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Authors

Albahsahli, Behnan

Dimitrova, Anna

Kadri, Nadine

et al.

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Mapping Climate-Related Hazards along Migration Routes: A Mixed Methods Study of Hypertensive Syrian and Iraqi Refugees Resettled in San Diego, California

Behnan Albahsahli,¹ Anna Dimitrova,² Nadine Kadri,³ Tarik Benmarhnia,^{2*} and Tala Al-Rousan^{1*}

¹Herbert Wertheim School of Public Health, University of California, San Diego, California, USA

²Scripps Institution of Oceanography, University of California, San Diego, California, USA

³Western University of Health Sciences, Pomona, California, USA

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Introduction

Climate change poses multiple threats to human health,¹ with those who have contributed the least to it generally suffering the gravest consequences. Refugees are victims of man-made disasters including wars, persecution, violence, and ensuing forced displacement. They remain among the population groups least equipped to protect themselves from environmental hazards due to a combination of psychosocial disadvantages¹ and the often precarious living conditions in temporary resettlement sites.² Previous research shows that refugees have a greater prevalence of poor physical health³ as compared to the general population, including chronic conditions such as hypertension, which are shown to be aggravated by exposure to extreme climate events.⁴ Yet, almost nothing is known about the implications of climate change for refugee health, mainly due to the difficulty of recruiting and studying displaced populations and mapping their exposures along the migratory route. Documenting refugees' cumulative exposure to environmental hazards and the health implications for this highly vulnerable group is critical for devising effective interventions and delivering adequate care in both transition locations and destination countries.

Methods

In this study, we demonstrate how some of the gaps in the literature can be addressed through a mixed-methods approach applied to a sample of Syrian and Iraqi war refugees residing in San Diego, California—a major resettlement place for refugees from the Middle East and North Africa (MENA) in the United States. All participants were diagnosed with hypertension and took part in an earlier study on hypertension management.⁵ Of the 109 participants in the parent study, we contacted 103 via phone to assess their interest in this follow-up study. Between July 2022 and January 2023, we interviewed those who agreed to participate (67 participants). A full description of the recruitment process is provided in the parent study.⁵ Some sociodemographic information of the participants who were interviewed for our study is presented in [Table 1](#). We conducted semi-structured interviews, asking participants about their refugee journeys before resettlement in the United States, spanning from 1992 to 2018, including the experience of

climate-related hazards and perceived health implications. The transcribed data from the interviews were analyzed qualitatively through inductive thematic analysis. Ethical approval was provided by the institutional review board at the University of California, San Diego. Additionally, we retrieved geocoded quantitative data on climate-related disasters (storms, floods, landslides, extreme temperatures, and droughts) from the Emergency Events Database (EM-DAT). The EM-DAT data were visualized through maps and charts, using the statistical software environment R, and visually linked with the refugee data via the refugees' self-reported migratory journey information (home and transition locations and transition dates). Data and codes for reproducing the figures are available at the following link: https://github.com/benmarhnia-lab/refugees_clim_hazards.

Results and Discussion

Although rarely studied in this context, the MENA region is unique since it has been severely affected by wars and is a major contributor to the global refugee crisis, with more than 12 million people currently displaced in the region, amid growing economic inequality and continued civil unrest.⁶ At the same time, this

Table 1. Sociodemographic characteristics and migratory information of interviewed refugees living in San Diego, California.

Sociodemographic characteristic	n (%) or mean ± SD (n = 67)
Age [mean ± SD (years)]	58.5 ± 9.96
Length of stay in the United States [mean ± SD (years)]	9.0 ± 3.83
Gender	
Male	30 (44.8%)
Female	37 (55.2%)
Country of origin	
Iraq	53 (79.1%)
Syria	14 (20.9%)
Annual household income	
<\$15,000	43 (64.2%)
\$15,001–\$25,000	17 (25.4%)
>\$25,000	7 (10.4%)
Number of transition locations	
None	6 (9%)
1	48 (71.6%)
2	10 (14.9%)
3	2 (3%)
Not reported	1 (1.5%)
Stayed at a refugee camp	
Yes	8 (11.9%)
No	56 (83.6%)
Not reported	3 (4.5%)
Length of stay in transition locations	
<1 month	4 (6.6%)
1 month to 1 year	13 (21.3%)
1 to 2 years	10 (16.4%)
2 to 4 years	16 (26.2%)
4 to 6 years	8 (13.1%)
Over 6 years	6 (9.8%)
Not reported	4 (6.6%)

Note: SD, standard deviation.

*These authors contributed equally to this work.

Address correspondence to Tala Al-Rousan, University of California, San Diego, Herbert Wertheim School of Public Health, 9500 Gilman Dr., La Jolla, CA 92037 USA. Email: talrousan@health.ucsd.edu

The authors declare they have no actual or potential competing financial interests.

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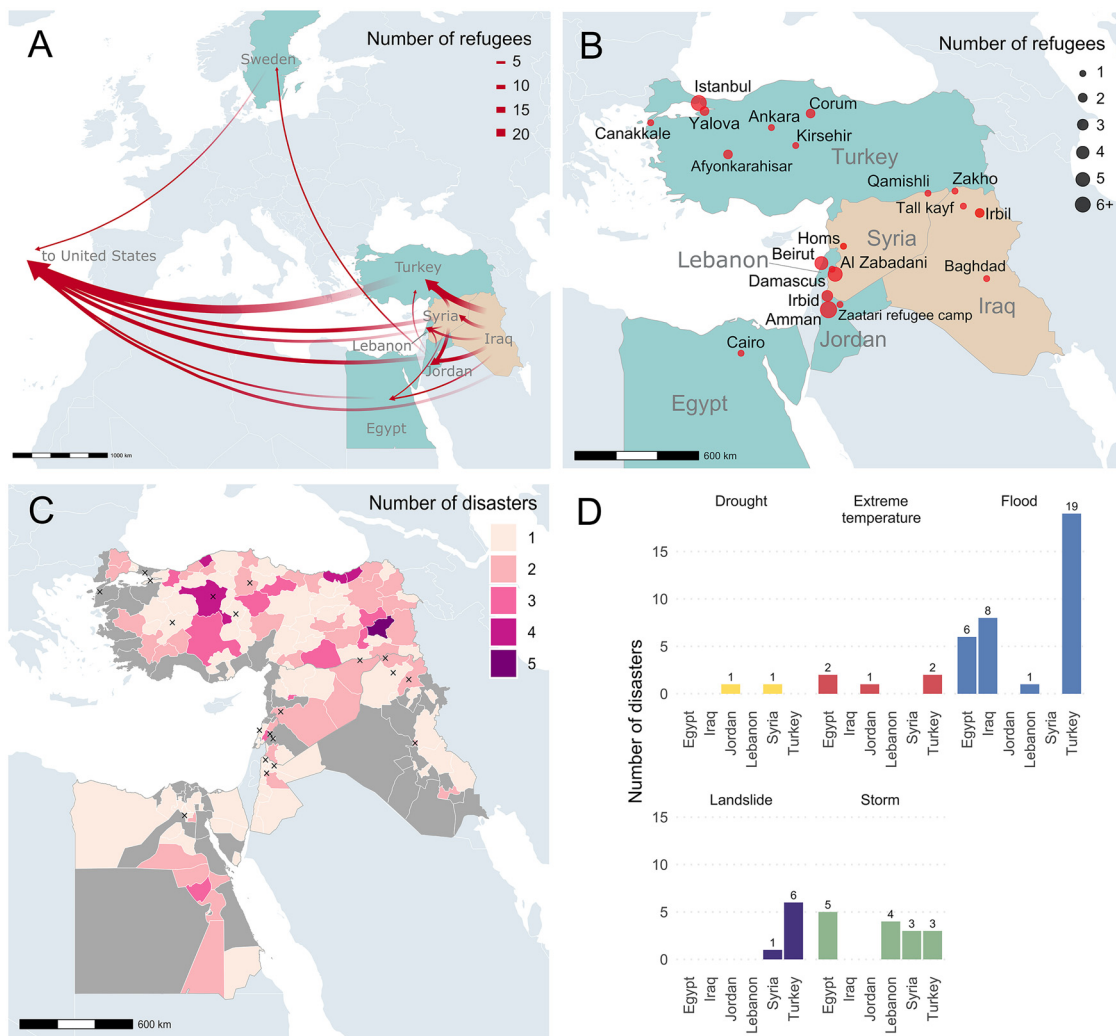


Figure 1. Descriptions of migratory routes reported by the surveyed refugees (A and B) and climate-related disasters in the reported transition countries (C and D). (A) The map shows the migration routes from Syria and Iraq to the United States reported by the 67 interviewed refugees; the red arrows indicate the departure and destination countries and the thickness of the lines indicates the number of refugees who took that route. (B) The map shows the transition locations in the MENA region prior to resettlement in the United States reported by the interviewed refugees. (C) The map shows the total number of climate-related disasters recorded per subnational administrative unit between January 1992 and December 2018, the period spanning the refugee journeys prior to resettlement in the United States. (D) The number and type of climate-related disasters recorded per country for the same time period. Data on migratory routes (A and B) are based on interviews with 67 adult refugees residing in San Diego. Data on disasters (C and D) are based on own calculations of climate-related disasters (storms, floods, landslides, extreme temperatures, and droughts) that occurred between January 1992 and December 2018 from the Emergency Events Database (EM-DAT) by the Center for Research on the Epidemiology of Disasters (CRED) at the School of Public Health of the Université Catholique de Louvain in Belgium. Spatial boundaries (A–C) were retrieved from Natural Earth (<https://www.naturalearthdata.com/>) using the “maturalearth” package (<https://github.com/ropenscilabs/maturalearth>).

region is warming significantly faster than other regions globally and incurs considerable human losses from global heating due to the poor adaptive capacity of local populations.⁷

In this study, most of the surveyed individuals ($n = 60$) stayed in at least one temporary resettlement site in the MENA region during their migratory journey (Table 1), primarily in Turkey and Jordan (Figure 1A,B). Besides being the top resettlement country per capita, Turkey is among the most disaster-prone countries in the region (Figure 1C,D). The frequent and catastrophic floods that have been recorded there (Figure 1D) can be of great concern for refugees because of the potential for further mass displacement, disruption of health services, difficulty in providing humanitarian assistance, and the increased risk of communicable diseases due to contact with contaminated water.

Some of the surveyed participants reported experiencing harsh weather conditions during their migratory journeys, including extreme heat ($n = 5$) and extremely cold temperatures ($n = 7$).

Access to heating during cold winters in Turkey was noted as a problem due to a lack of financial resources ($n = 2$). A few participants ($n = 4$) mentioned being exposed to large amounts of dust during their resettlement journey. Dust storms are becoming more common in the MENA region due to climate change.⁸ Both desert dust, which is a component of particulate matter with aerodynamic diameter $\leq 10 \mu\text{m}$ (PM_{10}), and extreme ambient temperatures have been shown in the literature to aggravate cardiovascular health.^{4,9} Such exposures pose a considerable risk to people with hypertension—a chronic cardiovascular condition that affected all survey participants included in our study. Some of the participants attributed their hypertension to the experience of war and violence ($n = 6$) and others directly related their poor physical health to poor environmental conditions, including poor air quality and heat during the migratory journey ($n = 5$). Moreover, some of the refugees we interviewed ($n = 7$) reported poor mental health due to poor environmental conditions. Overall, participants reported difficulties

adjusting to a climate that was different from their home countries.

A few of the survey participants ($n = 8$) reported staying in a refugee camp in Jordan (Table 1) and some of them spoke negatively of their experiences there ($n = 3$), describing conditions in the camp as ill-equipped for the desert climate in the region. The presence of dust, lack of clean water, and poor protection from the outside environment in the temporary tent structures were emphasized in the interviews. Although refugee camps are intended to be temporary resettlement sites, it is not uncommon for refugees to spend decades there¹⁰ in poorly constructed and overcrowded shelters.² Several participants reported suffering from asthma during their migratory journey due to poor air quality and other illnesses related to contact with contaminated water ($n = 6$). Among the refugees that spent some time in transition locations, nearly half ($n = 30$) stayed at such locations for 2 years or longer and some ($n = 6$) stayed for over 6 years (Table 1).

Conclusions

The impact of environmental disasters on refugees' health is an immensely understudied field of research. Applying a mixed-methods approach, we exemplified how such links can be studied, overcoming some of the current data limitations. Despite the limited scope of our study, we highlighted specific health risks faced by refugees in the MENA region, where violent conflict has displaced millions of people against the backdrop of escalating climate challenges. As climate change is expected to displace an ever-growing number of people in the next decades, there is an urgent need to develop actionable interventions to improve the quality of life and health of this highly vulnerable group.

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