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Impact of War on the Drug Supply for Cancer Patients in Sudan

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ABSTRACT

This review investigates the ramifications of conflict on chemotherapy drug accessibility for cancer patients in Sudan. For this review article, the data was collected from file records Port Sudan Oncology Center, Port Sudan, Sudan. Through a comprehensive analysis of drug supply frequencies during distinct conflict periods, the study reveals fluctuating availability and challenges in sustaining the supply chain. Grouping chemotherapy drugs according to their availability patterns elucidates the varying degrees of accessibility during conflict, ranging from consistent supplies to complete absence. The impact of these shortages on cancer patients is profound, resulting in compromised treatment outcomes, increased morbidity and mortality rates, and substantial socioeconomic burdens. Real-life patient accounts underscore the emotional, physical, and financial toll imposed by interrupted access to vital medications. Despite efforts by healthcare institutions, NGOs, and governmental bodies, persistent challenges hinder effective mitigation strategies during conflict, including logistical constraints, inadequate funding, and political instability. The socioeconomic and psychological implications of drug shortages are significant, pushing patients deeper into poverty and exacerbating psychological distress. Addressing these challenges necessitates sustained efforts to fortify drug supply chains, enhance infrastructure, and foster multi-stakeholder cooperation. The study emphasises the critical need for sustained interventions to ensure continuous access to chemotherapy drugs in Sudan and conflict zones globally. Immediate actions are imperative to alleviate the burdens faced by cancer patients and fortify healthcare systems to withstand the challenges of conflict-induced drug scarcity.

INTRODUCTION

Cancer, a formidable global health challenge, claims millions of lives annually, demanding comprehensive and timely treatment strategies. Within the complex landscape of cancer care, chemotherapy stands as a cornerstone in the battle against malignancies. However, in regions marred by prolonged conflict and societal upheaval, such as Sudan, the provision of consistent and adequate chemotherapy treatment becomes a daunting task (Chan, 2018). Sudan, a nation graced with diverse cultural heritage and natural landscapes, has been mired in protracted internal conflicts and political unrest for decades. These turbulent periods have had profound repercussions across Sudanese society, including its healthcare infrastructure. Amidst the geopolitical struggles and internal strife, healthcare services, including cancer care, have been subject to immense strain and disruption. The country's healthcare system, already burdened by limited resources and infrastructure challenges, has struggled to meet the escalating demands imposed by rising cancer incidence rates. The prevalence of cancers, spanning from breast and cervical cancers to lymphomas and leukaemias, has surged, creating an urgent need for comprehensive and accessible treatment options (Muchiri *et al.*, 2023). The ongoing conflicts have significantly hampered the healthcare infrastructure, exacerbating the already challenging circumstances faced by cancer patients. Infrastructure damage, scarcity of medical supplies, including chemotherapy drugs, and a shortage of skilled

healthcare personnel have combined to create formidable barriers to effective cancer care delivery (Hashim, 2023). The regions most affected by conflict, particularly in Darfur, South Kordofan, and Blue Nile states, have borne the brunt of these healthcare challenges. Access to essential services, including diagnosis, treatment, and follow-up care for cancer patients, has been severely compromised. Displacement, limited access to healthcare facilities due to safety concerns, and a disrupted supply chain for medications have further aggravated the situation for vulnerable individuals battling cancer (Organization, 2022).

Chemotherapy, recognised for its pivotal role in cancer treatment worldwide, assumes even greater significance in Sudan's healthcare context. The escalating cancer burden, encompassing a spectrum of malignancies, necessitates a multifaceted approach to treatment, where chemotherapy stands as a fundamental pillar. In Sudan, where access to advanced treatment modalities and resources remains a challenge, chemotherapy emerges as a primary modality for managing various cancer types. Its ability to target rapidly dividing cancer cells, impede their growth, and potentially eradicate malignant tumours makes it an indispensable tool in the hands of healthcare practitioners (Aldaak *et al.*, 2022). The successful implementation of chemotherapy protocols is contingent upon the consistent availability of a diverse array of drugs tailored to different cancer types and stages. Ensuring the uninterrupted supply of these medications becomes

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paramount in delivering comprehensive and effective cancer care to patients across Sudan (Yazdanian, 2020). The enduring conflicts in Sudan have inflicted profound and far-reaching consequences on the nation's already fragile healthcare infrastructure. Hospitals and medical facilities, vital for the provision of cancer care, have suffered damage due to direct targeting, collateral harm, or reduced functionality amid conflict-related disruptions. In conflict-affected regions like Darfur, South Kordofan, and Blue Nile states, healthcare facilities have faced resource scarcity, insufficient staffing, and infrastructural damage due to the violence and instability (Dafallah *et al.*, 2023). The lack of consistent electricity, water supply, and essential medical equipment compromises the capacity to store, administer, and preserve chemotherapy drugs, exacerbating the already precarious situation for cancer patients. The conflict-induced breakdown of transportation networks, roadblocks, and limited access to conflict zones hamper the timely delivery and distribution of essential medical supplies, including chemotherapy drugs. The resultant disruption in supply chains further amplifies the scarcity of medications, leading to erratic availability and inadequate stocks of vital chemotherapy agents (Al-Ibraheem *et al.*, 2022).

Sudan's healthcare system, already grappling with resource limitations, faces the added challenge of maintaining the integrity of drug supply chains during conflict periods. The intricate network of procurement, storage, and distribution is highly susceptible to disruptions arising from conflict-related constraints (Dafallah *et al.*, 2023). Limited access to raw materials, interrupted production processes, and logistical bottlenecks impede the consistent flow of chemotherapy drugs from manufacturers to end-users, exacerbating shortages and compromising patient care. Trade restrictions, both international and domestic, imposed as a result of conflict-related sanctions or disrupted trade routes further complicate the procurement of essential chemotherapy medications, which not only affects the availability of drugs but also escalates their costs, rendering them financially inaccessible for many patients already facing economic hardships due to the conflict's economic repercussions (Shukar *et al.*, 2021).

The cumulative impact of conflict on healthcare infrastructure and drug supply chains poses a grave threat to the continuity of cancer care in Sudan. It necessitates immediate action and strategic interventions aimed at safeguarding the integrity of supply chains, fortifying healthcare facilities, and ensuring uninterrupted access to chemotherapy drugs for cancer patients. Strategies encompassing collaborative efforts between governmental bodies, humanitarian organisations, pharmaceutical stakeholders, and international agencies are imperative. These strategies should focus on infrastructural rehabilitation, investment in secure supply routes, alternative procurement channels, and diplomatic advocacy to alleviate trade barriers and sanctions affecting the availability and affordability of essential chemotherapy medications (Alrawa *et al.*, 2023).

This review article aims to comprehensively analyse and elucidate the impact of war on the availability and accessibility of chemotherapy drugs for cancer patients in Sudan. Through an in-depth examination of data and trends, coupled with a critical analysis of the challenges faced, this article endeavours to shed light on the dire consequences faced by patients, healthcare providers, and the broader healthcare infrastructure due to drug shortages during conflict periods. This review serves as a call to action, emphasising the urgent need for concerted efforts and sustainable strategies to safeguard consistent access to chemotherapy drugs, ensuring optimal cancer care even in the midst of conflict-ridden environments.

LITERATURE REVIEW

List and Categorisation of Chemotherapy Drugs Used in Sudan

Chemotherapy in Sudan encompasses a wide array of vital drugs crucial for combating diverse cancer types and stages. The chemotherapy regimen in the country involves the use of various categories of drugs, such as alkylating agents like Cyclophosphamide, Ifosfamide, and Melphalan, essential for damaging cancer cell DNA. Additionally, antimetabolites like Methotrexate, Fluorouracil (5-FU), and Gemcitabine are employed to inhibit cancer cell growth. Anthracyclines such as Doxorubicin, Daunorubicin, and Epirubicin are crucial for disrupting cancer cell multiplication, while Taxanes like Paclitaxel and Docetaxel play a role in impeding cell division. Furthermore, the regimen includes platinum-based compounds like Cisplatin, Carboplatin, and Oxaliplatin that impede cell growth and division. Other significant drugs used in Sudan's chemotherapy arsenal comprise Vinca alkaloids (Vincristine, Vinorelbine, Vinblastine), Etoposide, Bleomycin, and targeted therapy drugs such as Herceptin (Trastuzumab) and Velcade (Bortezomib), each serving specific roles in combatting cancer by targeting distinct cellular mechanisms or pathways (Babokhov *et al.*, 2013).

Brief Description of Each Drug and its Role in Cancer Treatment

Alkylating agents, such as Cyclophosphamide and Ifosfamide, impede cancer cell replication by disrupting their DNA, while Melphalan primarily targets blood cancers by damaging cancer cell DNA to hinder growth. Antimetabolites like Methotrexate interfere with folate metabolism crucial for cancer cell multiplication, Fluorouracil (5-FU) disrupts cancer cell RNA and DNA synthesis, and Gemcitabine inhibits DNA synthesis to impede cancer cell replication. Anthracyclines such as Doxorubicin, Daunorubicin, and Epirubicin induce cell death by damaging DNA. Taxes like Paclitaxel and Docetaxel stabilise microtubules essential for cell division, hindering cancer cell growth. Platinum-based Compounds, including Cisplatin, Carboplatin, and Oxaliplatin, create DNA cross-links, inhibiting cell replication and causing cancer cell death. Other significant

drugs like Vinca alkaloids (Vincristine, Vinorelbine, Vinblastine) disrupt microtubule function, and Etoposide and Bleomycin affect DNA replication, inducing cell death (Weber, 2015). At the same time, targeted therapies like Herceptin (Trastuzumab) inhibit cancer cell growth in HER2-positive breast cancer, and Velcade (Bortezomib) inhibits proteasomes in multiple myeloma cells, leading to cell death. Each drug plays a distinct role in cancer treatment by targeting specific mechanisms crucial for combating various types of cancer (Cardoso *et al.*, 2006).

Importance of Consistent Drug Supply for Cancer Patients

The availability of a consistent and uninterrupted supply of these chemotherapy drugs is imperative for cancer patients in Sudan. Chemotherapy treatment plans often require a combination of these drugs administered in precise schedules and dosages tailored to individual patient needs (Aldaak *et al.*, 2022). Any interruption or inconsistency in drug supply can significantly compromise the efficacy of treatment, jeopardising patient outcomes and potentially leading to disease progression. The potency and effectiveness of chemotherapy drugs rely on maintaining continuous treatment cycles without interruptions. Disruptions in drug supply chains due to conflict-induced constraints such as transportation barriers, procurement challenges, or infrastructure damage not only hinder treatment but also lead to added stress and uncertainty for patients already battling cancer. The consistent provision of chemotherapy drugs plays a pivotal role in ensuring optimal cancer care and treatment outcomes for patients in Sudan. Efforts to secure and maintain a steady supply of these medications are critical to mitigate the adverse impact of interrupted drug access on the already challenging journey faced by cancer patients (Yun *et al.*, 2010).

MATERIALS AND METHODS

Analysis of Drug Availability During Wartime

In analysing drug availability during periods of conflict in Sudan, a detailed assessment of chemotherapy drug supply chains was conducted. The data was collected from file records at Port Sudan Oncology Center, Port Sudan, Sudan. The data presented a fluctuating pattern in the availability of essential medications crucial for cancer treatment. Some drugs exhibited consistent accessibility, albeit with occasional shortages, while others displayed irregular and intermittent availability trends (Sargidy *et al.*, 2022). The analysis revealed that certain chemotherapy drugs experienced significant challenges in maintaining consistent supply chains during wartime, potentially impacting the treatment continuity for cancer patients. The interpretation of this data sheds light on the vulnerability of drug supply networks in conflict-affected regions. It emphasises the critical need for robust strategies to ensure sustained access to life-saving medications for cancer care amidst tumultuous circumstances (Stocker *et al.*, 2023).

RESULTS

Group 1 chemotherapy medications showed varied frequency patterns during wartime. Avastino 100 displayed a substantial percentage (66.7%) of zero availability on 15.04.23 and limited presence (33.3%) on 01.05.23. Bleomycin exhibited fluctuations with different quantities, presenting 33.3% availability on 01.08.23, while Cisplatin 450 portrayed complete absence across the recorded dates. Cyclophosphamide 200 experienced intermittent supply with instances of availability across several dates, totalling 100%. Dactinomycin had an initial 100% availability on 15.04.23, while Daunorubicin demonstrated varying availability percentages across multiple dates, reaching 100% on 01.08.23. Dacarbazine showed a similar trend, with availability percentages

Table 1: First Group of Drugs

Avastino 100		Frequency	%	Date
	0	4	66.7	15.04.23
	5	2	33.3	01.05.23
	Total	6	100.0	
Bleomycin		Frequency	%	Date
	3	1	16.7	15.04.23
	4	1	16.7	01.05.23
	8	1	16.7	01.06.23
	14	1	16.7	01.07.23
	22	2	33.3	01.08.23
	Total	6	100.0	
Cisplatin 450		Frequency	%	Date
	0	6	100.0	15.04.23
Cyclophosphamide 200		Frequency	%	Date
	11	1	16.7	15.04.23
	52	1	16.7	01.05.23
	58	1	16.7	01.06.23

	75	1	16.7	01.07.23
	82	1	16.7	01.08.23
	84	1	16.7	31.08.23
	Total	6	100.0	
Dactinomycin		Frequency	%	Date
	8	1	6	15.04.23
	Total	6	100.0	
Daunorubicin		Frequency	%	Date
	12	1	16.7	15.04.23
	13	1	16.7	01.05.23
	28	2	16.7	01.06.23
	Total	6	16.7	01.07.23
			33.3	01.08.23
			100.0	
Dacarbazine		Frequency	%	Date
	17	1	16.7	15.04.23
	32	1	16.7	01.05.23
	147	1	16.7	01.06.23
	173	1	16.7	01.07.23
	196	2	33.3	01.08.23
	Total	6	100.0	

varying from 16.7% to 33.3% on different dates, as shown in Table 1.

In examining Group 2 chemotherapy drugs' supply frequency during conflict, the analysis displayed varied availability trends. Docetaxel 20 exhibited consistent availability across multiple dates, maintaining 100% supply. Conversely, Doxorubicin10 and Epirubicin50 showcased a complete absence throughout the reported period. Etoposide100 displayed varying availability

percentages across different dates, totalling 100%. Folinic acid demonstrated a consistent availability of 16.7% across several dates. 5- fu500 presented fluctuating availability percentages, while Gemzar200 showcased intermittent supply, reaching 33.3% availability on 01.08.23. Herceptin440 depicted a complete absence, paralleling Ifosphamide1 g, which showed inconsistent availability across recorded dates, as shown in Table 2.

Table 2: Second Group of Drugs

Docetaxel 20		Frequency	%	Date
	9	1	16.7	15.04.23
	14	1	16.7	01.05.23
	45	1	16.7	01.06.23
	120	1	16.7	01.07.23
	195	1	16.7	01.08.23
	203	1	16.7	31.08.23
	Total	6	100.0	
Doxorubicin 10		Frequency	%	Date
	0	6	100.0	15.04.23
Epirubicin 50		Frequency	%	Date
	0	6	100.0	15.04.23
Etoposide 100		Frequency	%	Date
	0	4	66.7	15.04.23
	12	1	16.7	01.05.23
	16	1	16.7	01.06.23
	Total	6	100.0	

Folinic acid		Frequency	%	Date
	233	1	16.7	15.04.23
	290	1	16.7	01.05.23
	399	1	16.7	01.06.23
	480	1	16.7	01.07.23
	506	1	16.7	01.08.23
	520	1	16.7	31.08.23
	Total	6	100.0	
5- fu 500		Frequency	%	Date
	38	2	33.3	15.04.23
	132	1	16.7	01.05.23
	224	1	16.7	01.06.23
	283	1	16.7	01.07.23
	297	1	16.7	01.08.23
	Total	6	100.0	
Gemzar 200		Frequency	%	Date
	0	1	16.7	15.04.23
	12	1	16.7	01.05.23
	62	1	16.7	01.06.23
	84	1	16.7	01.07.23
	104	2	33.3	01.08.23
	Total	6	100.0	
Herceptin 440		Frequency	%	Date
	0	6	100.0	15.04.23
Ifosphamide 1g		Frequency	%	Date
	0	2	33.3	15.04.23
	1	1	16.7	01.05.23
	10	1	16.7	01.06.23
	15	1	16.7	01.07.23
	16	1	16.7	01.08.23
	Total	6	100.0	

In evaluating Group 3 chemotherapy drugs' supply frequencies during conflict, the analysis shows diverse availability trends. Irinotecan 100g displayed consistent supply with 100% availability across multiple dates. Mesna demonstrated fluctuating availability, maintaining 100% supply on various dates. Methotrexate 50 showed fluctuating availability percentages across reported dates, totalling 100%. Melphalan exhibited a complete absence

throughout the recorded period. Mabthera 100 displayed intermittent availability, reaching 33.3% on 01.05.23. Oxaliplatin50 showcased a consistent availability of 16.7% across various dates. Paclitaxel30 and Vinorelbine exhibited intermittent supply with varying availability percentages on different dates. Vincristine depicted consistent availability across reported dates, maintaining 16.7% supply, as shown in Table 3.

Table 3: Third Group of Drugs

Irinotecan 100g		Frequency	%	Date
	32	2	33.3	15.04.23
	42	1	16.7	01.05.23
	48	1	16.7	01.06.23
	51	1	16.7	01.07.23
	54	1	16.7	01.08.23
	Total	6	100.0	

Mesna		Frequency	%	Date
	145	3	50.0	15.04.23
	166	1	16.7	01.05.23
	199	1	16.7	01.06.23
	211	1	16.7	01.07.23
	Total	6	100.0	
Methotrexate 50		Frequency	%	Date
	14	2	33.3	15.04.23
	23	1	16.7	01.05.23
	24	1	16.7	01.06.23
	32	1	16.7	01.07.23
	34	1	16.7	01.08.23
	Total	6	100.0	
Melphalan		Frequency	%	Date
	0	6	100.0	15.04.23
Mabthera 100		Frequency	%	Date
	0	4	66.7	15.04.23
	16	2	33.3	01.05.23
	Total	6	100.0	
Oxaliplatin 50		Frequency	%	Date
	82	1	16.7	15.04.23
	84	1	16.7	01.05.23
	111	1	16.7	01.06.23
	148	1	16.7	01.07.23
	180	1	16.7	01.08.23
	187	1	16.7	31.08.23
	Total	6	100.0	
Paclitaxel 30		Frequency	%	Date
	0	4	66.7	15.04.23
	5	2	33.3	01.05.23
	Total	6	100.0	
Vincristine		Frequency	%	Date
	16	1	16.7	15.04.23
	27	1	16.7	01.05.23
	34	1	16.7	01.06.23
	41	1	16.7	01.07.23
	45	1	16.7	01.08.23
	46	1	16.7	31.08.23
	Total	6	100.0	
Vinorelbine		Frequency	%	Date
	0	2	33.3	15.04.23
	1	1	16.7	01.05.23
	2	1	16.7	01.06.23
	5	2	33.3	01.07.23
	Total	6	100.0	

Group 4 chemotherapy drugs exhibited varying supply frequencies during the period analysed. Velcade showed consistent availability on different dates, reaching 100% supply on some occasions. Vinblastine displayed intermittent availability, with 66.7% supply on 15.04.23 and 33.3% on 01.05.23. Mtx5000mg showcased fluctuating availability percentages across recorded dates, totalling 100%. Carboplatin exhibited a consistent availability of 16.7% across various dates, similar to Cisplatin, which

also maintained a 16.7% supply throughout different reported dates. Cyclophosphamide depicted intermittent availability, reaching 66.7% on 15.04.23 and 33.3% on 01.05.23. Doxorubicin showed fluctuating supply percentages across different dates, totalling 100%, while Epirubicin displayed intermittent supply, reaching 66.7% on 15.04.23 and 16.7% on 01.05.23 and 01.06.23. Lastly, 5-Fu250 exhibited fluctuating availability, totalling 100% across recorded dates, as shown in Table 4.

Table 4: Fourth Group of Drugs

Velcade		Frequency	%	Date
	8	1	16.7	15.04.23
	14	1	16.7	01.05.23
	16	1	16.7	01.06.23
	21	1	16.7	01.07.23
	25	2	33.3	01.08.23
	Total	6	100.0	
Vinblastine		Frequency	%	Date
	0	4	66.7	15.04.23
	2	2	33.3	01.05.23
	Total	6	100.0	
Mtx 5000mg		Frequency	%	Date
	7	4	66.7	15.04.23
	10	2	33.3	01.05.23
	Total	6	100.0	
Avastin		Frequency	%	Date
	0	6	100.0	15.04.23
Carboplatin		Frequency	%	Date
	48	1	16.7	15.04.23
	57	1	16.7	01.05.23
	70	1	16.7	01.06.23
	79	1	16.7	01.07.23
	99	1	16.7	01.08.23
	104	1	16.7	31.08.23
	Total	6	100.0	
Cisplatin		Frequency	%	Date
	17	1	16.7	15.04.23
	35	1	16.7	01.05.23
	75	1	16.7	01.06.23
	112	1	16.7	01.07.23
	145	1	16.7	01.08.23
	147	1	16.7	31.08.23
	Total	6	100.0	
Cyclophosphamide		Frequency	%	Date
	0	4	66.7	15.04.23
	2	2	33.3	01.05.23
	Total	6	100.0	

Doxorubicin		Frequency	%	Date
	91	1	16.7	15.04.23
	104	1	16.7	01.05.23
	130	1	16.7	01.06.23
	136	2	33.3	01.07.23
	142	1	16.7	01.08.23
	Total	6	100.0	
Epirubicin		Frequency	%	Date
	0	4	66.7	15.04.23
	12	1	16.7	01.05.23
	16	1	16.7	01.06.23
	Total	6	100.0	
5-Fu 250		Frequency	%	Date
	16	1	16.7	15.04.23
	276	1	16.7	01.05.23
	352	1	16.7	01.06.23
	363	1	16.7	01.07.23
	369	2	33.3	01.08.23
	Total	6	100.0	

Group 5 drugs' supply frequencies were diverse throughout the analysed period. Gemzar1g exhibited varying availability, reaching 33.3% on 01.08.23 and consistently 16.7% on other recorded dates. Herceptin 150 displayed fluctuations, indicating 83.3% supply on 15.04.23 and intermittent availability on other dates. Ifosphamide 2g demonstrated fluctuating availability, varying from 33.3%

on 15.04.23 to 16.7% on other dates. Methotrexate500 showed no supply on all reported dates. Mabthera 500 displayed 83.3% availability on 15.04.23, with one missing entry on 01.05.23. Oxaliplatin100 showcased varied supply, with 33.3% availability on 01.05.23 and no supply on 15.04.23. Paclitaxel 100 indicated no supply across all reported dates, as shown in Table 5.

Table 5: Fifth Group of Drugs

Gemzar 1g		Frequency	%	Date
	14	1	16.7	15.04.23
	39	1	16.7	01.05.23
	65	1	16.7	01.06.23
	86	1	16.7	01.07.23
	105	2	33.3	01.08.23
	Total	6	100.0	
Herceptin 150		Frequency	%	Date
	0	5	83.3	15.04.23
	2	1	16.7	01.05.23
	Total	6	100.0	
Ifosphamide 2g		Frequency	%	Date
	0	2	33.3	15.04.23
	1	1	16.7	01.05.23
	3	1	16.7	01.06.23
	10	1	16.7	01.07.23
	12	1	16.7	01.08.23
	Total	6	100.0	
Methotrexate 500		Frequency	%	Date
	0	6	100.0	15.04.23

Mabthera 500		Frequency	%	Date
	0	5	83.3	15.04.23
Missing	System	1	16.7	01.05.23
Total		6	100.0	
Oxaliplatin 100		Frequency	%	Date
	0	4	66.7	15.04.23
	2	2	33.3	01.05.23
	Total	6	100.0	
Paclitaxel 100		Frequency	%	Date
	0	6	100.0	15.04.23

During distinct conflict periods, varied trends in drug availability and frequency were observed among the categorised chemotherapy drugs in Sudan. These drugs exhibited fluctuating supplies, with some showcasing intermittent availability, while others experienced consistent shortages across reported dates. The data portrayed an irregular pattern in drug accessibility during wartime, ranging from complete absence to sporadic supply. Such inconsistencies highlighted the substantial challenges encountered in accessing and sustaining drug supply chains amidst war. These challenges encompassed erratic availability, disruptions in transportation and logistics, insufficient resources, and compromised infrastructure, posing significant hurdles in maintaining a reliable and continuous supply of chemotherapy drugs to cancer patients in Sudan.

DISCUSSION

Impact of Drug Shortages on Cancer Patients

Personal narratives and case studies vividly depict the profound implications of drug shortages on cancer patients. These real-life accounts highlight the challenges patients face, ranging from the inability to access necessary medications to the detrimental impact on their treatment outcomes. Patient testimonials serve as poignant reminders of the struggles endured, shedding light on the emotional, physical, and financial burdens imposed by interrupted access to vital cancer medications (Sargidy *et al.*, 2022). Drug shortages significantly compromise the effectiveness of cancer treatment, leading to dire medical consequences for patients. Insufficient or interrupted treatment regimens result in compromised therapeutic outcomes, disease progression, and potential metastasis. Delayed or altered treatment plans can undermine the efficacy of chemotherapy, leading to increased side effects, decreased survival rates, and reduced quality of life for cancer patients. Moreover, incomplete or inadequate treatment due to drug shortages heightens the risk of treatment resistance, further limiting viable therapeutic options (Stocker *et al.*, 2023).

The scarcity or unavailability of essential chemotherapy drugs contributes to increased morbidity and mortality rates among cancer patients. Inadequate access to medications crucial for managing and treating cancer leads to disease exacerbation, tumour progression, and

worsened prognoses. The lack of proper treatment due to drug shortages amplifies the risk of complications, disease recurrence, and, ultimately, higher mortality rates among affected individuals (Alpert & Jacobson, 2019). The adverse impact of drug shortages on cancer-related mortality emphasises the urgency of addressing these challenges to safeguard the well-being and survival of cancer patients during periods of conflict or drug supply disruptions. The impact of drug shortages on cancer patients is profound, encompassing compromised treatment outcomes, increased morbidity and mortality rates, and substantial emotional distress. These adverse effects highlight the critical need to address drug supply chain disruptions and prioritise access to essential medications to ensure optimal cancer care, thereby alleviating the burdens faced by cancer patients during times of conflict or scarcity (Becker *et al.*, 2013).

Efforts and Strategies to Mitigate Drug Shortages

A multitude of initiatives have been undertaken by healthcare organisations, non-governmental organisations (NGOs), and governmental bodies in Sudan to combat the persistent issue of drug shortages during periods of conflict. Local healthcare institutions have endeavoured to improve drug availability by establishing alternative procurement channels, enhancing inventory management systems, and devising contingency plans to secure vital medications (Lucero-Priso III *et al.*, 2020). NGOs have played a pivotal role by providing humanitarian aid, contributing resources, and assisting in the distribution of drugs to affected regions. Government bodies have initiated policies aimed at streamlining drug procurement processes, subsidising medication costs, and fostering collaborations with international entities to alleviate shortages (Mackintosh *et al.*, 2011).

One significant approach to addressing drug scarcity has been collaboration with international organisations and neighbouring countries. Partnerships with global health organisations, such as the World Health Organisation (WHO) and the United Nations International Children's Emergency Fund (UNICEF), have facilitated aid provision, technical support, and capacity-building initiatives to enhance Sudan's healthcare infrastructure. Additionally, collaborations with neighbouring nations have been pursued to leverage drug procurement

opportunities, utilising shared supply chains and international aid efforts to alleviate shortages (Kruk *et al.*, 2018). Despite these efforts, several challenges and limitations persist in implementing effective strategies during conflict. Pervasive insecurity, logistical constraints, and infrastructural damage impede the efficient delivery and distribution of drugs to conflict-affected areas. Inadequate funding, bureaucratic hurdles, and regulatory complexities further hinder the successful execution of mitigation strategies (Krikorian & Torreele, 2021). Political instability and diplomatic tensions may restrict cross-border collaborations, limiting access to external aid and exacerbating the challenge of securing a consistent drug supply for cancer patients in Sudan during times of conflict. Addressing these challenges requires sustained commitment, resource mobilisation, and multi-stakeholder cooperation to effectively mitigate drug shortages in conflict-ridden regions (UniUnitm, 1982).

Socioeconomic and Psychological Impact

The prevalent drug shortages during periods of conflict in Sudan exert a profound socioeconomic burden on cancer patients and their families. The scarcity and irregular availability of essential chemotherapy drugs significantly escalate treatment costs, forcing patients to seek alternative, often more expensive, sources (Lucero-Prisno III *et al.*, 2020). This financial strain results in compromised access to healthcare services, further exacerbating the already challenging circumstances faced by individuals and families coping with cancer. Patients often resort to selling assets, borrowing money, or preceding essential needs to procure medications, pushing them deeper into poverty and hindering their ability to afford comprehensive cancer care (Omotoso *et al.*, 2023). The psychological distress and mental health challenges experienced by cancer patients due to drug shortages are substantial. The constant uncertainty surrounding drug availability induces anxiety, fear, and emotional turmoil among patients and their caregivers. The distress is amplified by the persistent fear of disease progression or mortality due to interrupted or inadequate treatment (Huda *et al.*, 2022). The psychological toll of grappling with the unavailability of vital medications in conflict zones contributes to heightened stress levels, depression, and feelings of helplessness among cancer patients, impeding their overall well-being and quality of life. The long-term implications of drug shortages on the healthcare system and cancer care in Sudan are multifaceted. Prolonged drug scarcities lead to suboptimal treatment outcomes, compromising the effectiveness of cancer therapies and potentially reducing survival rates. Persistent disruptions in treatment continuity contribute to disease progression, increased complications, and higher mortality rates among cancer patients. Moreover, the strain on the healthcare infrastructure, compounded by ongoing conflict, diminishes the capacity to provide comprehensive cancer care, impacting the overall quality and accessibility of healthcare services in the country

(Phuong *et al.*, 2019).

The socioeconomic and psychological consequences of drug shortages during conflicts underscore the urgent need for concerted efforts to address these challenges. Mitigating the impact on cancer patients and their families requires a multifaceted approach that encompasses not only improving drug supply chains but also implementing support mechanisms to alleviate the socioeconomic and psychological burden (Palmer, 2015). Collaborative efforts between healthcare providers, government agencies, NGOs, and international organisations are imperative to safeguard cancer care, alleviate financial burdens, and address the psychological distress faced by patients and their families in conflict-affected regions of Sudan (Rajabi *et al.*, 2021).

RECOMMENDATIONS AND FUTURE CONSIDERATIONS

Establishing resilient policies and emergency preparedness plans is paramount to fortify drug supply chains amid conflicts. These measures should encompass diversified procurement, buffer stock management, and improved distribution systems. Investing in infrastructure like secure storage and reliable transportation is pivotal. International collaboration with organisations, neighbouring countries, and humanitarian agencies is vital to ensure uninterrupted drug access. Proactive strategies focusing on contingency plans, diversifying sourcing, and bolstering local production capacities are imperative to prevent and mitigate drug shortages, emphasising resilience and responsiveness in conflict-affected regions.

CONCLUSION

In conclusion, the analysis underscores the critical repercussions of conflict on chemotherapy drug accessibility for cancer patients in Sudan. The findings reveal fluctuating supplies and intermittent availability, magnifying the challenges patients face in securing essential medications during wartime. It emphasises the immediate requirement for consistent and uninterrupted access to chemotherapy drugs, highlighting the imperative nature of sustained efforts in mitigating drug shortages. These insights extend beyond the immediate context of Sudan, shedding light on the broader vulnerabilities of healthcare systems in conflict zones. Urgent and sustained interventions are indispensable to fortify drug supply chains, ensuring continuous access to vital medications for cancer patients and enhancing the resilience of healthcare systems operating amidst conflict.

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