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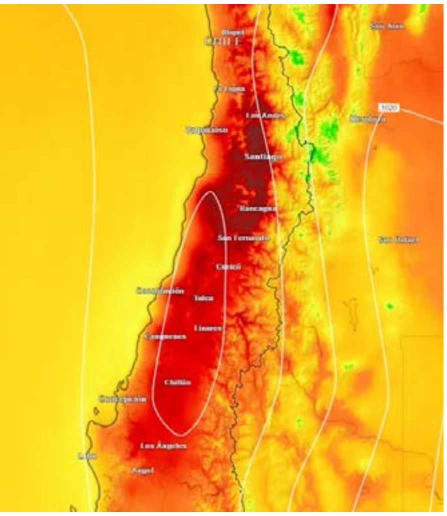

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Impacts of heatwaves on population health in Chile: evidence and recommendations

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SUMMARY

- Although sometimes overlooked, extreme heat events have an important impact on population health, especially among the most vulnerable ones. These impacts range from mild symptoms (e.g., headache or cramps) to death.
- Using a calculation method introduced by the United Kingdom Health Security Agency (UKHSA) and the Office for National Statistics of the United Kingdom, excess deaths were estimated during the heatwaves of 2017 and 2019 in Chile, years in which these events broke historical records in terms of magnitude and duration.
- 584 and 245 excess deaths have been estimated for the 2017 and 2019 heatwave events in Chile, respectively. People above 65 years old are more affected than younger people.
- Under a warming planet, health policies should address extreme heat in order to prevent negative health impacts on population. Three key areas are: *articulated national, regional, and local extreme heat policies, extreme heat risks assessments at national, regional, and local levels, and risk communication and social engagement.*

I.-INTRODUCTION[1]

The evidence is clear: anthropogenic climate change is happening now and affecting us all. As the climate changes, so does ambient temperature, with temperature extremes becoming more frequent than in past periods. In particular, extreme heat events are periods of unusually high ambient temperature (e.g., heatwaves) and have been increasing under a warming planet. Depending on the greenhouse gas emissions that humanity decides to emit over the next years, these events are expected to continue occurring to varying degrees (IPCC, 2021).

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Although warm ambient temperatures are comfortable for most people, extreme high temperatures, including heatwaves, can trigger a wide spectrum of physiological changes and health problems, ranging from headaches to critical organ failure and death (Ebi et al., 2021). For example, during an unusual hot 2003 summer in Europe, it was estimated that more than 70,000 additional people died compared to what is expected in European summers (reference period 1998-2002) (Robine et al., 2008). More recently, it was estimated that 60,000 heat-related deaths occurred in Europe in the summer of 2022 (Ballester et al., 2023). This evidence demonstrates that extreme heat events are a public health problem.

In 2023, extreme meteorological events were seen in Chile (Kew et al., 2023). Following significant heavy precipitation and flooding events (OCHA, 2023), intense winter heatwaves were seen in August across northern and central zones, reaching 40°C in Vicuña (Dirección Meteorológica de Chile, 2023). These scenarios make us think about the frequency and severity of extreme heat events under a warming planet in Chile and their potential effects on population health, especially among the most vulnerable ones.

According to the Dirección Meteorológica de Chile (DCM), heatwaves are defined when daily maximum or minimum temperature (for diurnal or nocturnal heatwaves, respectively) is above the historical climatology (defined as 90th percentile of the corresponding ambient temperature for a period of 30 years) for three or more consecutive days. Based on this definition, historical data show that important events occurred in the summers of 2017 and 2019 in Chile (Dirección Meteorológica de Chile, 2020; González-Reyes et al., 2023). Nonetheless, there is still a lack of clear information about the impact of heatwaves on population health.

In this policy brief, we fill this gap by presenting evidence on the impacts of the 2017 and 2019 heatwave events on population health in Chile. Additionally, we provide three main policy recommendations for strengthening the public response to extreme heat in order to protect the health of populations.

II.- THE 2017 AND 2019 HEATWAVE EVENTS AND THEIR IMPACTS ON POPULATION HEALTH IN CHILE

Heatwaves have always occurred in Chile; however, the events in 2017 and 2019 broke historical records in terms of magnitude and length. In 2017, several heatwave events occurred, especially from the Metropolitan to Los Lagos regions. The most noticeable events occurred between 11th to 31st of January, when daily maximum temperatures reached record breaking 43°C in Chillán (Dirección Meteorológica de Chile, 2017). In 2019, the heatwave events were lengthier and more extensive than in 2017, almost affecting the whole country. They started on the 23rd of January and ended on the 7th of February. Temuco had the highest daily maximum temperature of 42°C (Dirección Meteorológica de Chile, 2019).

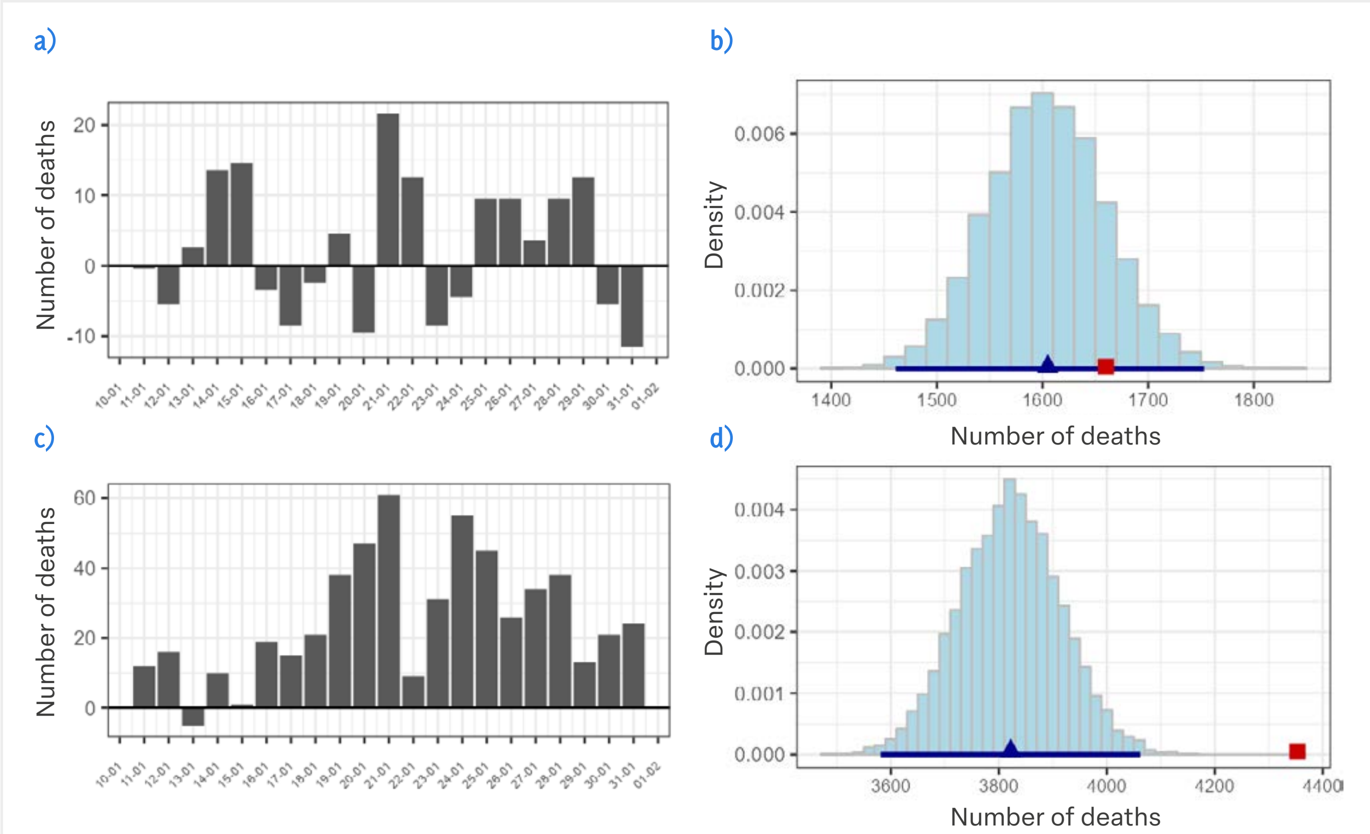
Given the available health data in Chile, it is possible to analyse the impacts of heatwaves on mortality by applying different statistical approaches. A very simple approach is to examine the primary cause of death given by the International Classification of Disease (ICD) system; however, exposure to high temperatures or heatwaves as cause of death is almost never registered (nationally or internationally), limiting this analysis. Another simple but robust approach is to examine the excess deaths during an extreme event (i.e., period of interest), which simply compare the observed deaths during that event with expected deaths with those during a comparable non-heatwave period.

After evaluating a variety of statistical approaches to obtain excess deaths, we estimated the excess deaths based on a method introduced by the United Kingdom Health Security Agency (UKHSA) and the UK Office of National Statistics in their recent heat mortality monitoring reports (Office for National Statistics & UK Health Security Agency, 2022), which is widely used in the United Kingdom and has demonstrated to be reliable and simple to implement. This method estimates the expected value of deaths as the average of the number of deaths over 14 days before and after the period of interest (i.e., non-heatwave period). Then, this expected value is subtracted from the observed values during the period of interest.

In this policy brief, we provide national and regional estimates of excess deaths for the 2017 and 2019 heatwave events for people under 65 years old and 65 years old or above. Additionally, we present the comparison between the observed deaths over the heat periods and the number of deaths within the context of what would be expected in the absence of the heatwave event. The range of variation expected in the absence of a heatwave is obtained by simulating from a negative binomial distribution fitted to the daily death counts in the non-heatwave period.

For the 2017 heatwave period, 584 excess deaths were estimated nationally. Figure 1a shows the daily excess deaths for individuals under 65 years old, totalling 54 excess deaths. Complementarily, Figure 1b shows the distribution of deaths for the same age group within the context of what would be expected in the absence of the heatwave event (light-blue area). The best estimate of the expected number of deaths in this case is 1,606 (blue triangle), with a 99% chance of between 1,461 and 1,753 deaths during the period (blue line). The observed number of 1,660 deaths (red square) is within the 99% range, suggesting that this number of deaths in the under-65 age group would not be unexpected in the absence of a heatwave. For individuals over 65 years old, the situation was different. Figure 1c shows the daily excess deaths for individuals over 65 years old, totalling 530 excess deaths. Figure 1d shows the distribution of deaths for the same age group within the context of what would be expected in the absence of the heatwave event. The best estimate of the expected number of deaths in this case is 3,823, with a 99% chance of between 3,581 and 4,062 deaths during the period. The observed number of 4,353 deaths is a long way outside the 99% range of expected deaths, providing evidence that 4,353 or more deaths would be very unlikely in the absence of the heatwave.

FIGURE 1. Excess deaths* for people under 65 (a) and over 65 years old (c) on each day of the period 11th January to 31st January 2017, and the corresponding distribution of total expected and observed deaths during this period** for people under 65 (b)*** and over 65 years old (d)***.



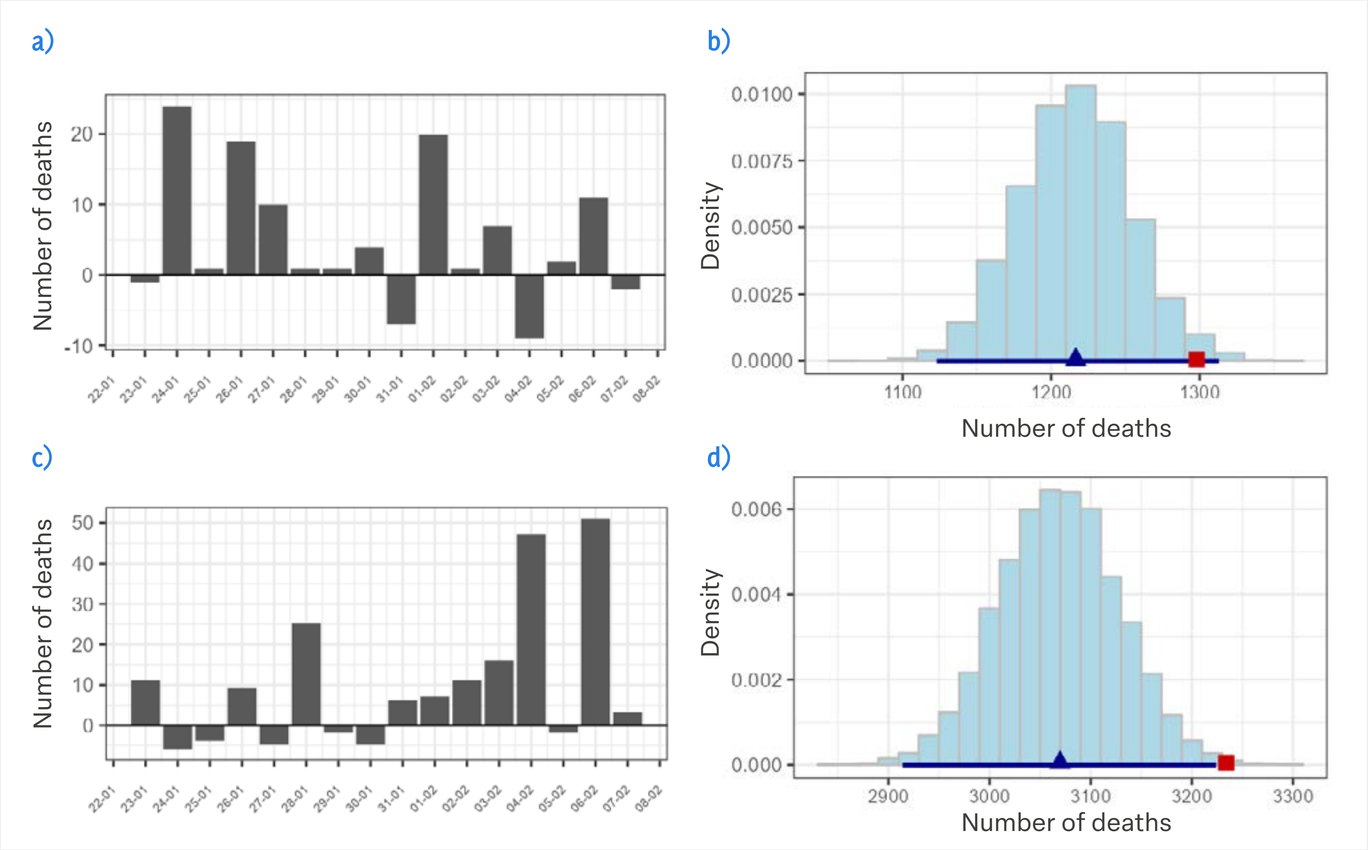
* Plots (a) and (c) show the daily excess deaths for each day of the heat period, which covered from the 11th to the 31st of January 2017.

** Plots (b) and (d) show the distribution of total deaths during the period, within the context of what would be expected in the absence of the heatwave event (reference distribution: light blue area); the best estimate of the expected number of deaths (blue triangle); the 99% range of the expected number of deaths (blue line); and the number of deaths recorded (observed) over the heat period (red square).

***The estimates for individuals under 65 years old (plot b) are: the best estimate of the expected number of deaths (blue triangle) is 1,606; the 99% range of the expected number of deaths (blue line) goes from 1,461 to 1,753; and the number of deaths observed over the heat period (red square) was 1,660. The estimates for individuals over 65 years old (plot d) are: the best estimate of the expected number of deaths (blue triangle) is 3,823; the 99% range of the expected number of deaths (blue line) goes from 3,581 to 4,062; and the number of deaths observed over the heat period (red square) was 4,353.

For the 2019 heatwave period, 245 excess deaths were estimated nationally. Despite the less striking difference in the estimated excess deaths for the separate age groups during the 2019 heatwave, individuals 65 years old and above are still shown to be more impacted than individuals under 65 years old in both excess heat events. For individuals under 65 years old, 81 excess deaths were estimated (Figure 2a). The best estimate of the expected number of deaths in this case is 1,217, with a 99% chance of between 1,123 and 1,313 deaths during the period. The observed number of 1,298 deaths is within the 99% range (Figure 2b), also suggesting that this number of deaths in the under-65 age group would not be unexpected in the absence of a heatwave. For individuals over 65 years old, the situation was similar to 2017. A total of 164 excess deaths was estimated (Figure 2c). The best estimate of the expected number of deaths in this case is 3,070, with a 99% chance of between 2,914 and 3,224 deaths during the period. The observed number of 3,234 deaths lies outside the 99% range, once again suggesting that that 3,234 or more deaths would be very unlikely in the absence of the heatwave.

FIGURE 2. Excess deaths* for people under 65 (a) and over 65 years old (c) on each day of the period 23rd January to 7th February 2019, and the corresponding distribution of total expected and observed deaths during this period** for people under 65 (b)*** and over 65 years old (d)***.



* Plots (a) and (c) show the daily excess deaths for each day of the heat period, which covered from the 23rd of January to the 7th of February 2019.

** Plots (b) and (d) show the distribution of total deaths during the period, within the context of what would be expected in the absence of the heatwave event (reference distribution: light blue area); the best estimate of the expected number of deaths (blue triangle); the 99% range of the expected number of deaths (blue line); and the number of deaths recorded (observed) over the heat period (red square).

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When looking at deaths regionally, some regions were more impacted than others. To facilitate the interpretation, Table 1 shows the observed value of deaths in each heat period under study for each age group and the corresponding 99% range of the expected number of deaths. In 2017 and 2019, the Metropolitana region showed a large observed number of excess deaths for individuals over 65 years old, demonstrating the negative impact of the heat period.

TABLE 1. Observed value and 99% range of expected number of deaths for the heat periods in 2017 and 2019 by region and age groups.

	2017				2019			
	Below 65 years		Above 65 years		Below 65 years		Above 65 years	
Region	Obs*	99% range**	Obs*	99% range**	Obs*	99% range**	Obs*	99% range**
De Arica y Parinacota	22	13 to 43	77	43 to 86	25	7 to 27	43	26 to 61
De Tarapacá	22	18 to 47	53	34 to 71	26	15 to 42	41	26 to 60
De Antofagasta	68	50 to 92	112	85 to 141	40	31 to 67	85	50 to 93
De Atacama	32	12 to 38	70	37 to 76	16	8 to 30	55	29 to 67
De Coquimbo	75	45 to 86	164	124 to 192	42	29 to 64	121	104 to 164
De Valparaíso	164	145 to 215	504	432 to 551	151	103 to 163	385	332 to 438
Metropolitana de Santiago	607	495 to 621	1,704	1,246 to 1,563	475	407 to 529	1,288	1,019 to 1,190
Del Libertador B. O'Higgins	92	55 to 115	248	165 to 250	73	38 to 78	171	129 to 201
Del Maule	100	74 to 130	257	196 to 277	86	50 to 93	201	151 to 233
De Ñuble	45	40 to 80	139	94 to 151	36	16 to 54	88	74 to 129
Del Bíobío	172	119 to 183	404	304 to 402	115	88 to 143	277	269 to 363
De La Araucanía	104	82 to 146	258	204 to 287	82	45 to 87	188	172 to 248
De Los Ríos	53	22 to 54	99	78 to 130	24	14 to 63	87	45 to 102
De Los Lagos	86	65 to 113	208	141 to 210	81	39 to 81	162	114 to 186
De Aisén del Gral. C. Ibáñez del Campo	8	1 to 13	14	9 to 31	8	5 to 25	13	6 to 25
De Magallanes y la Antártica Chilena	10	8 to 30	42	18 to 54	18	6 to 26	29	22 to 53

*Observed deaths over the heat period; **99% range of expected deaths.

III.- PATHWAYS TO STRENGTHEN THE RESPONSE TO EXTREME HEAT AND PROTECT POPULATION HEALTH

Considering the evidence provided in this study, and the fact that mortality is an extreme health outcome, it is possible to infer that less severe outcomes, such as emergency room visits, might show a similar pattern. In this sense, extreme heat events are a threat to the health of people; therefore, public health responses need to be appropriately put in place.

Given the complexity of the phenomenon, responses to extreme heat need to be multilevel, multi-agency, and intersectoral, as well as having a preventive and long- and short-term perspectives. This policy brief presents three areas that would strengthen the response to extreme heat in order to protect population health.

Articulated national, regional, and local extreme heat policies

National policies that guide and support action paths are key to regional and local action plans; therefore, good articulation and coordination between them is critical.

The National Disaster Prevention and Response Service (Servicio Nacional de Prevención y Respuesta ante Desastres - SENAPRED), dependent from the Ministry of the Interior and Public Security (Ministerio del Interior y Seguridad Pública), is the technical body responsible for planning and coordinating resources, as well as providing management plans for prevention and management of emergencies and disasters. Considering the wide scope of action of this entity, not only in terms of hazards but also in terms of geographical articulation, it has to be better supported, politically, financially, and organisationally.

Although a national policy for disaster risk reduction was published in 2020 (ONEMI - Chile, 2020), several gaps still remain in terms of action plans for extreme heat, nationally, regionally, and locally. This policy brief contributes to the first axis of this policy (i.e., to comprehend disaster risk), making visible that extreme heat is associated with higher mortality, and therefore, an important climatic impact-driver to be considered. A mandatory high level of rapid response is expected to be a basic condition at this level.

Furthermore, as the second axis of this policy aims to strengthen the governance of risk disaster management, it is imperative that action plans establish clear roles and responsibilities of other actors and organisations involved. This does not only support better coordination between them, but also political and social accountability. Several public agencies play a key role in the preparation for and response to extreme heat, including but not limited to:

- Meteorological Office of Chile (Dirección Meteorológica de Chile - DMC), which provides climatological and meteorological information.
- Ministry of Health, which is the responsible for i) public health surveillance activities, and therefore, able to inform actions by monitoring and evaluating the impacts of extreme heat on population health, and ii) coordinating the network of health centres in case of emergencies.
- Ministry of Social Development, which, along with the Ministry of Health, coordinates centres for senior and elderly care (ELEAM in Spanish). As people above 65 years old seem to be severely impacted by extreme heat, these centres are of special attention. For example, it is relevant to plan actions at the level of each centre to avoid major

impacts on this population, including training staff in identifying signs and symptoms of the effects of heat in adults, organising physical activities during periods of heat, implementing continuous hydration strategies, and condition the centres with appropriate curtains.

- Ministry of Finance, which provides specific budget to policies and programmes.
- Ministry of Labour, which is responsible for leading and coordinating labour policies, including those that protect the health of workers.
- Regional governments (Gobiernos Regionales - GOREs), which promote social development, including the health and wellbeing of people, with a regional perspective.
- Municipalities and the corresponding departments, which manage and coordinate all policies and programmes at the local level and are in charge of some schools as well as primary healthcare centres.

Extreme heat risks assessments at national, regional, and local levels

Vulnerability and risks assessments are critical tools for determining and prioritising adaptation measures at different levels. These tools inform public policies by allowing a better understanding of the main characteristics of the hazard, exposed and sensitive populations, and adaptive capacities. Therefore, coordinated assessments are critical to be undertaken at different levels and by different actors because of the potential interwoven and cascading effects of extreme heat.

Once a baseline risk assessment has been performed, then the risk of negative heat-related health outcomes may be reduced by adaptation measures that aim to i) reduce exposure of people to extreme heat, ii) reduce vulnerability of people, and/or iii) enhancing adaptive capacity.

Nationally, Chile has the Climate Risks Atlas (Atlas de Riesgos Climáticos – ARClim)[2], which includes data disaggregated at the municipal level and provides information on different climate risks by combining projections of the hazards, exposure, and sensitivity. This tool very useful to national and regional governments for long-term planning and funding prioritisation. However, there is a gap when it comes to local action and planning preventive measures in the short- and long-term.

Effective local action (i.e., sub-municipal and institutional levels) may need more specific information and plans. For example, employers whose workers are exposed to extreme heat need to establish clear action plans with measures to reduce the exposure to extreme heat, including shifts, cooling breaks, shade panels, ventilation, and hydration points. These measures need to be established and implemented according to the national law, organisational policies, resources, and local context. In this sense, private and public organisations need to perform climate risks assessments that include extreme heat as a hazard for occupational health.

Another example at the local level is related to the identification and support of people who may struggle with extreme heat. This process requires sub-municipal information as municipalities manage and prioritise resources considering a wide variety of local

2 https://arclim.mma.gob.cl/

contexts (for example, people with different levels of social vulnerability in the same municipality). Considering this and the need to strengthen local action, municipalities and primary healthcare centres are key in this planning. Since the centres have assigned populations, they know where the most vulnerable people live, the main characteristics of specific populations, the availability of basic services, among others. In addition, primary healthcare centres are the first point of contact for people, especially adults, and where preventive health measures can be put forward. In this sense, municipalities and local services play a key role in effectively reducing extreme heat risks as they know the community and the best way to act. However, for them to be successful, political and financial support is needed as well as coherent public health policies.

Risk communication and social engagement

Risk communication is a critical tool in emergency preparedness and response (World Health Organization, 2018). Therefore, articulated risk communication plans are relevant to consider by all agencies involved and may include i) internal communication channels between public and private institutions that promote unified information, and ii) communication channels to the general public. Much of this communication structure already exists for other hazards, including earthquakes; therefore, it would be easy to adapt the main structure of these plans for extreme heat.

Risk communication plans should also consider alert levels that are well-defined and associated with specific actions. These plans can be adapted to the level of action: i) governmental or public institutions, which will be responsible for coordinating and implementing high- and medium-level actions, and ii) individuals, who will adopt individual actions (e.g., drink water, avoid direct exposure to sun). In this case, it is important to convey clear and straightforward messages adequate to all levels of population health literacy and age categories.

Social engagement and cohesion are also key to effectively responding to extreme heat in the community. Two areas to explore are:

- Education, formal or informal, is critical for people to understand the risks associated with extreme heat and supports decision-making. For example, in schools, teachers, administrators, and students need to be aware of the dangers of extreme heat. In this sense, curricula need to integrate this kind of information as special activities, such as workshops, seminars, and social projects. Similarly, health professionals also need to be trained in these topics in order to correctly identify people who are suffering from heat-related disorders or diseases.
- Local community networks may provide a strong support to reduce vulnerability and increase capacities during extreme events. These groups are generally led by community agents, including workers from municipalities, juntas de vecinos, advocacy groups, healthcare workers from primary healthcare centres, educators from schools, voluntary leaders, among others. As some of them are already in place, it is relevant to support them by providing tools, knowledge, and recognition. Some examples of their roles include: increasing awareness of main impacts, vulnerabilities, and capacities to prepare for and respond to extreme events; guiding the implementation of national and regional policies according to the local context; and supporting vulnerable neighbours before, during, and after extreme events.

REFERENCES

Ballester, J., Quijal-Zamorano, M., Méndez Turrubiates, R.F., Pegenaute, F., Herrmann, F.R., Robine, J.M., Basagaña, X., Tonne, C., Antó, J.M. & Achebak, H. (2023). Heat-related mortality in Europe during the summer of 2022. *Nature Medicine*. 29 (7), 1857–1866. doi:10.1038/s41591-023-02419-z.

Dirección Meteorológica de Chile (2019). El calor sigue batiendo récord – Meteochile Blog. *Meteochile Blog*. https://blog.meteochile.gob.cl/2019/02/04/el-calor-sigue-batiendo-records/.

Dirección Meteorológica de Chile (2020). *Informe Técnico. Olas de Calor en Chile. Una nueva metodología para el estudio y monitoreo de los eventos de las altas temperaturas.*

Dirección Meteorológica de Chile (2023). *Servicios Climáticos. Monitoreo de olas de calor*. 2023. Servicios Climáticos. https://climatologia.meteochile.gob.cl/application/diario/mapaRecienteOlaDeCalor [Accessed: 21 December 2023].

Dirección Meteorológica de Chile (2017). *Temperaturas Máximas Históricas*.p.2. https://archivos.meteochile.gob.cl/portaldmc/meteochile/documentos/Temperaturas_Maximas_DMC.pdf.

Ebi, K.L., Capon, A., Berry, P., Broderick, C., de Dear, R., Havenith, G., Honda, Y., Kovats, R.S., Ma, W., Malik, A., Morris, N.B., Nybo, L., Seneviratne, S.I., Vanos, J. & Jay, O. (2021). Hot weather and heat extremes: health risks. *The Lancet*. 398 (10301), 698–708. doi:10.1016/S0140-6736(21)01208-3.

González-Reyes, Á., Jacques-Coper, M., Bravo, C., Rojas, M. & Garreaud, R. (2023). Evolution of heatwaves in Chile since 1980. *Weather and Climate Extremes*. 41, 100588. doi:10.1016/j.wace.2023.100588.

IPCC (2021). *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge, United Kingdom and New York, NY, USA, Cambridge University Press. doi:10.1017/9781009157896.

Kew, S., Pinto, I., Alves, L., Santos, D., Libonati, R., Liberato, M.L.R., Philip, S., Zachariah, M., Barnes, C., Vahlberg, M., Otto, F., Clarke, B.J. & Kimutai, J. (2023). *Strong influence of climate change in uncharacteristic early spring heat in South America.* doi:10.25561/106753.

OCHA (2023). *Chile: Floods - Jun 2023 | ReliefWeb*. 2023. https://reliefweb.int/disaster/fl-2023-000110-chl [Accessed: 21 December 2023].

Office for National Statistics & UK Health Security Agency (2022). *Excess mortality during heat-periods: 1 June to 31 August 2022*. 2022. https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/articles/excessmortalityduringheatperiods/englandandwales1juneto31august2022 [Accessed: 12 December 2022].

ONEMI - Chile (2020). *Política Nacional para la Reducción del Riesgo de Desastres. Plan Estrategico Nacional 2020-2030.*

Robine, J.-M., Cheung, S.L.K., Le Roy, S., Van Oyen, H., Griffiths, C., Michel, J.-P. & Herrmann, F.R. (2008). Death toll exceeded 70,000 in Europe during the summer of 2003. *Comptes Rendus Biologies*. 331 (2), 171–178. doi:10.1016/j.crvi.2007.12.001.

World Health Organization (2018). *Communicating risk in public health emergencies.*

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