Unravelling Stress Factors Among General Practitioners in Training During Weekend On-Call Duties: A Qualitative and Quantitative Causal Analysis

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ABSTRACT

Background: In recent years, the mental well-being of medical trainees is a growing concern. Particularly, out-of-hours services adversely affect occupational stress. Considering the continuity of healthcare, it is of high interest to identify the key contributors to occupational stress during weekend on-call duties among General Practitioners (GPs) in training. As such, the mental health of young doctors can be better understood and prioritized.
Objectives: We aim to identify the main stress factors related to a weekend on-call shift among GPs in training. We map out their relations with and causal effect on stress during an on-call shift.
Methods: We establish a Directed Acyclic Graph (DAG) to present the current evidence base of the cause-effect relationships between an on-call shift and occupational stress. To this end, we performed a literature review and qualitative focus group discussion. Furthermore, we conducted an observational survey to collect data on the identified stress factors, which we used to perform a regression analysis and isolate causal effects.
Results: We leveraged a DAG to structure the stress factors identified in literature and group discussion, allowing us to estimate causal effects in an observational study. The study revealed that weekend on-call duties increase occupational stress in GPs in training. Interruptions to leisure time, the fear of potential errors, and anticipatory and vigilant behaviour to potential calls emerged as key contributors to elevated stress levels in our analysis.
Conclusion: Our study revealed the importance of internal stress factors and their role in occupational stress during an on-call shift, emphasizing the need to focus on coping mechanisms in medical training and a structural empowerment of physicians in the organisation of out-of-hours care.

KEYWORDS
Occupational stress, On-call duty shift, General Practitioner (GP) in training, Directed Acyclic Graph (DAG)

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1. Introduction

Physician well-being is a growing concern within the medical profession. In recent years, the incidence of mental health problems among physicians has been increasing significantly [1, 2, 3]. Particularly, medical trainees appear to experience severe work-related stress and burnout. Dyrbye L. et al recognizes the impact on trainees professional development, the ideation of suicidal intentions and on the safety of patient care [4]. Although physician well-being is frequently discussed, it is not given enough priority [5]. Considering its widespread prevalence and serious repercussions, preventive measures are needed to tackle this problem.

Studies reveal that out-of-hours services harm the mental well-being of General Practitioners (GPs) in training [6, 7]. Previous research indicated that on-call duties in unfavourable working conditions are associated with medical errors, low sense of happiness, fatigue, and burnout [6, 7, 8]. Nevertheless, we have to admit the necessity and inevitability of on-call services for maintaining continuity of care. Therefore, it is valuable to identify the various factors that increase occupational stress during out-of-hours services among GPs in training to inform effective prevention strategies.

Today, we have some understanding of the adverse effect of on-call work on mental health and sleep quality in physicians [9, 10, 8]. Yet, there is a lack of research identifying the main underlying stress factors and etiological mechanisms leading to occupational stress during on-call shifts. For this reason, we set out to create a comprehensive overview of the main factors contributing to occupational stress during an on-call shift, while also mapping their relations using a Directed Acyclic Graph (DAG). DAGs have proven to be a useful tool for gaining insight in the cause-effect relationships between variables and offer an innovative framework to systematically conduct causal inference in observational data [11, 12]. We base our DAG on existing literature, as well as a focus group discussion with 11 GPs in training. Furthermore, we conduct an observational study to investigate which factors have the highest correlation with stress during an on-call duty shift. Therefore, 64 GPs in training completed a questionnaire about the character of a recent on-call shift they performed, inquiring on perceived stress factors and perceived stress level. The perceived stress levels during the on-call duty shift were compared with baseline stress levels during a random regular working day. We fit a regression model between the perceived stress factors and perceived stress levels, and analyse which factors significantly correlate with stress in our population. Therefore, the main objectives of our study are:

(1) To identify the main factors related to occupational stress during an on-call shift among GPs in training via literature review and focus group discussions.
(2) To establish a DAG that visually represents the detected stress factors and cause-effect relationships between them.
(3) To conduct an observational survey among GPs in training to obtain data on the retained stress factors in relation to occupational stress during a weekend on-call shift.
(4) To statistically analyse the obtained data in order to investigate the correlation and the causal effect of each factor in relation to occupational stress. We aim to draw meaningful conclusions about the etiological mechanisms by which an on-call shift induces occupational stress.

The main purpose of our study is to achieve a greater understanding of occupational

stress during out-of-hours care from the perspective of primary healthcare providers, with focus on GPs in training. In a later stage, this information could serve as input for establishing interventions on an individual, organizational, and structural level aimed at mitigating these occupational stress levels.

2. Methods

As depicted in Figure 1, the study design consists of three different parts, as outlined in the following sections. In Section 2.1, we identified the main variables causing occupational stress in GPs in training during on-call shifts. This was done through literature review and qualitative research involving a focus group discussion with 11 GPs in training. The aim was to identify the main factors related to occupational stress during on-call shifts and to represent these visually in a DAG.

In Section 2.2, this work was evaluated critically by a domain expert who was familiar with the concept of DAGs. Not only the variables were reviewed and refined, also the correlations between the variables were assessed and determined. After this review, the correlations between a limited group of variables remained uncertain. To tackle this problem, we developed a brief questionnaire that was completed by 14 GPs in training. These 14 respondents were randomly selected and contacted via email, independent of the rest of the study. Their input was used to determine whether there was a direct effect between the remaining variables under question, concluding the framework of the DAG.

In Section 2.3 we present a quantitative analysis comprising an observational survey using questionnaires. 76 GPs in training were recruited to participate in the study and 69 of those completed two questionnaires: the first was completed during the shift, the latter a week after the on-call shift. The purpose of this survey was to obtain observational data on the retained variables to perform a regression analysis and isolate causal effects, using causal inference. The study protocol was approved by the Ethics Committee of U/UZ Gent on the 16$^{\text{th}}$ December of 2022 (registration number: B6702022000712).

2.1. Exploration of stress factors

2.1.1. Literature review

We consulted existing literature to identify the variables that have previously been suggested in relation to occupational stress during on-call work. The aim of the literature review was to identify the variables potentially eligible as future nodes in the DAG.

Search strategy: We performed an extensive systematic search consulting Google Scholar and the PubMed database for English papers published since 2004, chosen as an arbitrary but necessary time limit. The search was undertaken in March and April 2023. The following terms were used in Mesh and free-text searches, targeting two main topics:

(1) "On-call modalities"[Mesh] OR "Night call"[Mesh] OR "Weekend call"[Mesh] OR "Out-of hours primary care"[Mesh]
(2) "Stress factors"[Mesh] OR "Stress"[Mesh]

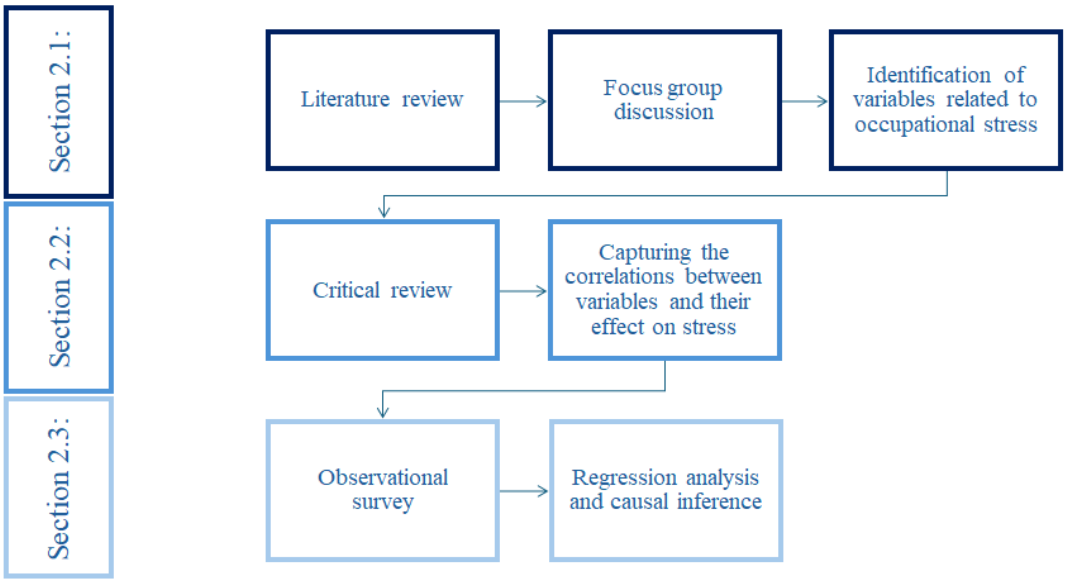


Figure 1.: Overview of the envisioned study design.

Inclusion criteria: The inclusion criteria comprised studies evaluating the impact of stress factors, whether shift-related or personal to healthcare professionals, on the outcome measure of occupational stress during on-call work. Given the scarcity of results, we included studies conducted with both primary care and specialist physicians (emergency medicine, internal medicine and surgical or interventional disciplines). Studies with nurses or other paramedical professions were excluded. We considered various on-call modalities such as a night float system, a traditional 24h call or an evening call. The outcome measure was restricted to occupational stress experienced during or in the first days following the on-call shift.

Selection and Data Extraction: Study selection was performed using a multi-stage approach. First, we checked titles to assess whether the articles were valuable to the research question. Subsequently, the abstracts of the remaining studies were examined and any articles that were not appropriate to answer the research question or failed to meet the inclusion criteria, were eliminated at this stage. Finally, all reports of studies identified as potentially eligible were assessed in full text. Additionally, we reviewed the reference lists of identified publications for other relevant studies that may have been missed previously.

2.1.2. Focus group discussion

After the literature search was complete, we organised a focus group discussion with 11 GPs in training. These respondents were recruited in collaboration with their internship coordinator who responded to an announcement published in the local newsletter *Icho Actua*. The respondents consisted of three men and eight women who were all in their final year before completing GP training. We aimed to gather clinical experiences to validate the literature findings and complement them with other relevant stress factors that may have been missed previously through literature search alone. The buildup of the focus group discussion was based on recent recommendations from

Mortelmans D. and Steenhuyzen S. et al [13, 14]. The interview was performed on 30 May 2023 in a quiet meeting room in Kortrijk where a snack and a drink was provided. At the start of the session, informed consent forms were handed to all participants. Participants were briefed on the procedure and purpose of the focus group discussion, as well as on the anonymity and confidentiality of data processing. The discussion was conducted in Dutch and consisted of a welcoming word, an introduction of the study protocol, a warm-up exercise and four open-ended questions scheduled for 1 hour in total. A detailed description of the protocol is provided in Appendix A. Participants were encouraged to share their clinical experiences. The first author led the discussion, supported by an external moderator who paid attention to nonverbal cues and dynamics to ensure that no opinion was overlooked. The discussion was voice recorded and transcribed verbatim afterwards. Eventually, the transcript was coded via NVIVO[1], with similar stress factors assigned the same code. This enabled the identification of all mentioned stress factors related to on-call work in the focus group discussion.

2.1.3. Identification of variables related to occupational stress

Figure 2 shows a flow diagram depicting the multi-step process of collecting the stress variables and filtering them for inclusion in the DAG. The initial literature search and focus group discussion identified respectively 25 and 16 factors that model the relationship between an on-call shift and occupational stress. After removal of 6 equivalents, a total of 35 variables remained. Secondly, we reviewed the literature variables by full-text assessment. 7 variables were excluded as they did not address the research question. Also, two authors assessed the relevance of the variables from the focus group, based on the frequency and depth of mentioning during the discussion, as well as consensus between participants. 28 variables remained of which 18 originated from the literature review and 10 from the focus group discussion. Based on these variables and acquired background knowledge, we started building a basic framework of the DAG.

2.2. Building the DAG

A DAG is a conceptual framework comprising 'nodes', which represent a set of related variables, and 'directed edges', representing causal or influential relationships between the nodes [15]. Nodes cannot have a causal relationship with themselves, hence ensuring the graphs remain 'acyclic' [11]. Using the DAG, we visualize the potential causal connections between the exposure of interest (a particular on-call shift), the outcome (occupational stress) and all recognized covariates within this pathway. This way, DAGs provide a transparent and comprehensive overview of existing knowledge, fostering constructive discussions among researchers. Moreover, DAGs offer an innovative approach to identify confounding variables and estimate causal effects in applied health research [11].

With this background knowledge in mind, we started by modelling the relationships between the retained variables from literature review and the focus group discussion using a DAG. Furthermore, we critically reviewed the retained variables and correlations between those in collaboration with a domain expert. Finally, we received feedback from a group of 14 GPs in training who answered a brief questionnaire

[1] `https://lumivero.com/products/nvivo/`

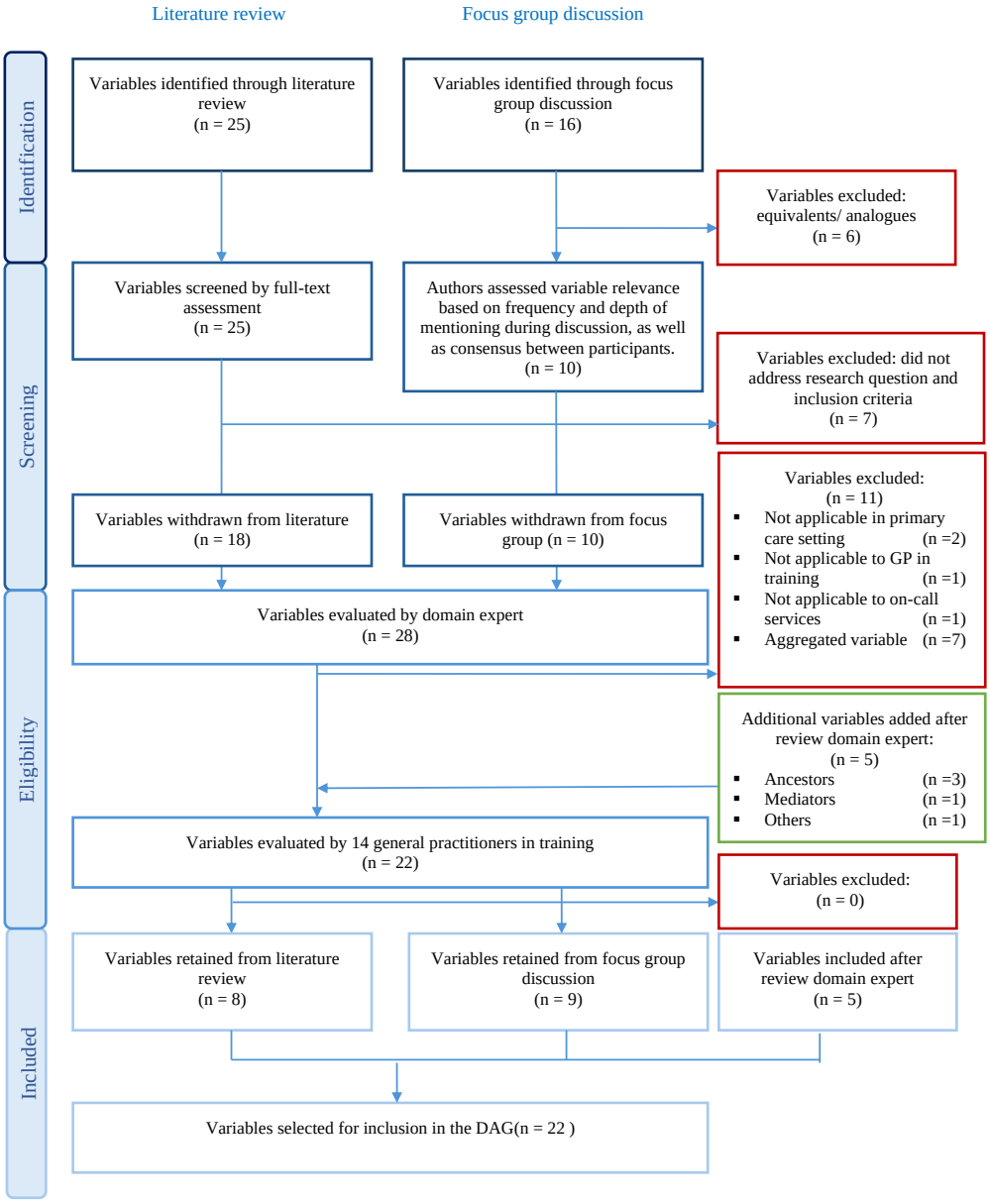


Figure 2.: Flowchart of the identification and collection process of the variables included in the DAG.

about the variables and effects that remained uncertain.

For this research, we applied our DAG analysis to GPs in training, since residency training or GP training is perceived as a particularly stressful time [16, 17]. Doctors in training face many challenges, such as combining their multiple educational and clinical responsibilities, the demanding workload and extensive duties, alongside a substantial volume of scientific literature and practical tasks that must be mastered within a limited time [18]. This way, handling on-call responsibilities poses challenges for this group of doctors in GP training or residency. Moreover, we restricted our analysis to weekend on-call shifts organised from a GP cooperative[2] to ensure some level of standardization among the responses. As such, the variable 'work environment' is limited to a single category of the weekend on-call centre setting at GP cooperatives. Restricting the data instances to a single type of work environment implies controlling for that variable by design, indicated in the DAG as a white node. The resulting DAG is shown in Figure 3.

2.2.1. Critical review

The DAG and its description were presented to a domain expert, a GP who was familiar with the framework of DAGs but otherwise not involved in this study. He reviewed the DAG critically and proposed some adaptations to cluster nodes, the addition of ancestors and refinement of the terminology used. Based on this discussion, 11 variables were excluded (2 were not applicable in primary care setting, 1 was not applicable to GPs in training, 1 was not applicable to on-call services and 7 were aggregated) and 6 additional variables were added. Furthermore, the arrows and variables that remained subject to discussion were evaluated by a group of 14 GPs in training by means of a brief questionnaire. Feedback from the domain expert, as well as from the 14 GPs in training was integrated, finalizing the DAG. Eventually, 22 variables fulfilled the inclusion criteria and were retained as nodes in the framework of the DAG.

2.2.2. Capturing the correlations between variables and their effect on stress

Although the importance of DAGs in causal research is widely recognised, the key guidelines and recommendations providing specific steps for DAG development remain limited and inconsistent. Here, we used a strategy proposed in recent studies consisting of five steps [11, 20, 21, 22]. To map the relevant factors as nodes and analyse their relationships, we use the online application *DAGitty version 3.1*[3], which also allowed making the DAG visualization in Figure 3.

In a **first step**, we defined the exposure and outcome variables. The exposure variable 'on-call shift' was defined as a weekend on-call shift in primary care. Additionally, the outcome variable 'occupational stress' refers to stress experienced as a doctor during or within the three days following an on-call shift.

Secondly, we incorporated the variables retained after screening the literature and focus group discussion, as nodes. With this step, we ensured that all potential

[2]A GP cooperative is a large-scale organizations of about 15 to more than 250 GPs. GPs rotate shifts to provide out-of-hours care for the combined patient population of all participating GPs. These cooperatives may also receive support from nurses, management personnel, drivers, and other staff. Such GP cooperatives are typically observed in countries like Belgium, the Netherlands, Germany, and other parts of Europe [19].

[3]`https://dagitty.net/dags.html`

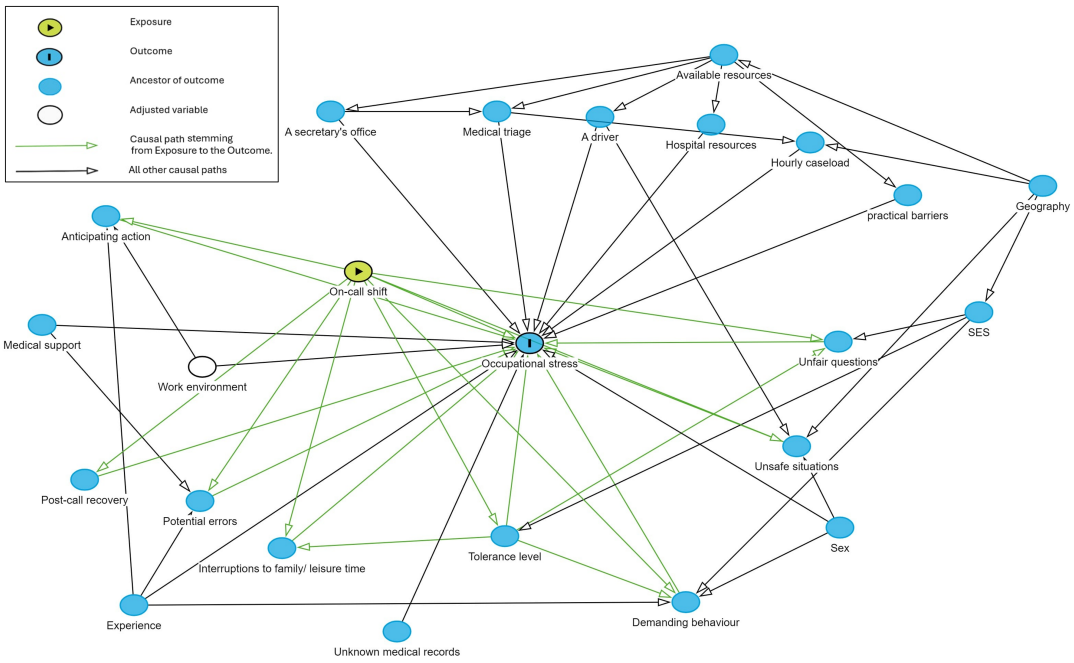


Figure 3.: A Causal Directed Acyclic Graph designed for the setting of occupational stress among GPs in training, with a weekend on-call shift as the exposure variable and occupational stress as the outcome variable, along with related variables.

causes of the outcome variable 'occupational stress' were integrated in the DAG.

In the third step, the question raised whether any variables within the DAG also influenced the exposure. In our case, we explored if there existed variables influencing whether or not a physician has an on-call shift planned. One could argue that some variables might have a direct impact on the subjective preference for a particular type of on-call shift, such as sex or experience. For instance, older or female doctors might have different preferences than younger or male colleagues. Physicians' preferences influence their assigned on-call shifts, as they can express their desired shift types and exchange shifts among themselves. However we did not include a variable named 'shift type preference' in the DAG since our study population is restricted to GPs in training who are required to complete a minimum of 60 hours of weekday and 60 hours of weekend on-call duties. As a result, individual preferences for a particular shift type do not translate into whether or not an on-call shift is ultimately assigned.

The fourth step involved representing all causal paths as directed edges in the graph. It is recommended to add directed edges wherever theory or logic suggests a potential direct effect between two variables, without necessitating explicit reasoning for included edges. Conversely, it is only justified to remove an edge between two nodes when there exists no direct causal influence between variables they represent [11].

In the fifth and last step, common causes for each pair of variables were identified and added. For instance, the node 'available resources' is defined as all tools, equipment, personnel, and facilities available and ready for use in a GP cooperative. This variable has a direct effect on the presence of a driver, a secretary's office, a

medical triage at the GP cooperative, as well as the available hospital resources which can be used at the GP cooperative. To this end, the node 'available resources' is a common cause for the mentioned variables and so included as an ancestor node in the analysis. Finally, we judged the DAG critically and made sure we met the criteria to be able to draw valid causal conclusions. On one hand, this entails accounting for every shared cause of any two variables in the DAG to prevent any omitted confounders. On the other hand, one should make sure that no edges between two nodes were removed without proper justification [23].

2.3. Quantitative analysis

In this part, we set out to conduct an observational study to investigate whether and to what extent an on-call shift induces occupational stress in GPs in training. To this end, we developed two types of questionnaires that participants were asked to complete: one to obtain information on the identified stress factors during the shift and measure the stress level on-call and a second to measure the stress level during daily life as a reference stress level. Moreover, we investigate the correlation with and the causal effect on stress for each measured variable. As such, we hope to gain insight into the etiological mechanisms of how an on-call duty shift induces occupational stress in GPs in training.

2.3.1. Observational survey

Study setting and participants: The survey was conducted by the first author GD from October 2023 to February 2024, collecting data from different GP cooperatives mainly in Gent, Brugge, Leuven, Mechelen and Antwerpen. Beforehand, GP cooperatives were contacted and informed about the study protocol. If they were willing to participate, a poster was given to the secretary's office, featuring a QR-code that respondents could scan with their smartphone to access the questionnaire. At the start of the survey, an e-mail invitation was sent to all GPs in training performing an on-call shift in the included areas. This e-mail included a welcoming word, the instructions of the study protocol and an electronic link to the questionnaire. Our inclusion criteria encompassed all GP trainees (first, second, or third year) scheduled for on-call duty in the aforementioned regions in the period between October 2023 and February 2024. Specifically, participants had to be healthy, mentally competent individuals capable of providing consent for the study. Only trainees with an atypical training trajectory, such as part-time employment, were excluded. As an incentive, the trainees who completed the questionnaire were eligible to win a 20 euro voucher.

Study protocol and measurements: Figure 4 gives an overview of the study protocol and timing of recruitment and surveys. The respondents were asked to complete two types of questionnaires: (1) Firstly, the respondents filled out a questionnaire that evaluates both the properties of the on-call shift identified as stress factors in Section 2.1 and the level of occupational stress they experienced during this shift. This questionnaire had to be completed as soon as possible, within a maximum timeframe of three days post-call. (2) The respondents repeated the stress questionnaire to estimate their stress level in daily life without any on-call shift on an arbitrary moment one to two weeks after performing the on-call shift.

The first questionnaire was structured into three parts. In the first part the main

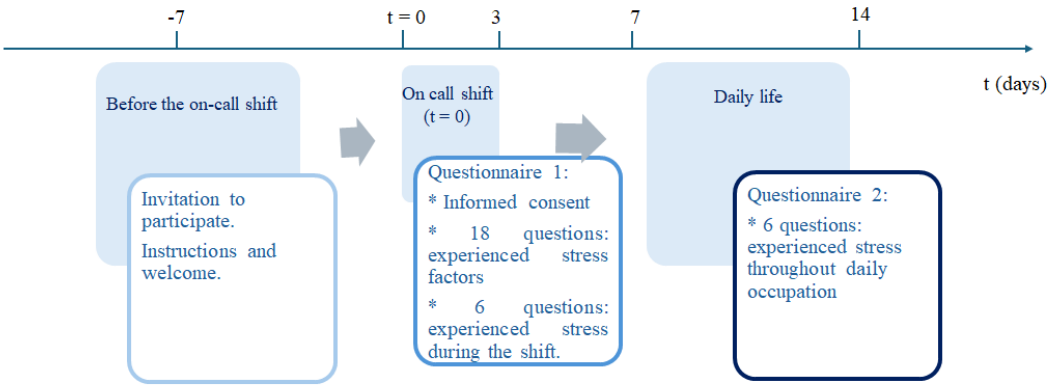


Figure 4.: Overview of study protocol

instructions and purpose of the study were explained followed by an informed consent procedure. Secondly, the stress factors isolated through literature review, focus group discussion and expert opinion were assessed by asking participants how often the stress factor described in the statement had concerned them, worried them or caused stress during the past on-call shift. In total, there were 18 questions and answers were assessed on a 5-point Likert scale. Thirdly, we provided 6 questions evaluating the stress of the respondents on the very moment of the on-call shift. We used the validated short form 6a 'TBI-CareQOL Caregiver Strain' to assess feelings of being overwhelmed, stressed, self-defeated, downtrodden and beat-down related to the caregiver role, as provided in Appendix B [10]. The items were rated on a 5-point Likert scale, ranging from 1 (never) to 5 (always). This third part was repeated after at least one week to obtain reference stress scores experienced by the GPs in training throughout daily occupation. We kept track of the questionnaire results and sent a new link via e-mail to repeat these 6 questions about stress. Respondents were only included in the study when they completed this second questionnaire as well.

2.3.2. Regression analysis

Univariate regression analysis: In a first step, we conduct a univariate linear regression analysis to explore the correlation between a candidate stress factor as an independent variable and the measured stress during the on-call shift as a dependent variable. Based on this regression model, we performed an Analysis of Variance (ANOVA) to examine whether there exists a significant association for each categorical variable. Importantly, since this analysis does not account for stress measured during daily life, we are not able to establish any causal effect, as detailed in Section 2.3.3. When a significant relationship with a specific variable is identified ($p < 0.05$), we conduct a pairwise Tukey Honestly Significant Differences (HSD) test to determine which categories within the variable are associated with elevated stress values.

Stepwise regression analysis: Stepwise regression analysis is a statistical method used to identify a subset of independent variables that best predict a dependent variable, in our case the stress during an on-call shift [24]. Two simple and popular stepwise regression techniques are forward and backward selection, where variables are itera-

tively added *(forward)* or removed *(backward)* in the process based on their statistical significance, aiming to build a regression model that accurately and precisely predicts occupational stress [25]. First, we conducted a backward regression analysis. To this end, we started from a complete regression model in which all variables are included, eliminating the variable with the highest p-value obtained from the ANOVA analysis at each state. We repeated this process until only significant variables remained in the model. Secondly, we performed a forward regression analysis reversing this process. We started from an empty regression model and added the stress factor with the lowest p-value according to the ANOVA analysis of the resulting regression model. We repeat this process, building up the regression models by adding variables one at a time, until we do not have any significant variables left.

2.3.3. Causal inference

We used causal inference to obtain the direct effect of some of the candidate stress factors during on-call duty. *Dagitty.net* allows estimating a causal effect of an exposure variable X on the outcome Y (stress on-call) without bias from confounders or improper adjustment. We used the following strategy to test the causal effect of each variable that appeared to be significant in the preceding regression analysis.

(1) Designate the variable for which we want to estimate a causal effect as the exposure variable X in *Dagitty.net*. On-call stress remains the outcome variable Y. The variable 'on-call shift' is no longer considered as an exposure but is adjusted for physicians who are on-call.
(2) Subsequently, *Dagitty.net* proposes minimal sufficient adjustment sets, telling us which variables we have to adjust for to block all backdoor paths from exposure X to outcome Y. We refer to these variables as C (confounders). For instance, if we take X to be 'anticipating action', we have to adjust for the confounder 'experience' to block all backdoor paths to the outcome of on-call stress.
(3) Fit a linear regression model. For example, when taking 'anticipating action' as an exposure, we land on the following model:

$$Y(\text{on-call stress}) \sim X(\text{Anticipating action}) + C(\text{Experience}) \tag{1}$$

(4) The p-value of X according to the ANOVA analysis of the regression model from Equation (1) tells us whether there is a significant effect of X on Y when controlling for C. If so, the coefficients of the various categories of X in the regression model inform us how many units stress increases or decreases on the 'TBI-CareQOL Caregiver Strain' scale per category.

3. Results

3.1. Analysis of literature review

The initial search yielded a total of 316 articles all of which originated from PubMed. Ultimately, 20 articles fulfilled the inclusion criteria outlined in our multi-stage search strategy from Section 2.1.1, and were subsequently assessed in full text. While some studies varied in design, most of them used a cross-sectional study design, assessing occupational stress via questionnaires. The oldest article dated from 2008. As depicted in Figure 2, a total of 8 variables were ultimately withdrawn from the literature review. Table 1 outlines the retained variables corresponding with nodes from the DAG and

Table 1.: Summary of literature review. The retained variables corresponding with nodes from the DAG are outlined and the references in literature regarding that particular node are discussed. For each variable in the table, we first describe the direct effect on occupational stress in the top row, with supporting literature on associated outcomes added in the rows below.

Nr.	Factor	Author (year)	Main findings	Study design	Statistics
1.	Hourly caseload	Çalişkan Tür, F. et al. (2016) [5]	Number of patients taken care of by physicians working night shifts was found as a significant job stressor.	Cross-sectional questionnaire study	$p < 0.05$
		Davenport, M. S. et al. (2010) [26]	Increasing cases/ hour were significantly and independently associated with increased resident-faculty discrepancy rates.	Prospective cohort study	$p < 0.001$ Odds Ratio $= 1.6$ $[1.5 - 1.7]$
		Zhou, Y. et al. (2017) [27]	The number of calls per night shift was significantly associated with burnout.	Cross-sectional questionnaire study	$p = 0.035$
2.	Medical support	Çalişkan Tür, F. et al. (2016) [5]	The social environment in a workplace was found to be an independent variable causing occupational stress.	Cross-sectional questionnaire study	NA
		Heponiemi, T. et al. (2015) [7]	Swedish and Finnish specialist trainees, considered that they had too little personal tutoring. They thought it was important to have someone more experienced in the background.	Cross-sectional questionnaire study	$p < 0.05$
		Jasti, H. et al. (2009) [28]	Inadequate supervision by attendings was considered to be a contributing factor to errors made.	Cross-sectional questionnaire study	NA
3.	Post-call recovery	Scott, O. et al. (2019) [29]	Data suggest that the extent of the off-call period is an important determinant of burnout and is instrumental in maintaining both mental and physical wellbeing.	Qualitative research with focus group discussion	NA
		Rose, M. et al. (2008) [9]	Residents were significantly sleepier after an on-call shift. Fatigue continued to recover the second and third day after the on-call shift	Prospective cohort study	$p < 0.05$
4.	Sex	Çalişkan Tür, F. et al. (2016) [5]	Job stress was higher in female physicians.	Cross-sectional questionnaire study	$p < 0.001$
		Saksvik, I. et al. (2011) [30]	In a recent review, it was concluded that male shift workers tend to sleep better and experience less fatigue and sleepiness when working shifts than women.	Systematic review	$p < 0.05$
		Heponiemi, T. et al. (2015) [7]	Women had more time pressure and stress related to team work compared with men. Women had lower levels of job control and organizational justice than men.	Cross-sectional questionnaire study	$p < 0.001$
		Zhou, Y. et al. (2017) [27]	In a multivariable analysis, female gender was found to be an independent factor associated with burnout in the pulmonary physicians in this study.	Cross-sectional questionnaire study	$p = 0.018$
		Vincent, G. E. et al. (2021) [31]	The odds of workers preplanning and thinking about interruptions to leisure/ family time were 2 times higher for females than males.	Cross-sectional questionnaire study	$p < 0.05$
5.	Experience	Çalişkan Tür, F. et al. (2016) [5]	Statistically significant weak negative correlation was found between age and job strain.	Cross-sectional questionnaire study	$p < 0.05$
		Vincent, G. E. et al. (2021) [31]	The odds of workers preplanning were 88% lower for those aged 35-44 years than those aged 18-24, 86% lower for those aged 45-54 years than those aged 18-24 years, and 84% lower for those >55 years than those aged 18-24 years.	Cross-sectional questionnaire study	$p < 0.05$
		Heponiemi, T. et al. (2015) [7]	It has been found that younger workers have better shift work tolerance regarding subjective sleepiness, performance tests, recovery after work, and sleep time. Older respondents had higher levels of stress related to patient information systems and teamwork than younger respondents.	Cross-sectional questionnaire study	$p = 0.006$
6.	Anticipating action	Vincent, G. E. et al. (2021) [31]	On-call workers rated preplanning in case of a call and fear of missing a call as main reasons for rumination.	Cross-sectional questionnaire study	$p < 0.05$
7.	Interruptions to family/ leisure time	Vincent, G. E. et al. (2021) [31]	On-call workers rated interruptions to family/leisure time as one of the main reasons for rumination.	Cross-sectional questionnaire study	$p < 0.05$
		Heponiemi, T. et al. (2014) [6]	Work interference with family was significantly associated with all the outcomes (distress, job satisfaction and work ability).	Prospective cohort study	$p < 0.05$
8.	Potential errors	Zahrai, A. et al. (2011) [32]	With regard to work-related stressors, "concern regarding potential errors" was the only significant work-related problem at 6 months for residents on the night float program.	Prospective cohort study	$p = 0.022$

the references in literature regarding that particular node with the main literature findings, study design and statistics from the study reference. For each variable in the table, we first describe the direct effect on occupational stress in the top row, with supporting literature on associated outcomes added in the rows below.

3.2. Analysis of focus group discussion

A total of 11 GPs in training agreed to participate in the focus group discussion. The participants consisted of three men and eight women and were all in their last year before completing GP training. All of them performed on-call duties in a Flemish GP cooperative. On the whole, all participants experienced on-call duties as a stressful event, impacting the physician's time allocation, thereby disrupting the balance between stress and resilience. The transcribed interviews were analysed using a framework described by Onwuegbuzie A. et al [33]. Analysing the results qualitatively, 3 overarching themes emerged, which are discussed in detail below. Each theme will be presented with quotes translated from Dutch to English.

3.2.1. Theme 1: Physician-patient relationship

All respondents expressed their dissatisfaction about the sheer number of unjustified patient complaints. In Flanders, primary care enjoys a high level of accessibility, allowing patients to consult a GP for as little as 4 or 6 euros at night or during weekends. Although participants agreed this is a good property of the healthcare system, it might encourage patients to present with non-urgent or unnecessary complaints. Examples included problems that have been ongoing for weeks, such as removal of earwax or administrative requests related to disability certificates. For instance, participants mentioned the following:

> "Our primary task during the COVID period consisted of conducting swab tests."

> "While accessibility is important, General Practitioners are not to be taken advantage of."

Furthermore, participants highlighted that some patients exhibit demanding behaviour. Sometimes, this may lead to unsafe situations. As an example, the experience of one participant:

> "I felt unsafe during my last shift at the emergency department. There was this patient, a former convict, wearing an ankle monitor. He demanded medication, threatening self-harm if he did not get it. As a young doctor, it was unsettling to deal with someone with a criminal history. I wondered if I could request another person to be present. I found myself more concerned about my own safety than the consultation itself. Afterwards, the patient could not pay for the consultation, and I wanted to leave as quickly as possible. Once outside, I felt relieved."

Regarding the topic of patient-physician relationship, the stress variables 'unfair questions', 'demanding behaviour' and 'unsafe situations' were retained as nodes in the DAG.

3.2.2. Theme 2: Logistic organisation and support

The topic of logistic organisation emerged spontaneously through discussion in different contexts. All respondents acknowledged the importance of having a competent

driver for home visits and a well-equipped secretary's office to answer incoming requests. Ideally, the secretary should have a medical background to create a triage system and filter non-urgent inquiries.

> "A better triage system would be a potential solution to mitigate stress. Many non-urgent inquiries are thus deferred until the next workday. If you receive a call from triage, you know you're being woken up for a reason."

> "From a social point of view, I enjoy having a driver. Someone to vent to!"

Furthermore, the organisational aspect also manifested in addressing practical barriers. Reported examples included problems with processing and sending out technical examinations (blood samples, urine samples...), or with completing the payment procedure. Furthermore, having recovery time would make a notable difference for many respondents. Unfortunately, the majority still noticed a taboo surrounding this topic.

> "In my opinion, recovery time would be a relief! Sometimes, I've had a busy night, which affects my sleep for several days afterwards. It's indeed unfortunate that there exists such a taboo, especially considering that we've already worked continuously for 24 hours. Moreover, recovery time is actually stipulated in our contract."

Respondents mentioned the presence of a supervisor, either by phone or in person, as an organisational advantage enabling medical support. Having someone more experienced in the background was generally considered stress-reducing. Finally, the lack of access to patient's medical records was frequently cited. Not knowing the history, allergies or medication list of the patient complicates the consultation and induced stress.

> "On the whole, I feel comfortable managing most complaints, but I can imagine there might appear new situations where I would feel overwhelmed. Take, for example, a collocation where we as junior doctors feel rather inexperienced."

Related to the topic of logistic organisation and support, the variables 'a driver', 'a secretary's office', 'a medical triage', 'work environment', 'practical barriers', 'unknown medical records' were added to the DAG. The variables 'post-call recovery' and 'medical support' were previously identified through literature review, but emerged again in the focus group discussion.

3.2.3. Theme 3: Professional and personal burden of the physician

In this final theme, physicians mentioned internal contributors to occupational stress during on-call duties. These contributors reflect ruminations and concerns originating from within the physician rather than being caused by external circumstances. While these ruminations varied within the focus group, most participants acknowledged a sense of anticipating action. In our focus group, anticipation emerged in different contexts. For instance, respondents expressed constant vigilance over their phones and fear of missing a call. During breaks between patients, they struggle to relax and remain alert, making sleep difficult. Additionally, they anticipate scheduled patient visits and preoccupy themselves considering the potential complaints beforehand.

> "It might sound odd, but your phone can ring at any moment. This leads to a lot of practical issues, for instance questions such as 'Should I go to the bathroom now?', 'When should I eat?', 'When should I change clothes and brush my teeth?'. Being constantly aware and vigilant burdens me, it even triggers anxiety."

Other ruminations included 'interruptions to family and leisure time', as well as 'fear of

making potential errors'. Notably, some participants mentioned that these ruminations evolved depending on the number of years of experience.

> "The stress before a shift does get better with experience. I still remember my first shift, 'hallelujah', whereas now I believe I have more knowledge. You trust yourself a lot more. I know what I need to do, and if I do not trust it, then I'll triage to the emergency department. If I was a first-year trainee General Practitioner, I would have panicked more."

Finally, the nodes 'anticipating action', 'interruptions to family/ leisure time', 'potential errors' and 'experience' were initially identified through literature review, and thus overlapped with the content of the focus group discussion.

3.3. DAG assessment

We present our established DAG in Figure 3. Each stress factor withdrawn from literature review and focus group discussion contributing to occupational stress during out-of-hours care, is depicted as a node in the DAG. The directed edges illustrate the directionality of the cause-effect relation between these nodes and should be interpreted as 'has a direct effect on'. Note that a green arrow depicts any causal path stemming from the exposure variable of interest, 'an on-call shift', to our outcome 'occupational stress'. All other causal paths are depicted in black. To aid the understanding of our DAG, we provided a clear definition of all included nodes in Appendix C. The exposure, 'on-call shift' is visualised as a green node with an arrow in the center. In fact, the exposure refers to whether a physician has a weekend on-call duty shift planned or not. The outcome, occupational stress during and shortly after the on-call shift, is depicted as a blue node with an 'I' in the center. The variable 'work environment' is coloured in white, indicating that it has been limited to a single category of the on-call centre setting at GP cooperatives. Readers should be aware that constructing a DAG involves a certain degree of subjectivity, leading to potential variation in the interpretation of causal assumptions among different researchers. Given this subjectivity, we relied as much as possible on existing knowledge from the literature and shared opinions gained from the focus group discussion to draw nodes and edges. We tried to minimize the addition of our own assumptions if there was not any scientific evidence to support them.

3.4. Survey measurements and cross-sectional survey outcomes

3.4.1. Demographic features

A total of 76 participants answered our email invitation to participate in the study and completed the first questionnaire regarding the characteristics of the on-call shift they performed. 69 of these participants completed the second questionnaire measuring reference stress level as well. We excluded five participants in total: two because they completed the questionnaire during a duty shift on a weekday instead of a weekend, and another two who misinterpreted the questionnaire. One respondent completed the questionnaire twice, so that one response was removed from the dataset. 64 respondents were included in the final analysis. 53 (82.8%) of these were female, the others were male. In Belgium, GP training entails three years of specialized training. The number of years of experience was relatively balanced between respondents who were in their first or second year (34 answers, 53.1%) and those who were in their third

Table 2.: Demographic features of respondents

Characteristic		Number	Percentage, %
Gender	Male	11	17.2
	Female	53	82.8
	Non-binary	0	0
Experience	1st or 2nd year	34	53.1
	3rd year	30	46.9
On-call shift type	Daytime shift	46	71.9
	Nighttime shift	17	26.6
	Split shift	1	1.6
Area of GP cooperative	Gent	26	40.6
	Brugge	10	15.6
	Antwerpen	15	23.4
	Vlaams-Brabant	13	20.3

year (30 answers, 46.9%). 46 respondents worked a daytime on-call shift (71.9%), 17 (26.6%) a nighttime on-call shift and 1 respondent did a split shift from 7 until 11pm (1.6%). In the further analysis, we did not differentiate between the various types of on-call shifts due to insufficient available data. Regarding geographical regions, 26 respondents completed the questionnaire during an on-call shift in Gent (40.6%), 10 (15.6%) in Brugge, 15 (23.4%) in Antwerpen and 13 (20.3%) in Vlaams-Brabant. Answers from respondents located at Mechelen, Heist, or Kempen were aggregated with those in Antwerpen. Similarly, answers from Leuven, Brussel or Beringen were aggregated with those in Vlaams-Brabant. Note, however, that for our analysis we deemed the work-environment over the different GP cooperatives to be sufficiently homogeneous (i.e. weekend on-call shifts in a similar setting) to encode the variable work environment into a single category. Out of 64 respondents, 37 (57.8%) completed the second questionnaire within two weeks after the first questionnaire, while the remaining 27 (42.2%) completed the second questionnaire between two to ten weeks after the first one. Table 2 shows the demographic characteristics of the GPs in training who completed both questionnaires successfully.

3.4.2. Effect of an on-call shift on occupational stress

The distribution of the difference between the stress scores during on-call duty and reference stress scores during daily life, is depicted in Figure 5, alongside each of the corresponding subscales of the validated short form of the 'TBI-CareQOL Caregiver Strain' on the x-axis [34]. Additionally, we added the overall difference between the total stress score during on-call duty and reference stress score during daily life. The calculated difference between the stress during the on-call shift period and the stress at rest assessed at least 1 week after the on-call shift is depicted on the y-axis. Intuitively, we would expect that most calculated differences of stress on-call versus daily stress will be positive. The mean score per subscale is indicated with a green dotted line. The individual subscales with corresponding p-value are listed below. We performed a one-sided Wilcoxon sign-rank test on the differences in stress, for each of the six subscales.

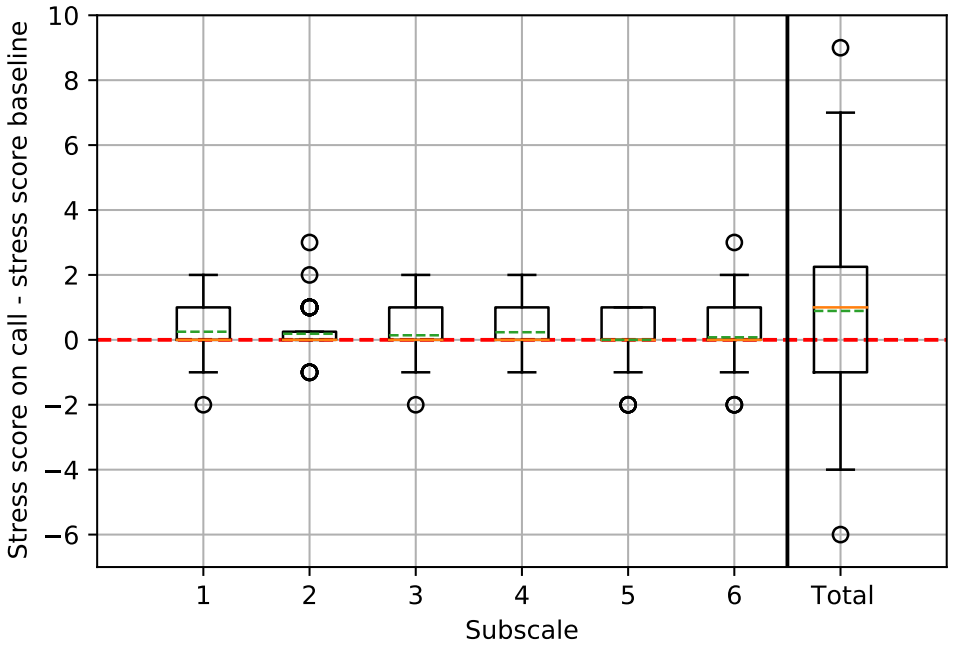


Figure 5.: Distribution of the difference between the stress scores during on-call duty and reference stress scores during daily life, shown for each of the 6 indicators of the "TBI-CareQOL Caregiver Strain" instrument. The overall difference between the total stress score during on-call duty and reference stress score during daily life is added at the end. We show boxplots for each of the 6 subscales, with the y-axis representing the difference in stress scores during on-call shift compared to stress score at baseline, recorded at least 1 week after the on-call shift.

(1) I feel that there are not enough hours in the day to get everything done.
p-value = 0.003
(2) I feel stressed when it comes to providing care for the person with the injury.
p-value = 0.020
(3) I feel that stress makes it difficult to start anything new.
p-value = 0.085
(4) I feel drained by my responsibilities as a caregiver.
p-value = 0.008
(5) I cannot handle any more responsibility when it comes to providing care for the person with the injury.
p-value = 0.522
(6) I feel burdened with the responsibility of caring for the person with the injury.
p-value = 0.288

This way, we generated a p-value of $p = 0.016$ to indicate the mean difference in stress during the on-call shift versus at baseline *(One-sided Wilcoxon Rank Test)*. It is noteworthy that time pressure (1), providing care for a specific group of patients (2), and exhaustion (4) emerge as significant components of the difference in stress between on-call and daily life. The sensation that stress impedes the initiation of something new (3) strongly trends towards significance ($p = 0.085$). The analysis does not reveal a significant increase in occupational stress during on-call duty in terms of handling

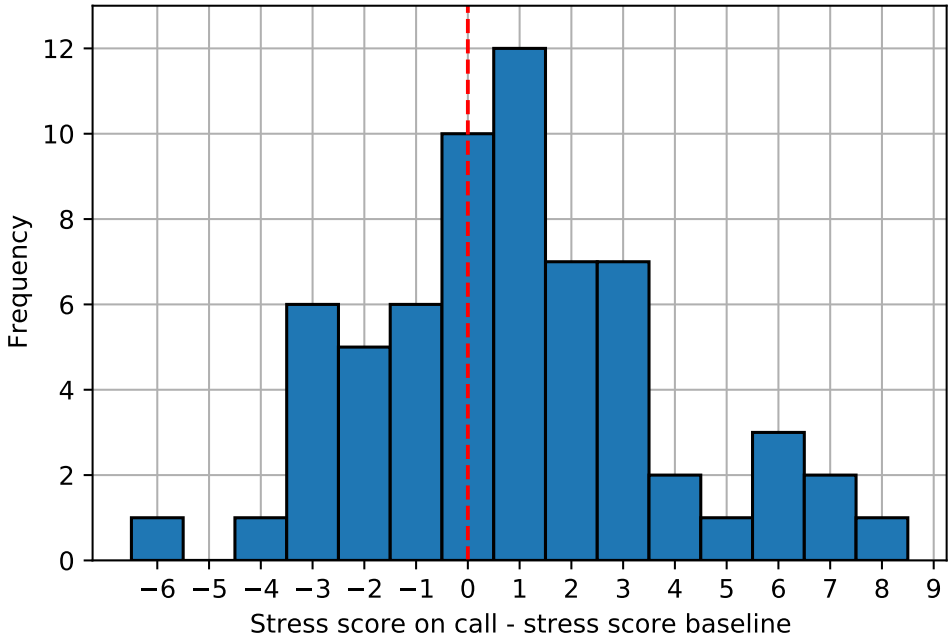


Figure 6.: Histograph displaying the distribution of the difference between between stress scores during the on-call shift and stress scores at baseline assessed at least 1 week after the on-call shift.

responsibility (5 and 6).

Figure 6 shows a histogram depicting the distribution of the overall difference in stress. The x-axis represents the difference between overall stress scores observed during an on-call shift and those under baseline conditions, while the y-axis denotes the frequency of occurrence of each measured difference. The red dotted line signifies the null line. Visually, we notice that the majority of data points exhibit positive values, suggesting a generally higher stress score during the on-call shift compared to baseline circumstances.

3.4.3. Regression analysis

Univariate regression analysis. The results of the univariate regression analysis are depicted in Table 3. We mention each variable separately alongside the corresponding p-value obtained from the ANOVA-analysis, revealing the significance of their contribution to the total stress score (score out of 30 units). Significant correlations are indicated in bold. Looking at the individual effects, three independent variables have sufficiently small p-values ($p < 0.05$), namely 'interruptions to leisure time' ($p = 0.0066$), 'potential errors' ($p = 0.0251$) and 'anticipating action' ($p < 0.001$), suggesting a significant correlation with occupational stress during the on-call shift. The Tukey HSD test reveals that, according to the variable 'interruptions to leisure time', the participants who experienced many interruptions to leisure time indicated elevated stress levels in comparison with those who experienced some interruptions ($p = 0.006$). Similarly, according to the variable 'potential errors', we may state that participants who were rather worried about making medical errors experienced elevated stress levels in comparison with those who were only slightly worried about

Table 3.: Results from univariate regression analysis. p-values are derived form an ANOVA-analysis.

Variable	p-value
Sex	0.8606
Experience	0.5199
Geography	0.8514
Tolerance level	0.1844
Hourly caseload	0.5351
Unknown medical record	0.6400
Practical barriers	0.9892
Post-call recovery	0.3883
A secretary's office	0.3672
A driver	0.6605
A medical triage	0.2909
Medical support	0.2384
Hospital resources	0.2151
Interruptions to social activities	0.2481
Interruptions to leisure time	**0.0066**
Unfair questions	0.9853
Demanding behaviour	0.6308
Socio-Economical State (SES)	0.2719
Potential errors	**0.0251**
Anticipating action	$<$ **0.0001**
Unsafe situations	0.9275

making medical errors ($p = 0.0191$). According to the variable 'anticipating action', we may conclude that the participants who recognized anticipatory actions to a strong extent experienced elevated stress levels in comparison with those who recognized anticipatory actions to a limited extent ($p = 0.0001$). In Appendix D, we provided an overview of the boxplots we generated for each independent variable in relation to occupational stress during the on-call shift. Visually, we can confirm that these variables have the highest difference in mean stress values during the on-call shift between individual categories.

Stepwise regression analysis. Table 4 presents the variables included in the final regression models obtained after applying the backward and forward stepwise analysis techniques. We report the p-values for each included variable, which are obtained through an ANOVA analysis conducted on the resulting regression model. We obtain comparable outcomes to those of the univariate analysis, where 'interruptions to leisure time' and 'anticipating action' are found to be significantly correlated with stress according to all aforementioned analyses. Consequently, we can assert with most confidence that these two stress factors exhibit a significant correlation with occupational stress during the on-call shift. Furthermore, the backward analysis reveals 'potential errors' as a significant factor, enabling us to construct the regression model in Equation 2, from which the ANOVA analysis results reported in Table 4 were obtained. 'Hospital resources,' 'unfair questions,' and 'tolerance level' demonstrate a tendency toward significance and appear to be interesting variables, yet we suspect that insufficient data for some of their possible categories render them insignificant in the end.

Table 4.: Results from stepwise regression analysis.

Backward Regression Analysis		Forward Regression Analysis	
Variable	p-value	Variable	p-value
Interruptions to leisure time	0.0015	Interruptions to leisure time	0.0045
Anticipating action	0.0008	Anticipating action	0.00003
Potential errors	0.0085		

In addition, the forward analysis suggests the construction of the regression model in Equation 3. In this analysis 'post-call recovery' is approaching significance, but the p-value is not less than 0.05 preventing this variable from being included in the forward analysis. Curiously, 'potential errors' exhibits a higher p-value and is thus excluded from the forward regression model, despite its inclusion in the backward approach. This discrepancy arises due to differences in ANOVA calculations depending on the ordering of factors in the regression model.

$$\text{Stress} \sim C(\text{Interruptions to leisure time}) + C(\text{Potential errors}) + C(\text{Anticipating action}) \quad (2)$$

$$\text{Stress} \sim C(\text{Anticipating action}) + C(\text{Interruptions to leisure time}) \quad (3)$$

3.4.4. Causal analysis

Results from the causal analysis are depicted in Table 5. The exposure X is represented in the first column, alongside the corresponding regression model built with the confounders we have to account for. Subsequently, we represent the p-value from the ANOVA analysis. The coefficients corresponding to the various categories of each exposure variable and their 95%-Confidence Intervals (CIs) are provided in the last two columns. Note that each category is plotted against a reference or baseline category indicated in parentheses. A recapitulation of all variables with their corresponding categories and assessment as used in the questionnaire, are provided in Appendix E. If our DAG is correct, we can interpret these findings as causal effects:

(1) Doctors experiencing many interruptions in leisure time due to an on-call shift have a stress level that is 2.81 units higher in comparison with doctors experiencing only some interruptions.
(2) Doctors who easily recognize the feeling of anticipating future events during their on-call shift experience a stress level that is 3.42 units higher than doctors who only slightly recognize this feeling.
(3) Doctors who are only slightly worried about the potential errors they may make during the on-call shift have a stress level that is 3.06 units lower than doctors who are rather worried about potential errors.

4. Discussion

4.1. Main findings and interpretation

Using data from a literature review, a focus group discussion and an observational survey, we have devised and tested causal relationships depicted in a DAG. Our DAG

Table 5.: Results from causal analysis. Each category is plotted against a reference or baseline category stated in parentheses. The coefficients of the various categories of each variable indicate how many units stress increases or decreases on a total of 30 units in the 'TBI-CareQOL Caregiver Strain' scale.

Exposure X	Model	p-value (ANOVA)	Coefficients	95 % CI
Interruptions to leisures time	On-call stress ∼ Interruptions to leisure time +Tolerance level	0.0060	Experienced many interruptions = 2.8087	[1.016, 4.601]
			Experienced little interruptions = 0.0046 (Experienced some interruptions)	[-3.627, 3.636]
Anticipating action	On-call stress ∼ Anticipating action +Experience	0.0001	Easily recognizable = 3.4241 (Only slightly recognizable)	[1.767, 5.081]
Potential errors	On-call stress ∼ Potential errors +Experience +Medical support	0.0245	Slightly worried = -3.0624	[-5.514, -0.611]
			Occasionally worried = -1.4507 (Rather worried)	[-3.393, 0.492]

was structured based on the hypothesis that weekend on-call duties increase occupational stress in GPs in training. Both our literature review and focus group discussion supported this hypothesis, as numerous articles and participants emphasized the significant impact of on-call duties on occupational stress. Furthermore, this initial hypothesis was confirmed by the results of our observational survey, which indicated elevated stress levels during on-call shifts compared to daily life for GPs in training.

Our study aimed to examine not only whether, but also how an on-call shift induces occupational stress. If our DAG is correct, we found that internal stress factors, stemming from psychological or emotional sources within the physician, contribute significantly to a feeling of stress or tension. Specifically, the experienced interruptions to leisure time due to an on-call shift, the fear of possibly making medical errors, and anticipatory behaviour in response to future calls or patient visits, emerged as key contributors to elevated stress levels in our study. However, it is important to interpret these findings with caution. There may have been greater variability in participants' responses related to external stress factors, potentially limiting our ability to measure their significance accurately. Other stress factors such as the resources available through collaboration with a hospital ('hospital resources'), patients' questions that are not appropriate for an urgent care setting ('unfair questions') and the level of

irritability that physicians experience before beginning their on-call shift ('tolerance level'), were approaching significance in our current study ($p < 0.1$). These are consistent with our previous finding that internal stress factors are the biggest contributors to occupational stress. However, we lack sufficient data points to further investigate these factors.

4.2. Comparison with previous literature

In recent years, the demands of on-call work and its impact on the well-being of physicians has been the focus in other studies as well. More specifically, numerous previous studies highlighted the association between an increasing hourly caseload on-call [26, 5, 35], an increasing number of shifts per month [27, 5, 10, 35, 36, 31], or number of hours per shift [6, 7, 29, 8, 37] and mental fatigue or occupational stress. Notably, these studies encountered not only occupational stress, but also mental fatigue or burnout as a long-term outcome. On the other hand, organizational justice [7], the presence of a recovery period post-call [29, 9], social support [5], a healthy team climate [7, 29] and a supporting supervisor available [7, 28] proved to be effective job resources balancing the experienced on-call demands and stress. Heponiemi T. et al. explored demographic features among physicians to assess whether there are groups who are more vulnerable to on-call work. Sex, age and specialization status appeared to be important demographic factors, but further research is still needed [7]. In other studies encountering GPs or specialist physicians, similar stress factors were identified as in our study conducted with GPs in training, such as interference with family or leisure time [31, 6], anticipatory behaviour to possible patient contacts [31] and concerns regarding potential errors [32]. As an example, Vincet G. et al, found out that on-call workers rated interruptions to leisure or family time (70%) or anticipatory behaviour encompassing preplanning in case of a call (69%) or worrying about missing a call (69%) as the main factors they ruminated about. Female on-call workers appeared to exhibit more anticipatory behaviour, such as thinking about the likelihood of being called and reporting thoughts about preplanning their visits [31]. In addition, the analysis of Zahrai A. et al, revealed that concerns regarding medical mistakes or death of a patient was the only significant work-related problem for residents during a night on-call, underlining the need for a helpful supervisor to ask advice to [32]. Other possible factors endangering the mental well-being of medical trainees or physicians, appeared to be time pressure [7], little educational value [29] and a disturbed sleep quality [9, 38, 8, 39, 31]. These results underline our research, emphasizing the need to arrange on-call duties in a way that physicians have a voice in organizational decisions.

4.3. Policy and practice implications

Our study suggest some implications for clinical practice and education of GPs in training, prioritizing their mental health. Given the finding that internal stress factors have proven to be particularly important, it is required to focus on coping mechanisms and resilience training in physicians' education. Anticipatory behaviour in response to potential calls or patient visits ('anticipating action'), as well as the level of irritability that physicians experience before beginning their on-call shift ('tolerance level') have both proven to be a significant predictor of the occupational stress level experienced during the on-call shift in our study. This finding underscores

the importance of maintaining a healthy work-life balance to be able to commence an on-call shift in balanced, well-rested mental condition. If decisions need to be made at the regulatory level, we may need to conduct a larger study focusing on internal stress factors, stemming from psychological or emotional sources within the physician, as we have demonstrated their significance above.

During the course of this research, we thought of some strategies to tackle such internal stress factors. Firstly, the presence of an external confidential contact person with whom physicians can share threatening patient encounters or mental problems, would be of great value. A confidant could primarily listen to the experiences of physicians, as well as catalog their experiences to address patients exhibiting unacceptable behavior or to identify underlying issues. In addition, the merit of a triage system was repeatedly mentioned during the focus group discussion. A triage system can function as a filter to avoid unnecessary patient encounters, reducing the caseload during the on-call shift. As such, physicians would be less fatigued after their shift, experiencing less interruptions to leisure time. In this perspective, recovery time post-call approached significance in our study, so would possibly be helpful to reduce the experienced interruptions. Furthermore, we believe that the competitive nature of medical school, imposing a perfectionist attitude and a performance pressure, creates a lot of stress during the clinical years [40]. Instead, we should foster a culture of teamwork among healthcare professionals in which responsibilities are shared. We should learn to have a more positive perspective on mistakes seeing them as a opportunities for growth. This way, the burden on individual doctors and the anticipatory behaviour prior to the shift, would be reduced. To this end, it would be helpful if GPs (in training) have a voice in the policy making and the organisation of the on-call system. Moreover, in society there should be a focus on preventive and educational measures to enhance patients' health literacy. Providing patients with guidelines on when to visit the emergency room or a GP cooperative on-call center, will reduce the number of patient visits, unnecessary concerns, and stress for both physicians and patients. If possible, such health skills or feedback on the appropriateness of the visit could be provided to patients after their visit. Finally, as physicians, we should make clear agreements and guidelines working together across different GP cooperative on-call centers, regarding which advices or practices can be performed in an on-call setting (e.g. concerning maintenance medication or joint infiltrations), to achieve uniformity and clarity to patients.

4.4. Strengths and limitations

4.4.1. The strength of using a DAG

Although DAGs are increasingly popular among scientists as a strategy to guide study design, they remain relatively uncommon within the broader scope of applied health research. To our knowledge, there are currently no other studies in primary healthcare that utilize DAGs as a method to explore the effects and mechanisms of on-call duties on occupational stress in physicians. Tennant et al. explored some challenges to the more frequent implementation of DAGs and, as a result, identified a knowledge gap regarding how to develop DAGs, emphasizing the need for practical guidance on their use [11]. In their review of 234 articles mentioning DAGs, the authors found substantial variation in size and structure. Moreover, several articles mentioning DAGs did not report their DAG (reported by 62%) and even fewer provided technical

details, such as the target estimand(s) of interests (reported by 21%), or DAG-implied adjustment set(s) (reported by 48%). Reluctance to share such information may reflect a lack of awareness of its benefits, a lack of confidence, fear of criticism or insufficient encouragement from journals and reviewers [11]. Barnard-Mayers et al. further investigated the barriers to more frequent use of DAGs and confirmed a knowledge gap on how to develop DAGs. The main challenges encompass omitting arrows, including arrows, identifying potential sources of error and identifying collider bias. This may result in the development of unconvincing DAGs and introduce biases into studies utilizing them. More training resources and guidance on the application of DAGs to health research is necessary to address the uncertainty surrounding this topic [41].

In our study, we are proud to have used a DAG as a methodological strategy to explore occupational stress during out-of-hours care. While mastering the use and development of DAGs demands some training and expertise, we remain fully convinced of its scientific merit. At the start of our research in Section 2.1, DAGs forced us to reflect deeply on our research questions. They proved to be a transparent way to structure and demonstrate our knowledge gained during the literature review and focus group discussion. Consequently, we developed a better understanding of our research aims and underlying assumptions, before collecting data via questionnaires. The DAG provided a simplification of the multidimensional concept of mental health which fostered the collaboration with colleagues and domain experts in Section 2.2. As Fleischer et al. mentioned, the strength of DAGs lies in making a simplification of reality open and explicit to scrutiny [42]. In Section 2.3 we used the DAG as a resource for gaining insight in the causal relations between the obtained stress factors and visualizing potential sources of confounding, selection and measurement bias. Via *Dagitty.net*, the DAG permitted a formal approach to identify minimal sufficient adjustment sets to reduce confounding bias for causal analysis. Consequently, the DAG allowed us to estimate causal effects based on observational data of variables highly correlated with occupational stress. Using a DAG, we believe we contributed to the 'Open Science Movement', which emphasizes on research quality characterized by transparency, rigor, reproducibility and replicability [43].

4.4.2. Limitations

We found some limitations as well, concerning the literature review and the survey we conducted. First of all, our systematic search was only performed by one reviewer (GD) in contrast to the current recommendation to involve at least two reviewers, as this increases the reliability of the assessment [44]. In addition, we recognize that our literature review is limited by the methodological quality of the studies included as we did not evaluate the quality of eligible studies. With this, rather 'pragmatic', strategy we aimed to obtain a comprehensive overview to approximate saturation on the most often published risk factors for occupational stress during out-of-hours care. Readers should keep in mind that the inclusion of a certain variable in our causal diagram may be based on limited evidence. Concerning the survey, we note that our sample size was rather small, especially considering we worked with categorical variables which typically necessitate larger datasets for effective regression modelling compared to continuous variables. Our sample encompassed mainly physicians in GP training who voluntarily chose to participate. This may have resulted in selection bias since students

with strong opinions regarding their call experience may have been more likely to participate. Finally, occupational stress during the on-call shift was assessed with a subjective measure, a questionnaire, which may lead to response bias or recall bias. Nevertheless, to minimize these problems, we opted for a well-known validated measure that has proven to be reliable [4].

4.5. Future research

We worked diligently to construct the present DAG to the best of our ability. Nevertheless, it remains subject to certain limitations, as outlined above. In this regard, we are aware of the potential for improvement and scrutiny of our DAG. We trust that the transparency in our DAG will offer a solid base for discussion between researchers and yield novel insights into this topic. We hope to inspire researchers to explore new perspectives and enhance our DAG in future studies. Together, we can strive towards refining the DAG to its highest potential. We believe that collaborative effort will enrich the causal diagram, advance the understanding of occupational stress factors in GPs in training and ultimately benefit their mental health.

5. Conclusion

This study presents an investigation into the occupational stress experienced by GPs in training during weekend on-call duties, and the properties of the shift that contribute to this stress level (called stress factors). We leveraged both a qualitative and quantitative design. In Section 2.1, a literature review and focus group discussion confirmed our research hypothesis that weekend on-call duties increase occupational stress among GPs in training. Moreover, several candidate stress factors contributing to occupational stress were identified. Based on the obtained stress factors and insights gained from a domain expert, we established a DAG in Section 2.2 to visually represent these factors and cause-effect relationships between them, providing a transparent overview of the multidimensional concept of occupational stress. Furthermore, the observational survey in Section 2.3 revealed that the experienced interruptions to leisure time, the fear of making potential errors, and anticipating behaviour to future patient contacts emerged as key contributors to occupational stress in our study. Hence, it appears that particular internal stress factors are important to consider, emphasizing the relevance to focus on coping mechanisms and resilience training in medical education of GPs. We invite others to use our DAG in their own research, and to refine it further to its highest potential. This way, we hope to contribute to research that investigates occupational stress in GPs in training, helping to improve the quality of out-of-hours care while prioritizing their mental well-being.

6. Acknowledgements

The process of writing this study has been an instructive and engaging experience. In particular I would like to thank Prof. Dr. Peter Decat and dr. Laure-Ann Quenon, who both were diligent and reliable supervisors to me. Dr. Laure-Ann Quenon, thank you for your support in navigating an early transition to a new topic and empowering

[4]The validated short form 6a 'TBI- CareQOL Caregiver Strain'

me to work individually. Prof. Dr. Peter Decat allowed me to choose my own topic beyond his own traditional expertise, to explore the world of DAGs and mental health in physicians. However, I would not be writing about DAGs and using causal inference techniques if it weren't for prof. dr. Thomas Demeester and Paloma Rabaey who gave rise to this idea, always keeping an open line and providing in-depth advice and detailed feedback when I requested it. Thank you!

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Appendix A. Buildup of the focus group discussion

Table A1.: Overview of the used structure in the focus group discussion

Fase 1: Introduction and informed consent	*5 min*	
Fase 2: Opening question/ icebreaker	*5 min*	'It is Friday evening. You look at your schedule and notice that you're on call on Sunday from 8 am to 7 pm. What is the first thought that crosses your mind?'
Fase 3 : Key questions	*10 min* *10 min* *10 min* *10 min*	'What are the most tiring or demanding aspects of being on call for you?' 'What are your primary concerns during on-call shifts?' 'Literature review has shown that following factors induce stress during on-call duties. What are the most significant ones for you, and why?' 'There are various types of on-call duty shifts across Europe. Which type of on-call duty would feel the most challenging for you and why?' 'Which type of duty would feel the safest for you and why?' 'If you were allowed to change one thing about the organization of the on-call schedule, what would help to reduce the stress?'
Fase 4: Closing question	*5 min*	'Have we overlooked anything during the discussion?', 'Does anyone want to add anything to this?'
Fase 5: Closing remarks	*5 min*	

Appendix B. TBI-CareQOL Caregiver Strain

Table B1.: TBI-CareQOL Caregiver Strain – Short Form 6a [10]

	Always	**Never**	**Rarely**	**Sometimes**	**Usually**
I feel that there are not enough hours in the day to get everything done.	1	2	3	4	5
I feel stressed when it comes to providing care for the person with the injury.	1	2	3	4	5
I feel that stress makes it difficult to start anything new.	1	2	3	4	5
I feel drained by my responsibilities as a caregiver.	1	2	3	4	5
I cannot handle any more responsibility when it comes to providing care for the person with the injury.	1	2	3	4	5
I feel burdened with the responsibility of caring for the person with the injury.	1	2	3	4	5

Appendix C. Definitions of all retained variables

Table C1.: Definitions of retained variables from literature review, focus group discussion and consulting a domain expert

Exposure	
On-call shift	Whether or not a physician has an on-call shift scheduled during the current weekend.
Outcome	
Occupational stress	The psychological and physical strain experienced by physicians while exercising their occupation.
Variabels retained from literature review	
Hourly caseload	The number of patients or cases that a physician handles within each hour of the on-call shift.
Medical support	The guidance or encouragement provided by a senior colleague or supervisor to the GPs in training in their clinical practice during the on-call shift.
Post-call recovery	A period of rest or recuperation provided to a GP in training after completing a weekend on-call shift.
Experience	The number of years of experience in GP training, typically ranging from 1 to 3 years.
Sex	The behavioral, cultural, and psychological aspects associated with being male, female, or non-binary.
Anticipating action	Maintaining a state of readiness and awareness in anticipation of potential calls or patient visits. It involves being mentally prepared and attentive to incoming tasks. As an example, anticipating action includes 'constantly keeping an eye on your phone', 'not being able to relax between calls', 'pre-planning scheduled patient visits', 'struggling to sleep well, even if there is no call'
Interruptions to family or leisure time	Work interference with family or leisure activities.
Potential errors	The concern felt by GPs in training about making medical errors or potentially missing serious diagnoses during the current on-call shift.
Variabels retained from focus group discussion	
Unknown medical records	Medical information or records of a specific patient that are inaccessible or unavailable to the attending physician during the on-call shift.
Unfair questions	Complaints from patients that are not appropriate for an urgent care setting, such as non-urgent long-term complaints, or elective care that should be postponed to a planned visit during regular working hours.

A driver	The presence or absence of a driver during the on-call duty who transports physicians to and from home visits.
Work environment	The work environment where the on-call shift takes place which is, in our study, limited to a single category of the on-call centre setting at GP cooperatives.
A secretary's office	A secretary or administrative assistant who is responsible for various administrative tasks, such as answering calls, scheduling appointments, managing correspondence, and the payment procedure.
Unsafe situations	The occurrence of certain situations in which the GPs in training feel unsafe in response to a patient contact.
Practical barriers	Experiencing practical or technical issues during the on-call shift, such as processing technical tests (nasal swabs, blood samples, urine samples...) or processing the payment procedure.
Demanding behaviour	Behavior exhibited by patients that is characterized by an insistence on specific treatments, services, or attention, often beyond what is deemed medically reasonable by healthcare providers.
Medical triage	The presence of a medical assistant able to prioritize patients based on the severity of their condition and the urgency of their need for medical attention.
Variables included after review domain expert	
Tolerance level	The level of irritability that physicians experience before beginning their on-call shift, ranging from being easily agitated or impatient to being calm and controlled during the patient visits.
Hospital resources	The resources available through collaboration with a hospital. This can include both technical resources, e.g. the availability of imaging tests or laboratory analyses, as well as the intercollegiate cooperation with specialist physicians.
Geography	A specific area or region where the duty is performed.
Available resources	The tools, equipment, personnel, and facilities that are accessible and ready for use in a GP cooperative to handle medical emergencies or patient needs during the out-of-hours care.
Socio-Economical State (SES)	The combined influence of social and economic factors on an individual's or community's overall well-being and financial status.

Appendix D. Separate boxplots resulting from univariate regression analysis.

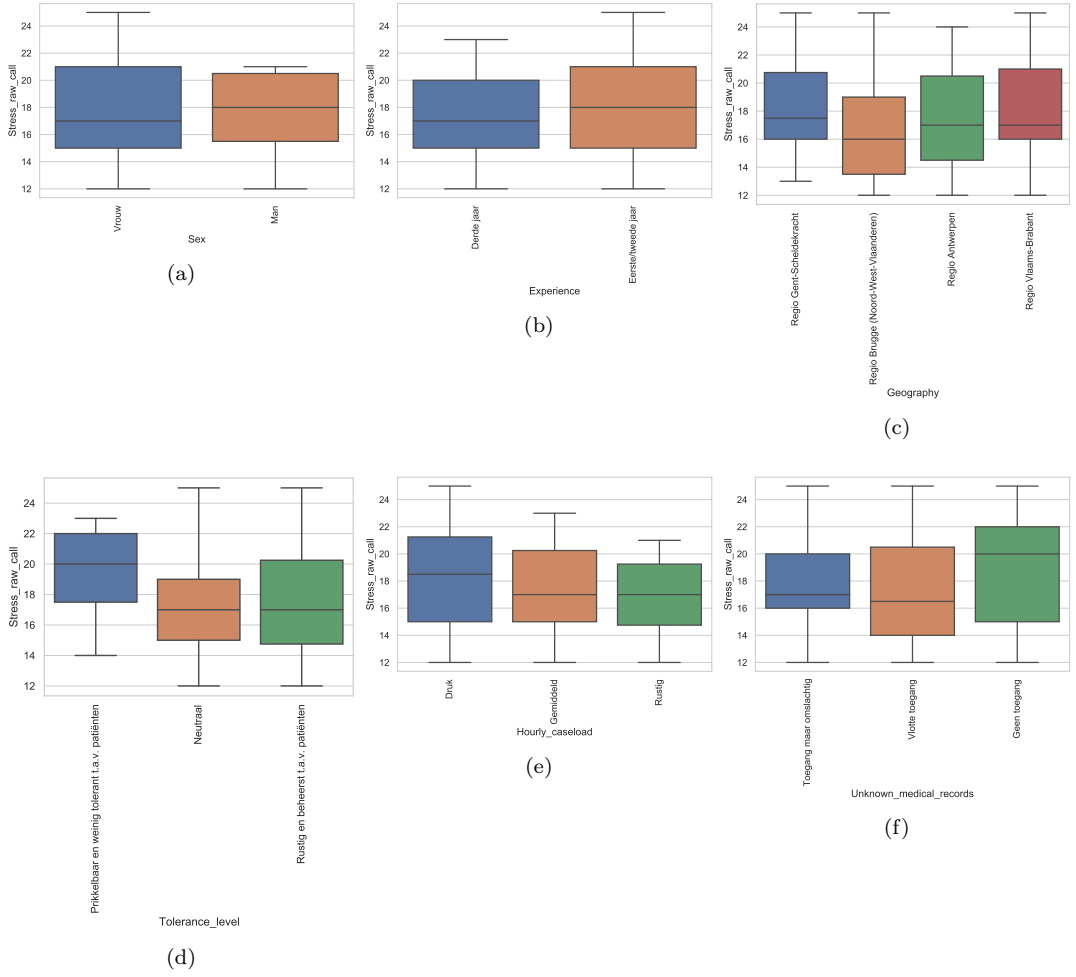
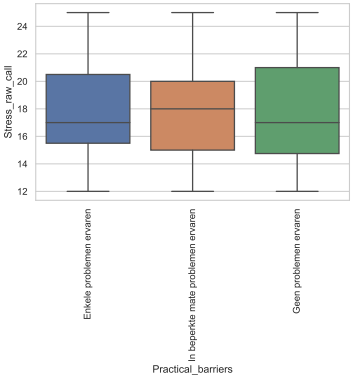
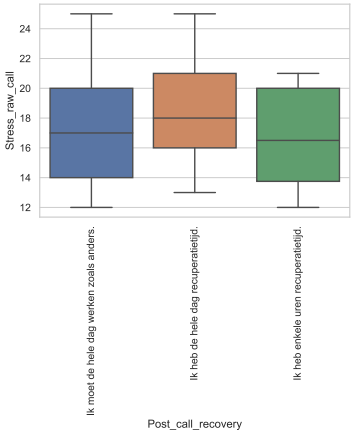


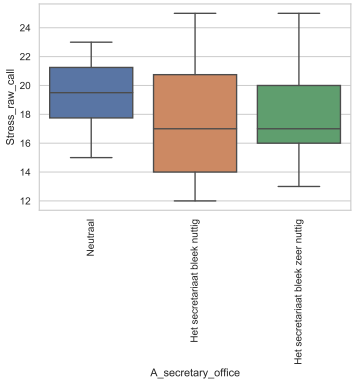
Figure D1.: Individual boxplots for each independent variable in relation to occupational stress during the on-call shift, resulting from univariate regression analysis.


Stress_raw_call
Enkele problemen ervaren
In beperkte mate problemen ervaren
Geen problemen ervaren
Practical_barriers

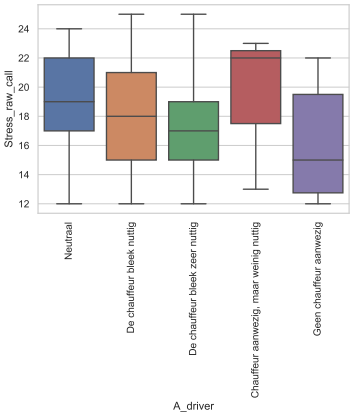
(g)


Stress_raw_call
Ik moet de hele dag werken zoals anders.
Ik heb de hele dag recuperatietijd.
Ik heb enkele uren recuperatietijd.
Post_call_recovery

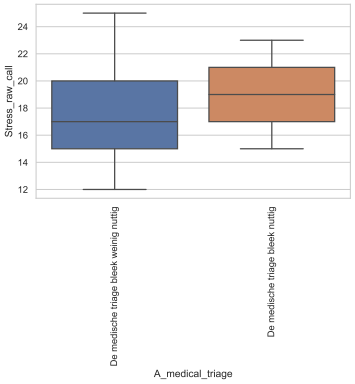
(h)


Stress_raw_call
Neutraal
Het secretariaat bleek nuttig
Het secretariaat bleek zeer nuttig
A_secretary_office

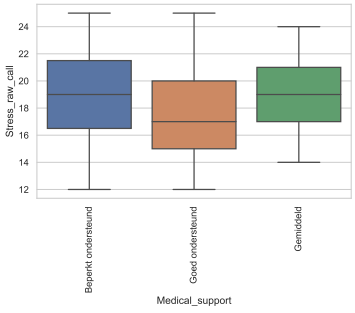
(i)


Stress_raw_call
Neutraal
De chauffeur bleek nuttig
De chauffeur bleek zeer nuttig
Chauffeur aanwezig, maar weinig nuttig
Geen chauffeur aanwezig
A_driver

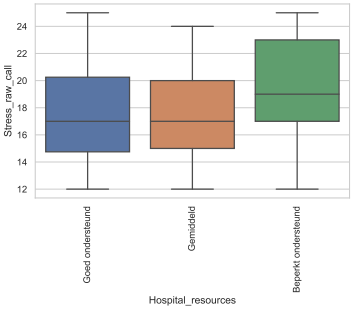
(j)


Stress_raw_call
De medische triage bleek weinig nuttig
De medische triage bleek nuttig
A_medical_triage

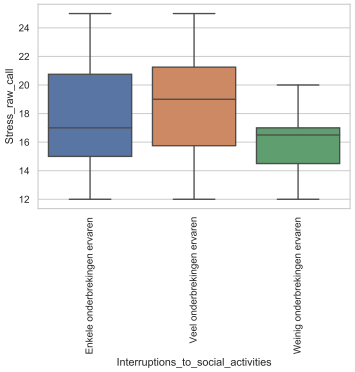
(k)


Stress_raw_call
Beperkt ondersteund
Goed ondersteund
Gemiddeld
Medical_support

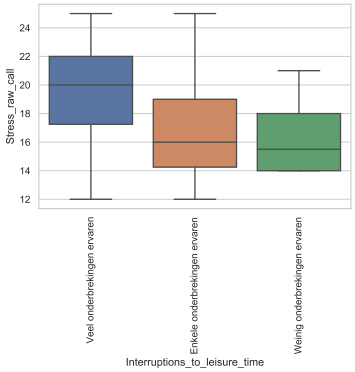
(l)


Stress_raw_call
Goed ondersteund
Gemiddeld
Beperkt ondersteund
Hospital_resources

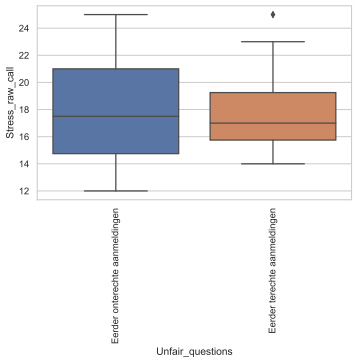
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Stress_raw_call
Enkele onderbrekingen ervaren
Veel onderbrekingen ervaren
Weinig onderbrekingen ervaren
Interruptions_to_social_activities

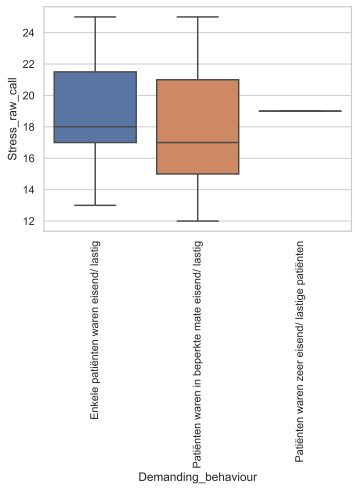
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Stress_raw_call
Veel onderbrekingen ervaren
Enkele onderbrekingen ervaren
Weinig onderbrekingen ervaren
Interruptions_to_leisure_time

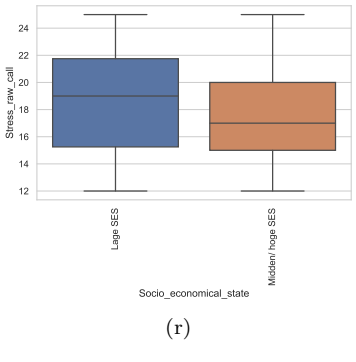
(o)


Stress_raw_call
24
22
20
18
16
14
12
Eerder onterechte aanmeldingen
Eerder terechte aanmeldingen
Unfair_questions

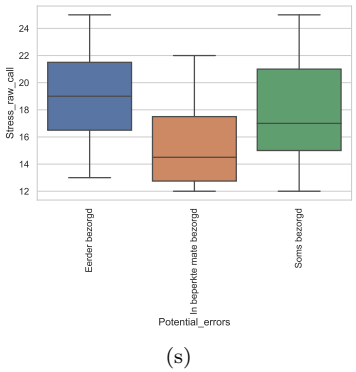
(p)


Stress_raw_call
24
22
20
18
16
14
12
Enkele patiënten waren eisend/ lastig
Patiënten waren in beperkte mate eisend/ lastig
Patiënten waren zeer eisend/ lastige patiënten
Demanding_behaviour

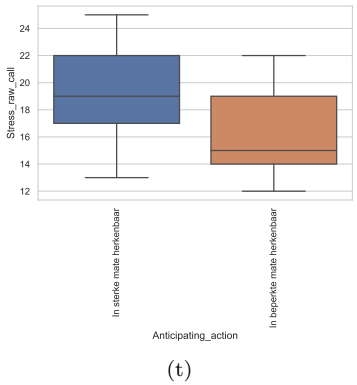
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Stress_raw_call
24
22
20
18
16
14
12
Lage SES
Midden/ hoge SES
Socio_economical_state

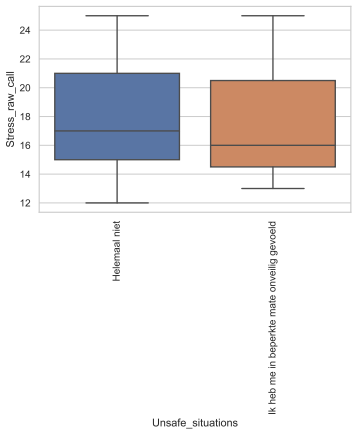
(r)


Stress_raw_call
24
22
20
18
16
14
12
Eerder bezorgd
In beperkte mate bezorgd
Soms bezorgd
Potential_errors

(s)


Stress_raw_call
24
22
20
18
16
14
12
In sterke mate herkenbaar
In beperkte mate herkenbaar
Anticipating_action

(t)


Stress_raw_call
24
22
20
18
16
14
12
Helemaal niet
Ik heb me in beperkte mate onveilig gevoeld
Unsafe_situations

(u)

Appendix E. Overview of the variables with corresponding categories and used assessment in the questionnaire

Table E1.: Retained variables with corresponding assessment used in the questionnaire en possible response options

Retained variables	**Corresponding assessment in questionnaire**	**Possible response options**
Hourly caseload	How busy did you experience the on-call shift?	Calm, average or busy
Medical support	How well did you feel medically supported during the on-call shift (by supervisor, colleagues,...)?	Supported to a limited extent, average or well-supported
Post-call recovery	If the day after your on-call shift is a working day... Do you have to work the day after your on-call shift, or do you have recovery time?	I have to work the whole day as usual, I have some hours of recovery period, I have the whole day to recover.
Experience	In which of the three years of specialized GP training are you currently?	The first or second year, the third year
Sex	What is your gender?	Man, female, non-binary
Anticipating action	To what extent did you recognize any anticipatory actions during the on-call shift? Examples include: *'I constantly keep an eye on my phone.', 'Between calls, I usually cannot relax well but remain alert.', 'I anticipate upcoming patient consults and think about the complaints.', 'During on-call shifts, I cannot sleep well, even if I am not called.'*	Recognizable to a limited extent, Recognizable to a strong extent
Interruptions to family time	To what extent did you engage in fewer activities with family or friends as a result of being on-call?	Experienced few interruptions, Experienced some interruptions, Experienced many interruptions
Interruptions to leisure time	To what extent did you experience interruptions in leisure time due to this on-call shift?	Experienced few interruptions, Experienced some interruptions, Experienced many interruptions

Potential errors	To what extent did you worry about making medical errors or potentially missing serious diagnoses during the on-call shift?	Slightly worried, occasionally worried, rather worried
Unknown medical records	What was your level of access to the patient's medical records (e.g. medical history, medication list, and allergies...)?	No access, access but not user-friendly, easy access
Unfair questions	In your opinion, were patients' chief complaints justified for an urgent on-call setting?	Rather unjustified questions, rather justified questions
A driver	If a driver was present, how useful was the driver?	Rather useful, rather useless, no driver present.
A secretary's office	If a secretary's office was present, how useful was the secretary?	Rather useful, rather useless, no secretary's office present.
Unsafe situations	Did you feel unsafe during this on-call shift due to threatening, aggressive, or demanding patient interactions?	Not at all, I felt (to a limited extent) unsafe
Practical barriers	Did you experience any practical/technical issues during this on-call shift? *For example, in processing technical examinations (nasal swabs, blood samples, urine samples...) or completing the payment procedure.*	No problems experienced, experienced problems to a limited extent, experienced some problems
Demanding behaviour	In your opinion, how demanding were the patients during the on-call shift? *Examples include patients with excessively high expectations or patients who were critical or suspicious towards your recommendations as a physician.*	A limited amount of patients was demanding, some patients were demanding
Medical triage	If a medical triage was present, how useful was the medical triage?	Rather useful, rather useless, no medical triage present.
Tolerance level	How did you feel when you left home for the on-call shift?	Irritable and less tolerant towards patients, average, calm and tolerant towards patients

Hospital resources	How well did you feel supported by the secondary care during the on-call shift? This entails not only the availability of technical resources such as a lab/rapid tests or imaging, but also the intercollegial collaboration with emergency physicians or specialists.	Supported to a limited extent, average or well-supported
Geography	In which region did you perform this on-call shift?	Gent, Brugge, Antwerpen, Vlaams-Brabant
SES	In your opinion, what seemed to be the average SES of the patients at the on-call center?	Low SES, average SES, high SES