INTRODUCTION

National-level cancer data have never been published from Pakistan. Cancer statistics outlined in the Globocan-2018 report for Pakistan are extracted from the Punjab Cancer Registry (PCR), which being a provincial registry, does not represent national level cancer numbers. Establishment of the National Cancer Registry (NCR) at the Pakistan Medical Council (now called the Pakistan Health Research Council) during 1970s was a commendable step by the Government of Pakistan. Another notable regional cancer registry was the Karachi
Cancer Registry (KCR), that was established during mid-1990s and published several reports describing cancer burden for the region of Karachi South (1/6 district regions of Karachi). However, after the demise of KCR founder, Dr. Yasmin Bhurgri, the KCR largely became non-functional until recently when it was revived by contribution from some of the major stake holders (including the Dow Cancer Registry) of cancer diagnostics and registration in the city. The revived KCR has recently started data collection and is in the process of publishing its first report. Despite these commendable regional efforts, there are high chances that many of the cancer patients are not even registered in Pakistan due to absence of an effective national level cancer registration system. It is therefore extremely important to regularly generate good quality regional cancer data.

With this context, we established the Dow Cancer Registry at the largest public-sector diagnostic & reference laboratory of Karachi – the Dow Labs. Our cancer registry registers patients/samples from all over the city via the Dow labs which has >25 collection points distributed throughout the city. Cancer data presented herein are therefore large-scale high quality regional data representative of all districts of Karachi (~17.4 million).

This report details cancer burden in Karachi during 2010-2019. These large-scale data will therefore significantly contribute/reflect towards identifying cancer burden in Karachi and will facilitate policy makers to devise appropriate strategies regarding cancer prevention and control in Karachi, Pakistan.

RESULTS

A total of 22,858 cancers were registered during the 10-year period from January 1, 2010 through to December 31, 2019. Of these, a total of 13,746 (60.1%) were diagnosed in females and 9,112 (39.9%) were diagnosed in males. Age wise, 97.4% cancers were diagnosed in adults while 2.6% cancers were diagnosed in children/young adults. Frequencies, percentages and ASR for all cancers in both genders and all ages are shown in Table-I. ASR of top five cancer sites in males and females are shown in Fig.1B and Fig.1C respectively. Overall (in both genders, all ages), breast cancer was the most common cancer (31.8% of all cancers) followed by cancers of lip and oral cavity (19.2%), oesophagus (5.8%), colorectum (7.0%) and non-melanoma skin cancers (NMSC) (6.9%).

In adult males, the most frequently diagnosed cancer was the cancer of lip and oral cavity (33.6% of male cancers), followed by NMSC (7.2%), oesophagus (6.8%), colorectum (6.7%), and cancer of stomach (4.9%) (Table-II). In adult females, breast cancer was the most common cancer (31.8% of all cancers) followed by cancers of lip and oral cavity (19.2%), oesophagus (5.8%), colorectum (7.0%) and NMSC (6.9%).

In children/young adults, the most frequently diagnosed cancer was breast cancer (53.2%), followed by cancers of lip and oral cavity (19.2%), oesophagus (5.8%), colorectum (3.3%) and NMSC (3.0%).
**Cancer patterns in Karachi**

Table-I: Frequency, percentages and age standardized incidence rates (ASR) of malignancies in males and females (all ages) in Karachi, 2010-2019 (N=22858).

| Site                              | Both Gender | Male | Female | ASR World |
|-----------------------------------|-------------|------|--------|-----------|
|                                   | ICD-10      | n    | %      | ASR       | n    | %      | ASR       | n    | %      | ASR       |
| Breast                            | C50         | 7270 | 31.8   | 46.2      | 73   | 0.8    | 0.9       | 7197 | 52.4   | 98.7      | 46.3   |
| Lip and oral cavity               | C00-06      | 4400 | 19.2   | 28.0      | 2986 | 32.8   | 35.4      | 1414 | 13.5   | 19.4      | 4.0    |
| Oesophagus                        | C15         | 1319 | 5.8    | 8.4       | 599  | 6.6    | 7.1       | 720  | 5.2    | 9.9       | 6.3    |
| Colorectum                        | C18-20      | 1094 | 4.8    | 7.0       | 625  | 6.9    | 7.4       | 469  | 3.4    | 6.4       | 19.2   |
| NMSC                              | C44         | 1078 | 4.7    | 6.9       | 656  | 7.2    | 7.8       | 422  | 3.1    | 5.8       | 10.1   |
| Stomach                           | C16         | 652  | 2.9    | 4.1       | 433  | 4.8    | 5.1       | 219  | 1.6    | 3.0       | 11.1   |
| Larynx                            | C32         | 538  | 2.4    | 3.4       | 400  | 4.4    | 4.7       | 138  | 1.0    | 1.9       | 2.0    |
| Lung                              | C34         | 496  | 2.2    | 3.2       | 374  | 4.1    | 4.4       | 122  | 0.9    | 1.7       | 22.5   |
| NHL                               | C82-85      | 487  | 2.1    | 3.1       | 294  | 3.2    | 3.5       | 193  | 1.4    | 2.6       | 5.7    |
| Liver                             | C22         | 458  | 2.0    | 2.9       | 257  | 2.8    | 3.0       | 201  | 1.5    | 2.8       | 9.3    |
| Corpus uteri                      | C54         | 384  | 1.7    | 2.4       | 0    | 0.0    | -         | 384  | 2.8    | 5.3       | 8.4    |
| Brain, nervous system             | C70-72      | 362  | 1.6    | 2.3       | 222  | 2.4    | 2.6       | 140  | 1.0    | 1.9       | 3.5    |
| Ovary                             | C56         | 338  | 1.5    | 2.1       | 0    | 0.0    | -         | 338  | 2.5    | 4.6       | 6.6    |
| Hodgkin's lymphoma                | C81         | 289  | 1.3    | 1.8       | 186  | 2.0    | 2.2       | 103  | 0.7    | 1.4       | 1.0    |
| Urinary bladder                   | C67         | 253  | 1.1    | 1.6       | 194  | 2.1    | 2.3       | 59   | 0.4    | 0.8       | 5.7    |
| Prostate                          | C61         | 242  | 1.1    | 1.5       | 242  | 2.7    | 2.9       | 0    | 0.0    | -         | 29.3   |
| Small intestine                   | C17         | 236  | 1.0    | 1.5       | 140  | 1.5    | 1.7       | 96   | 0.7    | 1.3       | X      |
| Thyroid                           | C73         | 215  | 0.9    | 1.4       | 53   | 0.6    | 0.6       | 162  | 1.2    | 2.2       | 6.7    |
| Cervix uteri                      | C53         | 175  | 0.8    | 1.1       | 0    | 0.0    | -         | 175  | 1.3    | 2.4       | 13.1   |
| Salivary gland                    | C07-08      | 148  | 0.6    | 0.9       | 90   | 1.0    | 1.1       | 58   | 0.4    | 0.8       | 0.6    |
| Nasopharynx                       | C11         | 146  | 0.6    | 0.9       | 95   | 1.0    | 1.1       | 51   | 0.4    | 0.7       | 1.5    |
| Pharynx                           | C9-10       | 143  | 0.6    | 0.9       | 100  | 1.1    | 1.2       | 43   | 0.3    | 0.6       | 2.0    |
| Bone                              | C40-41      | 139  | 0.6    | 0.9       | 81   | 0.9    | 1.0       | 58   | 0.4    | 0.8       | X      |
| Anal Canal                        | C21         | 134  | 0.6    | 0.9       | 84   | 0.9    | 1.0       | 50   | 0.4    | 0.7       | 0.5    |
| Omentum, mesentry                 | C48         | 130  | 0.6    | 0.8       | 38   | 0.4    | 0.5       | 92   | 0.7    | 1.3       | X      |
| Gall bladder                      | C23-24      | 128  | 0.6    | 0.8       | 39   | 0.4    | 0.5       | 89   | 0.6    | 1.2       | 2.3    |
| Testis                            | C62         | 81   | 0.4    | 0.5       | 81   | 0.9    | 1.0       | 0    | 0.0    | -         | 1.7    |
| Pancreas                          | C25         | 48   | 0.2    | 0.3       | 27   | 0.3    | 0.3       | 21   | 0.2    | 0.3       | 4.8    |
| Melanoma of skin                  | C43         | 44   | 0.2    | 0.3       | 26   | 0.3    | 0.3       | 18   | 0.1    | 0.2       | 3.1    |
| Others                            | -           | 1431 | 6.3    | 9.1       | 717  | 7.9    | 8.5       | 714  | 5.2    | 9.8       | -      |
| Total (all sites including NMSC)  | -           | 22858| 145.4  | 9112      | 108.0| 13746 | 188.6     | 197.9|
| Total (all sites excluding NMSC)  | -           | 21780| 138.5  | 8456      | 100.3| 13324 | 182.8     | 187.8|

* not reported in the Globocan 2018.
nervous system (15.3%), followed by Hodgkin’s lymphoma (14.2%), colorectal carcinoma (8.1%), cancers related to endocrine and related organs (8.0%) and Non Hodgkin’s lymphoma (7.8%).

We also compared our data with cancer numbers from the (old) Karachi Cancer Registry, Pakistan-Energy-Commission (PAEC); 2015-2017, and the Punjab Cancer Registry during; 2014-2018 (Table-II). While our data, by-enlarge, show patterns similar to other regional reports from Karachi, there were considerable differences compared to data from Punjab, particularly the very high burden of cancers of lip and oral cavity in Karachi.

**DISCUSSION**

Overall, we report breast cancer as the most common cancer in both genders with cancer of the lip and oral cavity as the most common cancer in males and second most common cancer in females. High prevalence of cancers of lip and oral cavity in Pakistan has been reported from other regional reports as well.\(^6,8,12-15\)

Alarmingly, we report highest ASR of cancers of lip and oral cavity in males of Karachi compared to any other city of Pakistan. Notably, many of the patients with oral cancers have chronic history of tobacco consumption,\(^16\) which takes several different forms including (1) smoking in the form of “cigarettes”, “shisha” (tobacco smoking with a tube immersed in fragrant liquid, “bidi” (dried rolled tobacco leaves) (2) chewing in the form of “betel quids” (paan), “beetle-nuts”, “naswar” (moist powdered tobacco kept in mouth for several hours) and “gutka” (mixture of various things including areca nuts, lime, paraffin wax, tobacco and catechu). Of these, consumption of gutka and naswar is very high in Karachi as compared to other cities of Pakistan.\(^17\) These are kept in mouth for several hours, thus exposing the mucosa to the chemicals and thus increased chances of developing oral submucosal fibrosis and oral cancers.\(^18\) Importantly, knowledge regarding the detrimental effects of smokeless tobacco is poor in Karachi.\(^19\) Therefore, relevant intervention by concerned authorities can play a vital role in controlling this preventable cancer.

Breast cancer was the most common malignancy in females and these findings are in line with other national and international reports.\(^3,13-15\) While breast cancers are by and large non-preventable, various socioeconomic factors such as increased use of contraceptives, lack of breastfeeding, and obesity...
Table-II: Comparison of percentages amongst Dow Cancer Registry data (2010-2019) and other regional registries in Pakistan.

| Site                  | ICD-10- | Dow Cancer Registry | Karachi Cancer Registry | PAEC | Punjab Cancer Registry |
|-----------------------|---------|---------------------|-------------------------|------|------------------------|
|                       | 2010-2019 | 1995-1997 | 1998-2002 | 2015-2017 | 2014-2018 |
| ADULT MALES           | n=8781 | n=2160 | n=14021 | n=12208 |
| Lip and oral cavity   | C00-06 | 33.6 | 10.0 | 22.5 | 25.9 | 8.2 |
| NMSC                  | C44    | 7.2  | -   | -   | -   | -   |
| Oesophagus            | C15    | 6.8  | 4.4 | 6.3  | -   | -   |
| Colorectum            | C18-20 | 6.7  | 3.9 | 7.8  | 5.6  | 7.2 |
| Stomach               | C16    | 4.9  | 2.8 | 6.0  | -   | -   |
| Larynx                | C32    | 4.5  | 5.8 | 11.8 | 4.6  | -   |
| Lung                  | C34    | 4.2  | 12.6 | 25.5 | 8.2  | 7.8 |
| NHL                   | C82-85 | 3.0  | 4.6 | -   | 3.7  | 7.4 |
| Liver                 | C22    | 2.9  | 3.7 | 5.3  | 8.1  | 5.4 |
| Prostate              | C61    | 2.7  | 3.1 | 9.8  | 3.2  | 8.5 |
| ADULT FEMALES         | n=13487 | n=2108 | n=14732 | n=16549 |
| Breast                | C50    | 53.2 | 33.1 | 69.1 | 32.2 | 45.0 |
| Lip and oral cavity   | C00-06 | 10.4 | 8.0 | 20.4 | 11.4 | 3.9 |
| Oesophagus            | C15    | 5.3  | 3.4 | 8.6  | 4.5  | -   |
| Colorectum            | C18-20 | 3.3  | 3.1 | 5.2  | 3.1  | 3.6 |
| NMSC                  | C44    | 3.0  | -   | -   | -   | -   |
| Corpus uteri          | C54    | 2.8  | 3.1 | 5.0  | 3.2  | 4.4 |
| Ovary                 | C56    | 2.3  | 6.5 | 7.8  | 5.3  | 4.2 |
| Stomach               | C16    | 1.6  | 1.7 | 4.0  | -   | -   |
| Liver                 | C22    | 1.5  | 2.0 | 4.0  | -   | 2.6 |
| NHL                   | C82-85 | 1.3  | 2.3 | -    | 2.7  | 2.3 |
| CHILDREN & YOUNG ADULTS | n=590 | n=2126 |
| Brain, nervous system | C70-72 | 15.3 | -   | -   | -   | 12.6 |
| Hodgkin’s lymphoma    | C81    | 14.2 | -   | -   | -   | 9.9 |
| Colorectum            | C18-20 | 8.1  | -   | -   | -   | -   |
| Endocrine & related organs | C74-75 | 8.0  | -   | -   | -   | 4.9 |
| Non-Hodgkin’s lymphoma| C82-85 | 7.8  | -   | -   | -   | 8.9 |
| Orbit                 | C69    | 7.5  | -   | -   | -   | 3.6 |
| Bone                  | C40-41 | 5.6  | -   | -   | -   | 4.9 |
| Lip and oral cavity   | C00-06 | 5.3  | -   | -   | -   | -   |
| Breast                | C50    | 4.4  | -   | -   | -   | -   |
| Ovary                 | C56    | 3.7  | -   | -   | -   | 3.9 |

*adult and paediatric population were not analyzed separately in these reports.
are known risk factors.\textsuperscript{20} Moreover, genetic factors, such as BRCA1 and BRCA2 mutations, have been identified in Pakistani patients.\textsuperscript{21} Nevertheless, detailed epidemiological and mechanistic investigations are scarce to delineate risk factors for breast cancer pathogenesis in Pakistan.

Oesophageal cancer was amongst the top cancers in both genders. This is consistent with our previously published report.\textsuperscript{8} High burden of oesophageal cancer has been previously reported in Quetta city of Pakistan which is in close proximity to Iran – one of the cities in the well-defined “Asian-oesophageal-cancer-belt” (Iran, Iraq, Turkey, USSE, China and Mongolia).\textsuperscript{22} Oesophageal cancer was also very common in Afghan population coming to PAEC for their treatment.\textsuperscript{15} It needs to be investigated if there is an increasing trend of consuming dietary risk factors for oesophageal carcinoma including alcohol, hot beverages, smoked meet (BBQ) in Pakistan.

Colorectal cancer was amongst the most commonly detected cancers in both genders. This is consistent with our previous report and other regional reports.\textsuperscript{8,13-15} While this cancer has traditionally been prevalent in developed countries, its high prevalence in Pakistan is alarming and may have been caused by increasing adaptation to westernized diet and life style in Pakistan.\textsuperscript{23}

We report non melanoma skin cancers (NMSCs) amongst the top cancers in both genders in Karachi. Since Karachi is located nearer to the equator (latitude 24.8ºN and longitude 67.1ºE) as compared to other parts of Pakistan, it is possible that its proximity to the equator imposes higher risk of developing skin cancers in Karachi.\textsuperscript{24} Another major risk factor could be increased production of hydochlorofluorocarbons (HCFC), leading to accelerated depletion of ozone as indicated by very high HCFC consumption that increased from 18.5 ODP metric tons in the year 1995 to 239.8 ODP metric tons in the year 2014, indicating a very high annual growth rate of 71.7%.\textsuperscript{25}

Comparison with other regional registries show that cancer profile from registry is by and large similar to the other regional reports. However, there were some noticeable differences from Punjab Cancer Registry, particularly the high burden of cancers of lip and oral cavity in Karachi.

In summary, we report high-quality, regional cancer data representing all districts of Karachi. High frequency of preventable cancers demands serious attention by relevant authorities to improvise the existing cancer control in the country.

\textbf{Limitations of the study:} While our data are representative of Karachi population, an unavoidable limitation could be a large number of cancer patients registering at other oncology/diagnostic centers of Karachi. This necessitates regular reporting of cancer data from all major stake holders to depict near-true picture of cancer burden in the city.

\textbf{Recommendations:} Effective national level cancer registration system should be formulated by relevant authorities in order to delineate true picture of cancer incidence, prevalence and mortality in Pakistan. Moreover, government of Pakistan should take appropriate steps to discourage/ban use of various forms of tobacco to prevent/control tobacco-associated cancers in the country.

\textbf{CONCLUSION}

Cancers of lip and oral cavity and breast cancer were the most common malignancies in males and females respectively. In children/young adults, cancers of brain and nervous system were the commonest malignancy. Alarming, Karachi males have highest ASR of cancers of lip and oral cavity compared to any other city of Pakistan.

\textbf{Conflict of Interest:} None declared.

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Authors’ Contribution:

MAQ: Founder of the cancer registry described. Conception of idea, execution and management of the whole project. Data indexation, analyses, manuscript drafting and is responsible for integrity of the study.

SK: Data indexation, analyses, manuscript drafting and proof reading of the manuscript.

SS, MSQ: Facilitation and Monitoring of data indexation, drafting and proof reading of manuscript.

All authors read and agreed to the final version of the manuscript.