



Multidrug-resistant bacteria amid health-system collapse in Gaza



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Gaza's health-care system has faced widespread destruction during the ongoing Israeli military invasion that began in October, 2023, leading to a proliferation of disease outbreaks.^{1,2} During this time, one of Gaza's only functioning microbiology services has been a small laboratory at Al-Ahli Arab Hospital in Gaza City, which retained power largely via diesel generators and battery inverters. The hospital, which is one of the only hospitals in Gaza that has remained partly operational, has treated large volumes of traumatic injuries despite frequent airstrikes (beginning as early as October, 2023, and continuing at the time of writing) in the northern two governorates of the Gaza Strip, and has been evacuated for periods between airstrikes. We reviewed every specimen collected and processed from the hospital's wards or emergency theatre between Nov 1, 2023, and Aug 31, 2024. 1317 primary samples—67.3% (886/1317) of which were from pus or wound swabs, 28.2% (372/1317) from urine, and 4.5% (59/1317) from other sample types (including sterile fluids)—were cultured within 1 h of collection on blood and MacConkey agar. Isolates were confirmed with Gram stain and analytical profile index testing and were tested against some of 24 antimicrobial agents by Kirby-Bauer disc diffusion (appendix), with zones interpreted with the Clinical and Laboratory Standards Institute's M100 (32nd edition).³ Multidrug resistance was defined as non-susceptibility to at least one drug in three or more classes;⁴ the multiple antibiotic resistance (MAR) index

was calculated for each isolate (ie, the number of drugs resisted divided by the number tested).⁵ Ethics approval was obtained from the local Helsinki Committee (PHRC/HC/1377/24).

Growth was observed in 982 (74.6%) of 1317 specimens; 746 of these (76%) were from wound material, reflecting the overwhelming burden of ballistic and crush trauma. *Pseudomonas aeruginosa* predominated (28.4% of isolates [279/982] and 35.9% of wound isolates [268/746]), followed by *Staphylococcus aureus* (22.4% of isolates [220/982] and 25.6% of wound isolates [191/746]), *Klebsiella* spp (18.5% [182/982]), and *Escherichia coli* (17% [167/982]). Two-thirds of all isolates (66.9% [657/982]) were multidrug resistant, and 86.3% (847/982) had an MAR index greater than 0.20 (mean 0.60), indicating sustained selection pressure. We found high resistance among Enterobacterales spp isolates, with more than 90% (384/413) of wound isolates resistant to amoxicillin-clavulanate, cefuroxime, and cefotaxime. Resistance to ceftriaxone and ceftazidime was also alarmingly high in wound isolates (83.4% [246/295] and 79.7% [244/306], respectively), which is suggestive of a widespread presence of extended-spectrum β -lactamase (ESBL)-producing Enterobacterales. Meropenem non-susceptibility reached 63.8% (67/105) in *Klebsiella* spp, and *Pseudomonas* showed 33.1% (217/656) multidrug resistance, 16.1% (15/93) colistin resistance, and the highest mean MAR index (0.68; table). Among Gram-positive bacteria, methicillin-resistant *S aureus* (MRSA) was found in 65.6% of samples (80/122; inferred by ceftazidime), and vancomycin non-susceptibility reached 53.7% (44/82) among *S aureus*. *Proteus* and coagulase-negative staphylococci had similarly high MAR values (0.67 for *Proteus* and 0.48 for coagulase-negative staphylococci).

A temporal comparison of two time periods of conflict escalation—Nov 1, 2023, to March 31, 2024, and April 1–Aug 31, 2024—found the prevalence of multidrug resistance to be unchanged (66.7% [150/225] for the first time period and 68.2% [507/743] for the second; $\chi^2=0.195$, $p=0.66$), but isolates with MAR indices greater than 0.20 decreased (from 91.6% [206/225] to 86.3%

See Online for appendix

	Isolates (n)	Multidrug resistance, n (%)	Mean multiple antibiotic resistance index (SD)
<i>Pseudomonas aeruginosa</i>	277	217 (78%)	0.68 (0.26)
<i>Staphylococcus aureus</i>	219	100 (46%)	0.46 (0.29)
<i>Klebsiella</i> spp	178	135 (76%)	0.66 (0.26)
<i>Escherichia coli</i>	165	118 (72%)	0.57 (0.25)
<i>Proteus</i> spp	59	47 (80%)	0.67 (0.24)
Coagulase-negative staphylococci	41	23 (56%)	0.48 (0.29)
Total	939	..	..
Isolates of less commonly presenting organisms are excluded.			
Table: Summary of multidrug resistance among clinical isolates at Al-Ahli Arab Hospital, Gaza, during 2023–24			

[641/743]; $\chi^2=4.41$, $p=0.036$), and MRSA showed a non-statistically significant increase (40% [46/115] and 66.7% [78/117]; $\chi^2=1.510$, $p=0.219$). The decrease in organisms with very high MAR indices probably reflects the depletion of stockpiles of broad-spectrum antibiotics rather than implementation of appropriate stewardship; conversely, the numerical increase in MRSA could suggest increased cross-transmission under crowded ward conditions. The pattern we observe is somewhat similar to the antimicrobial resistance landscape already mapped across Gaza: between February and April, 2015, 62 *S aureus* isolates in nasal swabs from health-care workers at Al-Shifa Hospital were recovered; 51 (82%) were MRSA inferred by oxacillin, 40 (65%) were mecA-positive, and 100% were resistant to penicillin.⁶ Between August and December, 2021, a cross-sectional study at Al-Nasser Pediatric Hospital found ESBL production in 58.9% (93/158) of Gram-negative bacilli overall, including in 65.5% (74/113) of urinary isolates, with 77.2% (122/158) of all strains being multidrug resistant.⁷ A retrospective analysis of bloodstream isolates collected in hospitals in the Gaza Strip from 2020 to 2022 recorded carbapenem resistance in 70–80% of *Acinetobacter baumannii* and a rise in carbapenem-resistant *Klebsiella pneumoniae* from 22.2% to 25.5%.⁸ A Médecins Sans Frontières limb-reconstruction programme (2018–22) reported that 70% of positive cultures were multidrug resistant, including ESBL positivity in 30% of Enterobacterales spp isolates, and 35% of *P aeruginosa* resistant to ceftazidime and imipenem.⁹ A 20-year synthesis of 29 primary investigations from Gaza hospitals (2002–21)¹⁰ highlighted how entrenched the antimicrobial resistance crisis was even before the invasion: multidrug-resistant *Acinetobacter* spp and *Pseudomonas* were highly prevalent; first-line amoxicillin resistance in uropathogenic *E coli* reached 73–98%; cephalosporin resistance in *Acinetobacter* spp was often more than 80%; and hospital-derived MRSA prevalence spanned 22.6–82.3%. What has altered is the scale and clinical context of the health system collapse: Al-Ahli Arab Hospital has had to manage an increased number of daily admissions with little sterile irrigation fluid,^{2,11} wounds remaining undressed for days,¹² interrupted theatre power, and only ad-hoc donations of broad-spectrum antibiotics.² Long-term sheltering of displaced families outside the hospital might also have contributed to transmission of infectious diseases.

The international medical community has a duty to act and respond to this crisis. First and foremost, health-care workers and governments worldwide must advocate for the cessation of the Israeli military invasion that has resulted in a surge of trauma injuries and the widespread deliberate targeting of hospitals, laboratories, and water desalination plants; without this ceasefire, the infection burden will escalate further. Second, laboratories that still exist should be stabilised—recurring convoys carrying culture media, discs, and generator fuel would help restore governorate-wide, culture-based prescribing; as such, restrictions on the entry of essential medical supplies must be lifted. Finally, drug supply should be coordinated across humanitarian agencies and donors, perhaps through WHO, so that the antimicrobial response is tailored to the documented need of hospitals.

Limitations of this analysis should be acknowledged: 24 discs cannot prove absolute resistance, polymicrobial wounds were analysed by dominant isolate only, and the absence of reliable denominators for total injuries precludes incidence estimates. Furthermore, our temporal analysis, which partitions the 10-month surveillance into just two broad intervals segmented around the time of destruction of the nearby Al-Shifa Hospital and major shifts in siege intensity, provides a crude signal of change over time; it does not capture weekly fluctuations or the confounding effects of intermittent stock depletion and the evolving case-mix, and should therefore be interpreted with caution. Nevertheless, these are among the few contemporaneous laboratory data available from Gaza. If protection of Palestinian health facilities, antibiotic supply pipelines, and functional laboratories are not secured soon, the resistant organisms documented here will probably disseminate far beyond Gaza's borders.

We declare no competing interests.

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Malaria resurgence in Africa: confronting the challenges



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WHO's 2024 World Malaria Report highlights that the global burden of malaria remains concentrated in Africa, accounting for 95% of the 263 million malaria cases and deaths worldwide.¹ Children younger than 5 years represent 75% of these fatalities. Malaria mortality and morbidity rates in Africa have gradually reduced over the past two decades, largely driven by coordinated international donor funding, scale-up of mosquito control interventions, artemisinin-based combination therapies, and diagnostic innovations.^{1–6} A turning point in global optimism for malaria control came from the resumption of health services disrupted by the COVID-19 pandemic^{2,3} and the regulatory approval (with phased rollout) of the new RTS,S/AS01 and R21/Matrix-M malaria vaccines.^{4,5} However, an alarming resurgence of malaria is currently occurring across sub-Saharan Africa.⁶ Between January and June, 2025, several African countries reported sharp increases in cases and deaths. For example, Zimbabwe reported 111 998 cases and 310 deaths (a case-fatality rate [CFR] of 0.27%), compared with 29 031 cases and 49 deaths (CFR 0.17%) in the same period in 2024. Botswana recorded 2223 cases and 11 deaths (CFR 0.50%) compared with 218 cases and no deaths in the same period in 2024. Namibia has reported 89 959 cases and 146 deaths (CFR 0.16%) since November, 2024.

The recent resurgence of malaria has largely been attributed to substantial reductions in external donor funding from the US Agency for International Development and UK Foreign, Commonwealth & Development Office, which have strongly supported

Africa's malaria programmes for the past three decades.⁸ Despite the 2001 Abuja Declaration, in which African countries committed to allocating 15% of their national budgets to health-sector improvements, most nations have not fulfilled their commitments and remain heavily dependent on donors, lacking resilient domestic financing mechanisms.^{1,8,9} This financial fragility hinders programmatic continuity, long-term planning, supply chains, and implementation of interventions. The 2024 World Malaria Report¹ indicates that the global malaria financing gap has widened to over US\$4.3 billion annually, with Africa alone requiring an additional \$1.5 billion to sustain core interventions in essential services, such as distribution of insecticide-treated nets, indoor residual spraying, access to artemisinin-based combination therapies, and surveillance.

Although funding cuts appear to be key drivers, the resurgence of malaria cannot be solely attributed to financial shortfalls. Deeper structural vulnerabilities have accumulated over time. Ecological shifts exacerbated by climate change are affecting malaria control programmes. With warmer temperatures, heavier rains, and flooding creating ideal conditions for mosquito breeding,¹⁰ transmission into peri-urban areas, neighbouring countries, and highlands has increased. Although piperonyl butoxide synergist nets offer promise in overcoming resistance to pyrethroids, high costs and operational barriers have slowed their widespread adoption. In parallel, artemisinin resistance is emerging in east Africa, with reduced parasite clearance rates