T/OP, the OP was determined by taking the max of O and P then the minimum of T and OP was taken.

TOP necessary condition (TOPnc), T given TOPnc (T/TOPnc), and T given O and P (T/OP) and TOP sufficient condition (TOPsc), T given TOPsc (T/TOPsc), condition were also sought as shown in Tables 24 and 25. If i equals one then $TOPsc(1) = \left[\overset{a}{.736}, \overset{b}{.879}, \overset{c}{.926}, \overset{d}{.926} \right]$ as shown in the TOPsc section of Table 25. The totality of $TOPsc = \left[\overset{a}{.736}, \overset{b}{.896}, \overset{c}{.943}, \overset{d}{.943} \right]$. This is shown in the last row of the TOPsc section of Table 25. If T_i is one then $T/TOPsc(1) = \left[\overset{a}{.506}, \overset{b}{.819}, \overset{c}{.881}, \overset{d}{.881} \right]$. The totality of $T/TOPsc = \left[\overset{a}{.657}, \overset{b}{.821}, \overset{c}{.907}, \overset{d}{.907} \right]$ as shown in the last row of the T/TOPsc section of Table 25. The totality of $T/TOPnc_i$, maximum of each a_i, b_i, c_i, and d_i of Table 24 was determined similar to the T/TOPsc as shown in the last row of the T/TOPsc section of Table 25.

From the totality of P/ (O/T), O/ (P/T), or T/ (P/O) of Table 26 and P/ (T/O), O/ (T/P), or T/ (O/P) that each of the six serial configurations (as shown in Figure 30) is equal and equivalent. Also, TOPnc or T/TOPnc was equal to any of the serial configurations. See Table 24 as shown in Figure 25, the T/(O/P) fuzzy set is represented along the *x* axis with green.

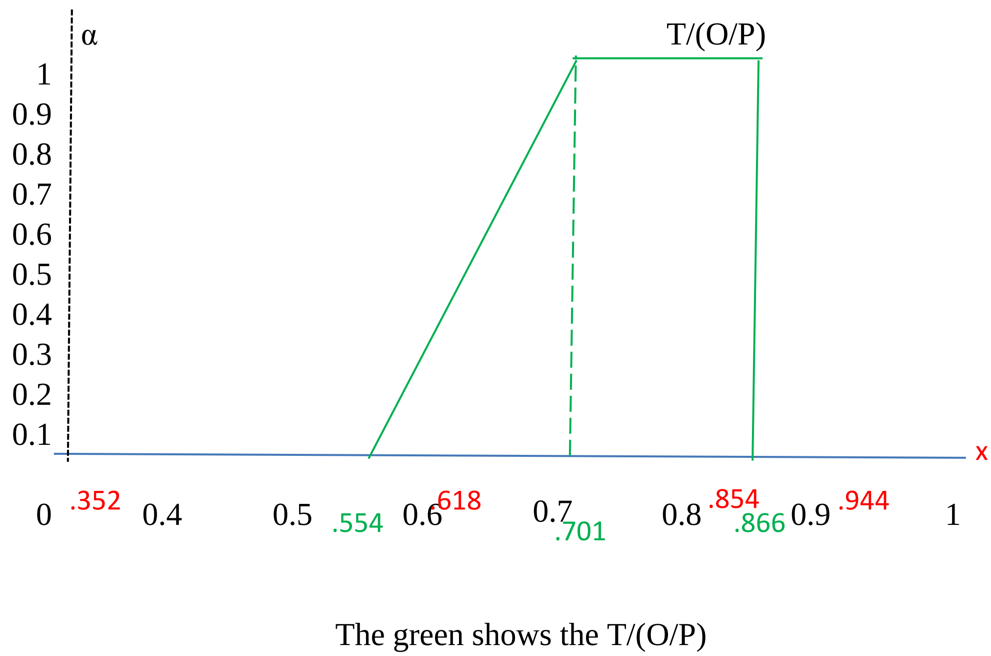
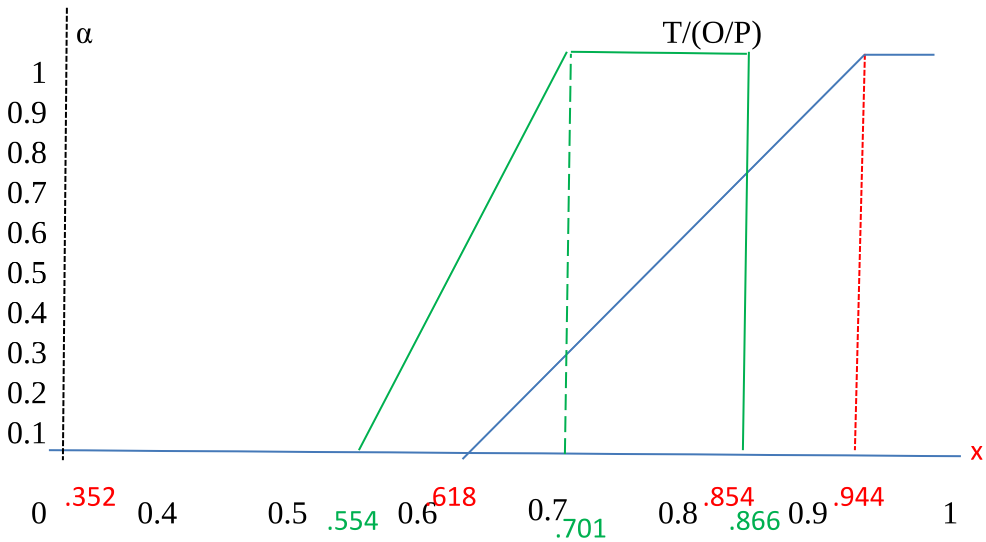


Figure 13: T/(O/P)

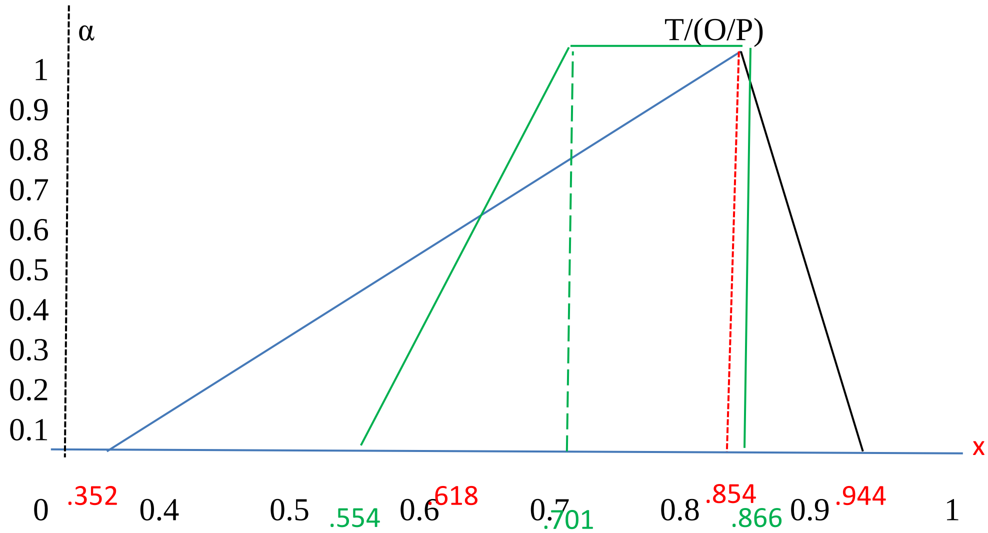
The T/(O/P) was chosen for this study because any of the serial configurations could be chosen to measure ESF. To determine the level of the ESF, the rightmost linguistic (numeral) variable or Figure 24 was chosen. The T/ (O/P) configuration (Figure 13) was then superimposed with the right-side linguistic (numeral) variable (Figure 25) as shown in Figure 14. Figure 14 shows that T/ (O/P) is partially in the right-side. But, when T/

(O/P) was compared with the center (see the Appendix B and Figure 13), as shown in Figure 15, the figure shows that T/(O/P) is more in the center.



T/(O/P) against the rightmost ESF, the green shows the T/(O/P)
Figure 14. Failure possibility distribution.

See Figure 15.



T/(O/P) against the Center ESF (The green shows the T/(O/P)

Figure 15. The superimposition.

Using the parallel method, Figure 16 or TOPsc (see Table 25) was selected. The works of Noor and McDonald (1996) and Verma, Srividya, and Deka (2004) provided the basis for calculating the ESF. See Appendix C. The figure was graphically compared to the right-side as shown in Figure 18.

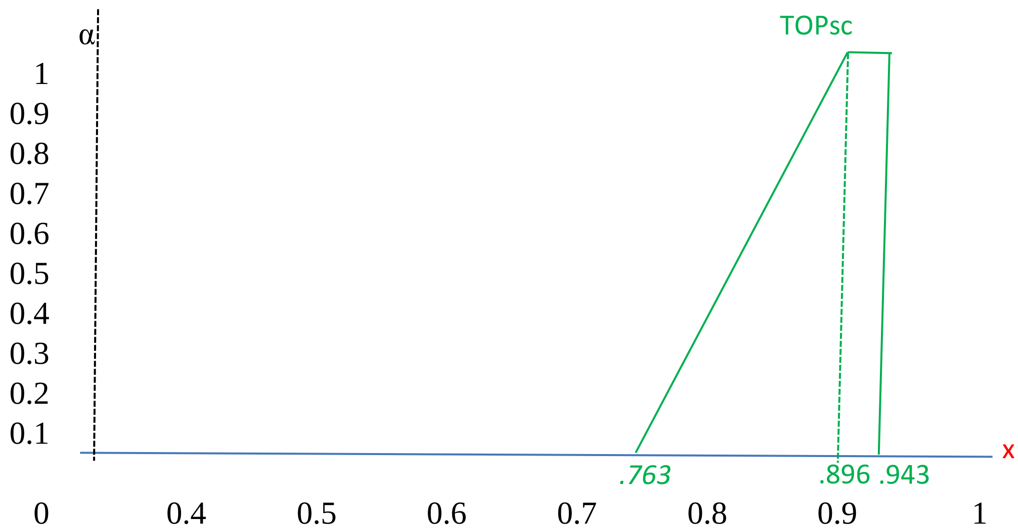


Figure 16. TOPsc for Ebola ESF.

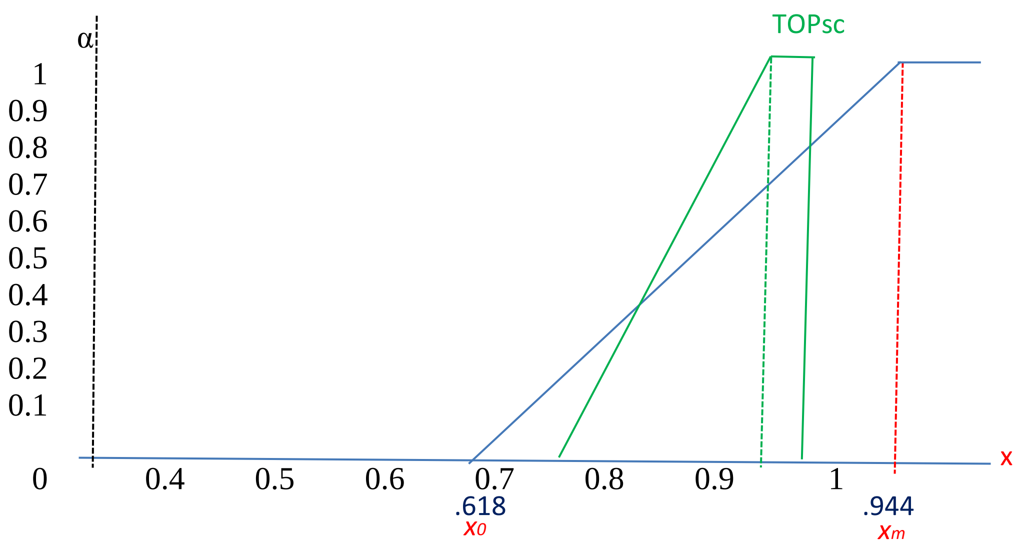


Figure 17: TOPsc superimposition with the right-side.

The next step was to select TOPnc as shown as Figure 14 (see Table 24) and compared with TOPsc as shown in Figure 19.

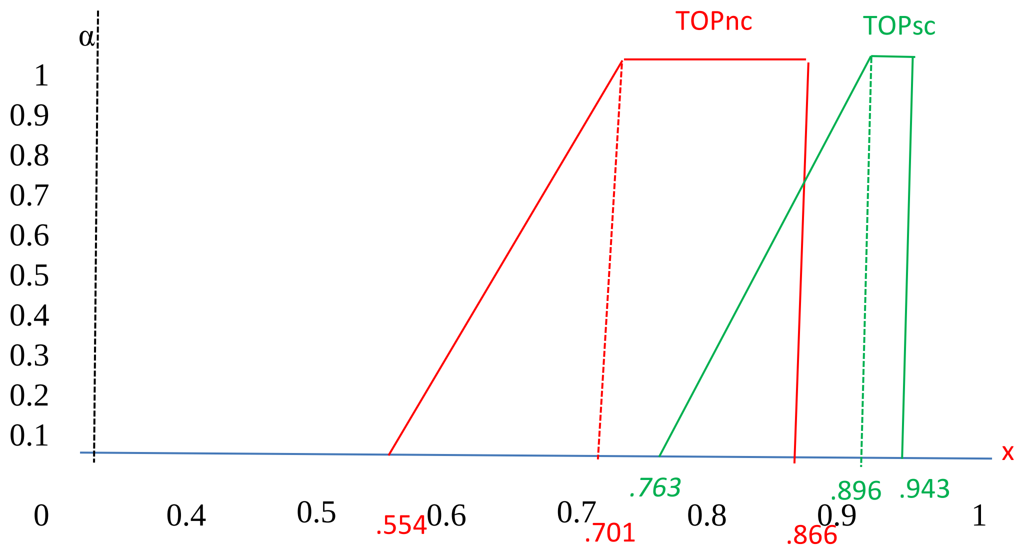


Figure 18: T/OPnc and TOPsc representation.

From Figure 18 this researcher calculated the arithmetic mean *x* between the two fuzzy sets. From the figure, $a = .896; b = .866$ then $x = .881.$ For survival (see Figure 19), $S_f(x) = 0$ because from the figure $.881 \succ .66 \mid x \succ x_o$; where

$x_o = \frac{.701 - .618}{2} \approx .0415 + .618 = .66$ or the mean along the X axis.

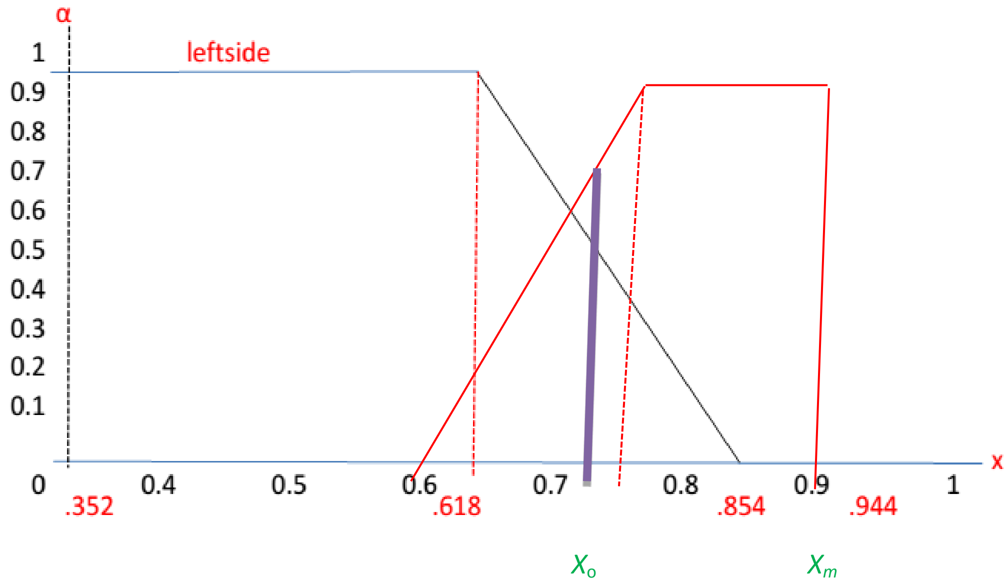


Figure 19: Survival possibility distribution determination (left-side and TOP_{nc})

Deviating from the works of Noor and McDonald (1996) and Verma, Srividya, and Deka (2004), the best representation of repair possibility distribution was determined. It was assumed that the distribution should show that epidemic system repair time usually differs from failure distribution. For example, epidemiologic system might fail for months whereas the repair might be in days or few weeks. The possibility was assumed to increase from 0 to x'_m where the alpha-cut is at a unit level. It would therefore be possible that the system could be repaired at x'_m. From Figure 19 $x'_m = .896$ and $x = .881$ then the equation becomes $\Pi_r(x) = \frac{x}{x'_m} = \frac{.881}{.896} = .983$ for $x'_m > x$. Given Figure 17, let $x'_m = .854$ and knowing that $x = .881$, then the possibility that the epidemiologic system was not repaired from time x_o to x is (a non-repairable possibility distribution) was

$$S_r(.881) = 1 - \frac{.881}{.854} = 1.0316 - 1 \text{ or } .0316.$$

Further, the mean time failure (MTTF) was obtained from Figure 14 as .853. The mean time to repair (MTTR) was also determined to be .427. Concluding with the parallel configuration, an epidemiologic forced outage rate (EFOR) was obtained such that $EFOR = \frac{MTTR}{MTTF + MTTR} = \frac{.427}{.853 + .427} = .446$. In addition, x is to the right (outside) of T/ (O/P) as if x is compared to Figure 28 which is the ESF according to the serial method. The parallel method is much intuitive.

Research Question 2 Summary

I answered two research questions in this study: How could the multiple perspectives inquiring systems (technical, organizational, and personal perspectives) by Linstone (1984) and fuzzy logic by Zadeh (1965) be used to discover the factors causing or influencing epidemiologic systems failure? The other is: How should a usable (efficient and effective) ESF monitoring tool be constructed from the synthesized perspectives? The answers were guided with three multiple perspective guidelines as prescribed by Linstone (1984). The T perspective was used to present graphic and quantitative indices for ESF; the O perspective focused on the ethics, and governmental legislations or trade consortium regulations aspects about epidemiology; and the P perspective focused on human (the patient and influential persons) views and reaction to the governmental health policy, health treatment, and the disease prevention.

The limitation (factors causing ESF) to epidemiologic system was reported (in the answer to question one) according to each perspective. The answer revealed, apart from the known views of each perspective, that to the P, ESF is a result of T incompetence and uncompassionate of the O. To this perspective, epidemiologic system should not have any flaw. For the second question, a golden mean linguistic (numeral) fuzzy number scaling by Ulinwa (2009) harmonized the perspectives. Fifteen conditioned fuzzy sets were configured to model an ESF. Two approaches were examined. The first was the serial configurations; and the other is parallel configuration. The similarity and the differences were reported. The interplay among the three perspectives was conditioned in a simulated case study to calibrate, better demonstrate, and explain an ESF as a fuzzy possibility set.

Summary

The broad themes bearing the names of the perspectives were discovered. The technical perspective consisted of the mathematical and geographic views. Of the mathematic are the mechanic and statistics. Given the mathematics, the compartmental approaches are popular among deterministic modelers. Biostatistics is more known among statistical epidemiologists. Both approaches however do not consider uncertainties in epidemiologic systems. Moreover, compartmental models, as with other models, over simplify the realty of infectious diseases. On the other hand, the exclusive use of T perspective always limits the technical know-how of epidemiologists. Because of the lack of know-how about other approaches such as systems approach, many epidemiologists apply T perspective to all kinds of epidemic problems or analysis. Therefore, the limitations of the technical perspective with respect to infectious diseases contribute to ESF.

The organizational perspective consists of the public health policies and regulations, health market determinants (controlled by pharmaceutical industry), and politics. For example, the 2016 US Congress refusal to fund Zika virus control before going on vacation invariably could propel the virus to spread more than expected. Such an action hinders epidemiologists' ability to minimize the spread. This is one form the organizational perspective contributes to ESF. The identified organizational parameters that could contribute to ESF are organizational incompetence, health policy inconsistency, legal threats such as quarantine or imprisonment, and public distrust (formal or informal private organizations) toward health institutions.

The last contributor to ESF is the personal perspective. The personal perspective (disease hosts and influential persons) most often than not resists how the technocrats' (the technical perspective) and the policy makers' (the organizational perspective) approach to infectious disease eradication. The disease hosts assume that they are the victims of overzealous health institutions (whether private or public). The identified influential individuals posited to defend the hosts with the premise that the technocrats are performing the mandate of tyrant organizational institutions or perspective.

For example, Mary Mallon and Andrew Speaker vehemently blamed the health agencies about their health predicaments. The influential individuals such as Lange blamed drug industries for limiting availability of drugs to certain disease hosts. Huckabee criticized the inconsistence of quarantine or isolation application.

If one imagines the effect of the T, O, and P (as shown in the simulated Ebola case study) towards epidemic diseases one would see reasons most infectious diseases are not contained quickly because of ESF. This study satisfied the major tenets of systems approach that a system is greater than its parts. Thus, ESF (the synergy among all the perspectives) is more than the arithmetic synergy of the three perspectives.

With a proxy (primary sources) I identified the research participants based on their direct statements about four epidemiologic systems. I queried how the multiple perspectives inquiring systems by Linstone (1984) and fuzzy logic by Zadeh (1965) could be used to discover the factors causing or influencing epidemiologic systems failure; and how should a usable (efficient and effective) ESF monitoring tool be constructed from the synthesized perspectives. The answers provided ESF and EVID professionals information and methods to characterize ESF. I differentiated three epidemic control mechanisms: the regulatory systems or legislated laws and health policies; technical systems or epidemiology in public and private sector settings or those that study or treat infectious diseases; and the compliance system or the individuals (infectious disease hosts and influential individuals. The lack of synergy among these mechanisms was identified as the ESF. With fuzzy set theory embedded multiple perspective tools may be resourceful to local, state, and national (if not international) health agencies for the prevention and control of ESF. This chapter therefore details participants' profiles, how they were selected, how their interviews were simulated, and the discovered themes recorded, analyzed, and reported.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

Through perspective classification, I examined factors causing ESF in this study. To understand ESF thoroughly, I defined three contextual perspectives as fuzzy possibility sets. I transformed the derived sets to linguistic fuzzy variables and methods. A multiple perspective analysis consisting of technical, organizational, and personal perspectives (the TOP model) were developed to demonstrate the degree of ESF using a synthetic data set. I assumed the set could be possible during the 2014 Ebola crisis. Use of the ESF-TOP model allowed me to appropriately cluster each perspective factor of ESF. The clustered sets were then cross-cued for order to obtain the research findings. I therefore grouped epidemic system (an infectious disease), the applications of epidemiologic methods, and other causes hindering the effectiveness and efficiency of controlling or preventing any infectious disease as factors of ESF. This TOP method is novel for it includes perspectives which other conventional research methods lack (Linstone, 1984).

I separated, juxtaposed, and examined the factors and methods for identifying and reporting ESF. ESF (as a fuzzy linguistic variable) is reported with fuzzy possibility sets. The purpose of the study, the theoretical framework, the research questions, the interpretative conclusion focusing on the data, the implications for social change, and recommendations for future research are contained in this chapter.

Purpose of the Study

The purpose of this qualitative case study was to examine factors of infectious disease control mechanisms useful for understanding ESF by using TOP perspectives. I thoroughly followed the TOP guidelines by Linstone (2011) or Yoo, Hawryszkiewycz, and Kang (2012).referencing Linstone (1984), to meet epidemiologic research standards. This approach ensured that a reliable method for identifying and reporting ESF is scientific. In complementing or supplementing how an ESF-TOP model is useful in clustering factors of ESF, this study informs epidemiologists and policy makers on the status of epidemiologic system and the effectiveness and efficiency of the applied health instruments. I used TOP fuzzy possibility set theory because the existing epidemiologic instruments for health prevention, control, or treatment focus either on the personal, technical, or organizational perspective and not multiple perspectives. Although there is a dearth of data on ESF, based on my review of the literature, the application of the TOP guidelines on the 350 papers revealed unexpected findings. A partial representation of the data set is provided in Appendix A. The data were grouped as based either on a technical (T), organizational (O), or personal (P) perspective; 245 (70%) had a T-perspective, 17 (5%) had an organizational perspective (O), and 88 (25%) had a P-perspective.

Four infectious disease cases inspired this study. The first was the handling of Mary Mallon's typhoid case; the second was the handling of HIV-AIDS cases by epidemiologists, the third was Andrew Speaker's tuberculosis case, and the fourth was the 2014 Ebola crisis. The main purpose of this study was to use the TOP fuzzy set method to reveal how to represent, interpret, and present ESF. This ESF study showed that the shortcoming of contemporary epidemiology methods contributes to ESF.

The Framework

This study was grounded on Churchman's (1968) and as explained by Ulrich (2016) five philosophies of scientific inquiries from which the first theory used, TOP, emanated. To ensure research integrity, emphasis on data and theory was balanced as Kantian theorists might suggest (Churchman, 1968). The importance of data and theory motivated the use of the multiple perspectives method and the use of three primary theories. To use TOP, I juxtaposed and unified three data sources to bring to fore a meaningful ESF knowledge. TOP therefore was the first theory

Another body of theories for ESF centered on fuzzy possibility set and were supplemented or complemented with appropriate linguistic variables. The applied mathematics was used to juxtapose, fuse, interpret, and report ESF. The theory was used in an artificial case study to demonstrate ESF with respect to the 2014 Ebola epidemic.

Finally, a collection of assumptions as research frameworks formed the study. I assumed that infectious disease researchers need an in depth, accurate, effective, efficient, and rapid method to observe a raging epidemic system. I also assumed that the findings should be applied to infectious diseases because every humanized problem such as infectious diseases, according to Linstone (2011), should be studied with TOP. Moreover, fuzzy sets approach (Zadeh, 2015), is suitable for representing and analyzing ill-defined problems or uncertainties in ESF. The study also hinged on relying on credible data source screened by appropriate experts for measuring factors of ESF.

Interpretation of the Findings

I presupposed that contextual environments of most EVID are unpredictable because some infectious diseases are airborne and the carriers could migrate from one area to another (Soriwel, 2014). I discovered that EVID could spread more if the applicable epidemiologic systems are ineffective or inefficient. I conceived ESF as the result of ineffectiveness and the inefficiency of current epidemiologic systems. ESF therefore was assumed metaphorically to be an unplanned shield of EVID. I avoided direct contact with the disease hosts or those having direct contacts with them. Moreover, because expensive protection gear is required if a contact had to be made (as in the case of Ebola), I relied instead on scientific secondary data. The focus of the two research questions used in this study concerned how to determine ESF and its measurement level using TOP and fuzzy possibility theory. I avoided conventional statistics and used fuzzy linguistic (numeral) sets that are understandable to research readers and epidemiologists. Per Molinari (2016) and Zimmerman (2010), fuzzy linguistic (numeral) sets are useful to represent uncertainties in human meanings of concepts and things. I used the sets to represent vague concepts such as extreme high (Zadeh, 2015).

The calibrated ESF was a result of translating quality to numeric fuzzy sets. With an Ebola case, I demonstrated the answer to Research Question 2. In spite of the dearth of ESF data, the TOP method was used to fuse the perspective multiple data sources..

Research Question 1

I queried in Research Question 1 how the multiple perspectives inquiring systems and fuzzy logic could be used to discover the factors causing or influencing epidemiologic systems failure. I rephrased the question to the following: How could T, O, or P factors cause ESF. When applied to the T perspective, the restatement for example differentiated the mechanistic from the statistic within the mathematic theoretic toolset.

Applying question 1 to the T-perspective I discovered two thematic (mathematics and geographic) approaches. The mathematics has mechanistic and statistics as types. Compartmental models, a deterministic approach, form the bulk methods of the mechanistic thematic. SEI, SEIR, SEIS, SEIRS, and MSEIR are the non-latent subthematic of compartmental model approach. The latent subthematic has SI, SIS, SIR, SIRS, SIRI, and MSIR. Epidemic modelers derived the initials from an assumed epidemic environmental context. For example, each individual in a population is susceptible (S), exposed (E), infected (I), or recovered (R). The first letter of each subgroup is used in naming each compartmental (latent or nonlatent) thematic branch. These are the thematic tools.

All the T thematic types were similar. First, all quantify, analyze, and report epidemic happening as the only scientific truth. With the T, any nonmathematical approach to epidemiology is unscientific and lacks scientific rigor. Notwithstanding T assumed scientific truth and rigor, answer to question 1 revealed that each T thematic contributes to ESF. On compartmental models as contributor to ESF, for example, Fung (2014) and Roberts and Andrease (2015) among other authors listed model misspecification, parameter uncertainty, modeling intervention, and model structure. Although powerful for predicting a disease behavior in a population, a compartmental model is an overly abstract of reality. Factors that are certain in compartmental models are not in real life.

The finding to question 1 showed that the procedural basics of epidemiology mask limitations of the current epidemiologic instruments. The masking (due to strong, weak, or lack thereof of statistical assumptions) contributes to ESF. Deriving from Frerichs, Lich, Dave, and Corbie-Smith (2016), almost all epidemiological studies on IDS focus on host-level risk factors leading tone-level statistical models. This method (including major statistical software) overlooks serious statistical implications: the hierarchy of data organization and the nonlinear and complex interactions among the selected variables. Also epidemiologists' lack of statistical understanding impedes the usefulness of statistical tools. Heafey (1988-1989), Galgut (2003), Livingston (2004b) and Hanf, Guégan, Ahmed, and Nacher (2014) implied that like biologists epidemiologists are not strongly grounded with statistical analyses (Livingston, 2004b). Moreover, Table 13 listed the most well-known statistical limitations that could contribute to ESF.

The O-perspective guideline (Linstone, 1984) was applied to understand how the O-perspective-based examination would explain ESF in contrast with the other perspectives. The O perspective exclusively focused on ethics and regulation. The application revealed formal and informal thematic. Within the formal were government and private. The government consisted incompetence, inconsistency, legal threat, and public mistrust as factors that impede the application of epidemiologic tools. The private thematic had economic of scale especially from the drug industries. Within the informal thematic was informal organization resentment similar to the occupy movement, the resentment of Liberians during the 2014 Ebola crisis, or the 2014 kidnapping and killings of health officials in Guinea during the Ebola crisis.

Applying question 1 to the P-perspective showed two thematic (disease host and influential individuals) as factors contributing to ESF. The disease hosts contributes through displaced aggression, unethical behavior, or unreasonable desire of freedom at the risk of the general public. The contributing factors are listed in Table 14, Table 15, and Table 16. The examination of influential individuals thematic revealed that influential individuals contribute to ESF through public encouragement to ignore public health policy. It follows that the P perspective showed how an individual or influential persons could impede the application or the effectiveness or efficiency of epidemiologic instrument during health crisis.

Succinctly, Research Question 1 juxtaposed how each perspective revealed factors that contribute to ESF. The first one is that T sought mathematical truth about ESF. The second is O perspective from which this study examined that governmental actions, drug industrial (including disease- based organizations) actions or inactions contribute to ESF. While the T was mathematical, O legislatively, the P qualified ESF or how human factors contribute to the system failure.

Research Question 2

For this research question, I specifically asked: How should a usable (efficient and effective) ESF monitoring tool be constructed from the synthesized perspectives? The finding of question 2 identified two modeling formations. The first is serial configuration. The other is parallel configuration. Each of the formations was operationalized with background and foreground information. The background specified ESF with fuzzy possibility linguistic (numeral) variables. The information was laced with nonsevere, severe, and extremely severe fuzzy linguistic (numeral) variables. The equivalent is shown and labeled in Figure 20 as left-side, center, and right-side. The variables qualitatively and quantitatively defined ESF variables to be measured.

The TOP serial background consisted of six sub-structures or formation as shown in Figure 27. The parallel formation has a single structure that joined at the left and the right. See Figure 28. The background guided me how to obtain and report the side information (data sources, classification, and fuzzy mathematical arrangements). The data sources or evaluators were considered experts according to each perspective.

The foreground was about data representations, calculations, and analysis. Each serial configuration and the parallel structure were seen as fuzzy possibility sets. The finding consists of raw, serial, and parallel formations. There were three raw single-valued conditions: O/T, P/T, and P/O of which, analytically, O/T = T/O, P/T = T/P, and P/O = O/P. The raw is about the effect of one perspective on another. The three raw formations differed among each other. Independent of the raw formations, serial, and parallel configurations were the core of the findings. Six serial conditions (such as T/(P/O)) were identified as shown in Table 26.

In the case of T/(P/O), the idea was that O influenced P and P influenced T. The resulting fuzzy trapezoidal possibility sets of all the serial structures are equal to $[.554,.701,.866,.866]$. This set was considered the ESF as represented with Figure 13. To determine its stage, the right-side of Figure 24 was chosen as the ideal ESF. Then T/(O/P) was graphically compared to the ideal as shown with Figure 14. To ensure reliability of T/(O/P), it was compared to the center of Figure 25 as shown in Figure 15. Graphically, it was obvious that T/(O/P) is more in the center than to the ideal or the right-side of Figure 26. It implies that the ESF was moderate.

Referencing Roig-Tierno, Huarng, and Ribeiro-Soriano (2016) two important conditions were determined: necessity and sufficiency. It is well-known in the fuzzy set theory literature that a necessitating condition is always less or equal to the conditioned. The theory also inferred that a sufficient condition should always be greater or equal to a necessitating condition. From Table 24, T/OPnc is less than T/OPsc; TOPnc is less than TOPsc; and T/OPnc is less than T/OPsc. The fuzzy mathematical fact (for example) is that $T/TOP_{nc} \leq T/TOP_{sc}$ or $[.554,.701,.866,.866] \leq [.657,.821,.907,.907]$ for TOPnc and TOPsc. However, any of the individual fuzzy possibility sets in TOPnc was not enough for ESF; but all were necessary. The finding also showed that the TOPnc and T/TOPnc of the parallel structure (see Table 24) were equal to any of the serial formation. Surprisingly, T/OPnc (a peculiar two-valued necessary condition for Ebola ESF), was equal to O/T, one of the raw conditions.

For sufficient condition, the finding showed that $TOP_{sc} \geq TOP_{nc}$ or from Table 25 that $[.763,.896,.943,.943] \geq [.554,.701,.866,.866]$. With TOPsc, the combination of all the sets was sufficient for ESF because all the sets shared the same occurrence. Unexpectedly, T/OPsc was equal to TOPsc. The T/TOPsc had no equivalence. Furthermore, any of the serial formations is a necessary condition (for the simulated parallel Ebola ESF) because any of the serial configurations is equal to the TOPnc. T/OPnc was rejected for it is equivalent to only O/T (a raw structure). However, TOPnc and TOPsc were used to determine the ESF using the parallel configuration as shown in Figure 14.

Given the ideal ESF (see Figure 24), the assumption was that the applicable epidemiologic system would possibly not fail from 0 to x_0 along the x axis. But the system would experience certain degree of failure (calibrated in [0, 1] along the alpha-cut (α)) as time progresses from x_0 to x_m. The system would fail or there would be ESF after x_m. The axis was seen as time frame. From x_m onwards to the right (along the x axis), α equals one.

The TOPsc was selected for determining the ESF with the parallel method. The ideal and TOPsc were graphically compared as shown in Figure 17 or indicated in Table 25. TOPsc along with the TOPnc were used to determine that x = .881. The possibility distribution was shown as Figure 16. Another presupposition for ESF is survival possibility distribution as shown in Figure 19. From the survival assumption and the mathematic constraints the survival distribution was zero because the result of its equation (.66) is less than x or .881. Repair possibility distribution was determined during the analysis. It is possible the system could be repaired at x'_m. The possibility is .983 the system could be repaired; and that it could not be repaired is .0316. The mean time to failure (MTTF) was .853 and the mean time to repair (MTTR) was .427. The epidemiologic forced outage rate (EFOR) was .33.

With the 15 fuzzy conditions analyzed in this study, three single conditioned perspective, six serial structures are equal. Any of the six sets was a pessimistic ESF. Notice that *x* is to the right (outside) of the T/(O/P) if *x* is compared to Figure 13—–which is ESF using the serial method. The serial formation (TOPnc) complemented TOPsc to determine ESF using the parallel method. The parallel method is much intuitive and optimistic because EFOR is the ESF.

The general finding in reference to question 1 and question 2 is that the lack thereof any of the three perspectives constrains the control of any infectivity. With the perspectives I indicated that to effectively and efficiently limit and eradicate infectivity the three perspectives should be applied concurrently. The determination of which of or if all of the perspectives is the cause of a spread requires epidemiologists apply the appropriate health care method beyond medicinal approach..

Limitations of the Study

The findings of this study should be generalized to a class of ESF involving hosts, epidemiologists, public health policy institutions, and infectious diseases. It should also not be applied in cases where legislation or administrative law is used to ban isolation facilities or quarantine. The result may not apply to authoritarian public health sector where a dictator could interfere in healthcare methods. Referencing Linstone (2015), the findings should not be generalized to implicit or explicit cases that are based on one (T, O, or P) perspective. The lack therefore leads to incomplete knowledge of the studied ESF.

The reliability as stated in the secondary data authors of the triumvirate method guideline, as stated by Linstone (1984), grounded the validity and reliability of this study. Moreover, fuzzy set theory has been used in cases that required validity and reliability checks (Ulinwa, 2008). This study should interest public policy, epidemiology, and medical professionals.

Recommendations

Recommended Action

For easy application, the method of calibrating ESF should be developed as a computer application. Analysts must be trained how to code the perspectives according to fuzzy method. Three groups of analysts would be expected: technologists (T), health policy makers (O), and end-users (P). The analysts should:

1. Determine if TOPnc will always equal T/OPsc; and if T/OPnc will ever be equal to any other measured other than T/O. Care should be taken to avoid claiming TOPsc will always equal to T/OPsc;
2. Determine abrupt contextual environment not suitable for using ESF;
3. Collecting data according to each perspective. The T should be quantifiable, the O focusing on health regulations promoting healthy environment; and P should focus on disease hosts perception and reaction to the applied technology and health policy;
4. Transfigure the obtained data to fuzzy possibility sets; and
5. Using the laid down fuzzy mathematics to calculate the ESF.

All these perspective measures are important. Epidemiology system fails if T, O, or P fails. The bedrock of the TOP ESF modeling is that the O perspective will always be the side-information. An ESF indicator is similar to a weather thermometer, but for showing the failure level of epidemiologic system.

All these perspective measures are important. Epidemiology systems fail if T, O, and or P fail. The bedrock of the TOP ESF modeling is that the O perspective will always be the side-information.

Future Study

The finding of this ESF study and the experimental case study focused on serial and parallel configurations. T, O, and P EVID experts are needed to characterize and standardize ESF variables. A study is needed on how to use ESF TOP to advise field technical manager, health coordinators, EVID prevention specialists, and epidemiology students. It is also important to theorize and conduct additional fuzzy mathematical methods for calibrating ESF. Boggs (2007) had suggested that ESF tool such as I conceptualized and exemplified in this study be computerized for easy application and adoption.

Implications

Positive Social Change

In accord with Dev, Sultana, Saha, and Mitra (2014) and Phillips and Linstone (2016), I expect that epidemiologists would not ignore qualitative and subjective aspects of epidemiology with the archetypal epidemiologic tool that I provide in this study. I also expect it would encourage publication of scholarly articles beyond the current dearth of literature on ESF. I think the embedded epidemiologic tool would reassure a depth and an easy application of fuzzy linguistic sets and TOP model to the field of epidemiology. Beyond research, I suggested a procedure that I envisaged is effective and efficient for a live monitoring and controlling of infectious diseases because the T, O, and P scopes of epidemiology were included. I reasoned that a lasting and an effective social change encompasses a change in the technical (T), the organizational (O), and the personal (P) perspectives of epidemiology. The change would be the interpretable positive synergy of TOP clinical findings by field epidemiologists. The ESF tool and the procedure would advance knowledge of epidemiology in line with a general definition of positive social change: a cultural change.

Therefore, this study is significant because ESF remains a hurdle to minimizing EVID. As stated previously, this study assumed that ESF will continue as long as EVID exists. Thus, ESF cannot be eliminated but controlled. First with TOP (Linstone. 2011), this study brings ESF to be one of the major concerns in the field of epidemiology. It would encourage epidemiologists to recognize there always is an ESF. This study pointed to the most common sources of ESF. Awareness of the ESF sources would assist epidemiologists to seek much more effective and reliable methodologies and which perspective to focus on. It is to say that ineffective and inefficient application of epidemiologic tools leads to ESF.

This study highlighted ESF factors and methods of evaluating EVID baseline data. It described the susceptibility and provided ESF and epidemiologists tools to characterize ESF. This includes the use of ESF programmatic planning and decision tools. The tools may be resourceful to local, state, and national (if not international) for the prevention and control of ESF and EVID. The findings would aid epidemiologists and ESF and EVID workforce understand and appreciate the differences between conventional methods and the robust fuzzy mathematical approach to ESF.

The implications for positive social change using the findings of this study will hopefully improve the knowledge of epidemiologists about ESF or what might prolong effective and efficient controls of a given disease spread. Cross-cuing the perspectives as Linston (2011) suggested requires establishing a mobile clearinghouse. The clearinghouse should receive, analyze, and interpret data using fuzzy TOP. The implications of this study will necessitate the clearinghouse to send the analysis and direct epidemiologists at the community level on how to simultaneously control the effect of the T, O, and P perspectives on a given contagion during a spread. In this case, the epidemiologists would use the synergy of the three perspectives as provided by the clearinghouse to control or minimize the infectivity. It is expected that the epidemiologists at the community level and the clearinghouse would ensure that the perspectives support each other to minimize or control the spread of an epidemic. Another implication for positive social change from the methodology used in this study is to demonstrate to epidemiologists how to develop a usable tool for ESF. The tool (explained and demonstrated as figures in Appendix C) included golden ratio calibrated fuzzy linguistic variables. The perspective-based data would then be collected, analyzed as fuzzy sets for each perspective, and reported as a cross-cued fuzzy TOP ESF.

The ultimate implication for positive social change supplements surveillance control and could help minimize ESF and EVID. The social change could directly and indirectly reduce political and social pressure on morbidity treatment resources. Succinctly, findings in this study suggest possible ways for ESF and EVID professionals to minimize ESF using fuzzy TOP. These recommendations could indirectly affect EVID control in addition to medical treatment.

Significance

There are two conflicting criteria this study attempted to solve to assist applied epidemiologists. From Linstone (2015) and Hudec (2016) this study provided a model of an elegant, useful, and reliable epidemiologic assessment tool. The assessment method, if computerize, is simple for reporting ESF using fuzzy linguistic variables understandable by epidemiologists and health scientists who may study ESF. The findings suggest that mere analysis of a disease outbreak using a single TOP perspective should not be reported because such reporting has little practical value. Rather, ESF studies would have far reaching applications in public health policy decisions, in health industries, epidemiology research and education if TOP approach is applied.

The findings support simultaneous use of the three perspectives during any EVID outbreak. The T perspective would let epidemiologists understand technical impact of the medical and professional remedy on the infectious disease. Monitoring the O perspective would enable epidemiologists to understand if the applied health policy is appropriate for preventing the spread of a disease. The importance of P perspective could have been noticed during the West Africa Ebola crisis. The perspective could have monitored signs of societal resentments towards health workers before they were attacked in Guinea or the riot in Liberia. Monitoring ESF would help epidemiologists develop methods to encounter societal ill treatment to health workers during health crisis. Deriving from (Ulrich, 2016), the P perspective would aid in monitoring, analyzing, and reporting how humans believe public health policy, epidemiologic industry (CDC included), and epidemiologists affect them.

There are possibilities that some T, O, and P assumptions about epidemiologic issues and applications are detrimental to public health. This study therefore would encourage full understanding of health policy with respect to epidemiology and allied sciences. This study would encourage health officials knowing more about the belief systems of disease hosts, their human environmental behavior about the disease, and reactions of influential persons to stop inexorable means to ineffectiveness and efficiency. In accord with Linstone (2015) and Hudec (2016), the findings suggest that human feelings should have a place in science. The method of ESF includes numbers, human experience, and method of guiding human conducts. The conduct is enshrined on the obligation to protect human health; obligation to use the appropriate legislative, administrative, and judicial to achieve right to health. The process of these procedural means to public health and minimize ESF is an essential tool for conditioning the populace to be healthy.

With the O perspective, referencing Ulrich (2016) and Hudec (2016), epidemiologists are equipped to determine if current public health laws empowers epidemiologists to control all aspects involving environment (individuals and businesses).

The O perspective would be useful in monitoring governmental power especially if it is overreaching with public health policies (Ulrich, 2016). Such overreaching implies that the government contributes to an ESF; and that this study would help monitor it. As a decisive instrument, the application of ESF method is practical with results that are epistemic idiosyncratic and epidemiologic distinctive.

Technical epidemiologists would concentrate on quantitative characteristics with no human meaning (Ulrich, 2016). Epidemiologic policy makers would focus on determining if health policies, health industrial, organizational practices are overreaching; and disease hosts and environment would examine subtle features boarding health safety. Pairing the perspectives for ESF measurement is akin to understanding the dynamics of EVID in addition to medical treatment.

Given the aforementioned and dearth of articles about ESF, a number of academic papers are being considered for publication in health, public health, and epidemiology journals. The publications would be an effective and efficient means to disseminate this study. There are also plans to publish the study as a college textbook; and software developers would be encouraged to develop an ESF instrument.

Conclusion

Concisely, this mixed method case study identified and contrasted the pre-emptive technical, organizational, and personal perspectives factors that could cause an ESF. The identified themes were technical limitations of personnel handling the outbreaks, confusing and conflicting weak health policies, and P perspective reservations about the intentions of health agencies. This study satisfied the major tenet of systems approach that a system is greater than its parts.

With the fuzzy TOP inquiring system, the general finding showed that ESF arises when T, O, and P perspectives are disjointed. Each of the perspectives has a conflicting view and solutions about the communicable disease. ESF also occurs when the T and O perspectives, T and P perspectives, or P and O perspectives overlap without the third perspective. It implies that an absence of one perspective leads to ESF when Ashby's (1956) law of requisite variety was applied. However, ESF is absent when the T, O, and P perspectives overlay signifying that each perspective has no or little conflicting views or solutions with the other perspectives about the contagion. In this case, epidemiologists could use the synergy of the three perspectives to control or minimize the infectivity as in the Nigeria Ebola case. In the case of Nigeria Ebola, the T, O, and P perspectives aligned to combat the contagion. This is typical when each perspective supports the other to minimize or control the spread of an epidemic. Thus, ESF (the synergy among all the perspectives) is more than the arithmetic synergy of the three perspectives.

With three broad preconceived epidemiological inhibitors, the T, O, and P, I was able to find in one instance that there was no much difference between the serial configuration and parallel configuration to determining the level of ESF. I discovered one outlier, $T/TOPsc$, or the effect of the T to the epidemiologic systems as applied to the infectivity given the combinations of the three perspectives (TOP) effects on the infectivity. Therefore, in this chapter I concluded the researched findings by presenting the purpose of this research, the theoretical framework, answers to the research questions, the social change, and future research recommendations.

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Appendix A: Primary Sources Used in the Study

This appendix includes an abridged list of the primary sources as selected by the participants. The selection is an abridged version of the consulted primary sources.

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Appendix B: Tables

Table B1

The Literature Summary

Terms	Books	Dissertations	Scholarly journals	Others
Systems theory	5	1	27	0
Selected epidemiologic systems	4	0	47	0
Forensic epidemiology (the selected toolkits)	9	1	36	0

Table 2

Interface Subsystems

Subsystems	Explanations
Reproducer	This subsystem carries instruction and mobilizes matter, energy, and information for producing similar systems.
Boundary	As a subsystem, it is the perimeter holding all the system's components; protects the system from environmental stress; and allows or excludes certain matter-energy and information.

Note: The Interface Subsystems

Table 3

Matter-Energy Subsystems

Subsystems	Explanations
Ingestor	It is an intake bringing matter-energy from the environment to the system.
Distributor	It distributes inputs among the components.
Converter	It transforms certain inputs into useful forms.
Producer	It stabilizes a system and synthesizes materials for growth, repair, and information replacement. It constitutes the system's outputs for significant periods.
Matter-Energy Storage	It is a container for preserving usable matter or energy.
Extruder	It transmits matter-energy (useful or waste) to the environment.
Motor	It controls relational interactions among other subsystems.
Supporter	It maintains the required spatial relationships among the system’s components.

Table 4

Information Subsystems

Subsystems	Explanations
Input Transducer	This sensory subsystem brings, transforms information to other matter-energy, and distributes them to other subunits.
Internal Transducer	This sensory subsystem receives significantly altered information about other subunits from those subunits; and changes the information to other matter-energy forms.
Channel and Net	It is a single route or multiple interconnected routes for transmitting information to all parts of the system.
Timer	This is a timed control subunit for it signals the system's start, stop, alteration rate, or advance or delay conditions (processes).
Decoder	The subsystem alters the informational input code from the input transducer into an internal code.
Associate	The subsystem is for learning process thereby relating all subunits with relevant information.
Memory	It stores retrievable information for different periods.
Decider	This is the executive subsystem that receives outputs for guidance, coordination, and control of the system.
Encoder	This subsystem transforms internal code into an external code for other systems use.

Note: Subsystems that process matter-energy

Table 5

Symptoms of Respiratory Infections

Common Cold versus Influenza		
Symptom	Influenza	Common Cold
Respiratory Infection	Yes	Yes
Fever	2-3 days	Rare
Headache	Common	Rare
Aches and Pain	Severe	Minor
Weakness and Fatigue	2-3 weeks	Sometimes
Stuffy nose	Sometimes	Common
Sneezing	Sometimes	Usual
Cough	Common	Mildly moderate
Sore throat	Sometimes	Common
Exhaustion	Usual	Rare

Note: The degree of respiratory infections symptoms that cause common cold and influenza

Table 6

Fields of Epidemiology

	Branches of Epidemiology
1	Infectious Disease Epidemiology
2	Chronic Disease Epidemiology
3	Cancer Epidemiology
4	Environmental Epidemiology
5	Reproductive Epidemiology
6	Injury Epidemiology
7	Psychiatric Epidemiology
8	Physical Activity Epidemiology
9	Genetic Epidemiology
10	Forensic Epidemiology
11	Aging Epidemiology

Table 7

Branches of Forensic Science

	Branches of Forensic Science
1	Forensic Anthropology
2	Forensic Engineering
3	Cyber Forensic
4	Computer Forensic
5	Forensic Entomology
6	Forensic Odontology
7	Forensic Toxicology
8	Medical Epidemiology
9	Forensic Accounting
10	Forensic Psychology
11	Forensic Epidemiology
12	Forensic Economics

Table 8

The Searched Terms

Terms	Systems Theory	Fuzzy Set	Systems Failure	Public Health Policy
Infectious Disease	x	x		x
Communicable Disease	x	x		x
Contagion	x	x		x

Note: The combined terms that were searched. For example, infectious disease was paired with systems theory. No data was discovered for failure and infectious disease, communicable disease or contagion.

Table 9

Video Documentary Observations

Video Documentary Observations			
Number of videos	Pretest	Testing	Analysis
25	Two per video documentary.	Three per perspective per documentary.	One per a documentary.

Note: The videos to be selected focused on ESF and the analysis phase included final observation of each video and transformation of derived data into fuzzy sets.

Table 10

Data Sample

Data Sampling	
Type	Description
T	Secondary data that quantitatively describe contagions.
O	Secondary data that legislatively describe contagions.
P	Secondary data focusing on how humans understand contagions,

Table 11

TOP ESF Participant Demography

T Primary Participants					
Participants	Gender	Race	Disease	Perspective	Comments
Mr. Monahan	Male	White	Infectious	T	T is insufficient for infectious disease control
Mr. Fung	Male	Asia	Infectious	T	Many T variables are not easily measured
Mr. Dimitrov and Meyers	Male	White	Infectious	T	T does not properly model disease spread
Mr. Willie	Male	White	Infectious	T	T drastically simplifies disease reality

O and P/O Primary Participants					
Participants	Gender	Race	Disease	Perspective	Comments
Opar	Male	White	Infectious	O	Quarantine when a host refuses treatment
Johnson (WHO)	Male	White	Infectious	O	Points to inconsistency in WHO claims
Boyle	Male	White	Ebola	P/O	Do not trust CDC or WHO
President Obasanjo	Male	Black	Ebola	P/O	Liberia Government played part in spreading Ebola to Nigeria
Mr. Huckabee	Male	White	HIV/AIDS	P/O	Isolate disease hosts
Mr. Lang	Male	White	HIV/AIDS	P/O	Drugs should be distributed similar as soft drinks or beer

ctd

P Primary Participants

Participants	Gender	Race	Disease	Perspective	Comments
Mr. Lewis Brown	Male	Black	Ebola	P	Mr. Sawyer escaped medical observation
Mr. Russell Wills	Male	Black	HIV	P	Intentionally infected associates with HIV/AIDS
Mr. Andrew Speaker	Male	White	Tuberculosis	P	Believed CDC misdiagnosed him
Ms. Mary Mallon	Female	White	Typhoid	P	Believed she was typhoid negative

Note: TOP research participants

Table 12

TOP data

Perspective	Data	%
T	245	70
O	17	5
P	88	25
TOP	350	100

Table 13

Weakness of statistical methods (data sample)

1	Confounding	Confounding occurs if a third factor associating an exposure-disease distorts both exposure and disease.
2	Selection bias	Systematic error is a result of choosing study groups; example being cases and controls, exposed and unexposed or error due to a mistaken estimate of an exposure-disease association.
3	Information bias	Information bias is also a systematic error. It occurs during the collection of exposure or outcome data about the study participants. Consequentially, a mistake is made in estimating the effect of an exposure to the risk, the disease. A common type of information bias is recall bias because one group is more likely than the other groups to remember and report an exposure.
4	Sample size	To find an association that is statistically significant with considerable important, sample size and power calculations estimate the number of subjects needed. Sometimes number of cases, time, and resources availability limit the sample size. Sample size does not influence risk ratio and odds ratio. However, sample size affects confidence intervals and measures of statistical significance such as p-values and chi-square tests.

Table 14

P perspective displaced aggression

		Displaced Aggression
P perspective on	Ebola	Mr. Sawyer blames Liberia's health systems instead of focusing on how not to infect others.
	HIV/AID	Mr. Johnson's displaced aggression was on those he deliberately infected with HIV.
	TB	Mr. Speaker blames the US Center for Disease Control and prevention for his dilemma instead of focusing the source of illness and the cure.
	Typhoid	Mary Mallon was bitter with New York doctor and health system instead of seriously accepting her medical condition.

Note:

Table 15

Unethical behavior (Unethical behavior)

		Unethical Behavior
P perspective on	Ebola	Mr. Sawyer intentionally urinated on the hospital staff and removed his IV.
	HIV/AID	Mr. Johnson's knowingly infected others with HIV.
	Typhoid	Mary Mallon's refusal to obey facts which led to the death of those that employed her services.

Note:

Table 16

P perspective (Unreasonable freedom)

		Unreasonable Freedom
P perspective on	Ebola	Mr. Sawyer avoided being quarantined; a Nigerian nurse fled to Eastern Nigeria despite being under surveillance.
	HIV/AID	The use of human right to aid the spread of aid (undermining the effect of quarantine).
	TB	49 South Africans TB patients fled from hospital to spend Christmas with family or friends.
	Typhoid	Mary Mallon's use of fake name to obtain brief freedom against being put in isolation.

Note:

Table 17

The reading stages

The stages	The reading
First	Abstract and Summary
Second	Casual reading
Third	Thorough Readings
Fourth	Reading and Note taking
Fifth	Marking the articles as T, O, P or the grouping

Table 18

TOP Simulated data

T Filter										
V	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
1	3	5	4	6	3	5	3	3	5	1
2	3	5	6	5	6	3	1	6	2	6
3	3	5	3	4	6	1	4	1	3	6
4	1	2	3	5	4	6	2	3	6	5
5	5	2	1	5	3	1	1	3	2	5
6	5	4	4	4	3	4	2	1	2	6
7	5	4	1	1	4	5	5	6	6	3
8	5	4	5	3	3	2	2	5	1	2
9	1	6	3	6	3	2	5	6	2	3
10	4	1	2	2	2	4	4	2	5	3
O Filter										
V	O1	O2	O3	O4	O5	O6	O7	O8	O9	O10
1	4	4	4	2	5	5	4	5	4	2
2	3	5	2	6	1	4	2	4	2	5
3	4	6	2	3	1	5	6	1	2	4
4	3	1	6	5	3	5	5	4	2	5
5	6	5	2	4	5	5	6	2	5	6
6	3	2	6	1	1	6	6	2	5	6
7	2	6	5	3	4	1	6	6	4	2
8	1	5	4	1	2	6	6	4	5	2
9	2	5	4	6	1	1	2	1	3	2
10	5	3	2	4	6	1	6	1	1	5
P Filter										
V	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
1	1	5	1	1	2	2	6	3	4	3
2	1	6	1	1	5	6	1	5	2	4
3	4	4	5	3	4	6	5	1	3	2
4	4	6	2	1	4	1	4	1	2	1
5	5	3	1	5	2	3	3	5	6	1
6	1	5	3	3	1	1	6	6	2	1
7	6	1	1	4	6	2	6	5	5	1
8	4	5	6	3	3	4	6	1	4	1
9	6	4	2	2	6	2	6	4	2	2

10	6	2	4	6	4	2	2	1	3	1

Table 19

T-perspective-based data

			T Perspective										
			L							*L*			
		3	0.352	0.854	0.854	0.854			3	0.352	0.854	0.854	0.854
		5	0.618	0.944	0.944	0.944			5	0.618	0.944	0.944	0.944
		4	0.854	0.944	0.944	0.944			6	0.944	1	1	1
		6	0.944	1	1	1			5	0.618	0.944	0.944	0.944
V1	=	3	0.352	0.854	0.854	0.854	*V2*	=	6	0.944	1	1	1
		5	0.618	0.944	0.944	0.944			3	0.352	0.854	0.854	0.854
		3	0.352	0.854	0.854	0.854			1	0	0	0.618	0.618
		3	0.352	0.854	0.854	0.854			6	0.944	1	1	1
		5	0.618	0.944	0.944	0.944			2	0.618	0.618	0.854	0.854
		1	0	0	0.618	0.618			6	0.944	1	1	1
			5.060	8.192	8.810	8.810				6.334	8.214	9.068	9.068
			10	10	10	10				10	10	10	10
			0.506	0.8192	0.881	0.881				0.6334	0.8214	0.9068	0.9068
		3	0.352	0.854	0.854	0.854			1	0	0	0.618	0.618
		5	0.618	0.944	0.944	0.944			2	0.618	0.618	0.854	0.854
		3	0.352	0.854	0.854	0.854			3	0.352	0.854	0.854	0.854
		4	0.854	0.944	0.944	0.944			5	0.618	0.944	0.944	0.944
V3	=	6	0.944	1	1	1	*V4*	=	4	0.854	0.944	0.944	0.944
		1	0	0	0.618	0.618			6	0.944	1	1	1
		4	0.854	0.944	0.944	0.944			2	0.618	0.618	0.854	0.854
		1	0	0	0.618	0.618			3	0.352	0.854	0.854	0.854
		3	0.352	0.854	0.854	0.854			6	0.944	1	1	1
		6	0.944	1	1	1			5	0.618	0.944	0.944	0.944
			5.270	7.394	8.630	8.630				5.918	7.776	8.866	8.866
			10	10	10	10				10	10	10	10

0.527	0.7394	0.863	0.863

0.5918	0.7776	0.8866	0.8866

ctd

		5	0.618	0.944	0.944	0.944
		2	0.618	0.618	0.854	0.854
		1	0	0	0.618	0.618
		5	0.618	0.944	0.944	0.944
V5	=	3	0.352	0.854	0.854	0.854
		1	0	0	0.618	0.618
		1	0	0	0.618	0.618
		3	0.352	0.854	0.854	0.854
		2	0.618	0.618	0.854	0.854
		5	0.618	0.944	0.944	0.944

3.794	5.776	8.102	8.102
10	10	10	10
0.3794	0.5776	0.8102	0.8102

		5	0.618	0.944	0.944	0.944
		4	0.854	0.944	0.944	0.944
		4	0.854	0.944	0.944	0.944
		4	0.854	0.944	0.944	0.944
V6	=	3	0.352	0.854	0.854	0.854
		4	0.854	0.944	0.944	0.944
		2	0.618	0.618	0.854	0.854
		1	0	0	0.618	0.618
		2	0.618	0.618	0.854	0.854
		6	0.944	1	1	1

6.566	7.810	8.900	8.900
10	10	10	10
0.6566	0.781	0.89	0.89

		5	0.618	0.944	0.944	0.944
		4	0.854	0.944	0.944	0.944
		1	0	0	0.618	0.618
		1	0	0	0.618	0.618
		4	0.854	0.944	0.944	0.944
V7	=	5	0.618	0.944	0.944	0.944
		5	0.618	0.944	0.944	0.944
		6	0.944	1	1	1
		6	0.944	1	1	1
		3	0.352	0.854	0.854	0.854

5.802	7.574	8.810	8.810
10	10	10	10
0.5802	0.7574	0.881	0.881

		5	0.618	0.944	0.944	0.944
		4	0.854	0.944	0.944	0.944
		5	0.618	0.944	0.944	0.944
		3	0.352	0.854	0.854	0.854
		3	0.352	0.854	0.854	0.854
V8	=	2	0.618	0.618	0.854	0.854
		2	0.618	0.618	0.854	0.854
		5	0.618	0.944	0.944	0.944
		1	0	0	0.618	0.618
		2	0.618	0.618	0.854	0.854

5.266	7.338	8.664	8.664
10	10	10	10
0.5266	0.7338	0.8664	0.8664

ctd

		1	0	0	0.618	0.618
		6	0.944	1	1	1
		3	0.352	0.854	0.854	0.854
		6	0.944	1	1	1
		3	0.352	0.854	0.854	0.854
V9	=	2	0.618	0.618	0.854	0.854
		5	0.618	0.944	0.944	0.944
		6	0.944	1	1	1
		2	0.618	0.618	0.854	0.854
		3	0.352	0.854	0.854	0.854
			5.742	7.742	8.832	8.832
			10	10	10	10
			0.574 2	0.774 2	0.883 2	0.883 2

		4	0.854	0.944	0.944	0.944
		1	0	0	0.618	0.618
		2	0.618	0.618	0.854	0.854
		2	0.618	0.618	0.854	0.854
		2	0.618	0.618	0.854	0.854
V1 *0*	=	4	0.854	0.944	0.944	0.944
		4	0.854	0.944	0.944	0.944
		2	0.618	0.618	0.854	0.854
		5	0.618	0.944	0.944	0.944
		3	0.352	0.854	0.854	0.854
			6.004	7.102	8.664	8.664
			10	10	10	10
			0.600 4	0.710 2	0.866 4	0.866 4

Table 20

O-perspective-based data

O perspective

	4	0.854	0.944	0.944	0.944		3	0.352	0.854	0.854	0.854
	4	0.854	0.944	0.944	0.944		5	0.618	0.944	0.944	0.944
	4	0.854	0.944	0.944	0.944		2	0.618	0.618	0.854	0.854
v1 =	2	0.618	0.618	0.854	0.854	*v2* =	6	0.944	1	1	1
	5	0.618	0.944	0.944	0.944		1	0	0	0.618	0.618
	5	0.618	0.944	0.944	0.944		4	0.854	0.944	0.944	0.944
	4	0.854	0.944	0.944	0.944		2	0.618	0.618	0.854	0.854
	5	0.618	0.944	0.944	0.944		4	0.854	0.944	0.944	0.944
	4	0.854	0.944	0.944	0.944		2	0.618	0.618	0.854	0.854
	2	0.618	0.618	0.854	0.854		5	0.618	0.944	0.944	0.944
		7.360	8.788	9.260	9.260			6.094	7.484	8.810	8.810
		10	10	10	10			10	10	10	10
		0.736	0.879	0.926	0.926			0.6094	0.7484	0.881	0.881

	4	0.854	0.944	0.944	0.944		3	0.352	0.854	0.854	0.854
	6	0.944	1	1	1		1	0	0	0.618	0.618
	2	0.618	0.618	0.854	0.854		6	0.944	1	1	1
	3	0.352	0.854	0.854	0.854		5	0.618	0.944	0.944	0.944
v3 =	1	0	0	0.618	0.618	*v4* =	3	0.352	0.854	0.854	0.854
	5	0.618	0.944	0.944	0.944		5	0.618	0.944	0.944	0.944
	6	0.944	1	1	1		5	0.618	0.944	0.944	0.944
	1	0	0	0.618	0.618		4	0.854	0.944	0.944	0.944
	2	0.618	0.618	0.854	0.854		2	0.618	0.618	0.854	0.854
	4	0.854	0.944	0.944	0.944		5	0.618	0.944	0.944	0.944
		5.802	6.922	8.630	8.630			5.592	8.046	8.900	8.900
		10	10	10	10			10	10	10	10
		0.5802	0.692	0.863	0.863			0.5592	0.8046	0.89	0.89

ctd

	6	0.944	1	1	1
	5	0.618	0.944	0.944	0.944
	2	0.618	0.618	0.854	0.854
	4	0.854	0.944	0.944	0.944
v5 =	5	0.618	0.944	0.944	0.944
	5	0.618	0.944	0.944	0.944
	6	0.944	1	1	1
	2	0.618	0.618	0.854	0.854
	5	0.618	0.944	0.944	0.944
	6	0.944	1	1	1
		7.394	8.956	9.428	9.428
		10	10	10	10
		0.7394	0.8956	0.9428	0.9428

	3	0.352	0.854	0.854	0.854
	2	0.618	0.618	0.854	0.854
	6	0.944	1	1	1
	1	0	0	0.618	0.618
v6 =	1	0	0	0.618	0.618
	6	0.944	1	1	1
	6	0.944	1	1	1
	2	0.618	0.618	0.854	0.854
	5	0.618	0.944	0.944	0.944
	6	0.944	1	1	1
		5.982	7.034	8.742	8.742
		10	10	10	10
		0.5982	0.7034	0.8742	0.874

	2	0.618	0.618	0.854	0.854
	6	0.944	1	1	1
	5	0.618	0.944	0.944	0.944
	3	0.352	0.854	0.854	0.854
v7=	4	0.854	0.944	0.944	0.944
	1	0	0	0.618	0.618
	6	0.944	1	1	1
	6	0.944	1	1	1
	4	0.854	0.944	0.944	0.944
	2	0.618	0.618	0.854	0.854
		6.746	7.922	9.012	9.012
		10	10	10	10
		0.6746	0.7922	0.9012	0.9012

	1	0	0	0.618	0.618
	5	0.618	0.944	0.944	0.944
	4	0.854	0.944	0.944	0.944
	1	0	0	0.618	0.618
v8=	2	0.618	0.618	0.854	0.854
	6	0.944	1	1	1
	6	0.944	1	1	1
	4	0.854	0.944	0.944	0.944
	5	0.618	0.944	0.944	0.944
	2	0.618	0.618	0.854	0.854
		6.068	7.012	8.720	8.720
		10	10	10	10
		0.6068	0.7012	0.872	0.872

	2	0.618	0.618	0.854	0.854
	5	0.618	0.944	0.944	0.944
	4	0.854	0.944	0.944	0.944
	6	0.944	1	1	1
v9 =	1	0	0	0.618	0.618
	1	0	0	0.618	0.618
	2	0.618	0.618	0.854	0.854
	1	0	0	0.618	0.618
	3	0.352	0.854	0.854	0.854
	2	0.618	0.618	0.854	0.854
		4.622 / 10	5.596 / 10	8.158 / 10	8.158 / 10
		0.4622	0.5596	0.8158	0.8158

	5	0.618	0.944	0.944	0.944
	3	0.352	0.854	0.854	0.854
	2	0.618	0.618	0.854	0.854
	4	0.854	0.944	0.944	0.944
v10 =	6	0.944	1	1	1
	1	0	0	0.618	0.618
	6	0.944	1	1	1
	1	0	0	0.618	0.618
	1	0	0	0.618	0.618
	5	0.618	0.944	0.944	0.944
		4.948 / 10	6.304 / 10	8.394 / 10	8.394 / 10
		0.4948	0.6304	0.8394	0.839

Table 21

P-perspective-based data

				P perspective							
	1	0	0	0.618	0.618		1	0	0	0.618	0.618
	5	0.618	0.944	0.944	0.944		6	0.944	1	1	1
	1	0	0	0.618	0.618		1	0	0	0.618	0.618
	1	0	0	0.618	0.618		1	0	0	0.618	0.618
v1 =	2	0.618	0.618	0.854	0.854	*v2* =	5	0.618	0.944	0.944	0.944
	2	0.618	0.618	0.854	0.854		6	0.944	1	1	1
	6	0.944	1	1	1		1	0	0	0.618	0.618
	3	0.352	0.854	0.854	0.854		5	0.618	0.944	0.944	0.944
	4	0.854	0.944	0.944	0.944		2	0.618	0.618	0.854	0.854
	3	0.352	0.854	0.854	0.854		4	0.854	0.944	0.944	0.944
		4.356	5.832	8.158	8.158			4.596	5.450	8.158	8.158
		10	10	10	10			10	10	10	10
		0.436	0.5832	0.8158	0.8158			0.4596	0.545	0.8158	0.8158

	4	0.854	0.944	0.944	0.944		4	0.854	0.944	0.944	0.944
	4	0.854	0.944	0.944	0.944		6	0.944	1	1	1
	5	0.618	0.944	0.944	0.944		2	0.618	0.618	0.854	0.854
	3	0.352	0.854	0.854	0.854		1	0	0	0.618	0.618
v3 =	4	0.854	0.944	0.944	0.944	*v4* =	4	0.854	0.944	0.944	0.944
	6	0.944	1	1	1		1	0	0	0.618	0.618
	5	0.618	0.944	0.944	0.944		4	0.854	0.944	0.944	0.944
	1	0	0	0.618	0.618		1	0	0	0.618	0.618
	3	0.352	0.854	0.854	0.854		2	0.618	0.618	0.854	0.854
	2	0.618	0.618	0.854	0.854		1	0	0	0.618	0.618
		6.064	8.046	8.900	8.900			4.742	5.068	8.012	8.012
		10	10	10	10			10	10	10	10
		0.606	0.8046	0.89	0.89			0.4742	0.5068	0.8012	0.8012

ctd

5	0.618	0.944	0.944	0.944
3	0.352	0.854	0.854	0.854
1	0	0	0.618	0.618
5	0.618	0.944	0.944	0.944
2	0.618	0.618	0.854	0.854
3	0.352	0.854	0.854	0.854
3	0.352	0.854	0.854	0.854
5	0.618	0.944	0.944	0.944
6	0.944	1	1	1
1	0	0	0.618	0.618
	4.472	7.012	8.484	8.484
	10	10	10	10
	0.447	0.7012	0.8484	0.8484

1	0	0	0.618	0.618
5	0.618	0.944	0.944	0.944
3	0.352	0.854	0.854	0.854
3	0.352	0.854	0.854	0.854
1	0	0	0.618	0.618
1	0	0	0.618	0.618
6	0.944	1	1	1
6	0.944	1	1	1
2	0.618	0.618	0.854	0.854
1	0	0	0.618	0.618
	3.828	5.270	7.978	7.978
	10	10	10	10
	0.3828	0.527	0.7978	0.7978

6	0.944	1	1	1
1	0	0	0.618	0.618
1	0	0	0.618	0.618
4	0.854	0.944	0.944	0.944
6	0.944	1	1	1
2	0.618	0.618	0.854	0.854
6	0.944	1	1	1
5	0.618	0.944	0.944	0.944
5	0.618	0.944	0.944	0.944
1	0	0	0.618	0.618
	5.540	6.450	8.540	8.540
	10	10	10	10
	0.554	0.645	0.854	0.854

4	0.854	0.944	0.944	0.944
5	0.618	0.944	0.944	0.944
6	0.944	1	1	1
3	0.352	0.854	0.854	0.854
3	0.352	0.854	0.854	0.854
4	0.854	0.944	0.944	0.944
6	0.944	1	1	1
1	0	0	0.618	0.618
4	0.854	0.944	0.944	0.944
1	0	0	0.618	0.618
	5.772	7.484	8.720	8.720
	10	10	10	10
	0.5772	0.7484	0.872	0.872

ctd

6	0.944	1	1	1
4	0.854	0.944	0.944	0.944
2	0.618	0.618	0.854	0.854
2	0.618	0.618	0.854	0.854
6	0.944	1	1	1
2	0.618	0.618	0.854	0.854
6	0.944	1	1	1
4	0.854	0.944	0.944	0.944
2	0.618	0.618	0.854	0.854
2	0.618	0.618	0.854	0.854
	7.630	7.978	9.158	9.158
	10	10	10	10
	0.763	0.7978	0.9158	0.9158

6	0.944	1	1	1
2	0.618	0.618	0.854	0.854
4	0.854	0.944	0.944	0.944
6	0.944	1	1	1
4	0.854	0.944	0.944	0.944
2	0.618	0.618	0.854	0.854
2	0.618	0.618	0.854	0.854
1	0	0	0.618	0.618
3	0.352	0.854	0.854	0.854
1	0	0	0.618	0.618
	5.802	6.596	8.540	8.540
	10	10	10	10
	0.5802	0.6596	0.854	0.854

Table 22

TOP configurations data

	T				O				P			
	a	b	c	d	a	b	c	d	a	b	c	d
1	0.506	0.819	0.881	0.881	0.74	0.879	0.926	0.926	0.4356	0.5832	0.8158	0.8158
2	0.633	0.821	0.907	0.907	0.61	0.748	0.881	0.881	0.4596	0.545	0.8158	0.8158
3	0.527	0.739	0.863	0.863	0.58	0.692	0.863	0.863	0.6064	0.8046	0.8900	0.8900
4	0.592	0.778	0.887	0.887	0.56	0.805	0.89	0.89	0.4742	0.5068	0.8012	0.8012
5	0.379	0.578	0.810	0.810	0.739	0.8956	0.9428	0.9428	0.4472	0.7012	0.8484	0.8484
6	0.657	0.781	0.890	0.890	0.598	0.7034	0.8742	0.8742	0.3828	0.5270	0.7978	0.7978
7	0.580	0.757	0.881	0.881	0.675	0.7922	0.9012	0.9012	0.5540	0.6450	0.8540	0.8540
8	0.527	0.734	0.866	0.866	0.607	0.7012	0.872	0.872	0.5772	0.7484	0.8720	0.8720
9	0.574	0.774	0.883	0.883	0.462	0.5596	0.8158	0.8158	0.7630	0.7978	0.9158	0.9158
10	0.600	0.710	0.866	0.866	0.495	0.6304	0.8394	0.8394	0.5802	0.6596	0.8540	0.8540

Table 23

TOP Partial serial conditioned configurations data

	O/T				P/T				P/O			
	a	b	c	d	a	b	c	d	a	b	c	d
1	0.506	0.819	0.881	0.881	0.436	0.583	0.816	0.816	0.436	0.583	0.816	0.816
2	0.609	0.748	0.881	0.881	0.460	0.545	0.816	0.816	0.460	0.545	0.816	0.816
3	0.527	0.692	0.863	0.863	0.527	0.739	0.863	0.863	0.580	0.692	0.863	0.863
4	0.559	0.778	0.887	0.887	0.474	0.507	0.801	0.801	0.474	0.507	0.801	0.801
5	0.379	0.578	0.810	0.810	0.379	0.578	0.810	0.810	0.447	0.701	0.848	0.848
6	0.598	0.703	0.874	0.874	0.383	0.527	0.798	0.798	0.383	0.527	0.798	0.798
7	0.580	0.757	0.881	0.881	0.554	0.645	0.854	0.854	0.554	0.645	0.854	0.854
8	0.527	0.701	0.866	0.866	0.527	0.734	0.866	0.866	0.577	0.701	0.872	0.872
9	0.462	0.560	0.816	0.816	0.574	0.774	0.883	0.883	0.462	0.560	0.816	0.816
10	0.495	0.630	0.839	0.839	0.580	0.660	0.854	0.854	0.495	0.630	0.839	0.839
	0.609	*0.819*	*0.887*	*0.887*	*0.580*	*0.774*	*0.883*	*0.883*	*0.580*	*0.701*	*0.872*	*0.872*

Table 24

TOP necessary conditional configurations data

TOPnc				T/TOPnc				T/OP			
A	b	c	d	A	b	c	d	a	b	c	d
0.436	0.583	0.816	0.816	0.436	0.583	0.816	0.816	0.506	0.819	0.881	0.881
0.460	0.545	0.816	0.816	0.460	0.545	0.816	0.816	0.609	0.748	0.881	0.881
0.527	0.692	0.863	0.863	0.527	0.692	0.863	0.863	0.527	0.739	0.863	0.863
0.474	0.507	0.801	0.801	0.474	0.507	0.801	0.801	0.559	0.778	0.887	0.887
0.379	0.578	0.810	0.810	0.379	0.578	0.810	0.810	0.379	0.578	0.810	0.810
0.383	0.527	0.798	0.798	0.383	0.527	0.798	0.798	0.598	0.703	0.874	0.874
0.554	0.645	0.854	0.854	0.554	0.645	0.854	0.854	0.580	0.757	0.881	0.881
0.527	0.701	0.866	0.866	0.527	0.701	0.866	0.866	0.527	0.734	0.866	0.866
0.462	0.560	0.816	0.816	0.462	0.560	0.816	0.816	0.574	0.774	0.883	0.883
0.495	0.630	0.839	0.839	0.495	0.630	0.839	0.839	0.580	0.660	0.854	0.854
0.554	*0.701*	*0.866*	*0.866*	*0.554*	*0.701*	*0.866*	*0.866*	*0.609*	*0.819*	*0.887*	*0.887*

Table 25

TOP sufficient conditional configurations data

TOPsc				T/TOPsc				T/OP			
A	b	c	d	A	b	c	d	a	b	c	D
0.736	0.879	0.926	0.926	0.506	0.819	0.881	0.881	0.736	0.879	0.926	0.926
0.633	0.821	0.907	0.907	0.633	0.821	0.907	0.907	0.633	0.821	0.907	0.907
0.606	0.805	0.890	0.890	0.527	0.739	0.863	0.863	0.606	0.805	0.890	0.890
0.592	0.805	0.890	0.890	0.592	0.778	0.887	0.887	0.592	0.805	0.890	0.890
0.739	0.896	0.943	0.943	0.379	0.578	0.810	0.810	0.739	0.896	0.943	0.943
0.657	0.781	0.890	0.890	0.657	0.781	0.890	0.890	0.657	0.781	0.890	0.890
0.675	0.792	0.901	0.901	0.580	0.757	0.881	0.881	0.675	0.792	0.901	0.901
0.607	0.748	0.872	0.872	0.527	0.734	0.866	0.866	0.607	0.748	0.872	0.872
0.763	0.798	0.916	0.916	0.574	0.774	0.883	0.883	0.763	0.798	0.916	0.916
0.600	0.710	0.866	0.866	0.600	0.710	0.866	0.866	0.600	0.710	0.866	0.866
0.763	*0.896*	*0.943*	*0.943*	*0.657*	*0.821*	*0.907*	*0.907*	*0.763*	*0.896*	*0.943*	*0.943*

Table 26

TOP sequential serial conditioned configurations data

	P/(O/T)				O/(P/T)				T/(P/O)			
	A	b	c	d	A	b	c	d	a	b	c	d
1	0.436	0.583	0.816	0.816	0.436	0.583	0.816	0.816	0.436	0.583	0.816	0.816
2	0.460	0.545	0.816	0.816	0.460	0.545	0.816	0.816	0.460	0.545	0.816	0.816
3	0.527	0.692	0.863	0.863	0.527	0.692	0.863	0.863	0.527	0.692	0.863	0.863
4	0.474	0.507	0.801	0.801	0.474	0.507	0.801	0.801	0.474	0.507	0.801	0.801
5	0.379	0.578	0.810	0.810	0.379	0.578	0.810	0.810	0.379	0.578	0.810	0.810
6	0.383	0.527	0.798	0.798	0.383	0.527	0.798	0.798	0.383	0.527	0.798	0.798
7	0.554	0.645	0.854	0.854	0.554	0.645	0.854	0.854	0.554	0.645	0.854	0.854
8	0.527	0.701	0.866	0.866	0.527	0.701	0.866	0.866	0.527	0.701	0.866	0.866
9	0.462	0.560	0.816	0.816	0.462	0.560	0.816	0.816	0.462	0.560	0.816	0.816
10	0.495	0.630	0.839	0.839	0.495	0.630	0.839	0.839	0.495	0.630	0.839	0.839
	0.554	*0.701*	*0.866*	*0.866*	*0.554*	*0.701*	*0.866*	*0.866*	*0.554*	*0.701*	*0.866*	*0.866*

Table 27

TOP sequential serial configurations data

P/(T/O)				O/(T/P)				T/(O/P)			
A	b	c	d	A	b	c	d	a	b	c	d
0.436	0.583	0.816	0.816	0.436	0.583	0.816	0.816	0.436	0.583	0.816	0.816
0.460	0.545	0.816	0.816	0.460	0.545	0.816	0.816	0.460	0.545	0.816	0.816
0.527	0.692	0.863	0.863	0.527	0.692	0.863	0.863	0.527	0.692	0.863	0.863
0.474	0.507	0.801	0.801	0.474	0.507	0.801	0.801	0.474	0.507	0.801	0.801
0.379	0.578	0.810	0.810	0.379	0.578	0.810	0.810	0.379	0.578	0.810	0.810
0.383	0.527	0.798	0.798	0.383	0.527	0.798	0.798	0.383	0.527	0.798	0.798
0.554	0.645	0.854	0.854	0.554	0.645	0.854	0.854	0.554	0.645	0.854	0.854
0.527	0.701	0.866	0.866	0.527	0.701	0.866	0.866	0.527	0.701	0.866	0.866
0.462	0.560	0.816	0.816	0.462	0.560	0.816	0.816	0.462	0.560	0.816	0.816
0.554	*0.701*	*0.866*	*0.866*	*0.554*	*0.701*	*0.866*	*0.866*	*0.554*	*0.701*	*0.866*	*0.866*

Table 28

ESF-based FOR

Concepts	Meaning
Time	Performance period of an epidemiologic system (ES)
Failure	Failed ability of an ES to operate as required.
Uptime	Time period an ES is in acceptable operating conditions
Downtime	Time period an ES is not in acceptable operating conditions

Note. FOR is forced outage rate

Appendix C: Fuzzy Mathematics

Background

I briefly introduced fuzzy set theory in Chapter 2. In this chapter, I lay the background and foreground useful for this study. The foreground is the worked out procedural answer to research question two. To comprehend the answer to research question two, I recommend reading first the answer to research question two, the foreground section of this appendix, and reread the answer to research question two.

The mathematics of ESF is a set of fuzzy arithmetic ideas and methods. The mathematical set can be represented as figures as shown in Figure 10 or Figure 19. Table 19 is the starting point to understand the mathematics explanation. The supporting broad considerations are listed in Table 19.

As a reminder, fuzzy sets are linguistic (numeral) calibrations as seen in Figure 20 and Figure 21. After identifying and selecting the individualities (participants), three timeframes pre-event, event, and post-event—as fuzzy sets are recognized as the ideal patterns. For example, the Nigeria pre-event (the Ebola index case) could be mapped as severe or very severe. A timeframe was defined as $A(x)$ such that $A(x) = 1$ if x is full in the timeframe; and $A(x) = 0$ implies that x is not in the timeframe. If $A(0) \leq x \leq A(1)$ indicates the membership degree the x is in the frame. The superset X of x such that x_1 is nonsevere; x_2 is severe; and x_3 is extremely severe are the linguistic (numeral) variable. Each of the timeframe is a fuzzy number because according Buckley and Eslami (2000), a fuzzy number $\overline{N}$ is a fuzzy set in $\Re$. It follows that $\overline{N}$ core is non-empty; α-cuts of $\overline{N}$ are bounded and closed intervals; and $\overline{N}$ support is bounded.

For example, a given severe timeframe for a particular infectious disease system could be defined as $\overline{N}(1) = [2,4]$. In this example it implies that the disease spread is severe in the month of February to April. The $\overline{N}(\cdot)$ could take value as days, weeks, months, or years. Mathematically, $\overline{N} = \left\{ \begin{cases} 1 & x \in [a,b] \\ 0 & otherwise \end{cases} \right.$. This researcher chose triangular and trapezoidal characteristics (membership) function. For triangular, $\overline{N} = (a/b/c)$ where a, b, and c are the support and b is the core. It is obvious that $a \prec b \prec c$. For trapezoidal, $N = (a/b/c/d)$ where a and d are the support and b and c are the core. The core is where the membership value is one. That is $T[0] = [a,d]$ and $T[1] = [b,c]$. Each of the set: nonsevere, severe, and very severe is a linguistic (numeral) variable or fuzzy set. In any case, see Buckley and Eslami (2000) for a good start. In the course of brainstorming, I used standardized TOP fuzzy linguistic (numeral) sets.

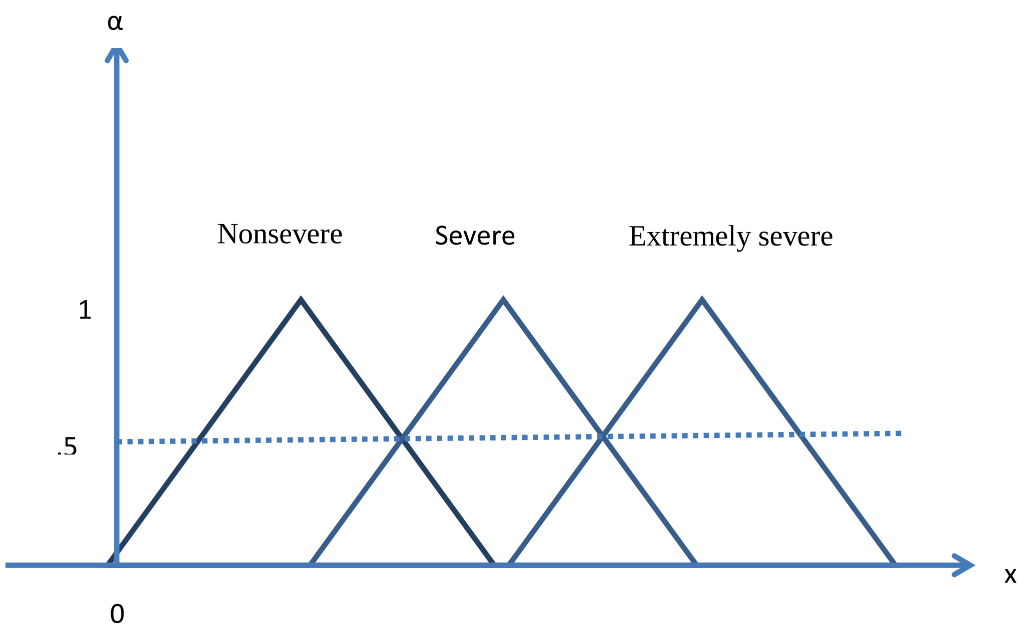


Figure 20: The fuzzy triangular linguistic (numeral) variables.

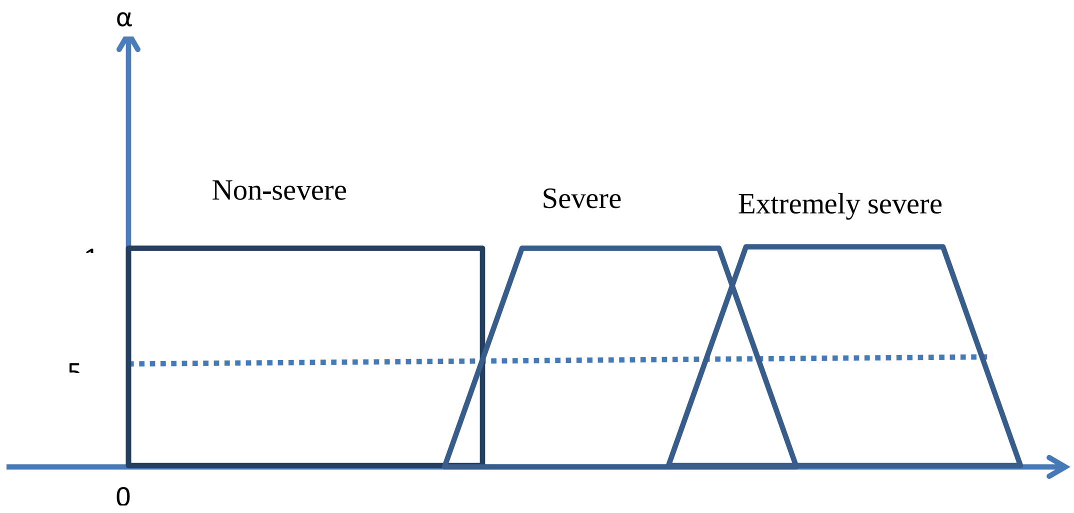


Figure 21: The fuzzy trapezoidal linguistic (numeral) variables.

I jettisoned the works of Grzegorzewski (2001) because the method tested statistical hypotheses with vague data. Instead, this research work is set with statistical hypotheses in fuzzy situations. The goodness of this option is that unquantifiable (linguistic (numeral)) variables are quantifiable in fuzzy membership degree. The opted approach (unlike conventional hypothesis testing to accept or reject a null hypothesis h_o) uses fuzzy linguistic (numeral) variables to accept or reject a null hypothesis. Given the linguistic (numeral) observations and Chen and Hwang (1992), I relied on a method of converting fuzzy populations mean in a null hypothesis to develop fuzzy trapezoidal numbers. Chen and Hwang (1992) explained the possibility to accept a null hypothesis as a matched ratio (*MR*).

First, a measure of the overlapping areas with the mean of fuzzy population and fuzzy samples means are obtained. Then the ratio is obtainable by dividing the measure by the fuzzy population mean. A rejection region (*RR*), the statistical value specifying when to reject a null hypothesis, is selected as a critical matched ratio. It follows that h_0 is rejected if *MR* is less than *RR*. It is accepted if *MR* is greater than or equal to *RR*.

Following the works of Cheng-Chen, Lai, and Nien (2005), this researcher calculated the difference between fuzzy functions with $D = \int_{s_{\bar{y}} \cup s_{\hat{y}}} \left| \mu_{\bar{y}}(y) - \mu_{\hat{y}}(y) \right| dy$; and $MR = \frac{1}{2} \cdot \frac{\int_{s_{\bar{y}}} \mu_{\bar{y}}(y)dy + _{s_{\hat{y}}} \mu_{\hat{y}}(y)dy - D}{_{s_{\bar{y}}} \mu_{\bar{y}}(y)dy}$. The linguistic (numeral)s were tableted in form of a *mn* matrix such that $A = \begin{bmatrix} Y_{11} & Y_{12} & \cdots\cdots\cdots & Y_{1m} \\ Y_{21} & Y_{22} & : & Y_{2m} \\ & & : & \\ Y_{n1} & Y_{n2} & \cdots\cdots\cdots & Y_{nm} \end{bmatrix}$. The derived set *A* as used in this study is shown Table 19. Then the fuzzy conversion is simplified as $\hat{\hat{Y}}_i = \frac{1}{m} \overset{m}{\underset{j=1}{\oplus}} Y_{ij}$ such that $i = 1,2,...,n$ and $j = 1,2,...,m$. Understandably, $\hat{\hat{Y}}_i = [a_i, b_i, c_i, d_i]; i = 1,2...n$. The $\oplus$ symbol is an extension principle based addition operator. The remaining tables were based on Table 19. Further, $S_{\hat{y}}$ and $S_{\bar{y}}$ are the supports for $\mu_{\bar{y}}$ and $\mu_{\hat{\hat{y}}}$. Figure 22 symbolizes an example of fuzzy sample mean.

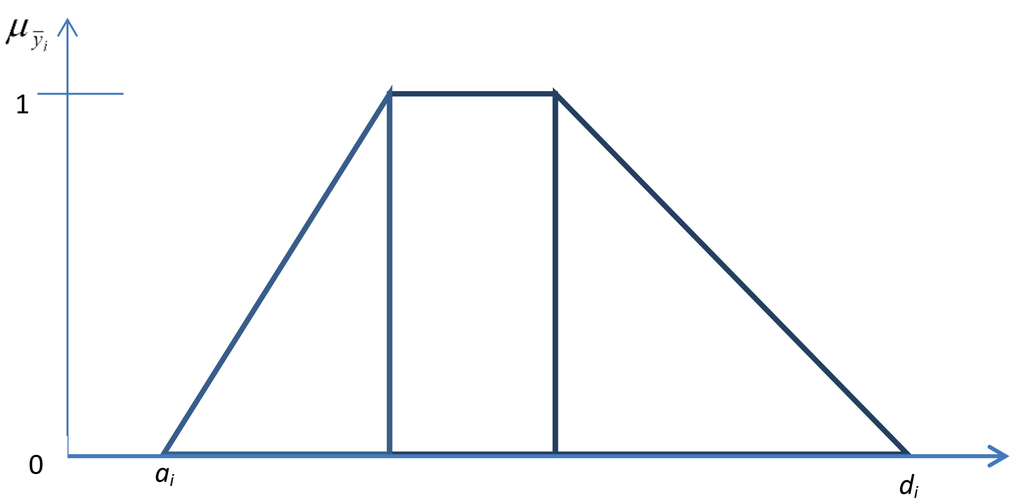


Figure 22: The fuzzy trapezoidal sample mean linguistic (numeral) variable.

To generalize the *RR* and *MR*, a standardized fuzzy golden ratio linguistic (numeral) scale developed by Ulinwa (2008) was used. It is well-known that golden ratio is determined such that $\phi = \frac{1+\sqrt{5}}{2} \cong 1.618$. The idea is that the ratio of a unit *u* to the larger portion equals the larger part of the lesser portion. Ulinwa (2008) scaled three linguistic (numeral) variables comparable to the linguistic (numeral) variables used in this study. Ulinwa (2008) established the rightmost of the left linguistic (numeral) variable at .854 at which the core of the second linguistic (numeral) variable ends. The leftmost of the second linguistic (numeral) variable is at .352 as a result of the golden ratio of .618. Like the first linguistic (numeral) variable, its rightmost leg stops at .854. The third linguistic (numeral) variable began at .618 and ends at a unit (1) with rightmost core at .944. It follows that $A = a_1, a_2, a_3$ such that $a_1 = [0,.854]; a_2 = [.352,.944]; a_3 = [.618,1]$. See Figure 23.

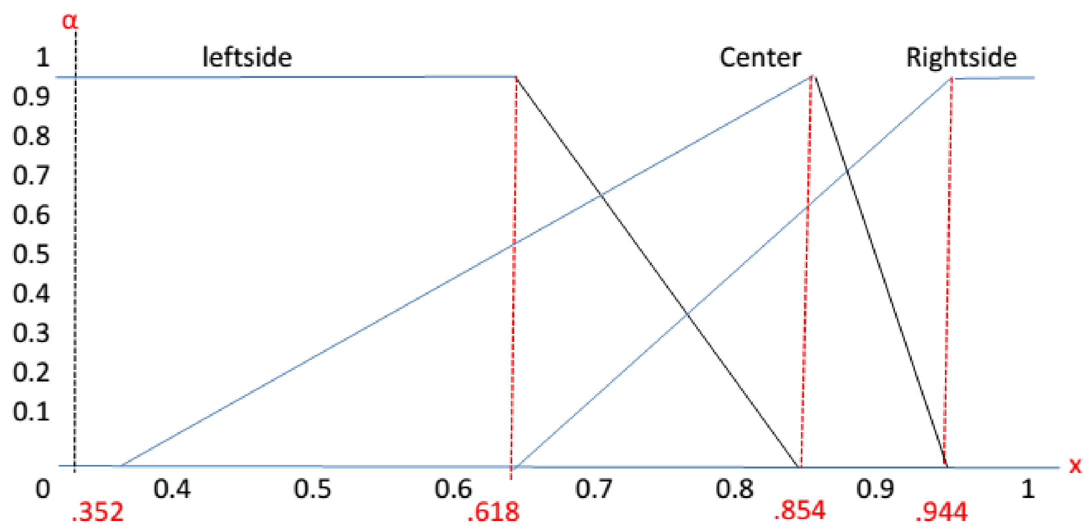


Figure 23: The fuzzy ESF linguistic (numeral) variable

Figure 23 is segmented to Figure 24, Figure 25, and Figure 26.

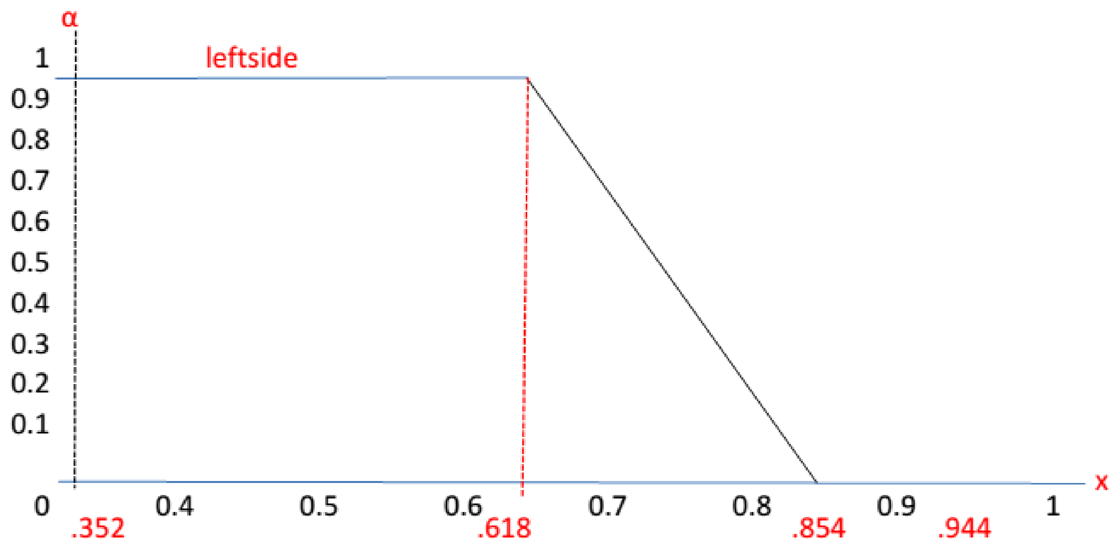


Figure 24: The left-side

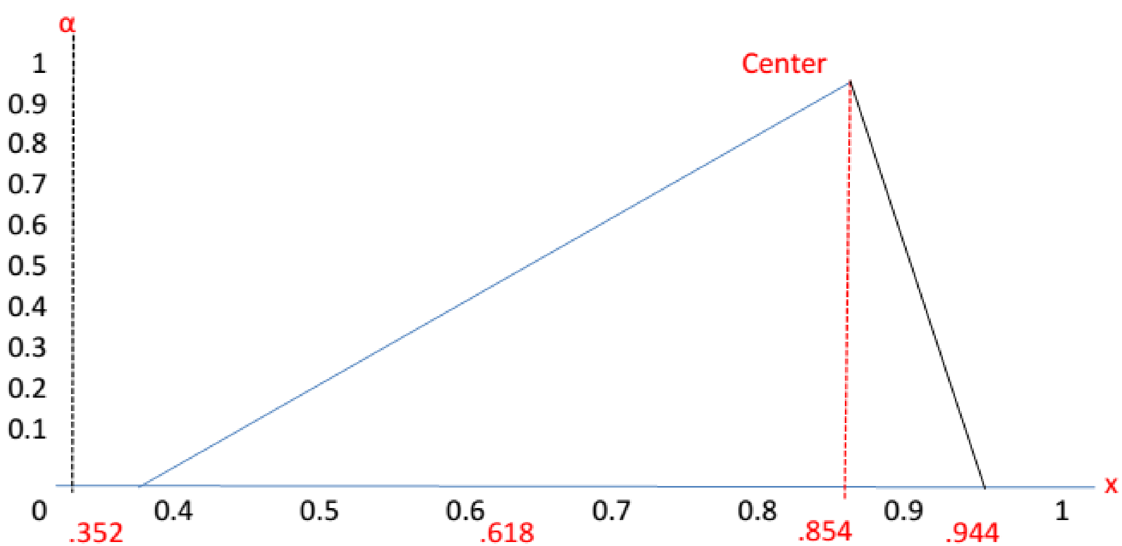


Figure 25: The center

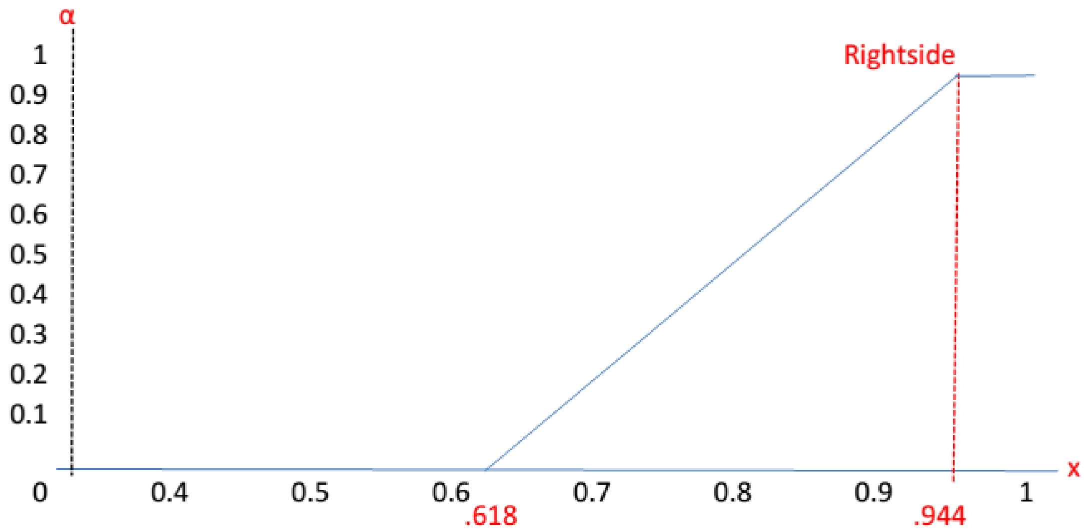


Figure 26: The right-side

Foreground

First, this researcher mapped two structural methods to determine level of ESF as shown in Figure 27 and Figure 28. The structures are serial and parallel.

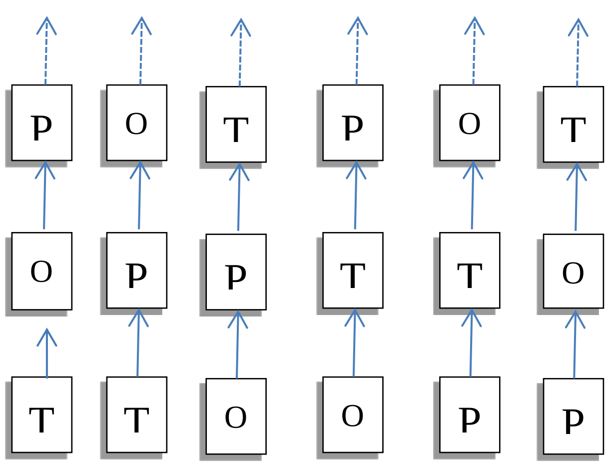


Figure 27. Six serial configurations

For example, any of the serial as shown in Figure 27 is the simplest TOP perspective configuration. The functionality of each perspective depends on the operation of the one before it. Take the leftmost configuration of Figure 27 as an example. If T fails then O that depends on T and P that depends on the O will also fail. The relational perspective shows that any of the TOP configurations could measure ESF.

Alternatively as shown in Figure 28, an ESF could be measured as a parallel system.

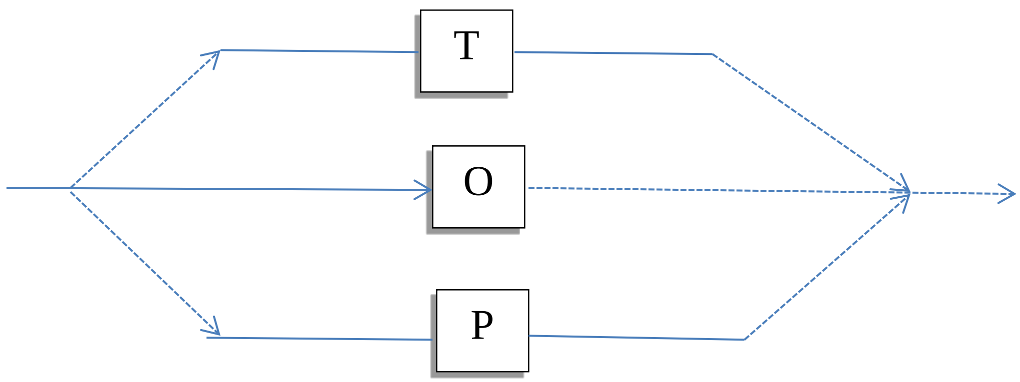


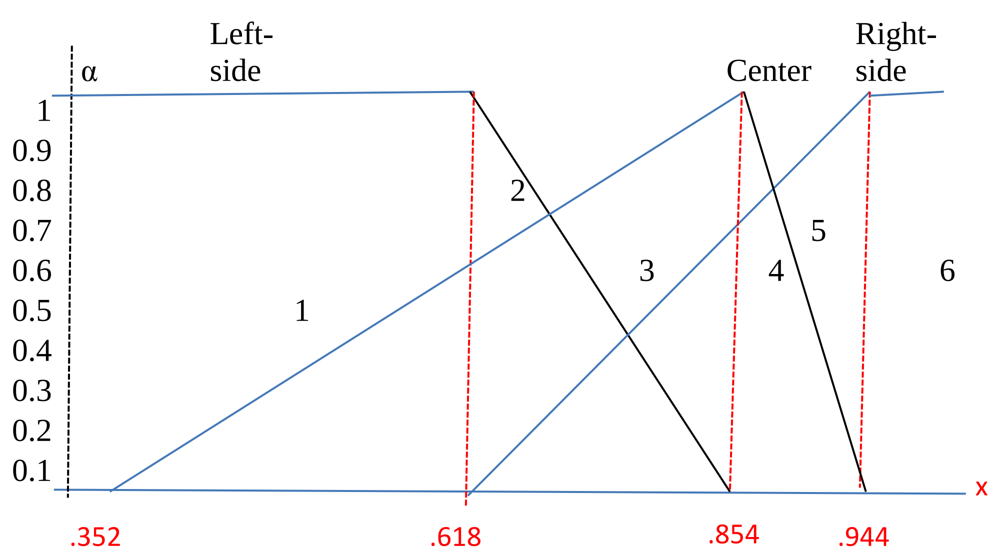
Figure 28. Parallel configurations.

With a parallel configuration as shown in Figure 28, each perspective is independent, but connected with the others in such that ESF occurs when all the perspectives fail. The failure occurs if ES is inapplicable, operates ineffectively, or partially efficient. Such a failure could be noticed during the earlier phase of operation, during the pick of epidemic system, or due to chance (random failures). Forced outage rate (FOR)—the estimated possibility ES is on a failure state—is a very important measure of system failure. See table 28. The forced outage is the state ES is not effective due to catastrophic happening to any of or all the ES (T, O, or P) subsystems.

Serial and parallel configurations are considered in this case study. The serial structure showed that ineffective of any of the ES subsystems leads to ESF. Compared to the serial configuration, the parallel structure indicated that failure of T, O, and P are sufficient to consider ES a failed system.

Step one. With both structures, this researcher considered ten T perspective observers, ten O perspective observers, and ten P perspective observers. Each observer is subscripted according to the assigned perspective; and assumed to have been shown Figure 29. The instruction was to rate his or her feelings about epidemiologic application during an epidemic system. For example, T_1 is the number one T perspective observer. See Table 19. Also ten unspecified variables (listed under the *V* in Table 19) are used in this demonstration.

Step two. Given any V_i, each of the perspective observers assigned a linguistic (numeral) variable L_i (from the six labeled linguistic (numeral) variables from Figure 29) to $V_{i.}$ For instance, T_3 assigned 1 as L_i to V_7. Table 19 shows the complete assignments. Using the numeric values of each of the linguistic (numeral) variable from Figure 29 each of the L_i is then converted to an appropriated fuzzy possibility set.



0 0.4 0.5 0.6 0.7 0.8 0.9 1

Figure 29. Golden rule linguistic (numeral) variables

For example, the T_3 assignment is $T_3(7) = 1 = V_7(3) = \left[\overset{a}{0}, \overset{b}{0}, \overset{c}{.618}, \overset{d}{.618}\right]$ as shown in Table 20. In furtherance of the calculation, all the fuzzy possibility sets of each variable were added with the ordinary arithmetic addition-operation. This addition gave $V_7 = \left[\overset{a}{5.802}, \overset{b}{7.574}, \overset{c}{8.810}, \overset{d}{8.810}\right]$ which was further divided by the number of each perspective observers. For example, the quotient of 5.802 into the ten observers gave 0.5802. See in Table 20 that $V_7 = \left[\overset{a}{.5802}, \overset{b}{.7574}, \overset{c}{.8810}, \overset{d}{.8810}\right]$ and listed in Table 20 in the seventh row under the T perspective section along with the other V_i calculations. All triangular fuzzy sets as picked by the participants were converted into fuzzy trapezoidal fuzzy sets for easy calculation. See Table 21 for the O participants and Table 22 for the P participants.

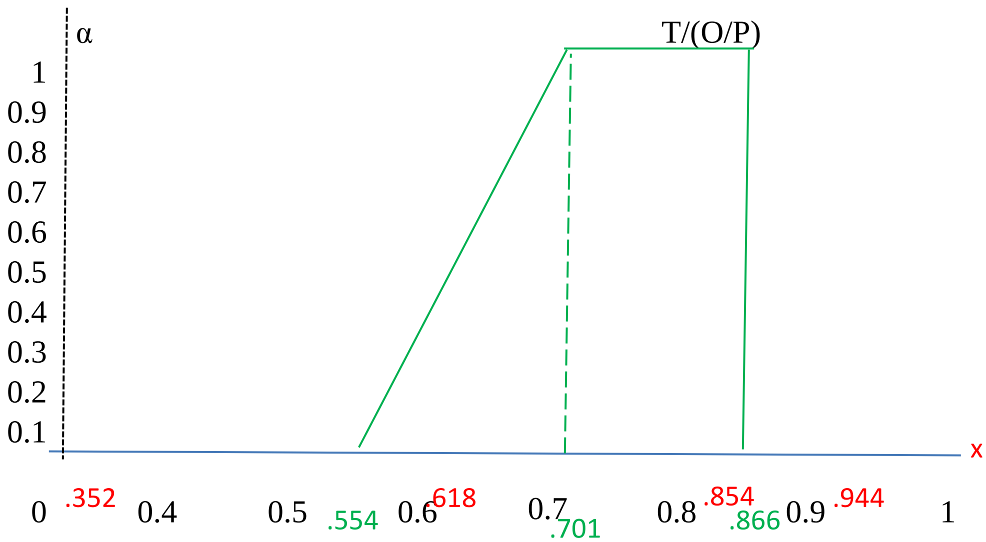
Step three. Using fuzzy min-operator I calculated the possibility of O given T (T/O) as shown in the T/O section of Table 24 for each V_i as L_i. For example, the minimum value of $T_1(a)$ and $O_1(a)$ is 0.506. The operation was applied to T_1 (*a*) and O_1 (*a*), T_1 (*b*) and O_1 (*b*), $T_1(c)$ and $O_1(c)$, and T_1 (d) and O_1 (*d*) similar to the T_n = [*a*, *b*, *c*, *d*].

Step four. For the T/OP, the OP was determined by taking the max of O and P then the minimum of T and OP was taken. The max-operator was applied to obtain the maximum value for *a*, *b*, c, and *d* columns of the T/O such that the *a* value is 0.609, *b* is 0.819, *c* is 0.887, and *d* is 0.887. Similar fuzzy possibility set calculations was performed for the P/O and P/T conditions.

Step five. TOP sufficient (TOPsc), T given TOPsc (T/TOPsc), TOP necessary (TOPnc), T given TOPnc (T/TOPnc), and T given O and P (T/OP) conditions were also sought. TOPsc was obtained by taken the maximum value among the T_i, O_i, and P_i of Table 23 such that $TOPsc(i) = \max(T_i = [a_i, b_i, c_i, d_i], O_i = [a_i, b_i, c_i, d_i], P_i = [a_i, b_i, c_i, d_i])$. If i equals one then $TOPsc(1) = \left[\overset{a}{.736}, \overset{b}{.879}, \overset{c}{.926}, \overset{d}{.926}\right]$ as shown in the TOPsc section of Table 28. To obtain the totality of $TOPsc_i$, the maximum of each a_i, b_i, c_i, and d_i was determined such that $TOPsc = \left[\overset{a}{.736}, \overset{b}{.896}, \overset{c}{.943}, \overset{d}{.943}\right]$ as shown in the last row of the TOPsc section of Table 28. The $T/TOPsc_i$ was obtained by taking the minimum value of T_i and $TOPsc_i$ such that $T/TOPsc(i) = \min(T_i, TOPsc_i) = \min(T_i = [a_i, b_i, c_i, d_i], TOPsc_i = [a_i, b_i, c_i, d_i])$. If T_i is one then $T/TOPsc(1) = \left[\overset{a}{.506}, \overset{b}{.819}, \overset{c}{.881}, \overset{d}{.881}\right]$. To obtain the totality of $T/TOPsc_i$, the maximum of each a_i, b_i, c_i, and d_i were determined such that $T/TOPsc = \left[\overset{a}{.657}, \overset{b}{.821}, \overset{c}{.907}, \overset{d}{.907}\right]$ as shown in the last row of the T/TOPsc section of Table 28.

$TOPnc_i$, the minimum value among the T_i, O_i, and P_i of Table 28 was obtained such that $TOPnc(i) = \min(T_i = [a_i, b_i, c_i, d_i], O_i = [a_i, b_i, c_i, d_i], P_i = [a_i, b_i, c_i, d_i])$. The totality of $TOPnc_i$ was calculated with the max-operator for each a_i, b_i, c_i, and d_i. $T/TOPnc_i$ was the minimum of T_i and $TOPnc_i$ for $T/TOPnc(i) = \min(T_i, TOPnc_i) = \min(T_i = [a_i, b_i, c_i, d_i], TOPnc_i = [a_i, b_i, c_i, d_i])$. The totality of $T/TOPnc_i$, maximum of each a_i, b_i, c_i, and d_i were determined similar to the T/TOPsc as shown in the last row of the T/TOPnc section of Table 27.

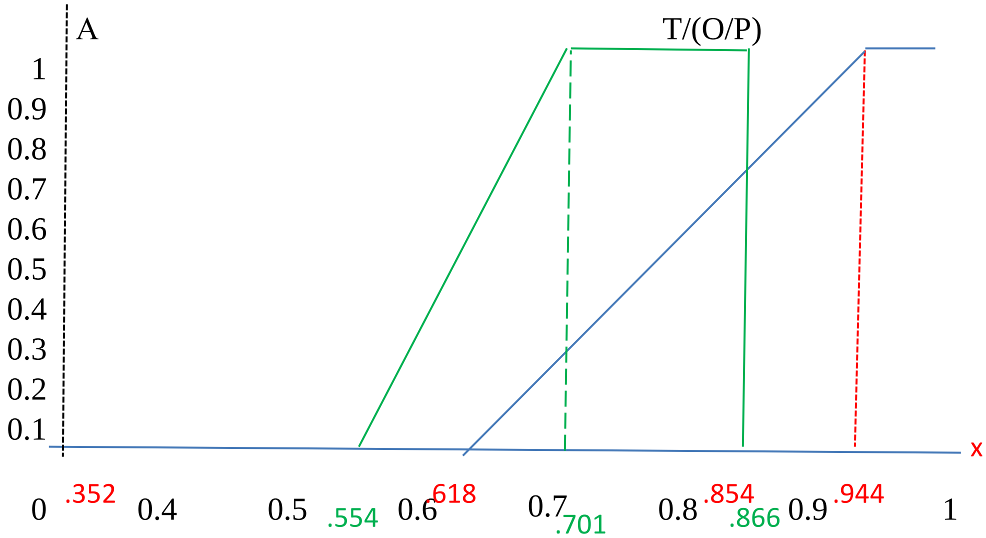
It follows from the totality of P/ (O/T), O/ (P/T), or T/ (P/O) of Table 25 and P/ (T/O), O/ (T/P), or T/ (O/P) that each of the six serial configurations (as shown in Figure 30) is equal and equivalent. Notice also that TOPnc or T/TOPnc was equal to any of the serial configurations. See Table 27 and Table 25, or Table 26 as shown in Figure 30. The T/(O/P) fuzzy set is represented along the *x* axis with green.



The green shows the T/(O/P)

Figure 30: T/(O/P)

Thus, any of the configurations could be chosen to measure ESF; and the T/(O/P) was chosen for this study. To determine the level of the ESF, the rightmost linguistic (numeral) variable or Figure 26 was chosen. The T/ (O/P) configuration, Figure 30, was then superimposed with the right-side linguistic (numeral) variable or Figure 26 as shown in Figure 31. Figure 31 shows that T/ (O/P) is partially in the right-side.



T/(O/P) against the rightmost ESF
The green shows the T/(O/P)

Figure 31. Failure possibility distribution.

When T/ (O/P) was compared with the center (Figure 25 and Figure 30), as shown in Figure 32, the figure shows that T/O/P is more in the center. See Figure 32.

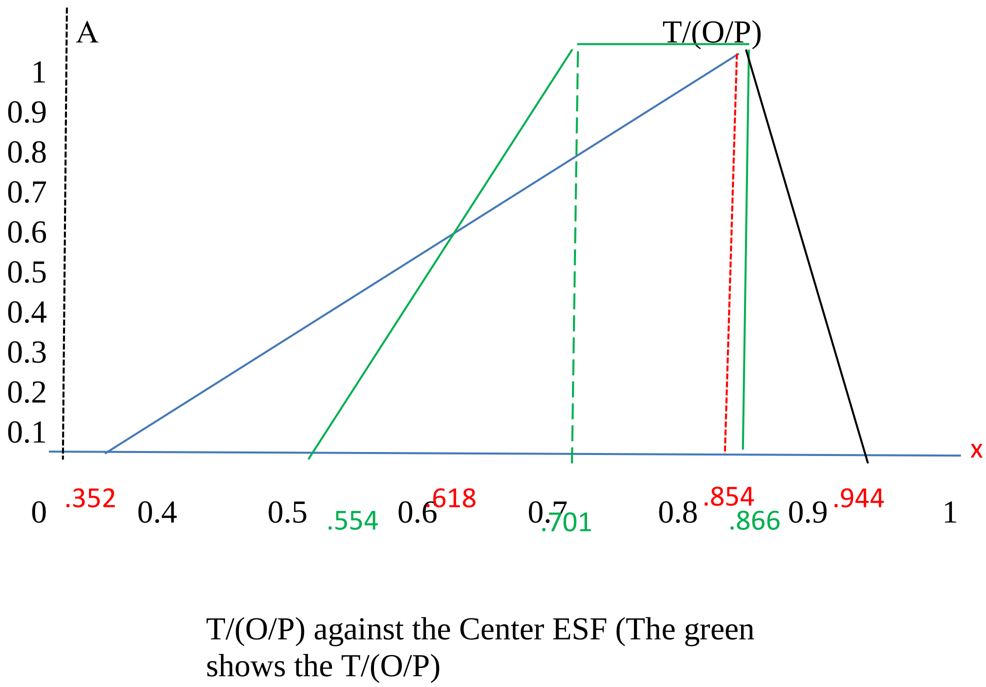


Figure 32. Superimposition of Figure 30 and Figure 25.

Step six. The works of Noor and McDonald (1996) and Verma, Srividya, and Deka (2004) provided the basis for the basic parallel ESF configuration calculation. The ideal ESF assumption (Figure 26), was expected that the applicable epidemiologic system would possible not fail from 0 to x_0 along the x axis. But the system would experience certain degree of failure (calibrated in [0, 1] along the alpha-cut (α)) as time progresses from x_0 to x_m. The system would fail or there would be ESF after x_m. The axis was seen as time frame. Notice that from x_m onwards to the right (along the x axis), α equals one. See Figure 34.

Using the parallel method, Figure 33 or TOPsc (Table 23) was selected.

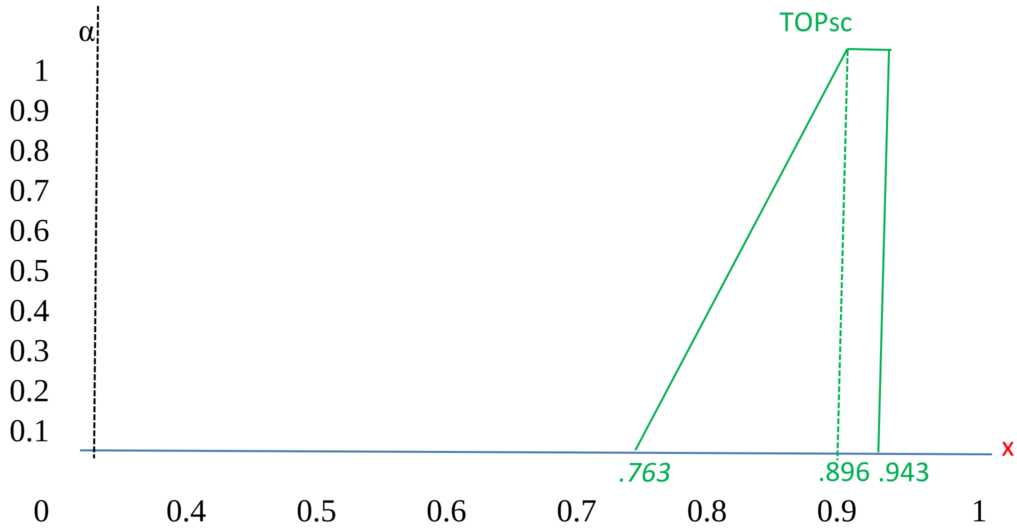


Figure 33. TOPsc for Ebola ESF.

The figure graphically was compared to the right-side as shown in Figure 34.

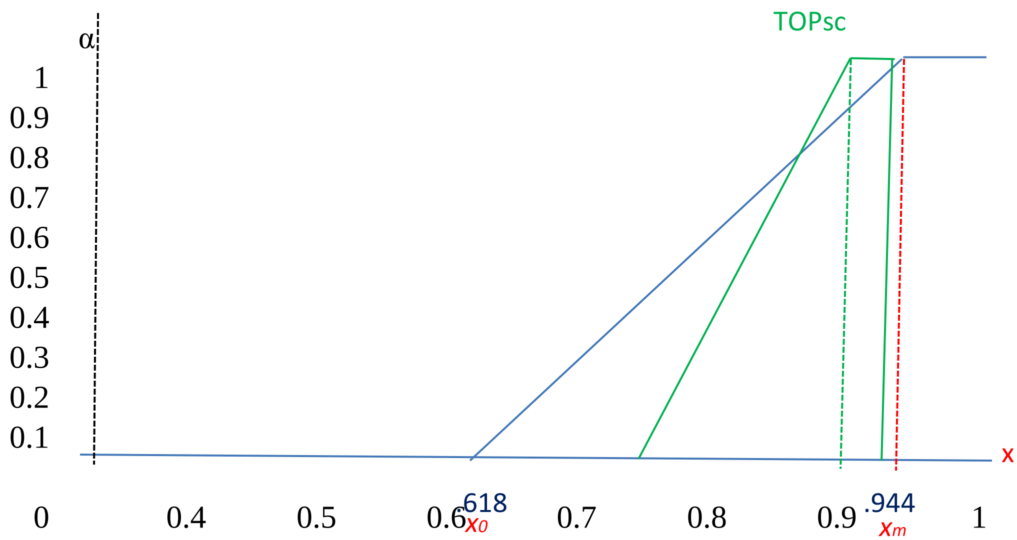


Figure 34: TOPsc superimposition with the right-side.

The next step was to select TOPnc as shown as Figure 30 or see Table 24 and compared with TOPsc as shown in Figure 35.

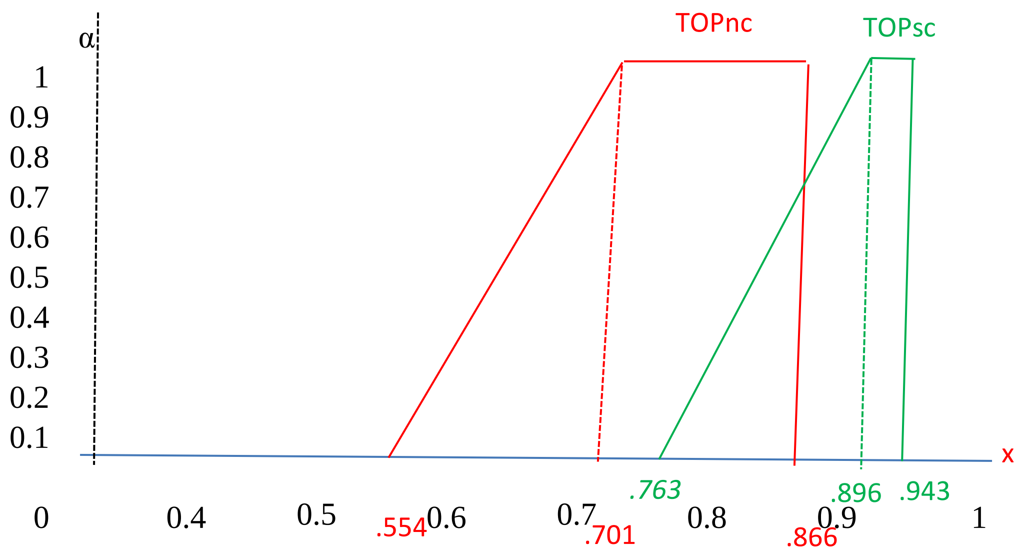


Figure 35: T/OPnc and TOPsc representation.

Step seven. First the arithmetic began by finding x from Figure 35. This was done such that $s = \frac{a-b}{2}$; $\mathrm{x} = a - s = b + s$. From the figure, $a = .896; b = .866$ then

$s = a - b = \frac{.896 - .866}{2} \approx .\frac{03}{2} \approx .015 \therefore x = .896 - .015 = .866 + .015 = .881$. In all, the fuzzy mathematics entails from $\Pi_f(x) = \begin{cases} M_X(x) = \quad 0; & x \prec x_0 \\ \Phi(x) \text{ or } \frac{x - x_0}{x_m - x_0} \quad ; & x_0 \le x \le x_m \\ 1 & x \ge x_m \end{cases}$. There would also be a commutative possibility of failure from the presupposition such that

$\Psi_f(x) = \max(\Pi_f(x) : x \in [0,1]$. Another presupposition for ESF is survival possibility distribution as shown in Figure 36. The survival possibility distribution was obvious because

$$S_f(x) = \begin{cases} 1-\Psi_f(x) = \quad 1; & x \prec x_0 \\ 1-\Phi(x) \text{ or } \dfrac{x_m - x}{x_m - x_0} \quad ; & x_0 \le x \prec x_m \\ 0 & x \ge x_m \end{cases}.$$

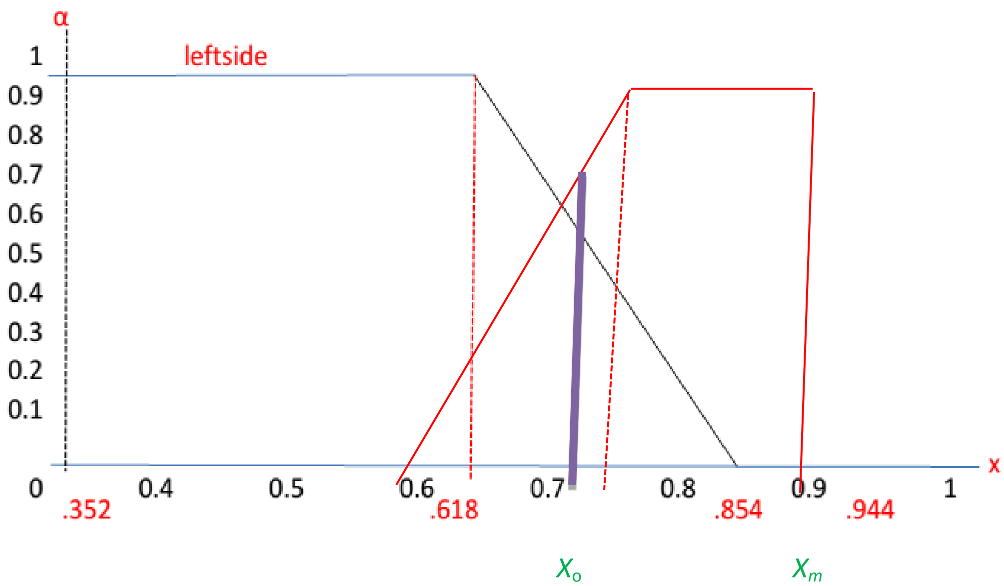


Figure 36: Survival possibility distribution determination (left-side and TOP$_{nc}$)

The survival $S_f(x) = 0$ because from the figure $.881 \succ .66 \mid x \succ x_o$; where

$$x_o = \frac{.701 - .618}{2} \approx .0415 + .618 = .66\,.$$

Deviating from the works of Noor and McDonald (1996) and Verma, Srividya, and Deka (2006), it was envisioned that the best representation of repair possibility distribution should be determined during analysis. The distribution should show that epidemic system repair time usually differs from failure distribution. For example, epidemiologic system might fail for months whereas the repair might be in days or few weeks. The possibility was assumed to increase from 0 to x'_m where the alpha-cut is at a unit level. The mathematics is

$$\Pi_r(x) = M_r(x) = \begin{cases} R_r(x) = R(x) \text{ or } \dfrac{x}{x'_m}; & 0 \prec x \prec x'_m \\ 1; & x \geq x'_m \end{cases}$$

. It would therefore be possible that the system could be repaired at x'_m. From Figure 32 $x'_m = .896$ and $x = .881$ then the equation becomes $\Pi_r(x) = \frac{x}{x'_m} = \frac{.881}{.896} = .983$ for $x'_m > x$. Given Figure 36, let $x'_m = .854$ and knowing that $x = .881$, then the possibility that the epidemiologic system was not repaired from time x_o to x is (a non-repairable possibility distribution), $\begin{matrix} S_r(x) = 1 - \Psi_r(x) = & 1 - p(t); 0 \prec x \prec x'_m \\ 0 & x \geq x'_m \end{matrix}$. The equation becomes $S_r(x) = 1 - \frac{x}{x'_m}$. The result is $S_r(.881) = 1 - \frac{.881}{.854} = 1.0316 - 1$ or .0316.

The mean time failure (MTTF) was obtained such that

$MTTF = \int_0^{x_0} S_f(x)dx = x_0 + \int_0^m (1 - \Phi(x))dx$ or $\frac{x_0 + x_m}{2}$. MTTF from Figure 33 gives $\frac{.763 + .943}{2} = .853$. The mean time to repair (MTTR) was also determined such that

$MTTR = \int_0^{x_0} S_r(x)dx = x_0 + \int_0^m (1 - p(x))dx$ or $\frac{x'_m}{2} = \frac{.854}{2} = .427$. Concluding with the parallel configuration, an epidemiologic forced outage rate (EFOR) was obtained such that

$$EFOR = \frac{MTTR}{MTTF + MTTR} = \frac{.427}{.853 + .427} = .33.$$

In addition, x is to the right (outside) of T/ (O/P) as if x is compared to Figure 30 which is the ESF according to the serial method. The parallel method is much intuitive.