

RESEARCH ARTICLE

Stress and salivary cortisol in emergency medical dispatchers: A randomized shifts control trial

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Abstract

Stress at work is a public health concern. Phone operators in emergency medical dispatch centers are particularly at risk. We aimed to demonstrate that the most stressful time for emergency medical dispatchers is the shift when they receive emergency incoming calls, with cortisol as a biomarker of stress. For each emergency medical dispatcher, we measured outcomes over a control day and during three types of shift: *Incoming emergency call*, *Dispatch* and *Re-assessment*. The pattern of shifts was randomized. Saliva was sampled every 15 minutes for 2 hours, i.e. 6 consecutive times, starting 15 minutes after the first life-and-death incoming emergency call between 2 and 5 pm during three types of shift. We measured saliva cortisol every 2 hours over a control day, from 7am to 9pm. Perceived stress was assessed by a visual analog scale. We recruited 22 phone operators aged 36.4 +/-10.8 years old (14 women and 8 men). Cortisol values were higher during the *Incoming emergency call* shift than during the *Dispatch* ($p = .04$) and *Re-assessment* ($p = .04$) shifts. The increase in cortisol levels was greater in men than in women ($p = .009$). There were no differences between control values and those of the three shifts. The kinetics of cortisol increased with greater perceived stress overall ($p < .001$) and for each type of shift (*Incoming emergency call*, $p = .02$; *Dispatch* $p = .03$; *Re-assessment*: $p < .001$). The kinetics of cortisol in response to incoming emergency calls was greater when the call was an absolute emergency ($p = .03$), and also tended to further increase when a subsequent absolute incoming emergency call was received ($p = 0.07$). In conclusion, the incoming emergency call shift carries particular risk for dispatchers, who have greater perceived stress and a greater increase in cortisol levels.

Competing interests: The authors have declared that no competing interests exist.

Introduction

Stress at work is a public health concern [1,2,3,4]. Emergency medicine is a field where stress is constant [5,6,7]. An emergency, by definition, requires a rapid response with no possibility of predicting the workload [8,9]. Phone operators in emergency medical dispatch centers are particularly at risk because they must assess the gravity of the situation without seeing patients, a judgement that requires experience [10]. They must localize the victims as quickly as possible and deal with aggressive and violent behavior from patients and their relatives, excessive alcohol consumption and road accidents sometimes involving young children [11]. Stress in emergency medical dispatchers can lead to work-related exhaustion with various physical and psychological symptoms [12], and delayed decision-making due to misjudgment of the seriousness of the patient's condition [13]. All these factors contribute to increased sick leave [14] and an increased turnover of phone operators owing to their premature departure to other less stressful professions [15]. Objective measurements of stress are therefore needed to develop evaluable preventive strategies of stress management [16,17,18]. To identify stress at a biological level, cortisol is the historical biomarker which can now be assessed easily and pain-free from saliva [19,20,21,22,23]. To our knowledge, only one study has used objective measurements to assess stress in emergency medical dispatchers [6]. The authors observed higher levels in the phone operators than in controls but did not compare levels at different shift times. In addition, although it is known that cortisol levels are related to perceived stress and acute mental stressful events [19,20,21,22,24], they did not investigate the specific effect of incoming emergency calls. Finally, the increase in cortisol levels in response to stress is greater in females [25] and in non-experienced workers/individuals [19,20,21,22].

From these observations, we hypothesized that 1) cortisol levels are a relevant biomarker of stress in emergency medical dispatchers during the *Incoming emergency call* shift 2) cortisol levels are related to perceived stress and 3) are able to identify stressful events (severity of incoming emergency call or effects of a subsequent absolute incoming emergency call) and 4) are related to sociodemographic variables such as gender and experience.

Thus, the aims of our study were to obtain objective assessments of stress by measuring saliva cortisol levels during the various shifts worked by emergency medical dispatchers, and to investigate the independent associations between perceived stress, severity of incoming calls and other variables.

Methods

Participants

Participants were phone operators working in the emergency dispatch center of the Mercy Regional Hospital Centre (CHR) of Metz-Thionville, France. Participants were recruited in May 2014 and we obtained complete data by October 2014. We recruited both men and women to better represent the whole team of medical dispatchers. Exclusion criteria were psychiatric disorders including depressive symptoms > 8 on the Hospital and Anxiety Scale [26], recent extraprofessional life stress event (such as death of a near relative, divorce) [27], alcohol consumption > 3 drinks per day for men and > 2 for women [28], endocrine disorder [29], oral contraceptive [25,30] and pregnancy [31], any medications used to modulate inflammatory diseases taken over the previous three months (corticosteroids, anti-inflammatory drugs, immunomodulatory drugs) [32], intensive sports > 3 hours per week of intense physical activity [33], and any current illness/infection [34] at the time of measurements (feeling feverish sensations or having hyperthermia above 38.5°C) [35]. The protocol was approved by the Human Ethics Committee of the University Hospital of Nancy, France (Clinical Trials identifier NCT02075424). The study was

explained to the phone operators, who provided their written informed consent. We did not exclude non-menopausal women because basal cortisol levels do not differ during the menstrual cycle [31]. In addition, studies involving work stress and cortisol levels in acute care settings have mainly involved women [36,37,38,39].

Work description of an emergency medical dispatcher

The same phone operator alternated three types of shifts.

- **Incoming emergency calls:** Dealing with emergency calls is considered to be the most stressful situation. The phone operator is the first to answer incoming calls and must evaluate the severity of the situation and choose from among the following courses of action: absolute emergency situation immediately requiring a mobile intensive care unit (MICU); relative emergency situation that needs to be first managed by phone by an emergency physician to decide the best option; relative emergency situation that can be managed on site by a primary care physician; no emergency situation and transfer the call to a general practitioner primary care physician for advice.

- **Dispatch:** The phone operator manages the deployment of the different intervention teams. She or he must organize transport by calling the MICU, private ambulances or the fire department depending on the severity of the case. She or he always follows the orders of the emergency physician or the general practitioner primary care physician of the emergency medical dispatch center.

- **Re-assessment:** The phone operator must re-assess the different interventions and list the management of each patient.

All phone operators do only one kind of shift per working day. All included EMDs had the same working schedule i.e. 7am-7pm. As the impact of night shifts on biomarkers of stress may last several days [40,41], we included in this study only shifts which did not follow a night shift (7pm-7am) over the three previous days.

Shift randomization

For each phone operator, we measured outcomes during a control day and during the three types of shifts: *Incoming emergency call*, *Dispatch* and *Re-assessment*. Latin squares were used to randomize first the order between *Incoming emergency call* and *control day*. The *Incoming emergency call* shift was always before the two other types of shifts. However, after measurements were made during the *Incoming emergency call* shift, Latin squares were used to randomize the pattern of shifts between *Dispatch* and *Re-assessment*. All outcome data remained blinded until the end of the study.

Main outcome: Saliva cortisol

During the *Incoming emergency call* shift, saliva was sampled every 15 minutes for 2 hours, i.e. 7 consecutive times (+15min, +30 min, +45min, +60 min, +75min, +90 min, +120 min), starting 15 minutes after the first life-and-death incoming emergency call between 2 and 5 pm. Sampling was then performed 7 consecutive times during the other two shifts. We began sampling at the same time for each shift. As fasting affects cortisol levels [42], we controlled that participants had lunch during shifts. On the other hand, to avoid contamination of salivary samples, participants were asked to fast and refrain from brushing teeth and chewing gum within the hour before the putative beginning of sampling (4pm).

As chronic stress may affect the nictemeral cycle of cortisol [26,27], we measured saliva cortisol levels every 2 hours during a control day, from 7am to 9pm [29]. The control day was a day-off after at least 8 days of vacation, without jet lag.

Secondary outcomes

Socio-demographic variables (age, gender, and experience in the unit) were retrieved by self-reported questionnaires.

Perceived stress was assessed by a visual analog scale (VAS), which is a horizontal, non-calibrated line of 100 mm, ranging from very low (0) to very high (100) [43]. Perceived stress was measured at the same time as the first saliva sampling during the three types of shifts.

During the *Incoming emergency call* shift, the severity of the calls was expressed as absolute or relative. Any subsequent absolute incoming emergency call was also recorded.

Phone operators had to report any stressful events during the control day.

Biochemical measurements

Assays were done on saliva samples, since saliva is a good alternative to steroid hormones, in particular stress hormones, including those of the HPA axis [44]. Cortisol levels were assayed by commercial ELISA kits (Salimetrics, State College, USA), according to the manufacturer's recommendations (including sampling step). All samples were analyzed in duplicate. Mean values of duplicates were used to represent measured values. Sensitivity and intra- and inter-assay coefficients of variation were 0.05 ng/ml, 7% and 9.3%, respectively. The saliva kit was designed to avoid cortisone cross-reactivity [45].

Statistics

The sample size calculation was estimated on the basis of a previous study by members of our team [6] which showed a 22.8% increase in cortisol levels in emergency medical dispatchers compared with control participants. Following the recommendations of Cohen [46], who has defined effect-size bounds as small (ES: 0.2), medium (ES: 0.5) and large (ES: 0.8, “grossly perceptible and therefore large”), we decided to include 22 participants to evidence an effect-size equals 0.7 at +120min for a two-sided type I-error at 0.017 (correction due to multiple comparisons), a statistical power of 80%, and within subject variability at 0.5 (due to the experimental design).

Statistical analyses were performed with Stata software (version 13, StataCorp, College Station, TX, US). Data were presented as mean \pm standard deviation (SD). A Shapiro-Wilk test was used to test the assumption of distribution normality of cortisol. For paired comparisons (according to time of first life-and-death incoming emergency call, type of shift and control day values), standard statistical tests were performed, either paired Student t-test or Wilcoxon test when appropriate. To compare the longitudinal kinetics of this parameter in the three shifts, a zero-inflated Poisson random-effects model [47,48,49,50] was used to take into account (1) between- and within-subject variability and (2) statistical distribution characterized by frequent zero-valued observations (random event containing excess zero-count data in unit time). The zero-inflated Poisson model employs two components that correspond to two zero generating processes. The first process is governed by a binary distribution that generates structural zeros. The second process is governed by a Poisson distribution that generates counts some of which may be zero. The covariates were studied according to their clinical relevance, as fixed effects with a particular attention on interaction effects. All tests were two-sided, with a type I error set at $\alpha = 0.05$, taking into account when appropriate correction of type I error due to multiple comparisons.

Results

Participants

We recruited 22 phone operators, out of a potential pool of 28 (Fig 1). We obtained complete data for 22 of the 22 phone operators. They were aged 36.4 \pm 10.8 years (14 women aged

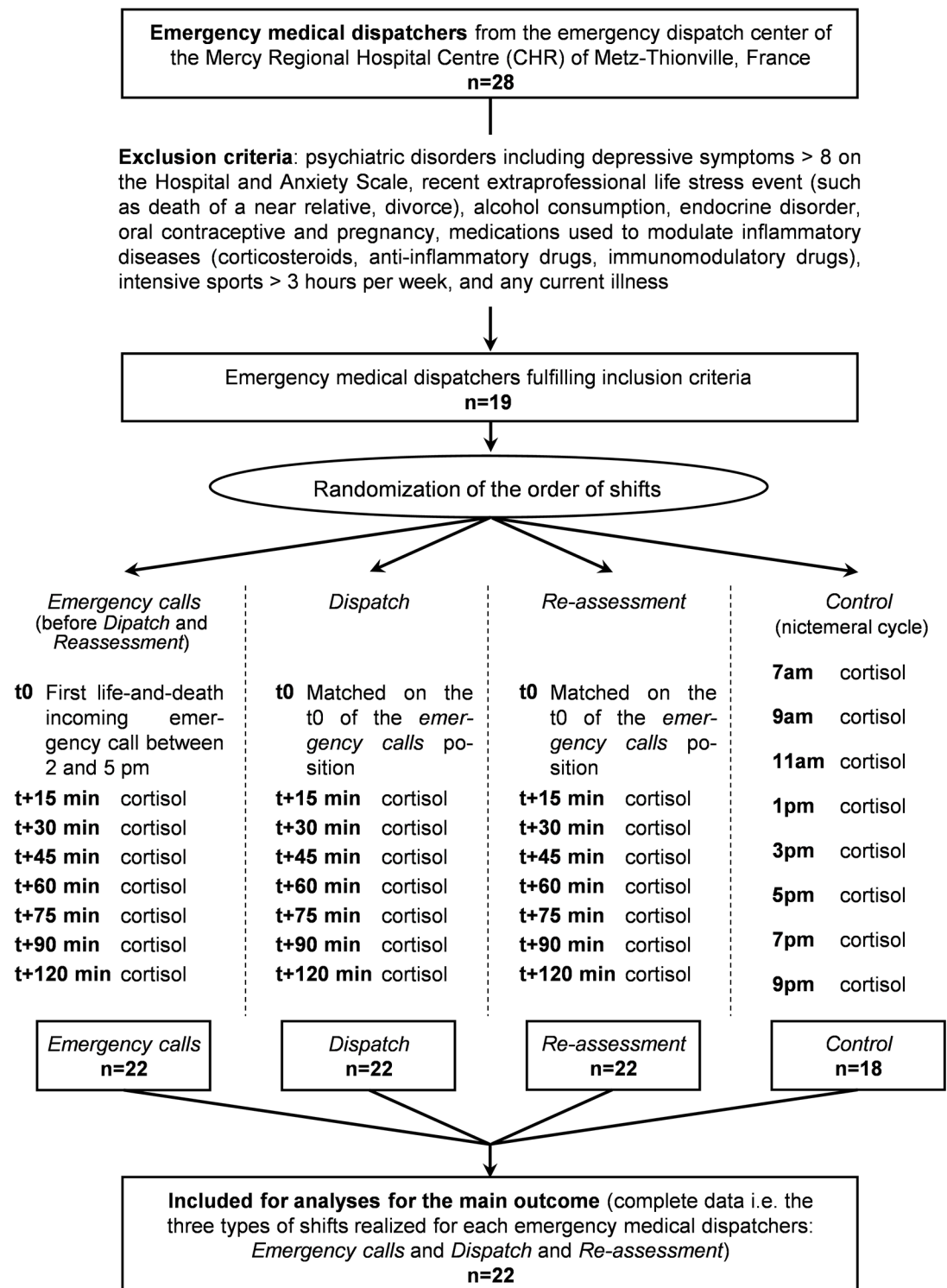


Fig 1. Flow chart and study design.

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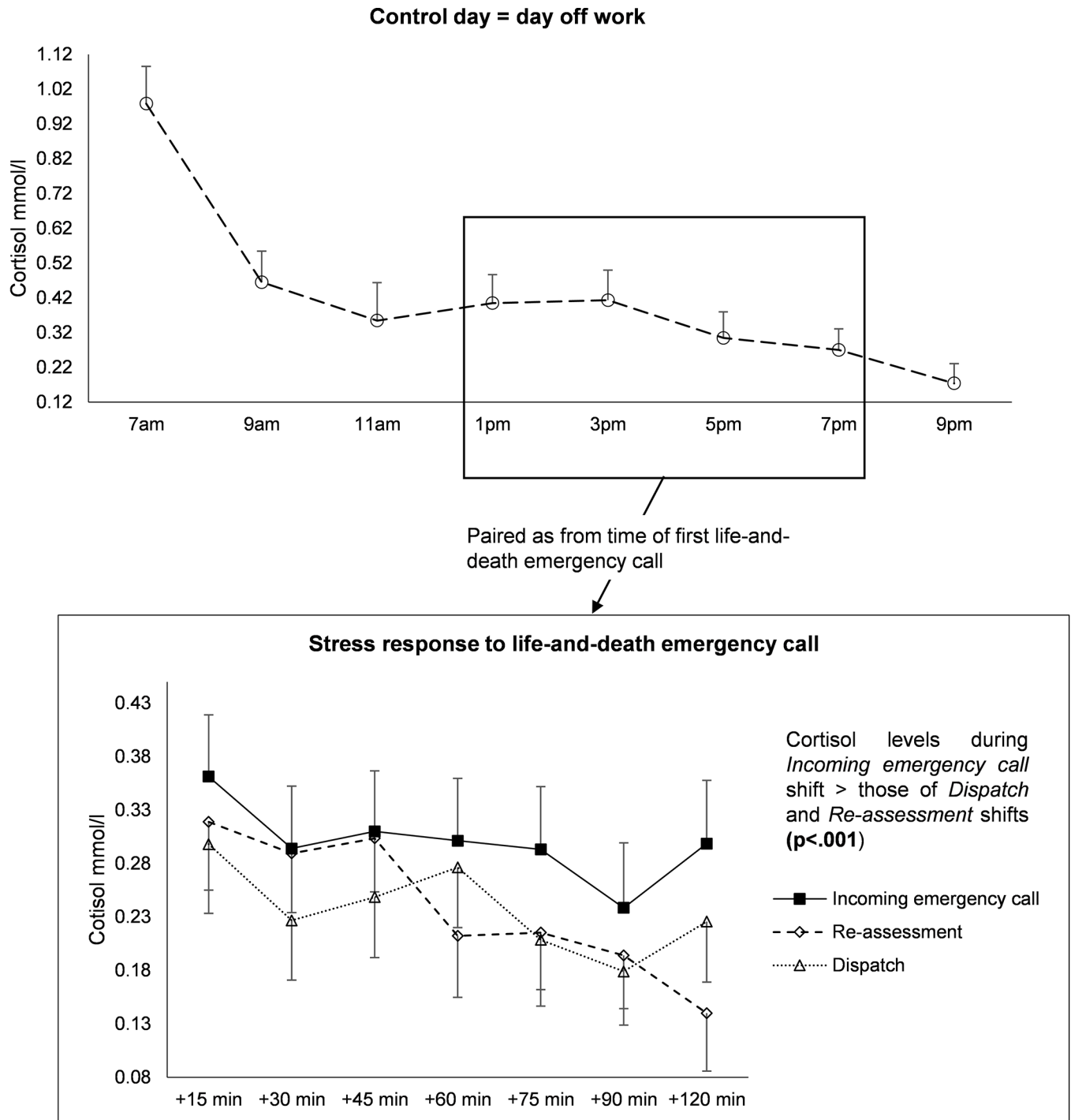


Fig 2. Cortisol levels during control day and paired cortisol levels as from time of first life-and-death incoming emergency call, and during Dispatch and Re-assessment shifts.

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37.9+/-10.7 years, 8 men aged 33.8+/-11.2 years). Men and women did not differ in age ($p = .35$) but female emergency medical dispatchers had greater experience: 86% of the women had a >5 year experience as against 25% of the men, $p = .004$. None of the participants were taking

routine medications and none took occasional medications during the study. No participant reported not having lunch before cortisol measurements during shifts.

Cross-sectional analyses of cortisol

Endpoint (+120min) between shifts. Cortisol levels at endpoint (+120 min) had a tendency ($p = 0.11$, effect-size 0.65) to be higher for *Incoming emergency call* shift (0.30 ± 0.28 mmol/l) than for *Re-assessment* (0.14 ± 0.23 mmol/l) and *Dispatch* shifts (0.23 ± 0.23 mmol/l) (Fig 2).

Baseline and endpoint between control day and shifts. Paired tests showed no differences between control values and shifts (15 minutes after *Incoming emergency call*, Control day vs *Incoming emergency call*: $p = .25$; Control day vs *Dispatch* $p = .66$; Control day vs *Re-assessment*: $p = .79$; Control day vs *Incoming emergency call*: $p = .25$; Control day vs *Dispatch*: $p = .66$; Control day vs *Re-assessment*: $p = .79$; 2 hours after *Incoming emergency call*, Control day vs *Incoming emergency call*, $p = .34$; Control day vs *Dispatch* $p = .18$; Control day vs *Re-assessment*: $p = .51$).

Longitudinal evolution of cortisol depending on shift

Comparison within shifts. For *Incoming emergency call* shift, cortisol values did not differ from baseline (+15min) except for +90min ($p = 0.02$). For *Dispatch* shift, the kinetic seemed comparable to *Incoming emergency call* shift with only significant difference at +90min ($p = 0.02$) and a tendency at +75min ($p = 0.08$). For *Re-assessment* shift, cortisol values differed from baseline after +60min ($p = 0.02$) (+75min, $p = 0.05$; +90min, $p = 0.02$; and +120min, $p = 0.001$).

Comparison between shifts. The study of interaction measurement-time x shift confirmed these results with no difference between *Incoming emergency call* and *Dispatch* shifts ($p = 0.91$) and between *Dispatch* and *Re-assessment* shifts ($p = 0.20$). However, there was a significant interaction between *Incoming emergency call* and *Re-assessment* shift ($p = 0.02$).

Zero-inflated Poisson random-effects model. A zero-inflated Poisson random-effects model [47,48,49,50] showed that kinetics did not differ between the three types of shift (interaction shift position x time, $p = .78$). However, when all measurements were taken into account, cortisol levels were higher during the *Incoming emergency call* shift than during the *Dispatch* ($p = .04$) and *Re-assessment* shifts ($p = .04$) (Fig 2). There was a tendency between the *Dispatch* and the *Re-assessment* shifts ($p = .095$).

Therefore, according to results of all those longitudinal analyses, *Incoming emergency call* and *Dispatch* shifts had a similar kinetic ($p = 0.91$) but with higher cortisol values for *Incoming emergency call* shift ($p = 0.04$). Moreover, *Incoming emergency call* and *Re-assessment* shifts had significant different kinetics ($p = 0.02$), with an increase of cortisol values for *Incoming emergency call* shift whereas cortisol values decreased for *Re-assessment* shift ($p = 0.04$).

Longitudinal evolution of cortisol levels depending on participants' characteristics

Gender. When all measurements were taken into account, cortisol values were greater for men ($p = .009$) (Fig 3). Subgroup analysis showed that this difference was only observed during the incoming emergency call shift ($p = .002$) (*Re-assessment*, $p = .075$; *Dispatch*, $p = 0.73$). The study of group x gender interaction confirmed this result ($p = .04$).

Age. There were no age-related differences in kinetics.

Experience in the EMD unit. An experience-related effect was observed ($p = .01$) but seemed to be dependent on gender. This was confirmed by multivariate analysis with experience and gender as covariates ($p = .21$).

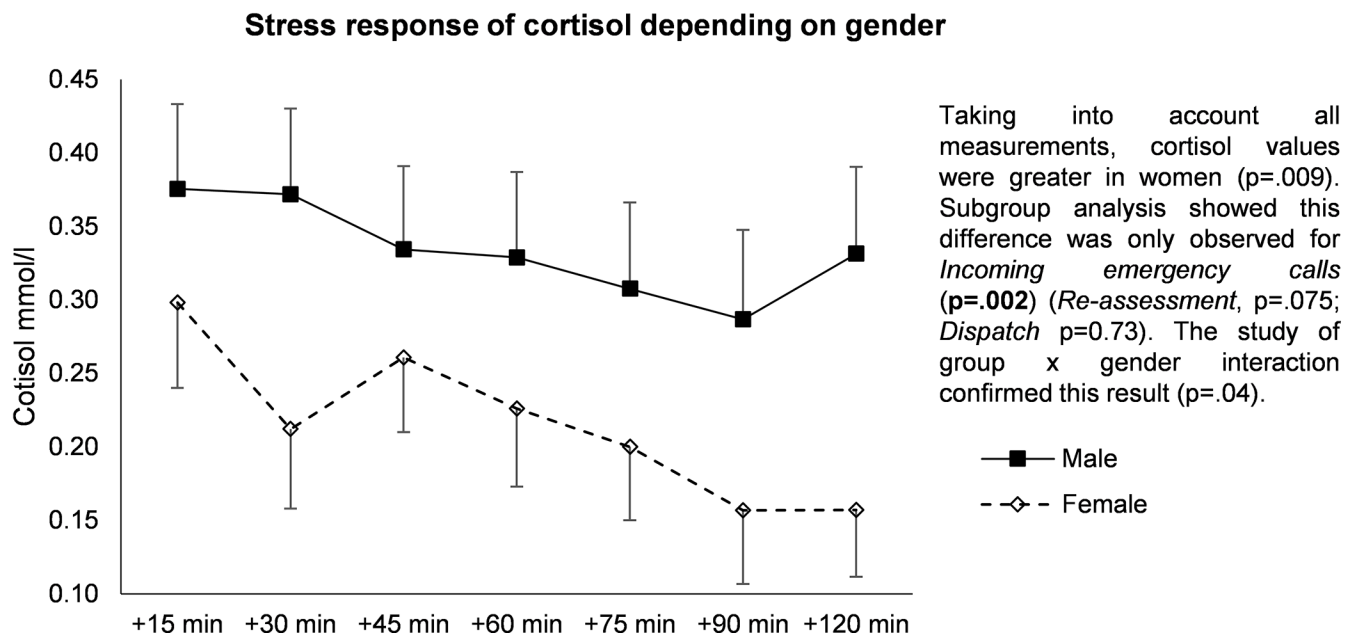


Fig 3. Stress response of cortisol depending on gender during the incoming call shift.

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Perceived stress. The kinetics of cortisol levels increased with greater perceived stress, overall ($p < .001$) and for each shift (*Incoming emergency call*, $p = .02$; *Dispatch*, $p = .03$; *Re-assessment*, $p < .001$).

Severity of incoming emergency call. The kinetics of cortisol levels in response to incoming emergency calls was greater when the call was an absolute emergency ($p = .03$ vs relative absolute incoming emergency call). In particular, participants dealing with an absolute emergency tended to have greater values of cortisol during the last four measurement times compared to workers who had no absolute emergency calls ($p = .09$) (Fig 4).

Subsequent absolute incoming emergency call. In phone operators who had a first absolute incoming emergency call, the kinetics of cortisol values tended to increase when there was a subsequent absolute incoming emergency call ($p = .07$) (Fig 5).

Discussion

The main findings to emerge from our study are that cortisol is a relevant biomarker of stress in emergency medical dispatchers, with higher values being recorded during the *Incoming emergency call* shift. Cortisol values were linked with perceived stress and identified stressful events (severity of incoming emergency calls or effects of a subsequent absolute incoming emergency call). We also observed relationships between cortisol levels and sociodemographic variables such as gender and experience.

Cortisol is a relevant biomarker of stress

In our study, the relationships between cortisol levels and perceived stress confirmed that cortisol is a relevant biomarker of stress in the workplace [22]. Emergency medical dispatchers are particularly at risk of stress because of the combination of witnessing medical distress [6] and the constraints of a call center [51]. There are usually strenuous demands by the employers and not much flexibility allowed for the employees [51]. Chronic stress can lead to basal

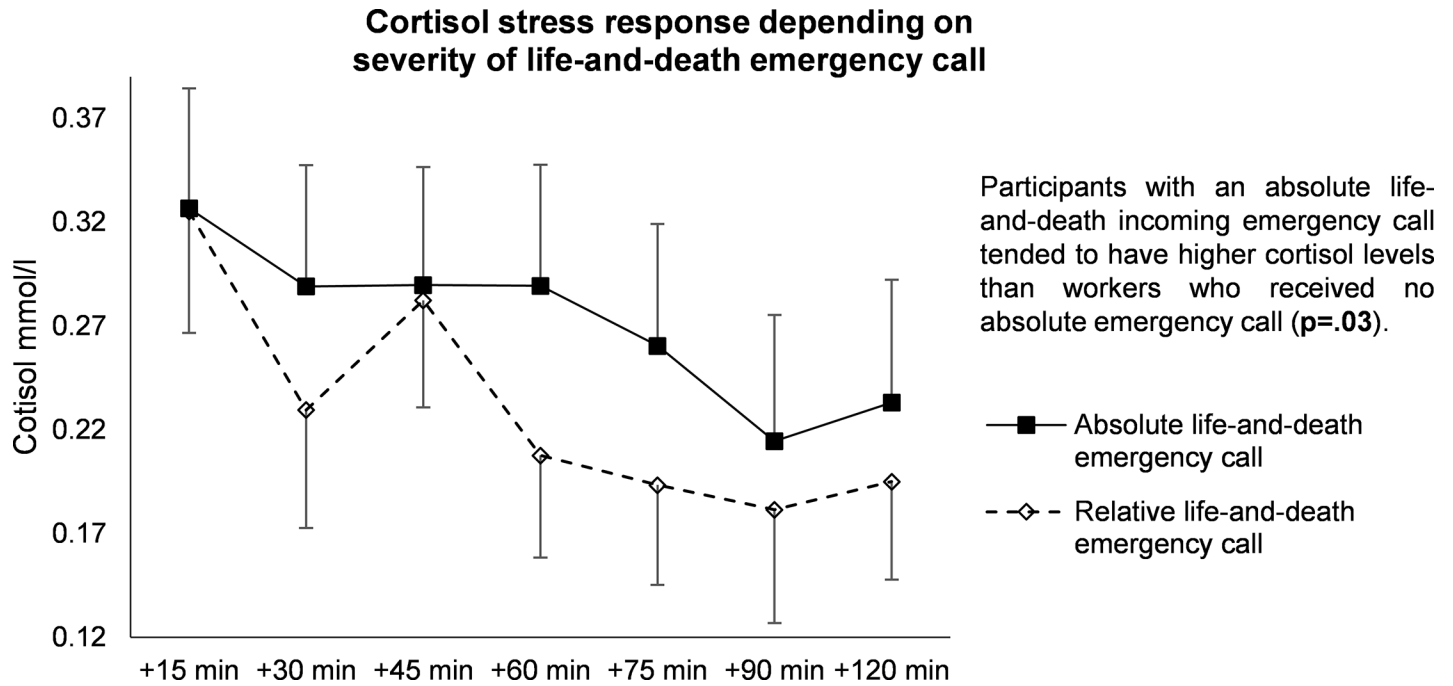


Fig 4. Stress response of cortisol depending on severity of life-and-death emergency oncoming call.

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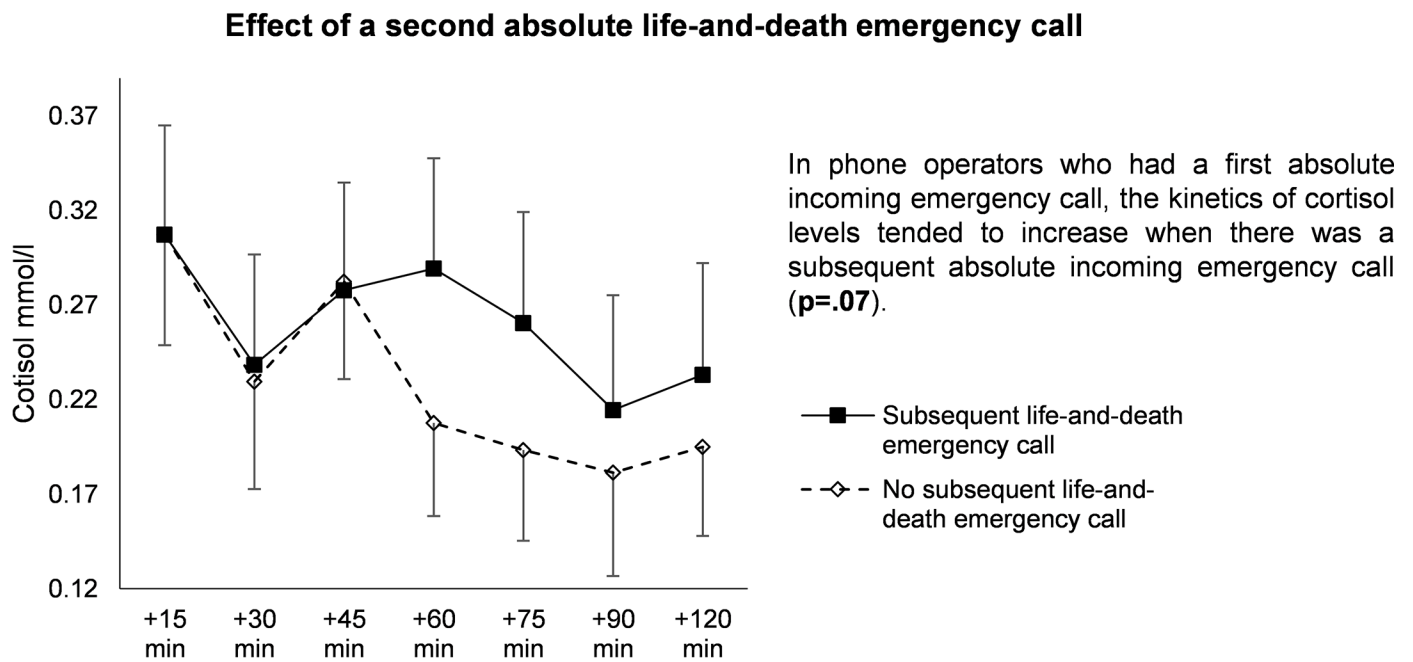


Fig 5. Effects of a subsequent absolute incoming emergency call after beginning of measurements.

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hypocortisolism characterized by a flattened cortisol rhythm with dramatically smoothed production of glucocorticoids [52]. In our study, the nictemeral cycle of cortisol on the control day was normal. Chronic stress at work can also lead to hyporeactivity [53]. However, we report here for the first time that the *Incoming emergency call* shift is the most stressful period, with phone operators having higher cortisol values than at other times when calls had already been dealt with and decisions already made without any direct contact with callers. In contrast, in some patients with post-traumatic stress disorders a stressful event induces hyporeactivity [54]. This confirms that our phone operators reacted to stressful stimuli but did not experience a biologically overloaded stressful experience. Identifying stressful events may be crucial for safety practice.

Identification of stressful events

In our study, the *Incoming emergency call* shift induced elevated levels of cortisol, depending on the severity of the emergency call. We also observed a cumulative effect of a subsequent absolute emergency incoming call. Our results bear similarity to the increased morbidity rates described in subsequent patients after surgeons had experienced a patient's death during emergency surgery [55]. In our study, the potential for residual effects of the *Incoming emergency call* shift need to be investigated, and the consequences of stressful events identified for both patients and phone operators. Phone operators often deal with many absolute emergencies during the same shift, which may produce substantial hypersecretion of cortisol. A succession of days with elevated levels of cortisol can lead to serious diseases such as metabolic disorders including type two diabetes, and also depression and psychiatric disorders [22]. The impact of night shifts can also contribute to stress and to the alteration of the nictemeral cycle of cortisol, which can also lead to an increased morbidity and mortality [16,22]. Thus, the possibility of long-term adverse effects raises the question of the management of stress at work. Further studies could investigate the length of shifts and introduce rotations during the day to reduce the impact of daily stress.

Sociodemographic variables such as gender and experience

The phone operators included in this study were representative of the overall population of emergency medical dispatchers. There was a greater increase in cortisol levels in response to stress in the men than in the women, as reported elsewhere [56]. Another report showed that experienced individuals had a lower increase in cortisol levels and faster recovery compared to those without experience [57]. Although we did not demonstrate an effect of experience, that the longer experience of the female emergency medical dispatchers may have affected the results. Preventive strategies at the workplace could therefore be personalized by taking into account gender specificity and experience.

Limitations

According to the sample size estimation, the estimated size effect was around 0.7. It is interesting to observe that all results showed an effect size at 0.66 underlying the fact that we lack statistical power for the primary outcome. However, additional exploratory analyses demonstrated significant results. This study has certain limitations. The sample size was small but each individual was their own control, which limited inter-individual cortisol variations. In addition, the high participating rate (75%) limited selection bias. Cortisol values are reported to depend on season, but sampling was conducted in a limited timeframe to limit intra-individual variations. Although cortisol levels are influenced by several factors such as nutritional intake and physical activity [21,29], our study design, which included specific measurements

at work, limited the potential effect of these major confounders. Saliva sampling every 15 minutes for 2 hours, starting 15 minutes after the first life-and-death incoming emergency call, were conducted only during the three types of shifts (*Incoming emergency call*, *Dispatch* and *Re-assessment*) and not during the at-home control day because eight measurements every two hours had already been performed to provide a nictemeral cycle of cortisol. Finally, our findings are not necessarily applicable elsewhere because organizational procedures may differ between emergency medical dispatchers. Further analyses should focus on relationships between cortisol secretion and personality traits [58] or other biomarkers of stress [41,59,60,61].

Conclusion

The shift on which phone operators received incoming calls was the most stressful. Cortisol levels were highest during this period, varying with perceived stress, severity of the emergency call, and the occurrence of a subsequent absolute incoming emergency call. The increase in cortisol levels was greater in the men than in the women during this shift. Preventive strategies in the workplace could be personalized by taking into account gender specificity.

Supporting information

S1 Appendix. CONSORT checklist.
(DOCX)

S1 Protocol. Study protocol in French.
(DOCX)

S2 Protocol. Study protocol in English.
(DOCX)

S1 Database. Titles of columns are written without abbreviations. 999 = missing data.
(XLSX)

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Author Contributions

Conceptualization: SB LW MA.

Data curation: SB LW.

Formal analysis: FD BP.

Funding acquisition: SB LW MA FB.

Investigation: SB.

Methodology: SB LW.

Project administration: SB MA FB.

Resources: SB FD FB.

Software: FD BP.

Supervision: SB.

Validation: SB.

Visualization: SB FD BP.

Writing – original draft: SB FD.

Writing – review & editing: SB FD LW.

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