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Dental Education in a Time of Conflict: A Longitudinal Qualitative Study of Resilience in Sudanese Universities

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Abstract

Background

Conflict severely disrupts critical societal infrastructure, including health professions education. This longitudinal qualitative study examined the impact of the ongoing conflict in Sudan on dental education and described the management and adaptation strategies implemented by Sudanese dental institutions.

Methods

Semi-structured interviews were conducted with deans of Sudanese dental schools across two time points: initially about seven months after the outbreak of the conflict (November-December 2023) and again over two years later (October-December 2025) to evaluate evolving institutional management and recovery strategies.

Results

Of the 34 dental schools operating in Sudan, 18 participated in Phase 1 (52.9%) and 16 participated in Phase 2 (47.1%). Qualitative analysis revealed seven themes: severe security instability and displacement; financial collapse and salary disruption; disruption of teaching and pedagogical transformation; clinical training disruption; student hardship, attrition and institutional damage; certification and documentation challenges; widespread infrastructural loss, emergency response and strategic recovery planning. Despite these challenges, institutions exhibited significant operational adaptation by developing digital education frameworks, forming external clinical training networks, and drafting emergency recovery plans.

Conclusions

Despite severe infrastructural destruction and ongoing financial strain, Sudanese dental universities demonstrated substantial adaptability. Strategic adaptation through digital platforms and decentralized clinical networks provided vital continuity, offering a model for health professions education during active conflict. Improving wages, standardizing and accrediting external clinical centres, establishing national digital learning platforms, and expanding student financial support were priorities reflecting institutional leaders' views across participating schools.

Background

Globally, an estimated 2 billion people live in contexts of high or extreme fragility, conflict, or violence (25% of the world's population), and 72% in extreme poverty.[1] Armed conflict has intensified across Middle East and North Africa over the past decade, disrupting civil services including public health infrastructure healthcare and education continuity.[2]

Before the war, Sudan was widely regarded as a leading educational destination in both the Arab and African regions, known for its academic excellence and cultural diversity. The country attracted students from across neighboring nations who sought quality education in fields such as medicine, engineering, and Islamic studies.[2]

The conflict in Sudan, that erupted on April 15, 2023, between the Sudanese Armed Forces (SAF) and the Rapid Support Forces (RSF), has led to one of the world's largest humanitarian crises: Over 15 million people have been displaced, including 11.6 million internally at the crisis's peak, and roughly 4 million who crossed international borders.[3]

Khartoum, Sudan's academic epicenter, hosting most of the country's prestigious higher education institutions; Has suffered extensive damage due to the ongoing conflict, with over one hundred universities reportedly destroyed, looted, or severely impaired.[4] This disruption has disproportionately affected specialized fields such as dental education, where academic schedules and infrastructure have been critically compromised. Students face frequent interruptions in their courses and clinical training, hindering their ability to complete studies and gain essential practical experience. Faculty members are similarly impacted, struggling to uphold academic standards while navigating serious threats to personal safety and institutional stability.[5]

A cross-sectional study of Sudanese dental schools in the first 3 months of conflict found that 79.3% had experienced military assault, 73.9% looted, and 60.9% conversion to military use, drawing on structured attack data and interviews with five informants from national regulatory and specialisation bodies.[6] That study established the scale of acute institutional damage but, by design offers a single snapshot. To our knowledge, no published study has followed the same Sudanese dental schools over time to examine institutional-level adaptation as the conflict continued.

This study aimed to evaluate the impact of the war on dental education, focusing on the key challenges encountered and the adaptive strategies implemented within academic and clinical training environments during this period of disruption. The study specifically examined: 1) The infrastructural, staffing, and financial shock experienced and how institutions managed them, 2) Which alternative pedagogical models proved sustainable, 3) The policy actions institutional leaders most wanted from the Ministry of Higher Education, and 4) The new partnerships institutions formed, and the factors enabled or constrained them.

Methods

Study Design

To evaluate the evolving impact of the Sudanese conflict on dental education, we used a longitudinal qualitatively-driven design with embedded quantitative indicators in the second phase. The study was conducted among governmental and private dental schools/colleges across Sudan, against a backdrop of wide scale displacement; many respondents were interviewed while residing outside their home cities or outside Sudan altogether.

Participants and Sampling

A census approach was used; all deans representing the identified 34 public and private dental schools registered with the Ministry of Higher Education as of April 15, 2023, were invited. 18 deans (8 public, 10 private; 53% response rate) were enrolled at baseline (November-December 2023), and at follow-up (October-December 2025) the same institutions were re-approached; 16 of them completed the follow-up phase (retention 89%), the remaining two did not respond. **(**Table 1**)**

Table 1
Participants and sampling characteristics of Phase 1 and Phase 2 respondents

Variable	**Phase 1 (n = 18)**	**Phase 2 (n = 16)**
Gender, n (%)	Female: 11 (61.1%)	Female: 10 (62.5%)
	Male: 7 (38.9%)	Male: 6 (37.5%)
Age, years	Mean (SD): 47.7 (10.8)	Mean (SD): 52.8 (11.8)
	Median (IQR): 45.0 (41.2–51.8)	Median (IQR): 53.0 (45.5–57.5)
Experience, years	Mean (SD): 16.4 (8.7)	Mean (SD): 19.3 (9.5)
	Median (IQR): 16.0 (10.5–23.8)	Median (IQR): 19.0 (11.2–24.0)
Response rate, n (%)	18/34 (52.9%)	16/34 (47.1%)

SD, standard deviation; IQR, interquartile range. Response rate calculated against the total population of 34 dental schools.

Data Collection Tools

Data were collected using two bilingual (Arabic/English) interview guide; that were developed by the research team for this study, to capture both immediate institutional shock and the long-term structural adaptation and recovery measures:

Phase 1: Baseline Semi-Structured Interviews

This initial phase involved semi-structured interviews with Deans and executive leaders of public and private dental colleges across Sudan. The interviews were conducted via secure voice/video call software to accommodate displaced and relocating participants' individual preferences. The primary objective was to establish baseline assessments regarding the immediate shocks caused by the conflict following its outbreak on April 15, 2023.

The Phase 1 interview guide **(Supplementary file 1)** was composed of 14 open-ended and demographic questions organized into key thematic domains:

Demographics and Administrative Background: Institutional affiliation (public vs. private), teaching experience, and personal displacement status/security conditions.

Institutional Disruptions and Human Resources: Operational changes, salary distribution, staff displacement rates, and staff willingness/capacity to continue duties.

Academic Continuity and Clinical Training: Obstacles to completing the academic calendar, emergency teaching modalities adopted, impact on clinical training, and academic timeline delays.

Administrative Infrastructure: Current mechanisms for issuing and authenticating academic certificates for graduates and faculty.

Phase 2: Follow-up Semi-Structured Interviews

Phase 2 built directly upon Phase 1 findings and developments in the conflict since baseline. It included follow-up semi-structured qualitative interviews with institutional leadership to assess the longitudinal progression, systemic resiliency, and recovery trajectories. The interview guide **(Supplementary file 1)** was structured into six functional thematic modules incorporating both qualitative assessment and numeric diagnostic indicators:

Infrastructure Damage Assessment: Evaluated physical damage, ongoing repairs, funding sources for reconstruction, and functional serviceability ratings (0–10 scale) for pre-clinical laboratories and clinical dental chairs.

Staff and Financial Sustainability: Quantified full-time faculty retention, return rates of displaced staff, major financial shocks encountered since late 2023, and the establishment of alternative revenue channels (e.g., tuition adjustments, diaspora funding, donor support).

Pedagogical and Clinical Delivery Models: the evolution of teaching delivery models, completion percentages of required final-year clinical hours, and international/cross-institutional partnerships for clinical slots.

Academic Calendar Management and Backlogs: Assessed academic calendar stability across multiple cohorts (2023–2026), exam conduct adaptations, management of overlapping student cohorts, and new admission statistics.

Administrative Systems and Verification: Explored resolution strategies for certification delays, including the adoption of digital verification mechanisms (e.g., electronic signatures or blockchain).

Future Preparedness and Institutional Outlook: Identified written emergency response plans, quantified 3-year capacity recovery confidence (0–10 scale), long-term academic impacts, and key policy recommendations for the Ministry of Higher Education.

Due to the ongoing conflict and the resultant physical accessibility challenges, data collection relied entirely on online interviews by members of the research team. However, there were significant field challenges with this remote method, chief among them being the challenge of contacting the deans because of their forced relocation to remote locations and serious internet outages. Sending numerous follow-up invitations, keeping a very flexible interview schedule, and providing adaptive data-collecting formats catered to participants' connectivity limitations; were some of the practical steps used to minimise these difficulties and increase participation. As a result, although Zoom was used for most of the interviews, some participants responded via asynchronous WhatsApp voice notes, and a smaller portion gave written answers in situations where live connection was not possible. Live interviews lasted approximately 40 minutes, reflecting participants' circumstances and connectivity constraints.

Data Analysis

Data from both phases were analysed using template analysis,[7, 8] a codebook-based form of thematic analysis in which an initial coding template is developed from the data of the first phase of the study, applied to the data of the second phase, and revised as analysis proceeds. Because the study aimed to characterize change across sectors rather than the change trajectory of individual institutions, a recurrent cross-sectional approach to longitudinal analysis was adopted, in which themes were compared between time points at the group level.[9]

Audio-recorded interviews and voice notes were transcribed verbatim in Arabic, while written responses were entered directly. Prior to translation, transcripts were de-identified by removing participant names, institution names, cities, and other potentially identifying details. Translation into English was done using Gemini 2.5 Flash (Accessed via Google API). All translations were reviewed against the original Arabic by a bilingual research member, and discrepancies were corrected before coding.

A hybrid deductive-inductive approach was used. Top-level themes were defined deductively from the study objectives, as operationalized in the domains of the interview guides, while codes and sub-themes within each theme were developed inductively from the data. Baseline transcripts were coded fully before any follow-up data were examined, so that the initial template would not be shaped retrospectively by known outcomes.

The follow-up interview guide was developed from the baseline findings and from developments in the conflict since baseline, including emerging institutional coping mechanisms. Accordingly, the template was extended at follow-up to incorporate the new domains of the follow-up guide, while baseline themes were retained to allow comparison across time points. Inductive coding continued at follow-up and new sub-themes were added where data could not be accommodated within the existing template (e.g., physical infrastructure damage and recovery confidence). The final template comprised seven themes, each described across the two time points to identify how the situation changed between baseline and follow-up.

Baseline data were coded by one researcher, who developed the initial template. Follow-up data were coded by a second researcher using this template. The analysis was overseen by a third researcher, where follow-up data did not fit existing codes, the second researcher and the third researcher discussed whether the

data could be accommodated within the template or warranted a new theme. Analysis was supported by NVivo 15 (Lumivero).

Quantitative indicators embedded at follow-up (0–10 scale items: pre-clinical and clinical-facility readiness; confidence in reaching pre-war capacity within three years. and count/percentage items: full-time staff; percentage of clinical-hour requirements completed) have no equivalent items exist in the baseline guide, consequently, they are reported as follow-up descriptive statistics (n, %). Where a respondent's own account provided a comparison across two internal time points (for example, two successive graduating cohorts of the same institution), this is reported as a within-institution qualitative comparison rather than pooled into a between-institution statistic.

Results

The participation rates were calculated against the total universe of 34 dental schools. Phase 1 achieved a 52.9% response rate out of the 34 total dental schools, which dropped slightly to 47.1% in Phase 2.

Thematic findings: (Table 2)

Table 2
Prevalent themes and evidence at baseline and follow-up

Theme	Sub-theme / specific finding	Baseline	Follow-up
Security instability, displacement & faculty loss	Personal displacement	16/18 (89%) personally displaced (internal or international); 2/18 explicitly did not relocate	*Not re-assessed as a discrete item*; most respondents had reached a stable (if displaced) location by follow-up
	Staff migration / return	16/18 (89%) staff emigration/displacement	Zero staff returned at 5/16 institutions (31%); all staff returned at 1/16 (the only full-return case, triggered by an end of online-only policy)
Financial collapse and salary disruption	Institutional financial strain	Explicit in ≥ 16/18 (≥ 89%)	Persisted; several institutions had nominally restored pay to 100% of pre-war levels while explicitly noting no adjustment for two years of inflation
	Salary cuts / suspension	9/18 (50%) explicit salary cut; 7/18 (39%) salary fully suspended	Salary cuts, delay, or stoppage continued in 15/16 (94%)
Disruption of teaching and pedagogical transformation	Teaching delivery mode	11/18 (61%) shifted to online/remote	Online/hybrid delivery matured into a settled model; effectiveness assessments diverged sharply by institution, from clear gains to an explicit self-assessed quality decline at one institution
	Academic calendar / cohort backlog	> 12/18 (> 67%) gave an explicit delay (3–7 months)	Backlog severity ranged from none to severe (one institution reported 6 backlogged cohorts plus a new intake)
Clinical training disruption	Clinical training stoppage / workarounds	8/18 (44%) reported complete stoppage at some point	At one institution, the first post-war cohort received only 50% of required clinical hours; the following cohort had this fully restored

Theme	Sub-theme / specific finding	Baseline	Follow-up
			(1,950 clinical + 2,238 theoretical hours)
Student hardship, attrition, and institutional adaptation	Attendance / displacement barriers	5/18 (28%) colleges reported significant attendance/displacement/insecurity challenges (e.g., students from other regions unable to attend; some froze their studies)	*Not re-assessed as a discrete item.*
	Financial-strain attrition	*(Not applicable - emerged at follow-up)*	11/16 (69%) of colleges reported fee-driven withdrawal after registration (e.g., large dropout attributed to economic hardship)
	Coping mechanisms	*(Not applicable — mechanisms emerged at follow-up)*	Hardship funds, instalment plans, discounts, case-based payment, ministry loans (e.g., instalment plans with extended deadlines)
	Offsetting admissions /other impacts reported by deans	*(Not applicable)*	1/16 (6%) reported psychological impacts (stress, emotional harm); 2/16 (13%) mainly safe-zone institutions, saw increased admissions from relocating families
Certification, documentation challenges, and institutional digital adaptation	Certification continuity	3/18 (17%) had moved to electronic certificates	Certification difficulty tracked closely with whether institutional records were server-dependent and Khartoum-based versus cloud-based or held by a displaced staff member

Theme	Sub-theme / specific finding	Baseline	Follow-up
Infrastructure loss, emergency response, and strategic recovery planning	Physical infrastructure damage	*(Introduced at follow-up only)*	14/16 (88%) major physical disruption (equipment, wiring, IT systems removed/destroyed); 2/16 (13%) no damage (safe-zone institutions)
	Emergency / crisis governance	*(Introduced at follow-up only)*	9/16 (56%) established crisis-management structures; 6/16 (38%) formed formal emergency committees from conflict onset; 10/16 (63%) lacked a written emergency plan
	Recovery confidence	*(Introduced at follow-up only)*	9/16 (56%) high confidence ('we will return stronger than before'); 6/16 (38%) partial-recovery expectation; 2/16 (13%) contingent on national peace/security
	Anticipated/observed future impact on quality	6/18 (33%) anticipated declining quality; 7/18 (39%) anticipated staff shortages; 2/18 (11%) questioned infrastructural recovery	Shifted from anticipation to partial observation; one institution linked faculty loss to a multiplier effect across the several colleges a single -part-time- specialist typically serves
	Systemic/sector observations & policy asks	Raised spontaneously by 5/18 (28%)	Extended into critique of tuition-dependent funding; recommendations: accredit external centres ~ 13/16 (81%), national digital platform 10/16 (63%), mandatory twinning 9/16 (56%), expanded student financial support 11/16 (69%)

Theme 1; security instability, displacement & faculty loss

Security instability and displacement were major challenges across institutions, with 16/18 (89%) reporting faculty displacement. Staff described fleeing to safer regions or abroad “I travelled abroad”, “I fled to Uganda”, and “We evacuated to Port Sudan”. Unsafe residential areas intensified disruption, with reports such as “Shambat neighborhood is full of RSF and suffers from random shelling”. These conditions produced faculty loss, with 16/18 (89%) of institutions reporting high migration “Most staff travelled abroad” and “40% of staff are outside Sudan”. Among those who remained, 60% continued working under hardship, often unpaid, noting “They teach online with no compensation”. Institutions also feared long-term attrition, warning that “Not all staff will return to Khartoum”.

Phase 2 findings reinforced this pattern. 5/16 (31%) of colleges reported near-total faculty loss “Zero permanent staff remain”, and “Most faculty have not returned; we face a major shortage”, and “No one is in Khartoum.” Another 4/16 (25%) reported partial return once conditions stabilized “Some returned because work abroad was not as expected”. Only 2 out of 16 institutions in safe zones retained full staffing throughout the conflict.

Faculties implemented several adaptations; Institutions hired temporary staff in safer regions, relied heavily on remote teaching from displaced faculty, and redistributed teaching loads among those who remained. Many colleges formed emergency committees to coordinate staffing, maintain academic continuity, and manage rapid operational decisions during the crisis.

Theme 2; financial collapse and salary disruption

All institutions faced severe economic disruption. In Phase 1; 16/18 (89%) reported salary instability, including cuts “Salaries reduced to 60%”, and “40% reduction”, and prolonged non-payment such as “Several months without salaries” and “Only half month salary after the first three months”. These conditions produced widespread hardship, reflected in statements like “The financial situation is extremely bad” and “Life became very expensive”. Institutional operations were similarly strained; with colleges noting “We lost many resources” and “The university cannot pay rent or utilities”.

Phase 2 reinforced this pattern, with 15/16 (94%) of colleges continuing to experience salary cuts, delays, or stoppages. Faculty described ongoing instability “Salaries were 40%, then 70%, now 100% but with no increase”. Payments were often irregular, with staff reporting, “We receive one month’s salary every two months”.

Theme 3; disruption of teaching and pedagogical transformation

Teaching was disrupted across all institutions at some point during the war. In Phase 1, 12/18 (67%) reported complete suspension of classes “Total stoppage of study and training for 3 months”, and “All academic activity stopped”. Universities shifted rapidly to online teaching 11/18 (61%), noting “We shifted to online teaching” and “Teaching continued through electronic platforms”. Practical and clinical delivery remained difficult, with staff reporting “Some courses cannot be taught online” and “The practical part was

the biggest challenge". 17/18 (94%) reported academic difficulties, and > 12/18 (> 67%) reported delays of 3–7 months and cohort overlap. Thus, leading to declined academic quality reflected in concerns such as "Academic level decreased" and "Online teaching has limitations".

In Phase 2, pedagogical transformation became more structured. All institutions modified their teaching models, with online learning adopted by 15/16 (94%). highlighting advantages of recorded content "Recorded lectures allowed students to replay content", and widespread reliance on asynchronous teaching, as it lacked real-time interaction. Thirteen faculties struggled with internet failures, noting "Online teaching was essential, but cannot be relied on completely". The academic calendar remained unstable, with 5/16 (31%) reporting ongoing instability and 2/16 (13%) facing severe delays, often accumulating multiple cohorts "We have six accumulated cohorts", and "We are still compensating for practical delays". A smaller group of 2/16 (13%) in safe zones reported no delays.

To compensate, 12/16 (75%) of colleges used blended learning, mixing online theory with in-person practical sessions, although this was often "at high expenses". Many Faculties digitized their records, reporting "We digitized all records from 2019". Emergency committees were formed to manage curriculum changes. 3/16 (19%) of institutions used compressed schedules, such as "One cohort does clinical in the morning and theory at night". Colleges also shared students and facilities across institutions, creating a two-way support system where "affected universities used our labs and clinics, and they provided us with specialists we wouldn't normally access".

Examination methods changed widely in Phase 2, with 14/16 (88%) of faculties updating exams delivery. 12/16 (75%) shifted to MCQ and problem-based formats to support multi-center administration and rapid auto-marking. Staff explained, "We shifted to 60% MCQ and 40% problem based" and "MCQs reduce bias in marking". 10/16 (63%) used multiple exam centers, often across different countries, as one faculty reported, "We had to scan papers from UAE and send them to Cairo for marking". To manage this new system, faculties built standard MCQ banks, "We are building a question bank so that if we lose contact with faculty during any future emergency, we can still administer valid examinations from the bank".

Theme 4; clinical training disruption

In Phase 1, 8/18 (44%) reported a complete suspension of clinical training in the first months of the war "Clinical training stopped completely". As faculties became inaccessible, 15/18 (83%) of universities relied on external training centers inside and outside Sudan, noting "We trained students in Rwanda and Ethiopia", "We used centers in Zanzibar and Sudan," and "We borrowed training centers from other institutions". This shift significantly increased costs in those faculties, with institutions reporting "Centers demand money per student" and "Training outside the institution is very expensive". These disruptions compromised clinical education, limiting its continuity, accessibility, and affordability.

Phase 2 findings confirmed the situation, with 14/16 (88%) of colleges relying on external centers in Egypt, Saudi Arabia, UAE, Rwanda, Uganda, Yemen, and Sudan. And one institution even set up a full branch campus in Rwanda "We formalized our Rwanda operations as a branch campus with a teaching hospital partnership, dedicated staff, and an established student community, The university now functionally operates in two countries". Training quality varied, with 9/16 (56%) reporting big differences between

centers, saying “Standards differ across six centers; unified training is better”. Colleges also stressed that students had to finish all clinical requirements, noting, “graduates must complete 100% of requirements; otherwise, they cannot sit for exams”. A major adaptation across both phases was the creation of a distributed network of external clinical training centers, nationally and internationally. Faculties in safe zones became hosts for displaced students. “We became a host; this was a real mutual benefit”. Colleges also introduced new ways to manage training, including a case-based payment system where centers were paid per completed case to help students finish their requirements. Faculties also introduced condensed clinical teaching blocks “Condensed three-month blocks are better than seven months of two-hour sessions”.

Theme 5; student hardship, attrition, and institutional adaptation

Student hardship was a major consequence of the conflict, affecting academic continuity, financial stability, and psychological wellbeing. In Phase 1, 5/18 (28%) of colleges reported significant challenges related to attendance, displacement, and insecurity. Students from unsafe or distant regions were unable to reach campuses, with faculties noting “Students from other regions can’t attend”. Others were forced to freeze their studies due to instability, reflected in statements such as “Some students froze their studies.” Financial strain further contributed to attrition, as families struggled to meet basic educational costs: “Parents struggled to pay fees” and “Students could not afford housing”. Phase 2 findings reinforced the severity of financial hardship. 11/16 (69%) of colleges reported students unable to pay external clinical training fees, leading to withdrawal even after initial registration. Faculties observed that “Students begin registration then withdraw due to the fees” and described “Large dropout due to economic hardship”. Despite that, institutions introduced several coping mechanisms and implemented emergency measures such as hardship funds, instalment plans, discounts, case-based payment systems, and ministry loans. Examples included “We created instalment plans and extended deadlines”. These adaptations helped in stabilizing operations, reducing dropouts, and sustaining essential academic functions. One dean reported psychological impacts, including severe stress and emotional harm. In contrast, 13% of institutions, mainly in safe zones, experienced increased admission as families relocated to more secure regions.

Implemented measures to support students along with adjusted admission policies to accommodate displaced students, helped maintain student engagement and provided some degree of stability.

Theme 6; certification, documentation challenges, and institutional digital adaptation

Institutions faced substantial certification and documentation challenges, with 4/18 (22%) of colleges in Phase 1 reporting major disruptions. Verification problems and administrative delays were reflected in statements such as “The problem is in Medical Council documentation”. In response, many institutions accelerated digital transformation, adopting electronic systems to maintain continuity. Faculties noted, “We issue electronic certificates”, demonstrating an early shift toward digital certification.

Phase 2 findings aligned closely with these earlier challenges. Faculties continued to report certification and documentation disruptions, with 4/16 (25%) adopting digital certification through electronic signatures, digital records, and remote verification. Participants explained, “We use electronic signatures for certificates”. However, delays persisted for 6/16 (38%) of institutions, largely due to Medical Council backlogs or missing records, as one faculty noted, “The Medical Council delays certificate processing”.

Across both phases, institutions adopted a series of strategies to maintain continuity in certification and documentation processes. Many universities shifted to electronic certification systems and digital records, reducing dependence on physical documentation. They also relied on remote verification mechanisms, allowing certificates and academic records to be authenticated even when staff, students, or regulatory bodies were displaced. These efforts were reinforced by a broader acceleration of digital transformation, which helped institutions reduce reliance on disrupted physical systems and sustain essential academic functions.

Theme 7; infrastructure loss, emergency response, and strategic recovery planning

14/16 (88%) of colleges experienced major physical disruption, including the removal of essential dental equipment such as chairs, phantom heads, compressors, wiring, doors, windows, and IT systems. Participants described severe destruction, noting that “The college was completely looted, even doors, windows, ACs, computers were taken” and “All electrical wiring were dug out of the building”. In several cases, damage resulted directly from armed conflict, as illustrated by reports such as “A rocket destroyed the paediatric unit, and five chairs were lost” and “Four chairs were burned by a rocket”. Only 2/16 (13%) reported no physical damage because they were located in safe zones, stating, “We were not affected; our college is in a safe area”.

Recovery Planning varied considerably, with 9/16 (56%) of institutions establishing crisis management structures; 6/16 (38%) formed formal emergency committees from the onset of the conflict, described as “The emergency committee formed from day one” and “We created a high-level emergency committee”. However, 10/16 (63%) lacked written emergency plans, revealing gaps in preparedness and institutional resilience. Despite these challenges, all institutions expressed confidence in eventual recovery: 9/16 (56%) reported high confidence “We will return stronger than before” while 6/16 (38%) anticipated partial recovery, and 2/16 (13%) noted that progress was entirely dependent on peace and security stabilization. All colleges identified faculty salary reform as the most urgent national need, emphasizing that “Fix the staff, everything else fixes itself” and “Universities must be forced to pay proper salaries”. Additional recommendations included standardizing and accrediting external clinical centers 13/16 (81%), establishing a national digital learning platform 10/16 (63%), strengthening interinstitutional partnerships through mandatory twinning 9/16 (56%), and expanding student financial support 11/16 (69%) through bursaries and hardship funds to ensure equitable access to training.

Discussion

The ongoing armed conflict has profoundly disrupted dental education in Sudan, affecting infrastructure, institutional finances, workforce stability, teaching, clinical training, governance, and academic administration. We conducted this study to capture the impact of this latest proxy war in Sudan on dental education and to highlight the management strategies adopted by the Sudanese dental education institutions to navigate this crisis. (Table 3)

Table 3
Longitudinal comparison, baseline to follow-up

P-code	Baseline (~ Dec 2023)	Follow-up (~ Oct 2025)
P0		
P1	Shifted to Online teaching; clinical training via inter-institution collaboration; 40% salary cut	Labs 3/10, clinical 5/10; confidence 9/10 (conditional); 'double-edged sword' reframing
P2	Anticipated shortage; outsourced training model	Used as a detention site, extensively looted; 6-cohort backlog; ~40% of intake lost
P3	Salaries stopped; teaching halted then shifted to e-learning	Rwanda branch established; 100% clinical completion; new admissions fell from 50 to 6
P4	Operations fully stopped at first months; e-committee discussed academic calendar and pedagogical plans	Detailed direct combat damage; 3 cohorts graduated regardless via remote teaching
P5	Calendar delayed at first 3 months; shifted to online teaching	Established external clinical training centres
P6	Online shift; salary suspended then resumed with 60% cut; 7-month delay in academic calendar	Confidence 10/10; admissions collapsed from 50 to 6 students
P7	Slow restart; synchronous online teaching	Split Khartoum (destroyed)/Port Sudan (operational) response; partial transcript
P8	Teaching fully stopped, active war-zone; 60% salary cut from April to September	Opened own dental centre; hybrid ~ 70% online; still catching up on calendar
P9	Could not organize even online learning at first; extension of the academic year	Reopened via 3 centres; respondent assesses quality as regressed, not recovered
P10	Lost main HQ; unpaid leave for staff; borrowed facilities	3 Khartoum campuses triaged; built their own Port Sudan campus
P11	Months unpaid; costly rented external clinics	~ 70–80% operational; all lecturer-rank+ staff returned
P12	Unaffected for attending students; salary unchanged	Minimal impact throughout; admissions increased
P13		
P14	Deferred clinical training until further notice; dental materials supply shortage	All 10 staff returned; one course flagged as inadequately delivered
P15	Academic activity near-frozen;	Cross-border Exam centres; anticipated serious staff shortage

P0 & P13 are omitted as they dropped the study at follow-up.

P-code	Baseline (~ Dec 2023)	Follow-up (~ Oct 2025)
P16	Paused at first, then resumed online; salary suspended	Staff fell from 26 to 19; incentive pay; ~90%+ clinical completion; 'blessing in disguise' framing
P17	Slow institutional reaction; salary dues paid at the 5th month after war onset	1st cohort 50% clinical hours; 2nd cohort fully restored (1,950 + 2,238 hrs)
P0 & P13 are omitted as they dropped the study at follow-up.		

Phase 1 (initial situation)

Security Instability, Displacement and faculty loss are the most immediate consequences inflicted on academic institutions by armed conflict: not only is the educational process disrupted, but the wider social, humanistic, and safety aspects of the learning environment are also compromised, with the need for migration often correlating more strongly with diminished educational quality than the conflict event itself. Our study found that security instability and displacement were among the most pervasive challenges, affecting 89% of institutions and resulting in widespread relocation of staff. These findings were similar to reports from Ukraine, where Goncharuk-Khomyn and colleagues reported that the need for migration from Ukraine after the Russian invasion had a stronger inverse correlation with education quality ($r = -0.58$) than did the fact of the war itself ($r = -0.32$), and noted a statistically significant drop in students' satisfaction with environmental safety and comfort during wartime ($p < 0.05$).[10] Similarly, Joury et al., in a comparative multicountry cross-sectional study, found that students in war-affected countries were significantly more likely to report wider contextual challenges—such as attendance issues due to the deterioration of security and a lack of flexibility in teaching time to accommodate the different circumstances induced by the war crisis—compared to their counterparts in unaffected countries.[11]

Online teaching has emerged as a solution to challenges facing traditional education, especially in conflict-affected scenarios. This method first gained global popularity during the lockdown of the COVID-19 period. Despite the difficulties of providing stable teaching online due to power outages and unstable internet connections, online education remains the most feasible method to deliver teaching in war circumstances. The participants in this study reported that universities rapidly shifted to online teaching (61%). Despite this adaptation, institutions struggled to deliver practical and clinical components digitally. Similar reports have come from Ukraine; Goncharuk-Khomyn et al. have called for investing in online education to mitigate the impact of war on medical education in Ukraine.[10] On the other hand, clinical training was one of the biggest obstacles at the beginning of the conflict. Participants reported that clinical training was disrupted across all institutions at some point, with many reporting a complete halt in hands-on activities (44%). As campuses and teaching clinics became inaccessible, universities relied heavily on external training centers (83%). Comparable dynamics have been observed elsewhere. In Syria, Antoun et al. reported that the conflict compounded pre-existing barriers by disrupting mentorship, access to academic networks, and institutional support, with subsequent high rates of migration of Syrian doctors to the United States and Europe.[12] In Gaza, Mostafa, NZA and colleagues found that 91% of healthcare students' universities were

within active conflict zones, 86% of buildings were no longer intact, 55% had their clinical training disrupted, and 62% had resorted to online lectures.[13]

Financial constraint is a vulnerability that civil services in Sudan—including dental education—have endured for several decades due to the crippling effect of economic sanctions imposed on the country since 1988. This vulnerability has been acutely exposed under the current conflict. This study reported that at the initial phase of this study, financial collapse was universal across all institutions, as they all reported severe salary disruptions (86%) and widespread personal financial hardship affecting both faculty and students. Some institutions reported substantial salary cuts of between 40% and 60%. Afshari et al., in a narrative review of studies published between 1995 and 2023 on the impact of economic sanctions on medical education, concluded that academic and research systems are often overlooked areas that are severely impacted by sanctions the negative effects of economic sanctions on education cannot be easily remedied, even long after the sanctions are lifted, and that countries including Sudan, Haiti, Zimbabwe, and Iraq have all demonstrated negative effects on education and health.[14] This is highly relevant to the Sudanese setting, where international sanctions and conflict-driven supply-chain breakdowns are mutually reinforcing. Furthermore, financial hardships emerged as a primary driver of attrition, reported by 28% of institutions; deans highlighted that, “parents struggled to pay fees amid widespread livelihood collapse and students could not afford housing in host cities, with some resorting to shared accommodations or dropping out entirely to support their families”. These findings mirror those from Syria, where transport to university was affected by fuel shortages (32%) and financial constraints (26%), illustrating that student attrition in conflict zones is rarely academic in origin but rather socioeconomic and logistical.[12]

Phase 2 (Adaptation phase)

Infrastructure destruction emerged as one of the most devastating consequences of the conflict. These findings are consistent with the national survey by Mahgoub et al., who reported that approximately 80% of Sudanese dental schools experienced direct military attacks and nearly three-quarters were subjected to looting, leading to severe disruption of undergraduate and postgraduate dental education.[6] The present study extends these observations by providing a detailed description of damage to clinical units, prosthetic laboratories, libraries, electrical systems, compressors, and central suction networks. More importantly, it demonstrates that the loss of essential clinical infrastructure, rather than structural damage alone, represents one of the greatest barriers to restoring dental education.

A notable finding was the widespread looting of specialized dental equipment and utility systems. More than half of the participating faculties reported complete or near-complete removal of dental chairs, phantom heads, compressors, computers, electrical wiring, and other essential infrastructure. Similar patterns were described by Mahgoub et al.[6] Suggesting that systematic looting has become a defining characteristic of the Sudan conflict. Unlike damaged buildings, specialized dental equipment cannot be rapidly replaced because of its high cost, dependence on international procurement, and installation requirements. Consequently, rebuilding dental schools requires restoration of both physical infrastructure and specialized clinical facilities.

Financial instability represented another major challenge. Nearly all institutions reported disruption of staff salaries, declining university revenues, and increasing financial hardship among students. These pressures reduced universities' ability to repair infrastructure, retain faculty members, and sustain educational activities. Similar disruption has been reported in Iraq, where prolonged conflict substantially reduced institutional capacity and compromised medical education.[15] To mitigate these effects, Sudanese institutions introduced hardship funds, flexible tuition payment systems, and emergency financial support for students. These adaptations align with the World Bank's recommendations that resilient tertiary education systems require sustained financial investment and institutional preparedness to maintain educational continuity during crises.[16]

Loss of human resources also significantly affected institutional capacity. Faculty displacement and migration resulted in substantial shortages of academic staff, requiring redistribution of teaching responsibilities, recruitment of temporary educators, and extensive reliance on remote teaching. The conflict accelerated major pedagogical changes across all participating institutions. Online and blended learning became the dominant approaches for delivering theoretical education, with asynchronous teaching offering flexibility for displaced students and faculty. Similar transitions have been reported in Ukrainian medical schools following attacks on educational infrastructure, while the World Health Organization has highlighted the widespread impact of attacks on education in Ukraine and their consequences for learning continuity.[17, 18] Medical schools in Gaza similarly relied on remote education to sustain teaching despite destruction of universities and teaching hospitals.[19] Although participants acknowledged the value of digital learning, they consistently emphasized that online education could not replace direct patient care and practical skills acquisition, reflecting the unique requirements of competency-based dental education.

Clinical education represented the greatest educational challenge. Nearly all institutions established external clinical training centers across Sudan and neighboring countries to enable students to complete mandatory graduation requirements. While international academic partnerships have also supported continuity of medical education in Gaza and Ukraine, Fehmi Z and colleagues demonstrated that transnational collaborations provide an effective mechanism for preserving health professional education during conflict.[20] The multinational clinical training network developed by Sudanese dental schools therefore represents an innovative adaptation that allowed educational continuity despite closure of university clinics. Nevertheless, variation in training standards among external centers highlights the need for standardized accreditation and quality assurance mechanisms to ensure consistency in clinical competency.

The conflict also accelerated substantial reforms in academic administration. Institutions compressed academic calendars, reorganized student cohorts, implemented multicenter examinations, expanded digital certification systems, and established emergency governance committees to coordinate institutional responses. These adaptations demonstrate considerable institutional flexibility under crisis conditions. However, the absence of formal emergency preparedness plans in many faculties indicates that higher education institutions remain insufficiently prepared for prolonged humanitarian emergencies. Experiences from Ukraine have similarly emphasized the importance of crisis governance, institutional planning, and coordinated emergency responses to maintain educational continuity.[18, 19] International partnerships

have also been recognized as an essential strategy for strengthening institutional resilience during conflict and supporting long-term educational recovery.

Overall, the findings reinforce growing international evidence that armed conflict has profound and long-lasting consequences for health professional education. Studies from Sudan, Iraq, Gaza, Syria, and Ukraine consistently demonstrate that destruction of infrastructure, financial collapse, workforce displacement, and interruption of clinical education reduce institutional capacity, delay graduation of healthcare professionals, and weaken national health systems long after active conflict has ended. Nevertheless, the remarkable adaptability demonstrated by Sudanese dental schools through digital transformation, innovative clinical training models, and institutional collaboration illustrates the resilience of higher education during humanitarian crises. Rebuilding dental education in Sudan will therefore require reconstruction of specialized clinical infrastructure, restoration of the academic workforce, sustainable financial investment, accreditation of external clinical training centers, and continued national and international collaboration to strengthen the future oral health workforce.[6, 15, 17–19, 21]

Limitations:

- Non-Response Bias: Differential participation across phases may have introduced survivorship bias, potentially favoring better-adapted institutions.
- Attrition of respondents: Decline in participating schools may have reduced the representativeness of phase 2 findings (Phase 1 capturing 52.9% (18/34) and Phase 2 capturing 47.1% (16/34) of dental schools).
- Single-Source Data: Information was gathered solely from deans and senior leadership. While this offers valuable executive oversight, the perspective of students was not recorded in this study.
- Varied Data Collection Methods: Severe telecommunication blackouts and displacement forced the use of multiple interview formats according to participants' connectivity rather than by design, which may have shaped response length and detail unevenly across institutions.
- Recall and reporting bias: Retrospective reconstruction of events, combined with single-informant reporting by institutional leaderships, may have introduced bias toward favorable self-representation.

Conclusions

This longitudinal qualitative study of Sudanese dental schools reveals a sector that has demonstrated substantial adaptive capacity under extreme adversity. Several findings warrant emphasis:

- The external training center network that emerged organically represents a genuine systemic innovation. If appropriately standardized and maintained post-conflict, this could permanently strengthen the sector.
- The digital skills developed by faculty and students during the conflict period represent a durable human capital gain that should be formally integrated into post-conflict curricula and faculty development frameworks.

- Faculty salary inadequacy is not merely a financial problem but an existential threat to the entire health professions education system.
- Particularly concerning is the reduction/loss of faculty members, because clinical competency in dentistry is transmitted through direct mentorship; such losses risk eroding not only immediate teaching capacity but the sector's long-term ability to reproduce specialist expertise.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki and approved by the ethical committee of the research unit at the community dentistry department, college of oral and dental medicine, Karary University, covering both phases of the study. All participants provided informed verbal consent, which was audio-recorded at the start of each interview, including those who responded asynchronously. Participants were assured of their right to withdraw at any time without penalty. Data were anonymized using unique institutional identification codes (e.g., P0, P1), with all identifying information removed before analysis. Confidentiality was maintained throughout, and all data were stored on encrypted, password-protected servers accessible only to the research team. De-identified transcripts were processed using a third-party AI translation tool, as described under Data Analysis.

Competing interests and funding

The authors declare that they have no known competing interests or personal relationships that could have appeared to influence the work reported in this manuscript. The authors also declare that they received no financial support that could have influenced the outcomes of this study.

Consent for publication (Not applicable)

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Authors’ contributions

AH, YM, HM, FA, HE, and NO contributed to the conceptualization, methodology, and study design, participated in data collection, drafted the initial manuscript, and reviewed and edited the final draft. RO and MS performed the formal statistical analysis, software implementation, and data validation. RO also participated in editing and provided critical revision of the final manuscript. HA contributed to the conceptualization and design, data collection, project supervision, and manuscript reviewing and editing.

All authors read and approved the final manuscript.

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References

1. OECD, Full Report. States of Fragility 2025. 2025; https://www.oecd.org/en/publications/states-of-fragility-2025_81982370-en/full-report.html
2. Embassy of the Republic. of the Sudan — Abuja [Internet]. [cited 2026 Oct 7]. https://www.embassyofsudan.ng/en/study-in-sudan/why-study-in-sudan. Accessed 7 Oct 2026.
3. International Organization for Migration. One-Third of Sudan Displaced in 1,000 Days of Conflict, IOM Urges Urgent and Sustained Action [Internet]. 2025. https://www.iom.int/news/one-third-sudan-displaced-1000-days-conflict-iom-urges-urgent-and-sustained-action
4. Hassan MHA. Sudan's disastrous war - and the science it is imperilling. Nature. 2023;623:10. https://doi.org/10.1038/d41586-023-03341-7.
5. Hashim NT, Padmanabhan V, Elsheikh ME, Gismalla BG, Rehman MM. The Impact of the Khartoum War on Dental Education. Pan Afr Med J. 2024;48:119. https://doi.org/10.11604/pamj.2024.48.119.44219.
6. Mahgoub EAA, Osman S, Haga MB, Khairy A, Osman SHM, Abbu Hassan AM. Dental Education amid Armed Conflict in Sudan: Unveiling the Impact on Training. PLoS ONE. 2024;19:e0311583. https://doi.org/10.1371/journal.pone.0311583.
7. Brooks J, McCluskey S, Turley E, King N. The Utility of Template Analysis in Qualitative Psychology Research. Qual Res Psychol. 2015;12:202–22. https://doi.org/10.1080/14780887.2014.955224.
8. King N. Doing Template Analysis. In: Symon G, Cassell C, editors. Qual Organ Res. Sage; 2012. pp. 426–50. https://doi.org/10.4135/9781526435620.n24.
9. Grossoehme D, Lipstein E. Analyzing longitudinal qualitative data: the application of trajectory and recurrent cross-sectional approaches. BMC Res Notes. 2016;9:136. https://doi.org/10.1186/s13104-016-1954-1.
10. Goncharuk-Khomyn M, Kaliy V, Pohorilyak R, Cavalcanti A, Keniuk A, Yavuz Y. Impact of war on foreign students' satisfaction with quality of dental and medical education in Ukraine. Braz Oral Res. 2023;37:e026. https://doi.org/10.1590/1807-3107bor-2023.vol37.0026.
11. Joury E, Barngkgei I, Al-Batayneh OB, El Tantawi M, Alhaffar MBA, Alshalabi F. Impact of Protracted War Crisis on Dental Students: A Comparative Multicountry Cross-Sectional Study. Educ Health. 2023;36:123–30. https://doi.org/10.4103/efh.efh_127_23.
12. Antoun I, Barakat O, Soqia J, Sultana B, Al-shafie M, Ali B. Medical education and health professional training during the Syrian conflict: a cross-sectional study. BMC Med Educ. 2025;25:1387. https://doi.org/10.1186/s12909-025-07953-7.
13. Mostafa NZA, Heen LA, Al-Saadi M, Al-Saadi N, Alganabi Z, Riyad ZM, et al. Impact of Conflict on Healthcare Education: A Survey of Healthcare Students in Gaza. Gavin; 2025. J Surg [Internet]. https://doi.org/10.29011/2575-9760.011428. [cited 2026 Oct 4]; https://doi.org/.

14. Afshari P, Mellat Parast M, Yazdani S. Do Economic Crises Affect Medical Education? A Narrative Review. J Med Educ Future Demands. 2024;23:e150892. https://doi.org/10.5812/jme-150892.
15. Barnett-Vanes A, Hassounah S, Shawki M, Ismail OA, Fung C, Kedia T. Impact of Conflict on Medical Education: A Cross-Sectional Survey of Students and Institutions in Iraq. BMJ Open. 2016;6:e010460. https://doi.org/10.1136/bmjopen-2015-010460.
16. Arnhold N, Bassett RM. Steering Tertiary Education: Toward Resilient Systems that Deliver for All [Internet]. Washington, DC: World Bank; 2021. https://documents1.worldbank.org/curated/en/394931632506279551/pdf/Steering-Tertiary-Education-Toward-Resilient-Systems-that-Deliver-for-All.pdf.
17. Mayer A, Yaremko O, Shchudrova T, Korotun O, Dospil K, Hege I. Medical Education in Times of War: A Mixed-Methods Needs Analysis at Ukrainian Medical Schools. BMC Med Educ. 2023;23:804. https://doi.org/10.1186/s12909-023-04768-2.
18. World Health Organization Regional Office for Europe, United Nations Children's Fund. Ukraine Witnessing Increasing Impact of Attacks on Health and Education. WHO/Europe; 2024. https://www.who.int/europe/news/item/07-02-2024-ukraine-witnessing-increasing-impact-of-attacks-on-health-and-education.
19. Abu Alamrain A, Irfan B, Irfan K, Ibsais A, Leister M, Raheel M. Medical education in Gaza: navigating disruption during the 2023–2025 Israeli military assault and beyond. Med Confl Surviv. 2026;42:278–306. https://doi.org/10.1080/13623699.2025.2605928.
20. Fehmi Z, Nakkash N, Jaroudi R, Effendi J, Loubani M, Pokanevych O. Preserving Medical Education in Conflict Zones through Transnational Partnerships: Field Lessons from Gaza and Ukraine. Disaster Med Public Health Prep. 2026;20:e101. https://doi.org/10.1017/dmp.2026.10359.
21. Bdaiwi Y, Sabouni A, Patel P, Ekzayez A, Alchalati S, Abdrabbuh O. Impact of Armed Conflict on Health Professionals' Education and Training in Syria: A Systematic Review. BMJ Open. 2023;13:e064851. https://doi.org/10.1136/bmjopen-2022-064851.

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