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Palestine 2023 in Global and Historical Context: A Cross-National Analysis of Conflict-Related Amputation Incidence Across 34 Years

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Abstract

Armed conflict produces amputations through direct trauma and healthcare system degradation. Using the Global Burden of Disease Study 2023, we conducted a cross-national comparison of amputation incidence across 204 countries over 34 years (1990–2023). Palestine's 2023 rate of 1,313 per 100,000 (95% UI: 444–3,069) exceeded all 203 other countries by 60 standard deviations. Demographic disaggregation revealed a pattern structurally inverted relative to comparator conflict states and consistent with indiscriminate civilian exposure to explosive weapons. Among children under five years, the combined rate reached 2,424 per 100,000, 110-fold above the conflict-state mean. Across 34 years, only two country-years have exceeded 1,000 amputations per 100,000: Rwanda in 1994 and Palestine in 2023. These findings provide a systematic epidemiological record of a civilian amputation burden that, across 34 years of global data, has only one precedent.

Introduction

Amputation is amongst the most severe and lasting consequences of armed conflict, driven by direct traumatic injury from explosive weapons, ballistic projectiles, and structural collapse; and by healthcare system degradation whereby damaged infrastructure, diminished surgical capacity, and prolonged treatment delays compel clinicians to perform amputations that would otherwise be avoidable.[1,2] Conflict-associated amputation has been documented across multiple settings; population-level analyses identify Afghanistan, Syria, Yemen, and several sub-Saharan African states among countries with the highest traumatic amputation burden globally, with rates increasing in temporal alignment with active hostilities.[3,4] The predominant body of peer-reviewed literature on conflict-related amputations, however, derives from military medicine contexts, focusing on injury patterns, surgical outcomes, and rehabilitation among combatants in military operations.[5] Civilian amputation burden at the population level, including among children, women, and older adults disproportionately exposed to explosive weapons, has received comparatively little systematic epidemiological attention.[6] To our knowledge, no prior study has undertaken a cross-national comparison of population-level amputation incidence across conflict-affected states over a multi-decade period, leaving a fundamental evidence gap for public health practitioners, rehabilitation planners, and humanitarian responders.

Since October 2023, the Israeli military hostilities across Gaza have caused injuries and disabilities on a scale that international agencies and rehabilitation experts have described as unprecedented.[7,8] By December 2024, an estimated 20,000 Palestinians had acquired conflict-related disabilities, 15% of whom were children.[9] That figure doubled to approximately 40,000 by September 2025, according to the World Health Organization's Gaza-based Rehabilitation Task Force.[10] Moreover, between January 2024 and November 2024, at least 15 children a day sustained traumatic injuries from explosives, injuries likely to cause permanent disability, including limb loss and permanent hearing impairment.[11] Providers on the ground have demonstrated incredible efforts to provide high quality rehabilitation, prosthetic and orthotic services despite dangerous conditions, severe infrastructure damage and resource

constraints.[12] Field-reported figures reflect clinically confirmed cases reaching partially functional facilities and are not directly comparable to population-level epidemiological estimates, which capture a broader scope of burden including cases that never reached care. Despite these reports, no systematic analysis or amputation incidence in Palestine has been conducted to ascertain how that incidence and its demographic patterns may compare to other conflict-affected states.

Here, we present the first comprehensive, cross-national analysis of amputation incidence across conflict-affected states over a 34-year period (1990–2023). Utilizing the Institute for Health Metrics and Evaluation (IHME) Global Burden of Disease (GBD) Study 2023 which provides standardized estimates across 204 countries and territories with demographic disaggregation and uncertainty quantification, we compare Palestine's 2023 amputation incidence against the amputation peaks in all states classified as “conflict-affected” by the Uppsala Conflict Data Program (UCDP). Through z-score analysis, fold-difference calculations, and demographic disaggregation, we quantify the magnitude of Palestine's amputation crisis and examine population-specific impact patterns that may distinguish this crisis from other global armed conflicts.[13,14]

Results

We performed four analyses: a global cross-section, a contemporaneous conflict cross-section, a demographic disaggregation, and a 34-year historical comparison. Across all four, Palestine’s rate is an extreme statistical outlier. For all analyses, reference distributions were constructed excluding Palestine, as the comparand cannot simultaneously constitute the reference distribution against which it is assessed. The findings from all locations including Palestine are derived from a GBD annual denominator of 365 days, however Palestine’s 2023 incidence rate includes only 86 days of conflict escalation (October 7, 2023-December 31, 2023); the reported rate therefore underestimates the true conflict-period burden.

Analysis 1 — Global Cross-Section (2023)

In 2023, Palestine recorded a major amputation incidence rate of 1,313.1 per 100,000 population (95% Uncertainty Interval (UI): 444.4–3,068.5), the highest of any country or territory among all 204 global locations. For the reference distribution (203 countries excluding Palestine), the global mean was 22.5 per 100,000 (SD = 21.5; median = 15.2); Palestine's rate was 60 standard deviations above the mean ($p < 0.001$) and 58.5-fold above it. The second-highest country, Ukraine, recorded 147.4 per 100,000 is 8.9-fold lower than Palestine, a gap larger than the distance between Ukraine and the twentieth-ranked country in the global distribution (Fig. 1, Panel A). Palestine's departure is robust across the full uncertainty range: its lower uncertainty bound of 444.4 per 100,000 alone exceeds the point estimate of every other country, including Ukraine at 147.4 per 100,000 (Fig. 1, Panel B). Geographic distribution of amputation incidence across all 204 countries and territories, and in detail across the MENA region, is shown in Supplementary Figure 1.

Analysis 2 — Contemporaneous Conflict Cross-Section (2023)

Restricting to the 33 active conflict states in 2023, the reference mean for amputation incidence excluding Palestine was 34.8 per 100,000 (SD = 36.9). Palestine's rate was 34.7 standard deviations above this mean ($p < 0.001$) and 37.8-fold above it. The second-ranked state, Ukraine, recorded 147.4 per 100,000 which was 8.9-fold lower.

We distinguished between war-level states (≥1,000 battle-related deaths per year) from conflict-affected states (≥25 battle-related deaths per year) to add further restriction. Amputation incidence in war-level states dominated the upper tier: Ukraine (147.4), the Russian Federation (129.1), Sudan (114.9), the Syrian Arab Republic (88.6), Burkina Faso (88.3), and Somalia (66.3) each exceeded 60 per 100,000; the full ranked distribution is in Supplementary Table S1. The war-level state reference mean was 252.6 per 100,000 (SD = 555.2) yet Palestine remained an extreme outlier in this group ($z = 1.91$, $p < 0.001$).

Analyses 1 and 2 establish the scale of Palestine's departure from global and conflict-state norms in amputation incidence.

Analysis 3 — Demographic Disaggregation of Palestine vs. 33 Active Conflict States (2023)

Analysis 3 asks a different question: which populations within Palestine are driving that departure, and in what proportion. Amputation incidence was examined across all age groups and by sex, using the same 33 active conflict states as the reference distribution that excludes Palestine due to its extreme outlier status (Fig. 3; Supplementary Tables S2–S3). Across every age-sex subgroup examined, Palestine's rate exceeded the conflict-state mean (all $p < 0.001$); full z-scores and the five-year age-band matrix are provided in Supplementary Tables S2–S3. At the all-ages level, Palestine's 2023 amputation incidence was 1,281.7 per 100,000 in males (95% UI: 469.5–2,712.8; 33.3-fold above the conflict-state male mean of 38.5 per 100,000) and 1,345.7 per 100,000 in females (95% UI: 352.2–3,504.6; 43.0-fold above the female mean of 31.3 per 100,000).

In comparator conflict states, amputation incidence rises progressively with age, peaking at 128.9 per 100,000 in the 95-and-older group. Palestine's age distribution is contrary to the established conflict-state pattern: incidence peaked in the 20–24 year age group (3,263 per 100,000 in males; 3,403 per 100,000 in females), with the relative departure from conflict norms greatest at the youngest ages and declining progressively through the oldest groups (Fig. 3, Panel A). Among children under five years, the combined amputation incidence reached 2,424 per 100,000 (110-fold above the both-sexes conflict-state mean of 22.0 per 100,000) -- the greatest relative departure from conflict norms of any age group examined. At the aggregated level of children under 20 years, rates were 1,488.3 per 100,000 in males

(95% UI: 505.3–3,381.0; 36.6-fold above the mean) and 1,643.0 per 100,000 in females (95% UI: 404.1–4,385.8; 45.8-fold above the mean).

Older adults aged 60 years and over recorded rates of 770.5 per 100,000 in males (15.4-fold above the mean) and 825.7 per 100,000 in females (18.6-fold above the mean). By contrast, males aged 95 years and over recorded 134.1 per 100,000, the only age-sex combination that does not significantly exceed the reference distribution. The progressive decline in relative excess from 110-fold in children under five to 1.1-fold in the oldest males is the inverse of the pattern dysvascular confounding would predict.

Across the 33 active conflict states, male amputation incidence exceeded female amputations in 30 of 33 countries, with a median M:F ratio of 1.38:1 (range: 0.45–1.75; Fig. 3, Panel B). Palestine recorded an overall M:F ratio of 0.95:1. Examined across five-year age bands, female rates exceeded male rates in 14 of 20 age groups, including among children under five years (3,142 vs. 1,740 per 100,000), at the 20–24 year peak (3,403 vs. 3,263 per 100,000), and across most age groups from 35 years onward (Fig. 3, Panel C). Three other active conflict states recorded female-predominant ratios: Türkiye (M:F = 0.45), Syria (0.54), and India (0.96), but at absolute female rates of 5 to 29 per 100,000, two to three orders of magnitude below Palestine's.

One feature of the age distribution warrants methodological note. In the 15–19 year band, Palestine's male rate of 1,003.8 per 100,000 produces a comparatively lower z-score of 4.5, reflecting the elevated reference mean for this group (116.7 per 100,000), driven by high rates in Ukraine (863 per 100,000), the Russian Federation (626 per 100,000), and Sudan (509 per 100,000). Palestine's 15–19 male rate nonetheless exceeds every active conflict state in 2023 except Ukraine. The female rate in this band (1,562.6 per 100,000; z = 16.5) is not subject to the same reference elevation and remains a pronounced outlier.

Analysis 4 — 34 Year Historical Conflict Comparison (1990–2023)

We then compared the amputation incidence rates of any state that was classified as a conflict zone from the period of 1990-2023 to understand the historical context of Palestine’s 2023 rate. Across 2,720 country-year observations from 80 UCDP conflict-affected states over the 34-year study period (1990–2023), the pooled mean amputation rate was 29.4 per 100,000 (SD = 86.3). Palestine's 2023 rate of 1,313.1 per 100,000 stands 14.9 standard deviations above this distribution ($p < 0.001$) and 44.6-fold above its mean. Syria's civil war produced a peak of 789.8 per 100,000 in 2014 after years of escalation; Bosnia and Herzegovina recorded 735.6 per 100,000 in 1992; Congo 514.9 per 100,000 in 1997; Eritrea 463.8 per 100,000 in 1990; and Tajikistan 418.9 per 100,000 in 1993 (Fig. 4, Panel B).

Between 2022 and 2023, Palestine's rate increased 76.9-fold (17.1 to 1,313.1 per 100,000), the second-largest single-year increase in the dataset after Rwanda's 1993–1994 transition, and 42.2-fold above its own decade mean of 31.1 per 100,000 (2013–2022; Fig. 4, Panel A). That Syria's peak of 789.8 per

100,000 accumulated across more than a decade of sustained conflict, while Palestine's rate of 1,313.1 per 100,000 emerged within a single calendar year only containing approximately 86 days of heightened escalation, is itself a finding: the speed and intensity of the amputation burden in Gaza is without parallel in the modern conflict record.

We then restricted the comparison to each country's all-time peak rate (n = 80, excluding Palestine and Haiti, the latter due to non-conflict status), which raises the reference mean to 153.0 per 100,000 (SD = 419.5; median = 46.3); Palestine remains 8.6-fold above this mean of peaks ($p < 0.001$) Across 34 years of GBD data, only two country-years have recorded rates exceeding 1,000 per 100,000: Rwanda in 1994 (3,608.4 per 100,000), during an internationally recognized genocide, and Palestine in 2023 (1,313.1 per 100,000), both more than 3-fold above the next-highest peak (Fig. 4, Panel B).

Discussion

Palestine’s amputation incidence rate of 1,313.1 per 100,000 exceeded that of all 203 other countries in 2023 by 58.5-fold and 60 standard deviations, surpassing the documented peak rates of every conflict in the prior decade, including Syria 2014 (789.8 per 100,000) and Ukraine 2022 (362.0 per 100,000). Against the contemporaneous active-conflict peer group (n = 33), Palestine’s lower uncertainty bound of 444.4 per 100,000 alone exceeded Ukraine’s point estimate, the second-highest rate, by 3.0-fold.

Demographic disaggregation reveals an age distribution that is the inverse of the typical conflict-state pattern, peaking in the 20–24 year age group and reaching its greatest excess in children under five years (110-fold above the conflict-state mean). At the aggregated level of children under 20 years, rates were 36.6-fold above the conflict-state mean in males and 45.8-fold in females. Across all three population groups accorded special protection under international humanitarian law[15]: children, older adults, and women; Palestine's rates exceeded conflict-state norms by 15 to 46-fold (Supplementary Table S2; all $p < 0.001$).

Historical record fared no better: the only instance in 34 years that exceeds this rate is Rwanda in 1994. That conflict has been recognized as a genocide.[20] Since Palestine’s 2023 rate captures only approximately 86 days of conflict escalation within a full calendar-year denominator, the true burden for 2024 and beyond is presumed higher still.

The amputation incidence rates documented in Palestine arise from direct trauma from explosive weapons deployed in densely populated areas and secondary amputations compelled by systematic healthcare infrastructure degradation.[21] Gaza is one of the most densely populated territories on Earth,[22] ensuring that blast radius effects reach civilian populations in close proximity to detonation; the resulting structural collapse generates crush injuries and prolonged entrapment scenarios that necessitate traumatic amputation.[23] Additionally, documented patterns of conflict conduct, including strikes in which first responders and medical personnel are targeted in secondary attacks,[24] systematically reduce the likelihood of timely evacuation and surgical intervention within the window required for limb salvage.

The degradation of the healthcare system transforms potential limb salvage procedures into amputations of necessity. Wound infections progress to necrotizing fasciitis when antibiotics are absent, and the absence of anesthesia, sterile equipment, and blood products renders limb salvage impossible even when surgical personnel remain available.[25] The longstanding medical siege imposed on Gaza[26] has produced systematic collapse across the surgical care pathway, and [27] intentional attacks on hospitals, supply warehouses, and healthcare personnel[28,29,30] reduce capacity precisely when trauma volume surges. Moreover, the destroyed infrastructure[31] produces delayed presentations with established infection or irreversible ischemia, leaving amputation as the only viable option.

The all-cause GBD approach captures both mechanisms within a single metric, appropriate here because the two are causally inseparable in a siege context where healthcare system dysfunction is itself conflict-attributable.[13,32,33]

In typical armed conflict settings, amputation burden is concentrated in adult males in the 15 to 44 year range, with older adult rates inflated by dysvascular and diabetic etiology accumulating independent of conflict exposure. Palestine's 2023 demographic distribution inverts this pattern simultaneously across both age and sex. The excess documented across all three groups represents a compound finding that cannot be attributed to any single demographic or methodological artifact: a finding extremely unlikely to occur by chance.

As seen in results, across 30 of 33 active conflict states in 2023, male rates exceeded female, with a median M:F ratio of 1.38:1. Palestine's overall M:F ratio of 0.95:1 inverts this norm, with female rates exceeding male in 14 of 20 five-year age bands. Palestine's female excess is present across the full age distribution including at the youngest ages where dysvascular burden is negligible, and its absolute magnitude is categorically distinct from any comparator state. The 76.9-fold national increase between 2022 and 2023 falls across the full population, with the greatest relative impact on the youngest age groups, those with the most complex long-term rehabilitation needs and the greatest dependency on functional health and social systems. This demographic pattern, and its speed of emergence, has one historical parallel in 34 years of global data: Rwanda.

Only two country-years in 34 years of GBD data record major amputation rates exceeding 1,000 per 100,000: Rwanda in 1994 (3,608.4 per 100,000), during an internationally recognized genocide, and Palestine in 2023 (1,313.1 per 100,000). Following the genocide in Rwanda, deliberate maiming was prosecuted as a constitutive act under Article 2(b) of the Genocide Convention in ICTR proceedings; the same provision is central to ongoing ICJ proceedings against the State of Israel.[34–36] These amputation incidence rates reflect one public health indicator of civilian harm without parallel outside of recognized genocide; analyses of serious bodily or mental harm are of critical importance to document.

Prior to October 2023, Gaza's rehabilitation sector was already chronically limited relative to population need, operating with limited prosthetic and orthotic capacity, a small specialist workforce, and infrastructure inadequate for the pre-existing burden of conflict-related disability;[37] the 2023 escalation

has layered an acute demand on a sector already at its limits.[12] The immediate crisis encompasses multiple reinforcing failures: a severe shortage of prosthetic and orthotic components, casting supplies, and essential consumables due to supply chain disruption and blockade restrictions;[26] a rehabilitation workforce depleted through casualties, displacement, inability to access clinical sites, and the disruption of technical and medical training;[7] and infrastructure destroyed or repurposed for emergency trauma care, foreclosing rehabilitation outcomes that might otherwise have been achievable.[28]

The long-term implications are anchored directly to the child data. Children amputated in 2023 face a 50–70 year device lifecycle requiring multiple prosthetic replacements during growth periods.[38] The rates documented among children under five years: 1,740 per 100,000 in males and 3,142 per 100,000 in females, define a cohort whose rehabilitation dependency will extend across the working life of any system built to serve them. The rehabilitation workforce pipeline has been disrupted at both ends, and rebuilding prosthetic-orthotic capacity in low- and middle-income conflict-affected settings typically requires five to ten years under optimal post-conflict conditions;[3940] the ongoing nature of hostilities makes that baseline inapplicable. Psychosocial burden compounds this: amputation here occurs alongside trauma, displacement, and bereavement, in an economy and healthcare system whose reconstruction timeline remains unmeasured and undefined. A child who loses a limb in 2023 will require prosthetic care into the 2070s and 2080s across a lifespan of geopolitical, economic, and technological change that a reconstruction plan must be designed to span.

Palestine's amputation burden opens several urgent research domains this analysis cannot address. Prosthetic design adapted for children with amputations sustained during developmental stages requires dedicated research; existing rehabilitation engineering frameworks are calibrated to adult prosthetic users and require substantial adaptation for growing bodies facing 50–70-year device lifecycles.[38] Amputation prevention research specific to chronically ill and older adults in conflict settings, specifically to improve the management of diabetes and peripheral vascular disease under conditions of healthcare system collapse is absent from the conflict health literature and directly relevant to the dysvascular-confounded population documented in this analysis. Inclusive post-conflict reconstruction frameworks must be empirically grounded in disability-prevalence data: Gaza's reconstruction will require built environment and service systems designed from the outset for a population with substantially higher rates of physical disability than any comparable post-conflict setting.

Six policy domains require immediate action. First, an immediate cessation of aggression, and the end of settler colonialism, is necessary to prevent further traumatic injury to the population and health infrastructure in Gaza, and to enable all other interventions; Second, unrestricted humanitarian access to rehabilitation supplies must be secured, comprising prosthetic and orthotic components, casting materials, anaesthesia, antibiotics, sterile consumables, and blood products. The absence of these items directly converts salvageable procedures into amputations of necessity.[25,26] Third, the protection of healthcare workers and facilities under international humanitarian law must be enforced; the evidence of

attacks on medical personnel and infrastructure documented above constitutes a direct violation of obligations binding all parties to the conflict.[15] Fourth, establishing a clinical amputation registry during active conflict is a critical prerequisite for evidence-based rehabilitation planning; GBD modelling provides the epidemiological frame, but service delivery planning requires prospective clinical data that model-derived estimates cannot substitute. Fifth, regional capacity building through pre-positioning of prosthetic and orthotic services in Egypt, Jordan, and Lebanon is necessary to support the population of evacuated patients requiring long-term care, and requires formal international agreements with receiving countries.[39] Finally, post-conflict reconstruction frameworks must explicitly mandate rehabilitation infrastructure. Historically, reconstruction packages have prioritised acute medical facilities, leaving rehabilitation systems excluded from the initial investment cycle, a pattern whose consequences, given the child-heavy burden documented here, would be particularly severe in this setting.[39]

Several limitations of this analysis warrant acknowledgement. First, GBD 2023 captures only approximately 86 days of conflict escalation (October 7–December 31, 2023) within a full calendar year denominator, and GBD data for 2024 and 2025 are not currently available.[13] Second, GBD estimates for Palestine are model-derived given the severe disruption of health information systems in Gaza, requiring greater reliance on regional priors, partial facility reports, and conflict analogues; cross-country comparative validity is preserved because all 204 locations are estimated using the same DisMod-MR 2.1 pipeline (further discussion is provided in the methodological supplement),[33] and directional corroboration is provided by WHO Rehabilitation Task Force and Save the Children International field data.[7,11] Third, the all-cause GBD approach includes dysvascular, diabetic, and congenital amputations alongside conflict-attributable cases; cross-national comparison is preserved by uniform application, and in the Gaza context the approach is analytically appropriate as secondary amputations from healthcare system collapse are conflict-attributable regardless of proximate clinical cause.[32] Natural disaster-driven amputations represent a distinct confound; Haiti's 2010 peak (501.0 per 100,000) is therefore excluded from all conflict-state comparisons. Fourth, GBD treats 'West Bank and Gaza' as a single location; with Gaza comprising approximately 39% of the unit population, the reported rate underestimates the Gaza-specific burden; the true Gaza-only rate would be approximately 2.6-fold higher.[21] The relationship between GBD population-level estimates and facility-based field counts[7,11] is addressed in the Online Methods (Section 7c).

Four independent analyses converge on a single finding: across 34 years of global data, 204 countries, and every demographic subgroup, Palestine's 2023 amputation burden has only one parallel: Rwanda in 1994, during an internationally recognized genocide. The data establish not only the magnitude of this crisis but its structure: rates inverted relative to every comparator conflict state, heaviest at the youngest ages, and concentrated in populations accorded special protection under international humanitarian law. These findings provide the epidemiological record. Cessation of hostilities, unrestricted humanitarian access, protection of healthcare infrastructure, and long-term rehabilitation investment calibrated to a child-heavy burden: these interventions must be scaled to what the data show. This crisis is still ongoing, and its full measure has not yet been taken.

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Online Methods

1. Data Source

We obtained amputation incidence data from the Institute for Health Metrics and Evaluation (IHME) Global Burden of Disease Study 2023 (GBD 2023) using the GBD Results Tool (vizhub.healthdata.org/gbd-results/).[32] GBD 2023 provides standardised estimates across 204 countries

and territories for the full data period 1990–2023, using a Bayesian meta-regression framework (DisMod-MR 2.1).[34]

We analysed amputation incidence, or new cases per year, rather than prevalence, because prevalence accumulates historical burden across prior decades and would dilute the acute 2023 signal. We extracted rates per 100,000 population for all causes across four major amputation types: lower limb unilateral, lower limb bilateral, upper limb unilateral, and upper limb bilateral. These four types were summed to a composite outcome. Minor amputations of thumbs, fingers, and toes were excluded; their inclusion would introduce systematic confounding through differences in diabetes prevalence and occupational injury rates across countries rather than conflict exposure.

Four queries were executed: (1) all 204 locations, all years 1990–2023, both sexes combined; (2) Palestine only, all individual age groups, 2023; (3) all 204 locations, individual age groups, 2023, both sexes; (4) all 204 locations, all age groups, 2023, male and female separately. Downloads 3 and 4 were combined (83,306 rows). All estimates include 95% uncertainty intervals (UI) derived from 1,000 draws from the posterior distribution, following standard GBD methodology.[34]

2. GBD Amputation Variable Construction

GBD 2023 classifies amputations by injury mechanism (transport, unintentional, self-harm, conflict and terrorism, other). Restricting to 'conflict and terrorism' would systematically undercount conflict-attributable burden for three reasons.[33]

First, amputations from building collapse, crush injury, and blast burns — all direct products of aerial bombardment — are coded under mechanism-specific categories rather than 'conflict and terrorism.' Second, siege warfare and health system collapse generate secondary amputations: wound infections, delayed wound closure, and overwhelmed trauma capacity compel clinicians to amputate limbs that would otherwise be salvaged. These are conflict-attributable regardless of proximate clinical cause. Third, applying a consistent all-cause capture rule across all 204 locations preserves the validity of cross-national relative comparisons.

Amputation incidence estimates are generated by DisMod-MR 2.1, a Bayesian meta-regression framework that synthesises hospital records, household surveys, vital registration, and published literature to produce consistent estimates across all locations and years.[34] The composite four-type outcome was selected to maximise sensitivity to total burden.

3. Conflict-Affected State Classification

Conflict-affected state classification used the UCDP/PRIO Armed Conflict Dataset v25.1 (UCDP/PRIO ACD), which defines armed conflict as a contested incompatibility where the use of armed force results

in ≥25 battle-related deaths per calendar year.[14] All four conflict types were included: Type 1 (extrasystemic), Type 2 (interstate), Type 3 (intrastate), and Type 4 (internationalized intrastate). Excluding interstate or internationalized conflicts would arbitrarily remove Ukraine, a primary reference comparator.

Two operationalisations of conflict-affected states were applied. For the historical comparison (Fig. 4), any country with at least one UCDP conflict year between 1990–2023 was included (n = 80 countries, excluding Palestine as comparand and Haiti; see Section 5). For the contemporaneous cross-section (Fig. 2), only countries with active UCDP conflict in calendar year 2023 were included (n = 33, excluding Palestine).[15,45]

Palestine appears continuously in UCDP records from 1990 through 2023 across nine conflict episodes (IDs: 207, 228, 234, 252, 301, 302, 426, 11343, 14609). Its 2023 classification is governed by conflict ID 234: Government of Israel vs. Fatah/Hamas/PIJ, coded as Type 4, Intensity 2 (war-level). Two periods where battle deaths fell below 25/year (2013; 2015–2017) do not affect conflict-ever classification. Palestine was excluded from all reference distribution calculations to avoid circularity.[15]

4. Country Name Harmonization and Data Linkage

Analysis used country-level GBD locations only, to match the UCDP country-year unit of analysis. Palestine appears as 'West Bank and Gaza' in GBD 2023 and was mapped to 'State of Palestine' in UCDP, consistent with UCDP's continuous tracking of Palestinian territory conflict since 1990.[14,15] Name standardisation used ISO 3166-1 alpha-3 codes as the common identifier, with manual reconciliation for Taiwan, Kosovo, and West Bank and Gaza.

GBD locations not classifiable under UCDP (overseas territories, small island states, sub-national units) were retained for the global cross-section (Fig. 1), where no conflict classification is applied, but excluded from all conflict-state comparisons (Figs. 2–4). GBD sub-national locations within UCDP conflict countries were handled at the national level.

Confirmed counts: 204 GBD locations retained for Fig. 1; n = 33 active conflict states for Fig. 2; n = 80 conflict-ever states (excluding Palestine and Haiti) for Fig. 4 historical peaks.

5. Conflict Intensity Subclassification and Haiti Exclusion

Within UCDP/PRIO, conflicts reaching ≥1,000 battle-related deaths per calendar year are designated war-level.[15] Palestine meets the war-level threshold in 2023. Across the full 1990–2023 study period, 44 additional countries met the war-level threshold in at least one year, forming the restricted reference distribution for Sensitivity Analysis A. In 2023 specifically, 11 countries were classified at war-level:

Burkina Faso, Ethiopia, Israel, Myanmar, Nigeria, the Russian Federation, Somalia, Sudan, the Syrian Arab Republic, Ukraine, and Palestine.

Haiti meets the conflict-ever inclusion criterion on the basis of a 2004 UCDP conflict episode. However, Haiti's all-time peak amputation rate of 501.0 per 100,000, recorded in 2010, is primarily attributable to the January 2010 earthquake — a natural disaster for which UCDP records no conflict entry. Including Haiti's 2010 peak in the conflict-state comparison distribution would conflate natural disaster-driven and armed conflict-driven amputation burden, introducing a category error. Haiti is therefore retained in the global cross-section (Fig. 1), where no conflict classification is applied, but excluded from all conflict-state comparisons (Figs. 2–4).

6. Study Design and Comparisons

Analysis 1 — Global cross-section (2023)

Palestine's 2023 amputation incidence rate was compared against all 204 global locations in the same year, independent of conflict classification. This establishes Palestine as a global statistical outlier in the broadest possible frame before any conflict-specific analysis is applied.

Analysis 2 — Contemporaneous conflict cross-section (2023)

Palestine's 2023 rate was compared against all other active conflict states in 2023 (n = 33), providing a contemporaneous conflict-specific perspective. Its comparator set — 33 active conflict states in 2023 — is the same reference distribution used for the demographic disaggregation in Analysis 3, ensuring temporal consistency across both analyses.

Analysis 3 — Demographic disaggregation (Palestine 2023 vs. 33 active conflict states)

Age-stratified and sex-stratified amputation incidence was examined for Palestine 2023 across all age groups and by sex, using standard five-year age bands as the primary analytic frame. For aggregated comparisons, children were defined using GBD's pre-built <20 years band as the closest available approximation to the CRC Article 1 definition of childhood (<18 years);[20] a sensitivity analysis restricted to children under 14 years was performed to assess robustness to the exclusion of the 15–19 age band, where the reference distribution is most elevated. Older adults were defined as 60 years and over (primary) and 70 years and over (sensitivity), consistent with WHO and UN General Assembly definitions.[46,47] The reference distribution is the same 33 active conflict states used in Analysis 2, maintaining temporal and comparator consistency.

Analysis 4 — Historical comparison (1990–2023)

Palestine's 2023 rate was compared against the full 34-year record of amputation incidence across all 80 UCDP conflict-affected states (excluding Palestine and Haiti), including each country's all-time peak. This historical framing is positioned last because it provides the broadest temporal context and introduces the sole historical comparator, Rwanda in 1994, whose significance is fully established only after the contemporaneous and demographic findings have been presented.

7. Statistical Analysis

Descriptive statistics and reference distribution construction

For each comparison group, means, medians, standard deviations, and ranges were calculated excluding Palestine to establish unbiased reference distributions. Palestine was excluded from all reference distribution calculations — including means, standard deviations, and z-score denominators — across every analysis in this study. This exclusion is methodologically necessary because Palestine is the comparand in all analyses; its inclusion would compress the reference SD and artificially reduce z-scores, introducing circularity.

Z-score analysis

Palestine's departure from comparison group norms was quantified as $z = (x - \mu) / \sigma$, where x is Palestine's 2023 rate, μ is the comparison group mean (excluding Palestine), and σ is the comparison group standard deviation (excluding Palestine). Z-scores were calculated relative to three reference distributions: all global states (2023, Analysis 1); active conflict states in 2023 (Analysis 2); and all conflict-affected state-years pooled 1990–2023 (Analysis 4). P-values were derived from the standard normal distribution (two-tailed). Given the extreme magnitude of observed z-scores (ranging from 2.8σ to 163.3σ), all reported p-values are effectively zero under any standard normal approximation; $p < 0.001$ is reported throughout as a conservative lower bound.

Fold-difference calculations

Palestine's rate was expressed as fold-differences relative to individual country comparators (Syria 2014, Ukraine 2022, Afghanistan 2021, Iraq 2006, Sudan 2023), group means, and the second-ranked country in each comparison.

7a. Uncertainty Interval Generation

Uncertainty intervals (UI) for all GBD 2023 estimates, including Palestine's amputation incidence rate of 1,313.1 per 100,000 (95% UI: 444.4–3,068.5), are derived from 1,000 draws from the posterior distribution of the DisMod-MR 2.1 Bayesian meta-regression model. The 95% UI is defined by the 25th and 975th ordered values of these 1,000 draws.[36,1] This procedure captures uncertainty propagated from multiple sources simultaneously: sampling variability in input data, model parameter uncertainty, covariate coefficient uncertainty, and cross-walking uncertainty between alternative measurement approaches and the reference definition. The resulting intervals therefore reflect total analytical uncertainty across the estimation pipeline, not merely sampling error from a single data source.

In settings with adequate primary data, narrower intervals reflect convergent evidence across sources. In data-scarce settings — including conflict-affected locations where health information infrastructure has been disrupted — the model's reliance on regional priors and covariate-based extrapolation produces wider intervals reflecting reduced data density.[36,2] Palestine's 95% UI of 444.4–3,068.5 per 100,000 explicitly captures this structural uncertainty. The width of this interval is methodologically appropriate: it does not signal model failure but rather the model's correct propagation of uncertainty under conditions of reduced primary data availability. Critically, even the lower bound of Palestine's UI (444.4 per 100,000) exceeds the point estimate of every other country globally in 2023 (Ukraine: 147.4 per 100,000), confirming that the primary comparative finding is robust across the full range of modelled uncertainty.

Reporting format

All estimates are reported as point estimates to one decimal place with asymmetric 95% uncertainty intervals (lower bound–upper bound), following standard GBD publication practice.31,15,48 This format reflects the structure of the underlying estimates: the 95% UI bounds are the 25th and 975th ordered values of 1,000 posterior draws from the DisMod-MR 2.1 Bayesian model, and the resulting distributions are non-Gaussian. Asymmetric interval presentation is therefore the methodologically appropriate format for this class of estimate. In the abstract, amputation incidence rates are rounded to whole numbers per standard convention for summary reporting; all other prose and table values retain one decimal place.

7b. DisMod-MR 2.1 Estimation Cascade and Behavior Under Data Scarcity

DisMod-MR 2.1 is a Bayesian meta-regression tool that simultaneously estimates incidence, prevalence, remission, excess mortality, and cause-specific mortality from heterogeneous sources, enforcing internal epidemiological consistency across parameters via a compartmental differential equation framework.[16,7] Estimation proceeds through a five-level analytical cascade: global, super-region, region, country, and (where applicable) subnational units. At each level, the fit from the parent level provides an

informative prior for the child level, so that data-sparse locations are regularized toward regional patterns while retaining the capacity to depart from them when local data support departure.[2]

For Palestine 2023, where near-total disruption of health information systems in Gaza severely limited primary data availability.[12] the model's estimates draw substantially on: (i) the regional prior derived from the Eastern Mediterranean super-region; (ii) covariate-based extrapolation using predictors associated with conflict-related trauma burden (including Socio-demographic Index, healthcare access indices, and conflict intensity proxies); and (iii) partial facility reports and conflict analogue data where available.[3,6,8] This is the standard behavior of the cascade for any location experiencing acute health system disruption — the same mechanism produced estimates for Rwanda 1994, Syria 2014, and Afghanistan 2021 under analogous conditions of primary data scarcity. Cross-country comparative validity is preserved precisely because this mechanism applies uniformly across all 204 locations: systematic biases in the estimation pipeline affect all countries proportionally, leaving relative comparisons unaffected even when absolute estimates carry greater uncertainty for individual data-sparse locations.

The model does not interpolate from facility-based case counts alone. DisMod-MR integrates evidence across hospital records, household surveys, vital registration, published epidemiological literature, and conflict analogues, weighting each source by its methodological quality and representativeness.[16,7] In acute conflict settings, this multi-source integration is designed to produce estimates of *true burden* — including cases that never reached a facility — rather than simply echoing the reported caseload of partially functional health systems. The systematic under-ascertainment of severe injuries in collapsed health systems (see Discussion §2) is precisely the problem this approach is designed to correct.

7c. GBD All-Cause Amputation Capture vs. Facility-Based Conflict-Attributable Counts

A methodological distinction critical to interpretation of this analysis is the difference between GBD all-cause incidence estimates and facility-based conflict-attributable case counts reported by field sources (e.g., Gaza MoH, WHO Rehabilitation Task Force). These metrics measure different quantities and are not expected to converge on the same figure.

GBD all-cause estimate	Includes conflict-attributable trauma amputations, secondary amputations from healthcare system collapse, dysvascular and diabetic amputations, congenital amputations, and non-conflict traumatic amputations. Unit: West Bank and Gaza combined (~5.4M population). Designed to estimate true burden including cases not reaching facilities.
Field-reported count (MoH / WHO RTF)	Records conflict-attributable amputations among patients who survived to receive care at partially functioning facilities in Gaza (~2.1M). Excludes: patients dying before care, secondary amputations in non-reporting settings, West Bank background burden. By design a lower bound on true conflict-attributable burden.
Expected relationship	GBD > field count, by a margin reflecting: (1) West Bank inclusion, (2) non-conflict etiology, (3) survival-dependent ascertainment in collapsed systems, (4) model extrapolation to unobserved cases. The gap is the expected product of methodological scope differences.

The capture-recapture analysis by Jamaluddine et al. (2024), already cited in the manuscript as Ref. 12, found that Gaza MoH records undercounted traumatic injury *deaths* by 41%.[9] Amputation ascertainment in the same conditions is subject to at least comparable under-capture, because patients sustaining amputations who die before reaching care are classified as deaths rather than amputees. Under conditions where only approximately 30% of Gaza's health service delivery units were functioning (HeRAMS September 2025), and where conditions were substantially worse during the acute phase of late 2023, facility-based counts represent a fraction of true burden. GBD's estimate of true burden therefore exceeds facility counts by design, and the gap between the two is evidence of the model working correctly, not evidence of model error.

Demographic analysis — by age

Amputation incidence was examined across standard five-year age bands to characterize the full age gradient across the life course. For aggregated comparisons, children were defined using GBD's pre-built <20 years band as the closest available approximation to the CRC Article 1 definition of childhood (<18 years).[20] A sensitivity analysis restricted to children under 14 years was performed to assess robustness to the exclusion of the 15–19 age band. Older adults were defined as 60 years and over (primary) and 70 years and over (sensitivity), consistent with WHO and UN General Assembly definitions.[46,47] Z-scores and fold-differences were recalculated for each subgroup against sex-matched reference distributions, with Palestine excluded from all reference distribution calculations.

Demographic analysis — by sex

Sex-stratified analyses used GBD male and female estimates separately. The term 'sex' reflects the biological binary categories reported in GBD source data, derived from vital registration and census records; these do not capture gender identity. Because GBD's 'both sexes' combined rate is population-weighted rather than the arithmetic sum of male and female rates, male rates were compared against

male reference distributions and female against female, preventing population-weighting structure from distorting sex-specific comparisons. The male-to-female (M:F) amputation incidence ratio was calculated for Palestine and each of the 33 active conflict states. Palestine was excluded from all reference distribution calculations in sex-stratified analyses.

Software

All analyses conducted in MATLAB. Bar charts and time-series plots (Figs. 1C, 1D and 2–4) were generated in MATLAB.

8. Sensitivity Analyses

Sensitivity A — Conflict intensity restriction (war-level only)

All primary comparisons were re-run restricting the reference group to countries that met the UCDP/PRIO war-level threshold (≥1,000 battle-related deaths per calendar year) rather than the standard armed conflict threshold (≥25 deaths per year).[15] This tests whether including low-intensity conflicts in the reference distribution artificially widens Palestine's z-score. Forty-three countries met the war-level threshold across 1990–2023 (excluding Palestine); their peak amputation rates formed the restricted reference distribution. If Palestine remains an extreme statistical outlier against this high-intensity subset, the primary finding is confirmed as robust to conflict intensity threshold selection.

Sensitivity B — Lower bound of Palestine's 95% uncertainty interval

All primary comparisons were re-run substituting the lower bound of Palestine's 95% UI (444.4/100k) for the point estimate (1,313.1/100k). This is the most conservative possible test: if Palestine's lower UI bound still exceeds all comparison countries' point estimates, the finding is robust to the full range of GBD modelling uncertainty.[34] Palestine's lower bound (444.4/100k) exceeds the highest 2023 rate among all other 203 countries (Ukraine: 147.4/100k), confirming robustness.

Sensitivity C — Peak-year conflict peers

Palestine's 2023 rate was compared against each conflict-affected country's all-time peak rate across 1990–2023, rather than only its 2023 rate. This ensures Palestine is assessed against each comparator's most adverse documented conditions rather than its 2023 snapshot. This comparison is equivalent to the Analysis 4 historical peaks comparison and is designated a pre-specified secondary analysis; no additional figure is required.[14,15]

9. Visualization

Choropleth maps (Fig. 1, Panels A–B) were generated using Datawrapper, with a sequential blue-to-red color scale on a log scale to prevent compression of the distribution, with Palestine labelled at the saturated extreme. Bar charts and time-series plots (Figs. 1C, 1D and 2–4) were generated in MATLAB. All figures were prepared at minimum 300 DPI, maximum width 180 mm, with sans-serif font (5–7 pt) per Nature Medicine specifications. Error bars represent 95% uncertainty intervals throughout.

10. Temporal Scope Rationale

The study period ends December 31, 2023. The October 2023 conflict escalation is captured in the 2023 GBD annual estimate but represents only approximately 86 days (October 7–December 31, 2023) within a 365-day calendar year denominator.[32] GBD data for 2024, 2025, and 2026 are not yet available. The reported rate of 1,313.1 per 100,000 therefore almost certainly underestimates the annualized burden during the active conflict period; the reported figure is a lower bound on true conflict-period burden.

11. Limitations (Methods-specific)

Limitation A — Model-derived estimates under data scarcity

GBD 2023 Palestine estimates are model-derived; health information systems in Gaza experienced severe disruption during 2023–2024, requiring greater reliance on regional priors, partial facility reports, and conflict analogues. Cross-country comparative validity is preserved because all 204 locations are estimated using the same DisMod-MR 2.1 pipeline; systematic biases affect all countries proportionally.[34] Directional corroboration is provided by WHO Rehabilitation Task Force (September 2025: ~40,000 disabilities)[10] and Save the Children International (2024: ≥15 children per day with permanent injuries).[11]

Limitation B — All-cause amputation capture

The all-cause approach includes dysvascular, diabetic, and congenital amputations alongside conflict-attributable cases. Cross-national comparison is preserved by uniform application.[33] In the Gaza context this is analytically appropriate: secondary amputations from health system collapse are legitimately conflict-attributable regardless of proximate clinical cause. Natural disaster-driven amputations (Haiti 2010) represent a distinct confound; Haiti is excluded from conflict comparisons for this reason.

Limitation C — Palestine as single GBD unit

GBD treats 'West Bank and Gaza' as one location. Gaza (~2.1M) is approximately 39% of the GBD unit total (~5.4M). The Palestine-wide rate substantially underestimates the Gaza-specific burden; reported figures are a lower bound on the Gaza crisis. The true Gaza-only annualized rate would be approximately 2.6× higher.[22]

12. Ethics, Data, and Code Availability

Secondary analysis of publicly available, aggregated population-level data. No individual patient data were accessed. No IRB approval required.

Data: vizhub.healthdata.org/gbd-results/ | ucdp.uu.se | Source data in Supplementary Tables S1–S4.

Analysis code: available from the corresponding author upon reasonable request.

Claude (Anthropic) was used to assist with manuscript drafting and reference formatting. All scientific content, analyses, and conclusions were verified and approved by the authors.

Figures

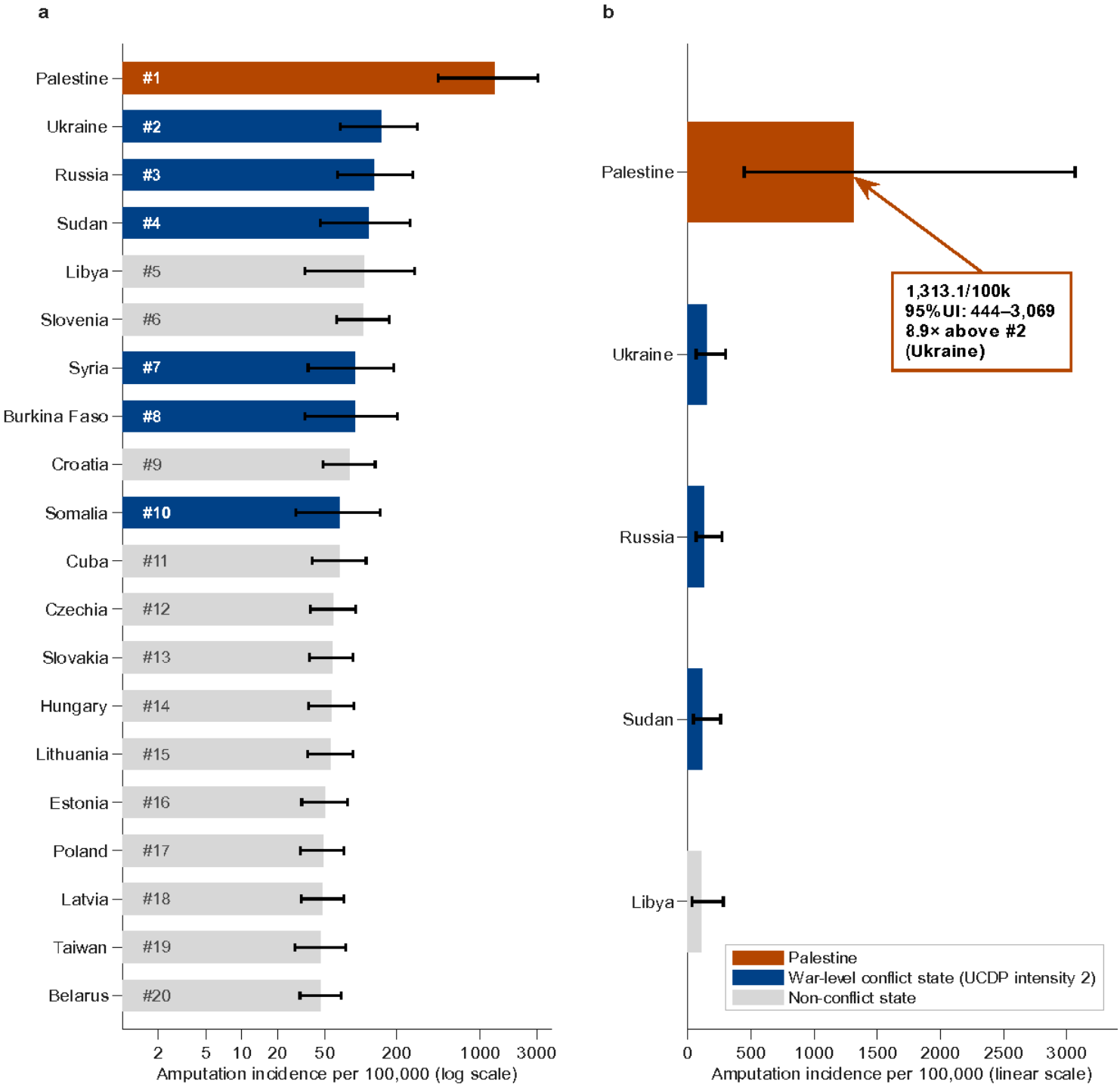


Figure 1

Global cross-section of major amputation incidence across 204 countries, 2023. (a) Top 20 countries ranked by major amputation incidence per 100,000 population, log scale. Burnt-orange filled bar, Palestine; dark navy filled bars, war-level conflict states (UCDP intensity 2); light grey filled bars, non-conflict states. Error bars represent 95% uncertainty intervals derived from 1,000 posterior draws of the GBD 2023 DisMod-MR 2.1 model. Palestine (1,313.1/100k) is 8.9-fold above Ukraine (147.4/100k); $z = 60.0$, $p < 0.001$ ($n = 203$ comparator countries, two-tailed z-test against mean). (b) Linear-scale

comparison of Palestine against the top four countries. Palestine's lower uncertainty bound (444/100k) alone exceeds every other country's point estimate. Error bars as in panel a.

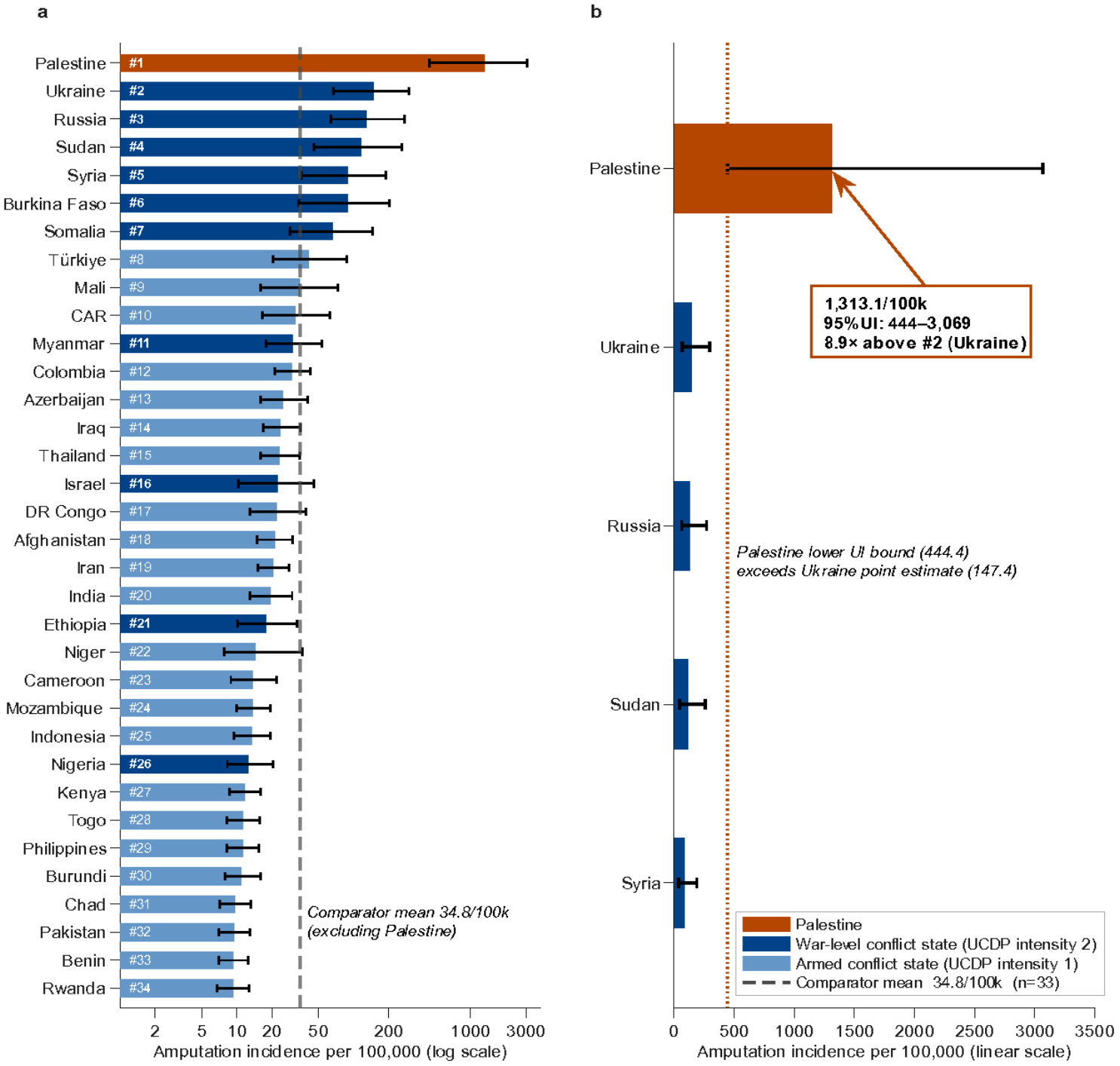


Figure 2

Contemporaneous conflict cross-section across 34 active conflict states, 2023. (a) All 34 active conflict states ranked by major amputation incidence per 100,000, log scale. Burnt-orange filled bar, Palestine; dark navy filled bars, war-level conflict states (UCDP intensity 2); medium blue filled bars, armed conflict states (UCDP intensity 1). Dashed grey vertical line, unweighted comparator mean of 34.8/100k (n = 33, excluding Palestine). Error bars represent 95% uncertainty intervals as in Fig. 1. Palestine (1,313.1/100k)

is 37.8-fold above the comparator mean; z = 34.7, p < 0.001. (b) Linear-scale comparison of Palestine against the five highest-ranking comparators. Dotted orange vertical line marks Palestine's lower uncertainty bound (444.4/100k), which exceeds Ukraine's point estimate (147.4/100k). Dashed grey vertical line, comparator mean. Error bars as in panel a.

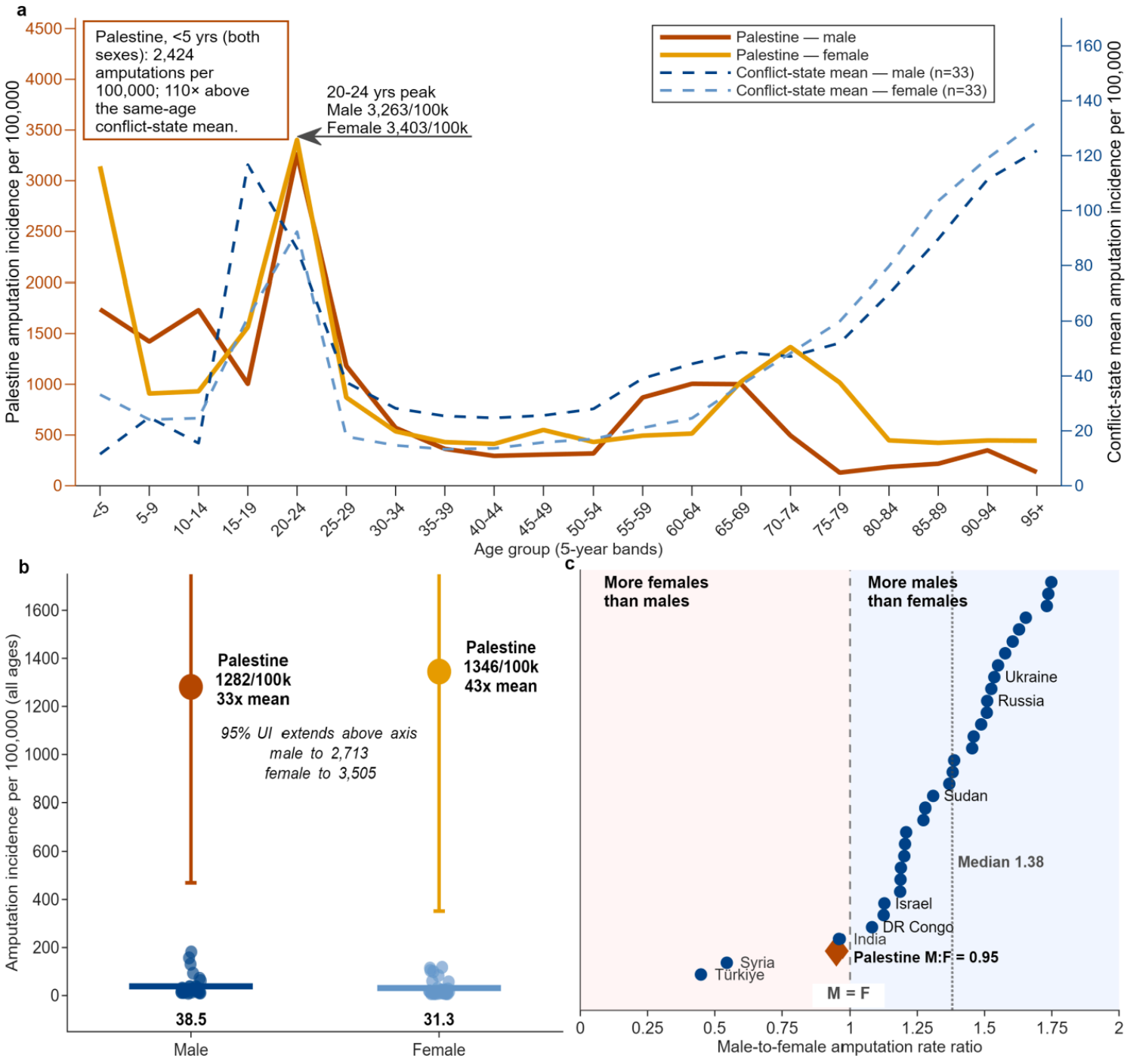


Figure 3

Demographic disaggregation of amputation incidence, Palestine vs. 33 active conflict states, 2023. (a) Age-stratified amputation incidence across 20 five-year age bands. Solid burnt-orange line, Palestinian males (left axis); solid gold line, Palestinian females (left axis); dark navy dashed line, conflict-state

mean for males (right axis); light blue dashed line, conflict-state mean for females (right axis). Lines represent mean values; n = 33 conflict-state comparators. All Palestine vs. comparator differences p < 0.001 (z-test). (b) All-ages amputation incidence by sex. Large burnt-orange filled circle, Palestinian male rate (1,282/100k); large gold filled circle, Palestinian female rate (1,346/100k); small blue filled circles, individual conflict-state rates; horizontal dark navy and light blue lines, conflict-state means (38.5/100k male and 31.3/100k female, respectively). Vertical error bars represent 95% uncertainty intervals as in Fig. 1; n = 33. (c) Male-to-female amputation rate ratio across all 34 active conflict states. Filled blue circles, individual countries; burnt-orange filled diamond, Palestine (M:F ratio = 0.95). Dashed grey vertical line, M = F (ratio = 1.0); dotted grey vertical line, median ratio across conflict states (1.38; n = 33 excluding Palestine).

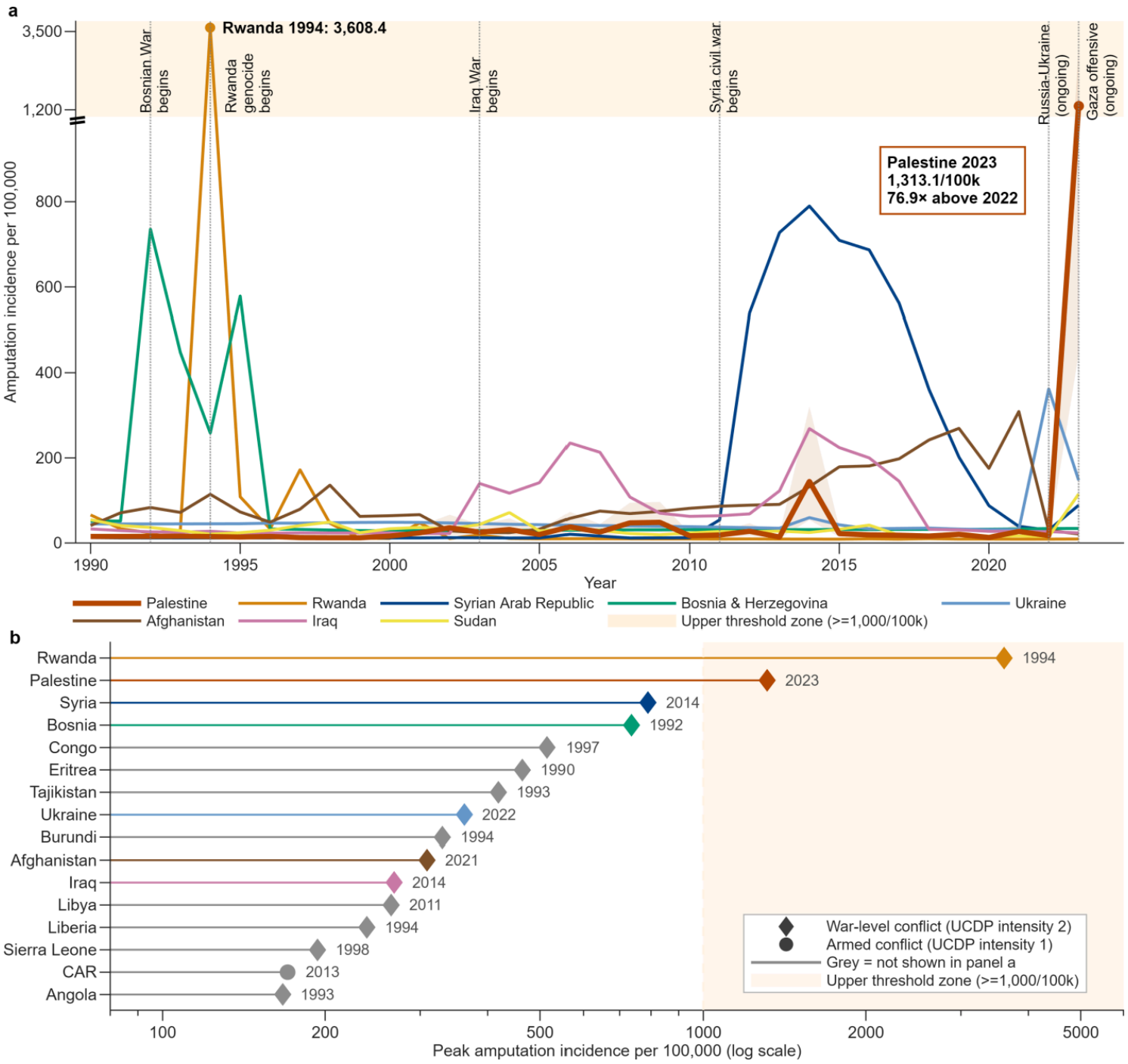


Figure 4

34-year historical comparison of amputation incidence across conflict-affected states, 1990–2023. (a) Annual amputation incidence time series for nine highlighted countries, each represented by a distinct coloured line. Shaded beige zone marks the 1,000/100k upper threshold, exceeded only by Rwanda 1994 and Palestine 2023 across the full 34-year dataset. Dotted grey vertical lines mark major conflict onset dates. Palestine's 2023 rate is 14.9 standard deviations above the pooled conflict-state mean of 29.4/100k; $p < 0.001$ (n = 2,720 country-year observations, 80 states). (b) All-time peak amputation incidence for 17 selected conflict-affected countries, log scale, plotted at peak year. Filled diamond markers indicate war-level conflict states (UCDP intensity 2); filled circle markers indicate armed conflict states (UCDP intensity 1); grey markers and connecting lines indicate countries not highlighted in panel a. Shaded beige zone marks the 1,000/100k threshold. Palestine is excluded from the comparator distribution (n = 80, excluding Palestine and Haiti).

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SupplementaryMaterials.docx