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A Prospective Observational Study of Drug Related Problems in Oncology Department

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ABSTRACT

This prospective observational descriptive study aimed to assess drug-related problems among in-patients in the oncology department of a superspeciality hospital. A total of 151 patients were evaluated, with data obtained from case sheets. The study identified various drug-related issues, including potential drug interactions (total=148; major=22, moderate=86, minor=40), medication errors (total=41), and adverse effects (total=252; vomiting=91, nausea=74, fever=44, abdominal pain=12, total blood count decrease=7, weakness=7, constipation=6, cough=4, hyperglycemia=2, eczema=2, throat pain=1). These findings underscore the importance of identifying and addressing drug-related problems in long-term hospitalized patients, particularly in oncology settings where the consequences can be severe. The outcomes of this study provide valuable insights for clinicians to enhance patient care and therapeutic outcomes, ultimately reducing mortality associated with drug-related complications.

Keywords: potential drug interactions, medication errors, adverse effects

INTRODUCTION:

Cancer is a disease marked by the uncontrolled growth of cells that can invade and spread to other parts of the body[1]. It can begin in almost any tissue in the body, which is composed of trillions of cells. Normally, cells grow and divide as needed, replacing old or damaged ones through a regulated process. However, cancer occurs when genetic mutations cause cells to grow and divide uncontrollably, bypassing the usual regulatory mechanisms[2].

A drug-related problem (DRP) refers to any issue related to medication that interferes with achieving desired health outcomes or causes harm[3]. The increasing complexity of modern drug therapies has made addressing DRPs critical, as proper medication management has become more challenging[4-6]. Unresolved or unnoticed DRPs can result in severe complications or even death[7]. Furthermore, DRPs can contribute to hospitalizations, emergency department visits, long-term care admissions, additional consultations, and prescriptions. This makes DRPs a significant source of economic burden[8].

The incidence of cancer has steadily risen due to factors such as an aging population, lifestyle changes, and advances in diagnostic techniques. For instance, in the Netherlands, 95,456 new cancer cases were recorded in 2010, reflecting a 3.3% increase from the previous year and a 35% rise over the past decade[9]. Age is a significant factor in cancer diagnosis, with 42% of new cases in 2010 found in people aged 60 to 75. As individuals age, the risk of developing cancer increases due to prolonged exposure to carcinogens and accumulated genetic mutations. Additionally, aging diminishes the body's ability to repair cellular damage, further elevating cancer risk[9]. This growing burden of cancer in older populations emphasizes the need for specialized care, early detection, and expanded research and treatment resources[9].

For cancer patients, particularly the elderly, meticulous medication monitoring is essential. Many older adults take multiple drugs to manage chronic conditions such as hypertension, diabetes, or heart disease. This practice, known as polypharmacy, raises the likelihood of DRPs, especially when combined with potent cancer therapies[10]. Treatments like chemotherapy and targeted therapies have narrow therapeutic windows, meaning even small changes in dosage can cause reduced efficacy or increased toxicity. Additionally, supportive medications—such as anti-nausea drugs, pain relievers, and immune boosters—are often prescribed

alongside cancer treatments. This increases the risk of drug interactions, where combinations of medications may cause unintended effects or altered effectiveness[11].

Cancer patients also face challenges in drug metabolism due to factors such as poor nutrition, low protein levels, swelling, or liver and kidney impairments, which further heighten the risk of drug interactions[11]. Research indicates that 20-30% of harmful drug reactions stem from drug interactions, affecting 18-58% of cancer patients[12-14]. Monitoring drug interactions is therefore vital to ensuring both the effectiveness and safety of cancer treatments, especially in older and medically complex patients.

LITERATURE REVIEW:

Woda et.al[1]: This book chapter provides a basic introduction to cancer pathology for those without specialized oncology training, offering essential insights into the nature of cancer.

Chu et.al[2]:This chapter explains cancer chemotherapy, including its pharmacology and clinical use, as part of a pharmacology textbook.

Suzuki et.al[3]: This article reviews recent progress in p53 research and its effects on cancer treatment, highlighting the significance of the p53 tumor suppressor protein.

Rashed et.al[4]: This study investigates medication-related issues in pediatric patients in Hong Kong, highlighting the challenges faced in managing medications for children.

Rashed et.al[5]: This research investigates drug-related issues in hospitalized children in the UK and Saudi Arabia, offering insights into the epidemiology and risk factors across different healthcare settings.

Blix et.al[6]: This article focuses on the characteristics of drug-related problems discussed by hospital pharmacists, highlighting the role of pharmacists in multidisciplinary teams in addressing medication issues.

Ibrahim et.al[7]: This study investigates drug-related problems in children with chronic kidney disease, providing valuable information on medication management in this specific pediatric population.

Lassetter et.al[8]: This literature review addresses medical errors, drug-related problems, and medication errors, with a focus on quality of care and cost issues in nursing.

Einarson et.al[9]: This article reviews drug-related hospital admissions, examining the causes and consequences of such admissions and their impact on healthcare.

Association of Comprehensive Cancer Centers[10]: This is a database providing information on Dutch cancer registration, useful for epidemiological studies and cancer research in the Netherlands.

Beijnen et.al[11]: This review article discusses drug interactions in oncology, focusing on the complexities of managing drug interactions in cancer treatment.

Riechelmann et.al[12]: This study looks at potential drug interactions and duplicate prescriptions among cancer patients, shedding light on medication management issues in oncology.

Voll et.al[13]: This article explores potential drug-drug interactions between anticancer agents and medications dispensed by community pharmacies, highlighting the need for careful medication management.

Van Leeuwen et.al[14]: This prevalence study uses advanced screening methods to identify potential drug interactions in cancer therapy, contributing to the understanding of drug interaction risks in oncology.

AIM OF THE STUDY:

The Aim of the study is to evaluate the incidence of drugs in inpatients of the oncology department.

To assess the drug-related problems like

- Drug Interactions,
- Medication errors,
- Adverse Drug Reactions.

METHODOLOGY:

- **Study design:** This is a prospective observational, descriptive study where data will be gathered as patients undergo their usual medical care. The prospective design means information is collected over time without altering patient treatment. Since the study is observational, researchers will not intervene in patient care, only recording data as it naturally occurs. The descriptive focus is on thoroughly documenting patient demographics, clinical characteristics, and other key aspects relevant to the study population.

- **Source of data:** The primary data will come from patient case sheets, which provide detailed clinical information, including diagnoses, treatment plans, and demographic details. Data will be obtained from records at Manipal Hospitals, Tadepalli, while ensuring confidentiality in line with ethical guidelines. Key clinical details such as cancer type, treatment methods, disease progression, patient demographics (age, gender), and any existing comorbidities will be extracted for the study.

- **Study site:** The study was conducted at a single center, Manipal Hospitals, Tadepalli. This site provides access to a diverse patient population, allowing for a comprehensive analysis of cancer patients diagnosed and treated at this hospital. All departments involved in cancer treatment, such as oncology, radiology, surgery, and palliative care, will be included to ensure a well-rounded collection of data.

- **Study duration:** The study was conducted for 6 months, with continuous data collection throughout this period. This duration enables the accumulation of a sufficient number of cases and data to track the natural progression of treatment and clinical outcomes in cancer patients.

- **Sample size:** The target sample size for this study was between 100 and 150 patients, diagnosed with various types of cancer. The chosen sample size is designed to provide enough data for meaningful statistical analysis, while remaining feasible given the study duration and site constraints.

- **Inclusion criteria: Cancer Diagnosis**:

All patients included in the study must have a confirmed diagnosis of cancer, as per the hospital's diagnostic criteria. This ensures that the study population is relevant to the research objectives.

Adult Patients (Optional):
If applicable, the study may restrict inclusion to adult patients (e.g., ≥ 18 years), depending on the hospital's patient demographics and the research focus.

- **Exclusion criteria: No Cancer Diagnosis**:

Patients without a confirmed cancer diagnosis will be excluded, ensuring the study focuses solely on individuals diagnosed with cancer.

Inability to Provide Complete Data:
Any patients whose medical records are incomplete or who are lost to follow-up during the study period may be excluded from the final analysis.

RESULTS:

During the study period we have observed 441 drug related problems in 151 subjects. Out of 441 Drug related problems 148 drug interactions, 41 medication errors, 252 adverse effects.

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TABLE 1 SHOWING DISTRIBUTION OF DRUG RELATED PROBLEMS:

pDDI	MEDICATION ERRORS	ADVERSE EFFECTS	TOTAL
148	41	252	441

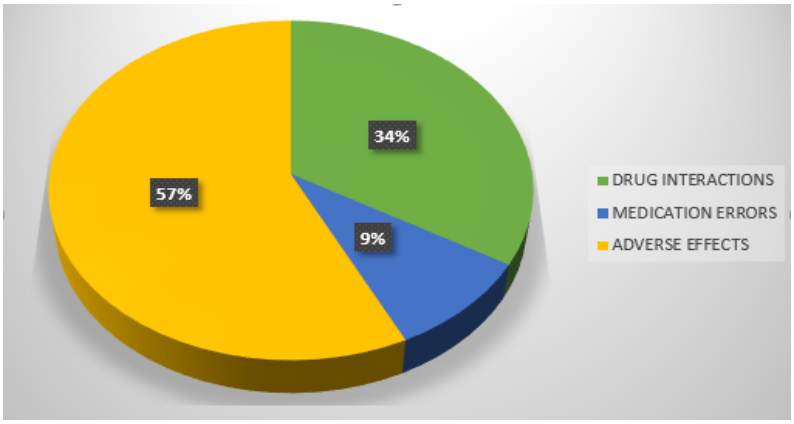

Fig.1 PIE CHART SHOWING DISTRIBUTION OF DRUG RELATED PROBLEMS:

TABLE 2 SHOWING AGE AND GENDER DISTRIBUTION:

LIFE STAGE	MALE(n=58)	FEMALE(n=93)	TOTAL(n=151)
Non-Geriatrics (<55Y)	18	33	51(33.774%)
Geriatrics (>55Y)	40	60	100(66.225%)
Total	58	93	151

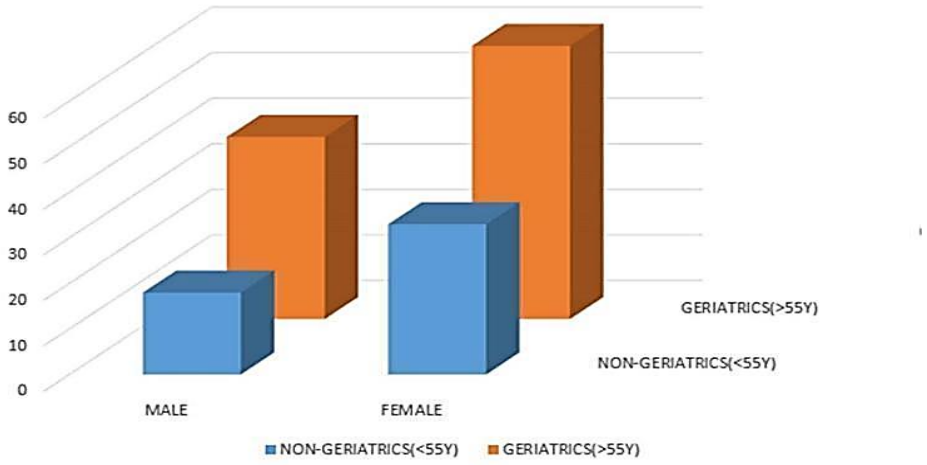

Fig.2 COLUMN CHART SHOWING AGE AND GENDER DISTRIBUTION

TABLE 3 SHOWING CASE DISTRIBUTION BASED ON TYPE OF MALIGNANCY:

CANCER TYPE	NUMBER (n=151)	PERCENTAGE(%)
Solid Malignancy	80	52.98
Hemato Malignancy	71	47.01
Total	151	100

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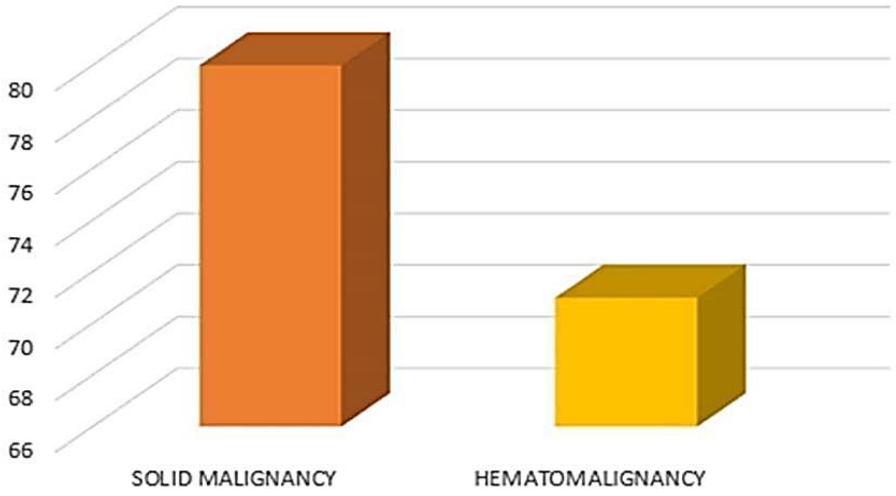

Fig.3 COLUMN CHART SHOWING CASE DISTRIBUTION BASED ON TYPE OF MALIGNANCY

TABLE 4 SHOWING TYPES OF SOLID MALIGNANCY

CANCER	NUMBER (n=151)	PERCENTAGE (%)
Carcinoma Kidney	08	5.29
Carcinoma Ovary	17	11.25
Carcinoma Endometrium	04	2.64
Carcinoma Stomach	07	4.63
Carcinoma Cervix	06	3.97
Carcinoma Esophagus	01	0.66
Carcinoma PostCricoid	02	1.32
Chondrosarcoma	01	0.66
Carcinoma Thyroid	01	0.66
Carcinoma Palate	01	0.66
Carcinoma Jejunum	01	0.66
Breast Cancer	31	20.52

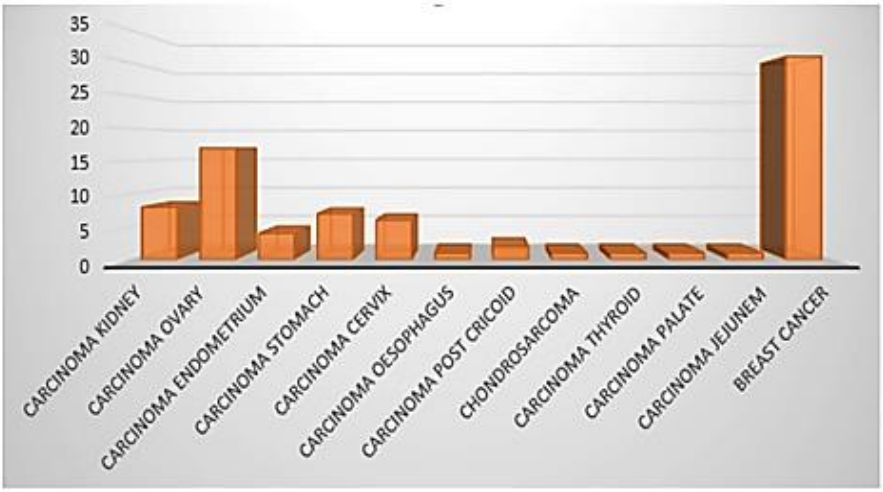

Fig.4 TYPES OF SOLID MALIGNANCY IN NUMBER

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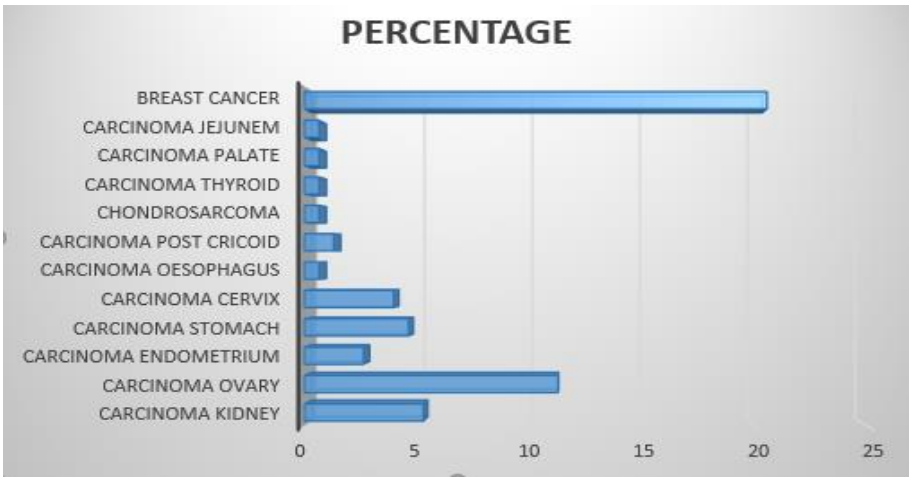

Fig.5 BAR CHART SHOWING TYPES OF SOLID MALIGNANCY IN PERCENTAGE

TABLE 5 SHOWING TYPES OF HEMATO MALIGNANCY

HEMATO MALIGNANCY	NUMBER(n=151)	PERCENTAGE(%)
Acute Myeloid Leukemia	32	21.19
Acute Lymphocytic Leukemia	35	23.17
Non Hodgkins	02	1.32
Hodgkin's Leukemia	01	0.66
Multiple Myeloma	01	0.66
CNS Lymphoma	01	0.66

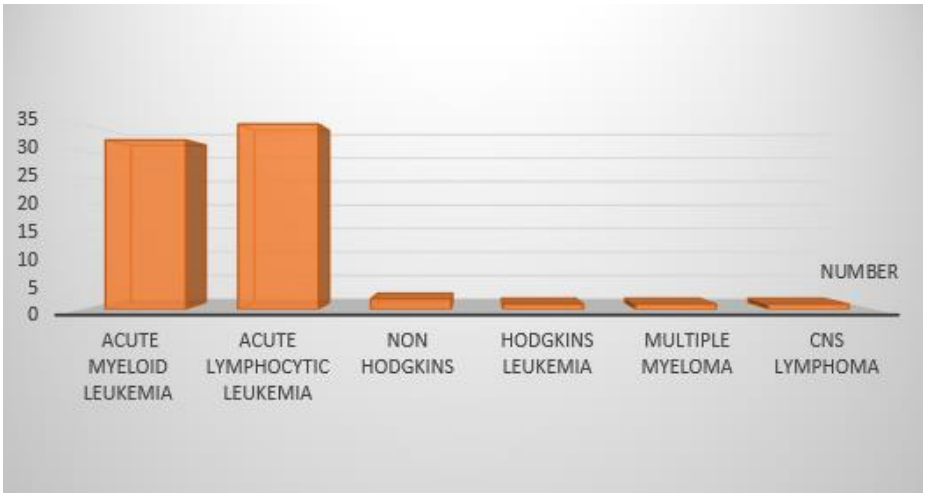

Fig.6 COLUMN CHART SHOWING TYPES OF HEMATO MALIGNANCY IN NUMBER

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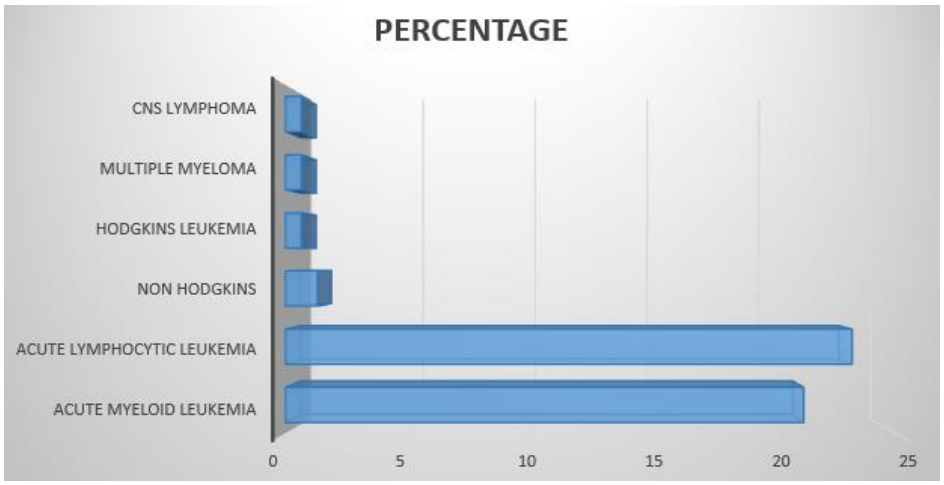

Fig.7 BAR CHART SHOWING TYPES OF HEMATO MALIGNANCY IN PERCENTAGE

TABLE 6 SHOWING SEVERITY OF DRUG INTERACTIONS

SEVERITY OF INTERACTION	NUMBER(n=148)	PERCENTAGE(%)
Major	22	14.86
Moderate	86	58.10
Minor	40	27.02

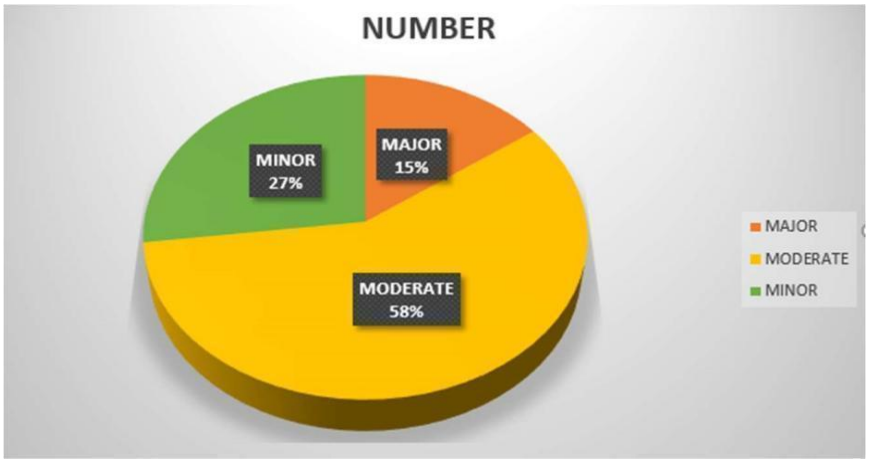

Fig.8 PIE CHART SHOWING SEVERITY OF DRUG INTERACTIONS

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TABLE 7 SHOWING DRUG INTERACTIONS BASED ON THEIR SEVERITY AND ITS TYPE

S.No	Drugs	Severity	Type Of Interaction	Interaction	No
1	Inj.Dexamethasone <> Inj.Paclitaxel	Moderate	Pk	Dexamethasone Reduce The Blood levels of Paclitaxel in Patients	26
2	Inj.Tramadol <> Inj.Ondansetron	Major	Pd	Serotonin Syndrome	12
3	Inj.Dexamethasone <> Inj.Doxorubicin	Moderate	Pk	Enzyme Induction By Dexamethasone leads To decreased level of Doxorubicin	9
4	Inj.Metrogyl <> Inj.Ondansetron	Minor	Pd	Rarely Qt Interval Prolongation	8
5	Inj.Carboplatin <> Inj.Ifosfamide	Moderate	Pk	Gi Interaction	6
6	Inj.Daunorubicin <> Inj.Cyclophosphamide	Moderate	Pd	Gi Interaction	6
7	Inj.Metrogyl <> Inj.Tramadol	Minor	Pd	Rarely Qt Interval Prolongation	6
8	Inj.Amikacin <> Inj.Magnex	Moderate	Pk	Kidney Damage	5
9	T.Fluconazole <> T.Levofloxacin	Moderate	Pd	Irregular Heart Beat	5
10	T.Ondansetron <> T.Levofloxacin	Moderate	Pd	Irregular Heart-Beat	5
11	Inj.Cytarabine <> In.Asparaginase	Moderate	Pd	Gi Interaction	5
12	Inj.LAsparaginase <> Inj.Dexamethasone	Moderate	Pd	Gi Interaction	5
13	Inj.Carboplatin <> Inj.Etoposide	Moderate	Pd	Gi Interaction	4
14	Inj.Etoposide <> Inj.Ifosfamide	Moderate	Pk	Vd of Ifosfamide Decreases due to Etoposide leads To Renal Dysfunction	4
15	Inj.Vincristine <> Inj.L-Asparaginase	Moderate	Pd	Cns Interaction	4
16	Inj.Gemcitabine <> Inj.Carboplatin	Moderate	Pd	Gi Interaction	4

17	T.Pantoprazole <> T.Fluconazole	Moderate	Pk	Fluconazole Increase Plasma concentration of ppi	4
18	Inj.Methotrexate <> Inj.Daunorubicin	Moderate	Pd	Gi Interaction	2
19	Inj.Dexamethasone <> Inj.Vincristine	Moderate	Pd	Gi Interaction	2
20	T.Lorazepam <> T.Hydrochlorothiazide	Moderate	Pd	Cvs Interaction	2
21	T.Lorazepam <> T.Telmisartan	Moderate	Pd	Cvs Interaction	2
22	Inj.Pantoprazole <> Inj.Amikacin	Moderate	Pk	Hypomagnesemia	2
23	T.Fluconazole <> T.Famotidine	Moderate	Pd	Irregular Heart Beat	2
24	T.Dexamethasone <> T.Fluconazole	Moderate	Pd	Increased Blood Levels	2
25	T.Prednisolone <> T.Fluconazole	Moderate	Pd	Increased Blood Levels	2
26	T.Ultracet t<> T.Alprazolam	Major	Pd	Sedation and Drowsiness	2
27	Inj.Methotrexate <> Inj.Trimethoprim	Major	Pd	Myelo suppression (Additive effect)	2
28	T.Septran <> T.Telmisartan	Major	Pk	Hyperkalemia	2
29	T.Ultracet <> T.Zolpidem	Major	Pd	Cns Depression	2
30	T.Ultracet <> T.Procarbazine	Major	Pd	Serotonin Syndrome	2
31	Inj.Carboplatin <> Inj.Paclitaxel	Moderate	Pd	Cns Interaction	1
32	Inj.Dexamethasone <> Inj.Irinotecan	Moderate	Pk	Enzyme Induction By Dexamethasone leads to decreased level of Irinotecan	1
33	Inj.Carboplatin <> Inj.Paclitaxel	Moderate	Pd	Gi Interaction	1
34	T.Septran <> T.Fluconazole	Minor	Pd	Rarely Qt Interval Prolongation	1

35	Inj.Doxorubicin <> Inj.Vincristine	Minor	Pk	Leads To Early Onset Of Action	1
36	Inj.Oxaliplatin <> Inj.Carboplatin	Moderate	Pd	Increase The Risk Of Nerve Damage	2

TABLE 8 SHOWING POTENTIAL DRUG-DRUG INTERACTION IN ANTICANCER-DRUGS

ANTI CANCER DRUGS WHICH HAVE INTERACTION	DESCRIPTION	SEVERITY
Doxorubicin/Ifosfamide/ Carboplatin/Gemcitabine/ Capecitabine/ Oxaliplatin/ Cyclophosphamide/ Etoposide /Methotrexate/Daunorubicin/ Ifosfamide/Vinblastine	GI Interaction and Effect Of Bone marrow	Moderate
Carbaplatin/Paclitaxel/ Methotrexate/Cytarabine	Peripheral neuropathy/ Nerve Damage	Moderate
Dexamethasone/Paclitaxel/ Irinitactan/Doxorubicin/ Daunorubicin/ Vincristine/Carbapaltin/ Etoposide	Enzyme Induction	Moderate
Methotrexate/Hydrocortisone	Enzyme Inhibition	Moderate
Doxorubicin/Ondansetron/ Levofloxacin/Oxaliplatin/ Epirubicin/ Arsenic Trioxide	Qt Prolongation	Moderate
Carbaplatin/Pantoprazole/ Cisplatin/Dexamethasone/ Methotrexate/ Trimethoprim/Prednisolone	Electrolyte Disturbances	Moderate

TABLE 9 SHOWING ERRORS WE HAVE IDENTIFIED

TYPE OF ERROR	NUMBER(n=41)	PERCENTAGE(%)
Prescribing Error	41	100
Omission Error	00	-
Wrong Time Error	00	-
Unauthorized Drug Error	00	-
Improper Dose Error	00	-
Wrong Dose Error Form	00	-
Wrong Drug Prescription Error	00	-
Wrong Administration Technique Error	00	-
Deteriorate Error	00	-
Monitoring Error	00	-
Compliance Error	00	-

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TABLE 10 SHOWING NARANJO ADVERSE DRUG REACTION PROBABILITY:

ADR	SEVERITY	SCORE
Hyperglycemia	Probable	7
Total Count Decrease	Probable	7
Nausea	Probable	7
Vomiting	Probable	6
Fever	Probable	5
Abdominal Pain	Possible	3
Constipation	Possible	3
Weakness	Possible	3
Throat Pain	Possible	3
Cough	Possible	2
Eczema	Possible	1

TABLE 11 SHOWING CAUSALITY ASSESSMENT BY NARANJO ALGORITHM

DEFINITE	%	PROBABLE	%	POSSIBLE	%	UNLIKELY	%
0	0	219	86.904	33	13.095	0	0

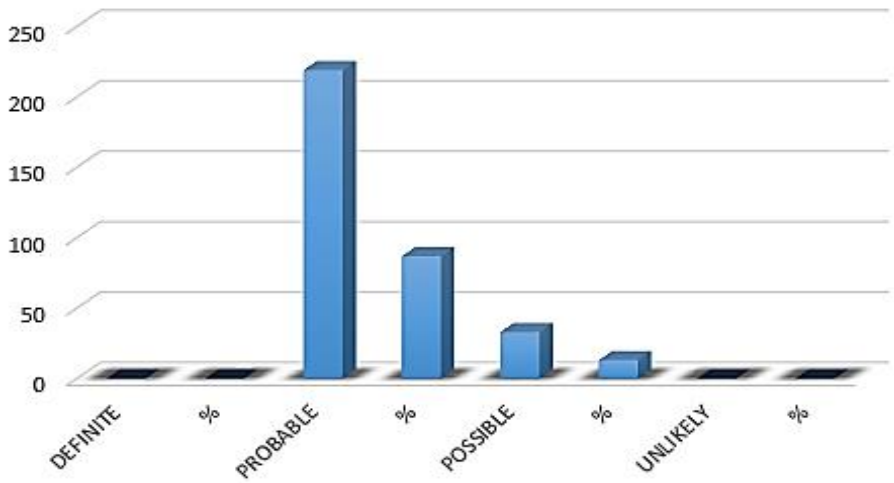

Fig.9 SHOWING CAUSALITY ASSESSMENT BY NARANJO ALGORITHM:

TABLE 12 SHOWING ADVERSE EFFECTS IN NUMBER AND PERCENTAGE

ADR	NUMBER (n=252)	PERCENTAGE (%)
Vomiting	92	36.5
Nausea	74	29.3
Fever	44	17.4
Abdominal Pain	12	4.7
TC Decrease	07	2.7
Weakness	07	2.7
Constipation	06	2.3
Cough	04	1.5
Hyperglycemia	02	0.8
Eczema	02	0.8
Throat Pain	02	0.8

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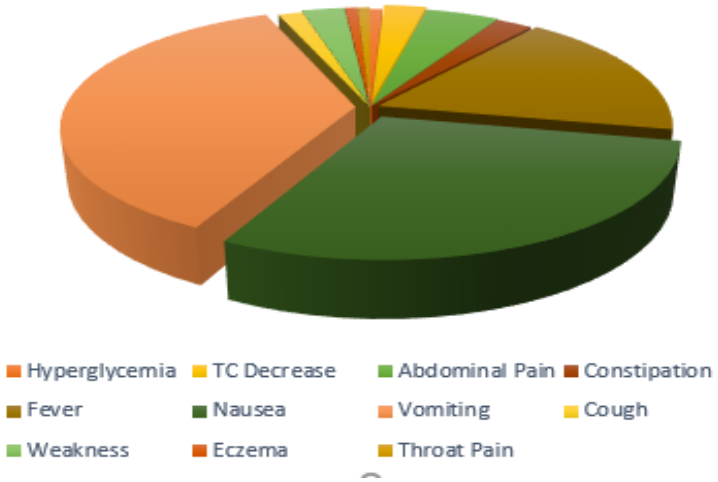

Fig.10 PIE CHART SHOWING ADVERSE EFFECTS IN NUMBER

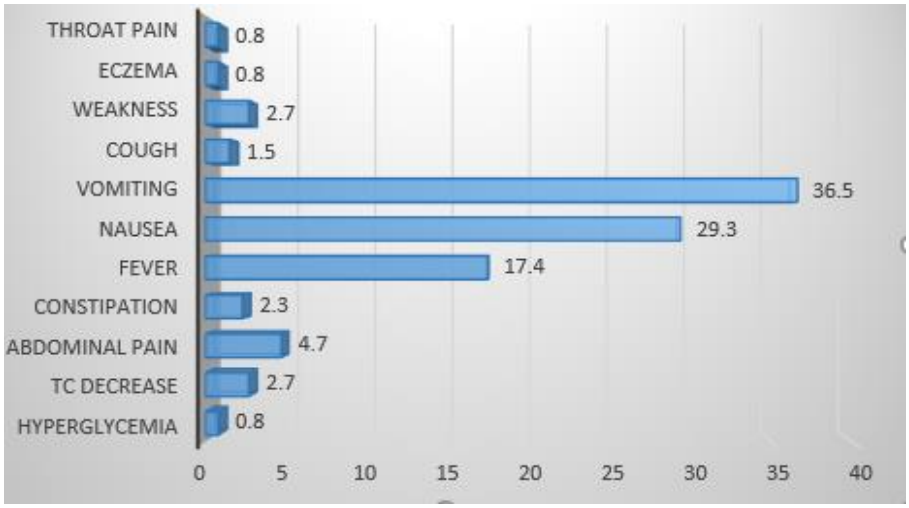

Fig.11 BAR CHART SHOWING ADVERSE EFFECTS IN PERCENTAGE

TABLE 13 SHOWING ADVERSE EFFECTS ASSESED BY USING CHI-SQUARE TEST:

PARAMETER	ADR OBSERVED	ADR NOT OBSERVED
Males	49(52.62)(0.25)	9(5.38)(2.44)
Females	88(84.38)(0.16)	5(8.62)(1.52)
Total	137	14
Grand Total		151

The chi-square static -4.3671,p-value is 0.3664 ,the result is significant p<0.5 ,Degree of freedom - 1

X2(1 ,N=151)= -4.3671,P- 0.3664(<0.5)

A chi-square test of independence was performed by using software to examine the males and females with and without adverse effects to determine which gender are getting more adverse effects in our study. The relation between the variables is significant,x2(1,N=151)=-4.3671,P-0.3664(<0.5).Females are getting more adverse effects when compared to males.

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TABLE 14 SHOWING DRUGS DISTRIBUTION BASED ON CLASS

CLASS OF DRUG	FREQUENCY(n=914)	PERCENTAGE(%)
Antineoplastics	244	26.695
Proton-Pump Inhibitors	123	13.457
Corticosteroids	119	13.019
Antiemetics	116	12.691
Anti-Bacterial For Systemic Use	78	8.533
NSAIDS	59	6.455
Multivitamins and Minerals	31	3.391
Laxatives	26	2.844
Nitroimidazoles	23	2.516
Anti-Viral	20	2.188
Colony Stimulating Factors	17	1.859
Anti-Helminthic	16	1.750
Xanthine Oxidase Inhibitors	12	1.312
Benzodiazepines	10	1.094
Protectants	04	0.437
Anti-Psychotics	04	0.437
GallStone Dissolving Agents	02	0.218
Anti-Platelet	02	0.218
Antihistamine	02	0.218
Anti-Fibrinolytic	02	0.218
Anti-Diabetic	02	0.218
Anti-Coagulants	02	0.218

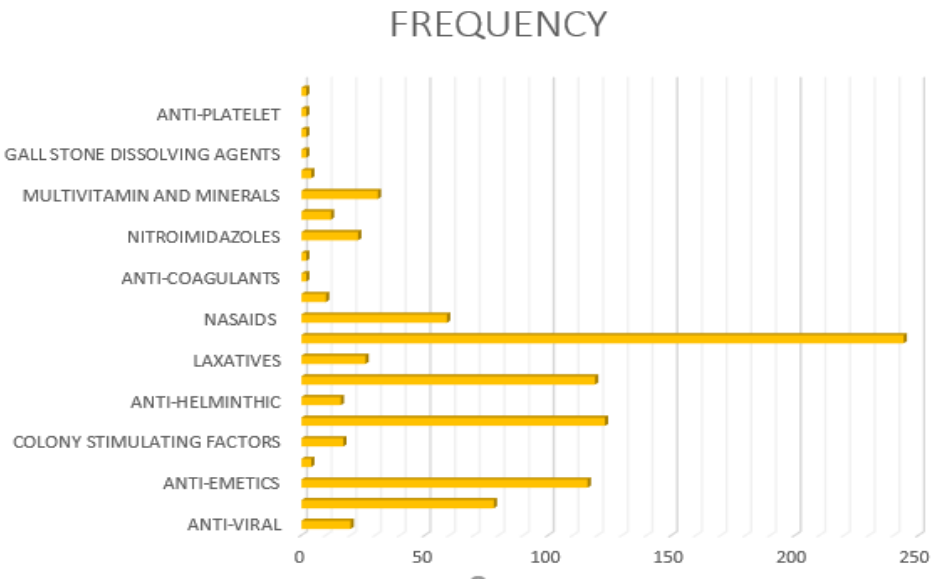

Fig.12 BAR CHART SHOWING DRUGS DISTRIBUTION BASED ON CLASS IN NUMBER

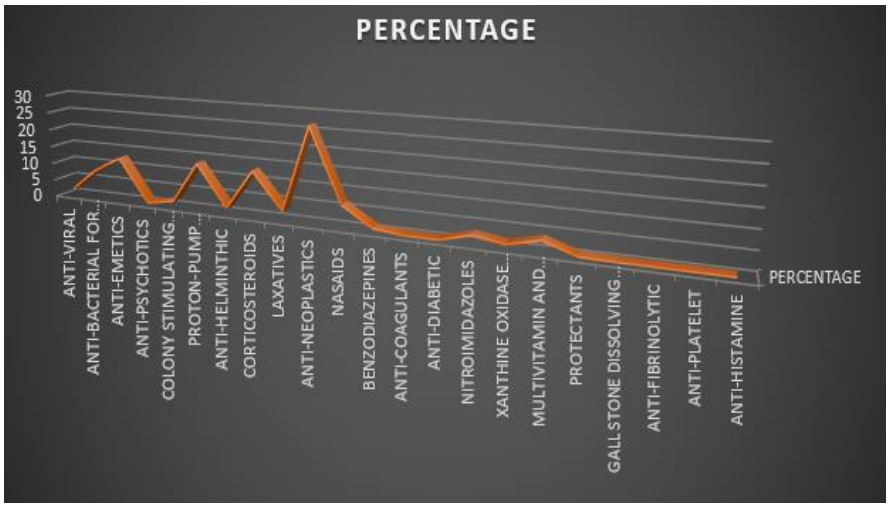

Fig.13 LINE CHART SHOWING DRUGS DISTRIBUTION BASED ON CLASS IN PERCENTAGE

DISCUSSION:

Pharmaceutical care services play vital role in identification and management of drug therapy problems and its clinical problems for the pharmaceutical care The purpose of drug related problems is to help the patients achieve their goals of therapy and realize the best possible outcomes from drug therapy. Identification of drug related problems in the prescription is the core activity in pharmaceutical care. The study was undertaken to identify drug related problems in oncology department and the data is useful for clinicians to provide better therapeutic outcome. In our study we completely analyzed the prescription of the patients and daily follow up and prescription monitoring is done for identification of problems. We have observed 519 drug related problems in 151 subjects. Out of 441 Drps, drug interactions are 148, medication errors are 41, adverse effects are 252. A total of 55 male gender cases in which 18 are non-geriatrics, 40 are geriatrics. A total of 93 female gender cases in which 33 are non-geriatrics and 60 are geriatrics. Types Of Malignancy: Out of 151 cases 80 cases are Solid Malignancy which include 8 Carcinoma Kidney, 17 Carcinoma Ovary, 6 Carcinoma Cervix, 1 Carcinoma Esophagus, 2 Carcinoma PostCricoid ,1 Chondrosarcoma, 1 Carcinoma Thyroid, 1 Carcinoma Palate, 1 Carcinoma Jejunum and 31 Breast Cancer. Out of 151 remaining 71 cases are Hemato Malignancy which include 32 Acute Myeloid Leukemia, 35 Acute Lymphocytic Leukemia, 2 Non-Hodgkin's Leukemia, 1 Multiple Myeloma and 1 CNS Lymphoma.

Drug-Drug Interactions: Treatment of cancer is complex since many drugs are used for treatment. A lot of drug interactions arise in the treatment regimen. Majority drug interactions are observed with drugs Tramadol and Ondansetron. Out of 151 cases 148 Drug Interactions are identified as mentioned in table 7 in which Major drug interactions are 26, Moderate drug interactions are 86 and Minor drug interactions are 40 affecting major organs like CVS, GIT and Liver as mentioned in table 8.

Errors Observed In Prescription: A medication error refers to any preventable mistake that can lead to improper use of medication or cause harm to a patient, whether it occurs while the medication is under the supervision of a healthcare provider or the patient. A prescribing error specifically involves mistakes made during the process of writing a prescription. In this study, we concentrated solely on the prescribing errors identified in the reviewed cases as mentioned in table 9.

Adverse Drug Reactions: An adverse drug reaction (ADR) is an unwanted and harmful effect from a medication that happens even when the drug is taken as prescribed for its intended use.

The Naranjo Algorithm, also called the Naranjo Scale, is a tool used to determine if a medication is likely causing the adverse reaction. It uses a series of questions to help decide if the drug is probably the cause of the problem or if other factors might be involved.

Probability is assigned via a score termed definite, probable, possible or doubtful. Out of 151 subjects we have identified 252 Adverse Effects in which Vomiting-92, Nausea-74, Fever-44, Abdominal pain-12, Total count decrease-7, Weakness-7, Constipation-6, Cough-4, Hyperglycemia-2, Eczema-2 Throat pain 2 as mentioned in table 12.

CONCLUSION:

In conclusion, our analysis of 151 patients with malignancies reveals critical insights into drug-related problems and their impact on patient care. The study identified 441 drug-related issues, including 22 major, 86 moderate, and 40 minor drug interactions, alongside 41 prescribing errors. Adverse effects such as vomiting, nausea, and fever were prevalent, highlighting the need for targeted management strategies.

This data underscores the importance of vigilant monitoring and precise prescribing to mitigate drug interactions and medication errors. Addressing adverse effects effectively can also enhance patient comfort and overall therapeutic outcomes. By leveraging these insights, clinicians can improve patient safety and optimize treatment regimens, ultimately leading to better care for individuals battling malignancies.

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