

# System Thinking Approach in Road Crash Analysis: A Catalyst to Improved Road Safety in Zambia

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**Abstract** Road Safety is currently one of the major problem for both developed and developing countries due to its negative impact on the economy. Although many scholars have advocated for numerous approaches in accident analysis, there seems to be an increase in road crashes every year. This study analyses two road crashes and one driver behavior case studies using system thinking analysis approach. The objective of this study was to develop models that could help in grasping the complexity in the underlying causes of road crashes in Zambia with the use of three case studies. Further in this discourse, we review literature to elicit discussion on the concept of ‘System Thinking’ in road crashes as a catalyst to improved road safety in Zambia. The case scenarios applied in the study illuminate how system thinking application can mitigate road crash investigation with the application of Swiss cheese accident causation and human factors analysis and classification system (HFACS) models. In addition the study focuses on how the application of system dynamics models with the use of causal loop diagram could help in understanding complex systems in road transportation and identify factors that contributes to road crashes. It is therefore concluded that adopting system thinking approach in road crash analysis could lead to greater understanding of the underlying factors and latent conditions in road crashes. This in turn will help inform the development of interventions, policies and strategies that will mitigate road safety challenges in road transport domain in Zambia and beyond.

**Keywords:** active failure, latent failure, safe systems, systems thinking, causal loop diagram, Zambia

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## 1. Introduction

This article explores the lived world of survivors of road crash accidents in Zambia as extracted from the principal researcher’s Doctoral Thesis. The Doctoral programme was offered by the University of Zambia (UNZA) in collaboration with the Zimbabwe Open University (ZOU) and had been running since 2014 [1,2,3,4]. The study explores the System Thinking Approach in Road Crash Analysis as a catalyst to improved road safety in Zambia. The study findings informs developing countries such as Zambia on system thinking, a novel approach to combating catalysts to crash accidents as a precursor to the realization of the Sustainable Development Goals by 2030.

## 2. Context

According to [5] report, road traffic crashes are the leading causes of deaths worldwide with more than 1.3

million deaths annually. While some countries have made progress in reducing deaths over the last several years, many continue to observe a stagnant or steadily increasing trend in casualties and many accident keep occurring that seem preventable and have similar systemic causes. According to [6] the reasons why accident keep occurring that seem preventable and have similar systemic causes is because accident analysis method do not discover underlying causes of events. In Zambia, though road traffic crashes have plateaued, crashes are killing an average of 1,800 people each year [7]. The mobility of people through road transport which is an important factor in the life of people and essential ingredient in economic and social development of Zambia comes at a high cost as it is paid through traffic related fatalities, injuries and related economic costs. In order to alleviate this persistence problem with such a magnitude in economic and public health, there is need to call for a system thinking approach to road safety practice. This if done, will help to prevent accident that are preventable and have similar systemic causes from occurring. However, many current accident analysis method do not discover underlying causes or events that might have led to the

accident. Barry Richard, the pioneers of system thinking term, defines system thinking as art and science of making reliable inferences about behavior by developing a deep understanding of the underlying structure of a system [8]. International transport forum report on ambitious road safety targets reviews that, system thinking has potential in delivering enormous safety benefits as exhibited in countries where it has been used in analyzing road accidents [9].

[10] proposes groundwork for introducing system thinking and system dynamics as a tool to investigate, analyses and model road crashes. However, system thinking approach does not only look at transportation system failures, it also looks at driver behavior that causes traffic violation such as drunk driving, failure to use seat belts ,over speeding etc. as the outcome of endemic system like political, social ,cultural and economic settings. This is because there exist complex relationships between road safety and social, cultural economic and environmental context of the people who are involved in road crashes [11]. According to [12] humans are influenced by social cultural, political and economic setup. This therefore means life style and road user behavior are likely to be similar among a grouping of people sharing similar standard of living characteristics. In order to undertake a holistic human centered crash analysis, it is inevitable to understand factors that influenced their human action. According to [13], many psychology and social science fields have established that there is a direct link between organization culture and practice, demographic groups, social-cultural, political, economic setup and driver behavior. It is for this reason that some scholars have advocated for road crash analysis with the use of system dynamics modelling within a mobility system of organization, social cultural, economic, political and environmental context in order to achieve and better understand interacting factors contributing to driver road behavior and crashes [10] (Thaller, et al 2017).

#### *Current State of Road Safety Practice*

Ever since it emerged that human factors are responsible for a high proportion of road traffic crashes, many safety specialist have become fixated on human error as the major cause of accident but without further analysis of why these errors occur [14]. In recent approach, road safety practices have been understood by means of attributing causality in crashes to element of the transport system. Arguably one of the dominant practice that surrounds road crash causation in Zambia is safety individualization a situation in which road crashes are attributed to individuals while neglecting the larger perspective and underlying factors from which crashes arises from. Many interaction factors are usually ignored in the way accidents are analyzed, a practice that makes it difficult to find solutions that will remedy the problems of road safety [15]. This linear approach makes road safety practitioners to believe that an intervention in one context will be equally effective in another context and sustainable. For example though the use of high visibility enforcement with the use of speed camera to reduce over speeding do record substantial speed reductions, driver speeds returned to pre-enforced levels when driving in places were enforcement is not present [16]. This is because human behavior regularly demonstrate dynamic change due to

broader organization culture and practice, social-cultural, political and economic conditions that interact to influence such behavior [17].

Despite the application of E's framework (Engineering, Education and Enforcement) have produced some success in road safety by increasing road safety profile since their inception, the battle for road safety has plateaued and is far from finishing [18]. This is because the E's traffic safety framework require drawing a straight line between the effect (traffic crash) and the cause (individual road user behavior) with discrete categories of interventions. E's frame work is also limited as it fails to deal with the social dynamics that interacts at the root of road crashes. However, many scholars have argued that new approaches are needed so as to move from the traditional approach to system thinking approach. According to [19] and [20] this will help in identifying complex relationships between factors that produced effects. It is therefore evident that in order to move away from the current traffic fatality plateau, road safety practice must evolve and have a paradigm shift in analyzing, determining and development of integrated accident prevention solutions [21] and [22].

Research over the last decades consistently shows that 80 percent to 90 percent of road traffic crashes are caused by human error [5]. However, though it has emerged that human factors are responsible for a high number of road crashes, many road safety practitioners have focused on human error as the cause of accidents and not why these errors occur [14]. Further, the conventional way of analyzing accident has failed to control human errors accident causation factor as it do not take into consideration the fact that human behavior is influenced by many factors such as social, cultural, political, economic and organization influence conditions. Over the past two (2) decades, system thinking approach to road safety investigation and analysis has been applied and this has brought significant gain in many critical safety domain [23]. In system thinking approach, safety is treated as an emergent of the overall system as opposed to solely responsibility of human operator or driver.

#### *Paradigm Shift on Systems thinking Approach in Accident Prevention*

The need to adopt a system thinking approach in accident analysis that will help to reduce human errors has been advocated by many researchers in recent times [11]. In early 1990s, Sweden and Netherland led a complete paradigm shift in road safety. Their vision Zero strategy was based on sustainable safety and its focus was safe system approach [24]. This safe system focused on a transportation system were transportation managers, vehicle manufactures, law enforcement officers, land use planners and road user are all responsible for mitigating risks of road crashes as interconnected stakeholders operating within the same system and not placing the responsibility on individual driver [24]. The use of safe system approach led to impressive results in Sweden and Netherland. James Reason in [6] suggested that human error is not essentially a matter of individual driver making mistakes but it should rather be the outcome of a total design of a system. This approach do not only share responsibility to the organization cultural context and other social economic factors but also to engineering through the construction of road ways infrastructure and vehicles.

According to [25] study on managing risks of organizational accident, the major difference between safe systems and the conventional road safety management paradigms is that the safe system considers outcomes of active failures as a product of latent errors in the transportation system. This is to say road crashes are a consequence of latent failures created by decisions and actions within organization, environmental, social, or political arrangement. [26] further highlighted that safety is a system failure and not element failure. This therefore qualifies and demands the use of models and tools that analyses and evaluates all elements in the system like Swiss cheese model, Human Factors Analysis and classification system (HFACS) and system dynamics models.

The Swiss cheese model is a system thinking approach to road crash investigations where human error is viewed as a symptom of a large problem in the organization and not the cause of the accident. Swiss Cheese Model or cumulative act effect is as also a model of accident causation which is likened to a series of slices of randomly Swiss cheese arranged vertically and parallel to each other with gaps in between each slice [27]. These are organization influence, unsafe supervision, precondition for unsafe act and unsafe acts. In Swiss cheese model, the walls in the cheese slices represents individual weakness in individual part of the system with varying sizes and different positions. Failure is attained in the all system when holes in all of the slices align and permits a trajectory of accident opportunity so that a hazard passes through the holes in all defenses resulting into an accident. The theory behind the model is that lapses and weakness in one defense in a layer do not allow a risk to materialize since other defenses exist to prevent a single point of failure. Though many layers of defense in the model lie between hazards and accidents, there are flows in each layer such that if they align can allow the accident to occur. Most accident therefore can be traced to more than one or more of four failure domains namely organization influences, supervision, precondition for unsafe act and unsafe acts. According to [25] active failure are failures which encompasses the unsafe acts that can be directly linked to the accident like the driver error or immediate causes while latent failures include contributory factors or underlying causes that might lie dormant for some time till they contribute to the accident. Within the organization, barriers can be established to prevent accidents.

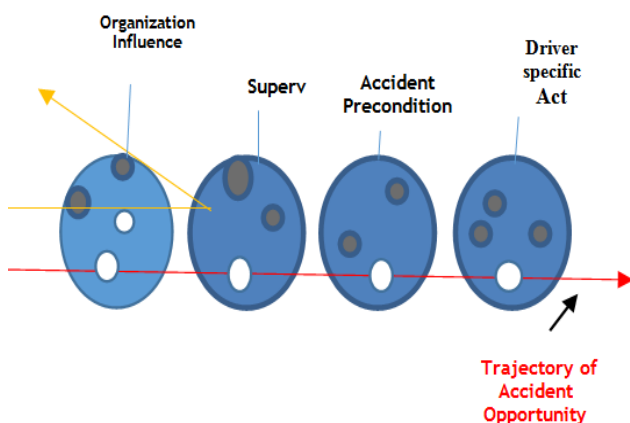


Figure 1. Swiss cheese model (Cumulative Act Effect)

Human factors analysis and classification system (HFACS) is the accident system thinking model which was developed by [28]. HFACS is a broad human error frame work established on principles of Swiss cheese model. According to [28] the HFACS just like Swiss cheese models has four levels namely organization influences, supervision, precondition and specific acts. Organization influence looks at organization resource, management, organization policies and culture and organization process that rules and govern the everyday activities within an organization. Supervision in the model refers to inadequate supervision, inappropriate operation plans, failure to correct known problem and supervisory violation in an organization. Precondition for unsafe act in the model refers to environmental factors, condition of operators, and personnel while unsafe act refers to the errors and violation of the driver on the road. HFACS frame work therefore provides a tool that supports Swiss cheese model in analyzing human factor aspect in an accident at each level of failure with the aim of preventing accidents. The framework goal is not to blame specific elements of the system but to understand the underlying causal factors that leads to an accident. If one failure occurs at each level, it will lead to an adverse event and if the failure is corrected the adverse event will be prevented and if failure is not corrected at any level, accident occurs. The use of HFACS for accident investigation enables an organization to identify the breakdowns within the entire system that allowed an accident to occur. It also used to proactively analyze historical events so as to identify reoccurring trends in human performance and system deficiencies. This helps to identify weak areas, implement targeted and data driven interventions that ultimately helps to reduce accidents.

In order to qualify Swiss cheese model (SCM) and human factors analysis and classification system (HFACS) as accident analysis models, we need to look at other theories that supports it like Tripod theory. According to [29], Tripod theory is defined as a root cause accident analysis approach that focuses on accident causation. The theory focuses on events that causes another event to occur. The theory is built on three steps of investigation of what happened, how it happened and why it happened. It also supports the accident analysis which look into underlying factors that contributes to the road crash. Just like the Swiss cheese model (SCM) and human factors analysis and classification system (HFACS), the tripod theory focuses on the underlying factors, precondition and immediate causes of the accident so as to identify what barrier should have applied to prevent the exposure of the accident.

#### *How Systems Thinking Can Help To Bridge The Gap*

The use of system thinking utilizes the principles in which we need to understand how stake holders, transportation system and policies in our communities interact to produce the undesirable outcomes we see over time [30]. The system must therefore be analyzed as a whole. The major objective of system thinking with the application of its tools is therefore to ensure that blame is not attributed to specific elements of transport system but to understand the underlying causal and contributory factors that leads to an accident [31]. In the conventional

accident analysis, accident are attributed to active failures while latent failures are ignored. However, this focus on human error as a cause of accident does not help in further analysis of why these errors occur. Analyzing accident using system thinking and its tools should therefore not only look at what happened but also why it happened. This is because most accident can be traced to more than one or more failure domain in a transportation set up. For example, an accident caused by driver fatigue does not only reveal drivers disregard for fatigue management policies and procedures but it might also reveal supervisors lack of involvement in journey management due to their lack of involvement and approval in trip planning or a driver performance rewarding scheme in the organization where drivers are rewarded according to the amount of deliveries, tonnage hauled or number of kilometers driven.

However, despite advocating for the use of system thinking approach by many researchers in road safety, it has not fully penetrated road safety research. One of the major barrier that has prevented system thinking application in road safety is lack of appropriate system thinking based road crash analysis [11]. Though there are many models and tools that many scholars have developed in accident analysis and investigation like Swiss cheese model (SCM), Human factors analysis and classification system (HFACS), system dynamics as well the tripod

theory framework, there is no standard analysis approach as well as method that will encourage all road crash investigators to analyze road crashes using system thinking.

This study will focus on the use of Swiss Cheese Model (SCM) and Human Factors Analysis and Classification System (HFACS) to analyses underlying factor to two (2) road crashes. It will further apply system dynamic model with the use of causal loop diagram to analyze the two (2) road crashes and one (1) driver behavior case studies. It will also propose how to approach the gap in the use of system thinking approach in accident analysis. This will help in justifying how system thinking models and tools can help enhance accident investigations. This in turn will help inform the development of interventions, strategies and policies that will mitigate road safety challenges in road transport domain in Zambia.

### 3. Methodology

The study applied qualitative methodology in which transcendental phenomenological design was applied to explore accident causing factors in Zambia. A system thinking theoretical framework with the use of Causal loop diagram were used for analysis of the variables in the model.

Table 1. Research Design Matrix

Phenomenological Attitude	Researcher Approach	Respondents Status	Interview Structure	Method
Phenomenological deduction	Active Listening	Bus Crew and passenger A	Contextualization (Eliciting on the causes)	Descriptive Context question
	Active Listening	Bus Crew and Passenger B	Contextualization (Eliciting on the causes)	Descriptive Context question
	Active Listening	Driver Association Representatives	Clarification of Phenomenon	Varying of interview questions

This study was situated within the interpretivist paradigm utilizing a qualitative research methodology which employs a transcendental phenomenological design to elicit evidence on first hand accounts from purposively selected survivors of road traffic accidents and driver representatives. Given the nature of this study, it was descriptive as opposed to predictive, and its purpose has been to make meaning of participants' perceptions, a qualitative methodology most fitting [32].

#### Data Generation and analysis

Data were generated through phenomenological observation, semi structured and focus group interviews as advanced by [33]. It was later analyzed through phenomenological reduction in which transcription of verbatim were clustered into themes by horizontalisation, creating meaningful units and developing textural descriptions.

#### Trustworthiness of the study

In this study, the process of data triangulation was used to confirm the data from multiple sources and with a variety of procedural steps [34]. Those multiple data sources were: (a) interviews, (b) focus groups, and (c) observations. Qualitative researchers frequently use terms such as validity, trustworthiness and reliability to describe the accuracy of their studies [35]. Since this study

was rooted in transcendental phenomenology, the concept of trustworthiness was a critical aspect throughout the research process. To ensure trustworthiness in this study, various strategies were constantly applied, including credibility, transferability, dependability and conformability [36].

### 4. Findings and Discussion

#### Road Crash and Driver Behavior findings and Analysis Using System Thinking Approach

In this segment, we focus on two (2) highway road crashes and findings that the researchers undertook and one (1) driver behavior case study on traffic contravening focus group meeting during road transport subsector consultative forum.

#### Road Crash A

Road crash A involved a Higer bus with a truck along Great North Road one (1) kilometer after Manyumbi toll gate on 31st January 2017 claiming ten (10) lives and twenty five (25) passengers injured. According to the active failure accident investigation and analysis the road crash was caused by dangerous driving and inappropriate speed. The following response was captured during interviews and interrogation from the bus crew and passengers.



*“As the driver of the Higer bus was driving towards a curve, 1 kilometer from Manyumbi toll gate towards the north direction, he saw the incoming truck. The bus driver applied brakes with the aim of reducing speed and negotiate the curve so as to avoid head on collision with the incoming truck. Owing to the defective and low brake efficiency that was experienced, the bus was pulled to the right where brakes were holding effectively thus moving it into the opposite lane. Later on when the driver of the bus realized that the bus had pulled to the right and it was now moving on the opposite lane and might collide with the incoming truck. His attempt to maneuver further to the right so as to avoid head on collision could not yield any fruit as the bus collided with the bus and 10 people died on spot and twenty five were injured.”*

However, after undertaking further investigation and analysis using the system thinking accident approach with the application of Human Factors Analysis and Classification System (HFACS) and Swiss Cheese Model (SCM) also called cumulative act effect, [27] it was discovered that though the accident was caused by active failure or immediate causes due to unsafe act by the driver, there were latent failures or underlying causes which were the contributory factors to the accident and if avoided, the bus could not have been involved in an accident. Despite the above outlined unsafe act by the driver which resulted in him being charged and jailed for two (2) years, there were underlying factors prior to the accident. Further investigation reviewed that prior to the bus being dispatched from Lusaka to copper belt, the driver had reported that the bus had a defective diesel fuel return pipe which was fixed without clamping it. However, due to the demand for transport service at intercity bus station on that fateful day, the bus was scheduled and routed to go to copper belt despite the defects. Further the driver had just driven the same bus from Livingstone to Lusaka for more than six hours

When the bus left the station and it was driven few kilometers into the Journey, it witnessed the fuel retainer pipe at the diesel fuel pump coming out at the fuel pipe joint which was connected but not clamped. Due to high diesel fuels pressure that was developed when the bus is being driving at high speed, diesel fuel which is lubricative in nature started splashing on the left front wheel assemble soaking the brake assembly (drum and shoes) and this caused defectiveness of brakes on the left front wheel. Effort by the bus crew to repair the defective diesel fuel pipe was done by reconnecting and tying with rubbers. This loss of brake efficiency on the left front wheel was the major contributing factor of the failure by the driver to control the bus despite the road condition and inappropriate speed.

Further analysis on why the proprietor of the bus scheduled and routed the bus and the driver to Copper belt immediately it arrived from Livingstone reviewed that bus operator procured buses through bank loan and they were compelled to over optimize the use of the buses so as to manage and pay back the bank loan. This forced operators to schedule and route the buses according to demand and not according to required vehicle management (bus condition) and Journey management (driver fatigue level).

Due to the outlined observation during investigation the following recommendations were made to the bus operator.

The bus operator needed to implement road transport safety management system in which the major emphasis would be on vehicle monitoring, motor vehicle and journey management as observed by [30]. This if implemented would help to:

- i. Improve the efficient and effectiveness of road transport safety management and ensure the operator has flexible scheduling and routing of his fleet;
- ii. Monitor and control driver working hours and help to control driver fatigue levels; and
- iii. Effectively monitor and apply mechanical service on motor vehicles (buses) before and after the journey as well as help to highlight the mechanical defects like the fuel leakage which the higer bus had. Effective vehicle management will also help to reduce poor workmanship as evident in the way the fuel return line was connected on the bus.

It's therefore evident that though active failure on accident A which involved a passenger Higer bus near Manyumbi toll gate reviewed that the accident was caused by dangerous driving by the driver who was later sentenced to two (2) years imprisonment, such investigation result cannot help to prevent further accident occurrence. This is because there were other interacting underlying factors which were responsible for the accident. There were accident latent failures that was exhibited prior to the crash under organization influence, supervisor influence and precondition for unsafe act and if they were avoided could have helped in preventing the accident.

In applying Swiss cheese analysis model, it is therefore evident that there was aligned weakness in organization influence, supervision, and precondition for unsafe act and unsafe act. This is witnessed by organization management decision to allow a defective bus and fatigued driver to proceed for another journey as they could not afford loss of business due to the financial burden placed on them by huge debts from the banks. Further there was a weakness by supervisor in supervising the mechanical staff on unprofessional works that was done on the broken diesel fuel retainer pipe. The loss of braking efficiency due to left front brake assembly being soaked with diesel fuel splashes from broken pipe was a key precondition for unsafe act that the driver experienced.

Going by the above analysis, it is therefore evident that focusing on unsafe act of the driver in this road crash and putting total blame on him while ignoring precondition for unsafe act that had developed, poor supervision in allowing a defective bus to proceed and organization failure on both vehicle and journey management is not the best approach in analyzing the causes of the accident. Organization failure on over optimization of resources (too many vehicle trips and fatigued driver), poor supervision on vehicle and journey management and precondition for unsafe act (defective brakes due to diesel fuel splashes on the left wheel assembly) that the bus developed were the key underlying factors that led to the accident and if these failures were avoided, the crash could have not occurred.

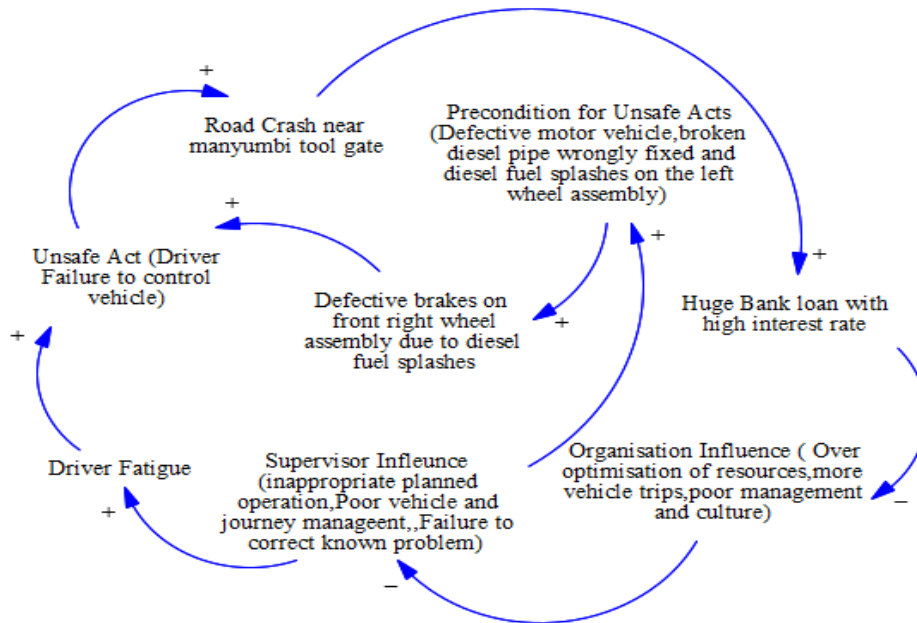


Figure 2. Causal loop diagram highlighting underlying accident factors on road crash A

### Road Crash B

Road crash B involves a Marcopolo bus which was involved in a road accident along Great North Road less than one (1) kilometer east of Luangwa bridge market on 23th May 2017. According to the active failure accident investigation which the principal researcher carried out, the crash which killed seven (7) passengers on spot was caused by driver failure to control the vehicle as a result of brake failure due to poor brake shoes to drum contact. Though brake liners were in very good working condition, the mechanical investigation on the braking material shows that brakes were binding prior to the accident. During investigation at the scene of accidents, the following were reviewed by the bus crew and passengers:

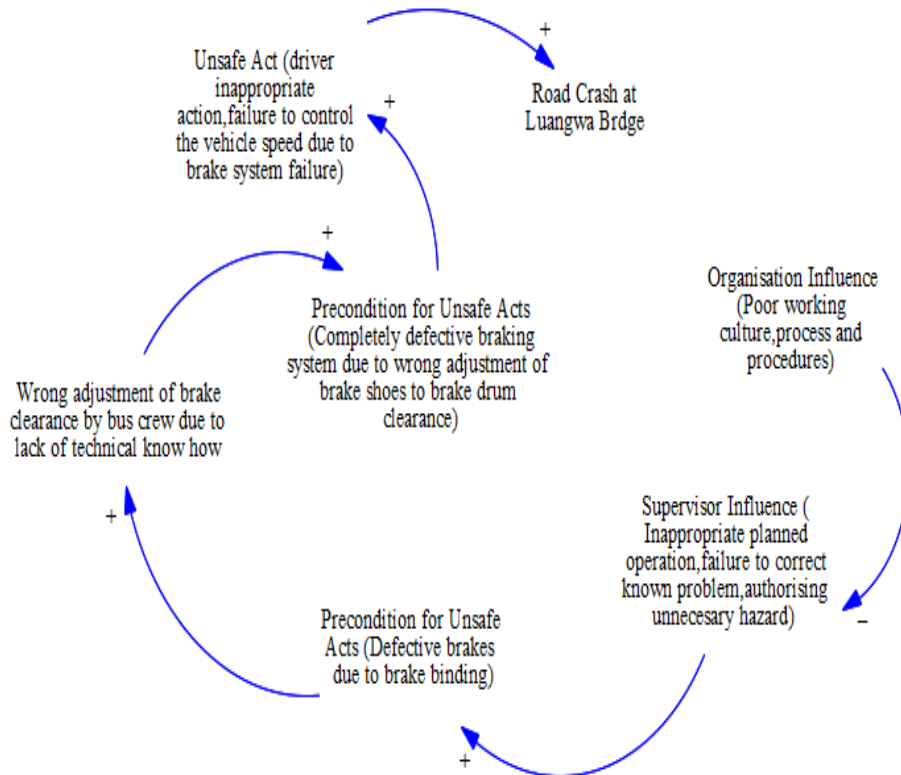
*“The bus had broken down at a place two (2) kilometers west of Luangwa bridge market. In an attempt to repair defective brakes which was experiencing brake binding, the driver and his crew tempered with the braking system by adjusting the brake to drum clearance in a manner that disturbed the brake drum to brake shoes contact. This loss of contact had to result in complete brake failure. When the driver drove the bus after tempering with brakes, the bus driver could no longer control the bus, stop or reduce speed due to brake failure and as a result he ended up hitting into the hill side and the bus had to fall into a gully killing seven (7) people.”*

However investigation using system thinking accident analysis approach reviewed that prior to the Journey, the bus had undergone mechanical service which included replacing brake shoes. However, according to mechanical workshop service practice, it is expected that whenever brake shoes are fitted on a vehicle braking system, the technician should undertake thorough road testing so as to achieve brake bedding. Brake bedding is the process were a motor vehicle is driven through road test after fitting new brakes with the objective of achieving smooth and even brake shoe to brake drum contact and achieve the required brake to drum clearance. This helps in resetting drum to brake shoe clearance during the mechanical

service and road testing and avoid brake binding which is the continuance contact of the brake shoes with brake drums.

Further analysis using system thinking accident analysis approach reviewed that the bus was dispatched to ferry passengers from Lusaka to Chipata immediately after fitting the brake shoes without carrying out driving road test. This had to result in the bus developing bake system challenge due to brake binding which the driver experienced all the way from Lusaka to Luangwa bridge and the driver was forced to stop several times during the journey due to heat that was developing as a result of brake binding. At approximately two (2) kilometers west of Luangwa bridge market, the bus brake drums were very hot due to continuance brake binding and an attempt to collect this situation by driver and his crew through brake adjustment failed as they also adjusted the brakes wrongly. The adjustment of brakes by the bus crew who had no technical know how did not take into consideration the required clearance resulting in the bus developing total brake failure due to poor brake drum to brake shoes clearance. This was the major factor that caused the driver to fail to reduce speed and control the bus as he drove passed Luangwa market towards to curves. This had to result in the bus falling into the gully killing 7 passengers on spot.

Though the driver was charged for causing death by dangerous driving due to his failure to control the vehicle and later imprisonment, the investigation approach which did not take into consideration latent failures prior to that accident cannot help to prevent further accident occurrence in the future. Punitive measures against drivers as an end in itself is synonymous to domino theory of Heinrich who originated the concept of the “safety pyramid”. He also developed the “five domino model” of accident causation, a sequential of accident model which has been influential on occupational safety thinking. His “domino theory” represents an accident sequence as a causal chain of events, represented as dominos that topple in a chain reaction. The fall of the first domino leads to the fall of the second, followed by the third [37] and [38].



**Figure 3.** Causal loop diagram highlighting underlying accident factors on road crash B

This is because the investigation omitted other interacting underlying factors which were responsible for the accident. In applying Swiss cheese analysis model, it is therefore evident that there was aligned weakness in organization influence, supervision, and precondition for unsafe act and unsafe act. This is witnessed by organization poor working culture, process and procedure in which they allowed the bus to be serviced by people with little mechanical know how. Further there was a weakness by supervisor in supervising the mechanical staff on unprofessional works that was done during servicing and fitting of brake shoes resulting in brake binding an accident precondition of unsafe act. This precondition that the bus developed has to result in another precondition in which the bus crew adjusted the brake clearance in a manner that had to result in total brake failure. Brake failure was therefore a key precondition for unsafe act that the driver experienced as he could not control the vehicle.

#### *Driver Behavior Findings*

The current public perception on minibus drivers in Lusaka considers driver behavior such as over speeding, dangerous driving, obstruction and overloading as a functional of moral failure, indiscipline and bad attitudes among the drivers. This public opinion has little consideration with regard to the context of behavior and the influencing factors. Road transport subsector technical committee stakeholders held a meeting on 7th April, 2017 to discuss and formulate mechanisms of cleaning up the transport subsector in the country and help enhance monitoring and enforcement. During the deliberation, stakeholders from government road transport regulatory bodies and the public had raised complaints in the manner

in which minibus drivers behave in the city. It was observed that public service bus drivers in Lusaka have little or no regard to traffic regulations.

In response to the concerns of government road transport regulatory bodies and the public, the driver association body representatives outlined factors that influences driver behavior in the city. The driver association representative reviewed that:

*“The problem that surround minibus drivers in Zambia is that the industry is organized around a target based system where the driver and his crew operate a bus on daily franchise basis because the minibus owner demands non-negotiable cutting throat daily cashing fees. The relationship between the minibus owners and the driver is often unmediated by the government agencies and lacks formal condition of employment as it is usually based on a one on one basis. Further, mini bus drivers operate in a precarious work environment with problems such as high level of Job insecurity, low wages, cut throat competitions, non-negotiable cutting throat daily cashing fees by vehicle owners and harassment from bribe demanding corrupt enforcement officer. It should therefore be noted that the demand to meet these numerous financial and other demands of their work is what fuel dangerous driving behaviors among the drivers and not necessarily driver morale failure as per public perception. This is the reason why punishing them through heavy fines and prison sentence has not helped in inducing safe driving behaviors in the city. The high unemployment levels tilts the balance of power in favor of minibus owners. Despite these irregularities and practices in the industry which results in minibus drivers’ work in extreme harsh working conditions with low wages*

which cannot support their families, the public and the government agencies condemns the driver without considering factor influencing their behavior”.

The driver association representative furthermore reviewed that:

“It should be noted that since minibus drivers are demanded to make enough to cover operational cost, pay bus owners, themselves and their crew, this is achieved by increasing the number of trips, overloading and working long hours. This culminates into dangerous driving, overloading, over speeding, aggressing driving behavior, and violations of many traffic regulations in the city. Additionally road engineers in the transport sector have a tendency of using concepts and techniques in constructing bus stations that sometimes lack the need and requirements of the community social- economic behavior in a particular setup. This results in bus stops being constructed in location against the wish of the residents due to lack of stake holder consultation which results in bus drivers stopping anywhere on the road to pick passengers and in many cases many roads in Lusaka do not have bus stops. These are some of the factors that public service drivers faces in their quest to obey or adhere to traffic regulations in their daily business operation especially in Lusaka city”.

Going by the dynamics that affects driver behavior as highlighted, it is evident that though moral failure and bad attitudes are the active failure factors in driver behavior leading to contravening and dangerous driving, there are a lot of underlying factors that induces this driver behavior in Lusaka. This is because there are latent failures in the industry that directly affect mini bus drivers in Lusaka as supported by [8]. Enforcing driver behavior through heavy traffic fines without taking into consideration the latent failure factors contributing to their behavior cannot yield sustainable result. This is because human behavior is dynamic and it responds to factors affecting its social economic issues. The current public perception on minibus driver behavior is not a functional of moral

failure, indiscipline and bad attitudes among the drivers but a result of influencing factors affecting their industry. The industry is organized around a target based system where drivers operate mini buses on daily franchise because the owner demands daily cashing fees. The industry lacks formal condition of employment and is usually unmediated by government Agencies. Drivers also operate in a precarious work environment with problems such as high level job insecurity, non-negotiable throat cutting daily fees by minibus owners, harassment from bribe seeking enforcement officers, extreme harsh working conditions with low wages which cannot support their families. In pursuit to make enough to cover operational cost, pay bus owners, themselves and the crew, they resort to cover a number of trips, overloading as well as work long hours. This culminates into dangerous driving, overloading, over speeding, aggressive driving behavior and violation of many traffic regulations in the city in order to meet the non-negotiable throat cutting daily cashing minibus owners demand without which they will lose their employment.

Condemning drivers and punishing them through heavy fines and prison sentence without looking into factors inducing their driving behaviors cannot yield any sustainable result because their behavior is not necessarily a morale failure, indiscipline or bad attitudes as per public perception but it is as result of latent failures in the industry. The thrust of this paper is similar to who argues that the policy of hunting for rogue drivers to make roads safer in the continent is as ineffective as killing mosquitoes one by one to control [39].

Bus drivers cannot therefore obey and have regard to traffic regulations in the circumstance were doing so directly affect their social economic needs and expectations. They usually tradeoff between obeying traffic regulations and make adequate cash so as to enable them meet there daily cashing with an expected surplus for their daily need.

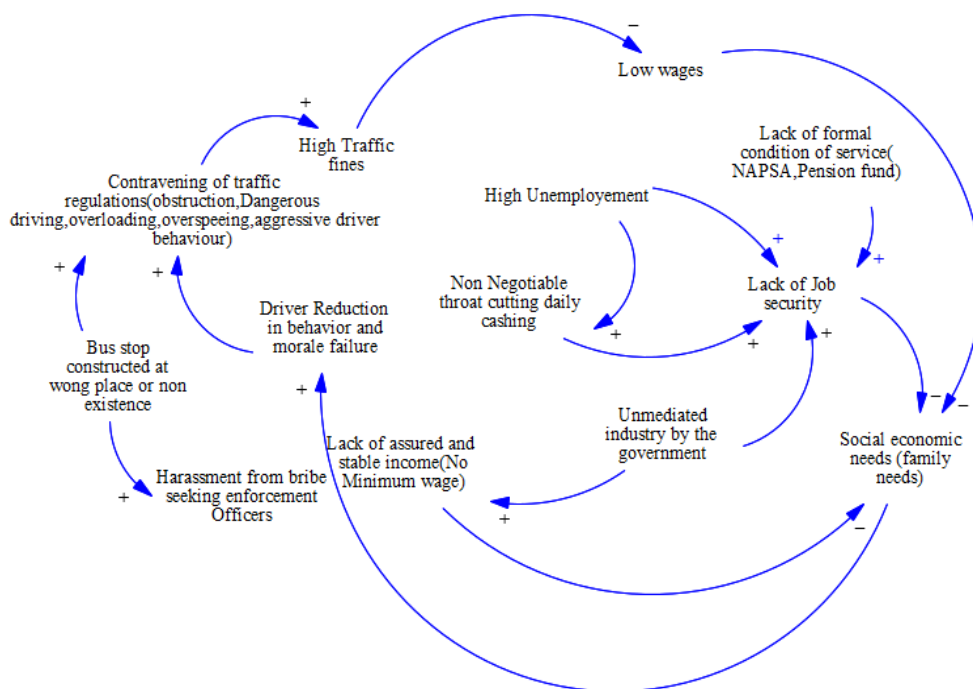


Figure 4. Causal loop diagram highlighting underlying factors in driver behavior in Zambia



It's therefore evident in this study that if a bus driver cannot contravene traffic regulations, he cannot manage to raise the expected daily cashing as the bus owners do not compromise on daily cashing due to cost of capital as a result of high interest rates in Zambia. If bus drivers were formally employed and are entitled to conditions of services like NAPSA and retirement pension to mention but a few, they could have high regard for traffic regulations and their focus could be long term. They could not easily trade off between breaking the law through traffic contravention and long term benefit through job security and retirement financial benefits. Further if their salaries were both adequate and secured, bus drivers could resort to obey the law as they could be assured of meeting their social economic need at the end of the day. Above all, the road transport regulators should not expect bus drivers to stop contravening especially in some new roads in Lusaka which has been built without a single bus stop. This is against the expectation of the passenger transport industry where passengers are picked at many multiple points. Enforcement of the law in such an environment is unattainable [40].

## 5. Conclusions

In conclusion, we note that one of the dominant practice that surrounds road crash causation in Zambia is safety individualization a situation in which accident are attributed to individuals while neglecting the larger perspective and underlying factors from which crashes arises from a practice that makes it difficult to find sustainable solutions that will remedy the problems of road safety. This linear approach in enforcement and accident analysis is not sustainable because human behavior regularly demonstrate dynamic change due to broader cultural-social conditions that interact to influence such behavior. System thinking approach to road safety investigation and analysis if applied will bring significant gains in safety domain because its underpinning assumptions is that human error accident causation may be the outcome of certain flaws in the design of various elements in the transportation system rather than it being a fundamental cause of crashes. This is because safety is a system failure and not element failure and road crashes are a consequence of latent failures or underlying factors created by decisions and actions within organization, environmental, cultural-social, economic and political system. This study has provided an explanation on the behavior of minibus drivers as a predictable action systematically connected to the industry. The study concludes that aggressive behavior among drivers in Lusaka are not driven by bad driver moral failure and attitudes but are rather a predictable action connected to the industry in which the driver operates. Thus, adopting system thinking approach in driver behavior and accident analysis in road transport in Zambia could lead to greater understanding of the underlying factors and latent conditions in contravening of traffic regulations and road crashes. This in turn will help inform the development of interventions and strategies that will mitigate road safety challenges in road transport domain in Zambia.

## 6. Implication of the Study

- i. The implication of this study therefore is to propose a paradigm shift from safety individualization of road crashes to system thinking analysis approach a practice that views road crash and as a symptom of a large problem in the system and organization. The new approach will help to find solutions that will remedy the problems of road safety. Zambia need to develop a practice of accident analysis which uses system thinking tools like Swiss cheese model (SCM), human factors analysis and classification system (HFACS) and system dynamics analysis tools so as to help analyses the weakness in the system that might have contributed to safety failure. This will help to highlight underlying factors in the system and stop allocation of blame on human error and behavior with regard to driver unsafe act.
- ii. The use of system thinking in ascertaining the underlying causes of the road crash will help remedy the problems of road safety through application of collective and effective interventions. This will bring significant gains in safety domain as it will target weak areas directly related to the accident predecessor events in the system. Adopting system thinking approach in accident analysis in road transport in Zambia could lead to greater understanding of latent conditions in road crashes and this will help in the development of interventions, strategies and policies that will mitigate road safety challenges in road transport domain in Zambia.
- iii. The study also contributes to the recognition that driver behavior inducing errors are usually not as a result of the flaws of morally, technical or mentally deficiency of drivers but are often a result of predictable action and omissions systematically related to social culture, economic, and political factors that influences the industry. The study proposes that the public, the police, road safety regulators and other government agencies should acknowledge the underlying factors affecting driver behavior so as to help come up with interventions that will mitigate the problem of driver behavior.
- iv. In order to further analyze the direct link between driver risk behavior and road users demographic characteristics, economic, social, culture, political there is need to involve the psychologist and social scientist in analyzing the relationship between these factors and driver behavior. This will help in anticipating the expected driver behavior and offer remedies. There is also need for researchers to develop system thinking based road crash analysis method so as to help in full utilization of system thinking application in road safety. The proposed study undertaking in appropriate system thinking based road crash analysis will help to formulate and harmonies accident analysis approach that will eliminate the current challenges.
- v. Further this study has provoked the need to carry out more studies on the implications of social culture, economic, and political environment to driver behavior in Lusaka.

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