Analyzing the Impact of Social Factors on Homelessness: A Fuzzy Cognitive Map Approach

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Abstract

The social and structural forces which affect homelessness are complex and often interactive in nature. Factors such as addictions, family breakdown, social disorganization, and mental illness impact levels of homelessness through dynamic relations. Historic models, which are static in nature, have only been marginally successful in capturing these relationships. However, fuzzy logic (FL) and fuzzy cognitive maps (FCMs) are particularly suited to the modeling of complex social problems, such as homelessness, due to their inherent ability to model intricate, interactive systems often described in vague conceptual terms and then organize them into a specific, concrete form (i.e., the FCM) which can be readily understood by social scientists and others. Using FL we converted information, taken from recently published, peer reviewed articles, for a select group of factors related to homelessness and then calculated the strength of influence (weights) for pairs of factors. We then used these weighted relationships in a FCM to test the effects of increasing or decreasing individual or groups of factors. Results of these trials were explainable according to current empirical knowledge related to homelessness. This FCM highlights and identifies factors related to homelessness which may respond positively to management and intervention. For those who determine social policy, this research may help to refine understanding and decision-making leading to effective changes in policies about homelessness and the factors which influence it.

Keywords: Mathematical modeling; Fuzzy logic; Fuzzy cognitive map; Homelessness

1 Introduction

Homelessness: Homelessness is defined and experienced in a variety of ways including: those with no home or permanent abode, those living on the street, in emergency shelters, in a vehicle, with family or friends, or in a long-term institution. It can also include those who are technically housed but reside in substandard shelter or who are at risk for losing their home. Homelessness is rarely a static state. Many who experience homelessness, do so in a variety of forms such as chronically homeless: permanently on the street with brief periods of respite in hospital emergency wards and emergency shelters; hidden or concealed homeless: living in cars, with family or friends or long-term institutions; and relatively homeless: those who are housed in substandard shelters or

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who are facing the imminent loss of their home. In addition, these forms of homelessness vary in duration and frequency and may present as chronic, cyclical, or temporary, depending on personal factors such as ability to earn income, mental health, physical health, addictions, race, family status, age, and gender. All forms of homelessness require varying policies and funding to alleviate and, thus, increase the complexity of dealing with the problem.

How homelessness is defined, for social and governmental agencies, reflects understanding or perception of the problem and its scope. Perceptions directly affect policies created and implemented to solve or alleviate homelessness. However, the very complexity created by personal factors intermingling with type and length of homelessness disallows a "one-size-fits-all" solution, making it difficult for governments to effectively manage programs and funding.

Levels of government, in countries like Canada, add to the complexity of dealing with homelessness. Being governed at three different levels, federal, provincial, and municipal, requires high levels of agreement to effectively create and administer policies. In Canada, each level of government is responsible for different facets of homelessness. The federal government, responsible for the whole of Canada, creates and administers policies and funding for aboriginal peoples (a segment of Canada's population over-represented in homeless counts), seniors, and social housing, as well as transfers funds to the provinces to help pay for their social programs. The provincial government, responsible for needs of the provinces and territories, creates and administers policies regarding mental illness, addictions, welfare, minimum wage laws, landlord and tenant acts, and child protection services and shares responsibility with the federal government for seniors and social housing. The municipal governments, are seen as the hands or arms of the provincial government, and are technically not responsible for homelessness; however are often involved in choosing sites for social housing, supporting emergency shelters and hospital emergency wards, as well as providing support, in a variety of ways, to facilitate these initiatives. The fact that there is no comprehensive national housing strategy to co-ordinate these levels of government often leads to inadequate policies and funding that fall far short of meeting the country's housing needs [1]. This lack of coordination towards policy and funding for homelessness has recently come to the attention of courts in Canada who have begun to make decisions which support shelter as an essential right for Canadians [2]. The UN Special Rapporteur on adequate housing in Canada has also strongly urged the federal government to commit sufficient funding to create a national housing strategy by working with the provinces and territories [3].

It is sufficiently difficult to enact policies to address complex social problems such as homelessness and even more so when the extent of the problem is still uncertain. At this point there is no accurate homeless count conducted nationally in Canada [4]. Estimates by Canada's National Secretariat on Homelessness estimate that there are 150,000 affected [4]. But social agencies in Canada criticize this number as being artificially low and claim the figure could be as high as 300,000 [5].

Metro Vancouver is one city in Canada which conducts a comprehensive homeless count every three years (City of Vancouver, 2011) [6]. Counters make every effort to include in the count those considered sheltered

homeless (individuals who spend nights in shelters, safe houses, transition houses, hospitals, jails, remand centres, and detox/recovery facilities) and those who are unsheltered homeless (individuals who spend their nights unsheltered on streets, in parks, or at drop-in programs (City of Vancouver, 2011). Counts are shown in Figure 1.

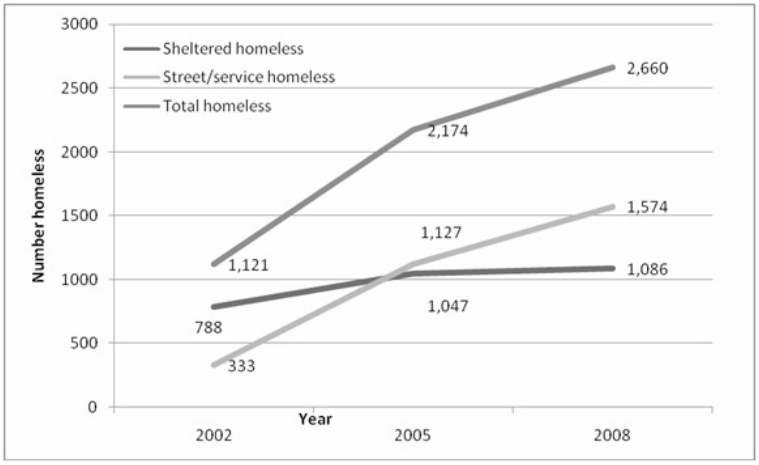


Figure 1: Homeless count in Metro Vancouver.

Metro Vancouver's count shows dramatic increases in homelessness during the first decade of the 21^{st} century (235% increase) and only in the last count have the numbers decreased (1%) (City of Vancouver, 2011). Despite policies enacted during this period to help alleviate homelessness, such as social housing assistance and, recently, increased shelter beds, little reduction in homelessness has been achieved.

Recent key findings in the Pathways Out of Homelessness Report identify affordable housing as the primary challenge for those either homeless or on the verge of homelessness [7]. Following affordability, barriers to housing vary from individual to individual and include mental illness, addictions, children, availability of public transit, lack of employment, social network support as well as others.

Individuals who, in the past, had been homeless, but who have managed to find affordable housing and remain housed for more than six months had access to affordable and safe housing, support services within walking or public transit distance, a personal commitment to pursue achievable goals, positive relationships and a community support network, with access to social housing assistance in the form of rental supplements [7].

Homelessness is a complex social problem because the underlying conditions that lead to it are so varied and complex. Those at risk of homelessness often experience a range of economic and social problems that have negative impact on health, wellbeing, and employment. Poverty, lack of affordable housing, health care problems, addictions, racial discrimination, gender discrimination, mental illness, family breakdown, and social disorganization are but a few of the problems commonly faced by individuals and families at risk of homelessness.

Most individuals acknowledge that a home is essential, without which it becomes difficult, if not impossible, to meet the basic physical needs of oneself and one's family, maintain social relationships, achieve community involvement, and acquire and maintain gainful employment. Therefore, understanding the factors that sepa-

rately, and in combination, lead to homelessness is critically important if countries such as Canada are to follow the United Nation's and their own court's recommendations and create a federal policy which will assure the essential right of a home for every citizen.

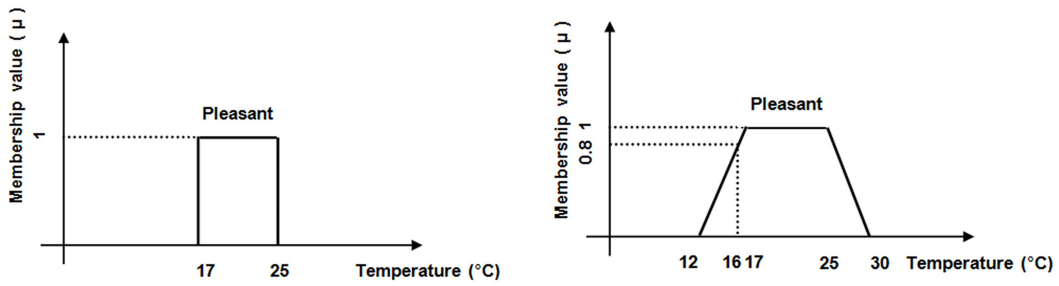
It becomes apparent that if the complex and oft-times chaotic experiences which lead to homelessness were better understood then social policies and procedures which constitute "best practices" would be more effective in efforts to reduce and prevent homelessness [8]. Fuzzy logic and fuzzy cognitive maps are especially useful for modelling complex social problems due to their inherent ability to capture and model vague concepts and values [9]. In relationship to homelessness, syllogisms such as, "if there is a lack of affordable housing, then there will be a significant increase in homelessness" can be accurately modelled by assigning a value to the parameter based on the retrieved linguistic terms taken from existing empirical literature. In this way greater meaning, which captures and aggregates the nuances of the stressors and protective factors, is given to the existing empirical literature related to homelessness. This allows the complex social issue to be graphically described in a manner which may be more readily understood. This, in turn, may then help social policy-makers to refine their decision-making, leading to effective changes in social policies with the goal of reducing homelessness. An explanation of fuzzy logic and fuzzy cognitive maps follows in the subsequent section.

2 Preliminaries of Fuzzy Logic and Fuzzy Cognitive Map

2.1 Fuzzy Logic(FL)

FL is a many-valued form of logic theory in which each variable takes a truth value between 0 and 1. This is different from traditional logic theory in which each variable can only take the values of 0 or 1 [10]. For the purpose of this research, four important concepts of FL will be used: fuzzy sets, linguistic variables, fuzzy rules, and defuzzification.

- **Fuzzy set:** A fuzzy set is usually defined through parameterizable membership functions. Therefore, it is a set in which a variable, O, can have partial membership. Traditional set theory is built on a fundamental binary relation of belonging to a set, a value described as 1, or not belonging to the set, a value described as 0. Thus, the variable O is assigned a value of 0 (does not belong) or 1 (does belong) for a given set, A. Fuzzy set theory relaxes this condition and allows the variable, O to have a degree of membership in a set, where, instead of taking on the value 0 or 1, it takes on a value between 0 and 1. For example, consider the set $Pleasant = \{temp \mid 17 \leq temp \leq 25\}$ which contains weather temperatures considered to be pleasant. Those temperatures bounded by this set are all pleasant. But what if the temperature is 16 or 26? According to traditional set theory these temperatures would be outside the crisp boundaries of the set and thus, not pleasant. This defies common sense. Fuzzy set theory overcomes this problem by introducing the concept of membership function as illustrated in Figure 2. A membership function permits a gradual transition between those members entirely inside the set and those members entirely outside the set.



(a) (b)

Figure 2: (a)Non-Fuzzy set membership function, (b)Fuzzy set membership function. The membership value of temperature 16°C is 0.8, partially in the set.

- **Linguistic Variable:** The linguistic variable is considered to be somewhat similar to a conventional math variable. Conventional math variables are described quantitatively and take on single, precise, numerical values at a specific time. Linguistic variables, which are described both quantitatively and qualitatively, take on imprecise numerical values. Using the temperature example, consider the statement: "The weather temperature is pleasant". The first portion of the statement, "The weather temperature", becomes the linguistic variable. The modifier, "pleasant", becomes the basis for the quantitative value and the imprecise mathematical value is determined for that modifier through its corresponding fuzzy membership function.

- **Fuzzy Rules:** Fuzzy rules are rule-sets which are defined through IF-THEN statement formats which capture human empirical knowledge regarding a given system. The fuzzy rule structure is as follows: IF < antecedent > THEN < consequent >

  The antecedent is the condition of the phenomenon of interest and the consequent is the conclusion about the phenomenon of interest. The structures of fuzzy and conventional rules are similar. However, instead of using crisp values/variables in the antecedent and consequent parts of the statement, as is done when using conventional rules, fuzzy rules encode using un-crisp values/variables. There are cases in which crisp values may be used but generally, fuzzy rules are described using linguistic terms which are un-crisp.

  Extending our previous example, a rule with a fuzzy antecedent can be of the following form: IF < the temperature is *Pleasant* > THEN < consequent >

  A similar procedure can be applied to consequent part of the rule. Hence fuzzy rule structure allows imprecise or vague linguistic terms to be utilized in the design of the rule base.

- **Defuzification:** To reach to a crisp value, we employ a defuzzification technique. The most common and useful defuzzification technique is center of gravity. These values are then used in the FCM.

  The research described in this paper utilizes a FL framework to model a group of concepts associated with homelessness. Current understanding of homelessness is that it has no single, identifiable cause. As well, the impact of any given cause may vary greatly depending on its interplay with other causes.

Given these qualities and the fact that most of the causes of homelessness have been historically described in linguistically imprecise or vague terms, determining the strength and interplay of these concepts is a problem ideally suited to the application of FL.

2.2 Fuzzy Cognitive Map (FCM)

The FCM is a framework used for modelling interdependence between concepts in the real-world [11]. This is achieved by graphically representing the causal reasoning relationships between vague or un-crisp concepts [12; 9]. FCMs allow scientists to construct virtual worlds in which some of the complex and interdependent concepts of a scenario can be captured and their interactions or causal relationships modelled. Knowledge representation in these maps has an acquisition-processing trade-off. FCMs, by providing a fuzzy graph structure for systematic causal propagation and ease in processing fuzzy knowledge, are applicable in soft-knowledge domains such as the social sciences. At the core of the FCM structure are the concepts to be studied and modelled. Concepts can be understood to represent actors or the parts of the environment which have impact on some phenomenon of interest (and each other), such as those included in the simple FCM of heart disease illustrated in Figure 3.

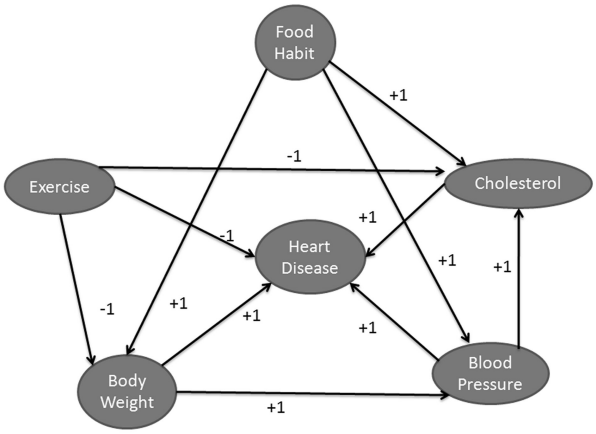


Figure 3: Example of a simple FCM to assess heart disease.

The concepts, determined empirically, which relate to heart disease in this model include: exercise (E), food habits (FH), cholesterol (C), blood pressure (BP), and body weight (BW). The links, directionally joining the concepts, represent the fuzzy causal relationships. The direction of the links demonstrate the causal flow between the two concepts and the corresponding weight (negative (-1), positive (1), or neutral (0)) providing the degree of fuzzy causal relationship. Concepts which have no impact on other concepts are not represented via links on the map, however are represented in the subsequent constructed adjacency matrix W and denoted, 0.

$$W = \begin{array}{c} \\ E \\ FH \\ C \\ BW \\ BP \\ HD \end{array} \begin{array}{c} \begin{array}{cccccc} E & FH & C & BW & BP & HD \end{array} \\ \begin{pmatrix} 0 & 0 & -1 & -1 & 0 & -1 \\ 0 & 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix} \end{array}$$

As can be seen in Figure 3, there is no direct effect of BW on C and therefore no link is drawn between these two concepts.

The heart disease FCM represents the causal relationships between the different concepts empirically assessed to increase or decrease the likelihood of experiencing heart disease. The arrows on the links indicate the direction or flow of the fuzzy causal rule between the pairs of concepts (antecedent to consequent) and the weight of the link $\{-1, 1\}$ indicates the type degree of the relationship. For example, the link directed from E to BW is linguistically stated, "exercise has a negative causal influence on body weight". The negative relationship indicates that an increase in E results in a decrease in BW.

The weight values $\{-1, 0, 1\}$ are used at this stage for simplicity and testing the FCM and will be later refined through the application of empirical linguistic terms and modifiers processed through FL. From the FCM a weight matrix is defined and constructed for propagating the causal influences and interplay amongst the different concepts. The rows of the matrix represent the causes and the columns, the effects. Exactly as is shown in the map, E has a negative affect on BW(seen in the element at row 1, column 4). Unlike the map, which does not show non-causal relationships, the matrix displays all causal and non-causal relationships and those concepts without causal relationship are indicated with a 0. Therefore it can be seen that E has no effect on FH or BP; FH has no effect on E and HD; C has no effect on E, FH, BW or BP; BW has no effect on E, FH, C or BW; and BP has no effect on E, FH or BW. All other relationships are shown as positive (the antecedent causes an increase in the consequent) or negative (the antecedent causes a decrease in the consequent). The use of an FCM is particularly advantageous for graphically representing the interacting relationships of concepts which appear in phenomena related to social science, political science, organizational theory, military science, and international relations [12]. The connection matrix, W, may also be defined algebraically, demonstrating the influence concepts have on one another [11].

Let us denote the i^{th} concepts of a system as C_i. Then the value A_i, of a concept C_i, expresses the quantity of its corresponding physical value. The FCM converges to a steady state when:

$$A_i(k+1) - A_i(k) \leq \epsilon \tag{1}$$

At each step, the value A_i of a concept is influenced by the values of concepts-nodes connected to it and is

updated according to the following formula:

$$A_i(k+1) = f\left(A_i(k) + \sum_{j=1, j\neq i}^{N} A_j(k).W_{ji}\right) \tag{2}$$

where $A_i(k)$ is the value of concept C_i at step k , $A_j(k)$ is the value of concept C_j at step k, W_{ji} is the weight of the interconnection from concept C_j to concept C_i and f is the threshold function used to bound the transformation to a limit cycle. In this example, $f(x)$ is a *sign* function defined in MATLAB [13] with the following functionality:

$$f(x) = \begin{cases} -1, & x < 0 \\ 0, & x = 0 \\ 1, & x > 0 \end{cases} \tag{3}$$

Following our heart disease example, consider: the concept, E, is active for some individual. Therefore, $E = 1$. No information is available for all other concepts in the map. Therefore, $FH = 0$, $C = 0$, $BW = 0$, and $BP = 0$. This is expressed by a vector $C_1 = (1, 0, 0, 0, 0, 0)$. According to equation 2 and 3, the processing is listed in Table 1:

Table 1: FCM processing when Excercise = 1

C_1W	=	$(0, 0, -1, -1, 0, -1)$	$\rightarrow$	$(1, 0, -1, -1, 0, -1)$	=	C_2	
C_2W	=	$(0, 0, -1, -1, -1, -3)$	$\rightarrow$	$(1, 0, -1, -1, -1, -1)$	=	C_3	
C_3W	=	$(0, 0, -2, -1, -1, -4)$	$\rightarrow$	$(1, 0, -1, -1, -1, -1)$	=	C_4	$\Leftrightarrow C_3$

The right arrow indicates the threshold function operation in Equation 3. The above results demonstrate that it takes four steps for the system to converge to a stable state (limit cycle). The vector C_4 demonstrates that the increase in E eventually leads to decreases in C, BW, BP, and HD.

FCMs have traditionally been implemented for the purpose of illustrating complex and interdependent disease systems such as heart disease and diabetes. These can then be used to inform health management knowledge systems [9; 14]. Illustrating complex health systems has allowed for greater ease in understanding how the relevant concepts act solely and in combination. This, in turn, has led to the development of new, more effective health care policies.

Using a similar process and reasoning, our research draws comparisons between a common sense virtual map of homelessness and an empirically refined map resulting in an illustration of the complex action and interaction of the factors which influence homelessness. This research demonstrates the vast potential for mathematical modelling to contribute to a greater understanding of social issues with the subsequent ability to inform social policy development.

3 Methodology

3.1 Virtual Common-Sense Map of Homelessness

First a virtual common-sense map was built based on the researchers' personal and historical knowledge of the factors which they perceived to affect homelessness. Using homelessness as the central hub of the map, concepts which directly or indirectly, positively or negatively affected homelessness, and each other, were linked through directed edges. Each edge was assigned a weight depending on whether the antecedent concept exerted a positive effect (+1) or a negative effect (−1) on the consequent concept (Figure 4). Three prototypical cases were then developed and the model was run to ensure it would function in accordance with the determined relationships prior to the actual weights on the edges being refined through a literature search for the linguistic terms.

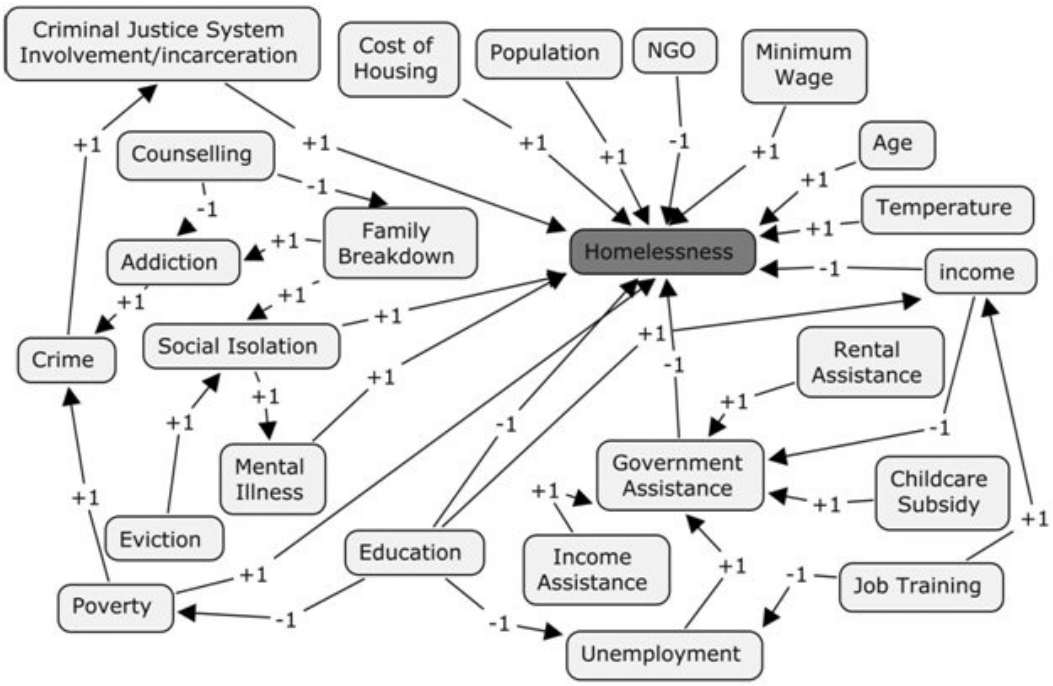


Figure 4: Virtual common-sense map of homelessness.

3.1.1 Experimentation: Virtual Common-sense Map

Experimentation with the virtual common-sense model was conducted to ensure that it would perform as expected and reach a stable state after iterating prior to the input of the actual weight values. Sample cases were constructed with the goal of describing an extreme case, most likely to result in homelessness; an extreme case, least likely to result in homelessness; and a middle case, more closely representing the possibilities of the real world, in which the likelihood of homelessness would be uncertain, see Table 2.

Table 2: Summary of expected outcome, concepts activated and iteration process for three sample cases

Case	Concepts Activated	Outcome
Case 1: Extremely likely to result in homelessness	criminal justice system involvement, addictions, mental illness, rental subsidy	Iteration 1: homelessness = 1; all other concepts, stable. Conclusion: extremely likely to result in homelessness.
Case 2: Extremely unlikely to result in homelessness	education, mental illness, non-government organization, and income assumed to be high	Iteration 1: homelessness = -1; increase in education; decrease in poverty, unemployment, and government assistance; all other concepts, stable. Iteration 2: homelessness = -1; increase in education and mental illness; decrease in crime; and all other concepts, stable. Iteration 3: homelessness = -1; increase in education, and mental illness; decrease in crime and criminal justice system involvement; all other concepts stable. Conclusion: extremely unlikely to result in homelessness
Case 3: Uncertain likelihood of homelessness	criminal justice system involvement, addiction, family breakdown, increased income, education, and social systems network.	Iteration 1: homelessness = -1; increase in addiction, criminal justice system involvement, family breakdown, income, counseling, crime, and social isolation; decrease in poverty, unemployment, and government assistance. Iteration 2: homelessness = +1; increase in addiction, criminal justice system involvement, family breakdown, income, counseling, crime, and social isolation; decrease in poverty, unemployment, and government assistance; all other concepts, stable. Conclusion: uncertain likelihood of homelessness.

- *Case1*: In this scenario, the protective factor of rental subsidy was incapable of preventing the negative social factors, criminal justice system involvement, addictions, and mental illness from overwhelming the model - resulting in certain homelessness.

- *Case 2*: In this scenario, the protective factors of education and increased income resulted in the elimination of the need for non-government assistance and a decrease in the likelihood of criminal justice system interaction. This is a highly likely outcome given that those with higher incomes and education are better able to identify and seek help for their mental illnesses which increases the likelihood that they will avoid incarceration. However, the strength of income and education as protective factors against increasing mental illness is shown to be ineffective and the level of mental illness continues to rise. Despite the increase in mental illness, education and income will ensure an ongoing ability to provide shelter, resulting in homelessness being an extremely unlikely outcome.

- *Case 3*: In this scenario, at the end of iteration 1, the effects of addiction, prior criminal justice system involvement, and family breakdown are held at bay by the protective factors of income, education and counselling. However, due to the known cumulative negative effects of addiction, social isolation increases, signalling the likelihood that, over time, there will be an increased possibility of family breakdown and greater challenges controlling the addiction resulting in the increased likelihood of crime. Iteration 2 demonstrates the actions of all the concepts present in iteration 1 continuing to exert force on the model with the addition of an increase in mental illness caused by the ongoing addiction resulting in an increasing

likelihood of homelessness. As the model continues to iterate, the addictions contribute to increasing social isolation and criminal behavior resulting in a greater likelihood of family breakdown. At this point the protective factors of education, income and counselling are overwhelmed by the ongoing addictions and resulting mental illness and crime and the likelihood of homelessness rises. However, given that education and income continue to exert force, homelessness is not a certainty.

Given the fully explainable results of the model and the fact that it was able to achieve stability after iterating, it was determined that the model functioned properly, and the process of refining the concepts through the search of timely empirical literature was conducted.

3.2 Fuzzy Cognitive Map of Homelessness Supported by Empirical Studies

To refine the edge weights on the FCM, timely, empirical literature was searched. The original causal map was referred to for the paired concepts such as, education and homelessness. These linked terms were then searched using the academic search engine, Google Scholar. Numerous articles were retrieved and scanned for each pair of linked concepts using only recently published (since the year 2000), peer reviewed, empirical articles. This culminated in the capture of three linguistic statements per concept pair for use in refining the map (see Appendix 1). Linguistic statements were required to be in the antecedent - consequent form as earlier described. In the process of searching, paired concepts were refined (edges and concepts added and removed) resulting in a final map of 14 concepts and 31 edges (Figure 5).

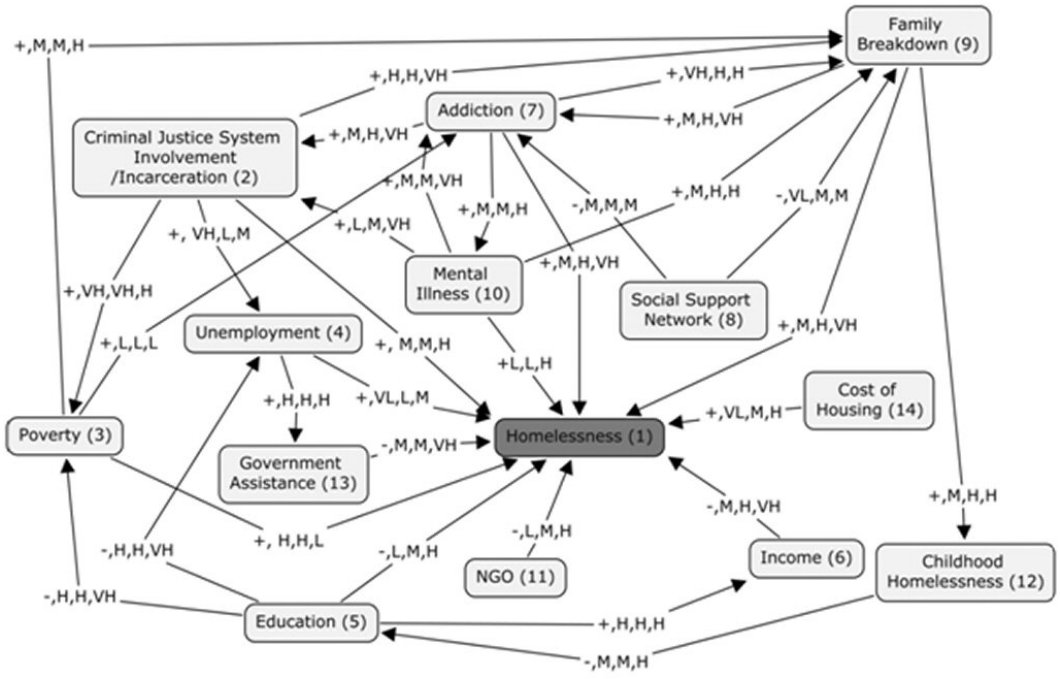


Figure 5: Fuzzy Cognitive Map with qualitative weighted edges.

To calculate the quantitative weight values for each edge, first the qualitative weight values for each of the

retrieved linguistic terms was assessed. A Likert-type scale was devised to determine the qualitative weight of each linguistic term. The values, Very Low (VL), Low (L), Medium (M), High (H), and Very High (VH) were used to categorize each term. We only consider five qualitative values for the sake of simplicity. However, the scale could be less or more than five, depending on the intricacies of the system under consideration. Consensus on meaning was achieved through discussion and vote. This process resulted in a scale of ordered and ranked values for each concept pair. For example, it might be stated in one peer-reviewed study that the effect of concept A on concept B was, "profound"; whereas another article may state that the effect was, "significant". These statements, "profound" and "significant", would be then ranked on the Likert- type scale in reference to their absolute meaning as well as their relative meaning. Thus, "profound", would be valued as VH and "significant" would be valued as H. In the case of disagreement or uncertainty regarding the precise meaning of the words, Oxford Dictionary Online was referenced for definitions and synonyms. A word bank was constructed during this process (see Appendix 2) listing all the retrieved terms for both comparative reference and to ensure consistency in the rankings. Once the different qualitative weight values were determined for each linguistic term, they were then collected into their groups of three and applied to the revised FCM.

Subsequent to the information from the literature review having been transferred to the FCM, the resulting map contained the concepts, the antecedent - consequent relationships indicated via edges, the weight value of each edge (five qualitative, linguistic terms - VL, L, M, H, VH), and the sign value showing the type of the influence ($+$ or $-$). Following the application of the qualitative values to the FCM the values were then converted to quantitative weight values using FL theory. Each link was first expressed as a fuzzy rule then used in the Fuzzy Inference System (FIS) to generate a crisp numeric value. For example, if the linguistic term retrieved from the literature was: "The impact of concept A is profound on concept B". It would then be converted to: "The impact of concept A is VH on concept B". This graded statement would then be transformed using the rule statement:

IF < A is ON> THEN< B is VH>

The linguistic term ON is a binary variable. VH is defined using the triangular fuzzy membership function, as shown in Figure 6. ON denotes the presence of the concept and VH denotes the weight value (qualitatively). For a more detailed explanation on selecting membership functions see [15].

- *Example 1:* As explained in the previous section, all qualitative values assigned to the edges came from the literature review. As shown in Figure 7, "addiction" has a positive impact on homelessness. This means that an increase in addiction in a society will lead to an increase in levels of homelessness. The three linguistic terms related to "addiction", extracted from the literature, were converted to the fuzzy notion of rules as follows:

  IF < Addiction is ON> THEN < Homelessness is M>

  IF < Addiction is ON> THEN < Homelessness is H>

  IF < Addiction is ON> THEN < Homelessness is VH>

  The degree of impact was then converted from its qualitative value (M, H, VH) to its quantitative value

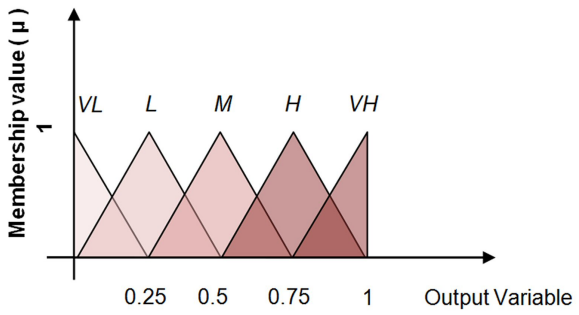


Figure 6: Triangular membership function.

of 0.648 using FL concepts described in section 2.1. All three studies indicated that as levels of addiction increase they exert a positive effect resulting in increases in levels of homelessness. Therefore, it can be stated that addictions affect homelessness by a factor of +0.648.

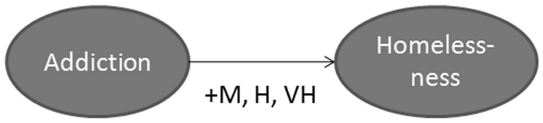


Figure 7: Impact of Addiction on Homelessness.

- *Example 2*: As shown in Figure 8, education has a negative effect on homelessness. This means that with higher levels of education in a society, the lower the levels of homelessness. Therefore, the impact of education on homelessness is modeled as negative - increases in education lead to decreases in homelessness. All literature scanned indicates that as education rises, homelessness falls. The first study stated that the impact of education on homelessness was low, the second, medium, and the third, high. Again, by having three different qualitative values, the three rules extracted from literature were constructed via FL concepts a quantitative weight of 0.5 was calculated which was then assigned to this edge.

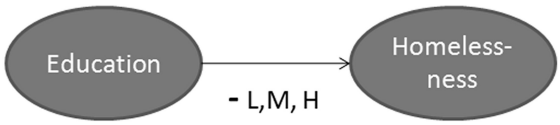


Figure 8: Impact of education on homelessness.

IF < Education is ON> THEN< Homelessness is L>

IF < Education is ON> THEN< Homelessness is M>

IF < Education is ON> THEN< Homelessness is H>

Similarly, each edge was given a quantitative weight by converting the qualitative values gleaned from the literature search. Once all links on the map had been fully articulated with the rankings of each of the 93 linguistic terms (three for each link), we refined the virtual FCM (shown in Figure 5) by substituting quantitative values for the previous qualitative values (see Figure 9).

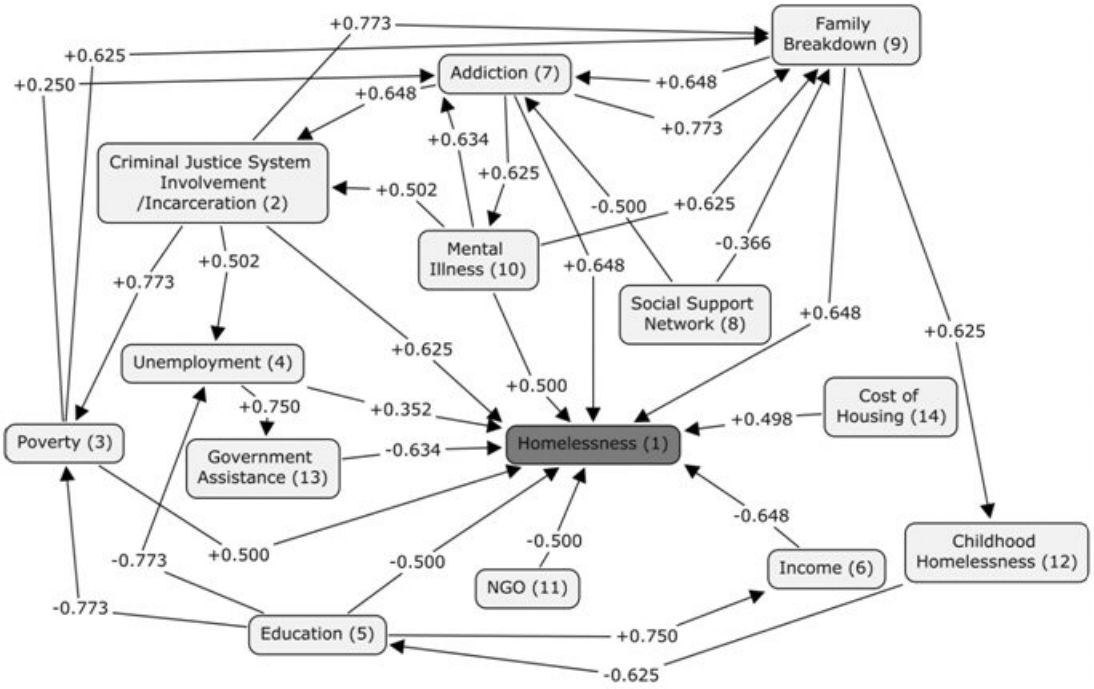


Figure 9: Fuzzy cognitive map with calculated quantitative weights assigned to edges.

4 Experimentation with the Weighted Fuzzy Cognitive Map

Experimentation with the weighted FCM was conducted, (see Algorithm 1), to ensure that it would perform as expected and that the map had captured the dynamics of the factors which affect levels of homelessness. We applied $tanh = \frac{e^{2x}-1}{e^{2x}+1}$ as the transformation function f of Equation 2.

Prototypical scenarios, similar to those used for the simplified FCM (Figure 4), were constructed with the goal of finding the extreme case most likely to result in homelessness, the extreme case least likely to result in homelessness and several middle cases, more closely representing the possibilities present in the real world, where levels of homelessness are less certain.

The output of each prototypical case was interpreted through knowledge gleaned during the literature search/scan and the opinion of the criminologist-researcher on the team. Each example case had a variety of concepts activated at varying levels. The models were then permitted to iterate as necessary to reach a stable state (no further movement, positive or negative, for all concepts in the model). Final iterations are reported for each model.

Algorithm 1 Basic structure of FCM Algorithm

Require: A (concept initial values between 0 and 1 in a $1 \times n$ matrix); B (weights between concepts -1 to 1 in an $n \times n$ matrix); m (maximum number of steps if concept is not convergent); ϵ (convergence condition)

Ensure: C (values of each concept along the procedure)

for $i = 1 \rightarrow m$ **do**
  $C_{i,1:n} \leftarrow A_{i:n}$
  $A_{1:n} \leftarrow tanh(A_{1:n} + A_{1:n} \times B_{1:n,1:n})$
  if $|SUM(A_{1:n}) - SUM(C_{i,1:n})| < \epsilon$ **then**
    $C_{i+1,1:n} \leftarrow A_{1:n}$
    Exit Loop
  end if
end for

Table 3: Simulating the result for Case 1

	Activated Concepts			
	Addiction	Family Breakdown	Government Assistance	Mental Illness
Inital Values	0.65	0.57	0.46	0.61

- *Case 1: Most likely to result in homelessness.* The concepts of addiction, family breakdown, government assistance, and mental illness were activated at levels considered sufficiently high to dominate the system leading to certain homelessness as shown in Table 3. It has been empirically determined that these concepts are often found together and often precede homelessness [16], [17],[18]. Addiction and mental illness are often co-morbid and both commonly precede family breakdown [19]. During times of increased addiction and mental illness in society it is the usual reaction of the government to put into place policies and funding which will address these problems [20].

  Tracking the effect of these concepts at strengths set to approximately 0.50, the graph initially shows that government assistance is at a lower rate and then sharply rises to address the increasing levels of addiction, mental illness, and family breakdown in the modeled society. However, it takes little time before the triple threat of addiction, mental illness and family breakdown overwhelm the system and levels of homelessness rise dramatically where they remain at a steady, high rate (indicated by the flat line at the top of the graph, Figure 10).

- *Case 2: Least likely to result in homelessness.* The concepts of addiction, education, income, family breakdown, and social network support were activated at levels considered sufficiently high to dominate the system leading to a certain outcome of no homelessness as shown in Table 4. In this case, the protective factors of education, income, and social network support protect society from the negative affects of addiction and prevent homelessness. The link between higher levels of education and higher

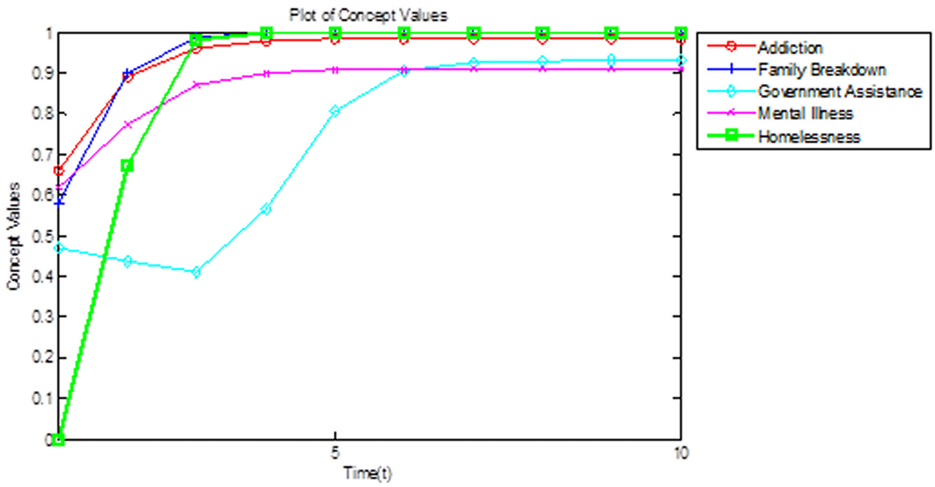


Figure 10: Activated concepts at levels most likely to result in homelessness with graphical representation of impact of concepts on levels of homelessness over time.

levels of income have been well documented [21]. Given that education prepares individuals to think creatively and to problem-solve, it is surmised that those with higher levels of education would have a greater ability to negotiate the complex rules that often are associated with government assistance. Those who are wealthy and educated are also much more likely to be capable of identifying and acquiring the services they might need, such as being able to pay for family counseling rather than being wait-listed for government supplied family counseling.

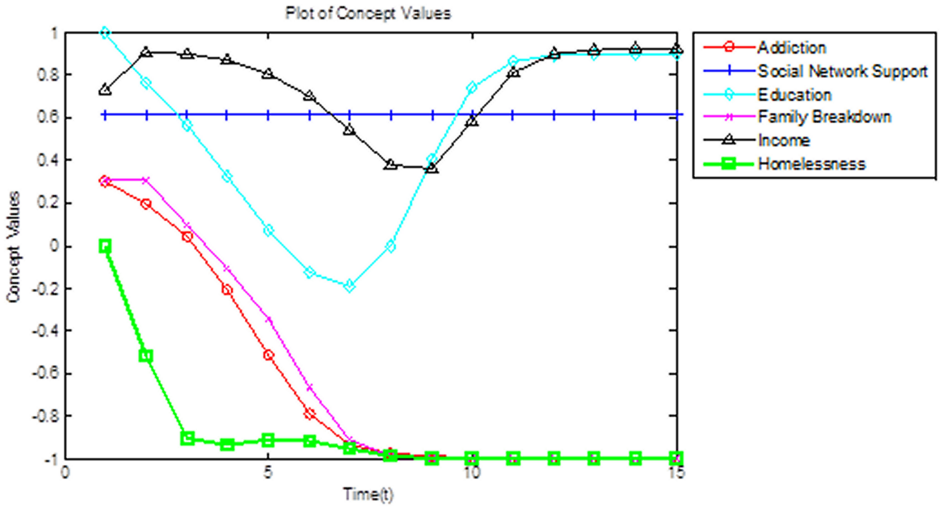


Figure 11: Activated concepts at levels least likely to result in homelessness with graphical representation of impact of concepts on levels of homelessness over time.

From Figure 11, it is noted that this model shows a initial dip in levels of income and education in the first

Table 4: Simulating the result for Case 2

	Activated Concepts				
	Addiction	Social Network Support	Education	Family Breakdown	Income
Inital Values	0.30	0.61	1.0	0.30	0.72

Table 5: Simulating the result for Case 3

	Activated Concepts				
	Addiction	Social Network Support	Education	Family Breakdown	Income
Inital Values	0.20	0.11	0.94	0.51	1.0

iterations as society attempts to deal with the addictions and threat to family cohesion that result from the addictions. However, very quickly, the protective factors of income, education, and social network support overwhelm the negative factors and the threat of homelessness diminishes and remains at levels close to zero (as indicated by the flat line at the bottom of Figure 11). Over time, the threat of family breakdown is also eliminated and income and education both rise back to their initial levels.

This second model demonstrates the critical importance of factors such as income - which lead to health, acquisition of knowledge, better food and health care; and education - which lead to wealth and all the positive factors which wealth can purchase. Though addictions are shown as present in this modeled society, the low levels are unable to overwhelm the model. Through model testing it became apparent that levels of addiction lower than 0.30 often fail to overwhelm the positive factors, as long as social support and education are both present at fairly high levels, see Figure 11. Much of the empirical literature support this [22; 23; 24]. Those with high levels of social support such as family, church, social groups, community groups, school friends and community friends are often better able to weather threats such as addictions and family breakdown.

- *Case 3: Uncertain outcome of homelessness.* In this model, we activated low levels of addiction and social network, high levels of education and income, and moderate levels of family breakdown as shown in Table 5. In this case, the protective factors of education and income delay the onset of homelessness but are insufficiently strong to prevent rising levels as the model iterates. Over time, due to family breakdown and the diminishing social network support, addictions begin to rise and as addictions rise, the likelihood of homelessness rapidly increases. This model demonstrates, once again, the importance of family and social support as well as the incredibly negative effects of drug addiction, both as a cause and result of family breakdown.

  As in the case of the common-sense map of homelessness (Figure 4), this final model (Figure 12), acted in a manner which was fully explainable based on information acquired during the literature searchand prior

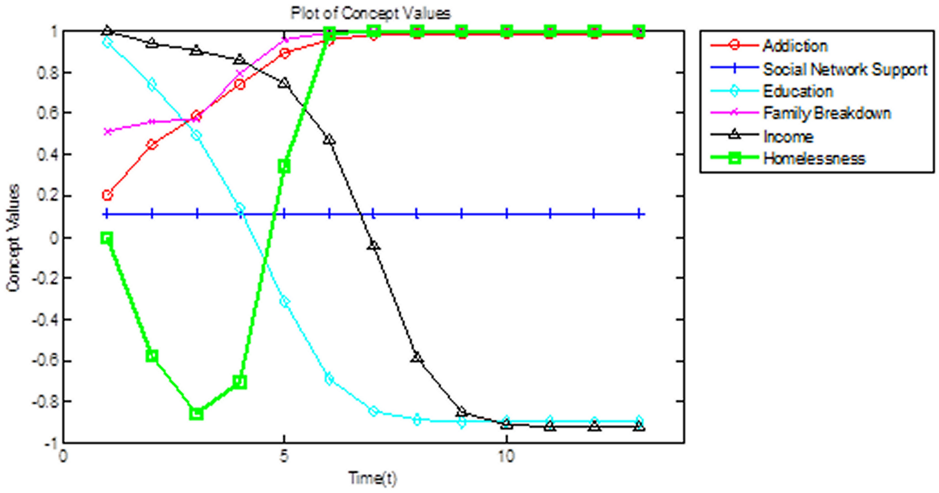


Figure 12: Activated concepts at levels most closely representing a typical real-world case with graphical representation of the impact of concepts on levels of homelessness over time.

knowledge of the research team. This allowed for confidence that the model was functioning as it ought to and that we had captured not only a number of the integral aspects which contribute to homelessness, but that they were functioning in the direction and strengths which approximated real-life conditions.

5 Analysis of Network Concepts

The purpose of this network analysis is to compare the degree of impact each of the concepts exerts on the model. During network analysis, we varied the initial value of a single concept from 0.1 to 1 while keeping the initial values of all other concepts at a static level; except for the concept representing homelessness. After several iterations, the value of homelessness was recorded. Then, for each factor, a plot of the value of homelessness versus the initial value of the concept was recorded. Ideally, for a factor with a positive effect on homelessness, the value of homelessness should increase as the value of the factor increases, gradually converging to a positive value. Concepts which have the reverse - a negative effect on homelessness, should demonstrate a decrease in homelessness as they are increased. Concepts which have higher convergent rates should demonstrate a greater impact on levels of homelessness.

To conduct the network analysis we first set the initial values for all concepts at a level of 0.5 and checked the levels of homelessness after 5 iterations. At this level and number of iterations, the majority of the plots resulted in a straight line at a value of +1. This told us that the initial value of the factor (0.1 to 1) made no difference on levels of homelessness and, obviously, was no help to our analysis. After analyzing the map, we tried reducing the level of the initial values for all concepts as well as reducing the number of iterations. Through a gradual reduction process we found that by setting the initial concept values at 0.01 and running three iterations we were able to generate reasonable and useful plots (see Figure 13) which could then be compared for effects on

levels of homelessness.

Plots can be examined in pairs or groupings so that the effect of the concepts on levels of homelessness can be compared for both intensity and speed. For example, in comparing the plots for, "Addictions", and, "Cost of Housing", it can be seen that they both are monotonically increasing. However, the plot for "Addictions" demonstrates a more dramatic increase, resulting in a quicker convergence to +1 than does the plot for "Cost of Housing". Therefore it can be concluded that addictions have a great impact on homelessness than does cost of housing.

A second method in which to compare the effects of the concepts on the levels of homelessness is through examination of the box plots (see Figure 14) which represent the same information in another way. Making the same comparison, "Addictions" to "Cost of Housing", it can be seen that the plot of "Addictions" has a narrower median and longer lower quantile.

5.1 Measure of Centrality

Another approach to analyze the most influential factor is through *measures of centrality*. There are also other measurements for analyzing an FCM, but here we focus on this property. In this subsection, we describe the results of the analysis based on two types of centrality: degree centrality and closeness centrality. Degree centrality of each node/concept, in a given weighted and directed graph, is defined as the sum of the absolute values of the weights of the outgoing and incoming edges [25; 12]. For the node, x, of the graph $G =< V, E >$ the degree centrality is mathematically defined as:

$$\sum_{\forall y \in V} |w_{xy}| + |w_{yx}| \tag{4}$$

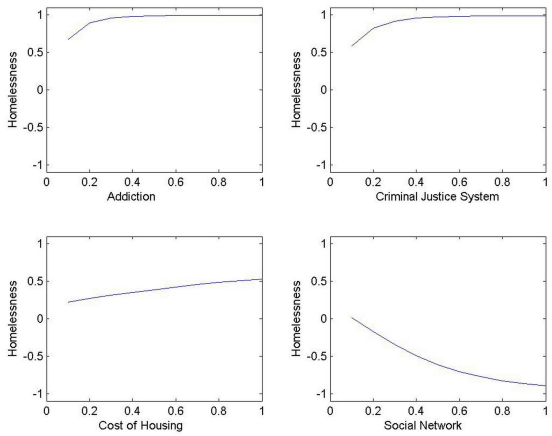
where w_{xy} and w_{yx} are the weights of the edge from x to y and the edge from y to x, respectively. Degree centrality of a graph indicates how strongly a concept node in an FCM affects other concept nodes of the graph [26].

Closeness centrality of a node is the inverse of the sum of the lengths of the shortest paths between that node and all other nodes. For the node, x, of the graph $G =< V, E >$, the closeness centrality is mathematically defined as:

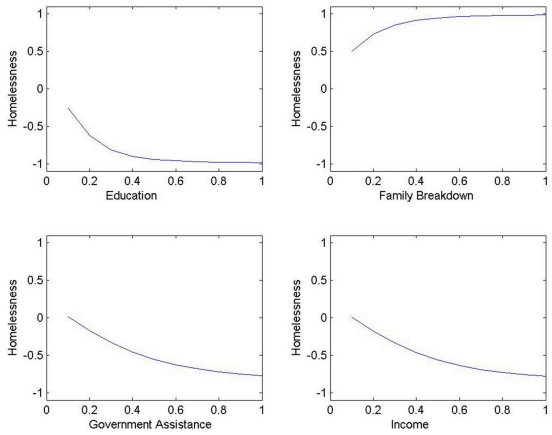
$$\frac{1}{\sum_{\forall y \in V} |d_{xy}|} \tag{5}$$

where d_{xy} denotes the length of the shortest path from node x to node y. Closeness centrality indicates how quickly a concept node affects other nodes of the FCM [26].

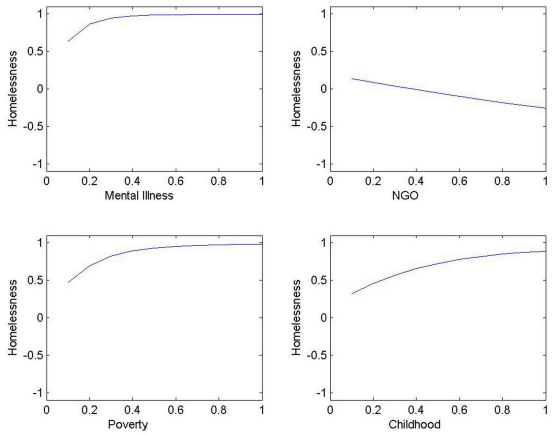
Note: For closeness centrality the distance measured between each pair of nodes is the inverse of the weight of the corresponding edge in the FCM. If there is no edge between nodes then the distance from the one node to the second node would obviously be infinite. Since the FCM is not strongly connected, the length of the shortest path for some pairs of nodes is, in fact, infinite. This then causes the closeness centrality for that node to drop



(a)



(b)



(c)

Figure 13: Graph comparison of the affects of individual concepts on levels of homelessness.

to zero. For example, the length of shortest path for each node to the node, "Cost of Housing", is infinite. This makes the centrality of all nodes to be zero. To conquer this problem, we choose a numerical value which is large enough to be considered as an infinite value. Since the distance measure between each pair of nodes is defined as the inverse of the weight between the nodes of the FCM, the greatest distance between each two nodes would be 4. This value is corresponding to the edge between "poverty"' and "addiction", whose weight is 0.25. The FCM has 14 concepts, thus each path of the FCM will, at most, have 13 edges. Therefore, the length of each path will be at most $4 = 52$, which is still an overestimation of the paths in the graph. Regarding this value, we picked 100 as an large enough value. This approach is similar to the Big-M method described in operation research theories [27]. Please note that changing 100 to a greater value, may change nodes' closeness centrality, but the order of the nodes' closeness centrality will not change.

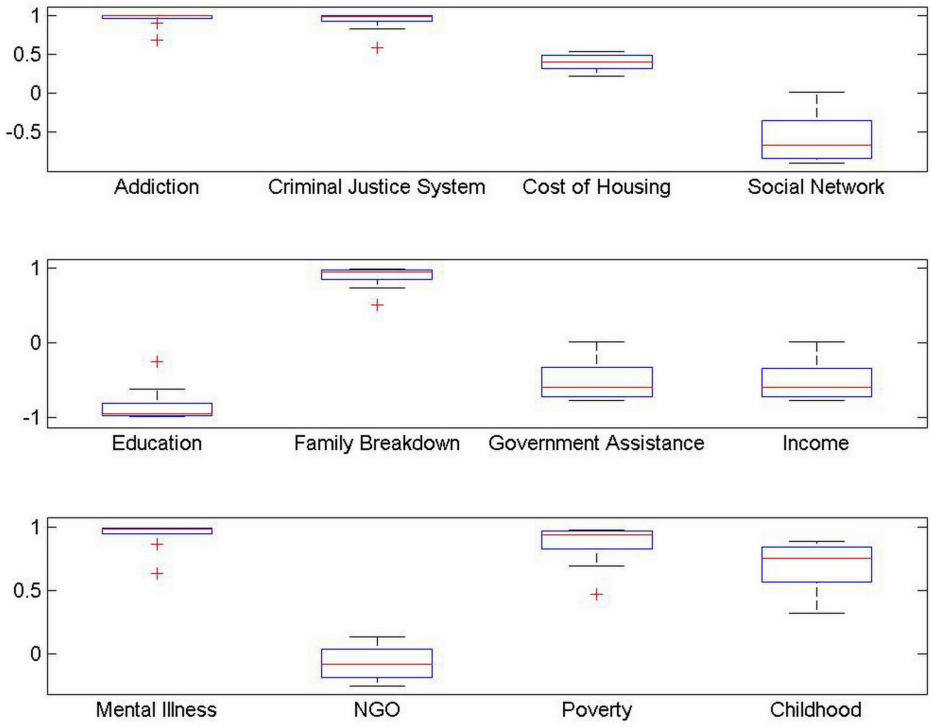


Figure 14: Boxplot comparison of the affects of individual concepts on levels of homelessness.

The result of the degree and closeness centrality computation in our FCM is displayed in Table 6. As shown, the concept "Education" has the greatest degree centrality while the concept "Cost of Housing" has the least. This means that "Education" gives and receives the greatest direct influence on all other concepts, whereas "Cost of Housing" gives and receives the least. Closeness centrality was determined to act similarly to degree centrality in that "Education" has the greatest amount of degree centrality whereas "Cost of Housing" has the least. This means that "Education" exerts the greatest force on the map in reference to closeness centrality with

Table 6: Degree centrality and closeness centrality of every concept

Concepts	**Degree Centrality**	**Closeness Centrality**
Criminal Justice System Involvement	3.0485	9.9514
Poverty	2.0451	8.3195
Unemployment	2.3763	9.0566
Education	5.4201	11.1514
Income	1.3978	8.3441
Addiction	3.7027	9.9533
Social Support Network	0.8656	9.1302
Family Breakdown	2.2862	9.9533
Mental Illness	2.2609	9.9446
NGO	0.5000	8.3472
Childhood Homelessness	1.2500	8.3445
Government Assistance	1.3844	8.3443
Cost of Housing	0.4984	8.3194

changes in "Education" resulting in the most prominent changes in the other concepts. Likewise, changes in "Cost of Housing" would result in the least amount of change in all other concepts. These results are consistent with the results of the overall experiment.

6 Discussion

This research helps to confirm the efficacy of using an FCM to model the complex social factors related to homelessness. By applying FL to linguistic terms, retrieved from peer reviewed, academic literature, they can be converted from their existing qualitative state to a quantitative state useful for weighting a FCM.

An FCM is particularly suited to the modelling of complex social systems, such as homelessness, due to its ability to capture and map vague concepts and values from language (syllogisms). In this way, the FCM ascribes meaning to the vast quantity of empirical literature available.

Prior graphic maps of homelessness have been of limited use due to the dynamic nature of the concepts related to homelessness but the static nature of available graphing systems for the purposes of depicting complex social systems. Fuzzy cognitive techniques capture greater degrees of dynamism and complexity in social systems, such as homelessness, allowing them to be captured and manipulated. This, in turn, allows for a much more realistic picture of homelessness, or any other complex social system, to be represented. Additionally, maps used in this manner allow for manipulation of the concepts in the social system, permitting experimentation in a manner which would be otherwise unworkable to manage and unethical to conduct. The FCM allows researchers to test concepts by varying levels to determine which exert the greatest impact on levels of homelessness - an incredibly

valuable tool for policy development. As is demonstrated by this project, policies enacted which would ensure an adequate supply of affordable and appropriate housing, access to support services for those with addictions or mental illness, access to family supports for those with children, positive community networks, and rental supplements would do much to alleviate the problem of homelessness and policy based interventions can be easily measured in a cost-benefit analysis to help governments choose which policies will be the most effective.

It is, however, recognized, that homelessness, given its degrees of actions and interactions at all levels: micro (personal), meso- (social network systems), and macro (structural) is a highly complex and oft times chaotic concept (and reality). We recognize that this model, despite its functionality in mimicking reality, is a simplistic representation of homelessness. Future research using FCMs to depict complex social issues should be refined to allow for more complex interacting systems which may more accurately represent the multiple levels of environment in which humans live and interact. As well, it was determined through the literature search, that many of the concepts we have treated as single-issue are, in fact, multi-faceted and may require configuring in a manner which more closely reflects that reality. Therefore, this model could potentially be broken down into a tripartite structure to reflect the three levels in which humans exist and interact. This would then allow for the capture of action and interaction at the individual or personal level, over which the individual has, at least, some control; at the structural level, over which the individual has little or no control; and at the meso level, which is a unique combination of the two, in which the individual may have some control over whether they end up interacting with the impersonal - such as is seen in systems like the criminal justice system. The criminal justice system exists separately from the individual, as do the laws which effect length of time an individual may be incarcerated, however, the individual makes some of the decisions which influence their interaction with this system.

Future refinements of the map should also be designed in a manner which will allow for the capture of the effect of time. Often concepts, such as unemployment, change significantly over time. The initial shock of unemployment may be partially buffered by the input of government supports such as unemployment insurance payments, but, over time, these benefits run out and increasingly detrimental effects of unemployment will certainly affect the individual and society in a vastly different manner than they had initially. The modelling of time would permit the effect of factors to be varied in a manner which more closely reflects reality.

It would also be desirable in future models to capture a greater nuance of understanding for the concepts included in the map as well as to capture more fully all of the concepts which really do impact the complex social system of homelessness. Concepts such as gender confusion; early childhood brain insult, such as fetal alcohol syndrome; early childhood sexual, physical and emotional abuse as well as learning disabilities, are just some of the other factors which did not make it into this map but which should be included in future maps.

The initial building of the common-sense map was an especially telling process as it revealed the acquired knowledge of the research team. This process had the effect of illuminating the half-truths and un-truths about homelessness which had been absorbed through a lifetime of media and other social propaganda. The disparity between the empirical truth of the action and interaction of certain concepts upon each other, and the semi-truth

that the researchers knew about those concepts, displayed what might be a crucial issue within government and society today. If those individuals within organizations informing government regarding its policies affecting homelessness hold the same levels of inaccurate information as did the research team, then the implication is that social policy may be currently determined on misinformation. This, of course, has far-reaching implications beyond the scope of this research to address. However, suffice it to say that if current policies are predicated on misinformation, then it is certain that public money is being spent ineffectively.

The literature search illuminated several issues affecting accuracy of this process as well. During the search, it became clear that over the last decade research has become increasingly and specifically focused. This practice has resulted in some very narrow aspects of each concept being studied. This situation left the literature retrieval team with the impression that, perhaps, for future research, the historical period should be widened to ensure the capture of both wide-angle and narrow-focus research to ensure the most complete information is collected and used for the map.

It is recognized that language is situated within cultural and historical time periods and impacted by age, gender, faith, as well as a myriad of other factors. This stresses the importance of the manner in which the ranking of the linguistic terms is completed. It is the opinion of this team that linguistic terms should certainly never be ranked by a single individual and that for all research a word bank be constructed so that it may be referred to during the process as well as added to during future research resulting in a more accurate and complete resource for the purposes of creating FCMs for complex social problems.

7 Conclusion

The FCM built to model the complex social system of homelessness reasonably represented reality for the sample scenarios created. This confirmed that the model worked and that a literature search of peer reviewed, academic literature is a reasonable foundation upon which to build the model. Further, it was determined that the direction and strengths of the concepts included in this map are a reasonable approximation of their action in reality. This research provides empirical support for the usefulness of this model, not only for researchers and social scientists, but for others who reside within a society where homelessness is experienced. The role of FCM for the purpose of modelling complex social systems has been strongly supported by this research and should continue to be utilized in future studies.

Acknowledgement

This research was supported by the SFU CTEF MoCSSy program. We are also grateful for technical support from the IRMACS Centre, Simon Fraser University, BC.

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Appendix 1: Extracted Linguistic terms

Table 7: Linguistic terms extrcted from Literature

Edge of the FCM	Type of Influence	Reference	Keywords	Linguistic terms
CJS(2) → Homelessness(1)	Positive	[28]	Significantly Associated	High
		[29]	Appear to increase	Medium
		[30]	Much more likely	High
CJS(2) → Poverty(3)	Positive	[31]	significantly increase	Very high
		[32]	Most important	High
		[33]	Significantly positive	Very High
CJS(2) → Unemployment(4)	Positive	[34]	Significantly lower	Very high
		[35]	Can diminish but not necessarily	Low
		[36]	Relatively low	Medium
CJS(2) → Family Breakdown(9)	Positive	[35]	Significant correlates	High
		[37]	Tremendous strains	Very high
		[38]	Important causal factor	High
Poverty(3) → Homelessness(1)	Positive	[8]	Significantly and independently	High
		[39]	Run a great risk	High
		[40]	May experience	Low
Poverty(3) → Addiction(7)	Positive	[41]	Good chance	Low
		[42]	Might be more limited	Low
		[43]	Likely to	Low
Unemployment(4) → Homelessness(1)	Positive	[28]	More likely	Medium
		[44]	Primary risk factor	Low
		[45]	Did not predict	Very low
Unemployment(4) → Government Assistance(13)	Positive	[46]	Play an important role	High
		[47]	Substantial	High
		[48]	Substantially	High
Education(5) → Homelessness(1)	Negative	[8]	Thereby increase	Medium
		[49]	Rectricts	Low
		[39]	Run a great risk	High
Education(5) → Poverty(3)	Negative	[50]	Strong positive correlation	High
		[51]	Vital	Very high
		[52]	Powerful instrument	High
Education(5) → Unemployment(4)	Negative	[53]	Significantly increases	Very high
		[54]	Much higher	High
		[55]	Strong determinant	High
Education(5) → Income(6)	Positive	[56]	Strongly correlated	High
		[57]	Strong positive	High
		[22]	Thwarted/an important means	High
Income(6) → Homelessness(1)	Negative	[30]	Significantly and strongly	Very high
		[58]	Strong	High
		[22]	Most effective	Medium
Addiction(7) → Homelessness(1)	Positive	[8]	Independently associated	Medium
		[59]	Key factor	High
		[60]	Statistically significant	Very high
Addiction(7) → CJS(2)	Positive	[28]	Major contributor	High
		[61]	More likely	Medium
		[62]	Extensive	Very high
Addiction(7) → Mental Illness(10)	Positive	[63]	Increased risk	Medium

		[64]	Strong evidence	High
		[65]	More likely	Medium
Addiction(7) → Family Breakdown(9)	Positive	[66]	Critical	Very high
		[19]	Significant connection	High
		[19]	Strong connection	High
Social Systems Network(8) → Addiction(7)	Negative	[18]	Less likely	Medium
		[67]	Benefit	Medium
		[68]	Lower levels	Medium
Social Systems Network(8) → Family Breakdown(9)	Negative	[69]	Small, short lived	Very low
		[70]	Effective	Medium
		[71]	Effective	Medium
Family Breakdown(9) → Homelessness(1)	Positive	[72]	More prominently	Very high
		[24]	Significant proportion	High
		[73]	Increased risk	Medium
Family Breakdown(9) → Addiction(7)	Positive	[66]	Profound effect	Very high
		[66]	Usually	Medium
		[19]	Strong connection	High
Family Breakdown(9) → Childhood Homelessness(12)	Positive	[74]	Highly predictive	High
		[75]	Important role	High
		[76]	Most common	Medium
Mental Illness(10) → Homelessness(1)	Positive	[8]	Significantly and independently	High
		[60]	Not significant	Low
		[61]	A risk factor	Low
Mental Illness(10) → CJS(2)	Positive	[77]	Significantly more	Very high
		[78]	May trigger	Low
		[61]	Independently associated	Medium
Mental Illness(10) → Addiction(7)	Positive	[79]	Significantly more likely	Very high
		[80]	Remain problematic	Medium
		[65]	Common and of concern	Medium
Mental Illness(10) → Family Breakdown(9)	Positive	[81]	Significant correlates	High
		[82]	Increases chances of	Medium
		[16]	Strongly associated	High
Non-Government Assistance(11) → Homelessness(1)	Negative	[83]	Crucial	High
		[21]	Address needs	Low
		[84]	Considerable	Medium
Childhood Homelessness(12) → Education(5)	Negative	[85]	At risk	Medium
		[86]	Restricts	Medium
		[87]	Strong evidence	High
Government Assistance(13) → Homelessness(1)	Negative	[88]	Widely used to support	Medium
		[23]	Associated	Medium
		[89]	Most effective	Very high
Cost of Housing(14) → Homelessness(1)	Positive	[90]	Positive/negative and significant	High
		[60]	Not important	Very low
		[91]	Implicated	Medium
Poverty(3) → Family Breakdown(9)	Positive	[92]	Not uncommon	Medium
		[17]	Associated with	Medium
		[93]	The bulk of responsibility	High

Appendix 2: Linguistic term Bank

Table 8: Linguistic terms extrcted from Literature

Very low	Low	Medium	High	Very high
did not predict, not important, small and short lived	might be more limited,likely to, a risk factor, address needs, good chance, can diminish but not necessarily, lack, leads to, disadvantage, to restriction, leads to, likely, may experience, may trigger, might be, not significant, primary risk factor, risk, risk factor	appear to increase, associated, at risk, benefit, common and of concern, considerable ongoing, cope, effective, implicated, increase risk, increases chances of, independently associated, less likely, lower levels, more difficult, more likely, most common, most effective, not uncommon, relatively, relatively low rates, remain problematic, restricts, thereby increase, usually, widely used to, support, associated with	crucial, highly predictive, important role, important causal factor, important means, key factor, major contributor, most important, much more likely, much higher, play important role, positive and significant, powerful, powerful instrument, significant correlates, significant, independent significantly associated, significant proportion, statistically significant, strong, strongly associated, strong connection, strong correlation, strong determinant, strong effect, strong evidence, substantial, bulk of, positive/negative and significant, significant connection, strong positive, strong positive correlation, run a great risk,thwarted	critical evidence indicates, extensive, more prominently, most effective, profound, significant and positive, significantly and strongly, significantly increase, significantly lower, significantly more, significantly more likely, statistically significant, tremendous, very high, vital