

# Drought amplifies the psychological burden of war

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The convergence of climate shocks and armed conflict poses a critical threat to human security and sustainable development. However, their joint impacts on human populations, particularly the erosion of psychosocial resilience, remain poorly quantified. Here, integrating georeferenced drought data from respondents' pre-displacement regions with survey data from Syrian and Iraqi refugees ( $N = 3,751$ ), we find that the association between war exposure and post-traumatic stress is stronger among those from more drought-affected areas of origin. Under severe drought conditions, the increase in post-traumatic stress associated with war exposure was more than twice as large as under average moisture conditions. This pattern is consistent with resilience corrosion, whereby climate-induced hardship may degrade mental health and weaken the adaptive capacities communities need to navigate future shocks. These findings support policy approaches that integrate mental health into climate adaptation and humanitarian response in settings shaped by overlapping crises.

Climate change is already producing severe and, in some cases, irreversible harms to ecological and social systems, with consequences for the resources and institutions that support human adaptation<sup>1,2</sup>. Armed conflict likewise has profound psychological consequences, including elevated levels of post-traumatic stress (PTS) symptoms among affected populations<sup>3–6</sup>. Extensive work links climate extremes to conflict, and migration<sup>7–10</sup>, yet these stressors are frequently studied in isolation. As a result, we know less about how environmental and political stressors jointly shape psychological well-being among populations exposed to both.

Exposure to climate hazards is associated with worse mental well-being<sup>11–18</sup>. Yet while sudden-onset events like floods are well-documented triggers of acute trauma, less is known about slow-onset stressors such as drought<sup>19–23</sup>. This gap is critical: unlike the immediate shock of a flood, drought operates as a pervasive condition, a chronic stressor that systematically erodes resilience over time. By depleting material and psychological reserves, drought may amplify the psychological consequences of conflict exposure, magnifying the

impact of violence on vulnerable populations. Yet, existing studies focus almost exclusively on high-income countries<sup>11,21,24,25</sup>, limiting insight into how these chronic climate stressors and war-related stressors interact<sup>16,26,27</sup>. Here we examine whether the association between war exposure and PTS among refugees is stronger among those originating from more drought-affected areas.

We draw on established theories of cumulative stress<sup>28,29</sup>, including allostatic load and stress proliferation, and conceptualize drought as a slow-onset, chronic stressor that progressively depletes economic, social and psychological reserves. We characterize this trajectory as resilience corrosion: a process of cumulative strain where environmental hardship degrades the very capacities individuals need to withstand the psychological burden associated with conflict exposure. Because drought unfolds gradually and often alongside political instability, its effects can accumulate over time and carry substantial long-term health consequences<sup>30</sup>.

Rather than viewing drought as a potentially traumatic event in itself, we argue it may act as a risk factor that amplifies vulnerability

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**Table 1 | Descriptive characteristics (N=3,751)**

| a)                                                  |                                                                                                                                                                                           |      |         |         |        |
|-----------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|---------|---------|--------|
| Continuous and ordinal variables                    | Mean                                                                                                                                                                                      | s.d. | Minimum | Maximum | Median |
| PTS symptoms                                        | 17.99                                                                                                                                                                                     | 4.78 | 6.00    | 30.00   | 18.00  |
| Pre-displacement drought exposure (SPEI-12)         | −0.68                                                                                                                                                                                     | 0.79 | −2.59   | 2.42    | −0.85  |
| War exposure index (HTQ count of event types)       | 3.39                                                                                                                                                                                      | 3.40 | 0       | 16      | 2      |
| b)                                                  |                                                                                                                                                                                           |      |         |         |        |
| Binary and categorical variables                    |                                                                                                                                                                                           |      |         |         |        |
| Drought indicator (SPEI-12 below −1)                | 38%                                                                                                                                                                                       |      |         |         |        |
| Female                                              | 51%                                                                                                                                                                                       |      |         |         |        |
| Age group, years                                    | 18–24 (36%), 25–34 (32%), 35–44 (17%), 45–54 (8%), 55–64 (3%), >65 (3%)                                                                                                                   |      |         |         |        |
| Education level (highest attained)                  | No formal education (4%), less than 6 years of schooling (5%), 6 years of schooling (13%), 9 years of schooling (24%), 12 years of schooling (30%), more than 12 years of schooling (24%) |      |         |         |        |
| Pre-displacement socioeconomic status (0–10 ladder) | Median: 5 (IQR: 3–8)                                                                                                                                                                      |      |         |         |        |
| Urban origin                                        | 48%                                                                                                                                                                                       |      |         |         |        |
| Years since migration                               | 1 (5%), 2 (14%), 3 (24%), 4 (23%), 5 (23%), 6 (8%), 7 (2%)                                                                                                                                |      |         |         |        |

Percentages are reported for binary and categorical variables. PTS symptoms were measured using the six-item PTSD Checklist–Civilian version; SPEI is the Standardized Precipitation–Evapotranspiration Index, where lower values indicate more severe drought. The drought dummy equals 1 when SPEI-12 falls below −1. Socioeconomic status is based on respondents' self-placement on a 0–10 ladder referring to their pre-displacement position in their country of origin. Age was collected in grouped categories.

through three concurrent pathways. Income volatility and livelihood challenges can create persistent stress and deplete material resources for coping<sup>7,12,14,16,31–34</sup>. Psychologically, deteriorating mental health may induce pessimistic risk perceptions, and debilitating feedback loops that further entrench vulnerability<sup>35–38</sup>. Socially, resource scarcity may fray the community bonds that serve as crucial buffers against trauma<sup>39,40</sup>. Our framework posits that, by degrading these foundational pillars of resilience, drought amplifies the psychological burden of war.

We test these arguments using a unique dataset that integrates georeferenced climate data with surveys of more than 3,000 Syrian and Iraqi refugees in Türkiye, a population exposed to both devastating war and recurring drought. We focus on displacement from Syria and Iraq to Türkiye during the 2010s. The sample reflects displacement generated by distinct but overlapping conflict trajectories during this period, including the Syrian civil war beginning in 2011 and conflict escalation in Iraq associated with ISIS/Daesh and related violence in the mid-2010s. Respondents left their areas of origin between 2010 and 2017 and came from multiple governorates that differed in both conflict exposure and drought severity. This makes Türkiye a useful receiving context for studying how environmental and conflict-related stressors intersect across heterogeneous displacement trajectories. To mitigate selection biases inherent in camp-only refugee research, we combine (1) an exit-point intercept survey of adult residents of a United Nations High Commissioner for Refugees (UNHCR)-registered refugee camp among individuals authorized to leave the camp during the fieldwork period and (2) a community-based survey of refugees living outside camps using a chain-referral design initiated from diverse seed points. Together, these two samples provide a rare and more comprehensive view of the refugee experience in Türkiye. Building on this empirical

foundation, we test two hypotheses: we expect (H1) greater exposure to war-related traumatic events to be associated with higher levels of PTS<sup>41–43</sup>; and (H2) this association is stronger in contexts characterized by more severe drought. Consistent with this framework, we find that drought exposure strengthens the association between war-related trauma and PTS, indicating that slow-onset climate stressors can compound the psychological harms of conflict.

## Drought and PTS among refugees

Before presenting the results, we briefly clarify the data collection and exposure measures used in this analysis. The study draws on a cross-sectional survey of Iraqi and Syrian refugees conducted in 2017, capturing retrospective information on war exposure and PTS symptoms among respondents living both in refugee camps and in host communities in Türkiye. For the present study, we restrict the sample to respondents who left Syria or Iraq in 2010 or later and who have complete information on the outcome and included covariates. The main regression models therefore include 3,751 respondents: 2,089 camp-based refugees (56%) and 1,662 refugees residing outside camps (44%).

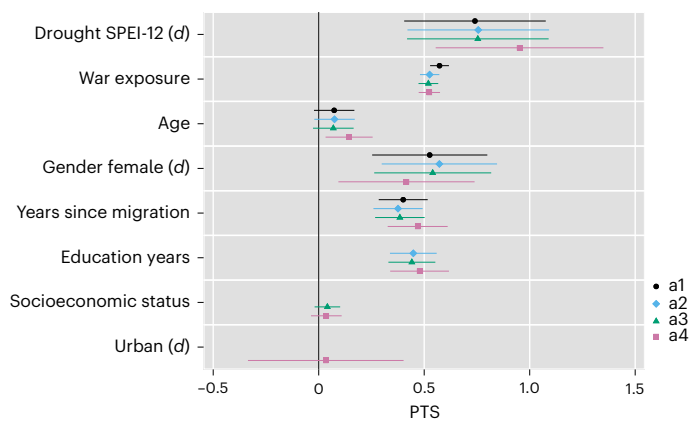
From this rich survey data, we derive our key variables. Exposure to potentially traumatizing war-related events was measured using a 16-item version of the Harvard Trauma Questionnaire (HTQ)<sup>44</sup>, covering direct experiences of violence, profound loss and extreme deprivation; full item wording and prevalence are reported in the Supplementary Information (Supplementary Fig. 18). Trauma exposure in our sample was extensive: on average, respondents reported experiencing 3.39 (standard deviation (s.d.) 3.40) distinct traumatic event types. The most documented events were 'lack of shelter' (39% of participants) and 'indiscriminate shelling or bombing' (33%). Our primary outcome, PTS symptoms, was measured using the short form of the PTSD Checklist–Civilian version<sup>45,46</sup>, which evaluates the extent to which respondents have been affected by PTS symptoms in the past month and captures core features of PTSD including intrusive re-experiencing, avoidance and emotional numbing (the full item wording is reported in Methods and Supplementary Information). The total score serves as an index of overall symptom severity, with a sample mean of 17.99 (s.d. 4.78).

This validated scale evaluates the extent to which respondents have been affected by PTS symptoms in the past month. Sample items capture core features of PTSD, including intrusive re-experiencing (for example, 'Repeated, disturbing memories, thoughts, or images of a stressful experience from the past'), as well as avoidance and emotional numbing (for example, 'Avoid activities or situations because they remind you of a stressful experience from the past'; 'Feeling distant or cut off from other people'). The total score serves as an index of overall symptom severity, with a sample mean of 17.99 and s.d. of 4.78.

Demographic information on age, education, gender and socioeconomic status comes from the survey responses. In the sample, 51% of respondents are female. Respondents are predominantly of working age with 57% aged 25–54 years.

Using the survey–climate linkage described by Döring and Hall (2023)<sup>40</sup>, we assigned each respondent a drought measure based on the reported governorate of origin and the reported timing of displacement. Drought was measured with the Standardized Precipitation–Evapotranspiration Index (SPEI-12)<sup>47</sup>, an index of cumulative moisture anomalies that incorporates both precipitation and potential evapotranspiration. Lower SPEI values indicate drier-than-usual conditions relative to a location-specific climatological baseline. Each respondent was assigned the SPEI-12 value for their governorate of origin in December of the year preceding displacement. The primary specification uses a binary indicator for moderate or more severe drought, coded 1 when governorate-level SPEI-12 was below −1 and 0 otherwise; 38% of respondents in our sample met this criterion. Descriptive statistics for the main variables are reported in Table 1.

We analysed the relationship between war exposure, drought and PTS using a hierarchical linear model with random intercepts



**Fig. 1 | Estimated coefficients of drought exposure on PTS across alternative model specifications.** Points show point estimates (measure of centre) from hierarchical linear mixed-effects models with random intercepts at the governorate level, fit by maximum likelihood; whiskers show two-sided 95% confidence intervals.  $n = 3,751$  independent respondents from 28 governorates in all models. The  $d$  denotes dummy (binary indicator) variables. The outcome is the PCL-C symptom-severity score; the main predictor is the binary drought indicator (governorate-average SPEI-12  $< -1$ ). All specifications include controls for war exposure, age, gender and years since displacement. Model a1 includes only the baseline controls. Model a2 adds education. Model a3 further adds pre-displacement socioeconomic status. Model a4 is the full specification, adding an urban/rural background indicator. Statistical inference is based on two-sided Wald  $z$ -tests on the fixed-effect coefficients; no adjustments for multiple comparisons were made.

for governorates, controlling for demographic and socioeconomic factors (Fig. 1). Consistent with prior research, war-related traumatic events were positively associated with PTS scores (model a1:  $b = 0.573$ , SE 0.023, where SE denotes the standard error of the regression coefficient). Crucially, we also observe a positive main association between drought exposure and PTS (a1:  $b = 0.741$ , SE 0.171,  $P < 0.001$ ). Individuals who resided in drought-affected areas before displacement reported higher PTS scores across levels of war exposure, indicating that slow-onset environmental stressors are independently associated with psychological distress.

Most critically for our resilience corrosion framework, we identify a significant amplifying interaction between war exposure and drought, indicating that the association between war-related trauma and PTS is stronger among individuals from more drought-affected pre-displacement environments (Table 2). Levels of PTS associated with war exposure are higher under more severe drought conditions, consistent with an amplifying interaction between environmental and conflict-related stressors. The nature of this interaction is illustrated in Fig. 2 (left panel), which graphs the predictive margins of PTS based on war exposure, conditional on our dichotomous drought measure. The two diverging lines visually confirm the synergistic effect: while PTS increases with war exposure for all respondents, this increase is significantly stronger among respondents exposed to both war-related trauma and drought conditions. Interpreted substantively, the interaction indicates that drought conditions characterizing refugees' pre-displacement environments are associated with higher PTS at high levels of war exposure.

We further examine this compounding relationship by tracing predicted PTS across the full range of drought severity captured by the SPEI. Figure 2 (right panel) shows predictive margins of PTS as a function of war exposure, conditional on drought conditions ranging from average moisture (SPEI=0) to extreme drought (SPEI=-2). Across the exposure distribution, lower SPEI values are associated with higher predicted PTS, but these differences emerge primarily at higher levels of war exposure. At these levels, the model predicts PTS scores

**Table 2 | Interaction models of war exposure, drought and PTS**

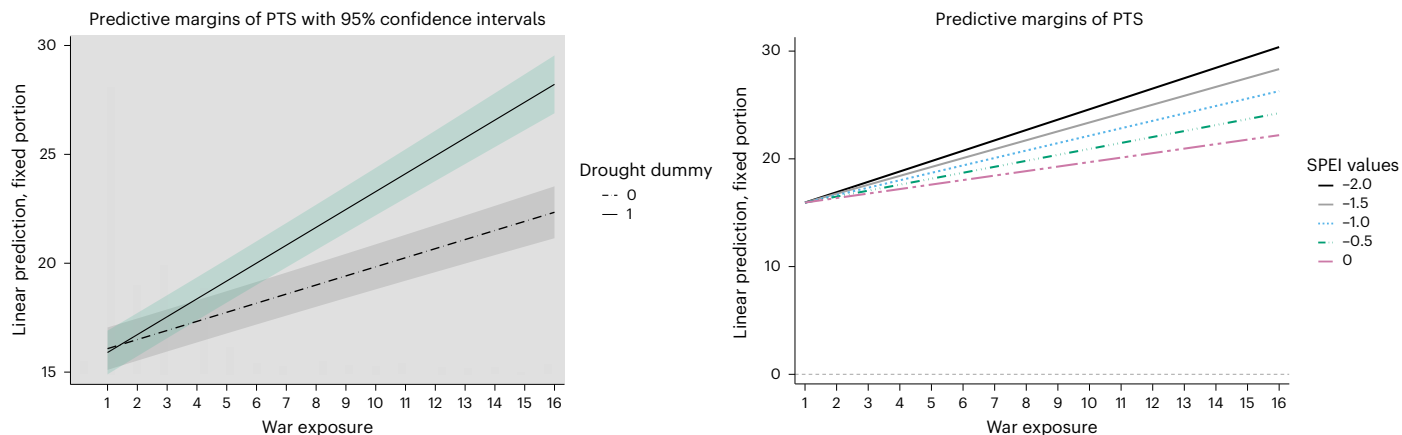
|                                       | (1)       | (2)      |
|---------------------------------------|-----------|----------|
| Drought (SPEI-12)                     | 0.274*    |          |
|                                       | (0.140)   |          |
| War exposure                          | 0.417***  | 0.418*** |
|                                       | (0.027)   | (0.028)  |
| Drought SPEI-12 $\times$ War exposure | -0.273*** |          |
|                                       | (0.027)   |          |
| Drought dummy                         |           | -0.580** |
|                                       |           | (0.221)  |
| Drought dummy $\times$ War exposure   |           | 0.403*** |
|                                       |           | (0.044)  |
| Age                                   | 0.077     | 0.079    |
|                                       | (0.048)   | (0.048)  |
| Years since migration                 | 0.460***  | 0.426*** |
|                                       | (0.059)   | (0.059)  |
| Female                                | 0.498***  | 0.515*** |
|                                       | (0.139)   | (0.139)  |
| Socioeconomic status                  | 0.061*    | 0.077*   |
|                                       | (0.030)   | (0.030)  |
| Observations                          | 3,751     | 3,751    |

Hierarchical linear mixed-effects models with random intercepts at the governorate level, fit by maximum likelihood;  $n = 3,751$  independent respondents from 28 governorates. Coefficients are fixed-effect estimates; standard errors in parentheses. Model 1 uses continuous SPEI-12; model 2 uses a binary drought indicator coded 1 when SPEI-12  $< -1$ . Statistical significance is assessed using two-sided Wald  $z$ -tests on the fixed-effect coefficients; no adjustments for multiple comparisons were made. Symbols: + $P < 0.1$ , \* $P < 0.05$ , \*\* $P < 0.01$ , \*\*\* $P < 0.001$ . Exact  $P$  values for the key coefficients were as follows. Model 1: Drought (SPEI-12)  $P = 0.050$ ; War exposure  $P < 0.0001$ ; Drought (SPEI-12)  $\times$  War exposure  $P < 0.0001$ . Model 2: Drought dummy  $P = 0.0087$ ; War exposure  $P < 0.0001$ ; Drought dummy  $\times$  War exposure  $P < 0.0001$ .

approximately four points higher under moderately dry conditions (SPEI=-1) than under average moisture conditions (SPEI=0), while differences are negligible when war exposure is low. This pattern indicates that drought conditions characterizing pre-displacement environments are associated with a stronger psychological burden of war exposure, consistent with an amplifying rather than additive relationship between slow-onset climate stressors and conflict. To assess whether this pattern also appears under longer drought accumulation windows, we checked that this synergistic pattern remains robust when defining drought over longer accumulation windows (24 and 36 months; Supplementary Section 8.2). In addition, subgroup analyses (Supplementary Information) indicate heterogeneity in the strength of this pattern. The estimated amplification of the war exposure-PTS association under more severe drought is stronger in the community-based sample than in the camp-based sample, and is also stronger among respondents from Syria than among respondents from Iraq. These subgroup comparisons should be interpreted cautiously, but they suggest that the observed interaction is context sensitive rather than uniform across displacement settings and national-origin groups.

## Discussion

Our findings quantify the human cost of the climate-conflict nexus. By linking pre-displacement drought exposure to war-trauma histories among Syrian and Iraqi refugees, we find that the association between war exposure and PTS symptoms becomes stronger under more severe drought conditions. This pattern is consistent with the view that slow-onset climate stress can erode psychosocial coping resources, making conflict-related trauma more psychologically costly.



**Fig. 2 | The association between war exposure and post-traumatic stress is stronger under more severe drought.** Left panel shows the predictive margins of PTS based on war exposure conditional on drought.  $n = 3,751$  independent respondents. The solid line (drought dummy = 1) represents individuals from governorates with average SPEI-12  $< -1$  in December of the year before displacement. Note that we report only PTS scores observed in the sample; the y-axis therefore starts at 15. Whiskers show two-sided 95% confidence intervals from the hierarchical linear mixed-effects model (maximum likelihood; Wald z-tests on fixed-effect coefficients; no multiple-comparison adjustment). Right panel displays dose-response relationship between drought severity and the

psychological impact of war. Predictive margins of PTS as a function of war exposure, conditional on varying levels of drought severity (SPEI-12 values from 0 to -2), from the same hierarchical linear mixed-effects model as in the left panel ( $n = 3,751$  independent respondents; maximum likelihood; two-sided Wald z-tests on fixed-effect coefficients; no multiple-comparison adjustment). Shaded bands show two-sided 95% confidence intervals. The diverging, fan-shaped pattern indicates that, as drought severity increases (moving from SPEI=0 to SPEI=-2), the association between war exposure and PTS intensifies. The steepest slope (solid black line) represents extreme drought, indicating that the joint burden on mental health is highest when environmental and conflict stressors are most severe.

More broadly, the results challenge approaches that model environmental and conflict-related stressors in isolation, suggesting that these stressors can interact rather than simply accumulate in contexts shaped by overlapping crises.

We observe an amplifying interaction: PTS symptoms are more strongly associated with war exposure under more severe drought conditions. We interpret this pattern as consistent with resilience corrosion, in which prolonged climate stress may weaken resources that typically buffer trauma responses. Three pathways are plausible in this setting, although we do not test them directly: drought-related livelihood and income losses may impose chronic strain that reduces cognitive and emotional reserves; drought may weaken community relations and erode informal support networks; and sustained hardship may increase hopelessness or perceived lack of control, altering responses to conflict-related trauma. Importantly, this dynamic is not reducible to immediate deprivation: the interaction persists even when excluding 'lack of food or water' from the trauma index (Supplementary Section 8.3). Finally, this proposed argument does not require drought to precede conflict; rather, it reflects the cumulative burden of overlapping environmental and political shocks in this setting.

This interaction may matter beyond symptoms. Elevated distress can reduce perceived efficacy and engagement with adaptation, potentially increasing vulnerability to overlapping shocks. Our findings add to evidence linking climate-related hardship to mental health<sup>16,27,31</sup> and show that, in this setting, drought and war-related stressors can interact rather than simply accumulate<sup>79,48</sup> consistent with research on compounded stress exposure<sup>16,22,24</sup>. We do not test behavioural pathways here, but such dynamics could be relevant for mobility decisions in regions facing simultaneous environmental stress and insecurity. With over 120 million people reported as forcibly displaced or stateless in 2024<sup>49</sup>, understanding how overlapping shocks affect psychosocial functioning is an important challenge for sustainable development and underscores the need for integrated policy approaches that include environmental and psychological resilience as two sides of the same coin. Our results imply that drought response and climate adaptation in conflict-affected and displaced populations should address trauma-related barriers to coping measures<sup>20,31</sup>. In practice, this can mean pairing livelihood

interventions with proactive outreach to households facing the greatest combined burdens of conflict exposure and climate stress, alongside identification of elevated distress and access to brief psychosocial support options where feasible.

Several limitations should be noted. First, although our analytical design links cumulative pre-displacement exposure to drought and war-related trauma to current PTS symptoms, the data are cross-sectional. We therefore cannot precisely date the onset, duration or sequencing of these exposures at the individual level, and environmental and conflict-related stressors probably overlapped in time for many respondents. Second, our war exposure variable is a cumulative index of traumatic events. While this is a standard and validated approach, it treats all events as having the same psychological weight, which may mask heterogeneity in severity (for example, loss of a family member may have a disproportionate impact). Third, environmental and sociopolitical post-migration stressors in Türkiye may also shape mental health outcomes<sup>50</sup>; the positive association with years since arrival is consistent with the possibility that prolonged displacement and integration challenges matter. Finally, our findings are drawn from a specific, highly vulnerable population of Syrian and Iraqi refugees. This context provides a strong test of our argument under severe conflict and environmental stress, but cautions against generalizing to settings without concurrent conflict or with less extreme environmental disruption. The subgroup analyses also suggest that the strength of the amplifying pattern varies across displacement settings and national-origin groups. This probably reflects meaningful differences in post-displacement context and conflict trajectory, suggesting that the observed interaction is context sensitive rather than uniform across refugee populations. Although we focus on drought, similar amplifying interactions may arise when chronic stressors erode coping resources amid shocks. Future work could test whether comparable patterns emerge under prolonged heat exposure or sustained economic volatility in other comparable settings.

The resilience-corrosion framework points to priorities for future research. Designs that track changes in economic security, social support and psychological resources under overlapping shocks are needed to test mechanisms directly. On the policy side, this work could evaluate whether embedding psychosocial support within climate and

livelihood programmes buffers distress and compare this approach with other scalable complements, such as strengthening social support and collective efficacy, reducing day-to-day stressors that impede programme uptake, or adding targeted follow-up for households facing the greatest combined burdens. Such evidence would help specify which combinations of material support and psychosocial design features most effectively build resilience at the climate–conflict nexus.

Overall, our findings suggest that slow-onset drought can amplify the mental health burden of war, underscoring the value of climate adaptation and humanitarian action that integrates psychosocial considerations alongside material support in climate-vulnerable settings.

## Methods

We use the same survey–climate data set-up as described by Döring and Hall (2023)<sup>40</sup>, which we used to study drought exposure and altruism among Syrian and Iraqi refugees in Türkiye. The present study draws on the same underlying survey collection effort and the same governorate-level climate linkage to address a distinct research question: whether pre-displacement drought conditions amplify the association between war-related traumatic event exposure and PTS symptoms. The sample is exposed to both intense armed conflict and varying degrees of meteorological drought in respondents' regions of origin, enabling examination of the compounding impacts of these stressors.

### Survey, sampling and exposure measures

The original survey procedures were described by Döring and Hall (2023)<sup>40</sup>. The data were collected in 2017 among Syrian and Iraqi refugees living in Türkiye using two complementary sampling strategies. The first was an exit-point intercept survey at the Midyat UNHCR-registered refugee camp in Mardin Province; 2,089 respondents from this component enter the present analysis sample. Camp management regulated short-term exits and maintained rosters governing daily departures, and Arabic-speaking research assistants approached authorized exiters consecutively outside the camp (consent rate >95%), so inference for this component pertains to adult exit-permit holders during the fieldwork period. The second was a community-based survey of Syrian and Iraqi refugees in multiple cities in Central Anatolia, initiated from a diverse set of seed points and expanded through chain-referral recruitment to reach refugees outside camp settings; 1,662 respondents from this component were included in the analytical sample. We restrict the broader survey to respondents who left Syria or Iraq in 2010 or later and who have complete information on PTS symptoms, war exposure, drought exposure and covariates, yielding  $N = 3,751$ . Additional sampling details are provided in the Supplementary Information. As a robustness check, we re-estimated the main models separately for the camp-based and community-based samples and separately for respondents from Syria and Iraq; subgroup estimates point in the same direction but are stronger in the community and Syria samples than in the camp and Iraq samples (Supplementary Information).

Respondents reported their governorate of origin, which was used to link individual survey responses to regional climate data. Origin locations are unevenly distributed across governorates, reflecting displacement patterns and proximity to Türkiye. Syrian respondents are concentrated in Aleppo, Damascus, Raqqqa, Deir ez-Zor, Daraa, Al-Hasakah, Homs and Idlib; Iraqi respondents are concentrated in Saladin, Baghdad, Nineveh, Al Anbar and Basra. More disaggregated geographic data were not collected for ethical reasons.

### Measures for PTS, drought and war exposure

PTS symptoms, our primary outcome, were assessed using the six-item short form of the PTSD Checklist–Civilian version (PCL-C), an established clinical measure<sup>45,46</sup>. Respondents rated how much they had been affected by each problem in the past month on a 5-point

scale. Sample items capture core PTS symptoms, including intrusive re-experiencing (for example, 'Repeated, disturbing memories, thoughts, or images of a stressful experience from the past'), as well as avoidance and emotional numbing (for example, 'Avoid activities or situations because they remind you of a stressful experience from the past'; 'Feeling distant or cut off from other people'). The total sum score was used as a continuous index of PTS symptom severity. Exposure to war-related traumatic event types was assessed using a 16-item version of the HTQ<sup>44</sup>, a standard instrument for this purpose<sup>51,52</sup>. Respondents indicated which of the 16 event types they had experienced before arriving in Türkiye. Our primary independent variable, the exposure index, is a cumulative count of the total number of distinct event types experienced by each individual, a standard approach for quantifying trauma load<sup>53,54</sup>.

Pre-displacement drought exposure was constructed using the governorate-level SPEI linkage described by Döring and Hall (2023)<sup>40</sup>. We use observational climate data rather than retrospective self-reports. For each respondent, SPEI-12 was assigned for the reported governorate of origin in December of the year preceding displacement, summarizing moisture conditions during the preceding 12 months<sup>47</sup>. SPEI standardizes the precipitation–evapotranspiration balance relative to a long-term, location-specific climatological baseline; negative values indicate drier-than-usual conditions. The primary analysis uses a binary indicator equal to 1 when governorate-average SPEI is below  $-1$ . Because administrative units may contain uninhabited, arid or agriculturally irrelevant areas, we test robustness to alternative spatial restrictions, including rainfed agriculture, agricultural land and high-value crop areas; results are similar in magnitude and statistical significance across these operationalizations (Supplementary Information). We treat governorate-level drought as informative because drought can generate spillover effects across nearby areas, and environmental hazards can shape perceived exposure even among those not directly affected<sup>55–57</sup>.

We estimate hierarchical linear mixed-effects models in which PTS symptoms are regressed on war exposure, drought exposure and their interaction, with governorate-level random intercepts to capture shared contextual factors in respondents' areas of origin. The models adjust for individual characteristics that may be associated with both pre-displacement drought exposure and mental-health outcomes: age, gender, education, pre-displacement socioeconomic status, urban/rural origin and years since displacement<sup>30,58–60</sup>. It is possible that the effect of drought also varies by governorate; we therefore consider random coefficients for drought as a robustness check (Supplementary Information).

Let  $y_i$  denote PTS symptoms for respondent  $i$  in governorate  $j$ ,  $\mathbf{X}_i$  the vector of predictors and covariates, and  $\alpha_{j[i]}$  the governorate-specific intercept. Following Gelman and Hill<sup>61</sup>, the varying-intercept model can be written as

$$y_i = \alpha_{j[i]} + \beta \mathbf{X}_i + \varepsilon_i, \quad (1)$$

with  $\alpha_{j[i]}$  treated as varying across governorates. This specification accounts for clustering by origin governorate without estimating a separate fixed effect for each higher-level unit, which would be impractical given the limited number of higher-level units and our focus on individual-level exposure. Models were estimated by maximum likelihood. Because a single  $R^2$  is not uniquely defined for linear mixed-effects models, we compare specifications using the Bayesian information criterion, with lower values indicating better fit; Bayesian information criterion values for all specifications are reported. Standard assumptions for the linear mixed-effects models were assessed using residual and random-effects diagnostics, with no evidence of major violations (Supplementary Information). Statistical significance for individual coefficients is assessed using two-sided Wald  $z$ -tests; no adjustments for multiple comparisons were made.

## Ethics

The survey project was reviewed and approved by the Regional Ethical Review Board in Uppsala in 2016 (decision number 2016/189). All participants provided informed consent before participation. Procedures complied with the local regulations governing research with refugees in Türkiye as well as with regulations for data management in Sweden. Participation was voluntary, as described in the Supplementary Information. Participants could withdraw at any time without consequence. Data were collected and stored in de-identified form, with any linkable identifiers stored separately and destroyed after data cleaning. No respondents under 18 years of age are part of the sample. Camp-based fieldwork was authorized by the local governor and the camp headmaster.

## Reporting summary

Further information on research design is available in the Nature Portfolio Reporting Summary linked to this article.

## Data availability

Replication data and do-files for the main analyses are available via Zenodo at <https://zenodo.org/records/20332387> (ref. 62).

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## Author contributions

S.D., T.H. and J.H. conceptualized the paper and methodology and wrote the original draft. S.D. performed data curation, formal analysis and visualization.

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## Competing interests

The authors declare no competing interests.

## Additional information

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### Reporting on sex and gender

Addressing problems with potential in-sample homogeneity, the data was stratified based on gender and country of origin. Regarding the former, 51% of respondents self-identified as female and 49 % as male. Gender (variable taking the value 2 for female) is a covariate in all analyses conducted

### Reporting on race, ethnicity, or other socially relevant groupings

Social groups are not reported in this study.

### Population characteristics

All respondents are refugees. For the community-based sample, about 50 % of the survey was completed by respondents from Syria and Iraq, respectively. Yet, Syrian respondents make up 78% of the full, pooled sample. Syrian respondents predominantly left their countries after 2012, which makes up 65 % of the sample. Furthermore, about half of respondents reported to have completed at least 9 years of schooling and about a quarter have 12 years of education or more. Self-reported socioeconomic status for the country of origin was reported on an 11-point scale (0-10) with an average of 5.54 (SD = 2.61). The settlement structures for participants' homes of origin were reported as urban by 48 % as compared to rural.

### Recruitment

#### Community-based sample:

In order to gain access to this population, a Turkish fieldwork coordinator and a team of local assistants, themselves refugees from Syria and Iraq, were recruited and trained to administer the survey. Using local assistants to administer the survey helped to ensure that the study was carried out with cultural sensitivity and in a context of interpersonal trust. We acknowledge the important contribution and immense work effort invested by these local research assistants; this research would not have been possible to carry out without them.

Data collection was initiated and completed in 2017. The same procedure for participant recruitment was carried in the cities of Konya, Yalova, Istanbul, Ankara, and Eskisehir. Potential survey participants were informed about the University conducting this study. Those approached were also provided with relevant contact information. Before being asked to give consent to participate, those approached were informed that their participation was completely voluntary and they could leave at any time and for any reason. Those who chose to participate received a small amount of money as compensation (20 Turkish lira). The study was administered inside private homes on tablet computers individually and anonymously. The only exception was made for illiterate participants. In these cases, the research assistant conducted an oral interview. Female RAs interviewed female respondents. This project received approval from the Ethical Review Board.

#### Camp-based sampling procedure:

Six months prior to collecting the second survey sample for this study, the research team invested substantial time and effort developing relationships and broad access within local communities living in the Midyat refugee camp, the nearby city of Mardin, and surrounding villages for a separate project. During this period, the team established trust with individuals and families that were well-known and well-regarded in the local community. The team further approached local non-governmental organizations to facilitate contacts with minority communities. This was very helpful for recruitment and developing a positive reputation locally. To establish trust, the background and purpose of the study was explained in broad terms using the background information sheet prepared by the project leader.

We obtained the support of the local governor and camp headmaster to conduct the study as long as the interviews were conducted outside the camp. To limit crowding in the city, the camp management limited the number of camp residents that could visit the city each day to 300-400 persons and alternated on a rolling basis. Living arrangements in the camp were segregated by country of origin and ethnicity. A gender-stratified sample of Arab residents leaving the camp to visit the city were approached each day by our team of research assistants (RAs) and offered to participate. Potential participants were informed that the study aimed to better understand how experiences during war and displacement impact decision-making. Potential participants were informed about the University conducting this survey and were provided with the contact information of the second author. Before being asked to give consent to participate, those approached were further informed that participation was completely voluntary and they could discontinue their involvement at any time and for any reason.

Those who agreed to participate were given a small sum of money (20 Turkish Lira) as compensation. The RAs were fluent in Arabic and familiar with local customs. They had received training and instructions in research methodology, in addition to having experience with similar research. Female RAs interviewed female respondents. Interviews occurred in a secluded area of a local tea shop and involved survey participants completing the survey questionnaire on a tablet device in the absence of the RA. The only exception was made for illiterate participants. In these cases, the RA conducted an oral interview. This project was approved by the Ethical Review Board.

### Ethics oversight

Ethical Review Board Uppsala (Etikprövningsnämnden, case number/Dnr 2016/189)

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## Behavioural & social sciences study design

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|                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Study description | This is a quantitative study drawing on cross-sectional survey data collected in 2017 from N = 3,751 Syrian and Iraqi refugees aged 18 + in Türkiye (51% female; 56% camp-based; age and education distributions reported in Table 1), linked at the governorate level to SPEI-12 drought data.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Research sample   | To study the impact of drought in a refugee sample, reaching populations directly affected by war is of central importance. Community-based samples of refugees with a high degree of exposure to potentially traumatic events are rarely researched due to the inherent difficulties in gaining access to such populations and the logistical barriers for surveys. We thus designed our sampling approach to ensure we could include a diverse sample of refugees living both inside and outside of Turkish refugee camps. The sample is not population-representative but provides a relatively rare community and camp based cross-section of refugees from two conflict-affected origin countries; the rationale for this sampling design is provided in the Methods.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Sampling strategy | <p>Community based sample:</p> <p>Building on the established trust networks, we employed chain-based sampling, whereby existing participants recruit future participants from among their social networks, a sampling procedure frequently employed to identify otherwise hidden populations. The team was trained in the city of Konya and then went to other cities depending on their personal networks and knowledge of local neighborhoods. In every location, teams of 2-3 assistants first established relationships of trust with individuals and families that were well-known and well-regarded in the local community. Upon completion of the session, the participants were asked to put us in contact with additional families for future sessions. Much of this work occurred in the evenings after work. During the day, strategy was evaluated and efforts were made to further diversify the sample, for instance, by approaching refugees standing in breadlines, outside aid organizations, in public transportation hubs, at universities and in front of refugee camps.</p> <p>Camp-based:</p> <p>We obtained the support of the local governor and camp headmaster to conduct the study as long as the interviews were conducted outside the camp. To limit crowding in the city, the camp management limited the number of camp residents that could visit the city each day to 300-400 persons and alternated on a rolling basis. Living arrangements in the camp were segregated by country of origin and ethnicity. A gender-stratified sample of Arab residents leaving the camp to visit the city were approached each day by our team of research assistants (RA) and offered to participate. Potential participants were informed that the study aimed to better understand how experiences during war and displacement impact decision-making.</p> <p>In order to determine sample sizes, we carried out power analysis, using G*Power (Faul, Erdfelder, Buchner, &amp; Lang, 2009), which indicated that a sample size of 1,548 (1 - beta &gt; .95) was sufficient to detect a small effect (effect size f = .10) in each sample.</p> <p>Reference: Faul, F., Erdfelder, E., Buchner, A., &amp; Lang, A. G. (2009). Statistical power analyses using G* Power 3.1: Tests for correlation and regression analyses. Behavior research methods, 41(4), 1149-1160.</p> |
| Data collection   | <p>Researchers were blind to the experimental condition.</p> <p>Community based sample:</p> <p>The study was administered inside private homes on tablet computers individually and anonymously. The only exception was made for illiterate participants. In these cases, the research assistant conducted an oral interview. Female RAs interviewed female respondents.</p> <p>Camp-based:</p> <p>Interviews occurred in a secluded area of a local tea shop and involved survey participants completing the survey questionnaire on a tablet device in the absence of the RA. The only exception was made for illiterate participants. In these cases, the RA conducted an oral interview.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Timing            | <p>Community-based sample: July 9, 2017 - August 11, 2017</p> <p>Camp sample: August 8, 2017 - September 8, 2017</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Data exclusions   | 117 participants were excluded from data as their age was self-reported as under 18.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Non-participation | Before being asked to give consent to participate, those approached were informed that their participation was completely voluntary and they could leave at any time and for any reason. No dropouts were observed.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Randomization     | Not applicable for this study. Participants were not allocated to experimental groups: this is an observational study using natural variation in pre-displacement drought exposure across governorates of origin, and covariates (age, gender, education, urban/rural origin, socioeconomic status, years since displacement) are controlled in the regression models.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |

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