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Analyzing emergency call volume, call durations, and unanswered calls during the first two waves of the COVID-19 pandemic compared to 2019: An observational study of routine data from seven bavarian dispatch centres

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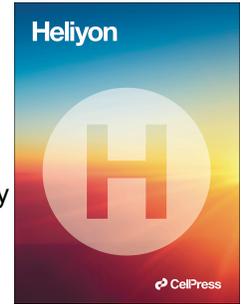
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Cover page

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4 Analyzing emergency Call Volume, Call Durations, and Unanswered Calls During the First Two Waves of
5 the COVID-19 Pandemic compared to 2019: An Observational Study of Routine Data from Seven
6 Bavarian Dispatch Centers

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10 *Article type: Original article*

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14 **Abstract**

15

16 **Background**

17 The spread of the COVID-19 pandemic and the corresponding implementation of
18 measures such as stay-at-home orders and curfews had a major impact on health
19 systems, including emergency medical services. This study examined the effect of the
20 pandemic on call volumes, duration of calls and unanswered calls to the emergency
21 number 112.

22

23 **Method**

24

25 For this retrospective, descriptive study, 986,650 calls to seven emergency dispatch
26 centres in Bavaria between 01/01/2019 and 31/05/2021 were analysed. The absolute
27 number of calls and calls per 100,000 inhabitants as well as the number of unanswered
28 calls are reported. The Mann–Whitney U test was used to compare mean call durations
29 between 2019 and 2020/2021 during several periods.

30

31

32 **Results**

33

34 Call volume declined during the pandemic, especially during periods with strict lockdown
35 restrictions. The largest decline (-12.9%) occurred during the first lockdown. The largest
36 reduction in the number of emergency calls overall (-25.3%) occurred on weekends during
37 the second lockdown. Emergency call duration increased, with the largest increase (+13
38 seconds) occurring during the “light” lockdown. The number of unanswered calls remained
39 at a similar level as before the pandemic.

40

41

42 **Conclusion**

43

44 This study showed that the studied Bavarian dispatch centres experienced lower call
45 volumes and longer call durations during the first two waves of the COVID-19 pandemic
46 (up to May 2021). Longer call durations could be the result of additional questions to
47 identify potentially infectious patients. The fact that the number of unanswered calls hardly
48 changed may indicate that the dispatch centres were not overwhelmed during the study
49 period.

50

51 Introduction

52
53

54 The number of pre-hospital emergency medical services (EMS) responses in Germany has
55 steadily increased for years [1]. The trend in the federal state of Bavaria is similar [2, 3].
56 However, pre-hospital EMS responses represent only a fraction of the chain of events initiated
57 by a medical emergency. At the beginning of the chain, dispatch centres handle requests for
58 help, alert fire services or ambulances, and coordinate the transport of patients to suitable
59 treatment facilities [4]. Hence, the rising number of pre-hospital EMS responses correlates with
60 a rising number of emergency calls. An effective dispatch centre is therefore a prerequisite for
61 adequate handling of medical emergencies. However, the workload of dispatch centres and
62 ambulances are not necessarily directly related, as dispatch centres also perform a filtering
63 function. Callers who seek only information must be referred to appropriate helplines to allow
64 the dispatch centres personnel to be available for medical emergency calls. The dispatch
65 centre plays an important role for the whole pre-hospital EMS system, as callers can be
66 directed to various health care settings [5].

67

68 The coronavirus disease 19 (COVID-19) pandemic has affected the utilization of pre-hospital
69 EMS in several ways. In response to the COVID-19 pandemic, the German federal government
70 and the Bavarian state government imposed a set of restrictions to contain the spread, shutting
71 down large parts of public life during several periods. These measures, as well as the fear of
72 infection in the early days of the pandemic, presumably affected the type and frequency of pre-
73 hospital EMS use. Consequently, this change would have altered the utilization of the
74 emergency number (112) and thus the integrated dispatch centres that answered these calls.
75 Moreover, people may have desired more medical information during the pandemic. In
76 response to the pandemic, dispatch centres altered several processes [6–8]. The Bavarian
77 Ministry of the Interior for Sport and Integration issued a directive that the dispatch protocol
78 includes additional questions to identify potentially infected patients [9]. These additional
79 queries likely increased the duration required to process an emergency.

80

81 Many analyses have focused on ambulance services; however, the role of the coordinating
82 dispatch centres has received less attention. Some studies have suggested that ambulance
83 dispatch centres faced an increase in calls during the COVID-19 pandemic [7, 8, 10–15]; in
84 contrast, a decline in the number of emergency calls has also been documented [16–20, 8].
85 This decline in emergency calls is in line with a decrease in the utilization of EMS [21, 22] and
86 decreasing numbers of patients admitted to emergency departments [23] at the beginning of
87 the pandemic. A combination of these phenomena has also been reported [24]. However, few

88 studies have focused on the change in the number of emergency calls and the time needed to
89 process these calls.

90 To the best of our knowledge, no studies to date have examined changes in the number of
91 medical emergency calls and the duration of these calls in Germany during the COVID-19
92 pandemic. For this study, we extracted and analysed telephone data of calls to the medical
93 emergency number (112) from seven integrated dispatch centres. We investigate changes in
94 the number of calls, the number of unanswered calls and call durations and compared these
95 values to the same period in previous years. The goal of the analyses was to examine the
96 workload of integrated dispatch centres to obtain a better picture of the changes that affected
97 the rescue chain during the pandemic.

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100 **Methods**

101

102 For this retrospective, descriptive study, data were extracted from the dispatch centres'
103 telephone systems, which automatically keep track of incoming calls, between 01/01/2019 and
104 31/05/2021. The seven investigated regional dispatch centres were operated by the Bavarian
105 Red Cross. A data usage agreement was concluded with the Bayerisches Rotes Kreuz (BRK)
106 for the use of the data, which permits the analysis and publication of the data from the dispatch
107 centres operated by the BRK. These integrated dispatch centres can be reached via the
108 European emergency number (112). They coordinate emergency and nonemergency ground
109 and air ambulance responses as well as the fire brigade and alert the appropriate vehicles
110 [25]. In Bavaria, 26 regional dispatch centres cover different areas and coordinate calls and
111 rescue vehicles. Each area covered consists of one or more counties and independent cities.
112 Response decisions are made by the dispatchers, who use a non-standardized, keyword-
113 based dispatch protocol. A guideline is provided to support the decision-making process [26].

114

115 Germany's first confirmed COVID-19 case was reported on 27/1/2020, near Munich, Bavaria.
116 This cluster was fully contained, but case numbers subsequently began to increase in March.
117 By 31/5/2021, Germany had undergone several waves of the pandemic. In response to rising
118 case numbers, on 18/3/2020, the Bavarian Ministry of the Interior for Sports and Integration
119 (StMI) issued several guidelines [9]. To identify patients potentially infected with severe acute
120 respiratory syndrome coronavirus 2 (SARS-CoV-2), additional questions were added to the
121 dispatch protocol for patients with nonspecific general symptoms, fever or respiratory
122 symptoms. These questions were as follows:

123

- Has the patient tested positive for COVID-19?

124

- Has the patient been in contact with someone with confirmed COVID-19 in the past 14 days?

125

126

- Has the patient recently (within the last 14 days) travelled to an international risk area listed by the Robert Koch Institute (RKI)?

127

128 All eight dispatch centres operated by the Bavarian Red Cross provided data for this study.
129 The information included when calls were made, when calls were answered, when calls ended,
130 and whether the caller hung up before the call was answered. Therefore, the number of calls,
131 call durations (answer until end of call), and the number of unanswered calls were analysed.
132 Data from one dispatch centre (Donau-Ilher) were excluded because the exported data were
133 incomplete. Thus, data from seven dispatch centres were included in the analysis. One
134 dispatch centre (Mittelfranken-Süd) was not able to provide data before September 2019; data
135 from this call centre is therefore not included in analyses comparing the observed (pandemic)
136 periods to corresponding periods in 2019.

137

138 The database included 986,650 calls between 01/01/2019 and 31/05/2021. After removing 15
139 duplicate calls for which values in all columns matched and removing records that could not
140 be assigned a date, the dataset consisted of 986,632 calls. Deviations of the number of calls
141 below the expected call volume were likely due to technical problems that led to incomplete
142 transmissions of call numbers on certain days. We assumed a data gap if a dispatch centre
143 did not receive a call within at least six hours. We detected data gaps at five dispatch centres
144 over a total of 68 days. On days with data gaps, the number of calls was corrected to the
145 median number of calls on the same day of the week in other weeks of that month if the daily
146 call volume fell below the median call volume of that day of the week and month. Thus, a total
147 of 2,778 calls were added to the dataset, and the analyses were based on 989,410 calls.
148 Upwards deviations in call numbers were permissible as events such as thunderstorms, fires
149 or heat waves can lead to high demand on individual days.

150

151 Usually, calls are terminated before or upon arrival of the ambulance at the scene. In Bavaria,
152 emergencies should be reached by a paramedic-staffed ambulance no later than 12 minutes
153 after dispatch. Thus, call durations of more than 15 minutes were considered implausible. A
154 total of 681 calls (0.07% of the available calls) lasted longer than 15 minutes and were
155 truncated at 15 minutes. Calls of shorter duration were deemed plausible and included in the
156 analyses.

157

158 Annual data on the population of Bavaria were provided by the Bavarian State Office for
159 Statistics. For 2021, the population count from 2020 was assumed. The analyses were
160 supplemented with publicly available data on the number of COVID-19 cases [27].

161

162 Periods defined by key pandemic-mitigation measures were determined and investigated. To
163 identify these periods, we screened official regulation documents (Bayerische
164 Infektionsschutzmaßnahmenverordnung (BayIfSM) and extracted the relevant dates. The
165 lockdown periods were mainly characterized by rigorous contact restrictions, closed
166 restaurants and shops as well as distance learning or restricted access to schools and daycare
167 centers whereas restrictions were less severe and depended on the incidence of the respective
168 district during the incidence-dependent restriction period. The period between 20/03/2020 and
169 10/05/2020 was labelled the first lockdown. Incidence-dependent restrictions were in place
170 between 11/05/2020 and 01/11/2020, followed by a "light" lockdown from 02/11/2020 to
171 9/12/2020. From 10/12/2020, the measures were tightened again, and the second lockdown
172 was in place until 23/04/2021.

173

174 Unanswered calls are calls where the caller hung up before the call was answered by a
175 dispatcher. These calls were classified as “unanswered” in the original dataset. The
176 emergency line (112) is subject to stringent safety protocols and compliance with the ‘Technical
177 Guidelines for Emergency Calls’ (Technische Richtlinie Notrufverbindungen -TR Notruf). If all
178 available lines are engaged, a series of technical mechanisms are employed to either
179 temporarily queue the caller or seamlessly redirect them to a nearby dispatch center.
180 Consequently, instances in which a call is left unattended are virtually eliminated.
181 Nevertheless, it is conceivable that a caller may elect to terminate the call prematurely due to
182 a preference not to endure any waiting period.

183

184 The number of calls is expressed as an absolute number or as the number of calls per 100,000
185 population (the call rate). Depending on the analysis, the rate refers either to calls per day or
186 to calls per a defined time period. These time periods were compared with the corresponding
187 periods in 2019.

188

189 The daily number of calls, daily number of unanswered calls, daily median call duration and
190 daily median 7-day incidence of COVID-19 were visualized as line graphs. The absolute
191 number per time period and relative change are presented for the number of calls. Median
192 relative changes \pm interquartile range (IQR) are presented for call durations. The Mann–
193 Whitney U test was used to compare the mean call duration of 2019 with that of 2020 and 2021
194 respectively.

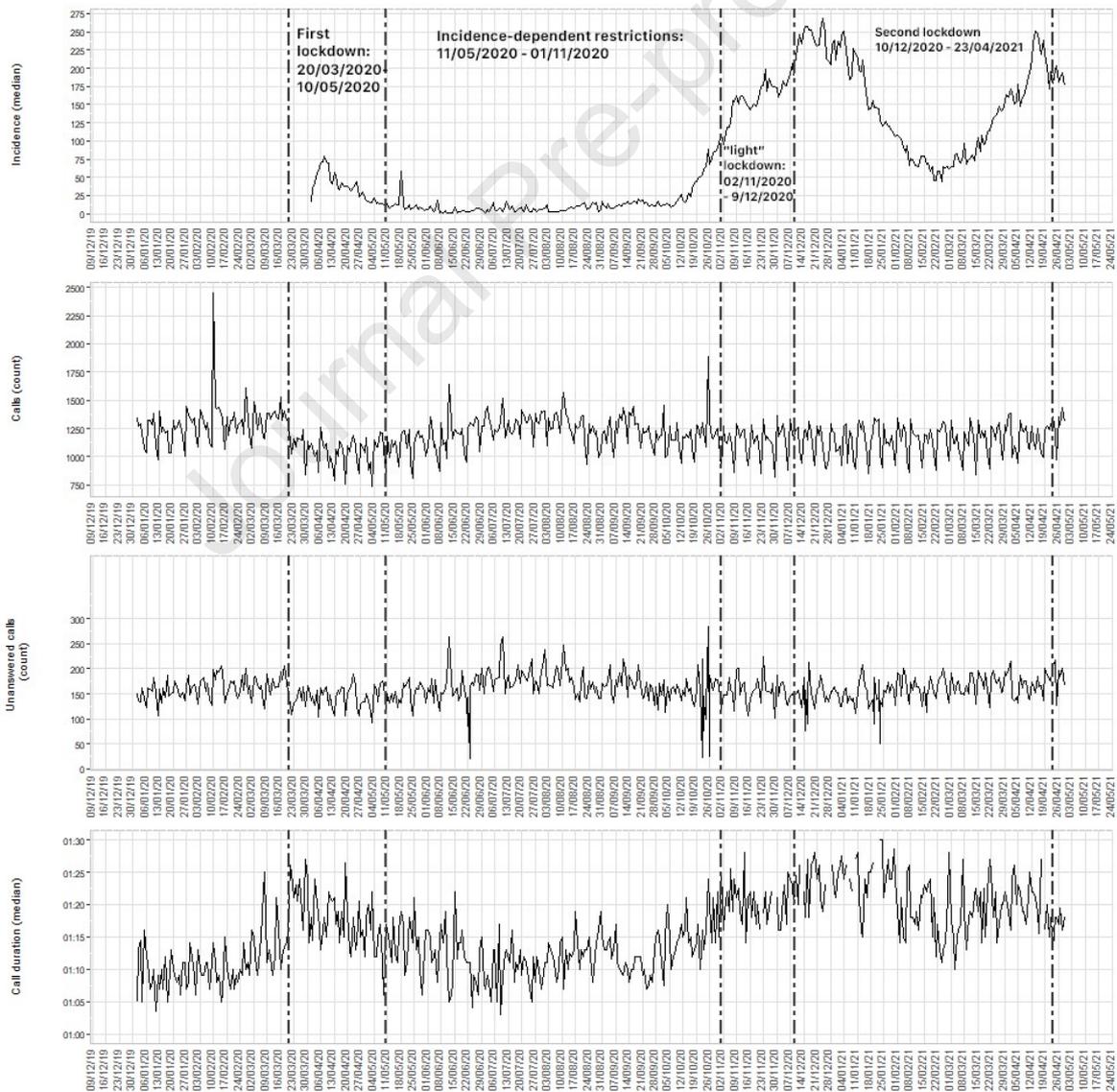
195

196 **Results**

197
 198 The fewest calls per day over the entire period occurred on 05/03/2020 (736 calls). The
 199 maximum number of calls per day (2,455 calls) was observed before the first lockdown on
 200 10/02/2020. The number of unanswered calls per day ranged between 17 (on 11/03/2019) and
 201 284 (on 25/10/2020). A total of 15% of calls was classified as unanswered. The median
 202 duration of answered calls was 0,03 (IQR 0,05) minutes.

203

204 *Figure 1 Median number of cases reported in the previous seven days per 100.000*
 205 *population (incidence), number of calls, unanswered calls and median call duration to the*
 206 *medical emergency number 112*
 207
 208



209

210

211 Figure 1 shows the daily median number of cases reported in the previous seven days per
212 100.000 population (incidence) in the areas covered by the dispatch centres in this study as
213 well as the daily number of calls, the daily number of unanswered calls, and daily median call
214 durations. Relevant periods during the SARS-CoV-2 pandemic in 2020 are marked by dashed
215 lines. At the beginning of the first lockdown, there was a decline in the number of emergency
216 calls and a large increase in median call duration. Both of these effects gradually decreased
217 over time and returned to initial levels around the middle of the following period (of incidence-
218 dependent restrictions). Subsequently, the number of calls dropped slightly and remained
219 below the baseline level. Call durations begin to increase again in August (during the period of
220 incidence-dependent restrictions). After a subsequent slight decrease, the median call duration
221 remained markedly above the initial level in the beginning of 2020.

222
223 In all examined pandemic periods, a decrease in the number of calls was observed compared
224 to the same period in 2019 (Table 1). The difference was greatest during the first lockdown,
225 with a total decrease of 12.9%. This decline was most pronounced on Wednesdays and
226 Thursdays; in contrast, an increase in the number of calls of 5.2% occurred on Saturdays.

227 During the period of incidence-related restrictions, the decrease in the number of calls was
228 distributed evenly across all days of the week. In contrast, during the "light" lockdown and the
229 second lockdown, the greatest reductions were observed on weekends, with up to 25.3% fewer
230 calls recorded on Sundays during the "light" lockdown. Additionally, during the "light" lockdown,
231 up to 14.6% more calls were recorded on Tuesdays and Wednesdays than in the same period
232 of the previous year.

233 While the largest decrease in the number of emergency calls during the first lockdown and
234 during the period of incidence-dependent restrictions was observed during the day (6 am–4
235 pm), the largest decreases in this number during the "light" lockdown and the second lockdown
236 were observed at night (8 pm–6 am). The largest decline in the number of calls (-17.1%) during
237 the first lockdown occurred during the morning (6 am–12 pm). In contrast, the largest decline
238 in the number of calls (-15%) during the second lockdown occurred at night (8 pm–6 am).

239
240 During the first lockdown, the number of calls exhibited similar decreases among all dispatch
241 centres analysed. Subsequently, greater heterogeneity in the declines in the number of calls
242 (i.e., large vs. small declines) was observed. Moreover, one dispatch centre (Oberland) even
243 reported no change in the number of calls (+0.4%) during the period with incidence-related
244 restrictions compared to the same period in the previous year.

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	First lockdown (20/03-10/05)			Incidence-related restrictions (11/05-1/11)			“Light” lockdown (2/11-9/12)			Second lockdown (10/12-23/4)		
	Comparison (2019)	Pandemic (2020)	Percent change	Comparison (2019)	Pandemic (2020)	Percent change	Comparison (2019)	Pandemic (2020)	Percent change	Comparison (2019)	Pandemic (2020/2021)	Percent change
Total calls	55.056	47.968	-12.9%	196.736	185.549	-5.7%	39.761	37.897	-4.7%	148.686	135.951	-8.6%
Calls per 100,000 inhabitants												
Dispatch centre												
Bayreuth-Kulmbach	2.424	2.147	-11.7%	8.884	8.467	-5.0%	1.703	1.534	-10.2%	6.350	5.843	-8.3%
Coburg	2.694	2.422	-10.4%	9.389	9.061	-3.8%	1.955	1.941	-1.1%	7.006	6.707	-4.6%
Hochfranken	3.345	2.977	-11.7%	11.809	10.795	-9.3%	2.545	2.280	-11.1%	9.205	8.834	-4.8%
Oberland	2.586	2.257	-12.5%	9.433	9.449	0.4%	1.877	1.725	-7.9%	7.176	6.090	-14.9%
Schweinfurt	3.138	2.641	-15.9%	11.026	10.510	-4.7%	2.229	2.204	-1.2%	8.247	7.858	-4.8%
Straubing	3.481	3.045	-12.5%	12.588	11.228	-10.7%	2.500	2.457	-1.6%	9.731	8.520	-12.4%
Rural classification												
Sparsely populated, rural	3.038	2.669	-12.2%	11.034	10.073	-8.8%	2165	2.071	-4.4%	8.313	7.400	-11.1%

Sparsely populated, predominantly rural	2.169	1.851	-14.5%	7.737	7.523	-2.6%	1554	1.492	-3.9%	5.828	5.298	-9.0%
Predominantly rural	2.987	2.671	-11.0%	10.477	9.838	-6.6%	2220	2.093	-6.2%	7.994	7.661	-4.7%
Day of the week												
Monday	7.863	6.697	-14.8%	29.346	27.644	-5.8%	6.909	6.670	-3.5%	22.573	20.709	-8.3%
Tuesday	7.750	6.569	-15.2%	28.697	26.826	-6.5%	5.404	6.192	14.6%	23.681	20.256	-14.5%
Wednesday	8.535	6.668	-21.9%	28.687	27.085	-5.6%	5.411	6.157	13.8%	21.413	19.880	-7.2%
Thursday	9.125	7.092	-22.3%	28.373	26.942	-5%	5.392	5.222	-3.2%	21.573	21.717	0.7%
Friday	8.563	7.596	-11.3%	29.833	28.417	-4.7%	5.620	5.166	-8.1%	21.604	20.895	-3.3%
Saturday	6.981	7.344	5.2%	26.627	24.944	-6.3%	5.845	4.618	-21%	19.366	17.021	-12.1%
Sunday	6.239	6.002	-3.8%	25.173	23.691	-5.9%	5.180	3.872	-25.3%	18.476	15.473	-16.3%
Time of day												
Morning (6 am–12 pm)	17.844	14.787	-17.1%	60.991	56.676	-7.1%	13.004	12.670	-2.6%	47.828	44.222	-7.5%
Noon (12 pm–4 pm)	14.015	12.045	-14.1%	49.113	46.621	-5.1%	10.090	9.796	-2.9%	37.211	34.991	-6%
Evening (4 pm–8 pm)	11.950	11.188	-6.4%	43.250	41.675	-3.6%	8.381	8.037	-4.1%	31.399	29.336	-6.6%
Night (8 pm–6 am)	11.247	9.948	-11.5%	43.382	40.577	-6.5%	8.286	7.394	-10.8%	32.248	27.402	-15%

Table 1: Total number of calls during the observation (pandemic) periods vs. comparison periods (the same period in 2019)

245 Call durations are presented in Table 2. Compared to the previous years, a higher median call
246 duration was observed during all periods examined. The smallest difference (+6 seconds,
247 ($p < 0.00$)) occurred during the period of incidence-dependent restrictions, and the largest
248 difference (+13 seconds $p < 0.00$) occurred during the "light" lockdown.

249 The call duration at the Hochfranken dispatch centre was consistently significantly longer than
250 that at all other dispatch centres, except during the period with incidence-dependent
251 restrictions.

252 In the Oberland dispatch centre, a shorter call duration (-5 seconds, $p = 0.000$) was found
253 during the period of incidence-dependent restrictions compared to the two previous years.

254 During the "light" lockdown, there was no significant difference compared to the previous year
255 at this dispatch centre. In the counties with higher population densities, there was a larger
256 increase in call duration in all time periods.

257 Calls tended to last longer at night than at other times of the day. Similar to differences in the
258 number of calls, the period of incidence-related restrictions was an exception, as the longest
259 calls were registered during the morning in this period.

260

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	First lockdown (03/20-05/10)				Incidence-related restrictions (11/05-1/11)				"Light" lockdown (2/11-9/12)				Second lockdown (10/12-23/4)			
	Comparison (2019)	Pandemic (2020)	p	Difference	Comparison (2019)	Pandemic (2020)	p	Difference	Comparison (2019)	Pandemic (2020)	p	Difference	Comparison (2019)	Pandemic (2020/21)	p	Difference
Total call duration	01:07 (01:13)	01:19 (01:31)	0.000	00:12	01:07 (01:16)	01:13 (01:28)	0.000	00:06	01:09 (01:15)	01:22 (01:34)	0.000	00:13	01:07 (01:15)	01:19 (01:31)	0.000	00:12
Dispatch centre																
Bayreuth-Kulmbach	01:13 (01:25)	01:24 (01:41)	0.000	00:11	01:10 (01:25)	01:15 (01:35)	0.000	00:05	01:16 (01:26)	01:30 (01:49)	0.000	00:14	01:12 (01:17)	01:31 (01:43)	0.000	00:19
Coburg	01:07 (01:13)	01:13 (01:22)	0.000	00:06	01:04 (01:13)	01:13 (01:27)	0.000	00:09	01:06 (01:12)	01:19 (01:32)	0.000	00:13	01:09 (01:13)	01:19 (01:32)	0.000	00:10
Hochfranken	01:07 (01:05)	01:28 (01:31)	0.000	00:21	01:07 (01:10)	01:21 (01:27)	0.000	00:14	01:10 (01:08)	01:34 (01:37)	0.000	00:24	01:10 (01:09)	01:31 (01:35)	0.000	00:21
Oberland	01:01 (01:17)	01:10 (01:30)	0.000	00:09	01:03 (01:21)	00:58 (01:20)	0.000	-00:05	01:04 (01:19)	01:06 (01:27)	0.881	00:02	01:04 (01:18)	01:10 (01:28)	0.000	00:06
Schweinfurt	01:15 (01:15)	01:28 (01:34)	0.000	00:13	01:10 (01:12)	01:25 (01:33)	0.000	00:15	01:13 (01:13)	01:30 (01:30)	0.000	00:17	01:15 (01:13)	01:28 (01:27)	0.000	00:13
Straubing	01:03 (01:11)	01:10 (01:24)	0.000	00:07	01:03 (01:15)	01:07 (01:19)	0.000	00:04	01:04 (01:13)	01:13 (01:28)	0.000	00:09	01:04 (01:09)	01:16 (01:29)	0.000	00:12
Rural classification																
Sparsely populated, rural	01:06 (01:16)	01:15 (01:29)	0.000	00:09	01:05 (01:18)	01:10 (01:26)	0.000	00:06	01:07 (01:18)	01:18 (01:35)	0.000	00:11	01:07 (01:13)	01:21 (01:33)	0.000	00:14
Sparsely populated, predominantly rural	01:10 (01:16)	01:21 (01:33)	0.000	00:11	01:08 (01:16)	01:14 (01:31)	0.000	00:06	01:10 (01:15)	01:21 (01:32)	0.000	00:11	01:10 (01:16)	01:21 (01:28)	0.000	00:11

Predominantly rural	01:07 (01:09)	01:21 (01:27)	0.00 0	00:14	01:07 (01:12)	01:17 (01:27)	0.00 0	00:09	01:07 (01:10)	01:27 (01:34)	0.00 0	00:20	01:10 (01:12)	01:25 (01:36)	0.00 0	00:16
Monday	01:09 (01:14)	01:19 (01:31)	0.00 0	00:10	01:07 (01:16)	01:16 (01:27)	0.00 0	00:09	01:10 (01:12)	01:22 (01:33)	0.00 0	00:12	01:09 (01:13)	01:22 (01:30)	0.00 0	00:13
Tuesday	01:09 (01:13)	01:18 (01:30)	0.00 0	00:09	01:07 (01:13)	01:13 (01:27)	0.00 0	00:06	01:09 (01:15)	01:22 (01:31)	0.00 0	00:13	01:07 (01:13)	01:21 (01:30)	0.00 0	00:14
Wednesday	01:07 (01:13)	01:18 (01:30)	0.00 0	00:11	01:06 (01:13)	01:13 (01:28)	0.00 0	00:07	01:07 (01:15)	01:19 (01:31)	0.00 0	00:12	01:09 (01:12)	01:21 (01:30)	0.00 0	00:11
Thursday	01:07 (01:16)	01:18 (01:32)	0.00 0	00:11	01:07 (01:12)	01:12 (01:27)	0.00 0	00:05	01:07 (01:15)	01:19 (01:35)	0.00 0	00:12	01:09 (01:13)	01:19 (01:30)	0.00 0	00:10
Friday	01:07 (01:14)	01:19 (01:30)	0.00 0	00:12	01:06 (01:12)	01:12 (01:28)	0.00 0	00:06	01:07 (01:12)	01:24 (01:32)	0.00 0	00:17	01:10 (01:14)	01:19 (01:31)	0.00 0	00:09
Saturday	01:06 (01:15)	01:19 (01:30)	0.00 0	00:13	01:07 (01:12)	01:12 (01:30)	0.00 0	00:05	01:07 (01:18)	01:19 (01:37)	0.00 0	00:12	01:09 (01:14)	01:25 (01:37)	0.00 0	00:16
Sunday	01:10 (01:13)	01:22 (01:31)	0.00 0	00:12	01:07 (01:16)	01:16 (01:30)	0.00 0	00:09	01:10 (01:16)	01:27 (01:37)	0.00 0	00:17	01:12 (01:27)	01:27 (01:34)	0.00 0	00:15
Morning (6 am – 12 pm)	01:09 (01:12)	01:21 (01:28)	0.00 0	00:12	01:07 (01:26)	01:16 (01:26)	0.00 0	00:09	01:09 (01:13)	01:22 (01:39)	0.00 0	00:13	01:10 (01:12)	01:22 (01:28)	0.00 0	00:12
Noon (12 pm – 4 pm)	01:06 (01:17)	01:15 (01:34)	0.00 0	00:09	01:04 (01:30)	01:10 (01:30)	0.00 0	00:06	01:07 (01:19)	01:18 (01:36)	0.00 0	00:11	01:07 (01:14)	01:19 (01:34)	0.00 0	00:12
Evening (4 pm – 8 pm)	01:04 (01:16)	01:13 (01:35)	0.00 0	00:09	01:03 (01:30)	01:07 (01:30)	0.00 0	00:04	01:04 (01:18)	01:16 (01:40)	0.00 0	00:12	01:06 (01:16)	01:18 (01:37)	0.00 0	00:12
Night (8 pm – 6 am)	01:12 (01:12)	01:27 (01:25)	0.00 0	00:15	01:09 (01:24)	01:16 (01:24)	0.00 0	00:07	01:13 (01:20)	01:31 (01:28)	0.00 0	00:18	01:13 (01:30)	01:30 (01:28)	0.00 0	00:17

Table 2: Call duration [median (IQR); in minutes: seconds] during the observation (pandemic) periods vs. comparison periods (the same period in 2019)

262 The number of unanswered calls changed only slightly (Figure 1). There was an initial slight
263 decline in the number of unanswered calls during the first lockdown. During the middle of the
264 subsequent period with incidence-dependent restrictions, this number returned to the
265 prepandemic level. Subsequently, the number of unanswered calls declined slightly and
266 remained just below the 2019 level for the rest of the year. Descriptively, no correlation with
267 the COVID-19 incidence was apparent.

268

269 Discussion

270

271 This study examined call volumes during the first two waves of the COVID-19 pandemic using
272 data from seven integrated dispatch centres in Bavaria. During periods with strict restrictions
273 and curfews ("lockdown"), call volumes to the emergency number (112) decreased. During
274 these same periods, the durations of emergency calls increased; however, the number of
275 unanswered calls remained at a similar level.

276

277 Call volume

278

279 In Bavaria, several periods had strict restrictions to prevent COVID-19 from spreading. At the
280 beginning of the pandemic (the first lockdown), public life was almost completely shut down
281 throughout Bavaria, and curfews were imposed. The second lockdown was largely similar.
282 Changes in call volume observed during these periods differed from changes observed during
283 the period with incidence-based restrictions. This pattern seems plausible since incidence-
284 based restrictions were only imposed in regional hotspots and not throughout Bavaria.

285

286 The greatest decline in call volumes occurred in periods with the most severe restrictions (first
287 and second lockdown). The extent to which contact and mobility restrictions contributed to this
288 decline is unclear. A decreased number of calls is consistent with reduced mobility and reduced
289 availability of recreational activities such as sports and nightlife, which could explain the sharp
290 declines in call numbers during periods with strict restrictions. Several studies have reported
291 declines in the number of emergency calls for traffic accidents and trauma associated with
292 mitigation measures [18, 24, 17, 16, 28]. Emergencies involving alcohol were also recorded
293 less frequently [17, 16, 24, 28]. Similar results were reported by Ferron et al., yet the authors
294 also reported an increase in the number of calls regarding substance overdose [18].

295 Patients avoiding emergency medical services and hospitals because of perceived greater risk
296 of exposure to the virus [29] and challenges in accessing medical advice during lockdowns

297 and movement restrictions might also add to the declines during periods with high COVID-19
298 incidence.

299

300 During the "light" lockdown and second lockdown, the number of calls exhibited the steepest
301 decline on weekends. This finding might be explained by some parts of daily life returning to
302 normal, such as workers returning to offices, but not others, such as recreational opportunities.
303 However, this theory is contradicted by the fact that approximately one-third of the patients
304 receiving pre-hospital EMS care were older than 75 years [30, 3], and thus presumably less
305 affected by reductions in recreational opportunities and nightlife scenes.

306

307 Several surveys have reported an increase in anxiety levels, especially at the beginning of the
308 pandemic and among people describing their health as "poor" [31–33]. In the prior severe
309 acute respiratory syndrome (SARS) epidemic of 2003, fear of infection led to avoidance of
310 medical services [34]. Delayed access and avoidance of emergency care due to fear of
311 infection has also been reported during the COVID-19 pandemic [35, 29]. Thus, fear of
312 infection while seeking pre-hospital EMS or hospital care could also have led to a reduction in
313 the number of calls.

314

315 Other countries have reported a sharp increase in call volume [36]. This observation, which is
316 contradictory to our findings, may be partly explained by the fact that our observation period
317 was long, whereas other studies focused on the peaks of the pandemic. In addition, the
318 structure of EMS systems differs among countries. Calls of people seeking medical advice are
319 often handled by dispatch centres as well. Jensen et al. reported that in Copenhagen, a year-
320 to-year comparison between 2020 and 2019 revealed that emergency calls (to 112) increased
321 by 4.4%; in contrast, calls to the medical advice number increased by 25.1% [7]. Our analysis
322 included only emergency calls (to 112). However, it is possible that in Bavaria, especially at
323 the beginning of the pandemic, requests for advice were also directed to dispatch centres via
324 the emergency number (112). The actual decline in emergency calls could thus have been
325 even greater than the observed decline. However, increased advertisement for the medical
326 helpline operated by on-call physician services (116117) [37], likely reduced advice-related
327 calls to the emergency number over the course of the pandemic. Increasing awareness of the
328 number of on-call services, a reduction in unnecessary emergency calls, containment
329 measures (such as entry restrictions at events), and the remaining possibility of working
330 remotely are all possible explanations why the number of calls did not return to prepandemic
331 levels, even by the end of the study period.

332

333 The decline in the number of calls probably correlated with the decline in the number of
334 ambulance deployments and was roughly proportional [3]. This finding indicates that there was
335 not increased filtering to separate advice-related calls from emergency calls at the dispatch
336 centres.

337

338

339 Call duration

340

341 At the beginning of the pandemic as well as at the end of 2020, an increase in emergency call
342 duration of several seconds was observed. Increased demand for advice is a plausible cause
343 for this increase at the beginning of the pandemic; later in the pandemic, additional questions
344 were added to the emergency call protocol. In a study from Berlin, Dahmen et al. reported that
345 the additional questions took an additional 1:36 minutes on average [38]. In Bavaria, additional
346 questions were also implemented. These questions presumably led to increases in call
347 durations overall, especially during phases with high COVID-19 incidence. When COVID-19
348 incidence was low, the additional questions concerning infection and contact with infected
349 individuals are assumed to have been usually answered in the negative. Follow-up questions
350 were thus often less necessary than in times of high incidence. Furthermore, the time spent
351 processing calls at the dispatch centre has increased in Bavaria for many years [39]. The
352 increase in call duration could therefore have occurred independently of the COVID-19
353 pandemic. This theory is supported by the fact that even during the pandemic, many
354 emergencies that were processed by dispatch centres were not related to COVID-19 and did
355 not come with an increased need for health-related advice.

356

357 The Coburg and Hochfranken dispatch centres were comparable in terms of their structure
358 and number of employees. However, the emergency call duration differed at these centres
359 after the outbreak of the pandemic. This difference could indicate different implementation of
360 the additional call questions by the two dispatch centres.

361 Unanswered calls

362

363 The number of unanswered calls (calls in which the caller hung up before being answered by
364 a dispatcher) hardly changed over the course of the pandemic and was also comparable to
365 before the pandemic. Unanswered calls were investigated as an indicator that the capacity of
366 dispatch centres were exceeded. While other studies have reported an increase in daily
367 workload for staff of integrated dispatch centres during the COVID-19 pandemic [40, 36], our
368 results suggest that dispatch centres were not overloaded. A possible reason for this lack of

369 overload could be decreased demand. Alternatively, the measures implemented to prepare
370 dispatch centres for the impending challenge could have been effective. Another explanation
371 is that sufficient staff were available because vacations and training sessions were cancelled
372 due to contact restrictions and curfews. Additionally, staff that usually operated nonemergency
373 patient transport could have been freed up because elective and ambulatory procedures were
374 postponed and access to medical rehabilitation services was temporarily restricted. Moreover,
375 employees could have compensated for the increase in calls by working extra hours or by
376 answering emergency calls more quickly, which could explain why employees still reported an
377 increased workload during these periods.

378
379

380 **Limitations**

381
382

383 The present study analysed only calls to the emergency number (112). Other service numbers
384 handled by integrated dispatch centres, such as the number for ambulance services (19222)
385 or direct lines to the police, were not considered. Furthermore, no numbers operated by other
386 parties, such as the numbers for the on-call services (116117) or health-office advice, were
387 included. It is possible that these service numbers compensated for some of the decrease in
388 emergency calls.

389 Since calls are registered automatically, the completeness of call records is considered high.
390 Nevertheless, we identified periods of data gaps explained by technical issues. To address
391 these gaps, the number of calls during these periods was estimated. A few calls (0.07%) that
392 lasted longer than 15 minutes were truncated, as longer durations than 15 minutes were
393 implausible. An analysis of the cut-off call durations showed no systematic differences with
394 regard to the dispatch centres as well as the temporal distribution.

395 The generalizability of these data to other states in the Federal Republic of Germany or to
396 other countries may be low due to differences in EMS systems.

397

398 **Summary**

399

400 This study shows that during the first three waves of the COVID-19 pandemic, dispatch centres
401 experienced lower call volumes but slightly longer call durations than corresponding
402 prepandemic periods. The number of unanswered calls remained largely the same. The
403 slightly longer call durations could be predominantly due to the addition of dispatch protocol
404 questions after changes in the mandatory statutory requirements. Other studies have shown
405 that dispatch centre employees report a higher burden. Yet the lack of change in the number

406 of unanswered calls might indicate that dispatch centres were not stretched beyond their
407 capacity. Indeed, an increase in demand was initially expected, and corresponding
408 countermeasures were initiated; however, contrary to expectations, the use of the emergency
409 number actually declined. The reasons for emergency calls and caller characteristics were not
410 investigated. Further research is needed to elucidate the reasons for the observed changes.

411

412 **Data availability statement**

413 The data used in this paper was a combination of data about 112 calls, population data, spatial
414 data, and reported COVID-19 incidence. 112 call data are third-party data analyzed with
415 permission of the Bayerisches Rotes Kreuz where the authors do not have the permission to
416 share the data. Population data are publicly available from the Bavarian State Office for
417 Statistics. Spatial data are publicly available from the German Federal Institute for Research
418 on Building, Urban Affairs and Spatial Development. Data of confirmed COVID-19 cases are
419 available from the Robert Koch Institute.

420

421 **Authors' contributions**

422 Florian Dax (FD), Moritz Waibel (MW), Katharina Kneißl (KK), Stephan Prückner (SP), Marc
423 Lazarovici (ML), Florian Hoffmann (FH), Kathrin Hegenberg (KH).

424 FD conceived of the presented idea, KH and KK extracted and processed the data from the
425 Integrated Dispatch Centre dataset existing in the INM. MW and KK performed the statistical
426 analysis, KH, ML, and KK verified the analytical methods. KH and SP supervised the findings
427 of this work. FH contributed to the interpretation of the results. FD, MW, ML, KH, FH and SP
428 contributed to the design and implementation of the research, to the analysis of the results and
429 to the writing of the manuscript. MW, FD, and KH wrote the paper. All authors discussed the
430 results, read and approved the final version of the manuscript. FD, KH, KK revised the
431 manuscript according to reviewer feedback.

432

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Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Florian Dax reports a relationship with Bavarian Red Cross that includes: employment. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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