Temperature and Risk of Infectious Diarrhea: A Systematic Review and Meta-analysis

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Abstract

There are many studies that have explored the relationship between temperature and the spread of infectious diarrhea (ID), but the results obtained are inconsistent. It is necessary to systematically evaluate the impact of temperature on the incidence of ID. ID is an intestinal infectious disease including cholera, typhoid and paratyphoid fever, bacterial and amebic dysentery, and other infectious diarrhea. This study is based on the PRISMA statement to report this systematic review. We conduct literature searches from CNKI, VIP databases, CBM, PubMed, Web of Science, Cochrane Library and other databases. The number registered in PROSPERO is CRD42021225472.

Finally, after searching a total of 4,915 articles in the database and references, a total of 27 studies were included. The number of people involved exceeded 7.07 million. The overall result demonstrated when the temperature rises, there is a significant increase in infectious diarrhea ($RR_{cumulative}$=1.42, 95%CI:1.07–1.88, $RR_{single-day}$=1.08, 95%CI:1.03–1.14). Subgroup analysis found that the cumulative effect of temperature on the bacillary dysentery group and other diarrhea groups. The result of the single-day effect subgroup analysis was similar to the result of the cumulative effect. And the sensitivity analysis proves that the above results were robust. This systematic review and meta-analysis support that temperature will increase the risk of ID, which is helpful for ID prediction and early warning in the future.

Introduction

Diarrheal disease is one of the major diseases with the highest incidence in the world, especially among children and the elderly (James et al. 2018). It is estimated that more than 10 million years lived with disability (YLD) due to diarrhea (James et al. 2018). Infectious diarrhea (ID) is an intestinal infectious disease caused by a variety of pathogens, including Salmonella, Shigella, Vibrio cholerae, and Rotavirus (Lin and Dong 2008). ID is an infectious disease that must be reported in accordance with the Law of the People's Republic of China on the Prevention and Control of Infectious Diseases, of which cholera is a category A infectious disease, bacterial and amebic dysentery, typhoid and paratyphoid fever are category B infectious diseases (NPC 2013) .

According to the statistics of infectious diseases in China, more than 1 million ID accidents are reported every year (DCFPH 2016). The pathogen of ID is very obviously affected by weather and climate, and it is easier to grow and reproduce under suitable temperature and relative humidity (Asadgol et al. 2020; Leddin and Macrae 2020). Therefore, a large number of epidemiological studies have explored the relationship between meteorological factors and ID. Campbell-Lendrum et al. report c due to changes in climatic conditions, the incidence of infectious diseases such as malaria, diarrhea, and cholera causes more than 3 million deaths each year (Campbell-Lendrum et al. 2015). Wang et al. study suggested that low temperatures during cold days could increase the risk of ID in China taking the median temperature as a reference (Wang et al. 2020). In the study of Liu et al., a mean daily temperature increases of 1°C would increase the relative risk of BD by 1.7% (Liu et al. 2020). Wang et al. investigated and found the low temperature (RR = 1.057, 95% CI: 1.030–1.084) will increase the risk of infectious diarrhea (Wang et al. 2019) .

For all-cause diarrhea, the meta-analysis of Carlton et al. has proved that the incidence rate ratio (IRR) between ambient temperature and all-cause diarrhea is 1.07 (95% confidence interval: 1.03–1.10) (Carlton et al. 2016). However, there is still a lack of relevant comprehensive evidence for the impact of ambient temperature on the risk of infectious diarrhea. There are many studies on the relationship between temperature factor and ID, but the conclusions are inconsistent. Therefore, we systematically reviewed and conducted meta-analysis to assess the impact of ambient temperature on the incidence of ID.

Methods

Identification and selection of studies

This systematic review is based on the Systematic Reviews and Meta-Analysis (PRISMA) statement. Before going through all the necessary procedures, we registered on the PROSPERO system and passed the registration (CRD42021225472).

For this meta-analysis, a comprehensive search strategy was carefully designed to find all eligible studies from multiple electronic databases, including Chinese National Knowledge Infrastructure (CNKI), VIP (Chinese) database, Chinese BioMedical Literature Database (CBM), and PubMed, Web of Science, Cochrane Library, from 1 January 1990 to 12 December 2020. The following combined search terms were used in the search: ("infectious diarrhea" OR "Cholera" OR "bacillary dysentery" OR "amoebic dysentery" OR "typhoid fever" OR "paratyphoid fever")) AND ("temperature" OR "ambient temperature"). Relevant Chinese technical terms for the Chinese databases were used to search for published articles (the detailed search strategy is shown in Appendix file 1).

References provided by all relevant articles were also searched to search for other studies that met the inclusion criteria. After deleting duplicate studies, two reviewers read the abstract and title respectively to screen out these not related to the purpose of this meta-analysis. We downloaded and read the full text of the standard studies to evaluate whether they can be included in the evaluation of this study. If the above two reviewers are still not sure whether an article meets the standard after discussion, a third party is required to establish a consensus.

Inclusion and exclusion criteria

The studies meeting the following criteria were included: (1) concerning the relationship between ambient temperature and incidence of ID; (2) diagnosis of ID must have clinical evidence; (3) providing the relative risk (RR) and 95% confidence interval (CI) of ID when the temperature increase; or complete data for calculating RR with 95% CI; (4) study design is correct and appropriate (epidemiological and statistical methods used in the study could achieve its research purposes); (5) no language restrictions applied. The exclusive criteria were as follows: (1) insufficient data to ascertain the RRs; (2) conferences/meetings abstracts, case reports, editorials, and review articles; (3) duplicate publication or overlapping studies.

Data extraction and assessment of study quality

The following information was extracted according to predesigned data extraction form by two independent reviewers: first author, year of publication, country, duration, total number of ID cases, diarrhea type, effect type, maximum lag days, study design, statistical model, and main findings of the study. Another reviewer checked the extracted data for completeness and accuracy.

Due to the heterogeneity of studies and the desire to understand the impact of the individual methodological components of studies, we focused on certain items that are reflective of methodological and reporting quality of the studies as delineated in The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement (http://strobe-statement.org) (Ip et al. 2009) .

Statistical analysis

The association of temperature increase with subsequent ID was assessed with RR with 95% CI. Simultaneously the *P* values less than 0.05 were considered statistically significant. Groups were separated according to different type of infectious diarrhea. Considering the potential for between-study heterogeneity, subgroup analyses were carried out based on stratification by different regions, how much temperature increased, and different lag days. The heterogeneity of meta-analysis was assessed using the I^2 statistic.

In order to promote the results of our study beyond the included studies and take other factors into consideration, we believe that the random effects model is the most meta-analysis model (Borenstein et al. 2010; Deeks et al. 2019; DerSimonian and Laird 1986) . The fixed-effect model was used to perform sensitivity analysis.

To test for publication bias in the results, the method for quantitative analysis of potential publication bias used Begg's and Egger's tests (*P* value greater than 0.05 indicated that no significant bias was found in this meta-analysis) (Begg and Mazumdar 1994; Egger et al. 1997) . The process of meta-analysis was performed using Stata (version 16.0; Stata Corp, College Station, TX) software.

Result

Characteristics of eligible studies

Figure 1 shows a flow chart of the literature search and screening process. A total of 27 studies met our inclusion criteria (Cheng et al. 2017; D'Souza et al. 2008; Dewan et al. 2013; Gao et al. 2020; Hao et al. 2019; Hashizume et al. 2008; Hu et al. 2019; Li et al. 2016; Li et al. 2019; Li et al. 2014; Li et al. 2013; Liu et al. 2019; Liu et al. 2020; Luque Fernández et al. 2009; Qiang et al. 2013; Thindwa et al. 2019; Trærup et al. 2011; Wang et al. 2019a; Wang et al. 2019b; Wang et al. 2021; Wang et al. 2019c; Wang et al. 2018; Wang et al. 2011; Wu et al. 2018; Xu et al. 2017; Zhang 2019; Zhang et al. 2021), with a total population of more than 7.07 million. Among the results of these models, not only some studies report the single-day effect of temperature (17 studies reported on the single-day effect of temperature, and a total of 28 estimates and effect intervals were collected), but some studies report the cumulative effect of temperature over multiple days (16 studies reported on the cumulative effect of temperature, and a total of 30 estimates and effect intervals were collected).

After literature search, 11 studies focusing on bacillary dysentery, 3 cholera, 3 typhoid or paratyphoid, and 2 rotavirus diarrhea studies. The other eight studies did not clearly indicate which ID they studied. All studies included were observational studies (Table 1). 3 studies using national data, 5 in northern China, and 12 in southern China. The remaining 7 studies are located in Australia, Bangladesh, Tanzania, Zambia and other countries. The quality evaluation found that inter-rater agreement among the reviewers was strong Appendix Table S1 and S2 summarizes the STROBE statement of the included studies.

Ambient temperature and risk of infectious diarrhea

After summarizing 30 cumulative effect estimates (Figure 2) and 28 single-day effect estimates (Figure 3), the relationship between temperature increase and the risk of ID incidence was found ($RR_{cumulative}$=1.42, 95%CI:1.07-1.88, $RR_{single\text{-}day}$=1.08, 95%CI:1.03-1.14).

There is obvious heterogeneity in the pooled cumulative effect and the single-day effect value (I^2 are both >99%). Therefore, we conducted a subgroup analysis according to different ID diseases to explore the source of heterogeneity (Table 2 and 3). For the cumulative effect, we divided the types of IDs into bacillary dysentery group, rotavirus diarrhea group, Cholera group, Typhoid group and other diarrhea group. In the result of subgroup analysis, temperature increased the risk of bacillary dysentery, and the risk may be the highest in northern China (RR=2.24, 95%CI: 1.83-2.73, I^2=55.57%). When the temperature increase more than 10 °C, the BD risk will increase by 218% (RR=2.18, 95%CI: 1.63-2.90, I^2=69.80%). When the maximum lag day > 10, the RR of the BD group is 2.16 (95%CI: 1.61-2.90, I^2=80.85%). Also in the “infectious diarrhea” group analysis, the highest risk was found in North China group (RR=3.85, 95%CI: 1.94-7.64, I^2= 86.89%). In the subgroup with a lag day > 10 days, only one study investigated in Jiayuguan, China (Li et al. 2019), and the cumulative effect of ID relative risk was 7.73 (95% CI: 4.25-14.05).

In the single-day effect analysis, we divided the types of IDs into bacillary dysentery group, Cholera group, Typhoid group and other diarrhea group. The risk of bacillary dysentery was similar to the result of the cumulative effect group and statistically significant (RR=1.10, 95%CI: 1.06-1.15, I^2= 86.89%). When the temperature rises more than 10°C, the RR of BD is 1.36 (95%CI: 1.18-1.57, I^2=0.00%). But for the results of other types of ID group analysis, some results that were not statistically significant were also found (Table 3).

The results of sensitivity analysis showed that the pooled RRs without great fluctuation, indicating that the results are robust. Regarding the cumulative effect of temperature, neither Begg's test (z = 0.96, P = 0.335) nor Egger’s test (z = 1.32, P = 0.188) manifested any distinct evidence of the publication bias. For the single-day effect, although Begg's test (z = -0.18, P = 1.14) did not show any obvious evidence of publication bias, Egger's test (z = 2.21, P =0.027) suggested that there may be publication bias.

Discussion

Infectious diarrhea contributes severe malnutrition and high mortality in developing countries, especially for infants and children (Kosek et al. 2003; Navaneethan et al. 2008). In recent years, a growing number of studies have investigated the relationship between temperature and risk of ID, but the current findings are inconsistent. This meta-analysis of all available articles provided the most current evidence for the relationship between temperature and infectious diarrhea. When the temperature rises, there is a significant increase in infectious diarrhea, no matter for the cumulative effect or the single-day effect.

Wei et al. considered that temperature affects the gene transcription of pathogens that affect disease, and a warm environment can help improve their adaptability (Wei et al. 2017). Checkley et al. reported that high temperature may promote bacterial growth and prolong the survival of bacteria in a contaminated environment, thereby increasing the risk of infection in susceptible individuals (Checkley et al. 2000) .

Eleven studies of bacterial dysentery were included in this study and the temperature increase in the subgroup analysis conducted significant results on both the cumulative effect and the single-day effect. Previous studies have suggested that the increased risk of BD can be explained by changes in microorganisms in contaminated food or water caused by increased temperature (Kotloff et al. 1999). Higher temperatures prolong the survival of BD pathogens(Black and Lanata 1995; Kovats et al. 2004). In addition, preference for cold food or cold drinks can also increase the risk of food-borne BD outbreaks under high temperature conditions (Kovats et al. 2004). For other infectious diarrhea groups, although there were significant results for cumulative effects, the subgroups did not show significant single-day effects. This may be related to the fact that single-day effects tend to be less obvious and easily overlooked in some studies(Min et al. 2019; Wang et al. 2019a; Wang et al. 2018). Previous studies have shown that the influence of ambient temperature is time-dependent, and in most cases there is a lag effect (Gasparrini et al. 2010). This effect may be related to the indirect effects of meteorological factors on immunity and body temperature regulation (Hu et al. 2019). In addition, Wang et al. investigated meteorological factors and infectious diarrhea incidence, they found that elevated temperature (31.85°C vs. 3.49°C) was a protective factor for ID (RR = 0.81, 95% CI: 0.80–0.83). This may indicate that the differences in meteorological conditions and physical geography between regions.

A previously published meta-analysis by Carlton et al. identified 26 studies, and they found there was a positive association between temperature and all-cause diarrhea (incidence rate ratio: 1.07, 95% CI: 1.03–1.10) (Carlton et al. 2016). Which is similar to our conclusion about infectious diarrhea. However, our study focused on the relative risk rather than the incidence rate of Carlton et al., which led to the different scope of the articles included in these two meta-analyses. This study is the first meta-analysis to investigate the impact of temperature increase on ID, which would help to further understand the relationship between meteorological factors and intestinal infectious diseases, but the limitations should be acknowledged.

First, most of included studies use ecological study methods, so ecological fallacies in the studies might be unavoidable. However, the duration of these studies is often several years or even longer, and therefore does not affect the evaluation of ID's long-term trends(Jelinski and Wu 1996; Zhang et al. 2020) .

Second, most of the studies included in this meta-analysis occurred in southern China, northern China, and a few other countries. Although a variety of temperature zones are involved, the studies in European and American countries are still lacking. The incidence of infectious diarrhea in these countries is also considerable (Shane et al. 2017), and further studies in these countries may further complete our conclusions in the future.

Third, we concluded in this meta-analysis that there is a correlation between temperature and ID. This relationship may be partly due to environmental factors, such as the impact of temperature on the survival and reproduction of pathogens in environmental media. In addition, behavioral and demographic factors may affect the relationship (weakened or enhanced) (Pitzer et al. 2011) between the detected ambient temperature and infectious diarrhea. This may require further research in related fields.

Fourth, some studies have found that various meteorological factors such as temperature, relative humidity, rainfall, and sunshine hours may also jointly affect the risk of ID (Liu et al. 2018). This study did not consider the correlation between various meteorological factors, which requires further research in the future.

Conclusions

This meta-analysis provided a comprehensive evidence to identify the risk of ID incidence associated with temperature. The results suggesting that the ambient temperature is closely related to the incidence of ID. Relevant departments should pay attention to the impact of meteorological factors on infectious diarrhea diseases and be prepared to prevent key meteorological diseases.

Declarations

Ethics approval and consent to participate:

Not applicable.

Consent for publication

There is no conflict of interest that exists in this manuscript and it is approved by all authors.

Availability of data and materials

Not applicable.

Competing interests

There is no conflict of interest.

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Authors' contributions

Mingming Liang: Data curation, Writing, Original draft preparation, Software. *Xiuxiu Ding*: Conceptualization, Methodology. *Yile Wu:* Data curation and Writing-Reviewing. *Yehuan Sun*: Supervision, Writing- Reviewing and Editing.

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Tables

Table 1 Characteristics of included studies.

	Author	Year	Country	Region	Duration	Total Number of Cases	Diarrhea type	Single day / cumulative effect	Maximum lag days	Statistical model	Main finding
1	Gao	2020	China	Southern China	2013-2018	835	Infectious diarrhea	Single day & cumulative effect	21	DLNM	Research has discovered the effect of temperature or Infectious Diarrhea and Diarrhea-like Illness.
2	Liu	2020	China	China	2014-2016	396134	Bacillary dysentery	Cumulative effect	8	DLNM	The positive association between temperature and BD in different climatic regions of China, and the projection for increased risk due to climate change, support efforts to mitigate future risks.
3	Wang	2020	China	China	2014-2016	2715544	Infectious diarrhea	Cumulative effect	30	DLNM	The overall positive pooled associations between temperature and category ID in China suggest the increasing temperature could bring about more category infectious diarrhea cases which warrant further public health measurements
4	Zhang	2020	China	Southern and northern China	2013-2017	710202	Bacillary dysentery	Single day effect	-	BSTHM	In northern and southern China, a 1 °C increase in the average temperature led to an increase of 1.01% and 4.26% in bacillary dysentery risk, respectively.
5	Hao	2019	China	Southern China	2010-2015	72649	Bacillary dysentery	Cumulative effect	4 weeks	DLNM	In Anhui, BD morbidity risk increased with increasing weekly mean temperature.
6	Hu	2019	China	Southern China	2008-2017	2308988	Infectious diarrhea	Cumulative effect	3	DLNM	High temperature could increase the risk of infectious diarrhea in the southeast coastal areas of China.
7	Li	2019	China	Northern China	2008-2016	1218	Infectious diarrhea	Cumulative effect	14	DLNM	Temperature might be one of the important reasons for other infectious

											diarrhea outbreaks in Jiayuguan City and it plays an important role in the occurrence and prevalence of infectious diarrhea in the population.
8	Liu	2019	China	Northern China	2005-2013	11738	Bacillary dysentery	Single day & cumulative effect	7	DLNM	Each 5 °C rise in temperature caused a 19% (RR = 1.19, 95% CI: 1.14–1.24).
9	Thindwa	2019	Malawi	Blantyre	2011-2015	2648	Typhoid	Single day effect	8	DLNM	The relative-risk function of temperature for typhoid was bimodal, with higher risk at both lower (with a 1-month lag) and higher (with a ≥4 months lag) temperatures, possibly reflecting the known pattern of short and long cycle typhoid transmission.
10	Wang	2019a	China	Southern China	2006-2017	167691	Infectious diarrhea	Single day & cumulative effect	21	DLNM	Compared with the lowest ID risk values, low mean temperature, relative humidity, and precipitation were associated with an increased risk for ID.
11	Wang	2019b	China	Southern China	2014-2016	42480	Infectious diarrhea	Single day & cumulative effect	30	DLNM	Both high temperature and low temperature increase the risk of other infectious diarrhea, and the attributable risk of low temperature is more obvious.
12	Wang	2019c	China	Southern China	2014-2016	301593	Infectious diarrhea	Single day effect	30	DLNM	Both high temperature and low temperature increase the risk of ID, and both have a lag effect.
13	Zhang	2019	China	Northern China	2014-2016	122678	Infectious diarrhea	Cumulative effect	21	DLNM	The relationship between temperature and exposure to other infectious diarrhea is non linear.
14	Wang	2018	China	Northern China	2008-2015	23108	Bacillary dysentery	Single day & cumulative effect	14	DLNM	The incidence of bacillary dysentery is affected by

											multiple meteorologica factors，but th primary one is high temperature.
15	Wu	2018	Bangladesh	Matlab	1983-2009	9519	Cholera	Single day effect	-	Logistic regression models	These findings suggest that heatwaves might promote the occurrence of cholera, while this relationship was modified by rainfall and tree cover.
16	Xu	2018	China	Southern China	2010-2015	44926	Bacillary dysentery	Single day effect	-	BSTHM	Among meteorologica factors, air temperature, relative humidity, and wind speed all played a significant role in the spatial-temporal distribution of bacillary dysentery risk.
17	Cheng	2017	China	Southern China	2006-2012	12717	Bacillary dysentery	Single day & cumulative effect	9	DLNM	The risk of bacillary dysentery increased with the temperature rise above a threshold, and the temperature effects appeared to be acute.
18	Li	2016	China	Southern China	2006-2012	6511	Bacillary dysentery (age 0-14)	Single day effect	6	DLNM	An increase in temperature was significantly associated with childhooc BD.
19	Li	2014	China	Southern China	2006-2012	4775	Bacillary dysentery	Single day effect	-	NBRM	Each 1°C rise of temperature corresponded to an increase of 3.60% (95%CI, 3.03% to 4.18%) in the monthly number of BD cases.
20	Dewan	2013	Bangladesh	Dhaka	2005-2009	4355	Typhoid	Cumulative effect	4 weeks	GLPRM	Temporally, typhoid incidence was seen to increase with temperature, rainfall and river level at time lags ranging from three to five weeks.
21	Li	2013	China	Southern China	2006-2011	36487	Bacillary dysentery	Single day effect	-	NBRM	A positive association was found for mean temperature (excess risk (ER) for 1°C increase being 0.94% (95% confidence

											interval (CI): 0.46% to 1.43 on the lag day 2).
22	Qiang	2013	China	Northern China	2005-2010	11218	Bacillary dysentery	Single day effect	5	GAM	It indicates tha the incidence of bacillary dysentery in Chengguan District of Lanzhou City i obviously seasonal, and high temperature is most likely to cause the disease.
23	Trærup	2011	Tanzania	Tanzania	1998-2004	-	Cholera	Single day effect	-	NBRM	For a 1-degree Celsius temperature increase the initial relative risk of cholera increases by 15 to 29 percent.
24	Wang	2011	China	Southern China	2001-2007	59373	Typhoid and paratyphoid	Single day effect	-	GLPRM	Based on results from panel data analysis, the incidence of typhoid and paratyphoid fever was shown to be associated with meteorologica factors such a temperature, precipitation, relative humidity and one-month lag of temperature increase.
25	Fernández	2009	Zambia	Lusaka	2003-2006	-	Cholera	Cumulative effect	6 weeks	GLPRM	A 1 degrees C rise in temperature 6 weeks before the onset of the outbreak explained 5.2 [relative risk (RR) 1.05, 95% CI 1.04-1.06] o the increase in the number of cholera cases (2003-2006).
26	D'Souza	2008	Australia	Brisbane, Canberra and Melbourne	1993–2003	5911	Rotavirus diarrhea	Cumulative effect	1 week	Log-linear regression model	The effects of both temperature and humidity on rotavirus admissions in Brisbane differed acros seasons.
27	Hashizume	2008	Bangladesh	Dhaka	1996-2001	3115	Rotavirus diarrhea	Cumulative effect	4 weeks	GLPRM	There was strong evidence for a increase in rotavirus diarrhea at high temperatures, by 40.2% for each 1°C.

DLNM: Distributed lag non-linear model; BSTHM: Bayesian space-time hierarchy model; NBRM: Negative binomial regression model; GLPRM: Generalized linear Poisson regression models; NBRM: Negative binomial regression model; GAM: Generalized additive model

Table 2 Cumulative effect of temperature increase and ID incidence.

Diarrhea group	Subgroup	Number of studies	RR	95% effect interval		Heterogeneity(I^2)
Bacillary dysentery		13	1.85	1.48	2.30	99.74%
Region	China	1	1.02	1.01	1.02	-
	Northern China	9	2.24	1.83	2.73	55.57%
	Southern China	3	1.43	1.04	1.96	95.33%
Temperature increase (°C)	1	2	1.02	1.01	1.02	0.01%
	>10	6	2.18	1.63	2.90	69.80%
	>5	5	2.00	1.63	2.44	56.54%
Lag days (day)	<10	2	1.29	0.96	1.75	99.71%
	>10	9	2.16	1.61	2.9	80.85%
	>20	2	1.72	1.35	2.19	74.04%
Other diarrhea		11	1.18	0.59	2.34	99.75%
Region	China	2	1.26	0.83	1.91	96.70%
	Northern China	3	3.85	1.94	7.64	86.89%
	Southern China	6	0.64	0.27	1.52	99.78%
Temperature increase (°C)	>10	6	0.98	0.58	1.67	99.58%
	>20	4	1.54	0.29	8.23	98.09%
	>5	1	1.43	1.05	1.95	-
Lag days (day)	<10	2	1.14	1.11	1.18	6.00%
	>10	1	7.73	4.25	14.05	-
	>20	8	0.95	0.42	2.15	99.07%
Rotavirus diarrhea		4	1.04	0.91	1.18	98.63%
Cholera		1	1.05	1.04	1.06	-
Typhoid		1	1.14	1.04	1.25	-

Table 3 Single-day effect of temperature increase and ID incidence.

Dysentery Group	Subgroup	Number of studies	RR	95% effect interval		Heterogeneity(I^2)
Bacillary dysentery		17	1.10	1.06	1.15	98.58%
Region	Northern China	11	1.17	1.10	1.25	19.53%
	Southern China	6	1.03	1.02	1.05	90.29%
Temperature increase (°C)	1	8	1.05	1.02	1.08	98.29%
	>1	5	1.18	1.14	1.23	0.00%
	>10	4	1.36	1.18	1.57	0.00%
Lag days (day)	0	14	1.10	1.05	1.15	97.94%
	>1	3	1.10	1.01	1.20	91.56%
Cholera		2	1.07	0.92	1.25	58.60%
Thphoid		3	1.09	0.79	1.52	88.36%
Other diarrhea		6	0.99	0.91	1.07	97.32%

Figures

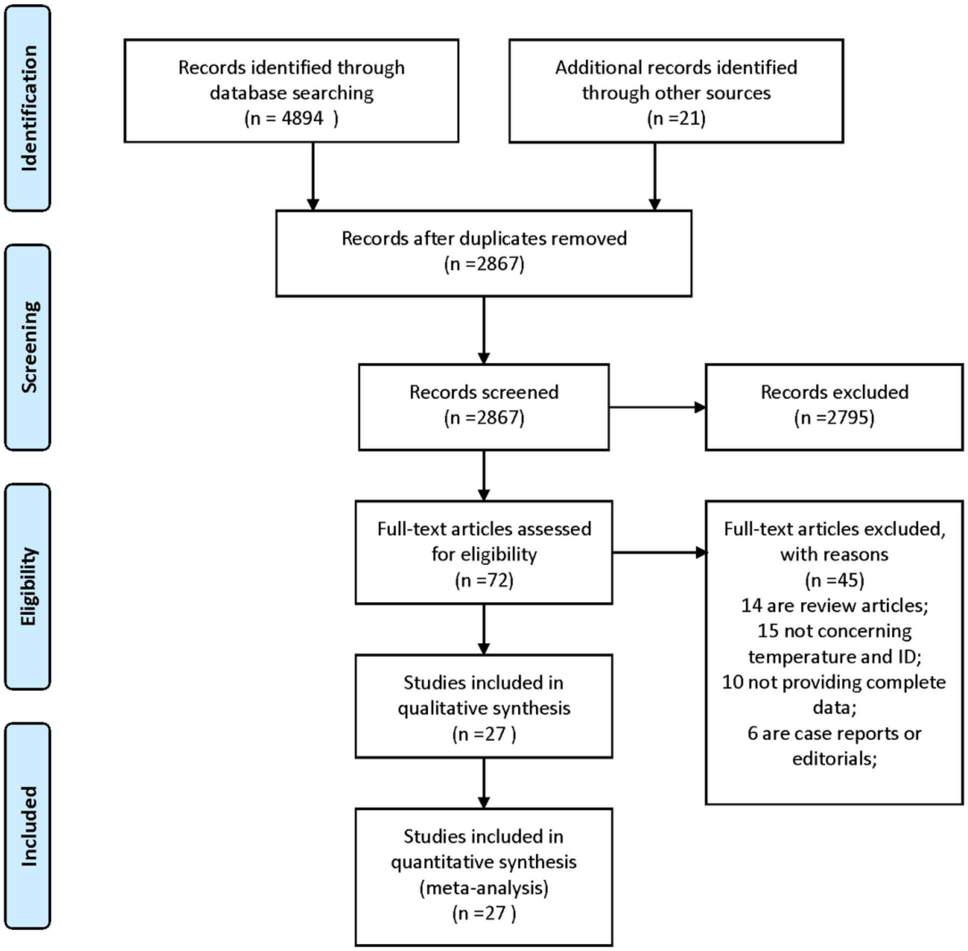

Figure 1

Figure 1 shows a flow chart of the literature search and screening process.

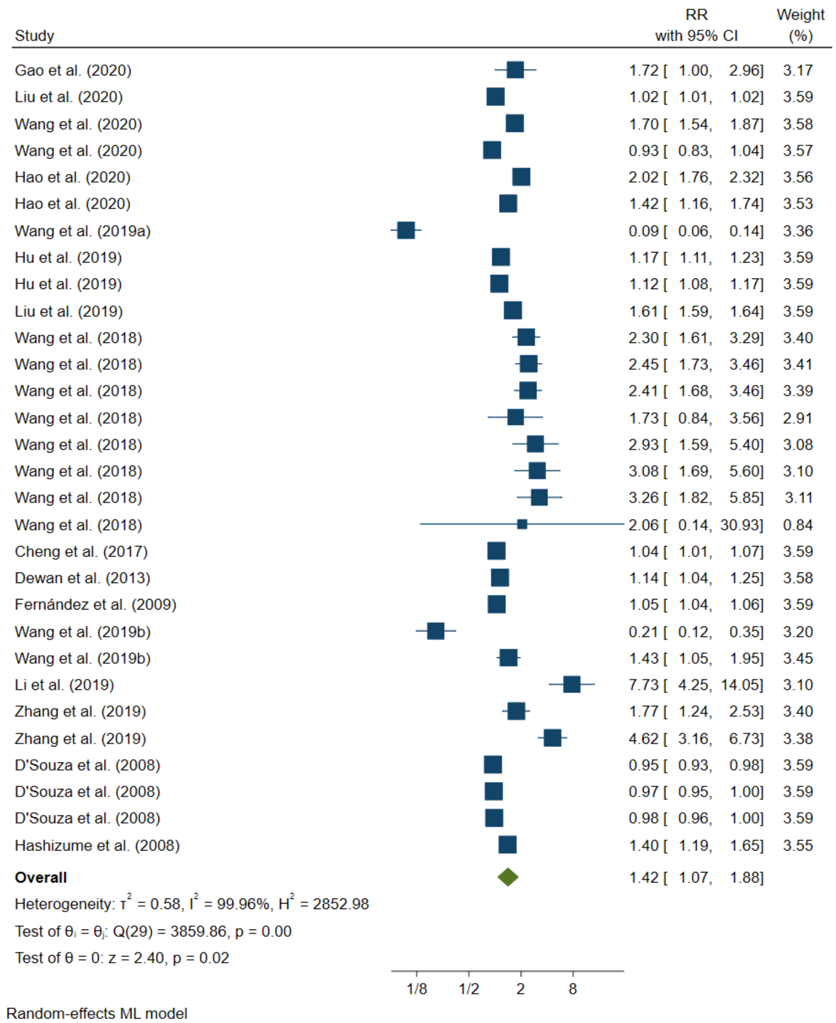

Figure 2

After summarizing 30 cumulative effect estimates (Figure 2) and 28 single-day effect estimates (Figure 3), the relationship between temperature increase and the risk of ID incidence was found (RRcumulative=1.42, 95%CI:1.07-1.88, RRsingle-day=1.08, 95%CI:1.03-1.14).

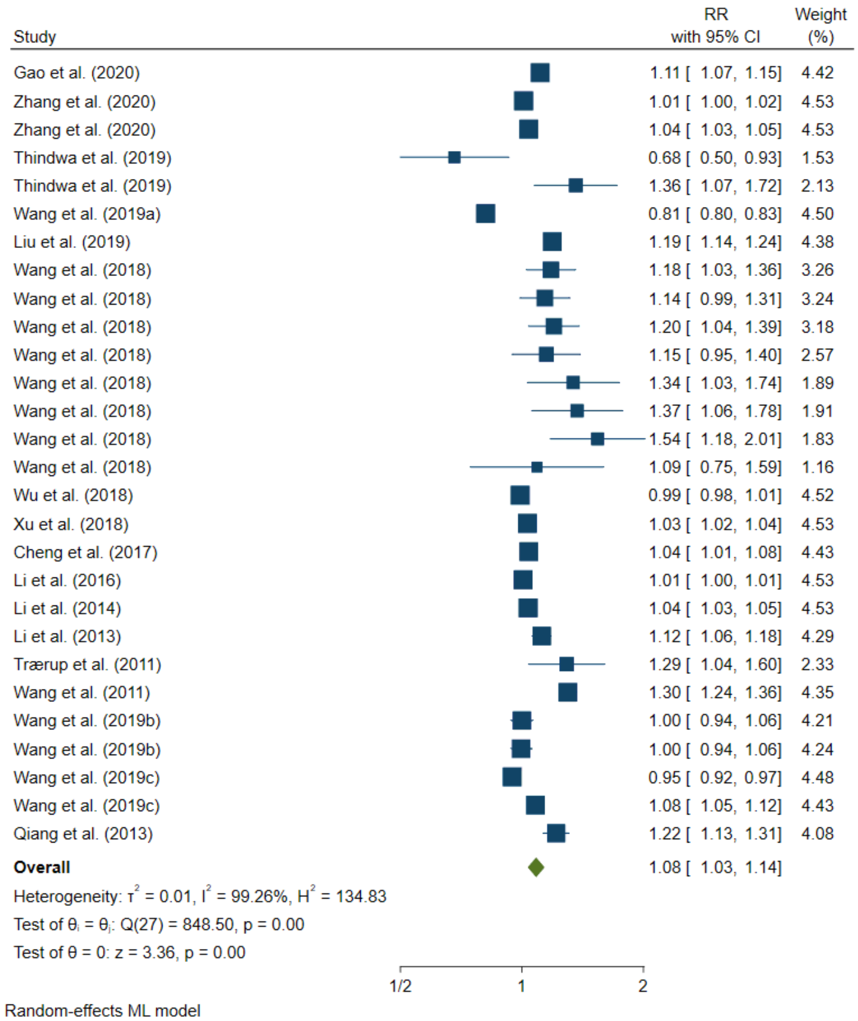

Figure 3

After summarizing 30 cumulative effect estimates (Figure 2) and 28 single-day effect estimates (Figure 3), the relationship between temperature increase and the risk of ID incidence was found (RRcumulative=1.42, 95%CI:1.07-1.88, RRsingle-day=1.08, 95%CI:1.03-1.14).

Supplementary Files

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- Appendixfile1.docx
- tableS1S2.docx