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Original Contribution

Disaster-related Stress as a Prospective Risk Factor for Hypertension in Parents of Adolescent Fire Victims

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Life stress has been related to hypertension in various studies, but well-designed research carried out in disaster settings is scarce. Moreover, most research focuses on the primary victims and disregards effects on their caregivers. In a prospective, population-based cohort study, the authors tested the hypothesis that parents of adolescents who had been involved in the Volendam, Netherlands, pub fire on January 1, 2001 ($n = 418$) were more at risk of developing hypertension than parents from the same community whose children had not been involved in the fire ($n = 1,462$). Only residents without prior evidence of hypertension were included. The follow-up period covered 4 years (2001–2004). Assessment of hypertension was based on the records of family practitioners and pharmacies. The odds of developing new hypertension were 1.48 times higher in parents of fire victims than in control parents during the follow-up period (odds ratio = 1.48, 95% confidence interval: 1.09, 2.02). All analyses controlled for age, gender, socioeconomic status, family practice, history of chronic disease, and number of contacts with the family practitioner during follow-up. Since hypertension is an important risk factor for cardiovascular morbidity, it is important to provide interventions that help people fight the negative effects of disaster-related stress.

blood pressure; burns; disasters; family practice; hypertension; life change events; prospective studies; stress, psychological

Abbreviations: CI, confidence interval; OR, odds ratio.

Disasters are dramatic examples of real-life settings that trigger intense physiologic and emotional reactions (1, 2). Acute blood pressure elevations in response to stress have been extensively documented in laboratory settings, and prolonged elevations have been observed with exposure to chronic or repeated stressors (3, 4). There are some examples of research dealing with hypertension in catastrophic situations. Most of these studies have described the effects of earthquakes (5–9). An exception is a study documenting increased blood pressure levels among immigrants to Israel who had been affected by the Chernobyl disaster (10). Research in disaster settings is difficult to implement, however, and many such studies suffer from methodological problems. Generally, the major problem is the lack of measurements taken before the event occurred. Other problems concern insufficiently long follow-up periods, lack of control groups, and inappropriate sample sizes.

To our knowledge, there have been only two studies performed in a disaster context where the investigators had access to predisaster assessments (11, 12). The findings were inconsistent. The subjects in the first study were participants in a blood pressure telemonitoring trial at four US sites. That study demonstrated significant increases in systolic blood pressure within a time window of 2 months after the terrorist attacks of September 11, 2001, in comparison with the preceding 2 months (11). A second study examined

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factory workers after a major earthquake in Italy. Here, blood pressure levels remained unchanged, both in the short term and 7 years after the quake (12). However, the participants lived 130 km (81 miles) from the epicenter. They were uninjured, did not suffer deaths in the family, and did not lose property or employment as a result of the quake.

The current cohort study also had a prospective design but dealt with a different type of disaster exposure. The disaster described here was considered one of the worst mass burn incidents ever to happen in the Netherlands. The fire occurred on January 1, 2001, in an overcrowded pub in Volendam where about 350 young people were celebrating New Year's Eve. It injured more than 200 people and killed 14 (13). After the disaster, the victims' parents were forced to deal with a number of stressful experiences. Without doubt, learning that one's child has been injured or killed in a fire is a strong, acute stressor. Over the long term, parents also must cope with the chronic physical disabilities and emotional scars that their children received from the traumatizing event (14). Negative affect, which may manifest itself as depression, anxiety, anger, or hostility, has been related to hypertension in various studies (15–19). Therefore, we hypothesized that parents of affected adolescents would be more at risk of developing hypertension than parents from the same community whose children had not been affected. Parents who had lost a child to death and parents of children who had suffered burns in the fire were expected to be more at risk than parents whose child had survived the fire without physical injuries.

MATERIALS AND METHODS

Setting

Volendam is a former fishing town located 32 km (20 miles) north of Amsterdam; it has approximately 20,000 inhabitants (20). The population is served by four family medical practices. In the Netherlands, family practitioners have a key position as gatekeepers of specialist care, which is only accessible after referral by a family practitioner. The health care system is organized on an insurance basis. Until 2006, two types of health insurance existed in the Netherlands, public and private. Patients with an annual income below a specific level were insured through public insurance; above this level, patients were privately insured. Insurance type can thus be used as a proxy for the socioeconomic status of the patient.

Dutch family practitioners have fixed patient lists, and patients are registered with one family practitioner only. In general, complete families are enrolled in the same practice (21). The participating family practitioners keep electronic registration systems, and they code all medical events according to the International Classification of Primary Care (22). Another source of information is the registrations of local pharmacies. The pharmacy records can be linked to the family practitioner registrations and contain virtually complete information on all drugs dispensed to outpatients (prescribed either by the family practitioners or, on an extramural basis, by specialists). All prescriptions are coded according to the Anatomical Therapeutic Chemical classification system (23).

Study population

Firstly, it was necessary to identify the fire victims. According to official estimates, approximately 300–350 people were in the building at the time of the fire. On request, the family practitioners identified 335 victims in their registrations (14 deceased adolescents and 321 survivors, with and without physical injuries). Thirty-five survivors were excluded because they belonged to a practice that was not yet fully computerized, leading to a sample of 300 victims (286 survivors and 14 deceased). The 286 survivors did not differ significantly from nonparticipants ($n = 35$) with respect to burn size, number of days spent in the hospital, gender, age, or insurance status. Participants with burn injuries ($n = 162$) had a mean total burned surface area of 14.9 percent (standard deviation, 17.1) and spent, on average, 34.2 days (standard deviation, 59.3) in the hospital during the first 12 months after the disaster. Secondly, we identified all cohabiting parents of deceased and/or surviving victims with the help of electronic patient registration ($n = 499$).

Thirdly, we selected all patients ($n = 1{,}756$) from the three participating family practices who had children within the age range of 14–20 years who had *not* been trapped in the fire (''community controls'').

Subgroups of parents of disaster victims

The affected parents were further subdivided into three groups according to their exposure to stress. The number of family units per cohort was 884 in controls and 250 in parents of fire victims. In 29 of these 250 units (11.6 percent), more than one child was present during the fire. If at least one child in the family had died as a consequence of the fire, the parent was included in the ''bereaved'' cohort (14 family units). If all children in the family had survived the fire and at least one child had suffered burns, the parent was assigned to the cohort ''parents of children with burns'' (140 family units). If all children in the family had survived the fire and none had suffered burns, the parent was included in the cohort named ''parents of children without burns'' (96 family units).

Inclusion of patients

Patients who were not enrolled during the full follow-up period were excluded. Figure 1 shows the numbers of patients selected for further analysis.

Baseline data and assessment of medical history

The characteristics of the cohorts are displayed in tables 1 and 2. In addition to basic demographic data (gender, insurance type, and age), patients' medical histories were assessed by screening their pharmacy and family practitioner records for the presence of or pharmacologic treatment of conditions often associated with hypertension (i.e., diabetes, cardiovascular disease, asthma/chronic obstructive pulmonary disease, migraine, and hyperthyroidism).

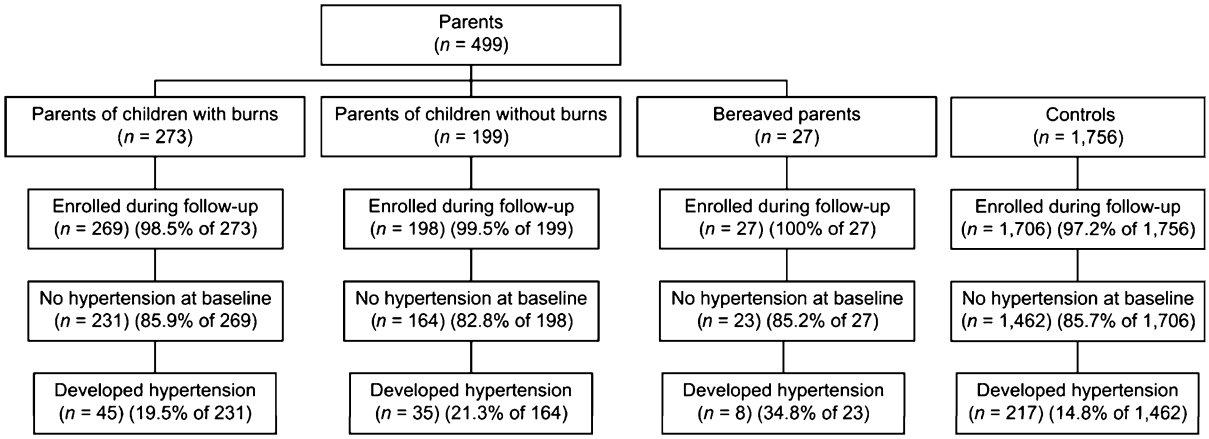

FIGURE 1. Distribution of parents of adolescent fire victims (parents of victims with burns, parents of victims without burns, and bereaved parents) and control parents in a study of stress-related hypertension, Volendam Hypertension Study, Volendam, the Netherlands, 2001–2004.

Assessment of hypertension

A patient was considered hypertensive if he or she was diagnosed with hypertension by the family practitioner (International Classification of Primary Care codes K86 or K87) and/or received at least one prescription for an antihypertensive medication (Anatomical Therapeutic Chemical codes C02, C03, C04, C07, C08, or C09). The codes K86 (uncomplicated hypertension) and K87 (hypertension with involvement of target organs) are assigned only when at least three measurements have yielded significantly elevated blood pressure levels (systolic blood pressure $\geq$140 mmHg and/or diastolic blood pressure $\geq$90 mmHg).

Analyses

Since the observations in our study were not fully independent (individuals were clustered within couples), all analyses were performed within a multilevel framework considering the patient as the first level and the family as the second level (24). All analyses were based on two-sided tests and were carried out using MLwiN software (available at http://www.cmm.bristol.ac.uk). In order to answer the study question, we constructed two logistic regression models with ''becoming hypertensive during the follow-up period'' (yes = 1, no = 0) as the dependent variable.

The first model was constructed in order to answer the question of whether the risk of becoming hypertensive was higher in parents of fire victims than in controls. The exposure variable thus was ''being a parent of a fire victim'' (yes = 1, no = 0). As covariates, age (in years), gender (male = 0, female = 1), insurance type (private = 0, public = 1), history of chronic disease (yes = 1, no = 0), being a single parent (yes = 1, no = 0), number of contacts with the family practitioner during follow-up (continuous), and the family practice in which the patient was enrolled were included (two dummy variables were used in order to model three practices).

In a second model, we explored whether different types of exposure increased the risk of becoming hypertensive. The three exposure groups (parents of children with burns, parents of children without burns, and bereaved parents) were modeled using three dummy variables, with controls serving as the reference category. The risk of parents of children with burns was compared with the risk of bereaved parents by means of a contrast (effect coding).

Another important question was whether some of the three practices were more likely to detect hypertension in parents of fire victims than in controls because of differential screening behavior. Therefore, we performed a third regression analysis including all centered covariates, one dummy variable for each practice, and interaction terms for the interaction of each practice with the variable ''being a parent of a fire victim'' (yes = 1, no = 0; the intercept was not included in the model). Consequently, these interaction terms were compared with the help of contrasts.

RESULTS

Baseline characteristics

Parents of fire victims and controls were comparable regarding gender, insurance type (public or private), history of diseases that may predispose to the development of hypertension, and number of contacts with the family practitioner during the 12 months prior to the disaster (table 1). The two groups were not equally distributed among the three practices, however; most parents were registered with practice 3. In addition, the percentage of persons who were single parents was significantly higher in controls than in parents of fire victims. Correspondingly, the mean family size was significantly lower in controls. Furthermore, parents of fire victims were significantly younger than controls, on average.

The three subgroups of parents (parents of victims with burns, parents of victims without burns, and bereaved parents) were comparable with respect to age, gender,

TABLE 1. Baseline characteristics of 418 parents of adolescent fire victims and 1,462 control parents without evidence of hypertension at baseline, Volendam Hypertension Study, Volendam, the Netherlands, 2001–2004

	Parents of victims ($n = 418$)		Control parents ($n = 1,462$)		p value†
	No.	%	No.	%	
Male gender	202	48.3	694	47.5	0.757
Public insurance	252	60.3	812	55.5	0.084
History of chronic disease					
Hyperlipidemia	40	9.6	107	7.3	0.131
Diabetes mellitus	2	0.5	20	1.4	0.195
Cardiovascular disease	2	0.5	13	0.9	0.405
Migraine	22	5.3	56	3.8	0.195
Asthma/chronic obstructive pulmonary disease	31	7.4	103	7.0	0.795
Hyperthyroidism	6	1.4	23	1.6	0.840
At least one of the above	92	22.0	287	19.6	0.285
Family medical practice					
Practice 1	91	21.8	452	30.9	0.000***
Practice 2	77	18.4	391	26.7	
Practice 3	250	59.8	619	42.3	
Single parent	10	2.4	109	7.5	0.000***
	Mean	SD‡	Mean	SD	
Family size	4.3	0.8	4.0	0.8	0.000***
No. of contacts with family practitioner prior to fire	4.7	4.3	4.3	4.3	0.104
Age (years)	45.9	4.4	46.4	4.8	0.033*

* $p < 0.05$; ***$p < 0.001$.

† Based on two-sided analysis (analysis of variance for continuous variables; chi-square test for discrete variables).

‡ SD, standard deviation.

insurance type, single parenthood, average family size, number of contacts with the family practitioner during the 12-month predisaster period, and the majority of diseases which may predispose to the development of hypertension (table 2). They significantly differed with regard to the proportion of persons with a history of asthma or chronic obstructive pulmonary disease, with the highest percentage being found in the group of bereaved parents. In addition, the three subgroups of parents were not equally distributed among the three practices.

Univariate analysis of patients' characteristics in relation to the development of new hypertension

Patients who developed hypertension during the follow-up period more often had a history of diabetes, cardiovascular disease, migraine, and asthma (table 3). In addition, more bereaved parents developed hypertension than parents of surviving victims. Moreover, persons with incident hypertension had significantly more contacts with their family practitioner during the postfire follow-up period than did patients without incident hypertension, and they were significantly older.

Multivariate analysis

We examined whether parents of fire victims were more at risk for developing hypertension than controls after adjustment for the covariates age, gender, insurance type, history of chronic disease, number of contacts with the family practitioner during the postfire follow-up period, family practice, and single parenthood. As table 4 indicates, the risk of becoming hypertensive during the 4-year follow-up period was 1.48 times higher (95% confidence interval (CI): 1.09, 2.02) in parents of fire victims than in controls.

We constructed a separate model in order to study differences in risk between the three subgroups of parents and the control group (not shown in table). When compared with controls, bereaved parents had the highest risk of becoming hypertensive (odds ratio (OR) = 2.42, 95 percent CI: 0.90, 6.55), followed by parents of victims with burns (OR = 1.43, 95 percent CI: 0.97, 2.11) and parents of victims without burns (OR = 1.44, 95 percent CI: 0.92, 2.26). However, these findings were statistically nonsignificant. We also tested whether the risk of becoming hypertensive was significantly higher in one subgroup than in another. More specifically, the pairs ''parents of victims with burns/parents of victims without burns,'' ''parents of victims with burns/bereaved parents,'' and ''parents of victims without burns/bereaved parents'' were compared. None of these pairwise comparisons reached statistical significance ($\chi^2 = 0.00$, 1 df, two-sided $p = 0.964$; $\chi^2 = 1.10$, 1 df, two-sided $p = 0.319$; and $\chi^2 = 1.10$, 1 df, two-sided $p = 0.341$, respectively).

Finally, we examined whether some of the three family practices were more likely to detect hypertension in parents of fire victims than in control parents. The analyses demonstrated that parents of fire victims enrolled with practice 1 were not more likely to be diagnosed with new hypertension than parents of fire victims enrolled with practice 2 ($\chi^2 = 2.26$, 1 df, two-sided $p = 0.132$) or practice 3 ($\chi^2 = 1.06$, 1 df, two-sided $p = 0.303$). Neither were parents of fire victims who were enrolled with practice 2 more likely to be diagnosed with new hypertension than parents of fire victims registered with practice 3 ($\chi^2 = 0.55$, 1 df, two-sided $p = 0.458$; results not shown in table).

DISCUSSION

The present study is one of the very few prospective population-based studies of hypertension to have been carried out in a disaster setting. Our results show that being the parent of an adolescent fire victim is independently related to the likelihood of becoming hypertensive. During 4 years of follow-up, the risk of parents' developing hypertension was 1.48 times that of controls (95 percent CI: 1.09, 2.02).

TABLE 2. Baseline characteristics of 418 parents of adolescent fire victims without evidence of hypertension at baseline, Volendam Hypertension Study, Volendam, the Netherlands, 2001–2004

	Parents of victims with burns ($n = 231$)		Parents of victims without burns ($n = 164$)		Bereaved parents ($n = 23$)		p value†
	No.	%	No.	%	No.	%	
Male gender	110	47.6	80	48.8	12	52.2	0.907
Public insurance	137	59.3	98	59.8	17	73.9	0.388
History of chronic disease							
Hyperlipidemia	24	10.4	16	9.8	0	0.0	0.270
Diabetes mellitus	2	0.9	0	0.0	0	0.0	0.443
Cardiovascular disease	0	0.0	2	1.2	0	0.0	0.211
Migraine	13	5.6	9	5.5	0	0.0	0.508
Asthma/chronic obstructive pulmonary disease	11	4.8	15	9.1	5	21.7	0.007**
Hyperthyroidism	3	1.3	3	1.8	0	0.0	0.761
At least one of the above	45	19.5	42	25.6	5	21.7	0.350
Family medical practice							
Practice 1	68	29.4	19	11.6	4	17.4	0.000***
Practice 2	40	17.3	30	18.3	7	30.4	
Practice 3	123	53.2	115	70.1	12	52.2	
Single parent	7	3.0	2	1.2	1	4.3	0.418
	Mean	SD‡	Mean	SD	Mean	SD	
Family size	4.3	0.7	4.2	0.7	4.1	0.7	0.310
No. of contacts with family practitioner prior to fire	4.7	4.5	4.6	4.0	4.7	5.0	0.955
Age (years)	45.6	4.1	46.3	4.8	45.7	3.9	0.254

** $p < 0.01$; *** $p < 0.001$.

† Based on two-sided analysis (analysis of variance for continuous variables; chi-square test for discrete variables).

‡ SD, standard deviation.

We also examined whether parents of adolescents who had suffered burn injuries during the disaster were more at risk for new hypertension than parents of adolescents who had been present but remained uninjured. The underlying assumption was that having a child who is suffering from burn injuries is especially distressing due to the high burden of care associated with burns (25). Another hypothesis was that parents who had lost a child due to the fire were more at risk of developing hypertension than parents whose child survived the disaster (26). None of the two assumptions was supported by our data, however. In the case of bereaved parents, the sample was very small, and therefore significant differences were hard to detect. In the case of parents of children with burns, the result was more surprising. One explanation could be that both groups were equally distressed. Another explanation could be that there were more stress-reducing interventions available to parents of victims with burns than to parents of victims who survived the catastrophe without burns. Neither can we exclude the possibility that community support was lower for these parents, since at first glance they may have seemed more fortunate than parents of burn victims. It should not be forgotten, however, that caring for an adolescent who has survived a life-threatening incident but has witnessed friends or family members die at the site can also be difficult (27).

As with any epidemiologic study, there are limitations to our analysis. Firstly, one could criticize the fact that we measured ''exposure to disaster'' (being the parent of a fire victim) and not disaster-related distress itself, which was assumed to result from exposure. Indeed, a direct assessment of the level of disaster-related stress among patients conducted by means of psychometric questionnaires or interviews could have shed more light on the underlying mechanisms that may link exposure to hypertension. There is no doubt, however, that this group of parents was considerably distressed. Another study of the same parents indicated that they contacted their family practitioners more often for problems related to mental health than did controls (28). This effect was sustained throughout the 3 years after the event (28). Interestingly, as in the present study on hypertension, no differences were found between parents of victims with burns and parents of victims who had survived the fire without physical injuries.

A second limitation concerns the lack of information on obesity, smoking, and alcohol use, all of which are important causes of hypertension. Equally, it is unknown how

TABLE 3. Characteristics of case and control parents according to the presence or absence of incident hypertension, Volendam Hypertension Study, Volendam, the Netherlands, 2001–2004

	Incident hypertension ($n = 305$)		No incident hypertension ($n = 1,575$)		p value†
	No.	%	No.	%	
Male gender	135	44.3	761	48.3	0.194
Public insurance	182	59.7	882	56.0	0.236
History of chronic disease					
Hyperlipidemia	27	8.9	120	7.6	0.463
Diabetes mellitus	8	2.6	14	0.9	0.010*
Cardiovascular disease	6	2.0	9	0.6	0.012*
Migraine	22	7.2	56	3.6	0.003**
Asthma/chronic obstructive pulmonary disease	30	9.8	104	6.6	0.045*
Hyperthyroidism	5	1.6	24	1.5	0.881
At least one of the above	81	26.6	298	18.9	0.002**
Family medical practice					
Practice 1	84	27.5	459	29.1	0.166
Practice 2	89	29.2	379	24.1	
Practice 3	132	43.3	737	46.8	
Single parent	21	6.9	98	6.2	0.663
Parental subgroup					
Parents of fire victims	88	28.9	330	21.0	0.002
Parents of victims with burns	45	14.8	186	11.8	0.152
Parents of victims without burns	35	11.5	129	8.2	0.063
Bereaved parents	8	2.6	15	1.0	0.015*
	Mean	SD‡	Mean	SD	
Family size	4.1	0.8	4.1	0.8	0.401
No. of contacts with family practitioner during follow-up	31.9	17.9	19.1	15.4	0.000***
Age (years)	47.2	5.1	46.2	4.6	0.001**

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

† Based on two-sided analysis (analysis of variance for continuous variables; chi-square test for discrete variables).

‡ SD, standard deviation.

TABLE 4. Odds† of incident hypertension among parents of adolescent fire victims ($n = 418$) and control parents ($n = 1,462$) during 4 years of follow-up, Volendam Hypertension Study, Volendam, the Netherlands, 2001–2004

	Odds ratio	95% confidence interval	p value‡
Age (years)	1.07	1.03, 1.10	0.000***
Gender (female = 1, male = 0)	1.07	0.80, 1.44	0.632
Type of health insurance (public = 1, private = 0)	0.98	0.74, 1.30	0.892
History of chronic disease (yes = 1, no = 0)	0.86	0.62, 1.19	0.360
No. of contacts with family practitioner during follow-up	1.04	1.03, 1.05	0.000***
Enrolled with family practice 1 (yes = 1, no = 0)	0.84	0.59, 1.21	0.352
Enrolled with family practice 3 (yes = 1, no = 0)	0.62	0.45, 0.87	0.005**
Single parent (yes = 1, no = 0)	1.06	0.62, 1.82	0.839
Parent of a fire victim (parent of victim = 1, control = 0)	1.48	1.09, 2.02	0.012*

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

† Multivariate logistic regression analysis.

‡ Based on two-sided multivariate analysis (Wald chi-square test).

lifestyle changes (which occur as a consequence of disaster-related stress) or psychosocial interventions that were provided in the aftermath of the disaster influenced the results (29).

Thirdly, one could speculate that parents of disaster victims are more likely to be examined for potential health problems. Therefore, the chance of detecting abnormal blood pressure in these parents could have been higher than in controls. Although such detection bias could not be directly assessed in our data, we carried out additional analyses to examine this issue indirectly. A generalized detection bias would be expected to also operate on other medical conditions of which patients were unaware. We therefore checked the incidence of diabetes and hyperlipidemia during the follow-up period in both parents of fire victims and control parents. None of the two conditions provided evidence for a systematic distortion of results. In addition, we controlled for the number of contacts with the family practitioner in our analyses in order to minimize the effects of a potential detection bias.

Finally, the Volendam disaster occurred in a close-knit community and probably had a disruptive effect on social networks. It is possible that some of the patients in the community control cohort were relatives or friends of the affected families. Therefore, we cannot exclude the possibility that some of the community controls were also distressed and prone to the development of new hypertension. Should this have been the case, however, it is even more surprising that differences between the two groups were found.

Next to these limitations, the study has several strengths. One is the use of physician-verified diagnoses and prescriptions. This kind of data is preferable because it is not prone to recall bias. Moreover, in the current study, the definition of hypertension was rather strict, since the diagnosis was assigned only when several measurements had yielded significantly elevated blood pressure levels or when the elevation was significant enough to necessitate pharmacologic treatment. This guaranteed that only clinically significant cases of hypertension were captured. Therefore, if anything,

the incidence of hypertension was underestimated rather than overestimated in our study.

Another strength of the study is that selection bias can be virtually excluded, since the patients were anonymously monitored. Because of this procedure, loss to follow-up was due only to patients' leaving the medical practice (e.g., dying or moving away) and not to other reasons common in studies based on questionnaires or interviews. Finally, the prospective design and the long follow-up period of the study were exceptional.

In general, the long-term effects described here are in line with the findings of Cwikel et al. (10), who studied immigrants to Israel who had been exposed to the Chernobyl disaster. At the same time, it contradicts the findings of Trevisan et al. (12), who did not find long-term effects in their study of workers exposed to an earthquake. Note that Trevisan et al. studied coronary heart disease risk factors in general and did not specifically examine hypertension. Also, one should not forget that a mass burn incident constitutes a different type of exposure than an earthquake or a terrorist attack. Clearly, the parents included here did not experience a threat to their own lives; rather, they were caregivers of potentially traumatized victims. The results presented here are therefore in line with the literature on secondary traumatic stress or ''compassion fatigue,'' which describes adverse effects on persons who are psychologically close to a victim (30).

Based on the finding that parents of adolescent disaster victims are more at risk of developing hypertension, two conclusions can be drawn. On the one hand, the finding emphasizes the impact stressful life situations can have on people's health. It is therefore important to provide interventions that help people fight the negative effects of disaster-related stress, be they short-term or long-term. This is of public health importance, because a substantial proportion of cardiovascular disease is attributable to hypertension. On the other hand, the study demonstrates that disasters or traumatic experiences affect not only those who are directly exposed but also those who are close to the victims. This points to the need to incorporate a family perspective when planning postdisaster interventions.

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