A Multi-criteria Decision Analysis for Youth Violence

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ABSTRACT

Youth violence is a significant public health problem with serious and lasting effects on our young people, families, and communities. But, it is not unavoidable or inevitable and can be prevented by applying significant measures. This study investigates the risk factors responsible for youth violence. The research utilizes Multi-criteria Futuristic Fuzzy Decision Hierarchy Methodology which combines Fuzzy Logic and Analytical Hierarchy Process (AHP) due to the multiplicity of criteria. Four factors and sub –factors were identified for the problem. It was found that Individual Risk Factors, Peer and Society Risk Factors and Community Risk Factors were ranked as the risk factors most contributing to youth violence.

Keywords: Multi-criteria decision analysis, Factors, Youth Violence, Strategies, Decision-making

1. Introduction

Decision makers often try to achieve multiple, and conflicting objectives. This has led to the development of multi-criteria decision analysis (MCDA). MCDA is considered to be a valuable tool as it focuses on what is important, is logical and consistent, and is easy to use. MCDA methods provide stepping-stones and techniques for finding a compromise solution by placing the decision maker at the centre of the process. Although MCDA problems could be very different in context, they share the following common features:

- Multiple attributes/criteria often form a hierarchy;
- Multiple criteria usually conflict with one another;
- Hybrid in nature because of incommensurable units, mixture of qualitative and quantitative attributes, and mixture of deterministic and probabilistic attributes;
- Uncertainty;
- Large scale; and
- Assessment may not be conclusive.

MCDA has been applied in the areas of management, informatics and social science. Nutt, King and Philips [13] applied MCDA modeling to a range of drug harms in the UK. Huang, Keisler and Linkov [5] reviewed environmental applications of MCDA. The papers were classified by the MCDA methods used in the analysis (analytic hierarchy process, multi-attribute utility theory, and outranking) and other criteria also. Akgun [1] compared the use of logistic regression, MCDA, and a likelihood ratio model to map landslide susceptibility in and around the city of İzmir in western Turkey. Parameters, such as lithology, slope gradient, slope aspect, faults, drainage lines and roads were considered for study. Durbach and Stewart [2] reviewed MCDA for cases where attribute evaluations are uncertain. The review includes models using probabilities; explicit risk measures such as quantiles and variances; fuzzy numbers, and scenarios. Schwenk et al. [15] applied MCDA and forest simulation models for (1) storing carbon, (2) producing timber and wood products, and (3) sustaining biodiversity. Authors estimated biodiversity implications with occupancy models for the terrestrial bird species Thokala and Duenas [19] analyzed the possible application of MCDA approaches in health technology assessment and described their relative advantages and disadvantages. Zhang, Li and Fung [20] considered two important issues in land use planning: land use allocation and land use proposal deliberation. A Conflict Resolution Framework was proposed based on GIS and MCDA techniques. Solomon et al. [18] presented a methodological framework for identifying municipal landfill sites in urban areas in Sierra. This framework involves a multi-criteria Geographic Information System (GIS) approach that blends two aggregation techniques: Weighted Linear Combination and Ordered Weighted Averaging (OWA). Khalili, and Duecker [9] proposed strategic positioning of pollution prevention and clean production projects via design of a sustainable environmental management system that is relevant to industry culture and business structure.

Feizizadeh, Jankowski and Blaschke [3] accessed the uncertainty of landslide susceptibility maps produced with GIS-MCDA techniques. A new spatially-explicit approach and Dempster–Shafer Theory was employed to assess the uncertainties associated with two MCDA techniques, Analytical Hierarchy Process (AHP) and OWA. Kavzoglu, Sahin and Colkesen [8] employed the MCDA and Support Vector Regression methods to assess the shallow landslide susceptibility of Trabzon province (NE Turkey) using different input parameters. Maxim [12] ranked different electricity generation technologies based on their compatibility with the sustainable development of the industry. The technologies were ranked using a weighted sum multi-attribute utility method. Rikalovic, Cosic and Lazarevic [14] presented a solution for spatial decision support using GIS and MCDA for spatial analysis of Vojvodina for industrial site selection. Güçdemir and Selim [4] proposed an approach for business customer segmentation that integrates clustering and multi-criteria decision making. Fuzzy AHP is employed to determine the importance of the segments. Mardani et al. [11] reviewed the applications and methodologies of the multi-criteria decision techniques and approaches. Shyur et al. [16] proposed a new multiple criteria decision-making method called ERVD (election based on relative value distances). The s-shape value function was adopted to replace the expected utility function to describe the risk-averse and risk-seeking behavior of decision makers.

Iskrov, Miteva-Katrandzhieva and Stefanov [6] developed an MCDA value measurement model to assess and appraise orphan drugs by exploring the preferences on decision criteria's weights and performance scores through a stakeholder-representative survey. Jovanovic et al. [7] presented a procedure to choose the optimal municipal solid waste management system for the city of Kragujevac (Republic of Serbia) based on the multiple attribute decision making methods: Simple Additive and TOPSIS. Each of the created strategies was simulated using the software package IWM2. Kolasa et al. [10] assessed the impact of the MCDA implementation on the Polish pricing and reimbursement (P&R) process with regard to orphan drugs. In the present paper a MCDA Technique, the Multi-criteria Futuristic Fuzzy Decision Hierarchy (MFFDH) Methodology (Singh, [17]) is applied for prioritizing the risk factors responsible for youth violence.

2. The Multi-criteria Futuristic Fuzzy Decision Hierarchy (MFFDH) Methodology

The MFFDH Methodology is a multi-criteria decision making tool based on reasoning, knowledge and experience of experts that enables the decision maker to weigh tangible and intangible criteria against each other for resolving conflict or setting priorities. It involves the systematic solicitation and collation of experts and general users on a particular goal through a set of carefully designed sequential questionnaires. Considering the fuzziness in the decision data and futuristic approach, strengthens the comprehensiveness and reasonableness of the decision making process. The Methodology comprises of five phases:

Phase I: Identification of Goal and selection of decision making group

- **Step 1:** Selection of Expert Group and Interdisciplinary Respondent (IR) Group from different geographical regions and related fields.
- **Step 2:** Dividing the IR Group into 4 or 5 teams based on their locations and computing Respondent Importance Weights $\left(I_k\right)$, here k is the number of teams

Phase II: Developing decision framework by selecting decision alternatives

- **Step 3:** As the problem has been specified as goals, criteria, and sub-criteria, it can be depicted as a set of individual components, and their linkages made explicit.

Phase III: Rating and ranking decision alternatives

- **Step 4:** Rating and ranking of generated parameters by the Interdisciplinary Respondent Group and Expert Group to take the views of general user of the system

Phase IV: Evaluation criteria (interests)

- **Step 5:** Calculation of Respondent Fuzzy Performance Score $\left(\tilde{J}_i^L\right)$ (L are levels and i are criteria)
- **Step 6:** Comparative judgment of the parameters by Expert Group to get the Experts Opinions and to generate Expert Fuzzy Pair wise Comparison Matrix
- **Step 7:** Calculation of Expert Fuzzy Decision Weights $\left(\tilde{G}_i^L\right)$
- **Step 8:** Computation of Fuzzy Judgment Weights $\left(\tilde{F}_i^L\right)$
- **Step 9:** Determination of Crisp value of Fuzzy Judgment Weights
- **Step 10:** Calculation of Normalized Futuristic Judgment Weights $\left(N_i^L\right)$

Phase V: Outcomes or consequences associated with alternative/interest combination

Step 11: Computation of Global Futuristic Judgment (GFJ) Weights for all levels using the Principle of Hierarchic Composition, from computed Normalized Futuristic Judgment Weights and generating Scenarios and Action Plan for the Goal.

This methodology will be applied in this study to prioritize the risk ***factors responsible for youth violence.***

3. Youth violence

Youth violence is a global public health problem. The term Youth Violence is used to describe when youth between the ages of 10 and 24 years intentionally use physical force or power to threaten or harm other people. Youth violence can take different forms. Examples include fights, bullying, threats with weapons, and gang-related violence. Youth violence is a significant public health problem that impacts thousands of young people every day. It has a serious, often lifelong, impact on a person's physical, psychological and social functioning. Youth violence greatly increases the costs of health, welfare and criminal justice services; reduces productivity; and decreases the value of property.

Worldwide an estimated 200,000 homicides occur among youth 10–29 years of age each year, making it the fourth leading cause of death for people in this age group. Youth homicide rates vary dramatically between and within countries. Globally, 83% of youth homicide victims are males, and in all countries males also constitute the majority of perpetrators. In India, according to data released by the government for 2014[1], juveniles continue to constitute 1.2% of the total cognizable crime rate in the country, a trend that has remained unchanged since 2012 (Figure 1).

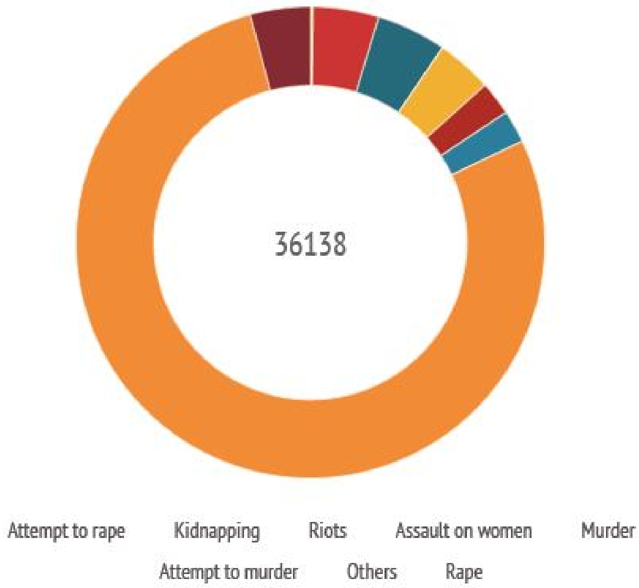

Figure 1: Cases against youth (*Source: NCBR Data*)

The main causes of violent youth behavior are:

- Media Influence
- Domestic and Child Abuse
- Insufficient Parental Supervision
- Peer Pressure
- Drug Use
- Traumatic Events
- Mental Illness

Table 1 presents the risk factors responsible for youth violence. These factors were determined using Delphi Technique. The framework suggests that the factors can be divided into 4 categories:

- Individual Risk Factors
- Family Risk Factors
- Peer and Social Risk Factors
- Community Risk Factors

These factors are prioritized using MFFDH methodology for identifying the factors most contributing to youth violence. The computations is shown below:

A. Selection of Expert Group and Interdisciplinary Respondent (IR) Group

The Goal of the Research Study was *to compute Global Futuristic Judgment Weights for prioritizing the factors responsible for youth violence*.

23 specialists from different fields were selected to form Expert Group. The IR Group, with 104 members, were divided into three teams. These Members were from different geographical regions, locations and inter-disciplinary areas.

B. Computation of Respondent Importance Weights (I_k)

The Teams were ranked to determine their knowledge levels. This ranking formed the Respondents Importance Matrix (A) and the Respondent Importance Weights $(I_k)\ (k = 1,2,3)$ were computed for each team.

	R1	R2	R3
R1	1	3	5
R2		1	3
R3			1

The Respondent Importance Weights I_k for the three teams R1, R2, and R3 are

R1 0.637
R2 0.258
R3 0.105

with principal Eigen value being 3.309, consistency index value 0.019 and consistency ratio 0.033, these values implied that the results are consistent**.**

C. Rating and ranking the factors by the IR Group

A Modified Delphi Questionnaire was developed for IR Group members. The Group rated and ranked the parameters by using the linguistic variables (Table 1) to achieve the Goal.

Table 1: Linguistic variables and triangular fuzzy numbers for rating

Linguistic variables	Triangular Fuzzy Numbers
Very Low (VL)	(1, 1, 3)
Low (L)	(1, 2, 3)
Medium Low (ML)	(2, 3, 4)
Medium (M)	(4, 5, 6)
Medium High (MH)	(6, 7, 8)
High (H)	(7, 8, 9)
Very High (VH)	(8, 9, 9)

Linguistic Ranking (example for first four members of the Team 1):

Individual Risk Factors (I) VH VH VH VH
Family Risk Factors (F) H H H H
Peer and Social Risk Factors (PS) VH VH H VH
Community Risk Factors (C) H H H H

This ranking was converted to the triangular fuzzy numbers, $\tilde{t}_{i,kj}^{L}$, (Table 1) for L (=1,2) levels, k (=1, 2, 3) respondent teams, j number of respondents in each of the three teams and i criteria.

D. Calculation of Respondent Fuzzy Performance Score $\tilde{J}_i^L$

From these triangular fuzzy numbers, Aggregate Fuzzy Ranking $\tilde{a}_{i,k}^{L}$ was computed using equation (1):

$$\tilde{a}_{i,k}^{L} = \left(\prod_{j=1}^{J} \tilde{t}_{i,kj}^{L} \right)^{1/J}, \text{ for every } i \qquad (1)$$

	R1	R2	R3
I	(7.0000, 9.0000, 9.0000)	(5.0000, 7.0000, 9.0000)	(3.5569, 5.5934, 7.6117)
F	(5.0000, 7.0000, 9.0000)	(3.0000, 5.0000, 7.0000)	(4.2172, 6.2573, 8.2768)
PS	(6.4353, 8.4519, 9.0000)	(7.0000, 9.0000, 9.0000)	(5.5934, 7.6117, 9.0000)
C	(5.0000, 7.0000, 9.0000)	(1.0000, 3.0000, 5.0000)	(2.0801, 4.2172, 6.2573)

Next the Respondent Fuzzy Performance Score $\tilde{J}_i^L$ was calculated using:

$$\tilde{J}_i^L = \left(\frac{S_{i1}^L}{\sum_{i=1}^{p} S_{i3}^L}, \frac{S_{i2}^L}{\sum_{i=1}^{p} S_{i2}^L}, \frac{S_{i3}^L}{\sum_{i=1}^{p} S_{i1}^L} \right) \qquad (2)$$

where

$$\tilde{S}_i^L = \left[\prod_{k=1}^{K} \left(I_k \otimes \tilde{a}_{i,k}^{L} \right) \right]^{1/K} \qquad (3)$$

Respondent Fuzzy Performance Score ($\tilde{J}_i^L$)

I (0.1555, 0.2729, 0.4870)
F (0.1241, 0.2329, 0.4606)
PS (0.1967, 0.3220, 0.5150)
C (0.0680, 0.1722, 0.3750)

E. Comparative judgment of the factors by Expert Group

Fuzzy Pair wise Comparison Questionnaire was prepared for Expert Group to rate and rank the parameters using Fuzzy Evaluation Scale (Table 2).

Table 2: Fuzzy Evaluation Scale

Relative Importance	Fuzzy Scale	Definition	Description
$\tilde{1}$	(1,1,1) if diagonal (1, 1, 3) otherwise	Equally important	Two criteria contribute equally to objective
$\tilde{2}$ $\tilde{4}$ $\tilde{6}$ $\tilde{8}$	$(2 - \Delta, 2, 2 + \Delta^a)$ $(4 - \Delta, 4, 4 + \Delta)$ $(6 - \Delta, 6, 6 + \Delta)$ $(8 - \Delta, 8, 8 + \Delta)$	Intermediate values between two adjacent judgments	When compromise is needed
$\tilde{3}$	$(3 - \Delta, 3, 3 + \Delta)$	Moderately more important	Experience and judgment slightly favor one criteria over another
$\tilde{5}$	$(5 - \Delta, 5, 5 + \Delta)$	Strongly more important	Experience and judgment strongly favor one criteria over another
$\tilde{7}$	$(7 - \Delta, 7, 7 + \Delta)$	Very strongly more important	One criteria is strongly favored and demonstrated in practice
$\tilde{9}$	$(9 - \Delta, 9, 9 + \Delta)$	Extremely more important	The evidence favoring one criterion over another is of the highest possible order of affirmation
$1/\tilde{x}$ b	$\left(1/\tilde{x} + \Delta,\ 1/\tilde{x},\ 1/\tilde{x} - \Delta\right)$	If criterion *i* has one of the above assigned to it when compared with criterion *j*, then *j* has the reciprocal value when compared with *i*	

[a] Δ is the fuzzification factor
[b] $\tilde{x} = 2 \cdots\cdots 9$

These matrices were used to generate Expert Fuzzy Pair wise Comparison Matrix, $\tilde{X}^L = \left[\tilde{x}^L_{mn}\right]$

	I	F	PS	C
I	1	(1.44, 3.51, 5.49)	(1,3,5)	(3.51, 5.49, 7.46)
F		1	(0.31, 0.41, 1)	(0.59, 1.44, 2.89)
PS			1	(3.51, 5.49, 7.46)
C				1

F. Calculation of Expert Fuzzy Decision Weights $\left(\tilde{G}^L_i\right)$

Expert Fuzzy Decision Weights $\tilde{G}^L_i$ were computed using

$$\tilde{G}^L_i = \left(\frac{v^L_{i1}}{\sum_{i=1}^{p} v^L_{i3}}, \frac{v^L_{i2}}{\sum_{i=1}^{p} v^L_{i2}}, \frac{v^L_{i3}}{\sum_{i=1}^{p} v^L_{i1}} \right) \tag{4}$$

$$\text{where } \tilde{v}^L_i = \left(\prod_{n=1}^{p} \tilde{x}^L_{mn} \right)^{1/p}, \text{ for } i, m = 1, 2, \ldots\ldots, p \tag{5}$$

Expert Fuzzy Decision Weights:
I (0.1920, 0.5270, 1.2120)
F (0.0540, 0.1220, 0.3820)
PS (0.1170, 0.2770, 0.7100)
C (0.0360, 0.0740, 0.1940)

G. Computation of Fuzzy Judgment Weights $\tilde{F}^L_i$

$\tilde{F}^L_i$ were calculated by averaging $\tilde{J}^L_i$ and $\tilde{G}^L_i$
I (0.1737, 0.3999, 0.8495)
F (0.0890, 0.1774, 0.4213)
PS (0.1568, 0.2995, 0.6125)
C (0.0520, 0.1231, 0.2845)

H. Determination of Crisp value of Fuzzy Judgment Weights

Crisp value of Fuzzy Judgment Weights $\tilde{F}^L_i$ was calculated using equation (6)

$$C^L_{l,r} = \left[g_\alpha\left(F^L_{il}\right), \; g_\alpha\left(F^L_{ir}\right) \right] \tag{6}$$

Where

$g_\alpha(F^L_{il}) = [(F^L_{i2} - F^L_{i1})\alpha + F^L_{i1}]$ represents the left value of α -cut for $\tilde{F}^L_i$, and
$g_\alpha(F^L_{ir}) = [F^L_{i3} - (F^L_{i3} - F^L_{i2})\alpha]$ represents the right value of α -cut for $\tilde{F}^L_i$.

I. Calculation of Normalized Futuristic Judgment Weights N^L_i

The Decision Weights were calculated using equation (7)

$$f_{\alpha,\beta}(\tilde{F}^L_i) = [\beta \; g_\alpha(F^L_{il}) + (1-\beta) \; g_\alpha(F^L_{ir})], \; 0 \le \beta \le 1, \; 0 \le \alpha \le 1 \tag{7}$$

which were then normalized using equation (8) to compute Normalized Futuristic Judgment Weights N_i^L

$$N_i^L = \frac{f_{\alpha,\beta}(\tilde{F}_i^L)}{\sum f_{\alpha,\beta}(\tilde{F}_i^L)} \qquad (8)$$

J. Computation of Global Futuristic Judgment (GFJ) Weights

Finally Global Futuristic Judgment (GFJ) Weights W_i^L were calculated for all levels using the Principle of Hierarchic Composition.

Global Futuristic Judgment (GFJ) Weights for L = 1

I	0.393
F	0.1865
PS	0.2949
C	0.1256

5. Results and Conclusions

The calculated GFJ Weights for all the factors are given in Table 4.

Table 4: W_i^L for the factors and sub-factors

Factors	Sub-factors	W_i^L
Individual Risk Factors $W_i^1 = 0.393$	History of violent victimization	0.083
	Attention deficits, hyperactivity or learning disorders	0.0784
	History of early aggressive behavior	0.1071
	Involvement with drugs, alcohol or tobacco	0.0995
	Low IQ	0.0473
	Poor behavioral control	0.0913
	Deficits in social cognitive or information-processing abilities	0.0812
	High emotional distress	0.0927
	History of treatment for emotional problems	0.0623
	Antisocial beliefs and attitudes	0.1533
	Exposure to violence and conflict in the family	0.1038
Family Risk Factors $W_i^1 = 0.1865$	Authoritarian childrearing attitudes	0.1147
	Low parental involvement	0.1615
	Poor family functioning	0.1557
	Low emotional attachment to parents or caregivers	0.112
	Low parental education and income	0.0833
	Parental substance abuse or criminality	0.0939
	Poor monitoring and supervision of children	0.1582
	Harsh, lax or inconsistent disciplinary practices	0.1208
Peer and Society Risk Factors $W_i^1 = 0.2949$	Social rejection by peers	0.2038
	Association with delinquent peers	0.2235
	Lack of involvement in conventional activities	0.1791
	Involvement in gangs	0.1502
	Poor academic performance	0.1136
	Low commitment to school and school failure	0.1297
Community Risk Factors $W_i^1 = 0.1256$	Diminished economic opportunities	0.1456
	High concentrations of poor residents	0.2005
	High level of transiency	0.1042
	High level of family disruption	0.192
	Low levels of community participation	0.1102
	Socially disorganized neighborhoods	0.2476

The results demonstrate that the most important factors for youth violence are (Table 5):

Table 5: Priorities Risk Factors

Factors	Sub-factors	W_i^L
Individual Risk Factors $W_i^1 = 0.393$	Antisocial beliefs and attitudes	0.1533
	History of early aggressive behaviour	0.1071
	Exposure to violence and conflict in the family	0.1038
	Involvement with drugs, alcohol or tobacco	0.0995
Peer and Society Risk Factors $W_i^1 = 0.2949$	Association with delinquent peers	0.2235
	Social rejection by peers	0.2038
	Lack of involvement in conventional activities	0.1791
	Involvement in gangs	0.1502
Family Risk Factors $W_i^1 = 0.1865$	Low parental involvement	0.1615
	Poor monitoring and supervision of children	0.1582
	Poor family functioning	0.1557
	Harsh, lax or inconsistent disciplinary practices	0.1208

The computations show that major causes for youth violence are Antisocial Beliefs and Attitudes (W_i^L = 0.1533); Association with Delinquent Peers (W_i^L = 0.2235), and Social Rejection by Peers (W_i^L = 0.2038); and Low Parental Involvement (W_i^L =0.1615), and Poor Monitoring and Supervision of Children (W_i^L = 0.1582). Based on the calculated GFJ Weights following strategies can be generated to prevent youth violence:

- Build children's and adolescents' skills and competencies to choose nonviolent, safe behaviors. This strategy focuses on providing opportunities for young people to build their skills, knowledge, and motivation to choose nonviolent behaviors and conflict resolution approaches. This can be done by developing the protective factors, such as effective problem-solving, communication, anger management, impulse control, and emotional regulation abilities.
- Foster safe, stable, nurturing relationships between young people and their parents and caregivers. Parents and other caregivers (e.g., grandparents) have a profound influence on young people's beliefs and behaviors, and this influence extends from early childhood through late adolescence and beyond. The risk of youth violence can be lowered by providing caregivers with support and knowledge about healthy child development, and by building caregivers' skills related to strong communication, setting age-appropriate boundaries and rules, monitoring young people's activities and relationships, and using consistent and nonviolent discipline.
- Build and maintain positive relationships between young people and caring adults in their community. Risk for youth violence can also be buffered by healthy and safe relationships with adults (such as mentors, teachers, and coaches) who are not their primary caregivers.
- Develop and implement school-wide activities and policies to foster social connectedness and a positive environment. When students believe that adults in their school care about their individual well-being as well as their learning, they are more likely to succeed academically and engage in nonviolent behaviors.
- Improve and sustain a safe physical environment in communities and create spaces to strengthen social relationships. Examples of these characteristics include availability of green spaces, and repair and upkeep of neighborhoods and schools. An important youth violence prevention strategy is the examination and potential modification of the physical characteristics of housing, schools, and community areas (e.g., parks, business areas, public transportation hubs) to improve perceived and actual safety and to reduce opportunities for crime and violence.
- Build viable and stable communities by promoting economic opportunities and growth. The economic climate of a community is created by the presence of legal and prospering businesses, the income level of residents, and stable employment of residents. By providing the infrastructure and incentives for businesses to expand their operations and invest in the community and the next generation of workers, a community can become more economically stable.
- Strategies must be built to team up parents to get involved in the community activities and by

  - ✓ Monitoring the media use of their children.
  - ✓ Being a role model by handling problems in nonviolent ways.
  - ✓ Helping the teens deal with their anger.

These strategies if implemented urgently can help the youth in changing their behaviour.

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