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Heatwaves Impact on Prehospital Emergency Medicine: A Qualitative Study to Improve Sustainability and Disaster Preparedness in Veneto Region, Northern Italy

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Abstract: Heatwaves are periods of unusual heat, whose frequency and intensity is increasing. Heatwaves also translate into emergency healthcare dysfunctions, but evidence on how to mitigate these effects still needs to be provided. This multicentric study aimed to identify the interactions between heatwaves and prehospital emergency medicine (PHEM). After obtaining informed consent, PHEM personnel working full-time in different districts of the Veneto Region, Northern Italy, were recruited. Their perspective was captured through semi-structured interviews and analyzed using content analysis methodology. Thirteen subjects participated in the study. Their insights were categorized into four themes: perception of heatwaves; clinical impact of heatwaves; social factors and heatwaves; heatwaves and emergency medical service (EMS). According to the interviewees, the strain on EMSs during heatwaves may be partially reduced by interventions targeting vulnerable populations, primary care, social networks, and education and information. Specific public health actions could follow the surge science principles of staff, stuff, structure, and system to help policymakers improve EMS surge capacity planning, preparedness, and responses. The present study also identified PHEM vulnerabilities and targets of interventions to implement heat–health action plans, mitigate the risk of prehospital emergency care dysfunction, and improve EMS sustainability and preparedness against heatwaves and the changing climate.

Keywords: heatwave; climate change; emergency medicine; emergency medical service; public health; sustainability

1. Introduction

Global warming, resulting from anthropogenic emissions of greenhouse gases since the Industrial Revolution, is significantly contributing to climate change [1]. Despite several meetings among countries in 2015 in Paris [2], in the Conference of the Parties (COP26;

Glasgow Climate Pact) in 2021 [3], and recently in Dubai (COP28) [4], GHG emissions are still rising. The mean surface temperature has increased by 0.76 °C as of 2007, but more recent studies have forecasted a rise as high as 4.2 °C by the end of the century [5,6].

As temperatures rise, climate-change-related extreme weather events are increasing in frequency and intensity [7,8]. In particular, there is clear evidence that exposure to heatwaves has worsened in the last decades [9–13], causing indirect damage to the economy and infrastructure and posing a serious risk to human health [14]. Heatwaves correlate with increased population mortality and morbidity, especially for vulnerable and fragile individuals, as well as for persons suffering from comorbid conditions [9].

Heatwaves also impact health systems' components by worsening population morbidity, determining higher access rates to emergency healthcare [10–12]. Such a higher input, prolonged for several days, inevitably translates into an Emergency Medical Service (EMS) and Emergency Department (ED) overload, the latter having well-known multifaceted, detrimental effects on patient care and already known as ED overcrowding [13]. Unfortunately, literature on optimizing emergency healthcare during heatwaves is scarce [12].

Given the need for better evidence and pursuing the United Nations' Sustainable Development Goal No.13: Climate Action, this qualitative study aims to clarify the interactions between heatwaves and prehospital emergency medicine (PHEM) systems. By interviewing EMS personnel, potential vulnerability factors predisposing EMSs to overload or dysfunction during heatwaves are identified to help stakeholders and policymakers improve EMS preparedness and resilience during these events.

2. Methods

2.1. Context

The Veneto Region, located in Northeastern Italy, has a population of about 4.9 million residents. The regional healthcare system provides universal coverage to all those in need. PHEM is coordinated by 7 dispatch centers, one per province, and is a physician-based, three-tiered EMS. The Veneto Region is particularly vulnerable to geological hazards, namely landslides and floods, resulting from an intense human manipulation of the landscape [15]. Climate change will worsen this trend, as seen with rainfall [16]. Also, temperatures showed an increasing trend of about 0.5 °C per decade between 1993 and 2019, as registered by the Regional Agency for Environmental Protection and Prevention of Veneto (ARPAV), making the whole region more prone to experience unusual heat spells.

2.2. Design and Population of the Study

These vulnerabilities, along with the identified gap in heatwave-related literature, identified the Veneto region as a case study within the project "Heatwaves And Emergency Departments In Italy (HEAT-ED IT): Strategies To Identify Determinants Of Overload And Mitigate Impact". A Delphi study stemming from the project provided valuable targets of interventions but with limited insight into PHEM [17]. Since measures applied to EMSs can reduce inappropriate input pressure on EDs, a multicentric qualitative study employing semi-structured interviews was conducted to collect the thoughts and perspectives of PHEM professionals working in this region. This qualitative design was chosen because it can reliably document opinions on a specific subject and because of the exploratory nature of the study [14]. The study methods have been reported in accordance with the Consolidated Criteria for Reporting Qualitative Research (COrEQ) (see Supplementary Materials) [18].

Participants were recruited through email and personal contact among PHEM physicians or nurses. A target of two participants per dispatch center was set, preferably 1 nurse and 1 physician each, to be representative of the regional EMS. Current literature suggests different strategies for determining the adequate sample size in qualitative studies, but non-probabilistic methods are widely diffused and rely on the predictability of data saturation. Guest et al. found that data saturation usually occurs at twelve interviews, especially when the scope of the research is narrow, and the target audience is similar [19]. In their review, Sim et al. confirmed the appropriateness of 12 as the minimum number of interviewees for studies similar to the present [20].

The inclusion criteria were full-time employment in the regional PHEM system and having at least 5 years of work experience. One of the authors contacted those interested and carefully provided information on the study objective, ethical implications, anonymity, and interview methodology. Upon confirmation and after signing the informed consent, the researcher scheduled and conducted interviews with each participant.

2.3. Data Collection

An interview guide, consisting of leading and probing questions, was elaborated based on the available literature and related research work previously conducted by the authors (see Supplementary Materials: Interview Guide) [9,12]. The guide was internally reviewed by experts in emergency medicine and disaster medicine for further adjustments and then pilot-tested on a pool of research fellows before making final modifications guided by their feedback. The same guide was used to carry out all the interviews, with minimal linguistic adaptations when needed. Interviews were conducted in October 2023 in the local language (Italian), each lasting approximately 30–40 min, with the interviewer and the participants alone. Each interview was audio-recorded, and manual notes were taken.

2.4. Data Analysis and Reporting

Interviews were manually transcribed and read multiple times for accuracy. Two researchers prepared two lists of potential codes, using inductive reasoning, after reading all the transcripts and extracting the most important topics addressed by the participants. The lists were then compared, and a unified codebook was devised to analyze the interviews. This codebook was used to code each transcript deductively, extracting significant quotes related to the generated codes by two authors to ensure consistency and reliability.

Data analysis was carried out using the Atlas.ti software (ver. 23.1.2; ATLAS.ti Scientific Software Development GmbH, Berlin, Germany) and using an inductive approach based on the thematic analysis methodology proposed by Braun and Clarke [21]. The answers dealing with factors affecting EMS performance during heatwaves and potential solutions were also classified according to the surge science principles of *staff*, *stuff*, *structure*, and *system* [22,23]. The "4-S approach" has been previously used to provide both experts and non-experts in disaster medicine with a schematic and intuitive framework to plan their interventions and guide surge capability expansion [23,24]. The analysis was conducted in Italian over one month, and approximately two hours were allocated to analyze each interview. After analysis, the results were translated into English to be integrated into the manuscript, with translation accuracy verified by a third author.

2.5. Ethical Considerations

The study was conducted according to the principles of the Helsinki Declaration. All participants signed a written informed consent after precisely explaining the study's aims and procedures and before their inclusion. Data collected from the interviews were anonymized, and access to the data was restricted to the co-authors of this paper only; only the principal investigator knew the identity of the participants. This multicentric study was approved by the Veneto Regional Ethics Committee, South-West Territorial Area section (No. 54564).

3. Results

Sixteen participants were recruited across the Regional EMS network, and 14 (7 nurses and 7 doctors) consented to participate in the study—randomly re-named S1–S14. The last subject dropped from the study due to personal reasons, thus bringing the final number included to 13. Data saturation was reached at 10 interviews. Four themes emerged during data analysis: perception of heatwaves; clinical impact of heatwaves; social factors and heatwaves; heatwaves and EMS (Table 1).

Table 1. List of themes (with operational definitions), subthemes, and topics emerging from the semi-structured interviews involving Emergency Medical Service (EMS) personnel.

Themes	Subthemes	Specific Topics (Number of Participants)
Perception of Heatwaves (*how did the interviewees define heatwaves*)	Heatwave definition	High temperatures (13) Humidity (9) Time factor (7) Location-specific effects (4) Urban Heat Island Effect (1)
Clinical Impact of Heatwaves (*health consequences of heatwaves on vulnerable groups and the general population*)	Concerns about vulnerable/frail groups and population at risk	Children, elderly, homeless (vulnerable/frail); and those working outside (exposed to risk) (6)
	Different case epidemiology	Acute on chronic illness (4) Syncope (4) + due to unmodified antihypertensive chronic therapy (2) Heat stroke: more frequent (2), or a rare event (2) More aggressive behaviors (3) Worsening psychiatric disease (2)
Social Factors and Heatwaves (*factors involving education and behaviors of population during heatwaves, or support of social and family networks*)	Culture	Lack of behavioral adaptations (4) Elderly not aware of their frailty (1) Elderly not relocating to better climate locations (2) Air conditioning not used (2) Air conditioning not installed or not working due to economic concerns (6)
	Social network	Lack or disruption of social connections (2)
	Family network	Lack or failure of family support (3)
Heatwaves and EMS (*factors influencing EMS performance during heatwaves—analyzed through the Staff, Stuff, Structure, and System framework derived from surge science*)	Gaps and Vulnerabilities	Staff—Concerns for safety and performance (3) Staff—Need for more personnel (2) Stuff—Need for more equipment (10) Structure—Need for places with higher capability (2) System—Information to the public needed (1) System—Information to the personnel needed (2) System—Inadequate availability of general practitioners (2) System—Population increase in touristic areas during holydays (2)
	Strengths	Staff—Training on heat illness dispatch, recognition, and treatment is adequate (3) Staff and Stuff—Capability of recruiting additional EMS vehicles or personnel (1) System—Awareness of alert systems and reminders to personnel (3) System—Flexible and adaptable to heatwaves (4) System—Adaptation to summer season (3)

Table 1. *Cont.*

Themes	Subthemes	Specific Topics (Number of Participants)
	Potential solutions to mitigate the impact	Staff—proportional personnel implementation (3) Staff—screening personnel for physical efficiency (1) Staff—reduce working hours (2) Staff—remind proper hydration (1) Stuff—implementation with specific materials (4) Stuff—increase the number of EMS means (4) Stuff—improve EMS means air conditioning (2) Structure—create triage points in the district (1) Structure—divert vulnerable individuals to shopping centers with air conditioning (2) System—Training and information to personnel (4) System—Training and information to the population (3) System—Strengthening primary care (8) System—Granular activation of civil protection (2) System—improvement of hospital resilience (1) System—improvement of heat alert systems (2) System—create a dedicated number for calls (1)

3.1. Perception of Heatwaves

When asked to define a "heatwave", all interviewees identified the temperature increase as the main characteristic. Nine participants mentioned "*humidity*" as a factor affecting temperature perception when increased, "*amplifying a bit the problem of temperature rise*" (S2); S8 and S12 explained higher humidity as potentially due to lower wind speeds in the area hit by a heatwave. Some participants added a time factor to their definition. Two referred to the event onset by using the terms "*sharp, fast [. . .] and not gradual*" (S6) and "*sudden, abrupt*" (S10). Five focused instead on the duration of the temperature anomaly, defining it a "*period*" (S3, S8), "*prolonged*" (S6), "*protracted*" (S4, S5), exerting its effects on "*many consecutive days*" (S8).

Four participants described the relationship between geography and peculiar climatic conditions of different locations in configuring a heatwave that can hit "*a specific region*" (S2). Temperatures can be "*higher in absolute terms, but also relatively higher than the normal of that geographical area, if compared with its historical average values*" (S3). According to S1, "*the concept* [of a heatwave, Authors'/Note (A/N)] *is also connected to where it happens*", and "*for example, a heatwave happening in Kenya is different from a heatwave happening in Italy, not only for the different humidity but also for how the population endures the heatwave*". S5 instead highlighted the influence of the urban heat island effect on heat perception: "*For sure*, [higher temperature and humidity, A/N] *are more perceived in areas, let's say, more urbanized than in others*".

3.2. Clinical Impact of Heatwaves

The most recurrent subtheme concerned those strata of the population defined as "*vulnerable*" or "*frailer*"—such as children, elderly, or homeless individuals—and those working outside (six participants): "*. . .we rescued several times people working in construction sites, or inside factories. . . or, for example, those working on highways*" (S8). Heatwaves seemed to cause "*a different epidemiology of presentations*" than usual (S3), characterized mainly by acute on chronic illness (four participants) or syncope (four participants), potentially due to unmodified antihypertensive chronic therapy despite high temperatures (two participants). Heat stroke was deemed frequent among frailer subjects (S7), and exertional heat stroke in "*athletes running under the sun*" (S13); however, S2 and S11 perceived heat stroke as a paradoxically rare event during heatwaves, compared to other diseases (S2: "*talking about real emergencies, namely heat stroke, I've only seen two cases in my 23 years-long career*").

Three participants underlined that, during heatwaves, those calling the emergency number have "*less patience*" (S3); "*From a psychological point of view, there is an alteration. There* *is a behavioral modification, less tolerance to specific things, and people become impatient*." (S6), or "*people are more nervous, and many times it's more difficult to interact with them when they call the emergency number*" (S5). S3 and S5 were concerned regarding patients suffering from psychiatric illness, "*calling you because they are feeling hot; and they call you because they are decompensated and don't know how to manage themselves*" (S5) and potentially more "*episodes of aggressiveness or violence*" (S3).

Other conditions pointed out by the participants included dehydration (n = 2), predisposing to urinary infections or exacerbated by acute gastroenterological diseases (n = 1), fatigue (n = 2), respiratory conditions (n = 1), and cardiovascular conditions (n = 1). None of the interviewees spontaneously mentioned an increase in mortality, and when probed, only two referred again to older people or comorbid individuals.

3.3. Social Factors and Heatwaves

Particular attention was dedicated to social factors, with four subthemes emerging from the interviews: culture, economic factors, social network, and family network.

Issues dealing with population culture and education concerned most of the participants. Four highlighted a lack of behavior modifications during heatwaves, with people "*continuing to travel or work although temperatures are higher*" (S4), mainly "*workers in the healthcare and construction sectors*" (S8), but in general "*not following common recommendations to stay hydrated or avoiding going outside during hottest hours*" (S7), such as "*athletes training in very hot conditions*" or "*kids excessively dressed*" (S13). Moreover, the elderly could "*underestimate or be unaware of their vulnerability to extreme heat*" (S4), thus not considering relocating to areas with better climate conditions during summer (S2, S10). According to three participants, such factors could determine more inappropriate care demands on both EMSs and EDs.

The participants paid particular attention to the misuse of air conditioning during heatwaves: S13 mentioned that older adults could "*refuse to install conditioning systems for cultural factors*", preferring to live in houses "*not suitable*" for hot temperatures; S2 highlighted that older adults could instead "*easily use air conditioning*". Six interviewees identified an overlap with economic factors—namely, the costs of installing or running conditioning systems—as a barrier hampering the use of air conditioning to mitigate elevated temperatures. Paradoxically, low-income individuals and families with a conditioning system could "*avoid operating them because of the skyrocketing high costs of electricity in these times*" (S7), forcing PHEM personnel to work in "*top floor apartments with prohibitively high temperature*" (S1), while "*as usual, rich people... have all the possibilities to keep cool, and who isn't* [rich, A/N] *gets sick*" (S8).

Both social and family network failures were perceived as significant in causing an overload during heatwaves, such as a disruption of connections with "*their community*" (S11), "*elderly living alone, without anyone reaching out to them*" (S13), and lacking "*family or support*" (S2, S9) or because family and caregivers "*want to go away for the summer leave, and don't know how to manage the old person: so, they call the emergency number to hospitalize them*" (S4).

3.4. Heatwaves and EMS

This topic included most of the themes captured by the interviews, divided into three subthemes related to the interactions between heatwaves and EMS: gaps and vulnerability factors, strengths, and potential solutions to mitigate the impact. Overall, the interviewees identified different vulnerabilities and solutions in the four domains of surge science principles defined as *staff*, *stuff*, *structure*, and *system* but expressed conflicting perspectives regarding PHEM system preparedness against heatwaves or information and communication between stakeholders and care providers.

3.4.1. Gaps and Vulnerability Factors

Regarding *staff*, the interviewees were concerned by the influence of extreme heat on EMS personnel safety and performance, especially when delivering emergency care "*under* *the sun on the streets or inside houses without air conditioning at the top floor*" (S5), "*performing cardiopulmonary resuscitation*" (S3), or attending a "*complex and prolonged extrication from a car accident, on the asphalt*" (S4). A lack of available EMS personnel was reported by two interviewees, from both the perspectives of acute response "*to answer a higher number of emergency calls*" and fatigue due to "*increased calls protracted for days*" (S5); also, poor heatwave awareness or training on "*materials used*", "*multiple casualty management*", "*triage*", were deemed significant.

Scarcity of resources (*stuff*) was highlighted by most of the participants, especially regarding the following: the number of EMS vehicles is insufficient "*to meet surges during heatwaves*"; inconsistent availability of instant ice on vehicles; no water availability for personnel; inadequate climatization of vehicles; clothes and personal protective equipment not comfortable at high temperatures; potential malfunctioning of medical devices.

Structures, namely places "*to accommodate multiple patients together during heatwaves*" (S1) because "*EDs are overcrowded*" or to "*gather persons to repair from heat*" (S5), were perceived as absent.

Most observations dealt with system preparedness and organizational factors. Initiatives and outreach efforts to inform and educate the public were deemed insufficient, as were structured prevention measures and, specifically, alerts and heat plans—which, for some interviewees, "*scarcely translate into concrete actions*" (S4). In particular, "*information to the personnel*" was "*the most vulnerable part*" (S7), configuring a gap between the governmental level and the end users of plans. The interviewees described the rise in calls to the emergency number and the high rate of emergency care requests as generally inappropriate. The participants explained this as caused by inadequate availability of primary care services, usually "*filtering non-urgent cases, easily manageable at home*" (S9) because the population attempting to reach their general practitioner (GP) "*can't find anyone*" (S8). Notably, a vulnerability factor was identified in the marked population increase in touristic areas during holidays, thus requiring more resources (S6, S11).

3.4.2. Strengths

According to three interviewees, *staff* "*knows well heat-related illness*" (S12), and "*a dedicated dispatch protocol has been introduced to specifically detect heat illness*" (S13), which is periodically reminded to dispatchers (S7).

Regarding the regional PHEM system, four interviewees perceived it as well prepared because it "*is flexible and adaptable*" to heatwaves (S8). Moreover, it can "*quite rapidly increase the number of rescue vehicles and personnel*" (S8) in case of surges. Three participants admitted being aware of the national and regional heat-response plans and advice to the population; also, periodic reminders before the hot season were noted by three. Of note, S11 reported "*improvements in climatization inside retirement homes*", S7 an "*increased capability proportional to the higher number of the population*" (tourists, A/N), and S8 "*the luck of having healthcare workers* (doctors or nurses, A/N) *on every ambulance, and not volunteers, prepared to manage correctly heat illness*"—factors potentially reducing heat-related morbidity in the population and the consequent overload of PHEM system.

3.4.3. Potential Solutions to Mitigate the Impact

Three participants suggested "*implementing personnel during these difficult periods*" (S13) by "*identifying best triggers*" (S11) or "*by local government levy*" (S1). To mitigate the adverse effects of heat on PHEM personnel, screening for "*physical efficiency*" (S3) was advised beforehand. Directors should contemplate "*improving personnel turnover*" (S11) by "*cutting down to the half active working hours*" (S8) and by reminding staff of "*proper hydration during shifts*" through "*periodic emails*" (S4).

Suggested implementations to *stuff* included ice (S3), cold crystalloids for intravenous infusion (S12), water for personnel hydration (S4, S8), and clothes and personal protective equipment more suitable for high temperatures (S4). Four participants confirmed the need to increase the number of EMS vehicles during heatwaves, and two suggested improving their air conditioning system.

Regarding *structure*, the interviewees suggested creating "*triage points in the districts, made available by local administrations, for example inside gyms*" (S1) and directing the frail population to shopping centers "*where air conditioning is easily available*" (S7) by "*establishing a public-private partnership*" (S3).

System modifications included most perspectives captured by the interviews in this subtheme. The interviewees mentioned training and information campaigns for PHEM personnel (n = 4) and the population (n = 3) as needed to improve the system. Particular attention was dedicated to primary care, with eight participants suggesting the improvement of integrated care at home, delivered by nurses or trained volunteers, and coordinated by local governments' social services. Interestingly, two interviewees manifested frustration regarding a reduced availability of GPs, causing "*patients to use the emergency number, ambulances, or access the ED for problems of minor entity*" (S8). Individuals deserving particular attention were suggested to be identified through "*new frailty scales and, therefore, preventively assisted if above a certain threshold*" (S9) to receive support from their social network or through "*economic incentives*" (S8). Two participants suggested strengthening the healthcare system with a more granular activation of civil protection (S3), while S7 suggested improving hospitals' resilience. Heat alert communication, or how the alert is communicated to both PHEM personnel and the population, was perceived by two interviewees to be improved: for communication to the population, S11 suggested the participation of mass media; for the interface between agencies and EMS, a standardized communication from the regional forecasts, followed by actions depicted and delineated on a paper to guide dispatchers' actions, was suggested as fundamental. Finally, a dedicated number to answer heat-related health questions was cited but deemed unimportant "*until a predefined threshold is exceeded*" (S12).

4. Discussion

Although several attempts have been made to increase the understanding of public health initiatives against heatwaves, results from the literature could be more consistent [9,25]. In particular, in the overlapping fields of emergency care and heatwaves, studies only confirm associations between heat anomalies and a substantial increase in care demand indicators, such as ambulance dispatches [26–29], ED presentations [10,11,27,28,30–34], or even mortality in EDs [35]. To fill this gap and provide possible targets of interventions to mitigate EMS overload and dysfunction during heatwaves, the present qualitative study was performed on PHEM workers of a high-income European region vulnerable to climate change.

As in a previous study on heatwave perception among German GPs, all the participants mentioned a "temperature" increase as the main characteristic of a heatwave, and 9 out of 13 also added "humidity" to better characterize their answer; other features regarded the time of onset, duration, geographic/location-specific features, and the urban heat island effect. These inconsistently described characteristics of a heatwave mirror the lack of a shared definition in the scientific community [9]. The first message is that a clear, operational definition of heatwave should be established to help stakeholders attain disaster risk reduction [36].

Regarding the impact on the population, the participants narrowed their attention to social and clinical factors. EMS personnel seemed to be aware of the vulnerability of some population strata to heatwaves, primarily citing those at the extremes of age. Only one participant mentioned homelessness as a vulnerability, consistent with literature and policy neglect concerns already expressed for this group [37]. Finally, the outside workers' group emerged as a population at high risk, as confirmed by two systematic reviews denoting an association between extreme heat and workers in general [38], but specifically in the agricultural and construction sectors [39]. The interviewees confirmed the complex spectrum of illnesses caused or exacerbated by heatwaves and described in the literature [9]. Surprisingly, only three participants mentioned heat illness or exertional heat stroke in athletes, medical emergencies whose prompt recognition and treatment tremendously impact patients' outcomes [40–43]. One affirmed that this is a rare event, but regional incidence data on heat stroke are lacking. On the one hand, this result potentially implies a poor awareness of the disease in some participants. It is also reasonable to think that other included participants were aware of these emergencies but manifested their disappointment (emerging from field notes of the interviewer) by describing a series of preventable diseases already described in the literature, such as syncope due to dehydration or consequences to the unadjusted antihypertensive therapy not meeting seasonal fluctuations in blood pressure [44]. The participants rarely mentioned other diseases pertaining to cardiovascular, pulmonary, and renal systems; none of them expressed concerns regarding mortality, which is significantly associated with heatwaves. Another possible explanation could be the limited time EMS personnel spend with patients without obtaining a definitive diagnosis (usually reached during ED or hospital admissions). Three participants mentioned an exacerbation of psychiatric illnesses during heatwaves and, more interestingly, highlighted a tendency of emergency number callers to be more nervous than in other seasons. While the former aspect is already described in the literature [9,45], the latter is a new finding; despite being subjective, it should be further studied to help deploy measures preventing verbal and physical aggression against healthcare workers, which is currently increasing. Therefore, a general recommendation arising from this section regards the need for personnel to be more aware of changes in the spectrum of diseases during heatwaves, specifically in vulnerable individuals, including behavioral changes.

The tendency to go "*against common sense*" reported by the interviewees, such as avoiding walking or exercising during a hot summer day or continuing work despite prohibitive environmental conditions, is consistently present in the literature [46,47]. In their scoping review, Mayrhuber et al. summarized that behavioral factors, awareness, and attitudes towards heatwaves were protective or risk factors; in particular, individuals unaware of their vulnerability were less prone to enact behavioral changes or defensive measures against unusual heat [46]. Social isolation due to reduced interaction and separation from family emerged as a potential cause of inappropriate EMS use, as previously demonstrated [48] and suggested as an essential target of public health interventions [49]. Also, the participants raised a point on the interconnected fields of economic restrictions, inequities, and air conditioning. A third point should, therefore, aim to reduce the inappropriate and preventable uses of EMSs during heatwaves, such as those due to inequalities or the lack of support to frail and comorbid individuals, by involving primary care and families and promoting heat awareness campaigns, inclusion initiatives, and safe behaviors during heatwaves, such as accessing public cooling centers [50,51].

The "heatwaves and EMS" section offers four groups of insights, organized through the surge science elements of *staff*, *stuff*, *structure*, and *system* to provide a more structured framework. Within gaps and vulnerabilities, the interviewees complained about the vulnerability of personnel as subjected to harsh working conditions, with heat posing a risk to their health and performance. When exploring the impact of heat on workers wearing personal protective equipment (PPE) against COVID-19, Davey et al. found a perceived worsening of performance [52]. Bonell et al. suggest that cooling strategies can improve workers' comfort but seem not to impact cognitive performance [53]. Unfortunately, these aspects have not yet been studied in heatwaves. A higher demand during heatwaves indirectly emerged from the interviewees, highlighting a lack of personnel and appropriate equipment. Primary care has also been mentioned as being unable to meet patients' needs during heatwaves, confirming a concern already noted by the literature [54]. Since in non-heatwave conditions, primary care failure correlates with ED overcrowding [55], probably through EMS overload, future initiatives should not target a single service but try to alleviate the pressure on the whole healthcare system with a holistic approach.

Among the strengths, the interviewees highlighted the capacity of EMSs to adapt to a sudden increase in emergency care demand during heatwaves thanks to a flexible system capable of recruiting further vehicles and personnel in the same district or requesting support from a bordering one. The response capability of EMSs in disaster medicine is intended as a coordinated effort to provide timely and effective medical care to those affected. Still, it should not be restricted to mass casualty incidents. Extreme weather events such as heatwaves can be protracted in time and require different recruitment strategies to preserve the system's resilience in a medium or long time. Potential solutions suggested by the interviewees mainly cited strengthening primary care, addressing known concerns related to vulnerable populations, and fostering a comprehensive and integrated approach that recognizes the interplay between population health, economics, and social interventions. Avoidable access to emergency care could be prevented with the temporary activation of dedicated numbers or helplines—offering non-urgent telephone consultation to the general population and providing active telemonitoring for pre-identified vulnerable individuals [56]. A more granular activation of civil protection in every district could help schedule periodic home visits by volunteers to check proper room temperature and adequate hydration and support out-of-home activities during the hottest hours, such as grocery procurement. Another subtheme focused on meeting the perceived lack of staff and EMS vehicles during heatwaves by implementing resources. Practical adaptations, for example, include the planned resource increase during summer in touristic locations—anticipating a growing population in coastal or mountain areas of the region—to meet a higher number of emergent care requests. Similar temporary adaptations could be triggered when forecasting heatwaves in specific areas to strengthen local EMS capability. Suggestions from the participants could also be used to mitigate heat strain on personnel, such as reducing working hours, maintaining proper hydration by using reminders and ensuring access to water, adopting more comfortable working clothes, and screening for physical efficiency. Also, high-performance air conditioning in air and ground vehicles was deemed essential to deliver better patient care, improve personnel comfort, and preserve medical equipment from malfunctioning due to overheating. Dedicated equipment should be available during summer to manage heat illness since this emergency requires immediate treatment already in the prehospital arena [40,57]. Finally, the interviewees deemed it important to implement interventions to improve healthcare workers' perception of heat illness and modify population behavior during heat spells, which has already been suggested in the literature [58] and can probably translate into reduced input to the EMSs.

In general, all these solutions should implement current Heat–Health Action Plans (HHAPs) and be triggered by early warning systems, with actions indirectly and directly targeting the resilience of EMSs, with a comprehensive approach—considering meteorologic, epidemiological, and public health concerns with particular attention towards vulnerable groups [59].

Limitations

This study has two main limitations. First, participants were recruited from a single region, so the findings could not apply to other contexts. Second, the small sample size (13 analyzed interviews) could hamper the generalizability of the results; however, data saturation was already reached after 10 interviews, which comprehensively answered the research questions. The scientifically sound methodology based on the COrEQ guidelines also increases the study's validity.

5. Conclusions

This study provides valuable insights into the perspectives of PHEM personnel from a high-income European region regarding EMS's vulnerabilities to heatwaves and potential solutions. The findings underscore the importance of addressing these vulnerabilities to mitigate the risk of health system dysfunction during such extreme weather events.

Concrete interventions should improve current HHAPs through strategic planning, resource allocation, training, and awareness campaigns, enhancing patient care and personnel safety during heatwaves. This approach, integrating other healthcare sectors, will enable PHEM to effectively adapt to a changing climate, resulting in a more streamlined service.

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