*Int. J. Environ. Res. Public Health* **2008**, *5(5)* 399-407

*International Journal of*
*Environmental Research and Public Health*
ISSN 1661-7827
**www.ijerph.org**


# Epidemiological Study of High Cancer among Rural Agricultural Community of Punjab in Northern India

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*Received: 12 May 2008 / Accepted: 29 August 2008 / Published: 31 December 2008*

**Abstract:** Based on a citizen's report, a house-to-house survey was conducted in Talwandi Sabo and Chamkaur Sahib Community Development Blocks in Bathinda and Roop Nagar District respectively in Punjab state located in a northern part of India to identify the number of existing cancer cases, and the number of cancer deaths that occurred in the last 10 years. Age adjusted prevalence of confirmed cancer cases per 100,000 population was 125 (107/85315) in Talwandi Sabo and 72 (71/97928) in Chamkaur Sahib. Cancer of female reproductive system, i.e., breast, uterus/cervix and ovary were more common in Talwandi sabo whereas cancer of blood and lymphatic system, esophagus, and bones were more common in Chamkaur Sahib. Cancer deaths per 100,000 populations per year were 52 in Talwandi Sabo compared to 30 at Chamkaur Sahib. A comparison of the characteristics of randomly selected individuals, from the villages where a cancer case existed or death due to cancer had occurred in last 2 years, revealed that involvement in cultivation, pesticide use, alcohol consumption and smoking were more common in Talwandi Sabo as compared to Chamkaur Sahib. Limited studies show that in drinking water the levels of heavy metals such as As, Cd, Cr, Se, Hg were generally higher, and pesticides such as heptachlor, ethion, and chloropyrifos were also higher in samples of drinking water, vegetables, and blood in Talwandi Sabo as compared to Chamkaur Sahib. As multiple factors were responsible for significantly higher prevalence of cancer cases in Talwandi Sabo, therefore, a multi-pronged strategy to discourage the indiscriminate use of pesticides, tobacco and alcohol needs to be adopted for cancer prevention, and a cancer registry should be set up for elucidation of the role of pesticides and heavy metals in the etiology of cancer in this area.

**Keywords:** Cancer, environmental pollution, agriculture, pesticides, occupational exposure, morbidity, mortality

## Introduction

Cancer patterns vary not only throughout the world but also between different population groups within the same country [1]. Of the ten million new cases of cancer diagnosed every year, over half are from the developing world. It is estimated that by the year 2020, over 10 million people worldwide would die of cancer every year and that 70 percent of these would be from the developing world [2]. Study of the magnitude and pattern of cancer is the first step in determining clues to the cause(s) of cancer and in having a baseline to plan and assess control measures. Epidemiological studies help in knowing what is happening and what can be done about it. In India, though infectious diseases continue to be a public health problem but an increase in the occurrence of non-communicable diseases has been noted particularly in urban areas and in economically advanced states [3].

Punjab is one of India's most prosperous states. This prosperity has been largely due to its success in the agricultural green revolution. Seventy percent of the population is directly or indirectly associated with

agriculture. As per 2001 census, 70% people live in villages and 30% in the urban areas [4]. Over the last five years, increased occurrence of cancer cases had been reported from Jajjal and Giana villages of Talwandi Sabo Community Development Block situated in the southern part of Punjab. Villagers attributed higher occurrence of cancer to unhygienic living conditions and poor quality of drinking water. Hence a study was planned to find out whether the cancer cases were higher in Talwandi Sabo area and if it was so, then what were the possible reasons for the same?

## Methods

### *Study Design*

A cross sectional study followed by a case control study was carried out in 36 villages of Talwandi Sabo Community Development Block of Bathinda district (study area) and in 93 villages of Chamkaur Sahib Block of Roop Nagar district (reference area) of Punjab. Study area is located more than 250 kms away from reference area. The reasons for selection of Chamkaur Sahib Block as a reference area were similar socio-economic conditions but different cropping pattern and source of drinking water. Cotton is the main crop in Talwandi Sabo where as wheat and rice is the predominant crop in Chamkaur sahib. Source of drinking water is from underground sources in Chamkaur Sahib and canal water in Talwandi Sabo.

### *Household Survey*

A total sample size of 3,56,000 (1,78,000 at Talwandi Sabo and 1,78,000 at Chamkaur Sahib) was calculated on the basis of estimated cancer prevalence of 1.1/1000 in the unexposed (reference) population and 1.4/1000 in the exposed (study) population with 95% confidence level and 80% power, to detect 25% difference in the exposed and unexposed populations. In the mid-term review, the technical committee of the project observed that prevalence of cancer was about two times higher at Talwandi Sabo as compared to Chamkaur Sahib, therefore, recommended a reduction in the sample size. Thus 85,315 individuals at Talwandi Sabo and 97,928 at Chamkaur Sahib were surveyed.

### *Study Tools*

A detailed village wise environmental profile of the area was prepared pertaining to the changes in cropping pattern, water and food sources in the last 30 years. A pre-designed and a pre-tested questionnaire were used to survey households in both the areas. It included inquiries on symptoms of cancer, diabetes, stroke, heart diseases and chronic obstructive pulmonary diseases/asthma among members of the household and deaths in the household during the last 10 years (1993-2003) among >5-year-olds. For each reported death, verbal autopsy was done using a semi-structured questionnaire, and a physician assigned the cause of death using predetermined guidelines. For any suspected case of cancer in the household, a detailed history of symptoms, signs, investigation and treatment was taken, which was reviewed by two physicians independently to diagnose cancer cases.

### *Survey Techniques*

Two survey teams having four surveyors and one supervisor each with one physician conducted house-to-house survey. The staff had received one week intensive theoretical training and one week field training. They were sent for field surveys after the investigators verified their competence in conducting household survey.

The supervisor interviewed the head or member of the village committee (*sarpanch/panch)* using the village profile proforma and recorded the information about village population, cropping pattern, water sources and food sources. Each surveyor visited about 30 households per day and interviewed an adult member of the household to record the names of all the household members above the 5 year age along with their age and sex, any history of chronic disease (hypertension, heart disease, stroke, diabetes, cancer, asthma and HIV/AIDS) and any person with following symptoms, i.e., a non healing ulcer or blister in mouth, unusual bleeding or discharge from genital tract in women, lump in the breast, difficulty in swallowing or indigestion, continuing of cough and hoarseness of voice, change in bowel or bladder habits and change in wart or mole. If there was any member in the household who had any of these symptoms and signs, detail case report on the chronology of the symptom and signs, investigations and treatment taken was prepared. Verbal autopsy was done for all deaths that had occurred in last ten years recording the sequence of events i.e. symptoms and signs leading to death. Physicians reviewed the case reports and verbal autopsy forms and categorized the cases and deaths into confirmed benign tumor, confirmed malignant tumor, suspected benign tumor, suspected malignant tumor and no cancer. Camps were organized at Talwandi Sabo and Chamkaur sahib to confirm clinically suspected cancer cases by biopsy/FNAC. Those who were found to have no cancer were excluded from the study. Only histological proven cancer cases were taken into consideration.

### *Laboratory Investigations*

Surface and ground water was tested for heavy metals and pesticides, vegetable and fruits were tested for pesticides, and blood and urine samples were also tested for heavy metals and pesticides. Three samples each of tap water; under-ground water and vegetable/fruits were taken from the study and reference area from March 2004 to May 2004. Three samples of blood (two from cases and one from a control) and three urine samples (two from cases and one from control) were also taken in the month of May 2004 from each of the study and reference area.

Gas chromatograph fitted with Electron Capture Detector (for organo chlorines) and Nitrogen Phosphorus Detector (for organo phosphorus) was used for pesticides residue analysis. Heavy metals viz. Copper, Lead, Mercury, Cadmium, Chromium, Selenium, Nickel and Arsenic were analyzed using Atomic Absorption Spectrophotometer for the quantification of heavy metals. The quality of laboratory results was ensured by sending samples to Indian Toxicology Research Centre (ITRC) lucknow for external quality control and results were compared.

*Case Control Study*

It was hypothesized that the occurrence of cancer in Talwandi Sabo Community Development Block could be due to more use of pesticides in agriculture, and/ or drinking of surface water from the canals; hence, a case control study was planned to find out various risk factors related with higher occurrence of cancer in Talwandi Sabo Block. A pre-tested questionnaire was used for collection of information on common risk factors from the cases and controls regarding the source of drinking water, health profile, use of pesticides, dietary habits, life style and menstrual history (in case of females only).

Case was defined as any person living or dead who has or had any of the seven symptoms related to cancer (described earlier) and was diagnosed as having cancer by a qualified medical practitioner in the last two years; i.e., 2002-03. Controls were selected from the same village as that of case randomly by matching age group, and from same sex who had no sign/symptom suggestive of cancer.

A total of 179 cases were selected from Talwandi Sabo and 129 from Chamkaur Sahib who were histologically proven prevalent cancers or deaths due to cancer, and 264 controls were chosen from Talwandi Sabo and 182 from Chamkaur Sahib. Out of the 179 'cases' at Talwandi Sabo, 83 were prevalent cancers and 96 were cancer deaths. Similarly, out of 129 'cases' at Chamkaur Sahib, 46 were prevalent cancers and 83 were cancer deaths. The number of controls was higher than the cases because initially controls were also selected for clinically diagnosed cases. Although some people refused on first visit, however on subsequent visit they agreed to participate in the study.

*Quality Control*

The supervisor independently re-assessed one death per village per surveyor and physician checked one death per village randomly. Physician reviewed the work done by surveyor and supervisor every week with regular feedback. Re-survey of one village per team was done which had been covered by the other team so as to check the quality of survey work. All diagnosed and suspected cancer cases were visited and verified by physician. Camps were organized at Talwandi Sabo and Chamkaur Sahib for confirmation of the suspected cancer patients. Retrospective study of the cancer cases belonging to area registered in local cancer hospitals also confirmed the completeness of the survey.

*Statistical Analysis*

Data was analyzed using EPI INFO 2000 and SPSS package. The data was further crosschecked and analyzed using standard statistical methods. Age and sex standardized prevalence of histologically and clinically diagnosed cancer cases was calculated by direct method. Univariate analysis was done for categorical data by chi-square test and Fisher's exact test wherever applicable. Estimate of risk for association of various risk factors for cancer was calculated by odds ratio by comparison of cases of study and controls of reference area.

## Results

As reported by the village committee members, there was increased cultivation of rice, cotton and sugar cane since last 10 years in Talwandi Sabo. However, there was no change in the cropping pattern in the last four decades in Chamkaur Sahib. Surface water consumption (91.6%) and perceived water pollution (83.3%) were higher in Talwandi Sabo in comparison with Chamkaur Sahib. It was noticed that 13.8% of villages of Talwandi Sabo and 5.3% in Chamkaur Sahib had industries closer to the inhabited areas.

**Table 1:** Distribution of Cancer Morbidity and Mortality in Talwandi Sabo and Chamkaur Sahib Community Development Blocks in Punjab, India

| *Parameter* | *Talwandi Sabo* | *Chamkaur Sahib* |
|---|---|---|
| Villages surveyed | 36 | 93 |
| Households | 20,164 | 19,568 |
| Population | 85,315 | 97,928 |
| *Gender distribution* | | |
| Males | 45371(53.2) | 53103(54.2) |
| Females | 39944(46.8) | 44825(45.8) |
| Age distribution | | |
| Children < 10 years | 2794(3.3) | 8588(8.8) |
| Adolescents 10-19 years | 16188(18.9) | 22578(23.1) |
| Adults 20-59 years | 55777(65.4) | 55626(56.8) |
| Elderly 60+ years | 10556(12.4) | 11136(11.4) |
| Deaths reported in last 10 years | 3,828 | 3,613 |
| Death rate per 1000 per year | 4.48 | 3.69* |
| Suspected cancer cases | 179 | 129 |
| Histologically confirmed cancer cases | 107 | 71* |
| Age adjusted prevalence of histologically confirmed cancer cases/1,00,000 | 125.4 | 72.5* |
| Clinically diagnosed cancer cases | 43 | 19 |
| Age adjusted prevalence of clinically diagnosed cancer cases /1,00,000 | 50.4 | 19.4* |

Figures in parenthesis are percentage *P<0.001

There were 107 histologically confirmed cancer cases at Talwandi Sabo, out of which 27 (25.2%) were males and 80 (74.7%) were females (Table 1). There were 71 confirmed cancer cases at Chamkaur Sahib, out of which 25(35.2%) were males and 46(64.7%) were females. Age adjusted prevalence of confirmed cancer cases was 125.4 per 100,000 at Talwandi Sabo as compared to 72.5 at Chamkaur Sahib ($p<0.001$). In Talwandi Sabo there were 3827 deaths in last 10 years, out of which 489 deaths were due to cancer whereas in Chamkaur Sahib there were 3621 deaths in the same period, out of which 314 were cancer deaths. Proportion of deaths due to cancer over the last 10 years remained between 10 to 13 % at Talwandi Sabo and 7 to 10% at Chamkaur Sahib. Age adjusted cancer death rate per 1,00,000 per year at Talwandi Sabo was 51.2 as compared to 30.3 at Chamkaur Sahib ($p<0.001$)).

Five leading sites of cancer deaths at Talwandi Sabo and Chamkaur Sahib were of reproductive system (breast, uterus/cervix, and ovary), leukemia /lymphoma, esophagus and skin (Table 2).

Out of the 179 'cases' selected from Talwandi Sabo (study area), 36.9% were males and, out of 129 cases from Chamkaur Sahib (reference area), 34.8% were males. The mean age of male cases was 53.5 (SD18.3) years and female cases was 52.8 (SD15.2) years at Talwandi Sabo as compared to 53.5 (SD18.5) years and 50.5(SD15.3) years respectively at Chamkaur Sahib ($p>0.05$).

The mean age of male controls was 51.9 (SD18.2) years and female controls was 48.3(SD14.9) years at Talwandi Sabo as compared to 52.8 (SD17.8) years and 47.8(SD15.3) years respectively at Chamkaur Sahib ($p>0.05$). The age and sex distribution of cases and controls is shown in table 3.

The pattern of usage of drinking water and other risk factors for cancer is shown in Table 4. The main source of drinking water among cases at Talwandi Sabo was hand pump (61.5%) followed by tap water (41.3%), while at Chamkaur Sahib 78.6% controls were using hand pump water and 23.6 % were using tap water as source of drinking water. Multiple sources were used for drinking water. At Talwandi Sabo 31.8% cases reported that the water used for various purposes including drinking was polluted, while among the controls at Chamkaur Sahib only 2.2% told about pollution ($p<0.001$). Cultivators among cases at Talwandi Sabo were 13.4% as compared to 4.4% among controls at Chamkaur Sahib (OR 3.4, 95%CI 1.4-8.5, $p<0.001$). Similar findings were noticed while comparing cases and controls of the two areas. Pesticides user in agriculture among cases at Talwandi Sabo were 17.3% as compared to 2.7% among controls at Chamkaur Sahib (OR 7.4, 95%CI 2.6-22.3, $p<0.001$) (Table 4).

**Table 2:** Five most common sites of cancer among deaths and confirmed cancer cases

| *Talwandi Sabo* | | | | *Chamkaur Sahib* | | | |
|---|---|---|---|---|---|---|---|
| Cancer | *N = 107* | | | Cancer | *N = 71* | | |
| | *Male* | *Female* | *Total* | | *Male* | *Female* | *Total* |
| Breast | 0 | 37 | 37(34.5) | Breast | 0 | 13 | 13(18.3) |
| Uterus/cervix | 0 | 22 | 22(21.2) | Uterus/cervix | 0 | 9 | 9 (12.7) |
| Leukemia / Lymphoma | 5 | 2 | 7(6.7) | Esophagus | 3 | 4 | 7(9.8) |
| Esophagus | 0 | 5 | 5(4.8) | Leukemia / Lymphoma | 4 | 2 | 6(8.5) |
| Skin | 2 | 2 | 4(3.9) | Skin | 1 | 2 | 3(4.2) |
| Ovary | 0 | 4 | 4(3.9) | Bone | 1 | 2 | 3(4.2) |
| Others | 20 | 8 | 28(26.1) | Other | 16 | 14 | 30(42.2) |

Figures in parenthesis are percentage

**Table 3:** Age and sex distribution of cases and control in study and reference area

| | *Talwandi Sabo* | | | | *Chamkaur Sahib* | | | |
|---|---|---|---|---|---|---|---|---|
| | *Cases (n = 179)* | | *Controls (n = 264)* | | *Cases (n = 129)* | | *Controls (n = 182)* | |
| | M | F | M | F | M | F | M | F |
| Children (<10 yrs.) | 1 (1.5) | 0 (0.0) | 1 (1.1) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 1 (0.8) |
| Adolescents (10-19 yrs.) | 1 (1.5) | 1 (0.8) | 3 (3.4) | 1 (0.6) | 3 (6.5) | 0 (0.0) | 4 (7.4) | 2 (1.6) |
| Adults (20-59 yrs.) | 36 (54.5) | 73 (64.6) | 51 (58.6) | 130 (73.4) | 24 (52.2) | 57 (68.7) | 28 (51.9) | 96 (75.0) |
| Elderly 60+yrs. | 28 (42.4) | 39 (34.5) | 32 (36.8) | 46 (26.0) | 19 (41.3) | 26 (31.3) | 22 (40.7) | 29 (22.7) |
| Total | 66 (36.9) | 113 (63.1) | 87 (33.0) | 177 (67.0) | 46 (35.7) | 83 (64.3) | 54 (29.7) | 128 (70.3) |

Figures in parenthesis are percentage

**Table: 4:** Pattern of usage of Drinking Water and other Risk factors among cases and controls

| *Variables* | *Talwandi Sabo* | | *Chamkaur sahib* | | *OR (95%CI)* | *P-value* |
|---|---|---|---|---|---|---|
| | *Cases* | *Controls* | *Cases* | *Controls* | | |
| | *N = 179* | *N = 264* | *N = 129* | *N = 182* | | |
| *Source of drinking water** | | | | | | |
| Hand pump | 110(61.5) | 0(0.0) | 94 (72.9) | 143(78.6) | 0.4 (0.3-0.7) | 0.0005 |
| Canal Water | 6(3.4) | 0(0.0) | 0(0.0) | 0(0.0) | - | 0.014 |
| Tap Water | 74(41.3) | 5(2.7) | 36 (27.9) | 43 (23.6) | 2.3 (1.4-3.7) | 0.0004 |
| *Perception about water pollution and usage of treated water for drinking* | | | | | | |
| Water pollution | 57(31.8) | 59(22.3) | 3 (2.3) | 4(2.2) | 20.8(7.0-69.3) | 0.0000 |
| Treated Water | 8(4.5) | 5(1.9) | 2 (1.6) | 1(0.5) | 8.5(1.1-182.4) | 0.019 |
| Cultivators | 24(13.4) | 34(12.9) | 11(8.5) | 8(4.4) | 3.4(1.4-8.5) | 0.0046 |
| Pattern of pesticide use | | | | | | |
| Pesticide user in agriculture | 31(17.3) | 37(14.0) | 5(3.9) | 5(2.7) | 7.4(2.6-22.3) | 0.0000 |
| Involved in spray | 29(16.2) | 37(14.0) | 5(3.9) | 5(2.7) | 6.8 (2.4-20.7) | 0.0000 |
| Storage of pesticide | | | | | | |
| Home | 14(7.8) | 20(7.6) | 4(3.1) | 3(1.6) | 5.1 (1.3-22.6) | 0.0117 |
| Farm | 14(7.8) | 17(6.4) | 2(1.6) | 2(1.1) | 7.6 (1.6-49.4) | 0.0044 |
| *Utensils washing after spraying* | | | | | | |
| Canal | 4(2.2) | 5(1.9) | 0(0.0) | 0(0.0) | - | 0.059 |
| Home | 2(1.1) | 1(0.4) | 1(0.8) | 0(0.0) | - | 0.245 |
| Farm | 22(12.3) | 31(11.7) | 5(3.9) | 5(2.7) | 5.0(1.7-15.3) | 0.0011 |
| *Dietary Pattern* | | | | | | |
| Vegetarian | 147(82.1) | 232(87.9) | 103(79.8) | 172(94.5) | 0.3(0.1-0.6) | 0.0004 |
| Non-vegetarian | 32(17.9) | 32(12.1) | 26(20.2) | 10(5.5) | 3.7(1.7-8.5) | 0.0005 |
| *Frequency of Spicy Food* | | | | | | |
| Not at all in last 7 day | 26(14.5) | 38(14.4) | 64 (14.4) | 12(6.6) | 2.4(1.1-5.3) | 0.022 |
| More than one day | 70(39.1) | 108(40.9) | 178 (40.2) | 109(59.9) | 0.4(0.3-0.7) | 0.0001 |
| More than three day | 10(5.6) | 19(7.2) | 29 (6.5) | 12(6.6) | 0.8(0.3-2.1) | 0.857 |
| On most days | 73(40.8) | 99(37.5) | 172 (38.8) | 46(26.9) | 2.0(1.3-3.3) | 0.0025 |
| *Tobacco use* | | | | | | |
| Smokers | 25(14.0) | 14(5.3) | 6(4.7) | 5(2.7) | 5.8(2.0-17.6) | 0.0002 |
| Chewing Tobacco | 14(7.8) | 13(4.9) | 5(3.9) | 3(1.6) | 5.1(1.3-22.6) | 0.011 |
| Passive smokers | 33(18.4) | 41(15.5) | 11(8.5) | 13(7.1) | 2.9(1.4-6.1) | 0.002 |
| *Drinking, Drug Abuse and Jaundice* | | | | | | |
| Alcohol drink | 24(13.4) | 23(8.7) | 17(13.2) | 7(3.8) | 3.9(1.5-10.2) | 0.002 |
| Drug abusers | 9(5.0) | 10(3.8) | 2(1.6) | 0(0.0) | - | 0.0016 |
| History of having Jaundice | 18(10.1) | 10 (3.8) | 9 (7.0) | 3(1.6) | 6.7(1.8-29.0) | 0.0014 |

Figures in parenthesis are percentage * Multiple sources of drinking water

**Table 5**: Area-wise Pesticides and Heavy metals in drinking water and vegetables in Talwandi Sabo and Chamkaur Sahib

| *Sample* | *Area with samples* | *March 2004* | | *April 2004* | | *May 2004* | |
|---|---|---|---|---|---|---|---|
| *Heavy Metals* | | *Detected* | *>MPL** | *Detected* | *>MPL** | *Detected* | *>MPL** |
| Tap water | Talwandi Sabo (n = 9) | Cr, Se, Hg | - | As, Ni, Se | - | As, Cd, Cr, Ni, Se, | - |
| | Chamkaur Sahib (n = 9) | As, Ni | - | As | | As, Cd, Ni, Se, Hg | - |
| Ground Water | Talwandi Sabo (n = 9) | As, Ni, Cr, Se | As, Se | As, Cr, Se | - | Cd, Cr, Ni, Se, Hg | Hg |
| | Chamkaur Sahib(n = 9) | As | - | Ni, Se | - | Cd, Ni, As, Se, Hg | - |
| Pesticides | | | | | | | |
| Tap Water | Talwandi Sabo (n = 9) | Heptachlor | Heptachlor | Heptachlor- exo and endoepoxide, Melathion, Dimethionate γ -HCH, δ-HCH | γ- HCH Melathion | Heptachlor, α - HCH, β- HCH, γ- HCH | Heptachlor |
| | Chamkaur Sahib (n = 9) | Heptachlor endoepoxide , Melathion, Dimethionate δ-HCH | - | Heptachlor-exoepoxide Melathion, Dimethionate γ -HCH, δ-HCH | - | Heptachlor, α - HCH, β- HCH, γ- HCH | - |
| Ground Water | Talwandi Sabo (n = 9) | Heptachlor | Heptachlor | Heptachlor, Heptachlor-exo and endoepoxide, , Malathion, γ -HCH, δ-HCH | Heptachlor, Melathion, γ- HCH | Heptachlor, Heptachlor-exoepoxide α -Endosulfan α-HCH, β-HCH, γ- HCH, Aldrin, Cholopyrifos | Heptachlor |
| | Chamkaur Sahib(n = 9) | Heptachlor exo and endoepoxide, Melathion, γ - HCH, δ-HCH | - | Heptachlor-exo and endoepoxide Melathion, β- HCH, γ- HCH | Melathion | Heptachlor, α - HCH, β- HCH, γ- HCH | - |
| Pesticides in Vegetables (Potato, Bottle gourd, Carrot, Round gourd, Cauliflower, Grapes, Bitter gourd) | Talwandi Sabo (n = 9) | Heptachlor, γ- HCH Chloropyrifos α-Endosulfan, Heptachlor-endoepoxide, Aldrin, Ethion | Ethion Chloropyrifos | Melathion, α-Endosulfan, Chloropyrifos, γ- HCH Phorate | Phorate Cholorpyrifos | α -HCH, γ- HCH,, Heptachlor, Malathion, Heptachlor exo and endoepoxide, Endosulphan sulphate β- endosulphan, 4, 4, DDT, Chlorophyrifos | - |
| (Cabbage, Bottle gourd, Brinjal, Potato, Capsicum) | Chamkaur Sahib (n = 9) | Heptachlor, Cholopyrifos, α - HCH, β- HCH, δ - HCH | - | Heptachlor, α endosulphan, Cholorpyrifos | Heptachlor, Cholorpyrifos | Hepatachlor, Endosulphan, β- endosulphan, Chloropyrifos, Malathion, Dieldrin | - |

MPL* (ppm) - As-0.01, Cd-0.005, Cr-0.1, Se-0.05, Hg-0.002(All in water), Heptachlor (Water)-0.00003, Melathion(Water)-0.0005, γ-HCH(Water)-0.00004, Heptachlor (Vegetables)- 0.055, Chlorpyrifos (Vegetables)-0.01, Ethion(Vegetables)-1.0, Phorate (Grapes)-0.05

At Talwandi Sabo, 16.2% cases were involved in spraying of pesticides as compared to 2.7% among controls at Chamkaur Sahib (OR 6.8, 95%CI 2.4-20.7, p<0.001). It was seen that 7.8% cases were storing pesticide at home in Talwandi Sabo as compared to 1.6% among controls at Chamkaur Sahib (OR 5.1, 95%CI 1.3-22.6). It was a common observation that people were using empty containers of pesticides for storing of most of the food items. Various pesticides i.e., monocrotofas (87%), imida super (16.1%), rogon (41.9%), endosulphan (58.0%) and ethion (70.0%) were used more often in Talwandi Sabo compared to Chamkaur Sahib. At Talwandi Sabo, 12.3% of cases were washing utensils after spraying in farm as compared to 2.7% controls at Chamkaur Sahib (OR 5.0, 95%CI 1.7-15.3) (p=0.001) (Table 4).

Number of cases taking spicy food on most of the days of the week was 40.8% at Talwandi Sabo as compared to 26.9% of the control at Chamkaur Sahib (p<0.001). Smokers among cases were 14% at Talwandi Sabo and 2.7% among controls at Chamkaur Sahib (p=0.0002). Tobacco chewing and passive stroking among cases was also higher at Talwandi Sabo as compared to controls at Chamkaur Sahib (p=0.01). Number of cases drinking alcohol in Talwandi Sabo was 13.4% as compared to 3.8% among controls in Chamkaur Sahib (P=0.001) (Table 4).

Level of As, Se, Hg in ground water at Talwandi Sabo were more than the permissible level of USEPA where as at Chamkaur Sahib the level of Se were above the permissible level. Similarly, As, Se were also above permissible level in tap water at Talwandi Sabo whereas as in Chamkaur Sahib only As levels were more than the permissible limit in tap water (Table 5).

In vegetable samples (cauliflower), the level of heptachlor (0.015ppm), heptachlor endoepoxide (0.0004ppm), α-endosulfan (0.0027ppm), chloropyrifos( 0.003ppm), α-HCH(0.0013ppm) and levels of ethion (1.68ppm) (carrot) were more in Talwandi Sabo as compared with vegetable samples (cabbage) of Chamkaur Sahib. Chloropyrifos and ethion levels were found to be above the permissible limits in vegetables and fruit samples of Talwandi Sabo. Heptachlor, aldrin and endosulfan were detected from blood samples taken from patients of cancer from Talwandi Sabo and Chamkaur Sahib. The results of our laboratory and those done for external quality assurance at ITRC Lucknow were comparable.

## Discussion

Age adjusted prevalence of confirmed cancer cases was significantly higher at Talwandi Sabo as compared to reference area (p<0.001). Cancer incidence rate are better measure in cancer studies than the prevalence. However, due to the lack of the cancer registry in the region, prevalence was used in this study. However, to overcome this shortcoming, age adjusted death rates for the last 10 years were compared in study and reference area. Age adjusted cancer death rate per 1,00,000 per year at Talwandi Sabo was 51.2 as compared to 30.3 in the reference area of Chamkaur Sahib. The age adjusted cancer death rate at Talwandi Sabo was higher than that of Barshi (38.4), a rural cancer registry in Maharashtra state [4] whereas the rates at Chamkaur Sahib were lower.

It was observed that most of the risk factors like participation in cultivation, usage of pesticides, spraying and storage of pesticides, consumption of non-vegetarian and spicy food, alcohol consumption, tobacco use, and drug abuse were significantly more common among cases and controls in Talwandi Sabo as compared to the controls of Chamkaur Sahib. This shows that controls are also at a higher risk of development of cancer in future as prolonged exposure is required for the same.

Cancer of female reproductive system, i.e., breast, uterus/cervix and ovary were more common in Talwandi Sabo whereas cancer of blood & lymphatic system, esophagus, and bones were more common in Chamkaur Sahib Block. As per the National Cancer Registry Program of Indian Council of Medical Research, there has been a lot of regional variation of cancer incidence in India [3]. Overall, among males, cancer of the lung is most common. It is the leading site in Delhi, Mumbai and Bhopal, second and third leading site among males in Bangalore and Chennai respectively. Another site of cancer associated with the use of tobacco, namely, cancer of the esophagus is an important leading site in both males and females. Cancer sites in Talwandi Sabo and Chamkaur Sahib are also comparable to the pattern found in Bathinda and Roop Nagar districts as per recently published Atlas of Cancer in India [5].

Age, sex and socio-economic status are well known risk factors of cancer. Therefore, these factors were kept similar in the cases and controls by selecting age and sex matched controls in the same village as that of the case. To find out the factors, which are different in the two areas, i.e., higher cancer prevalence (Talwandi Sabo) and lower cancer prevalence (Chamkaur Sahib), the risk factors in cases of Talwandi Sabo were compared with controls of the Chamkaur Sahib. Cultivators were more common in Talwandi Sabo as compared to Chamkaur Sahib. It was found that usage of pesticides, involvements in spraying, storage of pesticides in homes and farms were significantly more common in Talwandi Sabo area compared to the controls in reference population which has been highlighted by others also. Talwandi Sabo is the part of cotton belt of Malwa region of Punjab where there is very high use of pesticides. It was reported by farmers that they were using 30-35 pesticides spray for a single cotton crop as against 8-10 recommended by agriculture experts. Acute occupational exposure for pesticides among sprayers was also high as they occasionally use protective devices while spraying. Residents of the area were also using empty pesticide containers for storing food items. There are reports of widespread contamination of diet, liquid milk and butter with pesticide residues from Punjab [6-8]. A study conducted in cotton-growing area of Bathinda to see the chronic effects of pesticides among

rural children on the ability to perform developmental task has shown that in more than 80% children exposed to pesticides performed significantly worse than the less exposed children of Anandpur Sahib of Ropar [9].

Consumption of non-vegetarian food like chicken, mutton, fish and egg was significantly higher in cases of Talwandi Sabo (17.9%) in comparison with controls of Chamkaur Sahib (5.5%). Similar results were noticed while comparing controls in both areas respectively. Taking spicy foods on most of the days were more common at Talwandi Sabo as compared to Chamkaur Sahib. A study carried out in the Indian diet has mentioned that there is a role of spices and food additives in causation of cancer [10]. Similarly a hospital based case control study done at Dibrugarh had found that consumption of very spicy foods, hot foods and beverages, high amounts of chili, and leftover food was positively associated with the risk of esophageal cancer [11]. However a hospital-based case-control study conducted in Coimbatore, South India found that consumption of spicy, fried foods and salted fish did not contribute to the risk of cancer but the consumption of pickles did [12].

The proportion of people drinking alcohol in Talwandi Sabo was higher as compared to those in Chamkaur Sahib ($p<0.002$). It has been estimated by Guenel et al that alcohol drinking increases the risk of breast cancer in women by approximately 7% for each increment of 10 g alcohol per day [13]. It was noticed that smoking (14%), chewing tobacco (7.8%) and passive smoking (18.4%) were higher in Talwandi Sabo than Chamkaur Sahib ($p<0.002$). A hospital-based case-control study conducted among southern Indian patients suggests an association of cancer esophagus with smoking, alcohol and betel nut chewing, similar to reports from other parts of the country and the world [12].

It was shown that the level of heptachlor, a known carcinogen that is now banned in India were higher in samples of tap water in Talwandi Sabo as compared with Chamkaur Sahib[14]. A similar study carried out by Quintana et al in USA found that the highest quartile level of organochlorines were also associated with elevated Non Hodgkin lymphoma risk (OR 2.7) [15]. Mills et al in United Farm Workers of America had shown that risk of prostate cancer was increased with specific chemicals, including simazine, lindane, heptachlor and suggestive increases were observed with dichlorvos.

A comparison of Talwandi Sabo and Chamkaur Sahib shows that heavy metals like arsenic (0.015 ppm), selenium (0.09 ppm) and mercury (0.004 ppm) were above the permissible level. A study carried out by Dixit et al in industrial area of Delhi has shown that the levels of manganese, copper, selenium and cadmium were found marginally above the Indian Standards (IS) in groundwater supply [16]. A study carried out in Orsk city of Russia found that the high carcinogenic risk is associated with arsenic in water [17]. Similarly a study conducted by University of California recommended that developing countries with large populations exposed to arsenic should be advised to keep their arsenic drinking water standards at 50 µgm/l [18]. A study carried out in London observed that long-term exposure to arsenic in drinking water is mainly related to increased risks of skin cancer and also some other cancers [19].

In vegetable samples (cauliflower) level of heptachlor, heptachlor endoepoxide, α-endosulfan, α-HCH, and levels of ethion (1.85ppm) (carrot) and chloropyrifos (0.027 ppm), were more in Talwandi Sabo. A study conducted at Kanpur has also identified the problem of pesticide residues in fresh winter vegetables [20]. The pesticides and heavy metals have entered into food chain and thereby in human body of this population.

In conclusion, the cancer cases and deaths are higher in Talwandi Sabo block probably due to a cocktail of risk factors which were more common use of tobacco and alcohol, consumption of non-vegetarian and spicy food, high levels of heavy metals in water, and excessive pesticides use. It is difficult to pin point a single cause as cancer is caused by multiple factors. Therefore, a multi-pronged strategy to provide safe water supply, discouraging the indiscriminate use of pesticides, tobacco and alcohol is recommended. A cancer registry should be established in the area to see the trend of different cancers in the area.

**Recommendations**

It is recommended that Agriculture Department should educate people involved in agriculture about pesticide storage, use, and proper disposal of the empty pesticide containers. Steps should be taken so that pesticides are used judiciously and safely. Public Health Department should monitor the level of pesticides and heavy metals in drinking water periodically and monitoring reports should be communicated to Director, Health Services, Punjab for necessary action. Local Health Authority designated by Health Department under the Prevention of Food Adulteration Act should monitor the level of pesticides and heavy metals in food. Medical colleges/institutions should set up a cancer registry in the high risk areas of the state for monitoring the trend of cancer cases and should also for enhanced provision of screening, diagnosis and treatment facilities for cancer cases. Health Department should start a Non-Communicable Diseases Control Program focused on behavior change communication so as to change the harmful life styles, i.e. tobacco, alcohol, and other substance abuse. A comprehensive study of the status of environmental health in other cotton growing areas of Punjab should be conducted.

**Acknowledgments:** Authors are grateful to Mr. Malwinder Singh, Member Secretary, Punjab Pollution Control Board, Patiala for his guidance. We also express our sincere thanks to Prof. BD Gupta, Former Professor and Head, Department of Radiotherapy, PGIMER, Chandigarh, Dr. GL Goel, Director Health Services, Punjab and Mr. Manmohanjit Singh, Chief Engineer, Public Health, Punjab, and all members of Technical

Expert Committee of this project for their guidance and critical review of the project We express our thanks to Dr. K. S. Sandhu, Director, Punjab Post Harvest Technology Centre, Punjab Agriculture University, Ludhiana for laboratory support and Dr. Jai Raj Behari Scientist (F), IRTC, Lucknow for external quality assurance for laboratory samples.

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