Consequences of sudden onset natural disaster on the management of diabetes: A Systematic Review

Author

NWAKWUO, Geoffrey Chima

Master in Public Health in Disaster

Supervisor(s)

Rafael Delgado Castro

Pedro Arcos Gonzalez

Unit for Research in Emergency and Disaster
Faculty of Medicine and Health Sciences,
University of Oviedo, Campus del Cristo E-33006 Oviedo, Spain

Co-Supervisor

Dell Saulnier

Centre for Research on Health Care in Disasters
Health Systems and Policy Research Group
Department of Public Health Sciences,
Karolinska Institutet, Tomtebodavägen 18, 171 65 Stockholm

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UNIVERSIDAD DE OVIEDO

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ABSTRACT

Aim: To assess the impact of sudden onset natural disasters on the management of diabetes by identifying the consequences at both individual and institutional level.

Settings: The study did not consider sudden onset natural disasters and its consequences on diabetes management in a particular setting like geographical location due paucity of research in this area. Therefore, all studies despite the setting surrounding the topic were assessed.

Method: This study is a review and included the application of the integrative review methodology. The PRISMA 2009 checklist was used to guide the presentation of the study. The search was done on PubMed, Web of Science, CINAHL, and Science direct using a pretested search terms. Principles of qualitative research were employed for the evaluation and information were categorization into consequences on individuals and the institutional.

Results: The review identified and included 31 eligible articles. The majority of the disaster are Earthquake (55%) and Hurricane (32%), and most of the articles were from developed countries. The review showed destructions of medical facilities and pharmaceuticals causes' interruption of medical services and supplies, and loss/destruction of records. Evacuation, inadequate diets, and post-traumatic stress was associated with worsening of glycaemic control. Increases incidence was reported and exacerbation of diabetic condition, possess a risk of complication and death.

Conclusion: Traditional disaster preparedness plans in past decades did not include the management of diabetes in disaster and despite new frameworks developed, identification and understanding of the impacts, is needed for integrated implementation of the guidelines.

Keywords: Sudden onset; Natural disaster; Exacerbation, Diabetes; Management, Glycaemic control

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ABBREVIATIONS AND COMMON ACRONYMS

ALT	Alanine Aminotransferase
CRED	Centre for Research on the Epidemiology of Disasters
CSII	Continuous Subcutaneous Insulin Infusion
DST	Davidson Trauma Scale
FPG	Fasting Plasma Glucose
GEJE	Great East Japan Earthquake
GHQ	General Health Questionnaire
HbA1c	Glycated Haemoglobin
HDL	High-density lipoprotein
HDL-C	HDL Cholesterol
IDDM	Insulin-Dependent Diabetes Mellitus
IFG	Impaired Fasting Glucose
IGT	Impaired Glucose Tolerance
LDL	Low-density lipoprotein
MDI	Multiple Daily Insulin Infusion
NCDs	Non-communicable Diseases
NIDDM	Noninsulin-Dependent Diabetes Mellitus
OHA	Oral Hypoglycaemic Agent
OR	Odd Ratio
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PTSD	Post-traumatic Stress Disorder
RR	Relative Risk
SOND	Sudden Onset Natural Disaster
T1DM	Type I Diabetes Mellitus
T2DM	Type 2 Diabetes Mellitus
WHO	World Health Organization

INTRODUCTION

Background of Study

The 21st century has recorded an increase in the occurrence of natural disasters globally and the health consequences emanating from the aftermaths of major disasters have been of great concern. According to the CRED EM-DAT database, 13,835 natural disasters has occurred in the world from 1990 to the present, affected more than 7 billion people (7,431,865,721), killed more than 32 million inhabitants (32, 584,850) mostly in the Asia, America and Africa[1].

Non-communicable diseases (NCDs) are becoming the leading causes of death worldwide[2], and "by 2030, low-income countries will have eight times more deaths attributed to NCDs than high-income countries"[3]. This will be a threat to individuals and the health care system with the increasing occurrence of natural disasters. The resulting disruption of healthcare delivery systems can have both short- and long-term health impacts (i.e. exacerbation of glucose control, complications, and death)[4]. A Large-scale disaster can have a multiple of effects on the community: from economic (e.g. cost on health care system) to social (e.g. decrease in exercise), from physical (e.g. loss of medication and records) to psychological (e.g. PTSD) [5, 6]. Although natural disasters may cause massive loss of human life and destruction of resources, they also present rare opportunities to access external resources[7].

Non-communicable diseases (NCDs) also called chronic illness in emergencies has seldom being mentioned until recently. They are increasingly becoming a threat to population health and development[8] during a disaster. This include and not limited to the major non-communicable diseases published by the World Health Organization (WHO) such as heart disease, stroke, cancer, diabetes and chronic lung disease[9] but also include conditions like mental illness, and other NCDs. NCDs have been reported to account for 65.5% of global mortality[10] and 54% of disability-adjusted life years[11]. And the World health organization projected that, if nothing is done about it, "NCDs will account for 80% of the global burden of disease by 2020, causing seven out of every ten deaths in developing nations, compared with less than half today"[12].

Chronic diseases have accounted for significant numbers of consultations in the aftermath of natural disasters in both high-income countries and low-to-middle income countries[13, 14]. More than 70% of survivors of Hurricane Katrina reported, at least, one case of chronic disease condition[15]. Exacerbation of and death from chronic diseases (hypertension, cancer, diabetes and chronic

respiratory disease) was also reported due to direct stress and/or interruption of care in areas affected by the great East Japan Earthquake[16-21].

Despite efforts and recent advancement in response to emergencies during sudden onset disasters, responses guidelines so far, incorporates only short-term impacts on communicable disease like malaria and diarrhoea[22] injuries[23] and basic needs of the affected population[24-26] or more or less provision of acute medical services and the control of communicable diseases[7], with less attention given non-communicable diseases by humanitarian organization in the initial phase of disaster and emergency response as well as in the long-term[8, 27, 28].

Although there have been recent efforts to the inclusion of NCDs in disaster response and preparedness planning [8, 13], any suboptimal management can result in chronic morbidity and suffering for affected people[29].

Diabetes mellitus in this study will be defined as a metabolic disorder characterized by the presence of hyperglycaemia due to defective insulin secretion, low insulin action or both[30]. It shares similar risk factors with other chronic conditions, and inadequate care poses a risk for complication. Chronic hyperglycaemia is associated with relatively specific long-term microvascular complications affecting the eyes, kidneys, and nerves. It is also linked with increased risk for cardiovascular disease [30].

Common forms include type 1 diabetes mellitus which accounts for only 5–10% of those with diabetes and type 2 diabetes mellitus which accounts for only 90–95% of those with diabetes[31]. Type 1 diabetes primarily a result of pancreatic beta cell destruction and is prone to ketoacidosis. It results from an autoimmune process and those for which the etiology of beta cell destruction is unknown. Type 2 diabetes ranges from sufficient insulin resistance with relative insulin deficiency to a predominantly secretory defect with insulin resistance[32].

Diabetes is best diagnosed by an FPG ≥7.0 mmol/L or A1C ≥6.5% (in adults) or 2hPG in a 75 g OGTT ≥11.1mmol/L or Random PG ≥11.1 mmol/L and a clinical decision with safe management and continuing follow-up is a prudent approach for adequate management[30].

Evidence has shown an estimated that 8.2% of adults aged 20–79 (387 million people) living with diabetes in 2014 higher than with 382 million people expected in 2013 and the number growing projected to reach 592 million in 2035[33]. Yet, estimated 46% of cases are currently undiagnosed, and these individual are practically unaware of their increased risk of developing diabetes-related complications[34]. Diabetes was singularly responsible for 4.9 million deaths globally in 2014[34] and incurs an estimated annual global health expenditure of between USD 612 billion - USD 1099 billion[35].

Diabetes is a complex and complicated condition requiring a lot of time and skill to manage by individuals affected and the organizations taking care of diabetic patients. Previous studies have shown that diabetes mellitus and other chronic diseases may be exacerbated after a major disaster [6, 36]. A review of the research surrounding Hurricane Katrina indicated a significant loss of diabetic control as measured by A1C plus an increased cost of care for patients with diabetes after the disaster[37] and a worsening of metabolic control in subjects with diabetes[6, 38].

Although some studies such as a retrospectively reviewed data on disaster-affected patients with type 2 diabetes attending an outpatient department after the great east Japan earthquake disaster has shown no significant deterioration in HbA1c levels[39]. It suffices to say that information provided by these studies are not enough to substantiate an improvement in care for diabetics during a disaster or a decreased impact of disasters on diabetes, natural calamities results in disruption services, shortage of medical staff, medical supplies, improper diet and exacerbation of conditions[40-43].

This is despite the fact that presence of diabetes alone, is associated with an increase in treatment burden three times than that observed in other conditions[44], a huge treatment burden in patients with diabetes associated with continual monitoring, medication administration, access to services and treatment side effects[45]. But even with the difficulties to make manage diabetes, less information on how to maintain diabetes control during disaster [39].

Nations and organizations affect or concerned with/interested in the management of chronic diseases during the catastrophe have built knowledge on ways to be resilience. Lessons learned from diabetes in past disasters[17, 42] recommended the inclusion of diabetes management into emergency response plan have to need a compressive approach[28]. This is guideline necessary for effective prescription of medication for diabetic patients under various situation the event of a natural disaster[46]. Although there has recently been a developed timeline for preparation and response to disaster management for diabetes before, during and after the disaster [47, 48] (Figure 1), an optimal strategy for managing patients with diabetes especially type 2 diabetes following a catastrophe is yet to be determined [39]. Diabetes management in emergency involves complex mechanisms combining the continuation of treatment and drug regimen, maintenance of good lifestyle (diet and exercise) and good glycaemic control[17, 49, 50].

Limited studies have looked into the consequences of sudden onset natural disasters on diabetes management, and limited review has tried to look into this issue across different disaster type and geographical location and none has examined the consequences of individual's management and coping with diabetes after sudden onset natural disaster vis-à-vis the effects and impact on infrastructure and or health management systems for care and treatment of diabetes and diabetics.

To provide an evidence-based rationale to justify the incorporating diabetes management into existing emergency-related policies, standards, and resources[8], there is a need to assess the current status of the consequences of Sudden Onset Natural Disaster (SOND) on treatment, nutrition, and control of diabetic conditions.

Significance of study for Global health

Disasters complicate the management of diabetes and other NCDs by disrupting access to and delivery of health care, including medicines[51]. Despite these effects, Rapid health assessment tools do not tend to include questions about diabetes and all other NCDs or factors needed to respond to them post-disaster[52].

Available guidelines for response post-disaster mostly focus primarily on basic needs like WASH, nutrition, and food security, acute medical conditions, communicable diseases and injury with limited guidelines on non-communicable diseases (chronic illness)[52-54]. Thus, there is a need for research on both short and long-term impact and management of diabetes in disaster[8].

Aim of the Study

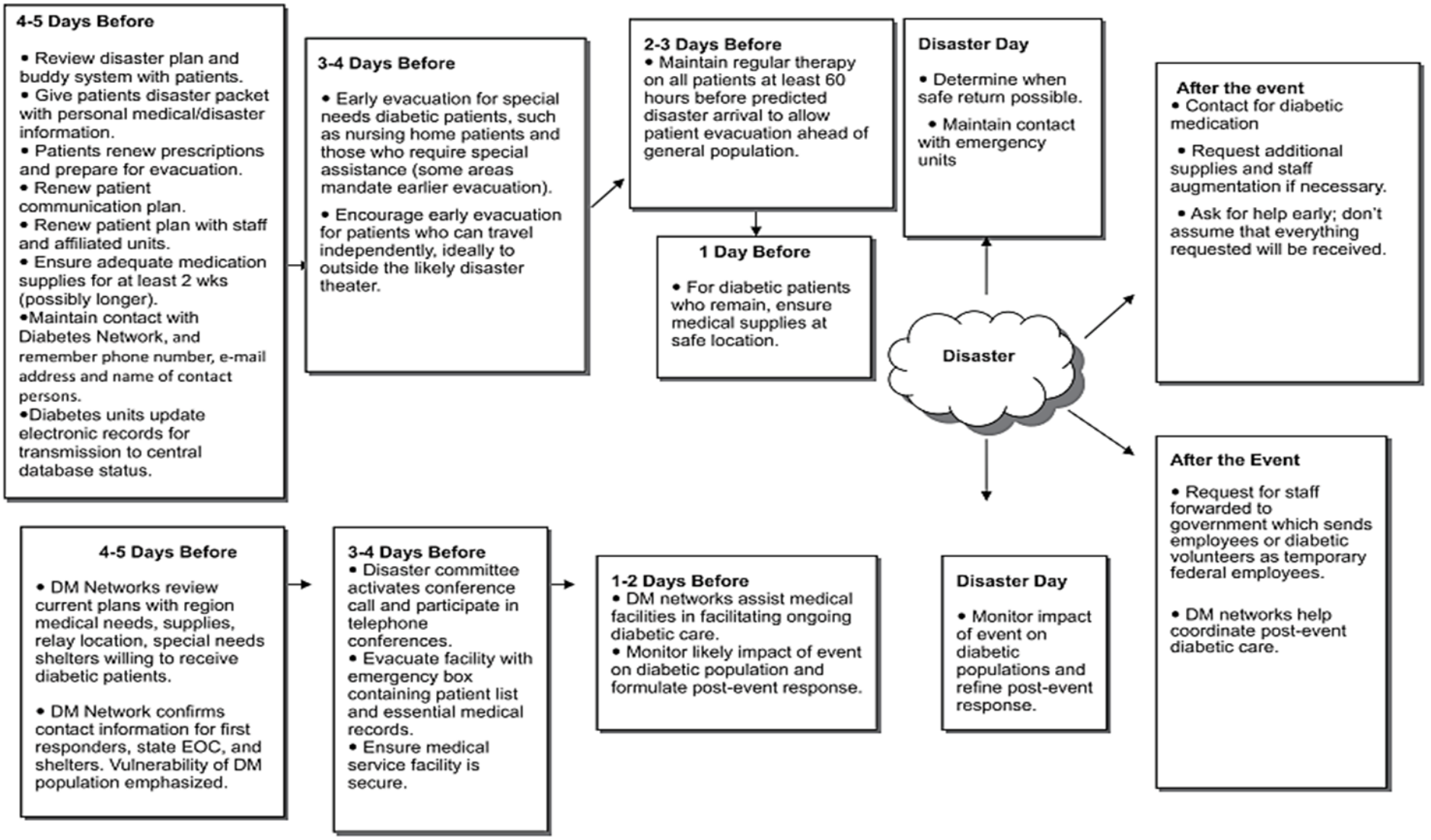
The study is aimed at assessing the consequences of sudden onset natural disasters on the management of diabetes. The study will assess the effects of sudden onset natural disaster(s) on management at the individual and institutional level. And will be guided by asking the question, what are the consequences of sudden onset natural disaster(s) on diabetes management at the individual and institutional level?

Setting of the Study

This study was done in collaboration with University of Oviedo and Karolinska Institute. The review was conducted while at Karolinska Institute, Sweden.

As the occurrence of sudden onset natural disaster increase, the impact on individual and health system also increases. Despite efforts (preparedness and response) after the disaster, management of diabetes and other non-communicable diseases has received limited attention. This is the more reason for the paucity of studies and publications globally.

Previous publication addressing diabetes management in the disaster were more concentrated in high-income settings. And due to this paucity, the review cannot focus on a particular setting or disaster but rather collected systematically using the PRISMA guideline.



Timeline for preparation and response to disaster management for diabetes [47, 48].

METHODOLOGY

This study is a review and included the application of the integrative review methodology so as to inclusive in the kind of study selected and due to its precision in defining new concepts and their application to policies and practice[55, 56] as well as critical and methodological evaluation of previous studies[57]. The PRISMA checklist of 2009[58] was used to guide the presentation and identification, screening, selection, data extraction from included articles for this review as well as the data evaluation and analysis (Appendix 2).

The study defined sudden onset disasters to include natural disasters such as weather phenomena like tropical storms (typhoon, tsunami, and cyclone), extreme heat or extreme cold, winds, floods as well as geological events like earthquakes, landslides, and volcanic eruptions among others.

Diabetes has earlier been defined as a metabolic disorder characterized by hyperglycaemia due to defective insulin secretion, inadequate insulin action or both[30] and its management requires alteration of this disorders to a normal state as possible. It involves treatment with drug or insulin replacement therapy, modification of diet and exercise and good glycaemic control which is the regulation and maintenance blood glucose levels within normal ranges aimed at reducing diabetic complications.

The adequate glycaemic control according to the International Diabetes Federation is defined as HbA1C < 6.5%. Diabetes as earlier stated is diagnosed by a recorded “FPG ≥7.0 mmol/L or A1C ≥6.5% (in adults) or 2hPG in a” 75 g OGTT ≥11.1mmol/L or Random PG ≥11.1 mmol/L[30].

Literature search

The literature search was done using search terms based on the definition of concepts in the research topic. It was followed by the search of selected databases and the screening of articles based on the inclusion/exclusion criteria as well as following the PRISMA guidelines[58, 59] (Appendix 2).

The search terms were selected pretested, modified based on the requirement of selected databases. The search and screening were conducted over a period of a month between May, 23 to June 23, 2016, and included relevant standard and published acronyms were also included in the search term to maximize the search.

(“natural disaster” OR “disaster” OR “sudden onset disaster” OR “SOD” OR “earthquake” OR “typhoon” OR “cyclone” OR “hurricane” OR “tsunami” OR “volcano” OR “floods” OR “landslide” OR “extreme temperature” OR “extreme heat” OR “heat wave” OR “extreme cold” OR “freezing” OR “wildfire” OR “tornado” OR “insect infestation” OR “epidemic” OR “drought” OR “erosion” OR “debris flow” OR “mud flow” OR “rock fall” OR “storm”) AND (“diabetes” OR “diabetes mellitus” OR “type 1 diabetes” OR “type 2 diabetes” OR “T1DM” OR “T2DM” OR

"NIDDM" OR "IDDM") AND ("management" OR "treatment" OR "drug" OR "medication" OR "lifestyle" OR "stress" OR "physical activity" OR "sleeping" OR "nutrition" OR "dietary" OR "diet" OR "education" OR "exercise" OR "glycaemic control" OR "glycemic control" OR "blood sugar" OR "blood glucose" OR "HbA1c" OR "post meal glucose" OR "plasma glucose").

Databases search

The search was done on PubMed, Web of Science, CINAHL and Science direct. To ensure that relevant articles not found in the databases are not missed and examined, the reference lists was reviewed, and those meeting the inclusion criteria were added.

Because of differences in the condition and protocol, the above search terms were applied for three of the four databases used while the search on PubMed included the MESH terms and was done in two different searches (which includes and limited to only the search terms presented above). The result of both searches was extracted into the online endnote account for screening.

Pubmed search 1

("natural disaster"[Title/Abstract] OR "disaster*"[Title/Abstract] OR "sudden onset disaster*"[Title/Abstract] OR "SOD*"[Title/Abstract]) AND ("diabetes"[Title/Abstract] OR "diabetes mellitus"[Title/Abstract] OR "type 1 diabetes"[Title/Abstract] OR "type 2 diabetes"[Title/Abstract] OR "T1DM"[Title/Abstract] OR "T2DM"[Title/Abstract] OR "NIDDM"[Title/Abstract] OR "IDDM"[Title/Abstract]) AND ("management"[Title/Abstract] OR "treatment"[Title/Abstract] OR "drug"[Title/Abstract] OR "medication"[Title/Abstract] OR "lifestyle"[Title/Abstract] OR "physical activity"[Title/Abstract] OR "nutrition"[Title/Abstract] OR "dietary"[Title/Abstract] OR "diet"[Title/Abstract] OR "education"[Title/Abstract] OR "exercise"[Title/Abstract] OR "glycaemic control"[Title/Abstract] OR "glycemic control"[Title/Abstract] OR "blood sugar"[Title/Abstract] OR "blood glucose"[Title/Abstract] OR "HbA1c"[Title/Abstract] OR "post meal glucose"[Title/Abstract] OR "plasma glucose"[Title/Abstract]) AND ("humans"[MeSH Terms] AND English[lang])*

Pubmed search 2

("earthquake"[Title/Abstract] OR "typhoon*"[Title/Abstract] OR "cyclon*"[Title/Abstract] OR "hurricane*"[Title/Abstract] OR "tsunami*"[Title/Abstract] OR "volcano*"[Title/Abstract] OR "flood*"[Title/Abstract] OR "landslide*"[Title/Abstract] OR "extreme temperature*"[Title/Abstract] OR "extreme heat"[Title/Abstract] OR "heat wave*"[Title/Abstract] OR "extreme cold"[Title/Abstract] OR "freez*"[Title/Abstract] OR "wildfire*"[Title/Abstract] OR "tornado*"[Title/Abstract] OR "insect infestation*"[Title/Abstract] OR "diseas*"[Title/Abstract] OR "epidemic*"[Title/Abstract] OR "drought*"[Title/Abstract] OR "erosion*"[Title/Abstract] OR "debris flow*"[Title/Abstract] OR (mud[Title/Abstract] AND flow[Title/Abstract]) OR "rock fall*"[Title/Abstract] OR "storm*"[Title/Abstract]) AND ("diabetes"[Title/Abstract] OR "diabetes mellitus"[Title/Abstract] OR "type 1 diabetes"[Title/Abstract] OR "type 2 diabetes"[Title/Abstract] OR "T1DM"[Title/Abstract] OR "T2DM"[Title/Abstract] OR "NIDDM"[Title/Abstract] OR*

"IDDM"[Title/Abstract]) AND ("management"[Title/Abstract] OR "treatment"[Title/Abstract] OR "drug"[Title/Abstract] OR "medication"[Title/Abstract] OR "lifestyle"[Title/Abstract] OR "physical activity"[Title/Abstract] OR "nutrition"[Title/Abstract] OR "dietary"[Title/Abstract] OR "diet"[Title/Abstract] OR "education"[Title/Abstract] OR "exercise"[Title/Abstract] OR "glycaemic control"[Title/Abstract] OR "glycemic control"[Title/Abstract] OR "blood sugar"[Title/Abstract] OR "blood glucose"[Title/Abstract] OR "HbA1c"[Title/Abstract] OR "post meal glucose"[Title/Abstract] OR "plasma glucose"[Title/Abstract]) AND ("humans"[MeSH Terms]

Articles Screening and selection

After the databases search, the articles were screened as shown on the flowchart below (figure 1).

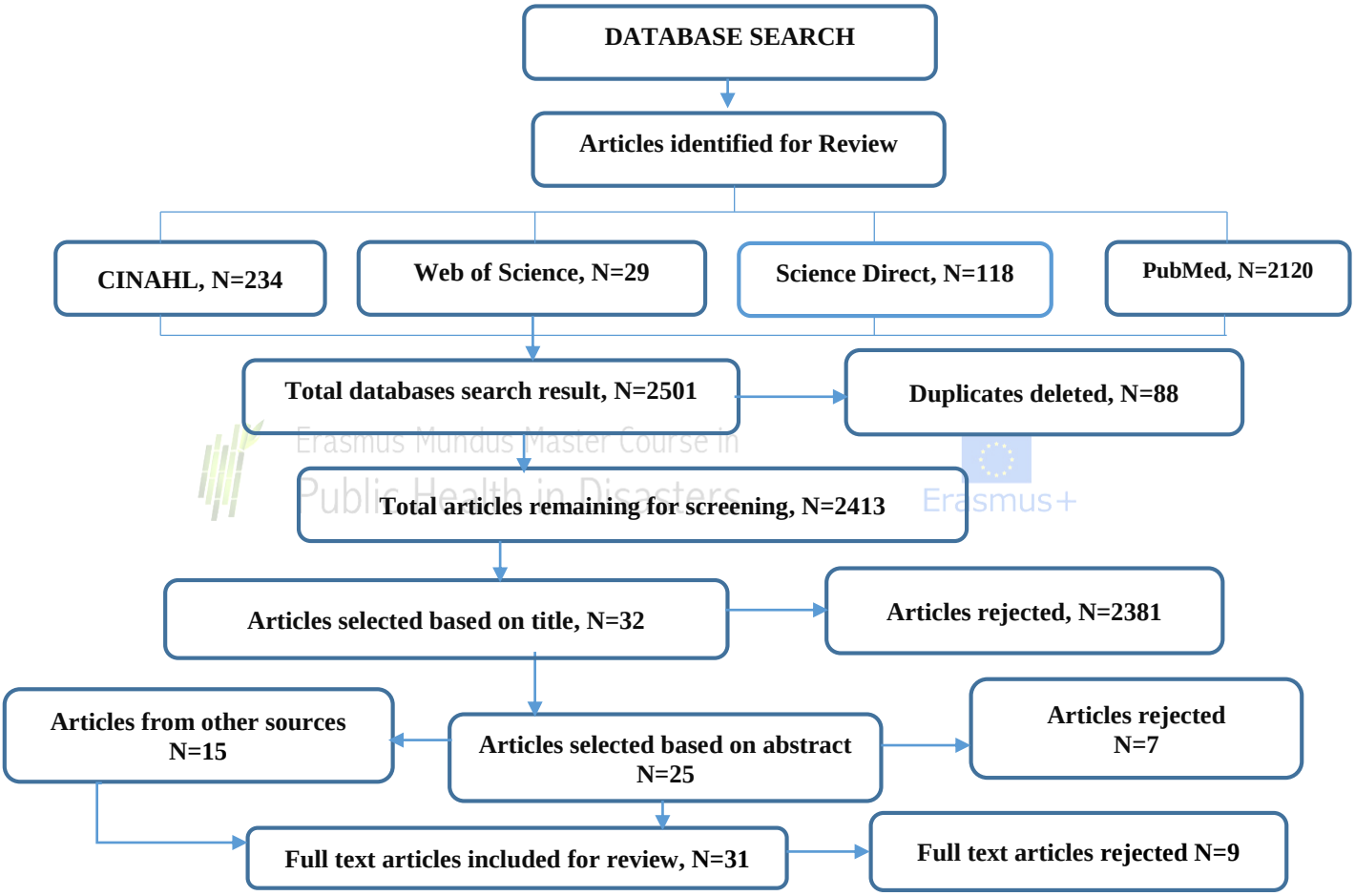


Figure 1: Flowchart of identification and screening of articles from database

Based on the search terms, some limitations were applied on each data based which forms part of the inclusion criteria.

The search was limited to articles published in English language and studies on human subjects. The flowing detail criteria were used to include articles in the review:

Inclusion criteria

i. Articles published in peer-reviewed journals and in English
ii. Studies that clearly defined issues on diabetes treatment, diet or control
iii. Participants who are or diagnosed of diabetics during disasters
iv. Participant exposed to sudden onset natural disaster
v. Articles will be included if their full-text is accessible.
vi. Studies such as perspectives, reviewed and published key interviews and letter to the editor were included

Exclusion criteria

i. Did not explicitly measure the providing diabetes care, access to treatment and medication, lifestyle (diet and exercise), health education and glycaemic control in the context of natural disaster (sudden onset disaster)
ii. Articles like conference presentation or unpublished articles were excluded.

Data extraction and evaluation

Information on the consequences of sudden onset disaster on diabetes management was collated from the reviewed articles.

The principles of qualitative research were employed for the evaluation which involves data description using key phrases and concepts[60, 61].

The information was entered into a matrix with information on the type of disaster, study design, characteristic of study participants as well as categorization of the consequences into the individual and institutional level.

Reviewed data were also evaluated based on the evidence leveling system of Collaborative Centre for Integrative Reviews and Evidence Summaries[62] which is an evidence hierarchy of research designs by identifying and prioritizing studies in descending order of strength and quantity, starting with the strongest level of proof, the systematic review.

Data analysis

Based on the categorization of the information gathered/extracted into two level (individual and institutional), a precise description of the effect of sudden onset disaster on the management of diabetes was done.

RESULTS

A total of 31 eligible articles were included in the final data extraction while 9 full-text articles were rejected on the basis of the fact that the content was not focused on the issues relating to the management of diabetes in a disasters context (Figure 1).

Earthquake forms the most common, n=17 (55%), hurricane n=10 (32%), multiple events/disasters n=2 (7%), flooding n=1 (3%) and tsunami n=1 (3%) (figure 2).

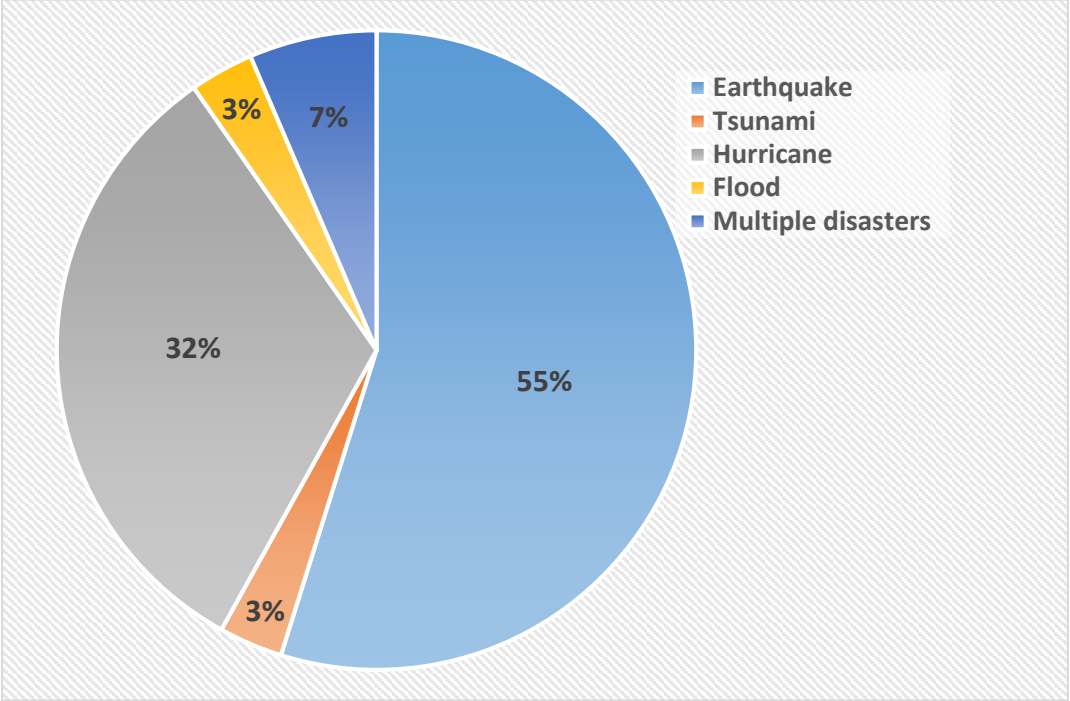


Figure 2: Distribution of reviewed articles by disaster type

Of the 17 reviewed studies on the earthquake, mostly on the Great Japan Earthquake of 2011, the Marmara earthquake of 1999, Hanshin-Awaji earthquake of 1995 and Mid Niigata Prefecture earthquake of 2004. Only one paper was one each (n=1) of 1995 Kobe earthquake, 1979 Tangshan earthquake, 2008 Sichuan Earthquake, and 2009 L'Aquila earthquake (table 1).

Eight articles were on Hurricane Katrina of 2005 and one (1) each on 1992 hurricane Iniki and Hurricane Andrew. Then one paper each on the tsunami that affects Southern India coastal population, and the flooding in Hull (table 1).

The articles were also graded based on the level of evidence. The # represents serial/article number of the article in table 1. Most n=13(42%) on level- C, n=12, (39%) were on the B-level, n=1 (3%) on Level-E and n=5 (16%) in the Level-MA (table 2).

Table 2: Evidence leveling hierarchy for reviewed articles

Evidence Grading			
Level	**Description**	**Relevant Articles**	**Article Number**
A	Meta-analysis of multiple large sample or small sample* randomized controlled studies, or meta-synthesis of qualitative studies with results that consistently support a particular action, intervention, or treatment	0	-
B	Well-designed controlled studies, both randomized and nonrandomized, prospective or retrospective studies, and integrative reviews with results that consistently support a specific action, intervention, or treatment	12	#2, #7, #8, #11, #13, #14, #17, #18, #19, #21, #24, #27
C	Qualitative studies, descriptive or correlational studies, integrative reviews, systematic reviews, or randomized controlled trials with inconsistent results	13	#1, #3, #4, #6, #9, #12, #15, #16, #20, #25, #26, #30, #31
D	Peer-reviewed professional organizational standards, with clinical studies to support recommendations	0	-
E	Theory-based evidence from expert opinion or multiple case reports, case studies, consensus of experts, and literature reviews	1	#23
MA	Manufacturer's recommendation; Anecdotes	5	#5, #10, #22, #28, #29
LR	Laws and Regulations (local, state, federal; licensing boards; accreditation bodies, etc.)	0	-
	TOTAL	**31**	-

Analysis of data on consequences of SOND on diabetes management

Individual and institutional consequences have been depicted or rather conceptualized on figure 2, but the results will rather be presented in an integrative way.

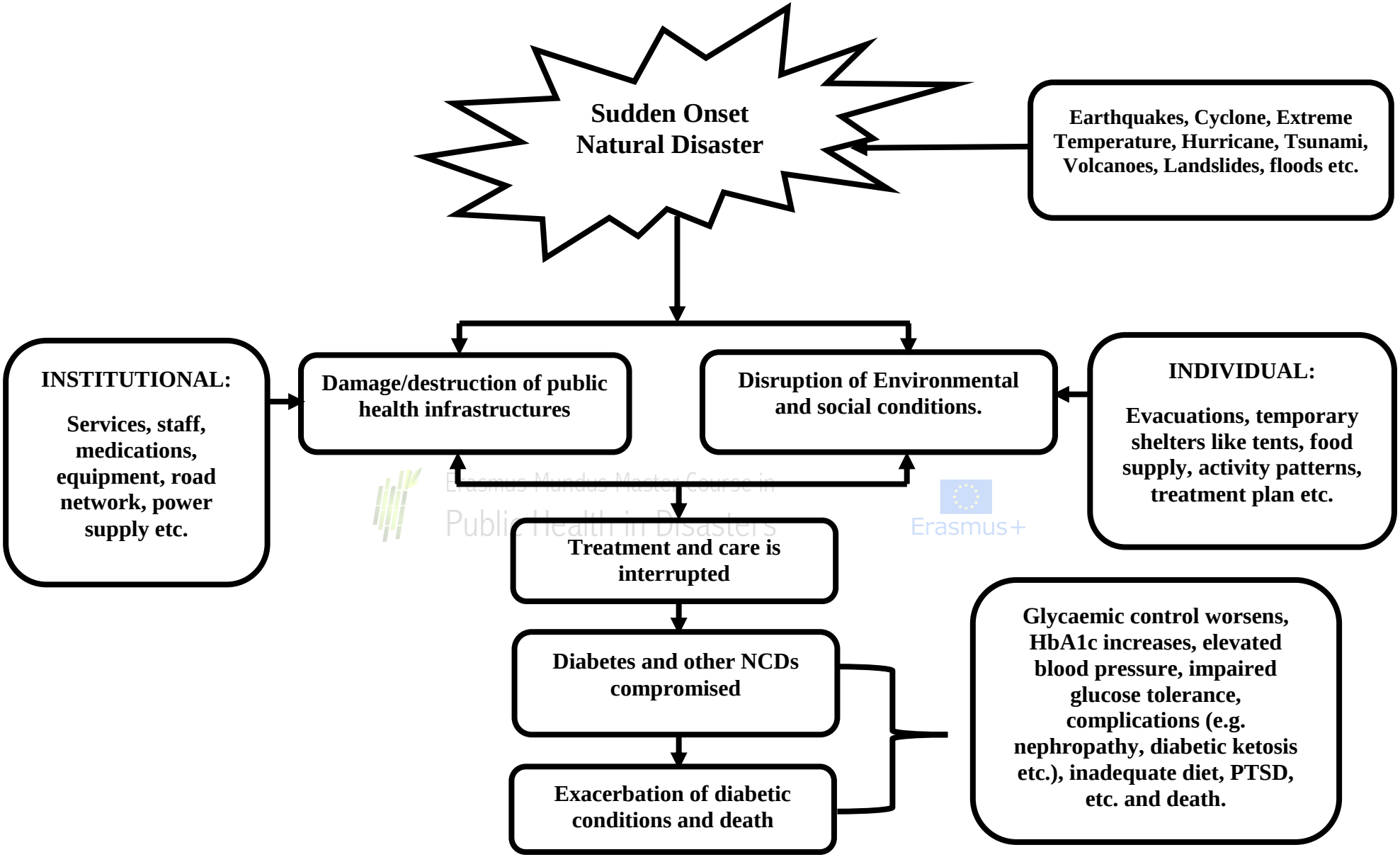


Figure 3: Conceptual framework on the consequences of Sudden onset natural disasters on the management of diabetes

Exacerbation and effects of disasters on glycaemic control

Acute exacerbation of diabetes conditions has been reported in several natural disasters. The mean HbA1c level in all patients after 2004 Mid Niigata Prefecture earthquake increased significantly in the third month after the first shock, it peaked at 5 months and then decreased at 12 months, but returned to the pre-quake level after the 12 months (P<0.03)[63]. The increase was less than 5% among those treated with MDI in the third month and in the second month among those treated with CSII (P<0.03). The study also reported that the mean blood concentration of LDL and HDL increased significantly in the third and sixth months, respectively [63].

In the same study, the incidence of nephropathy increased by 7% three months after the initial shock and returned to pre-earthquake level after the sixth month [63]. In the CSII group, the number of cases doubled at 3 months before returning to pre-quake level after the 12 months [63].

Another prospective uncontrolled study on type 2 diabetes mellitus patients after the 2004 Mid Niigata Prefecture earthquake, reported that the cases of nephropathy is increased to 41% by the third month among those who measured their blood pressure as compared to 38% in those who don't and all decreased by the sixth month[64]. The incidence of nephropathy was reported in 13 patients (16%) by third month and 17 patients (11%) by the sixth month, who measured their blood pressure. This was not different among those who don't. Generally, 34 patients without nephropathy before the earthquake had it in the third month and 14 continue to have it until the sixth month[64].

A follow-up study on The Great Hanshin-Awaji Earthquake reported an increase in HbA1c of 144 diabetic patients from 7.22% to 7.47% (P<0.05) after the earthquake among those on either insulin therapy, diabetic drugs or diet only[65]. A study on similar earthquake reported a significant but temporary increase in the mean value of HbA1c level (8.34±2.07% in March 1995 vs. 7.74±1.82% in December 1994, P<0.01)[41]. The elevation rate was higher than 1% of 63 patients and between 0.5 and 1% in 36 patients [41].

In the later study, ketoacidosis was reported within 2 months in two IDDM patients after the earthquake, gangrene of the foot in three NIDDM patients, brain haemorrhage in one NIDDM patient and pneumonia in one NIDDM patient. Also, reported are long-term complications such as haemodialysis in two patients, deterioration of retinopathy in five patients, deteriorated cataract in two patients, brain infarction and pulmonary tuberculosis in each patient [41].

Lesson learned from an observational study on the Marmara earthquake, reported that HbA1c and insulin requirements significantly increased 3 months after the earthquake[38]. Insulin requirement remained unchanged until one-year post-quake while mean HbA1c values in one-year post-quake

decreased by 43% the third-month values and 9.5% higher than the pre-quake value[38]. A similar study on Marmara earthquake also reported increase “HbA1c (7.4±1.5 vs. 8.8±2.5%; P<0.001) and daily insulin requirement (0.58±0.3 vs. 0.75±0.3 IU/kg per day; P<0.001)”[66].

Acute exacerbation was also reported after the Great East Japan earthquake (GEJE) in six papers. An observational study indicated that despite HbA1c level was not elevated 1 month after the quake and even decreased in the third month as compared to pre-quake level, glycaemic control among type 1 diabetics deteriorated significantly from the pre-quake level of 7.8 to 8.2% after the earthquake[67]. The hba1c value in a retrospective review was significantly higher among the study group (those issued with disaster victim certificate) than other groups (mean HbA1c, 7.3% [1.0] vs. 7.0% [1.3], P<0.05) after GEJE [39]. However, one of the studies reported that the mean level of HbA1c did not significantly change during the period before (7.7±1.3%) and after (7.7±1.4%) the disaster (p=0.10)[68].

The diabetic condition of many diabetic patients deteriorated because of the hostile environment after the GEJE vis-à-vis the tsunami that followed [17, 42]. In a retrospective study that observed the impact of the massive Tsunami aftermath, HbA1c value was significantly higher (5.9±0.2 vs 6.5±0.2; P<0.01) among other parameters such as blood glucose (P<0.01), and systolic and diastolic blood pressure (P<0.01) which also increased notably in tsunami exposed patients[69]. The tsunami was also shown to be an independent risk factor the increase in HbA1c[69].

The GEJE also affected the Fukushima Daiichi nuclear power plant causing a devastating accident that resulted in the evacuation of residents surrounding that area. After the disaster, the prevalence of diabetes increased significantly from 9.3% to 11% (P<0.0001) and so the incidence of average glucose from 61% to 62.8% (P<0.0001)[70]. The HbA1c levels also increase significantly from 5.20%±0.21% to 5.21%±0.26% (P<0.0001) in the normal glucose group (with 0.5% crude incidence rate) and among evacuees than in non-evacuees (P<0.0001). Cox proportional model in a study, found that evacuation was significantly associated with the incidence of diabetes “(Hazard ratio=1.399; P<0.0001) after adjusting for” blood pressure, AST, ALT, γ-GT and LDL-C which were also affected by the evacuation[70]

A different and comparative study on the Southern Indian coastal tsunami, reported that the prevalence of undiagnosed diabetes and impaired glucose tolerance were significantly higher in the tsunami population (undetected diabetes mellitus: Z=9.54, P<0.001; Impaired glucose tolerance: Z=12.8, P<0.001) as compared to the control group[71].

The only study flooding which longitudinally compared the effect of Hull flooding on glycaemic control of diabetic patients 12 months before and 12 months after reported that there was a rise in

mean HbA1c of affected individuals comparing 12 months before the floods with 12 months after [mean (95% confidence interval), 7.6% [7.5-7.7] vs. 7.9% [7.7-8.0], P = 0.002), but not those unaffected (7.5% [7.4-7.6] vs. 7.5% [7.4-7.6], P = 0.46). The difference was mainly seen in insulin-treated patients (8.6% [8.3, 8.9] affected vs. 8.2% [8.1, 8.3] unaffected, P = 0.002)[72].

The burden diabetes and other NCDs after a disaster has been reported in some studies. In cross-sectional study after 2008 Sichuan China earthquake, NCDs management requirement accounted for 30% of clinical burden [73]. The majority (77%) of the admitted patients after the quake had more than one NCD while 12% are unaware of their conditions before the clinical encounter. Diabetes alone accounted for 23% of the disease burden after that event [73].

Another comparative study on the impact of Tangshan earthquake on fasting glucose control and diabetes prevalence reported a slightly higher fasting blood glucose among exposed group who lost relatives (P=0.121) as compared to those who lost relative or those not exposed (control)[74]. The study used data from a database for its investigation and also showed that the incidence of IFG and diabetes for exposure groups were significantly higher than that of the "control group (P=0.043 for IFG; P=0.042 for diabetes)" but when stratified by gender, diabetes incidence was 5.8% higher in exposed group who lost relatives compared to 3% in expose-unlost relative and 0% in the control group[74]. And a report from a survey after Kobe earthquake showed a significant increase in HbA1c levels among patients from "Kobe (0.0744±0.0015 vs. 0.0764±0.0011 [7.44%±0.15% vs. 7.64%±0.11%]; n=110; P<0.01)"[6]. And a follow-up studies by similar authors showed that the HbA1c levels peaked 3 to 4 months after the earthquake(0.0075[0.75%]) compared to the pre-quake years 1993-1994[6].

Hurricane Katrina is among the most published articles in this review. A representative telephone survey of its aftermath reported that 20.6% of the respondent experienced disrupted treatment of at least one chronic condition with a moderate disruption experienced for diabetics (The disruption were common, occurring in over 1 of 5 of survivors with chronic illnesses)[15]. The prevalence of diabetes of 7.6% reported by the survey[15] was similar to 7.7% and 6.1% of hyperglycaemia, hypoglycaemia and diabetes mellitus reported for males and females respectively from a surveillance data collected after Hurricane Katrina[75].

The above-mentioned telephone survey also showed that after controlling for number and type of conditions, the disruption was 3.5 times more likely in those less than 65 years (OR=3.5, 95% CI 1.1-11.9), 2.7 times more likely in those lacking health insurance after Katrina (OR=2.7, 95% CI 1.2-6.0), 2.6 times among those without relative in hurricane area (OR=2.6, 95% CI 1.2-5.8), 3.4 times more likely among with not relative affected in unaffected areas OR=3.4, 95% CI 1.8-6.5), 3.6 more likely

in Katrina survivors with no confidant in hurricane area (OR=3.6, 95% CI 1.6-8.4) and 3 times more likely among survivors experiencing residential instability after the hurricane (OR=3, 95% CI 1.4-6.2)[15]. The disruption in this study was associated with limited access to a physician (41.1%), restricted access to medication (32.5%), financial/insurance problem (29.3%), transportation (23.2%) and competing demands on time (10.9%)[15].

Most of the previous studies on Katrina were among adult participant aged 18 years and above [15, 36, 40, 75]. One prospective study on children with type 1 diabetes after Hurricane Katrina, showed that participant in the Hurricane interrupted group had a higher percentage of blood glucose value ≥300 mg/dl, $F(1,147)=5.19$, $P<0.05$[76]. The HbA1c levels at Time 2 of data collection were accounted by 50% more variance in the HbA1c levels at the time one more than demographic variation. Similar significant increase ($P<0.001$) in HbA1c among patients at the Medical Centre of Louisiana, New Orleans from 7.7% to 8.3% was reported by an observational study after Katrina[36].

Consequences of disasters on medical supplies and treatment

Destruction or damage to medical facilities and/or pharmaceutical and medical equipment have been reported after several disasters. A prospective and uncontrolled study post-2004 Mid Niigata Prefecture earthquake, a showed that most of the type 1 diabetic patients lost insulin vials, needles or pen due to the destruction caused by the high initial shock [63].

Suddenly after the Prefecture earthquake, forty-two patients were obligated to discontinue the use of pens with replaceable cartridge, 40 could not find any pen with replaceable cartilage until the next morning [63]. Also, two patients using rapid-acting insulin lost all insulin vials, needles, and pen but did not lose long-acting insulin. One patient discontinued after a day, and other patients had 2 days of it. Two with CSII therapy lost their rapid-acting insulin supplies, but the continuous supply of supply of insulin into the body was not discontinued [63].

After Katrina, a large shelter in Louisiana housing 6000+ evacuees had only a handful of glucose meter in the first week of the crisis[77]. Also reported was a dropping in the number of children (covered by insurance-TexKat) receiving recommended test from 0.45 to 0.42 (during and post-TexKat period respectively) as compared increase from 0.45 to 0.65 seen in the control group[78]. Individuals evacuated with little or no planning after Katrina were faced with problems of obtaining the required antidiabetic medications and the lost medical records or history makes it difficult as doses were based on patients memory and knowledge[77]. This led to significant disruption in glycaemic control and treatment, and risk for both hyperglycaemia and hypoglycaemia. A similar loss of oral

antidiabetics agent or insulin after building collapse were reported post-GEJE, and the tsunami that followed helped wash everything away[17, 42].

According to a retrospective study, local pharmacies were either closed or destroyed, and a large number of residents were in need of their prescription after Hurricane Andrew of 1992; two hundred and six of such request were mostly for insulin[79]. The loss of medical record after the GEJE made it impossible to resume the particular treatment patients had before the disaster[69].

The rate of increase in HbA1c level after the Great Hanshin-Awaji earthquake was evaluated according to participant who received their treatment before the quake, and it was 7.19±1.87% vs. 6.62±1.60% ($P<0.05$) in patients on diet therapy only, 8.50±2.20% vs. 7.92±1.80% ($P<0.05$) in patients on OHA, and 8.91±1.98% vs. 8.22±1.90% ($P<0.01$) in patients with insulin, respectively [41]. A contrary study after the GJE showed that HbA1c level did not differ statistically despite the observed change in medication usage [39]. Changes (increase) were rather observed for LDL and HDL even no prescription changes were recorded in the type 2 diabetics [39].

Some health facilities faced problems of total hospital capacity to take care of the patient after a disaster. An after storm perspective report showed that after hurricane Katrina in New Orleans, hospital capacity was down to 1.99 hospital bed per 1000 population as compared to the average of 3.26 per 1000 for US cities[43]. Diabetic patients come into the facilities with ketoacidosis, and many have been off insulin for six months[43] and seven months after Katrina, the absence of chronic care facilities contributes to the lengthening of stays in acute care hospital exceeding centers for Medicare and Medicaid services reimbursement cost[43].

Problems faced after the Katrina also include non-availability of health care providers. Approximately 40 of Ochsner's 600 physicians and 1500 of its 7400 other employees resigned after Katrina. Mostly because their spouses no longer had employment, schools were closed, and housings were not available among other reasons[43]. Lack of primary health care providers was linked to a survey of displaced person after Katrina, with the absence of medication (OR=5.62; 95% CI 1.91-16.55; P=0.002)[40]. This includes 26% diabetics requiring medicine when arriving at the shelter and 8% at the time of the survey in a population diabetes 69 diabetics with a prevalence of 14.3 (95% CI 12.5-16.1)[40].

Also about 8.65% of the participant in a study after the GEJE experienced an interruption of their antidiabetics medication regimen[67] similar to 7% reported in the same earthquake[68]. Discontinuation of drug intake among diabetic patients (OR=4.48, 95%CI 1.57-12.7; P=0.01) was independently associated with worsening of glycaemic control after GEJE defined by a 0.5% increase in HbA1c [68]. A retrospective study of GEJE and aftermath tsunami presented the change in drug

usage as a decrease rather than interruption after the earthquake, and though not defective, the change was regarded as the chief reason for worsening of glycaemic and blood pressure control for an extended period[69].

Consequences of disasters on lifestyle and diets

Following a sudden onset natural disaster, not having adequate and appropriate food can affect medical nutrition therapy. After Marmara earthquake, not having appropriate and the proper diet was associated with lower Quality of life (QOL) in the third month (a short-term negative effect) on type 1 diabetes patient [38]. After the GEJE, there was still a shortage of food, with rationing of certain items (mostly preserved food) rich in calories and a risk for increased weight[69] and postprandial hyperglycaemia[42].

Change of dietary intake was a source of concern after Hurricane Katrina. Evacuees were forced to adjust to meals provided in shelters, which may not adhere to the daily requirement of the individual[77]. A reported 40.4% feeding composition change was experienced among 366 participants in a study after the GEJE[67] as compared to 64% changes in dietary intake reported by another study in a similar setting[68]. Patients have no choice but eat what the get and despites need to consume sufficient amount of liquid, some old ones avoid such to reduce lavatory usage leading to dehydration and aggravating diabetic control[42].

Diet study after Great Hanshin-Awaji Earthquake revealed a variance in the rate of increase in the mean level of HbA1c among 136 patients with IAD (8.53±2.17% in March, 1995 vs. 7.84±1.79% in December, 1994, $P<0.01$) and 41 patients with appropriate diet (7.81±1.94% vs. 7.52±2.04%, not significant)[41]. And after a further full examination of the dietary conditions in 99 patients, a 0.5% or more increase rate of the HbA1c level was shown.

Sedentary lifestyle as the result of living in camps and temporary shelters after a disaster has been associated with the poor glycaemic control. After the great Japan earthquake, the amount of exercise in a study was decreased for 21.1% of the participant[67]. This result is quite higher than 6% reported in a study on similar earthquake [68].

Psychological factors can also contribute to the exacerbation of diabetic condition. A comparative study on the long-term impact of stress after Tangshan on diabetes prevalence reported stress from loss of relatives as a significant predictor of diabetes incidence (P=0.021)[74]. Loss of family members is 1.9 times more likely to predict diabetes incidence (OR=1.863, P=0.042, 95% CI 1.0-3.4) and relative-unlost is 2.3 times more likely to predict diabetes incidence (OR=2.3, P=0.006, 95% CI 1.3-4.2)[74]. Aside factors such as age, waist, triglyceride and blood pressure that were also

mentioned as risk factors for diabetes in the study (β=0.039, β=0.042, β=0.387, and β=0.702 respectively), the risk of diabetes was shown to higher in women than men (Wald-value=6.520, P=0.089)[74].

More impact on quality of life was also felt in the wake of L'Aquila earthquake. An observational study of PTSD and type 2 diabetes after using the Davidson Trauma Scale (DTS), reported that 65% of patients in the post-quake group had PTSD in comparison to 335 in the pre-quake group and the difference was significant ($\chi 2$=21.78, P<0.0001)[80]. More diabetic women (DTS score 53.5, SD=23.06) were reported to develop PTSD (P<0.0001; t=4.364) than men (DTS score=31.65, SD=23.06)[80].

Psychological problems were linked with the aggravation of glycaemic control in diabetic patients aftermath of Kobe earthquake expressed by high GHQ scores among "diabetic patients with severe damage to houses (n=21) and/or fatalities or injuries within their families or among relatives (n=7)"[6].

Similarly, a GHQ score (OR=1.03, 95% CI 1.01-1.06) was reported among diabetic patients after the GEJE to be independently associated with worsening of glycaemic control indicated by a 0.5% increase in HbA1c [68]. Logistic regression analysis from that study revealed that scores on the GHQ, "for somatic symptoms (OR 1.18 [1.01-1.38]; p=0.03) and sleep disturbances or anxiety (OR 1.26 [1.08-1.46]; p<0.01) were independently associated with" glycaemic control [68]. In a letter to an editor, depression and anxiety scores was also reported to increase significantly (prior and after Marmara earthquake: 34±14 vs 54±13%; P<0.001 and 41±18 vs. 70±19%; P<0.001 respectively); and scores for positive well-being and energy in the study decreased from 64±21 to 36±20%; P<0.001 and from 73±18 to 62±20%; P=0.008 respectively[66].

According to an observational study, Hurricane Katrina increased direct and indirect, and total costs estimated as a lifetime cost of $504 million and reduce life expectancy as well as quality-adjusted life expectancy[36]. This was quite substantial because of the large population affected by the event.

It suffices to say that despite several the mentioned effect of the disaster, death is inevitable when lots of exacerbation occurs. In a post-Hurricane Iniki study, an increase in death from diabetes showed a statistically significant (RR=2.61, 95%CI 1.44-4.74) indicating that those with diabetes were 2-3 times at risk of dying after Hurricane Iniki[81]. The debated-related death observed in Kauai after Iniki had increased 161 percent much greater than 14 percent artefactual increased observed nationally.

DISCUSSIONS

The past decade has recorded an increased occurrence of sudden onset natural disasters. Today, the occurrence of natural disasters is still increasing and so the consequences they bring with them. The increase in the frequency of disasters and their consequences, however have been shown by a developed models to be associated with an increase in the vulnerability of communities globally[82].

The impact of disasters is usually enormous that it overwhelms the capability of any weak system and country. It ranges from economic losses to physical damage spreading beyond the immediate area of the event[83]. In this more or less precarious situation, developing a health system already fraught by inadequate infrastructure and scarce resources can be overwhelming[84].

Traditional disaster preparedness and response in the past decades have considered consequences such as communicable diseases, injuries, trauma and immediate basic need of disaster survivals [22-26] with less attention given to non-communicable diseases – diabetes. Several studies on NCDs in disaster has reported adverse effect of events such as earthquake[6, 38, 39, 41, 63-65, 67-70, 74, 80], tsunami[71], hurricane[36, 40, 43, 75-79, 81], flooding[72], and reviews of several events[13, 85] on the treatment and care (management) of people with diabetes during and after disaster. The impacts of disasters could be for short-term to long-term consequences[8] requiring rather a strategic and integrative approach to manage.

This study adopted the conceptual framework by Ryan et al. [86], to develop a conceptual framework for the consequences of sudden onset natural disaster on diabetes management at but institutional and individual level. Exacerbated of diabetes control can be both during and after an emergency has been reported in several studies [40, 42, 43, 73, 75, 80] and affects both those with type 1 diabetics [38, 67, 72] and those with type 2 diabetes [72]. A similar effect on both type 1 and type 2 diabetic resulted in complications such as cases of nephropathy which all increased in two studies after the 2004 Mid Niigata prefecture earthquake [63, 64].

Poor glycaemic control has most time been indicated in several studies such as a significant increase [74] in IFG or an elevated or significantly increased mean value of HbA1c [6, 36, 38, 41, 63-70, 72, 87] and this was also seen among patients taking insulin treatment after the flood in hull and East Yorkshire[72]. Although the effects were expressed more on a short-term basis, the long-term effect could result in complications or even death.

The burden diabetes and other NCDs after disaster has also been reported in a cross-sectional study after 2008 Sichuan China earthquake where NCDs management requirement accounted for 30% of clinical burden[73] and majority (77%) of the admitted patients after the quake had more than one

NCD while 12% are unaware of their conditions before clinical encounter. Diabetes alone accounted for 23% of the disease burden after that event [73].

In several situations, exacerbation results mainly as a result of interruption of treatment and care [15, 73, 85] because medical facilities and/or pharmaceutical and medical equipment [6, 38, 41, 75, 77, 85, 88], [39, 68, 81]. Problems expands to difficulties of accessing doctors and/or pharmacy [13, 15], and lost prescriptions and records [13, 17, 40-42, 63, 69, 73, 77].

The response in extreme situations usually involves patients evacuated for to safe areas and facilities. Sometimes, this facility might have no surge capacity[43] or be faced with increased emergency visitation[75] or lack facilities for management of cases like dialysis[63]. It suffices to mention that evacuation can also increase diabetes incidence [70] after the disaster because transferring patients could interrupt treatment of chronic conditions [41] which is dangerous for the management of type 2 diabetes patients [39].

Aside the destruction of facilities, lack of primary care providers for diabetic patients[39, 40] or resignation of some of them[43], could be devastating and hamper treatment and care especially in the initial phase of disaster[40, 77, 89] and can extend beyond and affect management post-disaster period.

Disruption of access to food [6, 13, 81] or an abrupt change in dietary intake or composition [17, 38, 41, 49, 65, 66, 69, 77] due to rationed food [38, 41, 49, 66, 69]; and lack of diabetes medication [6, 13, 15, 67, 73, 75, 77, 79, 89, 90] was associated with poor glycaemic control. An effect that can be complicated by damages to the transportation network[42], medical supplies[85] and with poor knowledge of treatment regimen[13, 41] among some diabetic patients, they are forced to use a replacement medication[69, 77] which might not match their normal patient's regimen.

An unfavorable environmental condition during disaster alters the activity pattern of affect people and increase more sedentary life in the camps and tents after the disaster [41, 67, 69, 85]. Inactivity can be an indication of the poor body mass index, obesity, and insulin resistance [70] and associated with elevation of mean HbA1c value [41].

The impact of the disaster on the quality of life of diabetics[38] influence the life of survivals and protract for a long time. Accepted are face increased post-traumatic stress disorder (PTSD) [6, 43, 71] due to stress[80] and stress increases with somatic symptoms, sleep disturbances[42, 68] and depression[77], and this worsens glycaemic control in patients with diabetes. Patients become at risk of severe hyperglycaemia, as well as hypoglycaemia [68, 91]. A study indicated that fear of

hypoglycaemia could increase anxiety for metabolic control of individuals with Type 1 diabetes[76] and pose a risk for hyperglycaemia among these patients.

Risks for cardiovascular complications become apparent with increased blood pressure [36, 64, 69], the mean blood concentration of LDL and HDL [63]. Other complications are also indicated such as increased risk of nephropathy[64]. For instance, during the 2004 Mid Niigata Prefecture earthquake, nephropathy rose by 7% (i.e. doubled) at about 3 months after the event [63].

Generally, the risk of death from diabetes during disaster increases [13, 81] not to mention direct and indirect heath care cost[36] incurred.

Summarily, the population is rapidly aging as the occurrence chronic disease such as diabetes is also increasing. Therefore, health care providers need to prepare to ensure continuity of care for patients in the event of disaster [92-94] especially for diabetic patients [95, 96].

Discontinuation of insulin injections for type 1 diabetics in need of insulin can lead to grievous consequences; and consequently, patients are required to stock kits in multiple places (home, office, and school) in preparation for sudden onset disaster[17].

LIMITATIONS

The study was conducted as a requirement for an Erasmus Mundus Masters of Public Health in Disaster, and the review was rather not a complete systematic review. It rather employed an integrative methodological approach.

This research was focused on only consequences of managing diabetes during and after a disaster and did not consider other NCDs that are correlated with diabetes.

Another limitation is that only peer-reviewed articles were included in the study. This makes a small sample size. Grey literature were not used for the review, which might have provided valuable information on the consequences disaster poses on diabetes management.

The consequences of sudden onset disaster on a long-term basis were not well addressed. Further studies should investigate and substantiate the long-term impacts of disasters on diabetes management as well as the pattern of diabetes mortality during and after a disaster.

CONCLUSIONS

Sudden onset natural disaster affects the management of diabetes at the individual level as well as at institutional level. It results in exacerbation of diabetic condition expressed by worsening of glycaemic control, increase in incidence and prevalence of diabetes and death of affected persons and population.

The review showed that after a disaster, medical facilities and pharmaceuticals were destroyed and thus services are interrupted, medical supplies and records are lost/damaged, and staffing becomes an issue. Other factors include the destruction of the transport network, affecting the distribution of medical and other aids; loss of power to maintain adequate treatment for patients requiring specialized care like dialysis, nephropathy, etc.

An Even intervention like the evacuation of patients, especially after the Fukushima plant accident, was associated with worsening of glycaemic control and increased mean HbA1c. Post-traumatic stress, on the other hand, was related to sleeping disorder and worsening of glycaemic control while both were linked to rising blood pressure.

Inadequate diets, resulting from rationing food supplies and distribution usually preserved foods, rich in sugar, fats and loaded with high carbohydrate. Patients when exposed to unfavorable condition, are forced to consume what they are provided with. This kind of food can result in weight gain and poor glycaemic control. Confinement to camps and other temporary shelters drastically reduces physical activities among diabetic and increase the risk of elevated BMI and related complications.

Previous disaster preparedness and response plans were more concentrated on communicable disease, injuries, and trauma immediately after the catastrophe. Limited operational emergency guidelines and policies have been in place to address NCDs or diabetes in disaster. And despite recent discussions arising and plans developed, for the management of diabetes in disaster; actualization of NCDs management in emergency context will require an integrated approach.

An integrated approach, there is a need to identify and better understand the consequences of disasters on the management of diabetes and other NCDs. This will ensure adequate implementation of policies, standards and appropriate channeling of resources in response to diabetes in the short term (during a disaster) and long term (after a disaster).

RECOMMENDATIONS

Most of the reviewed articles were predominantly from high-income nations and the low- and middle-income countries faced with the greatest burden of diabetes are under-researched especially in the disaster context. Thus more studies are needed.

Also, most of the reviewed articles were concentrated on either Hurricane Katrina or Great East Japan earthquake. As such the impact or consequences of other types of disaster on diabetes management are not well documented or researched.

Further studies are needed to investigate the morbidity and mortality pattern related to diabetes following natural disaster or emergencies, in particular on a long term basis so as to be able to quantify the impact of these disasters on diabetes management.

Studies are also needed to identify and investigate the impact of particular sudden onset natural disaster on diabetic management. This will make preparedness and response plans, policies and guidelines more target-oriented and be able to achieve efficient implementations. Disaster preparedness needs to be extended to individuals with diabetes through adequate education. This will help reduce the burden of complications that might arise during the response to disasters.

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Dios los bendiga a todos
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APPENDIX 1

Table 1: Presentation of data/information on consequences of SOND on diabetes management

S/N	Author(s)	Disaster type	Study design	Study characteristics	Study location	Individual consequences	Institutional consequences
1	Greenough et al.[40]	Hurricane Katrina 2005	Sample survey (Randomized 2 state cluster design)	499 Evacuees residing in American Red cross shelter in Louisiana (Head of households 18yrs & above)	Louisiana, USA	• Lack of prescribed medications when arriving the housing and at survey • Acute exacerbation of disease condition • Lack of treatment at arrival to shelter	• Lack of primary care providers
2	An et al.[74]	1976 Tangshen Earthquake	Comparative case-control study – data derived from database of Kailuan Medical examination centre	1030 participants exposed to the earthquake and 521 unexposed control group (aged 37-60 years)	Tangshen, China	• Significant (P<0.05) increase in IFG and diabetes in exposed group especially among female participants	• -
3	Ciocca et al.[80]	L'Aquila earthquake 2009	Observational study	100 participant aged 30-65 years (46 women and 54 men), with only sixty with diabetes pre-quake	L'Aquila, Italy	• Increase in PTSD among that diagnosed post-quake as well as exacerbation of condition especially among diabetic women	• -
4	Kirizuka et	Hanshin-Awaji	Descriptive study	177 diabetic	Hanshin-Awaji,	• "A significant increase in the mean value of" $HbA1_c$	• Destruction of houses and living in

	al[41]	Earthquake, 1995		patients	Japan	after the earthquake (8.34±2.07% in March 1995 vs. 7.74±1.82% in December 1994 P<0.01). More than 1% increase rate in 63 patients then decline to pre-quake level after a year • Inappropriate diet, Discontinuation of drug intake and Reduced exercise were associated with increase in the mean value of $HbA1_c$ • Misplacement of medical charts and patients lack knowledge of their treatment regimen	a shelter for more than one month (extended stay) was associated with an increase in the mean value of $HbA1_c$. • Damages on medical facilities. • Rationed food after the Hanshin-Awaji and Marmara earthquake was heavily carbohydrate-loaded • Patients transfer to less damaged hospitals thus affect/interrupted the treatment of chronic conditions • Loss of medical chart and lack of patient's customs to keep details of prescriptions hindered attempts to proper carry out treatment for them.

5	Sengul et al[38]	Marmara earthquake, 1999	Anecdotal evidence	88 people with type1 diabetes (42 females and 46 males)	Marmara, Turkey	• Glycaemic control and quality of life of people with type 1 diabetes affected in the short term rather than long term. • $HbA1_c$ level and insulin requirements increased at 3rd month after Marmara earthquake	• Effect on local medical organization hindering patients from reaching the doctors and/or pharmacy. • Many hospital staff opts to take care of their close relatives instead of working at the hospital. • Destruction of medical facilities as well as pharmaceutical and medical equipment(s). • Rationed food after the Hanshin-Awaji and Marmara earthquake was heavily carbohydrate-loaded.
6	Takakura et al.[65]	Hanshin-Awaji Earthquake, 1995	Descriptive study	Data available on 144 diabetic patients before and after the	Ashiya Municipal Hospital, Japan	• Increased $HbA1_c$ of 144 diabetic patients from 7.22% to 7.47% ($P<0.05$) after the earthquake	• -

				earthquake		• Inadequate food intake was associated with higher $HbA1_c$	
7	Inui et al.[6]	Kobe earthquake, 1995	Comparative and prospective study	434 diabetic outpatients. 157 diabetic patients from Kobe and 277 diabetics from Osaka as control	Kobe, Japan	• $HbA1_c$ levels were significantly increased in the patients of Kobe ($P<0.01$) (worsening of glycaemic control). • Followed up showed that $HbA1_c$ level peaked 3 months after the earthquake and returned to pre-quake levels 5-6 months later • Emotional stress was associated with worsening of glycaemic control • Less than 10% of the total number of diabetics in Kobe were either death or transferred to other hospitals in the 1-2 months after earthquake	• Disruption of access to food and medication • Structural and non-structural damage of modern medical facilities and technologies in Kobe[88]
8	Alson et al.[79]	Hurricane Andrew 1992	Retrospective study	"1,544 patient encounter forms generated at a field hospital set up in Homestead, Florida, after Hurricane Andrew	Florida, USA	• Inability to obtain needed medications, such as insulin. • Two hundred and six patients were in most pressing need insulin	• Local pharmacies closed or destroyed, a large number of residents required to have their prescriptions refilled.

				in August 1992”			• Insulins supplies were exhausted within 24 hours
9	Miller et al[13]		Comprehensive review	Search of PubMed, Ovid, and Medline database		• Poor glycaemic control and increased the risk of morbidity and mortality due to diabetic complications. • Need for insulin-loaded syringes by elderly[97] • Difficulties in obtaining diabetic supplies • About 100,00 individual with diabetes has to cope with stress of finding medication, food testing supplies and shelter • Inability to reach doctors and altered drug regimens[90] • Diabetes deaths increased to 161% (RR=2.61, 95%CI 1.44-4.474) after 1992 Hurricane Iniki in Kauai[81] • Misplacement of medical charts and patients lack knowledge of their treatment regimen[41]	• Lack of diabetic medications and supplies[79] • Supplies of insulin and other drugs for diabetics were depleted[90] • Diabetic supplies were rapidly depleted and not replenished[89] • Treatment was restricted to hydration, a scanty supply of insulin Lantus (long-lasting)[89] • Paucity of oral medications[89] • Surge in the number of newly diagnosed IDDM admitted to children’s Hospital of Los Angeles[98] • Rationed food after the Hanshin-Awaji

							and Marmara earthquake was heavily carbohydrate-loaded[38, 41, 49, 66]
10	Cefalu et al.[77]	Hurricane Katrina 2005	Commentary/Anecdotal evidence	Hundreds of thousands of evacuees that flooded Baton Rouge after the Hurricane	Baton Rouge, Louisiana	• Obtaining the required antidiabetic medications was particularly a problem including insulin syringes • Loss of medical records and uses of medication based patient memory and knowledge • Replacement medication at initial state did not match normal patient regimen but based on availability • Financial and property loss led to depression and in turn affecting glycaemic control • Only a handful of glucose meter was available to 11% diabetics of the population of Orleans and Jefferson Parishes in the	• Lack of medical care, appropriate food and medications • Major medical centres were not accessible-surrounded by floodwater and remained closed for months

						first week of the crisis • Change in dietary intake was also a concern as it does not adhere to daily requirements	
11	Tanaka el al[67]	Great Japan earthquake	Prospective study	497 diabetic patients treated in hospitals in Miyagi and Fukushima. Mean age 65.8±11.8 years and 60.2% were male	Tohoku district, Japan	• HbA1c level of the participant "was not elevated at 1 month and was significantly decreased at 3 months as compared with the pre-earthquake HbA1c value" • Amount of exercise was reduced by 21.1% in the participant • Smaller portion 9.8% of participants suffered from Tsunami • Glycaemic control of type 1 diabetic patient deteriorated significantly from pre-quake level of 7.8 to 8.2% after the quake (p=0.009) • Worsening of glycaemic level in patients with low insulin secretory capacity due to sympathetic hyperactivity under stressful circumstances	• 8.6% experienced interruption of antidiabetic medication

12	Fonseca et al [36]	Hurricane Katrina 2005	Descriptive study	1795 adults with A1c measurement 6 months before and 6-12 months after the Hurricane. Mean age 61.9 years and 61.2% were male.	Louisiana, New Orleans, USA	• Mean-post-Katrina A1c significantly increased in one of the systems observed in the study as compared to pre-Katrina. This system had >80% African American population patients • Increased modeled direct, indirect and total health care costs.	• "Increased modeled direct, indirect and total health care costs."
13	Nishikawa et al.[39]	Great east Japan earthquake, 2011	Retrospective case series	767 Patients with Type 2 Diabetes Mellitus attending outpatient department three months before the disaster. 65.5% male participant.	Soma, Fukushima, Japan	• HbA1c levels did not differ statistically despite observed change in medication usage between pre and post-disaster • Change in dietary patterns leads to the deterioration of glycaemic control	• Several hospitals in the affected area were forced to close shortly after the disaster due to a staffing shortage. • Difficulties in managing patients with type 2 diabetes
14	Ogawa et al.[69]	Great east Japan Earthquake 2011	Retrospective study	63 patients receiving diabetic treatment in a facility pre and post-quake	Tohoku University, Japan	• Worsening of glycaemic control in 63 patients with diabetes living in the coastal areas likely due to traumatic changes • Change in drug users impairing glycaemic control	• Loss of medical information from tsunami and prescription of less efficient medications • Loss of medical records making

						• 44% of the subjects were affected by Tsunami • Values in blood glucose and HbA1c, as well as BP, was higher among those affected by the aftermath Tsunami • Difficulties in sticking to diet and exercise therapies • Food shortage and rationing contributed to inappropriate diet and ingestion of preserved foods rich in sugar, fats with resulted weight gain	resuming exact treatment received earlier impossible
15	Fujihara et al.[68]	Great east Japan Earthquake 2011	Descriptive study	375 eligible and consecutive diabetic patients attending outpatient department. 320 consent patient's data analyzed	Mito, Japan	• Mean HbA1c did not significantly change before and after the quake. • Group with worsening glycaemic control had substantial increase in HbA1c in short period • Stress-related somatic symptoms and sleep disturbance was associated with worsening of glycaemic control	• Heavy damage to hospital necessitated evacuation of patients
16	Sharma et	Hurricane Katrina,	Descriptive study	Surveillance data on burden of visits	New Orleans,	• Problem of medication refills (7.2%)	• Loss of health cares infrastructure

	al.[75]	2005		at emergency treatment facility plus survey of emergency staff in 29 treatment facilities in 6 parishes	USA	• Exacerbation of disease condition	• Increased emergency treatment visitation to facilities • Shut down of smaller treatment facilities and pharmacies
17	Kamps et al.[76]	Hurricane Katrina, 2005	Prospective study	158 children aged 8-16 years of age with type 1 diabetes for at least 6 months and their caregivers. Divided into 2 group pre-hurricane group and hurricane interrupted group	New Orleans, LA	• Participant in the interrupted group had higher percentage of blood glucose value >300mg/dl ($p<0.05$) • Fears for hypoglycaemia were found to be associated with increased blood glucose level and consequent higher HbA1c.	• -
18	Kamoi et al.[63]	Mid Niigata Prefecture Earthquake, 2004	Prospective uncontrolled study	65 type 1 diabetes patients with insulin therapy age 25 to 88 years and duration of diabetes range from 2 to 47 years.	Chuetsu Districts, Japan	• Loss of insulin vials, needles or pen due to destruction caused by the high initial shock • The mean HbA1c level in all patients increased (<0.5%) significantly (<0.03) in the third month after the first shock, it peaked at 5 months and	• -

						then decreased at 12 months but did not return to pre-quake level. • Mean blood concentration of LDL and HDL increased significantly in the third and six months, respectively • The incidence of nephropathy rose by 7% i.e. doubled 3 months after the initial shock. • One patient developed acute hyperglycaemia due to inability to inject rapid-acting insulin. • One patient needed dialysis two months after the earthquake and had severe clinical problems	
19	Quast et al.[78]	Hurricane Katrina 2005	Comparative study	Children up to 17 years of age enrolled every month between 2004-2006	Louisiana, USA	• HbA1c test for all given prior and during Katrina was same in Texas group (Medicaid emergency waiver) and the control group • Microalbumin and thyroid test was higher in the	• -

						Texkat group • During the post-Texkat period, test in the Texas group decreased, and the drops in the proportion of HbA1c and thyroid test were driven by males.	
20	Satoh et al.[70]	Great Japan earthquake and Fukushima Daiichi nuclear disaster 2011	Prospective health management survey	27,486 subjects (Japanese men and women living near the Fukushima Daiichi Nuclear plant before the disaster) aged 40-90 years with mean follow-up of 1.6 years in 66%	Fukushima Daiichi, Japan	• Prevalence of diabetes increases significantly during the disaster from 9.3% to 11% (P<0.0001) • Among the normal glucose group, HbA1c levels increased significantly after the disaster from 5.20%±0.21% to 5.21%±0.26% (P<0.0001) mostly among evacuees • Among the borderline glucose group, HbA1c levels increased significantly after the disaster from 6.10%±0.13% to 6.14%±0.61% (P<0.0004) non-evacuees • There was a significant increase in BMI among evacuees within the	• -

						normal, normal-high and borderline glucose group (P<0.0001). Obesity is a risk to insulin resistance. • The evacuation was significantly associated with the incidence of diabetes after adjusting for age, sex, BMI Smoking status, Systolic blood pressure, HDL-C, ALT, and ɣ-GT level. • Crude incidence of diabetes was higher at 25.1% among subjects/group with borderline glucose	
21	Kamoi et al.[64]	Mid Niigata Prefecture Earthquake, 2004	Prospective uncontrolled study	222 type 2 diabetic patients	Niigata, Japan	• Significant increase in the morning home blood pressure level among diabetics • HbA1c level increased significantly in the second month of study post-quake all patients independent of whether they measure blood pressure in the morning after the disaster or not • Percentage of patients	• -

						with nephropathy is increased. 13 new cases (16%) in the third month and 17 patients (11%0 in the sixth month • Stress was associated with elevated BP and a risk factor for the development of macrovascular complication among diabetic.	
22	Kishimoto and Nada[42]	Great East Japan Earthquake, 2011	Perspective/ Anecdotal evidence		Tohoku District, Japan	• Loss of blood glucose control • Loss of oral antidiabetic agents or insulin in collapsed houses whereas other were washed away by tsunami • Deterioration of diabetic condition due to hostile living environments of patients. • Refugee condition made it difficult for patients with diabetes to eat properly. • Refugees had plenty of sweet burnt, snacks, rice balls mostly high in carbohydrate	• Loss or damage of medical records and difficulty for medical team to treat/manage patients • Difficulties in transporting supplies due to the destruction of transportation networks.

						• Grief due to loss induced loss of appetite • Stress and dehydration - due to low liquid intake also associated with aggravated diabetic control	
23	Kishimoto and Nada[17]	Great East Japan Earthquake, 2011	Special report		Japan	• Loss of oral antidiabetic agents or insulin in collapsed houses whereas other were washed away by tsunami • Deterioration of diabetic condition due to unfavourable living environments. • Food is limited and available ones are high in carbohydrate	• Loss or damage of medical records in collapsed building or tsunami. So difficult to manage patients with new medications
24	Hendrickson and Vogt[81]	Hurricane Iniki, 1992	Retrospective study	"Mortality data for residents of Kauai for the 5-year" periods of 1987-1991	Kauai, Hawaii	• Increased deaths from diabetes mellitus post-Iniki (RR= 2.61)	• Limited disruption of medical care and supplies • Limited food supplies after Iniki
25	Ryan et al.[85]		Integrative review			• Risk of severe exacerbation or even death with inadequate treatment • Damage of medication,	• Disruption of treatment, poor nutrition, loss of power for insulin

						loss of prescription and disrupted activity patterns.	storage.
26	Ng et al.[72]	flooding in Hull	Longitudinal study	"1743 respondents, 296 patients had been affected by the floods (110" insulin-treated, 186 lifestyle and oral agents) and 1447 unaffected (482 insulin-treated, 965 lifestyle and oral agents) "12 months before and after the floods in Hull and East Yorkshire, UK."	Hull and East Yorkshire, UK.	• Rise/deterioration in mean HbA1c of affected individuals comparing 12 months before the floods with 12 months after [mean (95% confidence interval), 7.6% (7.5–7.7) vs. 7.9% (7.7–8.0), • P =0.002]. mostly among those taking insulin treatment [8.2 (8.1–8.3) vs. 8.6 (8.3–8.9), *P*=0.002] • Patients with Type 1 diabetes (*n* = 60) had an increase in HbA_{1c} [8.1% (7.9–8.5) vs. 8.6% (8.2–8.9), *P*= 0.02] as did the patients with insulin-treated Type 2 diabetes (*n*=50, HbA_{1c} 8.2% (7.9–8.4) vs. 8.6% (8.3–8.8), *P*=0.04).	•
27	Ramachandran et al.[71]	Southern India coastal population	Comparative study	"Subjects aged 20 years or above were randomly selected (control	Southern India	• "Prevalence of undetected diabetes (5.7 % vs. 3.8 %; Z = 9.54, P < 0.001) and impaired glucose	•

		affected by tsunami		population n = 1176; tsunami population n= 1184)."		tolerance (9.8 % vs. 8.3 %; Z = 12.83, P < 0.001) higher in the tsunami area." • High stress is associated with the poor glycaemic control.	
28	Berggren and Curiel[43]	Hurricane Katrina, 2005	Perspective/ Anecdotal evidence		New Orleans	• Complications in patients with untreated chronic diseases e.g. diabetic ketoacidosis • Diabetics have been off their insulin for six months • Stress was also associated with exacerbation of underlying health problems	• Emergency department patients can't move into the hospital because beds aren't available. And there is no surge capacity. • Some medical staff resigned (Approx. 40 of Ochsner's 600 physicians)
29	Salman et al.[66]	Marmara earthquakes 1999	Letter to the editor	Patients (*n* = 77; males 47%; age 24.2 ± 8.5 years) who had participated in a previous Quality of Life study in October 1998 and they were affected by at least one of the quakes.	Turkey	• HbA1c (7.4 ± 1.5 *vs* 8.8 ± 2.5%; *P* < 0.001) and daily insulin requirement (0.58 ± 0.3 *vs* 0.75 ± 0.3 IU/kg per day; *P* < 0.001) were increased	•

30	Kessler et al.[15]	Hurricane Katrina 2005	Descriptive survey	1043 displaced and nondisplaced English-speaking Katrina survivors aged 18 years and above		• 30.6 % reported disrupted treatment of diabetes after the hurricane. This was common among those aged <65 years, without health insurance, having no relative in unaffected areas and those without confidants in a hurricane area. • Treatment disruption was 3 time more likely in those experiencing residential instability after hurricane • Limited access to Physicians leading to more of disturbance of services • Restricted access to medication	• Small reduction in care
31	Chan and Kim[73]	2008 Sichuan, China Earthquake	Descriptive, cross-sectional study	Record-based data of 132 patients evacuated to a triage centre. Women 55% and men 45% with a mean age 79 years.	Sichuan, China	• Majority (77%) had at list one underlying NCDs (diabetes, 23%) • Increase incidence of diabetes • Diseases exacerbation and increase in clinical complications	• Lack of medications • Lack of requited active clinical management of chronic conditions

APPENDIX 2: PRISMA 2009 CHECKLIST

Section/topic	#	Checklist item	Reported page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	

Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	