

A Mathematical Model For out of Control Cells In Cancer Patients In India.

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Abstract: It has been found that 8 to 9 million cancer patients are diagnosed and around 4.8 million patients died from cancer in every year all over the world. In India, hospital based cancer registration reports that 8 lacs cancer patients approx and 3.75 lacs patients died by cancer every year approx. The most important think is that in India there are 5.56 lacs patients killed in year 2010. In India from census It has been observed that in states the mortality rate in Muslim is higher compare to Hindus in the case of all cancers disease beside liver cancer. Out of these 8 lacs cancer patients there are 2.3 lacs cancers are tobacco related. Now cancer become a great challenge for mankind. The basic reason is that poor life condition of low income peoples increased due to least diagnosis and their treatments. In India there are different types of cancer diseases like liver, lungs, breast, rectus, stomach, cervix, protest, skins, blood and mouth etc. In above references an attempt has been made to translate a real world problems of cancer patients by mathematical modelling in which the growth of out of control cells is discussed assuming that the mortality depends on increasing density of cancer cells in the cancer patients and concentration of out of control cells growth.

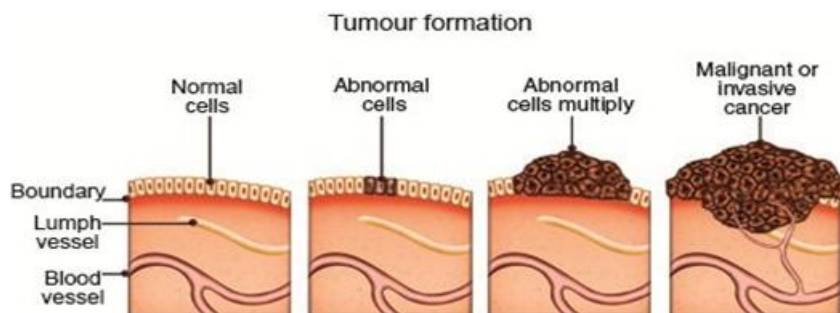
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I. Introduction

The disease cancer (malignant neoplasm) is the most fatal , a huge of more than hundred disease due to uncontrolled cell growth continuously in organs. In over all world there are different types of cancer. All cancers start due to abnormal cell increasing at high rate and their symptoms is illness and death. When in a part of body cells are start to grow out of control then cancer is start. . The development of cancer cells growth in organs is distinct from normal cell growth. Cancer cells is rapidly to grow and generate as new, where abnormal cells zigzag due to the DNA (deoxy ribonucleic acid) damaged in human organs. In a normal cell, when DNA gets damaged the cell either repairs the damage or the cell dies. In cancer cells, the damaged DNA is not repaired, the cell goes as making new cell that body does not need.(i.e.,[1]) Cancer cells often travel to other parts of the body where they begin to grow and form new tumors. This happens when the cancer cells get into the body blood stream or lymph vessels. The treatments of cancer is difficult to cure is that it can spread to a different part of the body from where it started. The cancer that grows where it first started in the body is called the primary cancer. The place a cancer spreads to and the starts growing is called the secondary cancer or metastasis (cancer that has spread to another part of the body is called metastatic cancer. There are three main ways a cancer spread (i) The cancer grows directly in to nearby body tissues.(ii) by blood circulation (iii) Through the lymphatic system. The symptom of cancer depend upon its type and that's area covered by cancer disease there are different symptoms like diarrhea, constipation, cough, short of breathing and blood in stool. There are different tests for its recognize MRI, CT Scan , CBC test, Biopsy. From India and its neighborhood countries approx 43000 newly cancer patients come for diagnosis. Nearly 65% patients obtain primary treatment. Approx 1000 patients join continuously medical treatment whereas 6300 found major operations yearly and 6000 patients found their treatment with radiotherapy and chemotherapy .Cancer is unknown cell growth .Cancer cells increases by accelerating cells division and prevents the growth of normal cell in the system so normal cells die. Due to growth of cancer cells it converts in to tumor and due to its increment it travels and generates new tumor in related part.(i.e.,[2])



Fatigue, severe, weight loss, coughing shortness of breath diarrhea, constipation blood in the stool ,an alter of metabolism, blood clot, weakness and dizziness and sores that don't heal. There are various different methods of treatment for cancer, by surgery, chemotherapy, radiotherapy, biological therapy or hormone therapy, the aim is to kill the areas of cancer cells before they grow big enough to be seen as scan. During these therapy there are many side effects like tiredness, reaction in skin such as rash or redness and loss of appetite, lowering of the WBC count loss of normal growth control. There are many types of cancers .Cancer can develop in almost any organ or tissue, such as lung, colon, breast, skin, bones or nerve tissue(i.e.,[3])

II. Cancer Patients In India:

In India there are many cancer patients their data from year 2004-2010 have represented in below table-(a)

Table(a)

Years	No. of cancer patients	Male	Female
2004	819354	390809	428545
2005	846635	413212	433423
2006	863575	422310	441265
2007	907838	429874	477954
2008	846172	447399	498773
2009	962832	454842	507990
2010	979786	462408	517378

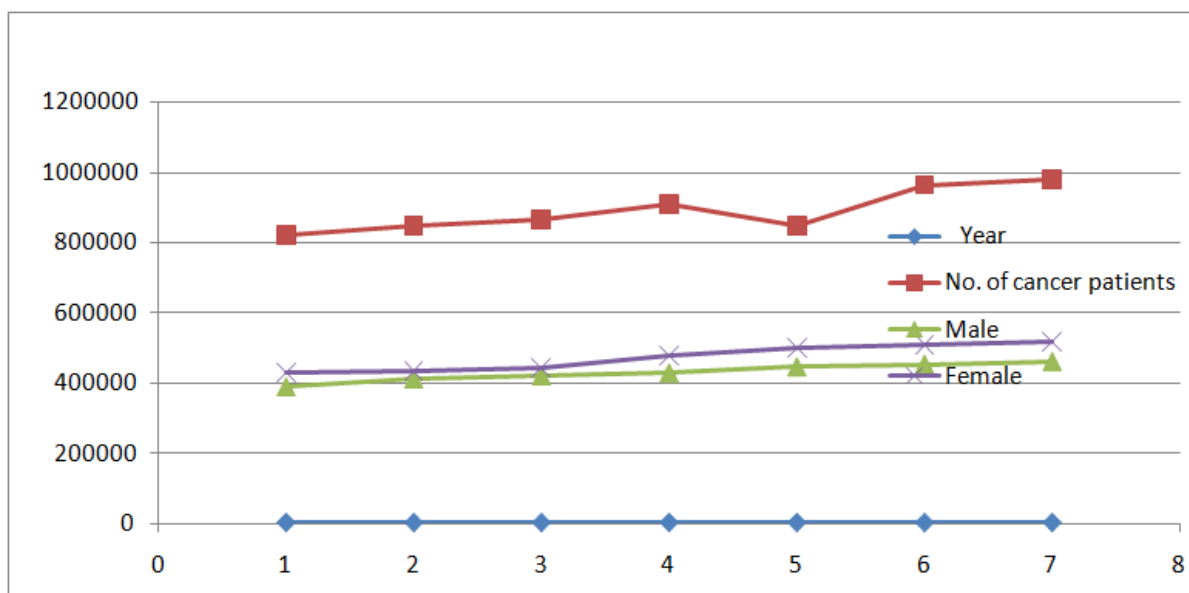


Fig.(a) No. of cancer patients in India in different years (ICMR,2006-2009)

Estimated Incidence cancer cases in India-statewise(2011-2014)-both:

States	2011	2012	2013	2014
Jammu & Kashmir	10688	11052	11428	11815
Himachal Pradesh	5836	5966	6097	6230
Punjab	23506	24006	24512	25026
Chandigarh	893	915	937	960
Uttaranchal	8633	8899	9173	9455
Haryana	21539	22122	22721	23336

Delhi	14204	14517	14836	15160
Rajasthan	58426	60065	61743	63459
Uttar Pradesh	170013	175404	180945	186638
Bihar	88563	91721	94981	98346
Sikkim	490	513	539	571
Arunachal Pradesh	1108	1134	1160	1187
Nagaland	1579	1595	1612	1630
Manipur	2149	2119	2092	2066
Mizoram	871	885	900	914
Tripura	2944	3036	3141	3259
Meghalaya	2367	2413	2460	2507
Assam	24846	25119	25391	25663
West Bengal	77806	79915	82087	84325
Jharkhand	28135	29067	30026	31012
Odisha	35736	36599	37478	38375
Chattisgarh	21835	22569	23325	24105
Madhya Pradesh	61883	63814	65797	67831
Gujarat	51415	52920	54469	56061
Daman & Diu	209	232	259	288
Dadra & Nagar Haveli	293	310	328	349
Maharashtra	95508	97674	99871	102101
Andhra Pradesh	72395	74900	77543	80334
Karnataka	52099	53476	54886	56330
Goa	1240	1266	1293	1321
Lakshadweep	55	58	60	63
Kerala	28583	29434	30372	31400
Tamil Nadu	61266	62049	62830	63609
Pondicherry	1069	1114	1160	1208
Andaman & Nicobar Islands	321	326	331	335
Total	1028503	1057204	1086783	1117269

Source – ICMR, Based on cancer incidence report (2009-2011) and the Report on Time Trends in Cancer incidence Rates (1982-2010).

Estimated mortality cancer cases in India-statewise (2011-2014)-both sexes:

States	2011	2012	2013	2014
Jammu & Kashmir	4703	4863	5028	5198
Himachal Pradesh	2568	2625	2683	2741
Punjab	10343	10563	10785	11011
Chandigarh	393	403	413	423
Uttaranchal	3798	3916	4037	4160
Haryana	9477	9734	9998	10268
Delhi	6250	6387	6529	6670
Rajasthan	25707	26429	27168	27922
Uttar Pradesh	74806	77178	79616	82121
Bihar	38968	40357	41792	43272
Sikkim	216	226	237	251
Arunachal Pradesh	487	499	510	522
Nagaland	695	702	709	717
Manipur	946	932	920	909
Mizoram	383	389	396	402
Tripura	1295	1336	1382	1434
Meghalaya	1041	1062	1082	1103
Assam	10932	11052	11172	11292
West Bengal	34235	35163	36118	37103
Jharkhand	12380	12790	13211	13645
Odisha	15724	16103	16490	16885
Chattisgarh	9607	9930	10263	10606
Madhya Pradesh	27229	28078	28951	29846
Gujarat	22623	23285	23966	24667
Daman & Diu	92	102	114	127
Dadra & Nagar Haveli	129	136	144	153
Maharashtra	42023	42976	43943	44924
Andhra Pradesh	31854	32956	34119	35347
Karnataka	22923	23529	24150	24785
Goa	546	557	569	581
Lakshadweep	24	25	27	28
Kerala	12576	12951	13363	13816
Tamil Nadu	26957	27302	27645	27988

Pondicherry	470	490	510	532
Andaman & Nicobar Islands	141	143	145	148
Total	452541	465169	478185	491597

Source-ICMR based on Cancer incidence cases and pooled M/I ratio of Mumbai data(2009-2011) report.

In table (b) the data given by the national of cancer registry program (i.e.,[4]) of the Indian council of medical research have been made to find out the total number of cancer patients in five metro cities in India .The rate of increase of cancer patients due to gastric in Chennai (i.e.,[5]) is low and Delhi is very high, due to distinct life style by different level of food, population and less nutrition.

Table (b)

City	Total patients	Male	Female
Bhopal	12155	701	554
Chennai	4824	2296	2825
Mumbai	8505	4170	5335
Delhi	13920	6815	7105
Bangalore	5250	2262	2998

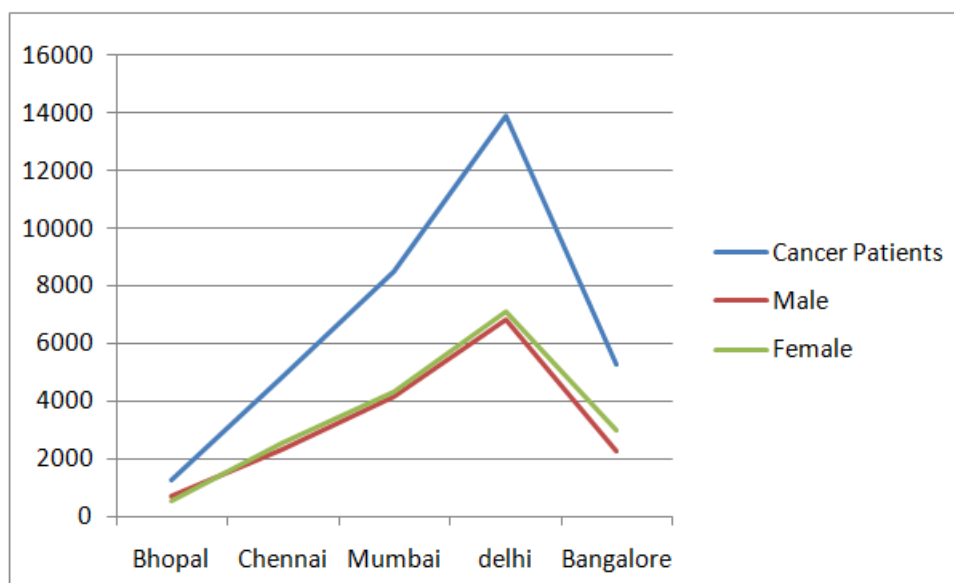


Fig (b): Projection of cancer incidence in metropolitan cities of India(i.e.,[6]).

In Table I there are many types of cancers which can generates in any organs or tissue, in the form of breast, skin, bones, nurve tissue ect., its reason that the development of uncontrolled growth of abnormal cells in the body. The top five types of cancer in man and women for 47.2% of all cancers these cancer prevented at early stage before fatal

Table (c)

Man	Women
Lip, Oral cavity	Breast
Lung	Cervix
Stomach	Colorectum
Colorectum	Ovary
Pharynx	Lip, Oral cavity

Source: National Cancer Registry Programme.

In table(d) cancer among women which is estimated No. of Gynaecological related cancers by years in India (2010-2015).By Globocan 2012 the mortality rate in women is very high. Out of total registered women 123000, 144937 and 77003 for cervical, breast and oral respectively whenever 67500, 70258 and 52067 has died.(i.e.,[7,8]).

Table (d)

Site of cancer	In year 2010	In Year 2015
vagina	2238	2439
cervix	103821	113138
corpusuteri	14848	16181
ovary	30482	33218
pleacenta	484	527
Gynaecological cancer	153850	167658
breast	90659	106124

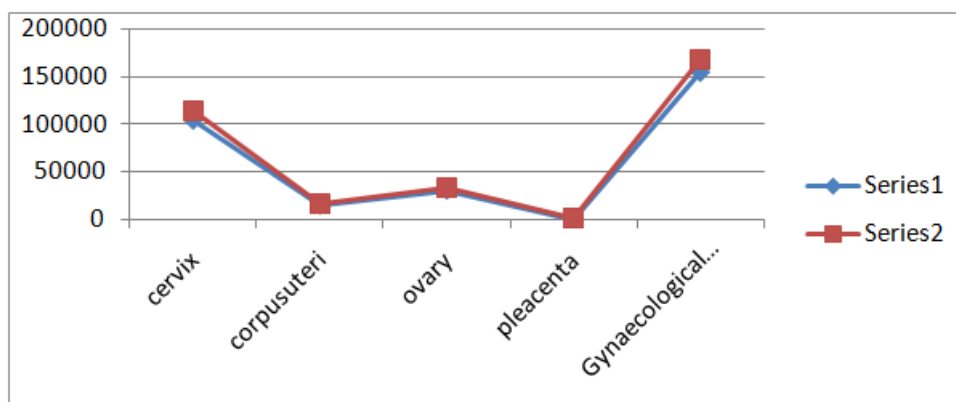


Fig3: Estimated no. of Gynaecological related cancers by years in India (2010-2015)

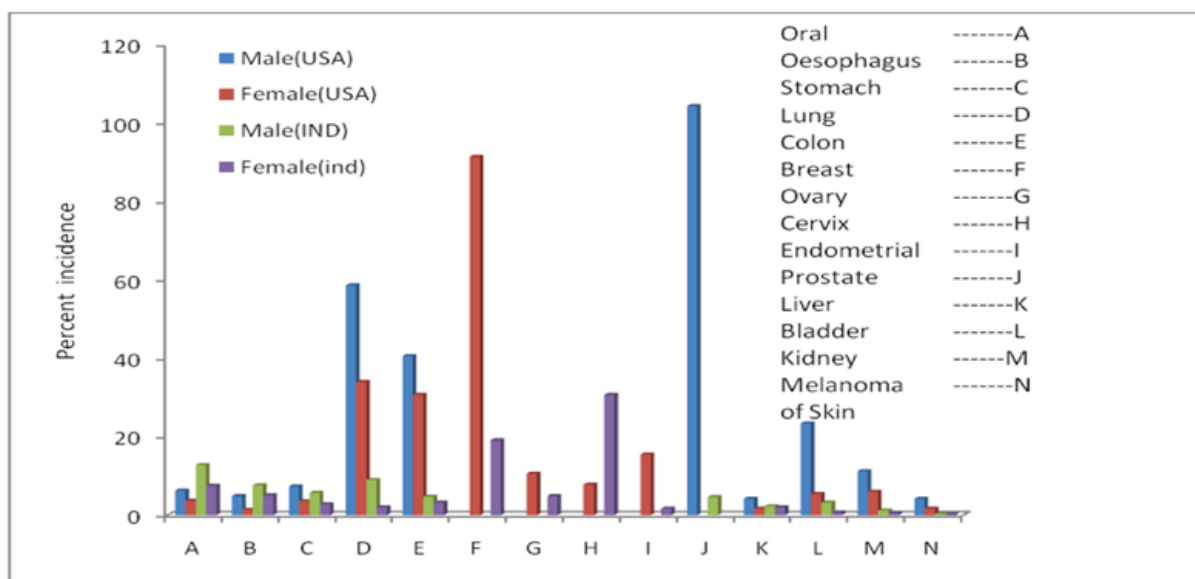


Fig 4: Comparison of cancer; Indian scenario with USA [Fenley et al, 2001].(i.e.,[9]).

III. Cancer Patients Growth Model:

The study of growth of cancer cells in cancer patients is a great interest in population dynamics. In spite of good advancement for diagnosis and treatment, cancer is still a big challenge to our society.(i.e.,[10]). The simplest exponential growth model for human as well as for cancer cells in cancer patients due (i.e.,[11]).

$$\text{as } \frac{dn}{dt} = un, t > 0$$

Where $n(t)$ is the number of patients in the population at some time t and $u > 0$ is specific growth rate of the population. This model is valid only in unlimited environment. The population density first increases, but at higher density the rate of increase decreases. Assuming this (i.e.,[12]) modified the above patients growth model is

$$\frac{dn}{dt} = un - vn^2, t > 0$$

Where $v > 0$ reflects the degree to degree to which density decreases the rate of increase of cancer cells in patients.

In certain cancer patients out of control cell are produced by DNA damaged which is not repair as further and form new cells which become a limiting factor to their further growth by increasing rapidly the mortality rate of organism.

In the present problem, we will develop the cancer patient growth model (i.e.,[13]) under out of control cells by following assumption that:

- (i) Mortality depends on increasing density of out of control cells.
- (ii) There is rapid decreases in the number of DNA cells in cancer patients due to production of new cancer cells.

IV. Formulation of The Model And Its Solution

Let $n(t)$ =total number of DNA(normal cells) at some time t . in a cancer patient. The change in the number, $\frac{dn}{dt}$ is equal to different of generation of birth rate of new cells and their death rate.

Assuming that mortality rate (i.e.,[14]). is influenced by two factors (i) increasing density of cancer cells (ii) increasing concentration of new DNA produces by cancer cell. The cancer cells growth model of cancer patients can be given as

$$\frac{dn}{dt} = un - vn^2 - kcn$$

Where k is a positive constant and where the term $un - vn^2$ refers to logistic growth rate of the cancer cells in patients and c denotes the concentration of new out of control cells. It is assumed that mortality dependent linearly on the concentration c . We further suppose that the new cancer cells is produced at a constant rate k

per organism. Then $\frac{dc}{dt} = kn$

Hence we get

$$\frac{dn}{dt} = un - vn^2 - kn \left(\int_0^t n_1(s) ds \int_0^t n_1(s) ds \dots \int_0^t n_r(s) ds \right) \quad \dots(i)$$

where $n_1(s) = n_2(s) \dots = n_r(s) = n(s)$ (say)

$$\frac{dn}{dt} = un - vn^2 - kn \left(\int_0^t n(s) ds \right)^r$$

This integro-differential equation can be solved for $n(t)$ by special way as follows

We put $y(t) = \int_0^t n(s) ds$, then eq. (1) reduces to second order differential equation as

$$y'' = uy' - v(y')^2 - ky'y^r$$

Multiplying by e^{vy} we have

$$\frac{d}{dt} (e^{vy} y'') = \frac{d}{dt} \left[\{ uy' - v(y')^2 - ky'y^r \} e^{vy} \right]$$

Now integrating between limit 0 to t we have

$$e^{vy} y'' - n(0) = e^{vy} \left(\frac{u}{v} + \frac{k}{v^2} - \frac{k}{v} y^r \right) - \left(\frac{u}{v} + \frac{k}{v^2} \right) \text{ since } y(0) = 0 \ \& \ y'(0) = n(0)$$

$$\begin{aligned} \text{It gives } n(t) &= n(0)e^{-vy} + \left(\frac{u}{v} + \frac{k}{v^2} - \frac{k}{v} y^r \right) - \left(\frac{u}{v} + \frac{k}{v^2} \right) e^{-vy} \\ &= \left(\frac{u}{v} + \frac{k}{v^2} - \frac{k}{v} y^r \right) - \left(\frac{u}{v} + \frac{k}{v^2} - n(0) \right) e^{-vy} \quad \dots(2) \end{aligned}$$

$$= f(y) \quad (\text{say})$$

$$\frac{dy}{dt} = f(y)$$

$$\text{Here } t = \int_0^y \frac{dy}{f(y)}$$

Equation (2) gives the no. of cancer cells in cancer patient at time t .

V. Result And Discussion

We may now analyze the behavior of curve $n(t)$ obtaining $\frac{dn}{dt}$ and finding maximum value of $n(t)$.

from (2), on differentiation we get

$$\frac{dn}{dt} = f'(y) \frac{dy}{dt} = f'(y)n(t)$$

$$= \left\{ \left(-\frac{k}{v} r y^{r-1} y' \right) - (-v) e^{-vy} \left(\frac{u}{v} + \frac{k}{v^2} - n(0) y' \right) \right\} n(t)$$

$$= \left\{ \left(-\frac{k}{v} r y^{r-1} \right) - v e^{-vy} \left(n(0) - \frac{u}{v} \right) - \frac{k}{v} r y^{r-1} + \frac{k}{v} e^{-vy} \right\} n^2(t) \quad \dots(3)$$

Hence it follows that

- (i) If $n(0) \geq \frac{u}{v}$, then $\frac{dn}{dt}$ is always negative and number of cancer cells steady decreases to zero.
- (ii) If $n(0) < \frac{u}{v}$ then $\left(\frac{dn}{dt} \right)_{t=0} = - \left(v(n(0) - \frac{u}{v}) \right) > 0$

So that the number of cancer cells initially increases and reaches a maximum

when $\frac{dn}{dt} = 0$ which gives

$$y_{\max} = \frac{1}{v} \log \left\{ \frac{k + uv - n(0)v^2}{uv + k} \right\} \text{ then equation (2) implies}$$

$$n_{\max} = \frac{u}{v} - \frac{k}{v^2} \log \left\{ \frac{k + uv - n(0)v^2}{uv + k} \right\} < \frac{u}{v}$$

After this the number of cancer cells decreases and tends to zero. Thus we conclude that in both the cases

- (i) $n(0) \geq \frac{u}{v}$ and (ii) $n(0) < \frac{u}{v}$ the number of cancer patients tends to zero that is the cancer cells in cancer patients tends to extinction.

Hence from above analysis we have seen that cancer is fatal disease where cancer cells growth out of control and destroy normal cells as DNA. With the advancement of medicinal- techno society we need to awareness about it as earlier stage it recognize and have to find proper medicinal treatment .India is a developing country set a dynamic presence over all of the world We should awareness the people by different governmental schemes and by NGO's in rural areas and poor family in urban areas who live not in good economic condition and there is a need to adopt good nutrition and good conduct to change the life style.

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