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Suicide data analysis using multi-criteria decision-making

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Abstract

Suicide is a serious concern influenced with many socioeconomic, demographic, and psychological variables. A person commits suicide due to reasons like mental illness, inability to face pressure from family or peer, financial burden etc. varying for different sex or age groups. We use five different Multi-Criteria Decision-Making methodologies to analyze suicide data and examine the relationships between a number of characteristics, including gender, age and profession of victims, reasons for committing suicide and the methods used for it. We use majority voting to aggregate the results which may be useful to concerned authorities to create suicide prevention strategies.

Subject Classification: *68T99.*

Keywords: *MCDM, TOPSIS, VIKOR, MABAC, MAIRCA, CODAS, Suicide, Ensemble.*

1. Introduction

One of the major public health issues that claims a lot of lives is suicide. Suicide is intentional taking of one's own life. It is death brought on by self-inflicted harm done with the aim to die. Every suicide-related death is a big tragedy having repercussions on the entire family members. As per the World Health Organization's (WHO) statistics, around one million individuals lose their lives to suicide annually, with an average suicide occurring every forty seconds [1]. Thirty-five thousand of the total deaths linked to suicide happened in India.The National Crime Records Bureau (NCRB) reports that over 150,000 lives are lost to suicide in India each year, making it a serious public health concern. The shockingly high suicide rates of India highlights the seriousness of the situation.

There are times in one's life when he/she is no longer able to cope with life's stresses which leads to impulsive suicides during such times of crisis [2] [3]. There are many different and intricate elements that contribute to suicide, including individual, biological, relational and societal, concerns. Individual factors of suicide include past suicide attempts, mental health issues like depression, thoughts of hopelessness, impulsive and aggressive tendencies, substance abuse, alcoholism, financial difficulties, unemployment, economic recession, social isolation and criminal problems etc. Biological factors include pre-existing chronic diseases and other health issues. Relational factors include issues with family communication, domestic losses, gender-based violence in relationships and child abuse. Societal factors include obstacles to mental health care, stigma surrounding psychiatric illness, intra-communal conflicts, and cultural differences resulting from migration, easy access to suicide vehicles, cultural, religious, and legal considerations. Research has indicated that demographic factors, including age, gender, and educational attainment, also have a notable influence on suicide rates. Suicide rarely has a single reason; instead, it frequently has several reasons together which results in a suicide [4]. The causes of suicide in India are diverse and include societal and individual factors like mental illness, family problems, love affairs, poverty, failure in examinations, conflicts from extramarital affairs , and sexual harassment [5], [6]. These factors contribute to the anomic conditions in society, leading to isolation and loneliness, which in turn can lead to suicide [6], [7].

Research suggests that better property rights for women in India are associated with a decrease in the difference between female and male suicide rates, but an increase in both male and female suicides [8]. Education level, marital status, and occupation play a significant role in suicide rates in India. For instance, people with higher education levels and those currently married have higher suicide death rates [9]. Indian women face various stressors like domestic violence, conflict within households, dowry demands, changes in expectations about marriage relationships, widowhood and social exclusion that contribute to the high rates of suicide among them [8] [10]. Even though the number of suicide cases is rising, they can be partially avoided by being aware of risk factors associated with suicidal behaviour in the early phases of the suicidal process. The key to lowering the number of suicide deaths is prevention. Focused preventive strategies are required which should aim to enhance the care of suicidal people, along with psychiatric and pharmaceutical treatments as well as coordinated social and public health initiatives. Limiting access to pesticides along with addressing family problems, and involving various stakeholders in suicide prevention are identified as effective strategies to reduce suicides [11], [12]. Inappropriate media reporting, and legal conflicts are identified as major barriers to effective suicide prevention in India [11].

The aim of conducting an analysis on the causes of suicide is to develop preventive strategies that consider various factors like gender, age, and cause [13]. Developing preventive efforts can be aided by comprehending the causes of stress experienced by working professionals and determining the connection between suicidal ideation and stress [14]. This may help in developing a national suicide prevention strategy. There is an urgent need for targeted prevention and intervention programs to address the complex societal issues contributing to women's suicides in India.

In their paper, Aggarwal [15] discuss the pressing need for approaches to deal with India's suicide problem. In order to provide policymakers and medical experts with insights into the trends and drivers of suicide in India, this study uses five most popular different MCDM techniques (TOPSIS, VIKOR, MABAC, MAIRCA, CODAS) to analyze suicide data and majority voting ensemble method to collate the results. As far as we know, no one has used MCDM methods to analyze suicide data.

2. Theoretical Concepts

2.1 *Multi-criteria Decision Making (MCDM)*

A collection of techniques or procedures known as "multi-criteria decision-making" (MCDM) are used to assess, contrast, and prioritize various possibilities or alternatives according to simultaneous consideration of several factors/criteria. The main elements of the MCDM technique are the alternatives/choices, factors/criteria, the weights and impact of these criteria. In essence, this strategy uses the scores that have been calculated for each accessible alternative to choose the best one.

Decision-making consistency is ensured by the transparent and repeatable nature of MCDM. It is devoid of human bias resulting from manual decision-making because it is mathematical in nature. These techniques provide an organized and methodical approach which helps to simplify and manage challenging issues in decision making. MCDM is employed in different domains like engineering, business, and healthcare and also for making public policy [16].

There exists multiple MCDM techniques in literature. One of the popular MCDM technique in decision-making is Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) [17] which contrasts options according to their deviation from best and the worst solution. The optimal solution is selected as the one which is closest to the ideal positive solution and farthest from negative ideal solution.

Multi-Criteria Optimization and Compromise Solution, or VIKOR (**VI**se**K**riterijumska **O**ptimizacija I Kompromisno **R**esenje) by Opricovic and Tzeng [18] is a compromised version of TOPSIS which uses linear normalization technique. The opponent has the least degree of personal remorse and the majority the most group utility in the solution obtained using the VIKOR method of adjusted ranking. Compromise solution that is closest to ideal solution is identified by method.

Developed by Pamučar and Ćirović in 2015 [19], the Multi-Attributive Border Approximation area Comparison (MABAC), finds the distance between each option and the border approximation area. The border approximation area stands for a middle ground between the ideal and anti-ideal solutions. This space is used to quantify the distances between each option and the ideal and anti-ideal solutions. Finally option closest to the ideal solution is selected as the best option.

The MAIRCA method [20] assesses discrepancies between theoretical and empirical assessments. It looks for the superior alternative by calculating the difference between the two for each decision. The choice with the lowest utility score is the best one. The technique can be used with datasets that have both qualitative and quantitative requirements.

Combinative Distance-based Assessment (CODAS) method created by Ghorabaee et al. in 2016 [21] uses both Euclidean and Taxicab distances to assess the performance of each choice. The total efficacy of an alternative is measured by these separations from the negative-ideal point. If two alternatives' Euclidean distances are very close to each other, the taxicab distance is used to compare them.

2.2 *Ensemble MCDM*

Different rankings are produced by using different MCDM methods even on giving the same input [22]. Ensemble approaches combine these results into a common consensus to increase the process's accuracy, robustness, and dependability [23]. Comparable to machine learning ensemble methods, which combine predictions from multiple models to reach a conclusion, ensemble MCDM combines the results of various MCDM approaches to produce a more thorough and dependable conclusion. Through the integration of numerous methodologies, ensemble MCDM methods offer a sophisticated approach to decision-making, resulting in more accurate, dependable, and balanced decisions in a variety of complicated scenarios.

Majority voting ensemble approach is a straightforward but efficient way to combine the output from several classifiers or decision-making algorithms. In this method a number of decision-making models that are appropriate for the given situation are chosen. Based on the specified criteria, each chosen model separately assesses the options and generates a decision or ranking. The choices made by each model are then compiled. This involves determining the number of votes each option gets from each of the individual models. The option that receives the most votes is chosen to be the final choice. When it comes to rankings, the option with highest overall rank is selected. This method has been shown to perform without requiring the domain expertise [24].

Table 1
Reason Age Table

	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21	R22	R23	R24	R25	R26
F_0-14	56	10	30	26	134	2	180	35	2138	87	2302	16	66	67	658	847	3	20	1322	29	101	160	20	20	137	47
F_15-29	1071	95	4524	332	1958	1151	22701	418	9439	2111	60299	424	1639	1070	10898	16190	241	2303	23032	472	1566	2517	627	1265	4573	1838
F_30-44	1559	149	1382	867	1456	1116	7767	413	433	1605	44238	226	625	1061	11009	3980	236	2499	20879	558	754	2921	606	1756	2918	1335
F_45-59	922	80	168	1104	802	254	535	243	42	692	19924	87	61	470	7197	314	64	658	14470	717	194	1743	292	1234	422	473
F_60+	269	24	22	549	357	12	23	96	2	202	6418	23	0	224	3590	8	0	43	9369	508	47	564	51	326	43	55
M_0-14	51	7	19	8	133	3	11	79	2126	82	1952	18	1	38	565	403	0	8	930	41	19	163	12	46	54	44
M_15-29	4725	374	3179	590	1462	401	319	6960	11889	2608	61128	401	63	1344	16361	16833	56	497	27174	579	499	5610	2851	3068	2992	10576
M_30-44	12023	944	1673	1671	1908	788	331	12710	821	3358	80897	497	29	2442	21497	5886	97	1224	39395	1233	485	9824	4835	5448	2745	9521
M_45-59	9499	718	271	2398	1402	361	94	7338	103	2117	49541	338	8	1393	15551	548	60	487	36281	1692	236	7157	2751	4390	936	3153
M_60+	2580	254	28	1513	709	45	9	1754	12	602	15253	88	2	614	6903	30	9	83	21713	1457	91	2025	509	1099	91	323

R1: Bankruptcy, R2: Sudden change in Economic Status , R3:Cancellation/Non-Settlement of Marriage , R4:Cancer, R5:Death of Dear Person, R6:Divorce, R7:Dowry Dispute, R8:Drug Abuse/Addiction, R9:Failure in Exam, R10:Fall in Social Reputation, R11:Family Problems, R12:Ideological Causes/Hero Worshipping, R13:Illegitimate Pregnancy, R14:Illness (Aids/STD), R15:Insanity/Mental Illness, R16:Love Affairs, R17:Impotency, R18:Barren, R19:Other Prolonged Illness,R20:Paralysis,R21:Physical Abuse (Rape/Incest), R22:Poverty,R23:Professional/Career Problem,R24:Property Dispute,R25:Suspected/Illicit Relation, R26:Unemployment

Table 2
Method Age Table

	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15
F_0-14	225	2767	2413	2051	1756	70	3671	122	126	72	11	26	67	38	108
F_15-29	3581	44066	36212	15177	41575	810	72036	915	941	751	91	347	1390	684	763
F_30-44	3089	28405	26598	11248	26170	473	45333	709	811	646	67	356	1173	513	727
F_45-59	1691	13890	13677	5895	10226	195	20351	405	419	240	45	289	805	220	421
F_60+	780	5588	4738	3934	4612	56	7032	203	201	117	10	139	573	120	169
M_0-14	306	2213	1917	2774	750	108	3621	121	172	92	21	32	74	46	312
M_15-29	10283	55883	44648	17280	13327	1545	97586	1544	1718	1876	503	2645	1458	1079	2944
M_30-44	13292	64149	51763	20070	17288	1788	1E+05	2242	2116	2410	552	6058	1961	1244	3052
M_45-59	8643	42478	35840	12432	9210	954	72104	1179	1173	1374	313	4639	1578	776	1799
M_60+	3409	16062	13372	5850	3092	295	25366	431	450	538	48	1442	881	373	521

M1: By coming under running vehicles/trains, M2: By Consuming Insecticides, M3: By Consuming Other Poison, M4: By Drowning, M5: By Fire/Self Immolation, M6: By Fire-Arms, M7: By Hanging, M8: By Jumping from(Building), M9: By Jumping from(Other sites), M10: By Jumping off Moving Vehicles/Trains, M11: By Machine, M12: By Over Alcoholism, M13: By Overdose of sleeping pills, M14: By Self Infliction of injury, M15: By touching electric wires

3. Method

National Crime Records Bureau (NCRB), India keeps track of data regarding the number of suicide fatalities in the country. This information is kept for a variety of characteristics, including age, gender, social class, economic condition, level of education, professional status, occupation, etc. Data is categorized into reasons like bankruptcy, failure in exams, rape, impotency etc. Classification based on number of suicides by different professionals is also available. We also have the data about the number of suicides committed by various methods like by consuming poison or by hanging etc. Essentially, the data is classified according to the gender and different age groups committing suicide along with the method, reason and professional status. Data was downloaded from NCRB site [25], pre-processed and formatted for our use. To study the reason for committing suicide by different age groups we constructed a *Reason Age* table as shown in Table 1. It has different age groups for both male and female along its rows and various reasons for committing suicide on the columns. Each entry t_{ij} contains the number of suicides committed by i^{th} gender age group and j^{th} reason.

Similarly, to analyse the method of suicide in different age groups we constructed a *Method Age* table as shown in Table 2. It has different age

Table 3

Profession Age Table

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
F_0-14	526	569	49	30	7	98	9	167	7340	382
F_15-29	10495	127415	1472	2299	80	2114	1703	9156	24887	10459
F_30-44	9347	96636	1204	1958	123	2190	1699	5977	1059	6160
F_45-59	5096	43579	664	1110	347	1099	743	2678	84	2573
F_60+	1836	17044	228	133	1130	288	77	644	22	971
M_0-14	515	0	107	33	2	155	6	177	7279	499
M_15-29	42205	0	9602	7166	205	18177	4208	30012	31332	35783
M_30-44	64287	0	14180	10187	352	29989	8443	40103	2054	34765
M_45-59	45070	0	9330	6848	1858	19306	6224	23041	243	17313
M_60+	18546	0	2368	1022	7230	4696	213	3517	23	5469

P1: Farming , P2: House Wife, P3: Professional, P4: PSU, P5: Retired, P6: Self-Employed, P7: Govt Service, P8: Private, P9: Student, P10: Unemployed

Table 4

States Suicide Table

	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13
A & N Isla	3	0	7	5	10	1	0	0	30	6	99	0	0
Andhra Pr	8112	140	814	1304	777	281	2769	754	2549	982	30696	314	132
Arunachal	8	0	4	0	2	0	0	3	5	1	96	0	0
Assam	99	5	281	344	280	188	146	169	1352	346	4312	19	192
Bihar	34	3	103	19	53	40	415	184	281	57	1824	66	48
Chandigar	9	1	3	2	0	1	16	31	45	8	303	0	11
Chhattisga	449	39	200	124	341	40	649	1695	593	452	8066	23	61
D & N Hav	4	0	8	2	9	2	0	41	2	11	187	0	1
Daman &	0	0	0	0	0	1	0	0	1	1	16	0	1
Delhi (Ut)	223	18	159	28	79	35	589	308	510	160	4105	15	13
Goa	58	5	5	11	14	4	13	49	44	58	470	0	2
Gujarat	1509	132	1220	530	700	348	453	364	1049	1068	13057	81	47
Haryana	147	4	162	70	213	87	275	616	476	228	5045	261	5
Himachal	21	2	89	48	9	3	45	57	134	44	1144	1	3
Jammu &	48	0	54	25	5	17	96	94	69	45	426	2	19
Jharkhand	246	21	84	10	160	91	112	286	396	146	1146	8	31
Karnataka	2286	237	560	729	807	142	712	765	1869	670	24042	97	45
Kerala	7827	1135	433	1248	1097	246	252	2113	728	659	36327	144	56
Lakshadw	0	0	0	0	0	0	0	0	0	0	1	0	0
Madhya P	802	84	719	339	851	190	7368	3031	1661	1386	18281	62	333
Maharash	6732	367	1714	1237	1585	376	3391	12671	3284	1370	65341	108	121
Manipur	0	0	0	0	0	0	0	9	0	0	26	0	0
Meghalaya	3	0	0	1	1	3	0	10	11	1	180	2	2
Mizoram	4	0	0	0	3	10	0	112	0	7	32	0	5
Nagaland	1	0	0	0	0	1	0	23	0	0	26	0	1
Odisha	163	42	412	195	250	128	1206	78	843	670	11924	51	218
Puducherr	35	17	116	37	124	0	2	1	79	68	2724	0	1
Punjab	84	1	30	28	105	70	143	598	151	254	1506	93	39
Rajasthan	611	98	255	81	214	157	615	1589	606	299	11430	9	33
Sikkim	22	0	59	10	14	3	0	84	31	53	234	4	3
Tamil Nad	1617	136	1031	368	994	593	1234	1952	3011	1789	49663	575	253
Tripura	114	0	102	59	57	61	332	35	302	31	2743	30	42
Uttar Prad	398	63	536	328	141	230	4606	1210	1429	664	9733	51	187
Uttarakha	92	42	30	13	14	18	130	84	93	62	862	56	21
West Beng	994	63	2106	1863	1412	766	6401	1030	5371	1868	35885	46	568

	R14	R15	R16	R17	R18	R19	R20	R21	R22	R23	R24	R25	R26
A & N Isla	0	238	75	0	3	341	2	0	16	7	6	6	24
Andhra Pr	3885	10521	3325	27	614	33836	1248	233	13357	1096	2026	1132	1893
Arunachal	0	20	27	0	0	28	1	0	9	3	1	2	20
Assam	158	513	4852	0	62	1953	92	107	2189	152	2293	249	1515
Bihar	29	294	478	4	39	405	24	28	68	14	46	267	99
Chandigar	0	40	41	1	3	70	1	5	18	0	2	2	66
Chhattisga	383	2972	1306	23	201	6576	194	370	244	205	151	435	238
D & N Hav	1	61	42	1	14	59	5	9	1	4	1	10	11
Daman &	0	17	12	0	1	10	0	0	1	1	0	0	1
Delhi (Ut)	43	308	584	4	39	927	12	19	403	113	115	106	544
Goa	15	602	194	6	18	300	11	1	29	30	9	16	142
Gujarat	276	6761	2318	79	626	8352	424	255	1354	941	407	842	3042
Haryana	223	1327	429	7	179	1925	116	57	319	328	1041	172	734
Himachal	12	377	216	4	17	363	22	7	36	24	65	88	50
Jammu &	13	34	121	0	22	148	28	6	35	12	28	46	56
Jharkhand	44	426	408	0	79	209	34	49	142	100	116	369	281
Karnataka	577	7325	1701	99	988	31625	755	108	4212	605	626	375	1788
Kerala	47	15276	1223	26	383	14640	664	40	36	672	412	240	1050
Lakshadw	1	3	0	0	0	2	0	0	0	0	0	0	0
Madhya P	523	4670	2303	60	620	9380	366	1436	604	1081	1233	1347	1047
Maharash	1268	14859	2872	120	1251	33808	1069	394	4083	3019	818	813	4493
Manipur	0	0	19	0	0	0	0	0	1	2	0	0	2
Meghalaya	1	48	47	1	1	56	3	0	16	8	1	4	5
Mizoram	10	1	7	0	0	1	0	0	29	1	0	0	2
Nagaland	0	2	6	0	0	6	0	2	0	8	0	3	7
Odisha	189	1044	2585	20	203	1684	66	13	421	279	474	1555	1485
Puducherr	8	369	88	1	31	1691	16	1	2	19	2	8	33
Punjab	48	2182	185	1	63	654	240	120	286	60	152	137	233
Rajasthan	31	4782	1109	30	167	3301	38	26	315	492	764	600	319
Sikkim	0	291	47	0	12	84	1	3	1	19	1	16	21
Tamil Nad	206	4974	5684	78	916	31304	1034	248	3188	1374	2552	1523	4171
Tripura	6	260	812	15	20	370	47	14	138	59	48	237	138
Uttar Prad	292	1880	2166	38	546	3227	95	264	668	301	686	1212	907
Uttarakha	6	188	151	1	23	185	11	3	72	22	10	66	108
West Beng	428	11564	9606	120	681	7045	667	174	391	1503	4566	3033	2840

	E1	E2	E3	E4	E5	E6	E7	E8
A & N Isla	3	14	126	404	672	121	3	280
Andhra Pr	1265	3047	10799	20602	34544	54938	696	36929
Arunachal	2	9	61	246	331	327	8	344
Assam	260	350	2682	6098	10932	6531	83	7533
Bihar	73	250	590	1545	1788	3012	60	1927
Chandigar	3	103	130	405	182	103	7	101
Chhattisga	225	547	3512	8737	15421	15612	128	16313
D & N Hav	4	7	26	75	91	310	0	173
Daman &	7	9	13	68	69	30	5	78
Delhi (Ut)	164	577	2044	4136	4084	2815	88	2949
Goa	14	84	331	758	979	651	38	620
Gujarat	264	965	3368	10204	12236	14504	181	24455
Haryana	686	592	2747	7640	6021	6021	542	5188
Himachal	76	176	656	1921	1110	553	42	785
Jammu &	42	71	215	712	681	718	62	467
Jharkhand	92	491	1127	1755	1805	3018	121	1541
Karnataka	1299	3076	10306	22572	28726	42311	568	38107
Kerala	952	2808	10611	29826	33401	5001	551	24786
Lakshadw	0	1	0	5	2	0	0	2
Madhya P	767	1264	8601	14502	19524	23384	635	21630
Maharash	1377	2146	11715	41304	47927	27088	358	48474
Manipur	2	5	60	149	129	33	0	43
Meghalaya	10	19	95	194	293	241	4	230
Mizoram	18	6	36	126	357	93	0	198
Nagaland	1	2	13	85	123	41	1	81
Odisha	428	2442	5298	9910	11197	11877	260	12036
Puducherr	80	162	523	1931	2723	166	42	802
Punjab	117	170	745	2272	1411	3045	242	1268
Rajasthan	389	993	3753	8947	9571	14653	284	12437
Sikkim	23	27	90	246	329	612	16	581
Tamil Nad	3348	4633	16244	22762	41180	39499	1393	34754
Tripura	25	87	433	1418	3196	1302	16	2717
Uttar Prad	641	1513	5999	8617	8942	11248	383	9337
Uttarakha	44	170	563	882	715	543	35	750
West Beng	1452	4458	15396	25512	42279	31356	623	54911

	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15
A & N Isla	0	63	130	24	57	1	1332	0	0	0	0	0	1	0	2
Andhra Pr	8404	54555	23831	9681	15070	461	33074	643	576	858	57	1835	1080	510	803
Arunachal	26	18	58	65	18	31	1017	6	7	0	0	10	0	1	6
Assam	750	522	6168	3643	854	64	16818	104	208	484	41	179	51	102	646
Bihar	54	1273	1240	836	878	97	1256	79	68	29	25	168	94	88	212
Chandigar	0	18	204	34	121	19	585	17	2	0	0	7	1	4	0
Chhattisga	1306	11877	4973	2024	5297	558	24038	117	49	400	69	885	31	344	483
D & N Hav	0	26	126	7	34	0	470	1	4	0	0	0	0	0	0
Daman &	0	6	40	27	47	2	131	1	2	0	0	1	0	0	0
Delhi (Ut)	70	763	2262	154	1330	240	10069	253	100	78	7	139	39	89	83
Goa	41	135	282	598	251	13	1819	15	36	7	0	57	23	15	5
Gujarat	2748	16126	11306	4817	10472	144	16663	473	288	281	29	111	410	288	217
Haryana	1553	3232	5653	1648	2300	147	5117	156	171	42	61	426	82	189	1161
Himachal	11	1007	1750	339	152	31	1132	13	201	4	5	95	11	9	25
Jammu &	71	366	611	121	115	121	370	29	59	24	31	46	8	10	87
Jharkhand	104	1159	692	1044	924	105	2518	163	190	163	39	398	226	151	202
Karnataka	5413	13980	36107	13350	8432	850	43293	622	716	40	65	1953	495	418	768
Kerala	2841	18659	17454	6802	5369	37	53171	258	138	666	20	550	493	418	123
Lakshadw	0	0	0	0	6	0	4	0	0	0	0	0	0	0	0
Madhya P	1844	22152	7410	5601	11109	462	31522	301	369	673	160	1139	598	176	825
Maharash	2565	55773	13248	18923	22552	157	61651	1164	362	550	21	2331	325	414	213
Manipur	1	20	79	1	7	63	235	0	0	0	0	0	2	1	0
Meghalaya	0	13	18	87	36	27	735	4	10	1	3	17	0	5	4
Mizoram	1	1	3	39	7	21	608	5	21	1	6	1	7	3	12
Nagaland	2	1	13	10	10	23	200	2	1	6	0	7	9	3	4
Odisha	2208	12953	7651	1777	1131	182	14393	102	361	424	5	167	87	263	356
Puducherr	7	739	485	54	778	1	4262	11	37	7	0	1	26	19	1
Punjab	3181	917	747	251	296	129	2087	79	62	16	15	34	39	119	212
Rajasthan	1660	8308	4478	4552	3318	156	12896	405	697	719	177	817	467	64	988
Sikkim	0	27	30	89	9	3	1206	3	35	0	0	82	9	4	9
Tamil Nad	2759	23335	35531	10638	23089	144	39880	966	1273	789	287	1854	1198	391	1341
Tripura	5	1118	2397	206	250	21	4172	6	4	2	3	17	11	7	29
Uttar Prad	2059	5870	4862	2781	6239	1591	14608	563	359	882	119	1045	899	323	912
Uttarakha	82	865	489	307	261	37	955	8	17	16	3	83	56	144	41
West Beng	5533	19624	40850	6181	7187	356	58668	1302	1704	954	413	1518	3182	521	1046

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	S1	S2	S3	S4	S5
A & N Isla	94	360	2	7	32	32	191	552	156	77	3	1078	533	3	6
Andhra Pr	26587	27634	4923	3799	845	11076	2607	12007	6609	7504	2148	122261	23527	6612	8272
Arunachal	185	202	3	12	5	108	174	182	109	115	3	954	357	2	12
Assam	3418	5789	1261	974	80	4307	267	1011	2422	1666	534	20039	10157	2394	1345
Bihar	806	1893	108	84	58	205	125	339	776	631	132	5827	2477	307	502
Chandigar	3	219	5	24	9	39	59	190	155	151	2	669	363	0	0
Chhattisga	14344	9285	1505	440	87	1385	618	2709	3344	3637	197	42938	14489	438	2433
D & N Hav	168	222	0	0	5	11	8	127	39	31	4	508	157	6	11
Daman &	4	54	2	2	0	4	4	93	20	13	1	141	128	3	6
Delhi (Ut)	166	3548	97	278	75	342	318	2527	1759	3518	47	11003	4924	620	263
Goa	98	646	27	37	53	134	80	701	225	737	20	2020	1316	39	80
Gujarat	6466	18513	5136	1175	1745	3471	862	6568	3374	6123	895	47143	13975	1050	3114
Haryana	2548	4273	454	775	241	824	927	2815	1596	3137	225	21653	5403	800	1356
Himachal	538	937	91	201	22	249	202	476	448	465	33	3636	1351	139	160
Jammu &	165	602	38	47	29	65	194	166	272	392	48	1806	920	126	68
Jharkhand	1051	1723	274	126	53	309	145	665	957	853	178	6243	2705	303	521
Karnataka	25803	22460	2143	3177	793	7455	2485	12852	6037	7259	949	102867	33440	3947	5762
Kerala	13050	16155	2356	1154	1232	5435	1196	5224	3422	13655	999	82456	18556	1846	4079
Lakshadw	0	6	0	0	0	0	2	0	0	0	0	10	0	0	0
Madhya P	16190	26724	2858	1742	239	4278	1720	5063	4640	3595	790	61103	23211	1178	4025
Maharash	44769	42059	6665	1771	1727	5932	2913	19754	10441	11389	892	134843	37539	958	6157
Manipur	18	65	0	7	0	11	80	2	83	75	0	244	174	0	3
Meghalaya	130	114	16	11	12	69	72	52	164	171	15	587	424	12	48
Mizoram	73	23	0	13	7	45	62	39	48	205	54	347	340	77	16
Nagaland	16	38	16	2	0	11	74	6	28	48	1	191	148	5	2
Odisha	2988	8344	1122	1510	434	3635	690	3959	3441	5324	683	34747	14035	1370	2613
Puducherr	1041	1253	647	51	28	222	174	707	375	1146	0	4673	1612	0	144
Punjab	821	1377	250	96	86	531	250	870	411	761	174	5661	2903	234	298
Rajasthan	6526	11312	602	534	133	2168	616	4358	2300	1918	241	35583	13470	485	1248
Sikkim	336	140	84	94	17	99	107	224	123	267	74	1025	595	95	135
Tamil Nad	10491	28165	3407	3864	1239	11650	2825	17159	5818	20770	1777	115005	29005	9512	8514
Tripura	328	1545	195	128	39	623	207	254	1195	1125	79	5722	2848	207	338
Uttar Prad	6854	12476	906	706	162	2015	811	3427	3089	4050	586	31391	11222	1237	2244
Uttarakha	357	834	78	80	88	162	132	453	243	385	63	2358	1060	63	158
West Beng	11491	36253	3933	7865	1759	11210	2128	9941	10204	13181	3425	115042	44937	4403	8180

R1: Bankruptcy, R2: Sudden change in Economic Status , R3:Cancellation/Non-Settlement of Marriage , R4:Cancer, R5:Death of Dear Person, R6:Divorce, R7:Dowry Dispute, R8:Drug Abuse/Addiction, R9:Failure in Exam, R10:Fall in Social Reputation, R11:Family Problems

R12:Ideological Causes/Hero Worshipping, R13:Illegitimate Pregnancy, R14:Illness (Aids/STD), R15:Insanity/Mental Illness, R16:Love Affairs, R17:Impotency, R18:Barren, R19:Other Prolonged Illness, R20:Paralysis, R21:Physical Abuse (Rape/Incest),

R22:Poverty, R23:Professional/Career Problem, R24:Property Dispute, R25:Suspected/Illicit Relation, R26:Unemployment

E1: Diploma, E2: Graduate, E3: Hr. Sec., E4: Matric, E5: Middle,

E6: No Eduaction, E7: PG, E8: Primary

M1: By coming under running vehicles/trains, M2: By Consuming Insecticides, M3: By Consuming Other Poison, M4: By Drowning, M5: By Fire/Self Immolation,

M6: By Fire-Arms, M7: By Hanging, M8: By Jumping from(Building), M9: By Jumping from(Other sites), M10: By Jumping off Moving Vehicles/Trains,

M11: By Machine, M12: By Over Alcoholism, M13: By Overdose of sleeping pills, M14: By Self Infliction of injury, M15: By touching electric wires

P1: Farming , P2: House Wife, P3: Professional, P4: PSU, P5: Retired

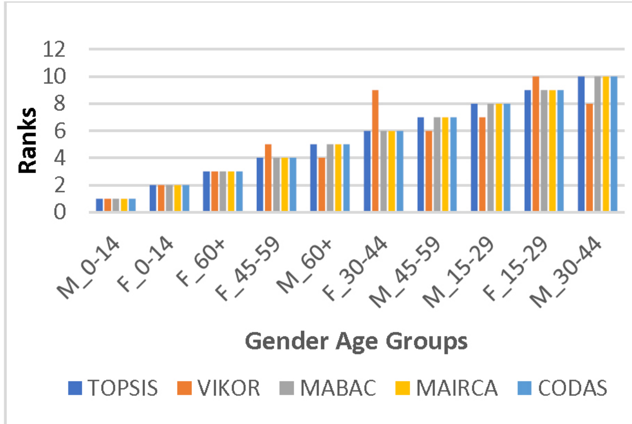
P6: Self-Employed, P7: Govt Service, P8: Private, P9: Student, P10: Unemployed

S1: Divorcee, S2: Married, S3: Never Married

S4: Separated, S5: Widowed/Widower

Gender + Age Groups	TOPSIS	VIKOR	MABAC	MAIRCA	CODAS	Majority Voting
F_0-14	2	2	2	2	2	**2**
F_15-29	9	10	9	9	9	**9**
F_30-44	6	9	6	6	6	**6**
F_45-59	4	5	4	4	4	**4**
F_60+	3	3	3	3	3	**3**
M_0-14	1	1	1	1	1	**1**
M_15-29	8	7	8	8	8	**8**
M_30-44	10	8	10	10	10	**10**
M_45-59	7	6	7	7	7	**7**
M_60+	5	4	5	5	5	**5**

(a)



(b)

Figure 1

Results obtained by different MCDM methods and Majority Voting from Reason Age Table

Figure 1(a), Figure 1(b) Ranks for different gender age groups

groups for both male and female along the rows and various methods used for committing suicide on the columns. Each entry t_{ij} contains the number of suicides committed by i^{th} gender age group using j^{th} method. Finally, we constructed a *Profession Age* table as shown in Table 3 to study the profession of different gender age groups committing suicides. It has different age groups for both male and female along the rows and along the columns it has their profession. Each entry t_{ij} contains the number of suicides committed by i^{th} gender age group of j^{th} profession.

To find the most vulnerable age group for committing suicide in relation to all the criteria such as reasons, methods, and profession taken together, we concatenated *Reason Age* table, *Method Age* table and *Profession Age* table. The *States Suicide* table was constructed to analyse suicides in Indian states based on all criteria such as reason for committing suicide, method used, the level of education, profession and the marital status of people who committed suicide as shown in Table 4. The table has Indian states on the rows and all these criteria on the columns.

We analysed the dataset constructed to extract valuable information about various variables of suicide. Python code using *pymcdm* [26] library was used for the task. PyMCDM, python package created especially for MCDM, is a useful tool for researchers, analysts, and decision-makers in a variety of domains since it offers a strong foundation for using multiple criterion decision-making techniques. It gives users a complete toolkit and approach to solve MCDM issues, allowing them to assess and prioritize options according to a variety of factors. To gain more confidence in our results we used five different MCDM methods, namely TOPSIS, VIKOR, MABAC, MAIRCA and CODAS. We used Majority voting ensemble

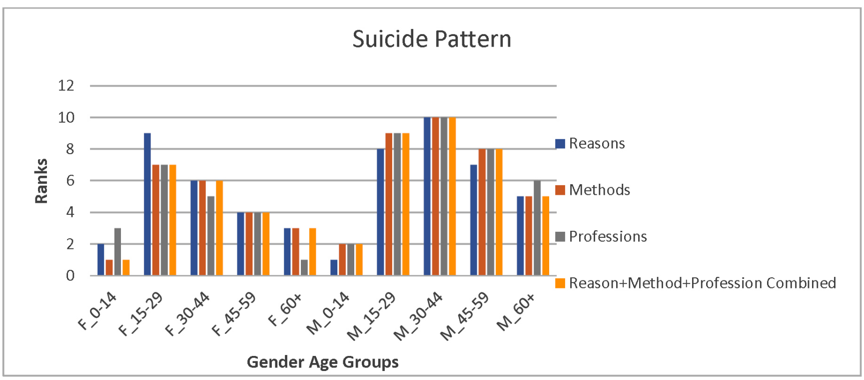


Figure 2

Ranks of age groups obtained from Tables 1, 2, 3 & 1 to 3 concatenated

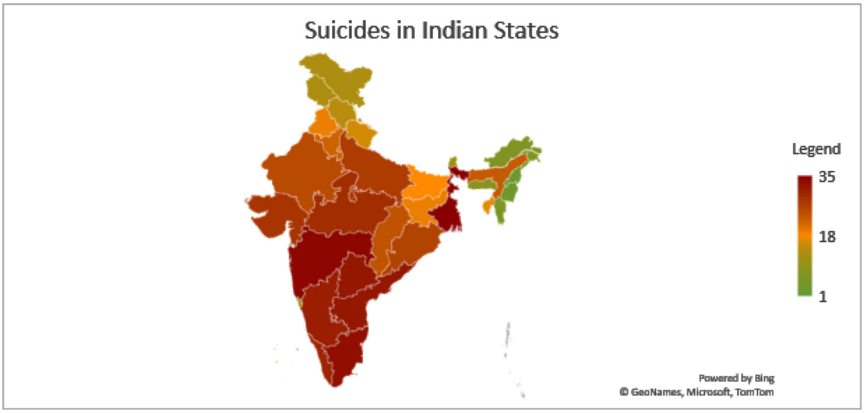


Figure 3

Incidents of suicide in Indian states

method to aggregate the obtained results from different MCDM algorithms.

4. Experiments and Results

We used five MCDM techniques (TOPSIS, VIKOR, MABAC, MAIRCA, CODAS) on *Reason Age* table to find out the most vulnerable (indicated by highest rank 10) age group amongst males and females based on the reason for committing suicide. The results obtained were combined using majority voting ensemble method and are shown in Figure 1. As is seen in Figure 1(a), suicide is more common among the Indian males aged 30 to 44 years and 15 to 29. In females, maximum suicides are committed by those between the ages 15 to 29 years. Graphical representation of ranks is shown in Figure 1(b).

Similar method was applied to obtain results from all other tables. This involved using all five methods of MCDM followed by majority voting ensemble method to obtain the result. *Method Age* table was used to find the most vulnerable age group according to the method used for committing suicide. We used *Profession Age* table to find out the most vulnerable age group according to their profession. We concatenated *Reason Age* table, *Method Age* table and *Profession Age* tables to find the most vulnerable age group according to all the above factors taken together. Figure 2 shows the results obtained from *Reason Age* table, *Method Age* table and *Profession Age* tables and the combined tables (1 to 3).

Using MCDM on States suicide table gave us insight into the Indian state where maximum suicides have taken place taking all factors into account. The results are shown in Figure 3. Authorities may take

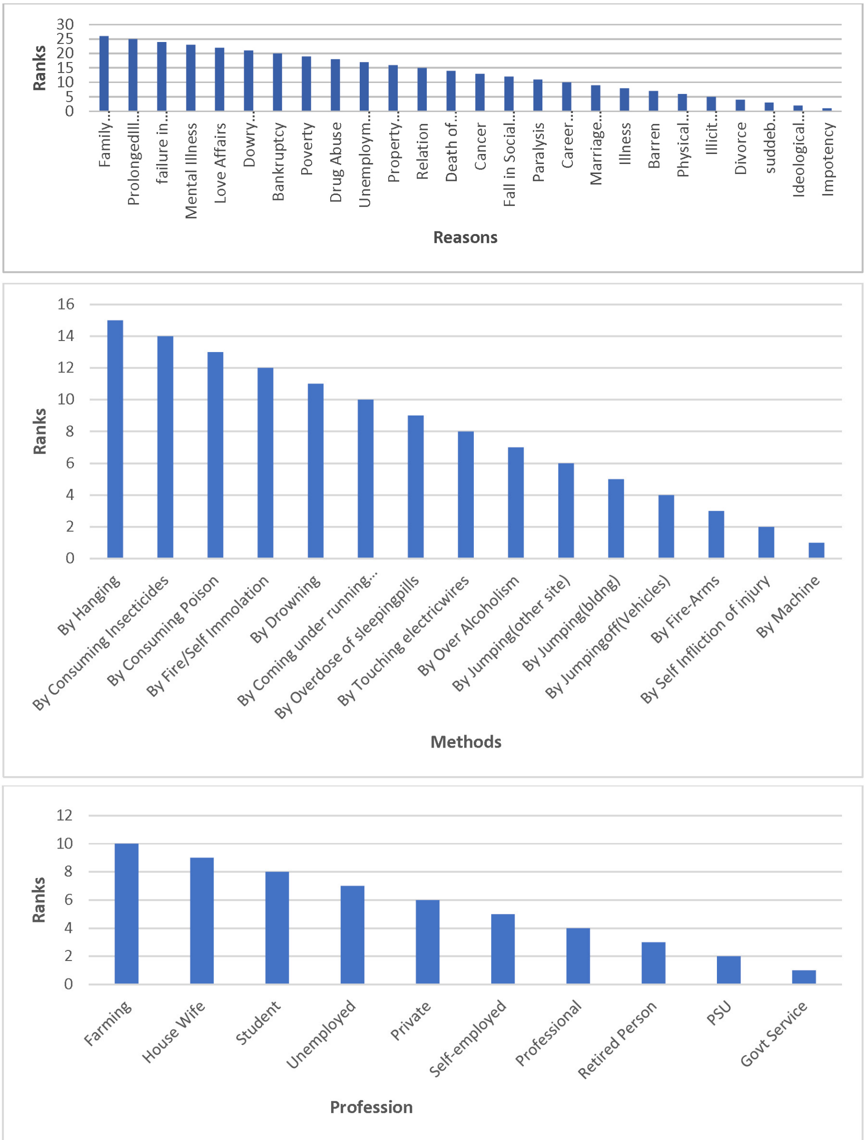


Figure 4

Analysis of traits of people committing suicide

Figure 4(a), Figure 4(b), Figure 4(c) Reasons, Methods and Professions

appropriate steps from this information with a special focus on states like West Bengal, Maharashtra, and Tamil Nadu etc. Northeastern states reported the minimum number of suicides.

Figure 4 shows the result of our in-depth study of traits of the people committing suicide. We used *Reason Age* table to study the main reason behind suicides for all age groups for both males and females. MCDM methods followed by majority voting was done to get the results as shown in Figure 4(a). We found that problems in family was the main reason due to which people committed suicide. Also, failure in exam or their inability to cope with prolonged illness was also the reason for them to take their lives quite often. Similarly, *Method Age* table was used to find the most frequently used method to commit suicide. Most of the people had hanged themselves to commit suicide. Many people had committed suicide by consuming insecticides or poison as shown in Figure 4(b). Running MCDM on *Profession Age* table gave us insight into the profession of the people committing suicides as shown in Figure 4(c). According to the results, maximum number of suicides were committed by farmers or house wives.

To find the most vulnerable age group along with gender and the common reason to commit suicide, all the results obtained from *Reason Age* table are combined and are shown in Table 5. We observe that females in the age group 15 years to 29 and males in the age group of 15 years to 44 years commit suicide mainly due to family problems, unable to face failure in exam or unable to cope with prolonged illness. Also, females aged 30 years to 44 years and males aged 45 years to more than sixty years commit suicide due to a dowry demands, broken love affair or some mental health issue. We also conclude that females aged 45 years and above, both males and females till 14 years of age commit suicide because of poverty, drug abuse or bankruptcy.

Similarly, the most vulnerable age group for both males and females and the common method used to commit suicide was inferred by combining all the results obtained from *Method Age* table and are shown in Table 6. We conclude that males of age 15 to 59 commit suicide mostly by hanging or by consuming poison or insecticides. Further females in the age group 15 to 44 years and males aged sixty plus commit suicide by self-immolation, drowning or by jumping in front of vehicle. Also, females aged 45 years and above both males and females till 14 years of age commit suicide by consuming alcohol or excess sleeping pills, or due to electric wires. Similarly, the profession of the most vulnerable age group for both males and females was inferred by combining all the results obtained from

Profession Age table and are also shown in Table 6. We conclude that farmers, unemployed youth and male students who commit suicide belong to age group 15 to 59. Further females in the age group 15 to 44 years and males aged sixty plus who commit suicide either are doing private job or are self-employed professionals. Also, females aged 45 years and above, both males and females till 14 years of age who commit suicide are retired or are government/PSU employees.

Table 5

Reasons, Age and Gender groups

Age group	Gender	Reasons
15 to 29	Females	Family Problem, Failure in Exam, Prolonged illness
15 to 44	Males	
30 to 44	Females	Dowry demands, Mental Health, Love affair
45 to sixty plus	Males	

Table 6

Method, Profession, Age and Gender groups

Age group	Gender	Method	Profession
15 to 59	Males	Hanging, Consuming Insecticides and Poison	Farming, Unemployed students
15 to 44	Females	Self-Immolation, Drowning, Jumping in front of vehicle	Private-job, Self-employed, Professional
Sixty plus	Males		

5. Conclusion

From our analysis of suicide data, we conclude that in India younger people generally unemployed youth or students or even farmers commit suicide mainly due to unemployment, failure in exam, family problems, poverty etc by hanging or by consuming poison or insecticides. Also, steps should be taken by the authorities to help the farmers and the unemployed with a special focus on states like West Bengal, Maharashtra, and Tamil Nadu etc. There is an urgent need of a multifaceted strategy for India's suicide prevention. Steps should be taken to bridge gap between rich and poor tackling socioeconomic activity, providing employment, skill-based education and affordable mental health services etc. Regulating and limiting the sale of highly toxic pesticides can greatly lower the suicide rate in rural areas where pesticide consumption is a popular means of suicide. It is worth noting that many students commit suicides as they are unable to face failure in exam so, teaching young people about coping strategies, stress management, and asking for help by incorporating mental health education into the curriculum beginning at school level should be a mandatory requirement. Not only students but parents need to be taught about parenting, how to handle failures of their children and how to recognize and respond to indicators of mental illness in kids and teenagers. Campaigns to increase public awareness, programs for economic support like job opportunities, cash incentives for disadvantaged groups, and support for education. Programs made keeping women in mind should be of high priority.

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