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Trends in tropical nights and their effects on mortality in Switzerland across 50 years

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Abstract

Increasing temperatures and more frequent and severe heat waves in Switzerland are leading to a larger heat-related health burden. Additionally, high nighttime temperatures or tropical nights (TNs) also affect the well-being of the population. We aimed to assess the spatiotemporal patterns in the frequency and the exposed population to TNs, and its mortality effect in Switzerland. We identified the TNs (minimum nighttime temperature ≥ 20˚C) in each district in Switzerland using population-weighted hourly temperature series (ERA5-Land reanalysis data set) between 1970–2019. We assessed the change in the frequency of TNs and the exposed population per district and decade through a spatiotemporal analysis. We then performed a case time series analysis to estimate the TN-mortality association (controlled for the daily mean temperature) by canton and for the main 8 cities using data on all-cause mortality at the district level between 1980–2018. We found an overall increase in the annual frequency of TN (from 90 to 2113 TNs per decade) and the population exposed (from 3.7 million to over 157 million population-TN per decade) in Switzerland between 1970–2019, mainly in the cities of Lausanne, Geneva, Basel, Lugano, and Zurich, and during the last two decades. The TN-mortality association was highly heterogeneous across cantons and cities. In particular, TNs were associated with an increase of 22–37% in the risk of mortality in the cantons of Vaud (Relative risk: 1.37 (95%CI:1.19–1.59)), Zurich (1.33 (0.99–1.79)), Lucerne (1.33 (0.95–1.87)) and Solothurn (1.22 (0.88–1.69)), while a negative association was observed in Ticino (0.51 (0.37–0.7)), Basel-Land (0.4 (0.24–0.65)) and Thurgau (0.65 (0.5–0.85)), and a null association in the remaining cantons. Our findings indicate that TNs are a relevant health hazard for a large part of the Swiss population leading to potentially larger impacts in the future due to climate change and increasing urbanization.

1. Introduction

Due to climate change, the frequency and intensity of hot temperature extremes have increased in recent years [1–4]. Along with the increasing number of hot days, also nighttime

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temperatures, and thus, the frequency of hot nights increased in the last years in most regions of the world, and it is expected to further increase in the future decades [1]. On top of the progressive warming of the climate, the accelerated growth of the cities and increasing urbanization of the land surface is expected to further amplify the increased frequency of hot nights due to the urban heat island effect [5]. The urban heat island effect consists of the release of the absorbed heat during the night in urban areas, which prevents the urban area from cooling down and can lead to increased nighttime temperatures [5].

Numerous studies showed that extreme heat impacts human health by increasing human mortality and morbidity [6–10]. This association is usually J-shaped for the summer months with increased mortality risk with increasing temperatures [11,12]. Due to this significant association between temperature and mortality, increasing temperatures represent a considerable risk to human health [13]. Most studies so far have used the daily mean temperature to analyze the association between heat extremes and mortality, as a representation of the average heat exposure during the day [13,14]. However, there is some evidence suggesting that elevated nighttime temperatures may additionally increase the mortality risk during heatwaves [5]. Increased minimum nighttime temperature leads to insufficient sleep and disturbs the nocturnal rest of the human body [15–17]. Several studies found an independent effect of hot nights on mortality in several cities in Europe [18–20]. In particular, in a multi-location assessment hot nights were associated with an increase in mortality risk of 12% in France, and 37% in Portugal [19]. These episodes result in prolonged thermal stress, negatively impacting human health, comfort, and performance, especially among the older populations [15,19,21–23]. Evidence shows that short sleep duration and poor sleep quality are associated with increased mortality [24–26].

In Switzerland, events of extremely high nighttime temperatures are defined as tropical nights (TNs) when the nighttime temperature does not drop below 20˚C (293.15K) [27–29]. Under present-day conditions, TNs mostly occur in Switzerland in low-lying urban areas and Ticino [22]. However, it is expected that its frequency and intensity will increase throughout Switzerland in the future under all emission scenarios [22]. Several studies analyzed the association between heat and mortality in Switzerland and found an effect of extreme heat on mortality [13,14,28,30]. However, to the best of our knowledge, no comparative studies on TNs and mortality have been conducted for Switzerland so far. Advancing knowledge on the impact of TNs on health is needed to design more efficient public health plans, especially given the expected increase in the frequency and magnitude of hot nights in future.

This study, therefore, aimed to comprehensively assess the frequency and exposure to TNs and their impact on mortality in Switzerland in a spatially explicit, nationwide study using high-resolution data. In particular, we investigated the spatiotemporal patterns in frequency and exposed population to TNs since 1970 across districts and estimated the TN-mortality association in each canton and the eight largest cities in Switzerland between 1980–2018.

2. Data and methods

2.1 Data

2.1.1 Temperature data. We obtained gridded hourly mean temperature data for the period 1970 to 2019 with a 9-km resolution across Switzerland from the ERA5-Land reanalysis data set provided by Copernicus Climate Change Service (C3S) [31,32]. We derived hourly series in each of the 143 districts using the grid cells that intersect their boundaries [33], based on the district boundaries of the year 2018 (Federal Statistical Office). We obtained population weighted-hourly district-specific temperature series using the spatially-resolved total population data in the year 2010 at 1-km resolution [34] to account for the heterogeneous distribution of the population due to the irregular orography, as explained elsewhere [35]. We defined TN was defined as a night where the minimum temperature between 9 PM and 6 AM was above 20˚Celsius (293.15K) following the official definition of MeteoSwiss (Federal Office of Meteorology and Climatology) [27]. While some studies used a 20˚C (293.15K) threshold to define a TN [19], others have used thresholds based on temperature percentiles (i.e., 95th or 99th of the temperature distribution) [18,20].

2.1.2 Mortality data. We collected data on all-cause mortality at the municipality level in Switzerland from 1980 to 2018 from the Federal Office of Statistics. We aggregated the data into daily counts of all-cause deaths in each district for total-all cause mortality, by age categories (below or equal to 75 and over 75 years old) and sex (male and female).

2.2 Methods

2.2.1 Hazard and exposure assessment. We computed the average annual frequency of TNs for each year, decade and district, and analyzed and mapped their respective spatiotemporal patterns. Similarly, we performed an exposure assessment by quantifying the population exposed to TNs by district and decade. We multiplied the total number of TNs per district and decade by the population size at the midpoint year of each decade.

2.2.2 Vulnerability analysis. We applied a case time-series design to determine the association between TNs and mortality in Switzerland [36]. This study design allowed us to model the TN-mortality association in each Canton using the exposure and mortality data defined at the lower spatial unit (i.e., district) [37]. Specifically, we performed a conditional quasi-Poisson regression and included a matching stratum by year, month, and day of the week at the district level to control for long-term trends and seasonal patterns. The analysis was restricted to the months from May to September and covered the period between 1980 and 2018 due to low TN frequencies before 1980 and limited availability of mortality data (i.e., until 2018). We modelled the TN-mortality association with an unconstraint-distributed lag linear model (DLM) with three days of lag to account for delayed effects and harvesting [38]. To estimate the independent TN-mortality association, we controlled for daily mean temperature using an unconstraint-distributed lag non-linear model (DLNM) with three days of lag and a quadratic B-spline with two internal knots placed at the 50^{th} and 90^{th} percentile of the canton-specific temperature distribution. In an additional analysis, we performed a city-specific analysis of the eight largest cities in Switzerland by restricting the data to the specific district. We also stratified the analysis by sex (male/female) and age (under or equal to 75/over 75 years). To explore the potential role of the implementation of public health measures, we performed an additional sub-analysis by subperiods before and after the year 2003, when the Swiss public health authorities established a national heat action plan. We also estimated the mortality risk for TNs without adjusting for mean temperature. Finally, we computed the TN-mortality risks for TN defined based on the 95th percentile for a subset of cantons. All analyses were performed in R, version 4.1.1 (2021-08-10), using the gnm, and dlnm packages.

3. Results

3.1 Hazard

Table 1 shows the average number of TNs per decade from 1970–2019 in each canton. Out of the 26 Swiss cantons, 7 were not included since no TNs were registered. For the reported canton-specific summaries, only the districts with at least one TN are considered. The total number of TNs is added for each canton and then divided by the number of considered districts in the canton. The number of TNs per district is reported in S1 Table.

Table 1. Average number of TNs per canton and decade from 1970–2019. Sum of TNs of all districts per canton divided by the number of districts.

	1970–1979	1980–1989	1990–1999	2000–2009	2010–2019
Zürich	0	2	5	12	16
Bern	0	1	4	14	20
Luzern	0	1	6	11	14
Schwyz	0	0	2	6	6
Nidwalden	0	0	0	1	0
Zug	0	1	0	4	5
Fribourg	0	1	2	6	14
Solothurn	0	2	3	16	21
Basel-Stadt	0	8	3	19	30
Basel-Landschaft	0	1	1	13	13
Schaffhausen	3	8	22	23	35
St. Gallen	0	0	1	2	6
Aargau	1	3	9	21	29
Thurgau	4	7	21	29	50
Ticino	0	8	14	23	47
Vaud	4	7	21	29	50
Neuchâtel	0	0	1	7	7
Genève	1	5	10	29	51
Jura	0	0	0	12	11

* Cantons without TNs are excluded (Uri, Obwalden, Glarus, Appenzell Ausserrhoden, Appenzell Innerrhoden, Graubünden, and Valais).

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Over the last five decades, the frequency of TNs increased in Switzerland (from 90 TNs in 1970–1979 to 2113 TNs in 2010–2019 in all districts) (Table 1, Figs 1 and 2). The heatmap in Fig 1 illustrates the annual number of TNs per district, listing all districts having experienced at least one TN within the analyzed period. Fig 2 shows the number of TNs per district and decade. Our results suggest that TNs are not only increasing in frequency across time but also across space (i.e., districts), with more districts affected every decade. In the first decade (1970–1979), at least one TN occurred in 20 districts, then increased to 68 districts in 2000 and 85 districts by the end of 2019. TNs mainly happened on the Swiss Plateau and in Ticino and the areas of larger cities (i.e., Lausanne (77 TNs in the last decade), Geneva (51), Basel (30), Lugano (21), and the region of Zurich (190 in 12 districts). We observe the largest increase in the number of TNs around Lake Geneva and Lake Constance, as well as in Ticino (Fig 2). Fig 1 also shows that the year 2003 registered the largest number of TNs (2003 European heatwave), followed by the more recent summers (e.g., 2015 also characterized as particularly hot.

3.2 Exposure

Fig 3 illustrates the population exposed to TNs per district and decade. It shows that the population exposed to TNs strongly increased between 1970 and 2019. A substantial increase happened mainly in the cities of Zurich, Basel, Lausanne, and in the south of Ticino (i.e., Lugano and Mendrisio), with the most significant increase in Geneva. In particular, in the first decade (1970–1979), Geneva had around 33'733 population-TN per year, whereas in the last decade (2010–2019) on average almost 2.5 million people were exposed to at least one TN each year (S2 Table).

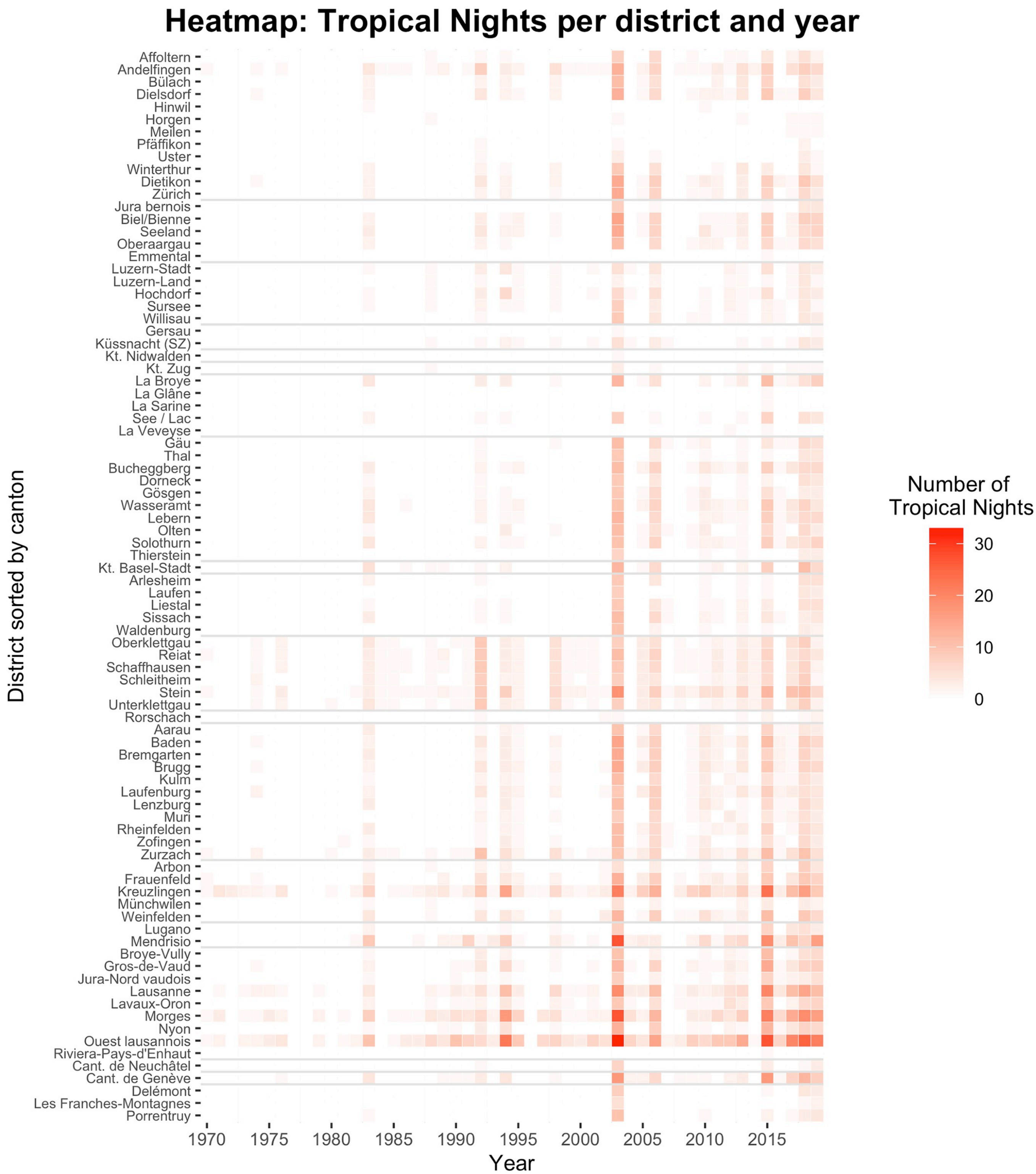

Fig 1. Heatmap representing the number of tropical nights (TNs) per year for each district in Switzerland, sorted by canton, from 1970 to 2019.

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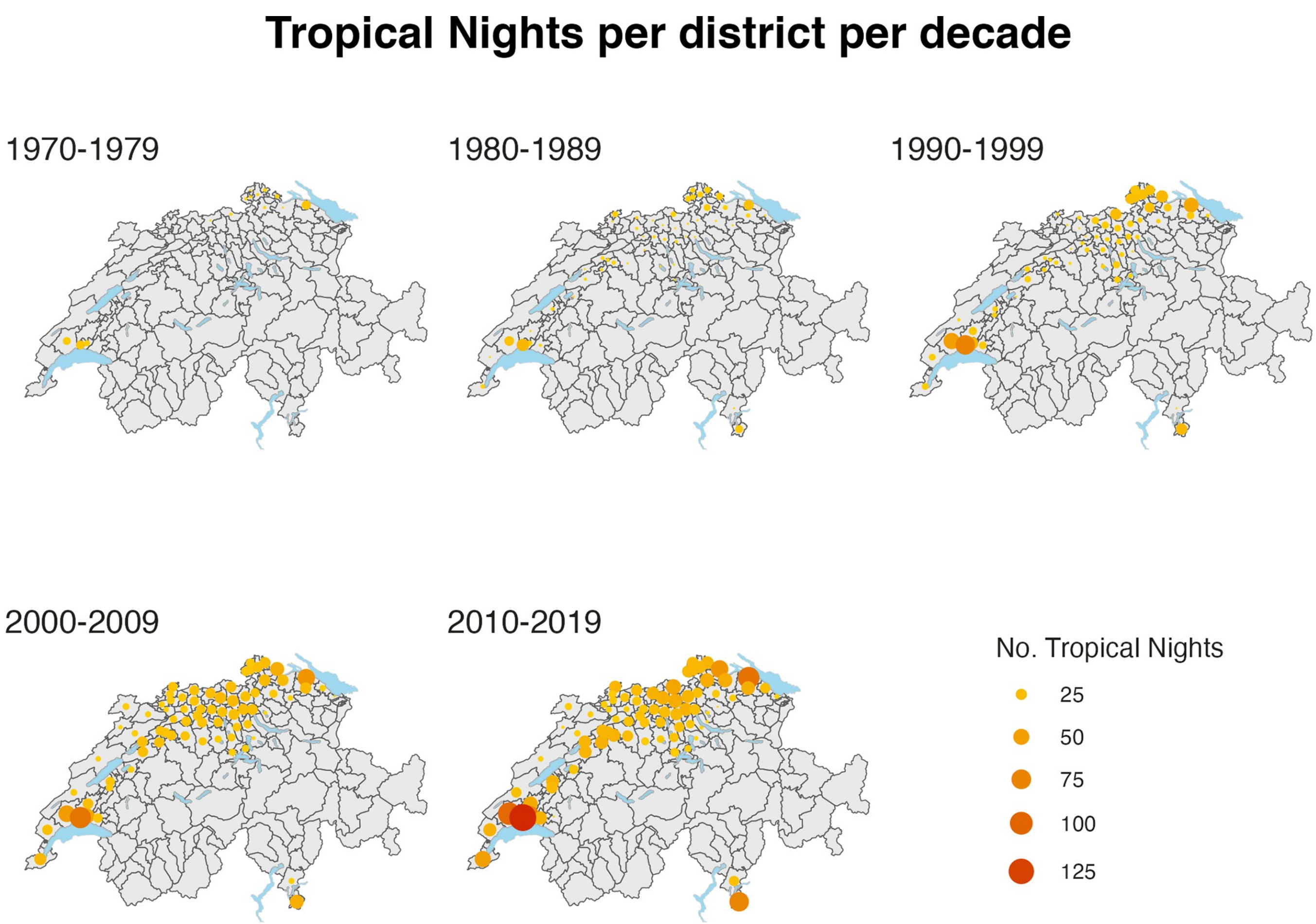

Fig 2. Number of tropical nights (TNs) per district and decade in Switzerland from 1970 to 2019. Basemap—SwissTopo (https://www.swisstopo.admin.ch/en/geodata/landscape/boundaries3d.html). Terms of use in https://www.swisstopo.admin.ch/en/home/meta/conditions/geodata/ogd.html.

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3.3 Vulnerability

3.3.1 Description of the temperature and mortality data between 1980–2018. We analyzed 646'983 death records in 14 cantons and 230'627 death records in the eight main cities throughout Switzerland (Table 2). The canton of Vaud reported the highest average number of TNs per district with 113 TNs between 1980 and 2018, and the city of Lausanne reported the highest number of TNs among the selected cities (167 TNs). In addition, most of the cities reported more TNs than the average number of TNs occurring in their corresponding canton (i.e., Lausanne (city) 167 vs. Vaud (canton) 113). The highest mean temperature was measured in the canton of Ticino (17.4˚C) and the city of Basel (16.9˚C), respectively.

3.3.2 Nationwide analysis of TN-mortality risks. Fig 4 shows the relative risk (RR) and 95% confidence interval (CI) of mortality associated with TN per canton. TNs were somewhat positively associated with an increased mortality risk between 22–37% in the canton of Vaud (1.37 (95% CI: 1.19–1.59)), Zurich (1.33 (95% CI: 0.99–1.79)), Lucerne (1.33 (95% CI: 0.95–1.87)), and Solothurn (1.22 (95% CI: 0.88–1.69)). While we found evidence for a negative association in the canton of Ticino (0.51 (95% CI: 0.37–0.7), Basel-Land (0.40 (95% CI: 0.24–0.65)) and Thurgau (0.65 (95% CI: 0.50–0.85)). The cantons of Basel-Stadt and Geneva also showed a risk of around 0.85. Null associations were found in the remaining cantons, (e.g., Bern, with a

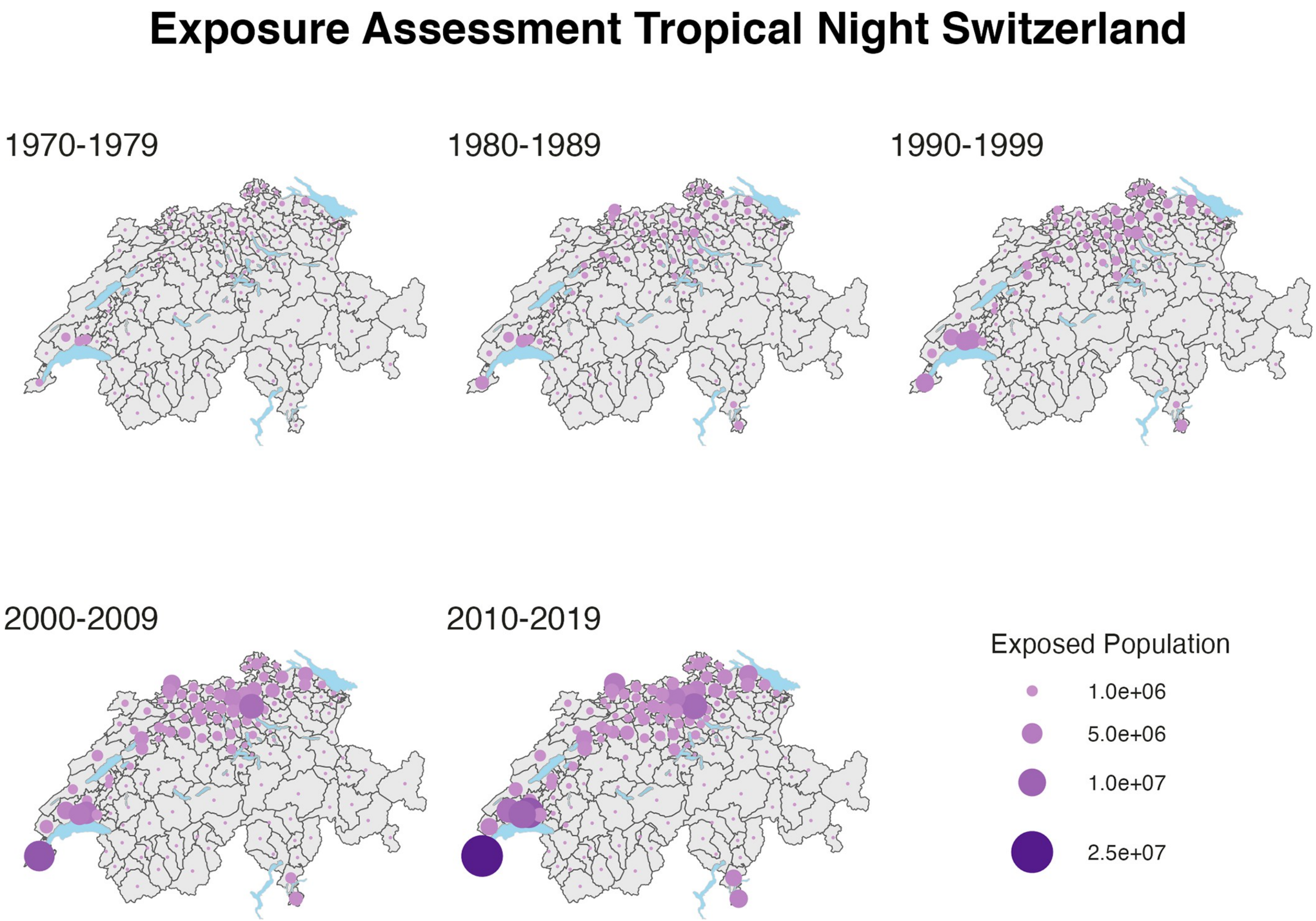

Fig 3. Population exposed to tropical nights (TNs) per district and decade in Switzerland from 1970 to 2019. Basemap—SwissTopo (https://www.swisstopo.admin.ch/en/geodata/landscape/boundaries3d.html). Terms of use in https://www.swisstopo.admin.ch/en/home/meta/conditions/geodata/ogd.html.

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risk of 1.03 (95% CI: 0.79–1.35)). The results of the subgroup analyses show no consistent patterns, with varying risks across sex and age groups (S1 and S2 Figs).

3.3.3 City-specific analysis of TN-mortality risks. Fig 5 illustrates the RR of mortality associated with TNs across the 8 selected cities. TNs were associated with an increased risk, although with substantial uncertainty, in the cities of Lugano (1.19 (95%CI: 0.78–1.8)), Lucerne (1.46 (95% CI: 0.85–2.49)), and Winterthur (1.34 (95% CI: 0.78–2.31)). Whereas the other cities show some evidence of a protective effect although highly uncertain, such as Geneva (0.83 (95% CI: 0.69–1.00)) and Basel (0.82 (95% CI: 0.65–1.04)).

The comparison between Figs 4 and 5 shows different trends between some cities and their corresponding canton. For example, a negative association is found in the city of Zurich (0.83 (95% CI: 0.63–1.07)), while there is a positive association within the canton of Zurich (1.33 (95% CI: 0.99–1.79)). The same difference is found in Lausanne and Vaud, and the opposite trend is in Lugano and Ticino.

The results by subperiod before and after 2003 show diverging patterns (S3 Table). For example, in the cantons of Basel-Landschaft and Luzern, the mortality risk associated with TN decreased substantially after 2003. While in other cantons such as Vaud and Ticino, we observe a reverse pattern with an increase in the most recent period. However, we cannot

Table 2. Descriptive statistics by canton and city for the number of tropical nights, number of deaths, daily mean temperature (in ˚C) and interquartile range(IQR) from May to September (in ˚C) 1980–2018.

		Tropical Nights	Deaths	Daily mean temperature (May-Sept)	
		Number	Number	Average	IQR
Canton	Zürich	37*	161368	15.86	5.54
	Bern	41*	54172	15.43	5.58
	Luzern	35*	39077	15.46	5.56
	Fribourg	25*	23145	15.33	5.57
	Solothurn	43*	41030	15.78	5.52
	Basel-Stadt	64*	36639	16.91	5.61
	Basel-Landschaft	30*	30513	15.93	5.52
	Schaffhausen	92*	10909	16.09	5.59
	Aargau	66*	62135	16.17	5.53
	Thurgau	91*	27735	16.16	5.57
	Ticino	96*	22607	17.38	5.19
	Vaud	113*	79376	15.80	5.69
	Genève	99*	48489	16.47	5.72
	Jura	16*	9788	14.76	5.56
City	Zürich	57	64518	16.05	5.59
	Genève	99	48489	16.47	5.72
	Basel	64	36639	16.91	5.61
	Lausanne	167	19851	16.36	5.67
	Winterthur	36	18094	15.64	5.57
	Luzern	43	12613	15.49	5.55
	Lugano	36	16397	16.86	5.14
	Biel/Bienne	65	14026	15.69	5.57

*Total number of TNs per canton divided by the number of districts.

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derive robust conclusions about time trends due to the high uncertainty of the period-specific estimates.

Regarding the sensitivity analysis, when we did not consider mean temperature in the model, TN-mortality risks were substantially different in most of the cities and some cantons (e.g., Basel-Stadt, Basel-Landschaft) (S4 and S5 Tables). These findings suggest that part of the effect of mean temperature is captured by the effect of TNs on mortality (i.e., additive effect). Finally, the association estimates remained similar when considering the 99th percentile as the threshold for the definition of TNs (S6 Table).

4. Discussion

Our findings indicate that the frequency of TNs in Switzerland overall increased between 1970 and 2019, mainly in urban areas (Lausanne, Geneva, Basel, Lugano, and Zurich). The population exposed to TNs in Switzerland also increased, with the most substantial increases in the largest cities. However, the vulnerability to TNs in terms of associated mortality risk seems to be highly variable across cantons and cities. Our results suggest that TNs should be still considered a relevant health hazard in Switzerland. This has a sense of urgency since it has been suggested that due to climate change, the frequency of TNs will increase in the future in Switzerland [4,22].

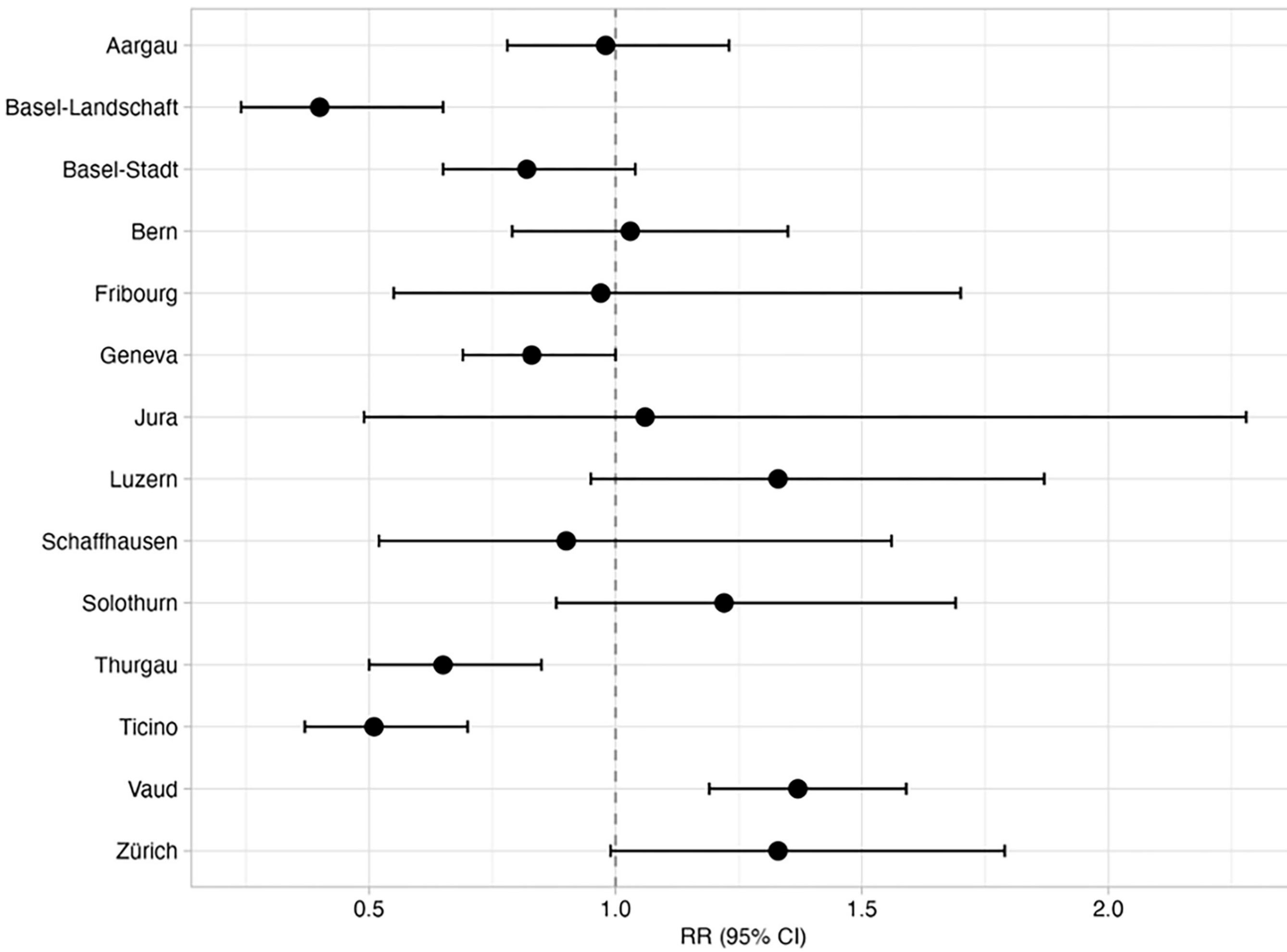

Fig 4. Nationwide analysis of the TNs-mortality association. Relative Risk (RR) (and 95% confidence interval (CI)) of mortality associated with TNs in the cantons of Switzerland (1980–2018).

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4.1 Hazard

Due to climate change, the average temperature has increased during the last decades and is projected to further increase in all regions of Switzerland in the future [22]. The CH2018 report [22] states that Switzerland represents a hotspot for changes in hot temperature extremes, such as heatwaves and TNs. Our results confirm these observations with an increasing trend in the frequency of TNs. In addition, these changes occur in low-lying areas with high population density, where the urban heat island effect may further amplify these extremes [22,39], as we observed in this study with larger increases in urban regions. Other studies from Georgian Territory, the Spanish Mediterranean coast, and Seoul, also showed a significant increase in TNs during the last decades [40–42].

4.2 Exposure

The population exposed to TNs increased in Switzerland between 1970 and 2019, due to both the exponential increase in the frequency of TNs and in the population [43], which mainly occurred around the largest cities and urban agglomerations. Our findings are similar to a

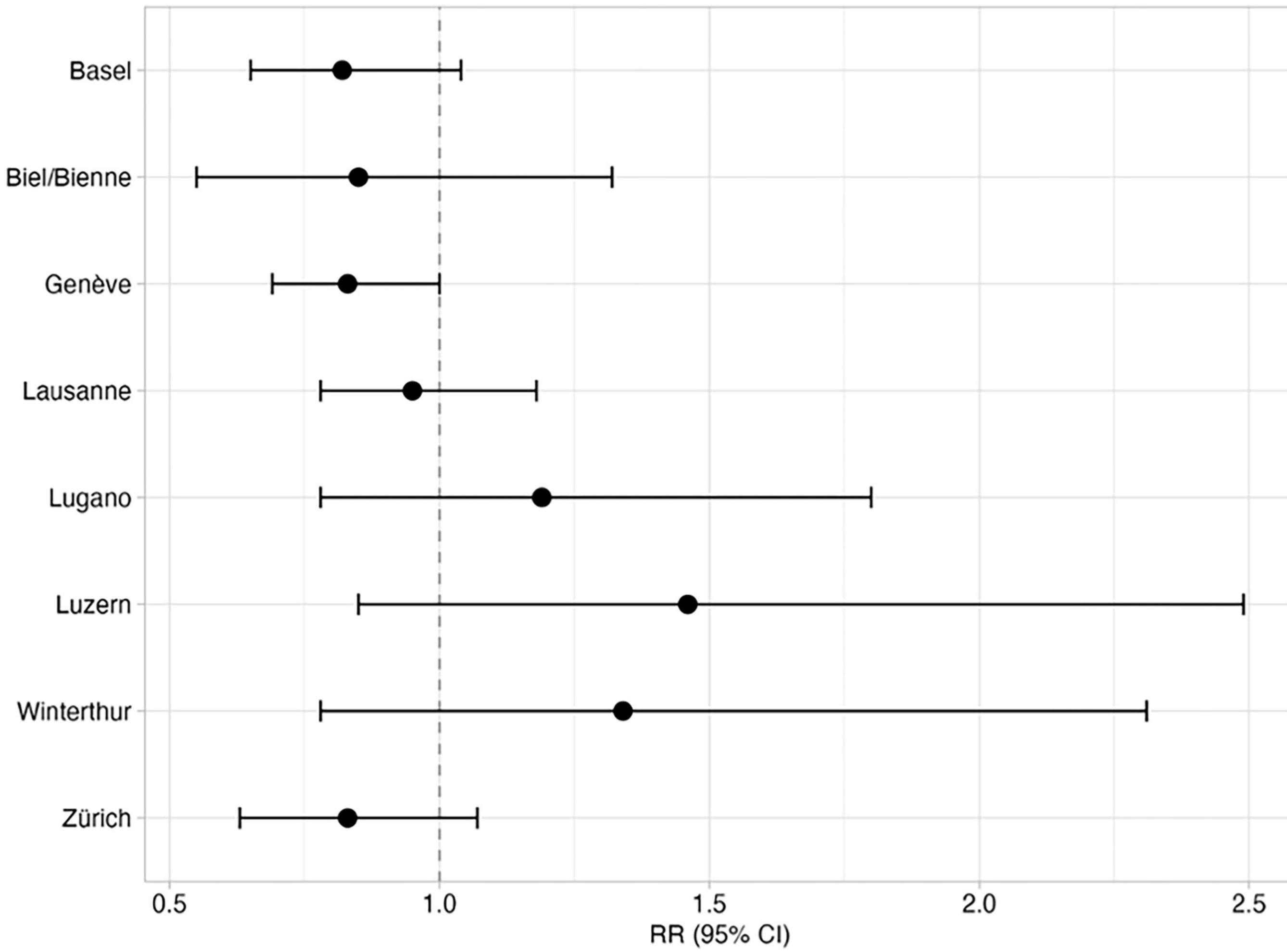

Fig 5. City-specific analysis of the TNs-mortality association. Relative Risk (RR) (and 95% confidence interval (CI)) of mortality associated with TNs in the largest cities of Switzerland (1980–2018). The cantons of Basel-Stadt and Geneva consist of a single district that at the same time corresponds to the two cities.

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previous study by Tuholske et al. which explored whether population growth or increasing temperature is the main driver of the increasing exposure to extreme heat [44].

4.3 Vulnerability

We did not observe a clear spatial pattern in vulnerability to TNs across the cantons or the largest cities of Switzerland (Figs 4 and 5). For example, TN may represent a risk for the health of the population living in Vaud, Zurich, Lucerne, and Solothurn, with increased mortality between 20–40%. Whereas TNs may be associated with a protective effect in Ticino, Basel-Land, Geneva and Thurgau. Previous studies also found similar TN-mortality risks with highly heterogeneous patterns between populations [19,20]. This disparity across cantons can be attributed to differences in public health strategies, infrastructure (i.e. greenness), socioeconomic status, social equity, and cultural characteristics [45–49]. Heat action plans might explain in part the protective effect of TNs in Basel-Land, but not in Thurgau, Geneva and Ticino, as shown in the subperiod analysis (S3 Table). These would suggest that the implementation of more ambitious plans in the cantons of Geneva and Ticino may not explain the protective effect. Recent studies exploring the effectiveness of heat-health warning systems on preventing heat-related mortality also showed heterogenous results [28,50–53]. Additionally, a recent study concluded that vulnerability factors to heat differed between urban and rural populations in Switzerland [54]. Finally, we cannot disregard that different climatic characteristics of the TNs potentially more prevalent in some regions in Switzerland, such as a different intra-day temperature variability, may also explain differences in mortality risk associated with these events [55].

We also observed substantial heterogeneity in the TN-mortality risk between the cantons and their corresponding main cities. For example, while TNs may have a protective effect in the city, they may represent a risk at the cantonal level (i.e., Lausanne and Vaud). We hypothesize that there could be a gap between rural and urban residents' sensitivity to heat. Urban residents may be more aware and potentially acclimatized to heat compared to the rural population and, therefore, better prepared in case of a heat wave and increased occurrence of TNs [56,57]. Although we did not observe substantial differences in the risk of TNs between decades due to large uncertainty, few studies have explored the temporal impact of heat on mortality. Possibly some of the variation over time could in part be explained by increased air conditioning uptake, increase in socio-economic status as well as changes in demographic structure [30,58].

We acknowledge several limitations of this study. We may consider our results as a conservative estimate because of the following reasons. First, although gridded temperature data has shown to be useful in epidemiological analysis [59], it is likely that in this study it might have partly removed the temporal and spatial variability in nighttime temperature. Second, we might have not fully captured the effect of urban heat island in the main cities due to the nature of the ERA5-Land reanalysis data. As an illustration, S3 Fig shows a higher frequency of TNs registered in areas with complex orography (i.e., Ticino) when met-station data is used compared to ERA5-Land, while a similar number is obtained in areas with more homogeneous characteristics (i.e., Zurich). Other similar studies on TNs and mortality alternatively used temperature data from meteorological stations [18–20]. However, we decided to not use temperature data from weather stations because it was very complex to derive district-specific temperature series given the heterogeneous orography and the limited number of stations, in particular before the 2000s. Additionally, we decided to use the definition of TNs established by MeteoSwiss, the climatological service in Switzerland. Other studies used percentile values (95th, 99th) to define a TN or hot nights because it would account for the characteristics of the local climate [18,20]. Future studies are warranted to explore how the choice of data set and the definition of TNs may influence the TN-mortality association.

We did not control for potential confounders such as air pollution and humidity since data on these variables were not available for the whole study period. However, we expect that the confounding effect, if any, would be small, as shown in recent studies [9,60]. In addition, we did not assess the role of contextual variables in explaining the differences across cantons and cities. And, finally, we cannot disregard the presence of exposure misclassification (i.e., Berkson error) typically found in this kind of ecological analysis which would lead to an increase in the imprecision of our estimates However, would also affect the precision of our estimates [61].

5. Conclusion

Our findings indicate that the number of TNs has increased in the last five decades in Switzerland. Together with population growth, this trend has translated into a substantial increase in the population exposed to TNs since 1970. However, the vulnerability of the population to TNs, in terms of increased mortality risk, seems to be highly variable across regions and cities. These heterogeneous patterns could be explained by the different characteristics of the population and public health measures. Further research is needed to better understand these vulnerability drivers to improve current national and cantonal public health strategies.

Supporting information

S1 Fig. Subgroup analysis by sex. Relative risk (RR) and 95% confidence interval (CI) of mortality associated with tropical nights across cantons in Switzerland from 1980–2018 (blue: Males; purple females).
(TIFF)

S2 Fig. Subgroup analysis by age. Relative risk (RR) and 95% confidence interval (CI) of mortality associated with tropical nights across cantons in Switzerland from 1980–2018 (dark brown: Over 75 years old; bright brown: Under 75 years old).
(TIFF)

S3 Fig. ERA5-Land vs. Monitoring station data. Comparison of mean temperature data from ERA5-Land (red) with monitoring station temperature data (blue) in the cities of Lugano and Zurich. Left: Overall nighttime temperature distribution (May-September) and 99th and 20°C threshold denoted with vertical lines. Right: Nighttime temperature series from May–September in 2015 and TN-Events (vertical lines) defined with ERA5-Land (blue) and monitoring station data (red).
(TIFF)

S1 Table. Number of tropical nights per decade from 1970–2019 for each district in Switzerland.
(XLSX)

S2 Table. Population exposed to tropical nights (TNs), defined as population per TNs per decade from 1970–2019 for each district in Switzerland.
(XLSX)

S3 Table. Sub-analysis by subperiod (before (1980–2002) and after (2004–2018) the European heatwave in 2003). The first, third, and fifth column show the number of tropical nights (N TN) per district in the given period. The second, forth, and sixth column show the relative risk (RR, and 95% confidence interval (CI)) of mortality associated with tropical nights in the given period.
(XLSX)

S4 Table. Nationwide analysis (1980–2018). Relative risks (RR) and 95% confidence interval (CI) of mortality associated with tropical nights (TNs) for each canton from 1980–2018 controlling or not for mean temperature, and the average number of TNs per canton and the number of deaths.
(XLSX)

S5 Table. City-specific analysis (1980–2018). Relative risks (RR) and 95% confidence interval (CI) of mortality associated with tropical nights (TNs) for each city from 1980–2018 controlling or not for mean temperature, and the average number of TNs city and the number of deaths.
(XLSX)

S6 Table. Relative risks (RR) and 95% confidence interval (CI) of mortality associated with tropical nights defined using the 99th percentile (pctl) as threshold for a set of selected cantons.
(XLSX)

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