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A Study on the Response System through Analysis of Fire Reports According to Environment Changes

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Abstract: *A surge in emergency calls occurs when the number of emergency calls received simultaneously exceeds the limits of firefighting capabilities, such as call reception desks and emergency call lines. When the number of emergency calls received simultaneously is so large that the General Situation Room (GSR) is operating normally with its firefighting capabilities, some calls cannot be processed, which can be called a surge in emergency calls. In this paper, we examined the capacity of the emergency GSR nationwide to identify problems and countermeasures due to the surge in emergency calls. In particular, we presented countermeasures to minimize the surge in calls by identifying the rate of increase in the number of calls received at the emergency GSR in each region. As a result, it is necessary to designate emergency call agents in response to a surge in reports, and to designate the duties of emergency call agents in response to a surge in reports. In addition, it is thought that securing additional locations for emergency reception desks in response to a surge in reports, education in response to the operation of emergency reception desks, and especially training in response to a surge in reports should be carried out in stages.*

Keywords: *Report surge, Emergency response, General situation room*

1. INTRODUCTION

In general, public fire brigades are organizations that provide public safety services, such as simple firefighting activities, fire prevention and suppression, rescue of people from various natural disasters and catastrophes, emergency services from accidents, and support for life safety. In order to provide such public safety services, each country must first smoothly receive reports in the emergency management center, and the dispatch, control, and command of firefighters must be carried out organically. Currently, each country's regional fire departments have established and are operating separate management centers to facilitate the reception of reports, and although there is no priority for receiving reports, received reports are processed with priority according to the urgency of the situation [1,2].

A surge in reporting occurs when there are more reporters than staff answering the phone in the central situation room, and this is bound to happen in a crisis situation. The number of reports has been increasing recently, and this seems to be due to the influence of the natural environment and changes in the public's perception of reporting. The influence of the natural environment is due to the increased frequency of natural disasters such as torrential downpours and typhoons whose scale of damage is unpredictable, and the influence of changes in the public's perception of reporting is that when a large-scale disaster occurs, calls from nearby residents asking for information and checking on their safety, as well as calls for power outages, water supply and sewage restoration, and telephone failures, are also flooding into emergency reporting calls.

The problem with the surge of emergency reports is that emergency reports are delayed in response due to waiting or reports that cannot be responded to. The central situation room responds to reports in the order in which they are received, and it is not possible to distinguish between emergency and non-emergency reports before talking to the reporter. Therefore, when an emergency report surge occurs, the level of urgency of the reporter is not known, and reports are responded to in order, so emergency calls are not answered, resulting in loss of life.

Since the emergency report surge does not occur all the time, it is necessary to analyze the situation when it occurs, and research is needed on how to receive the maximum number of emergency reports and how to respond to the emergency report surge. It is necessary to analyze the actual situation of when, how, and how often accidents occur due to the failure to process emergency reports smoothly, and find the cause and come up with alternatives. Therefore, this paper aims to identify the problems caused by the emergency report surge and suggest countermeasures to it, and to confirm the capacity of the national integrated situation room to receive reports. In addition, it aims to suggest countermeasures to minimize the report surge by identifying the increase rate of reports received in the relevant integrated situation room in cases where the emergency report surge occurred in each region.

2. OPERATION OF EMERGENCY CALL GSR

2.1 Work of emergency call GSR

2.1.1 Division of duties of emergency call GSR

The emergency call GSR for receiving emergency call reports is installed in each fire department of 18 cities and provinces nationwide, and the duties of the emergency call GSR are stipulated in the "Rules on Local Fire Organization and Staff Management" [Appendix 3] as follows [2].

The work patterns and division of work by team in the emergency call GSR are as shown in Table 1. Looking at the work patterns by team, there is a situation analysis team and an information and communication team that are in charge of the work related to the operation of the comprehensive situation room. These two teams must receive emergency call reports 24 hours a day in the form of a day shift. In addition, the fire operation situation center and the emergency situation management center are stipulated to work in shifts. The division of work by team is that the situation analysis team is in charge of the work related to the operation of the emergency call GSR and the work related to situation management statistics and manual management, while the information and communication team is in charge of the maintenance of the emergency call information and communication system, communication, and wired/wireless equipment. The fire operation situation center is organized as a situation management team in the emergency call GSR and is in charge of the work related to receiving emergency call reports, issuing orders, and controlling, while the emergency situation management center is in charge of the work related to medical guidance and medical consultation of the ambulance.

Table 1: Team work style and division of work in the emergency call GSR

Division	Work
Situation Analysis Team (Daily)	a) 119 GSR Management b) Reporting and Statistical Analysis c) Situation Management Manual Management d) Comprehensive Situation Room Training and Education e) Mobile Situation Management Operation, etc.
Information and Communication Team (Daily)	a) Operation of emergency call Comprehensive Computer Information System b) Maintenance of communication and wired/wireless equipment c) Management of administrative network server and DB management d) Management of emergency call command system e) Promotion of protection measures for major information and

	communication infrastructure and management of fire information and communication security, etc.
Fire Operations Situation Center (Shift Work)	a) emergency call report reception and dispatch order/control b) Disaster situation management c) Notification to relevant organizations, etc.
Emergency Situation Management Center (Shift Work)	a) Emergency medical guidance and national medical consultation b) Emergency situation and quality management c) Medical institution status survey and power supply work, etc.

2.1.2 Operation of emergency call GSR nationwide

The current status of the organization and operation of the emergency call GSR nationwide is as shown in Table 2, and it is operated in the form of 2, 3, and 4 teams, not the 4 teams of the Situation Analysis Team, Information and Communication Team, Fire Operation Situation Center, and Emergency Situation Management Center as presented in the "Rules on Local Fire Organization and Staff Management, Appendix 3" [2]. This shows that the work is being operated in teams according to the size of the organization and the population of the city or province[3-5].

Among the 119 GSR nationwide, the 119 Integrated Situation Rooms of the provinces and cities operated by 4 organizations were Busan, Gwangju, Daejeon, Chungnam, Jeonnam, Chungbuk, and Southern Gyeonggi. Except for Southern Gyeonggi, there are 6 provinces and cities that operate separately, such as the situation analysis team, information and communication team, fire operation situation center, and emergency situation management center, as presented in the "Regulations on Local Fire Organization and Staff Management, Appendix 3]. Southern Gyeonggi did not have a separate emergency situation management center, but was organized within the fire operation situation management team, and unlike the 119 GSR of other provinces, it had a separate computer security team[6].

Table 2: Organization of the emergency call GSRnationwide

Division	Situation Management Team (SMT)	Information and Communication Team (ICT)	Fire Operations Center	Emergency Management Center (EMC)
Seoul	SMT		SMT (Team 3)	EMC (Team 3)
Busan	Situation Analysis Team (SAT)	Information and Communications Industry	SMT (Team 4)	EMC
Daegu	SAT	ICT	SMT (Team 4)	
Incheon	Situation Support Team (SST)	ICT	SMT (Team 4)	
Gwangju	SAT	ICT	SMT (Team 3)	EMC (Team 3)
Daejeon	SAT	ICT	SMT (Team 3)	EMC Team 3)
Ulsan		ICT	SMT (Team 3)	
Sejong		ICT	SMT (Team 3)	
Southern Gyeonggi	Situation Management Support Team	Disaster Information and Communication Team Computer Security Team	SMT (Team 4)	
Northern Gyeonggi	SMT	ICT	SMT (Team 4)	

Gangwon	SMT	ICT	SMT (Team 3)	
Chungbuk	SMT	ICT	SMT (Team 3)	EMC (Team 4)
Chungnam	SST	ICT	SMT (Team 3)	EMC (Team 3)
JeonBuk	SMT		Situation Team (Team 3)	
Jeonnam	SMT	ICT	SMT (Team 4)	EMC (Team 3)
Gyeongbuk	Information Planning Team	Fire Communication Team	SMT (Team 3)	
Gyeongnam		Fire Information and Communication Team	Situation Team (Team 3)	
Jeju	Situation Planning Team	ICT	SMT (Team 3)	

2.2 Fire Fighting Personnel in Emergency Call GSR

When comparing the personnel operation status of the emergency call GSR Fire Operation Situation Center with the deployment criteria and personnel deployment status of the reception and control personnel of the Situation Management Team 1, it was confirmed that there were differences from the "Rules on Firefighting Force Standards, Appendix 3" as shown in Table 3. This is presumed to be due to differences in firefighting force and report characteristics by each city/province emergency call GSR.

Comparing the deployment criteria and current status of firefighting personnel, Daegu was the most short of 4 personnel compared to the deployment criteria of 16 personnel, while Seoul, Jeonbuk, and Jeonnam were short of 3 personnel. In the case of Seoul, 3 personnel were short of 46 personnel, while Jeonnam and Jeonbuk were short of 14 and 15 personnel, respectively.

Looking at the situation reception personnel, Seoul and Gyeonggi were short of 5 and 9 personnel, respectively, compared to the deployment criteria of 40 personnel. However, it can be seen that these personnel were deployed as situation control personnel and that the integrated situation room was operated according to the characteristics of receiving and processing emergency call reports.

In addition, the emergency call GSR in Daejeon and Ulsan did not have separate situation control personnel, which shows that the situation reception personnel are also handling situation control work. The situation control personnel of the emergency call GSR in nine locations in Busan, Chungcheongbuk-do, Jeollabuk-do, Jeollanam-do, Gyeongsangbuk-do, Sejong, Jeju, and Changwon were operating with one person, but in reality, there were differences in the personnel allocation standards, so Busan could be said to be the largest, and Sejong, Jeju, and Changwon the smallest.

Table 3: Comparison of personnel deployment standards and current status of the emergency call GSR

Division		**Situation reception**			**Situation control**			**Total**
		Criteria	Current Situation	Shortage Personnel	Criteria	Current Situation	Shortage Personnel	
Group 1	Seoul	40	35	-5	6	8	+2	-3
	Gyeonggi	40	31	-9	6	15	+9	0
Group 2	Busan	17	22	+5	5	1	-4	+1
	Daegu	11	10	-1	5	2	-3	-4
	Incheon	12	11	+1	5	5	0	+1
Group 3	Gangwon	9	13	+4	4	2	-2	+2
	Gyeonggi North	9	12	+3	4	6	+2	+5

	Chungbuk	10	13	+3	4	1	-3	0
	Cuungnam	13	13	0	4	4	0	0
	Jeonbuk	11	11	0	4	1	-3	-3
	Jeonnam	10	10	0	4	1	-3	-3
	Gyeongbuk	14	16	+2	4	1	-3	-1
	Gyeongnam	13	14	+1	4	6	+2	+3
Group 4	Gwangju	7	7	0	3	2	-1	-1
	Daejeon	9	9	0	3		-3	-3
	Ulsan	5	9	+4	3		-3	+1
Group 5	Sejong	2	3	+1	2	1	-1	0
	Jeju	4	5	+1	2	1	-1	0
	Changwon	5	5	0	2	1	-1	-1

2.3 Set up a report reception desk for emergency call GSR in cities and provinces nationwide

2.3.1 Comparison of the criteria and status of the emergency call GSR report stand

When comparing the report reception desks installed in the fire operation situation center of the emergency call GSR nationwide with the required report reception desks according to the "Rules on Firefighting Force Standards, Appendix 3," it was confirmed that there were a total of 97 more report reception desks installed in the emergency call GSR nationwide, as shown in Table 4. This can be seen as indicating that most emergency call GSR were not able to smoothly receive reports using only the report reception desks that met the calculation criteria for the number of required reception desks, and thus additional report reception desks were installed and operated accordingly.

When comparing the difference in the number of reporting desks in each city/province's emergency call GSR, cities/provinces with fewer reporting desks, such as Ulsan, Sejong, and Jeju, saw an increase of more than 200% in the number of reporting desks installed, while cities/provinces with more reporting desks, such as Seoul and southern Gyeonggi, saw fewer reporting desks installed. In cases where many emergency call reception desks have been installed, such as in Seoul and Gyeonggi, it is presumed that this is due to differences in emergency call reception capacity, such as the simultaneous emergency call reception rate.

Looking specifically at the differences in the number of emergency call reception desks by city, the places with fewer emergency call reception desks than required were Seoul and the southern Gyeonggiemergency call GSR, which had more than 40 emergency call reception desks, while places like northern Gyeonggi and southern Jeolla, which have newly installed 119 GSR, had 16 and 15 more emergency call reception desks than required.

Table 4: Comparison of regional staffing standards and emergency call GSR status

Division	Required Report Reception Desk	Installation Report Reception Desk	Over installation	Division	Required Report Reception Desk	Installation Report Reception Desk	Over installation
Total	259	356	97	Gyeonggi Buk	11	27	16
Seoul	42	36	-6	Gangwon	9	16	7
Busan	16	19	3	Chungbuk	10	14	4
Daegu	11	12	1	Chungnam	14	21	7
Incheon	13	18	5	Jeonbuk	12	12	0
Gwangju	7	10	3	Jeonnam	12	27	15
Daeheib	9	17	8	Gyeongbuk	16	23	7
Ulsan	5	14	9	Gyeongnam	13	22	9
Sejong	2	5	3	Changwon	5	9	4

Gyeonggi Nam	47	46	-1	Jeju	5	8	3

2.3.2 Problems with the standards for the establishment of the emergency call GSR report receiver

Most emergency call GSR across the country receive emergency call reports through report reception desks, emergency rescue units, or emergency phones, but only the report reception desks provide standards for the number of units installed, and emergency rescue units or emergency phones are installed in each city/province emergency call GSR according to the local situation. The report reception desk is based on processing one report per 15 minutes, but the emergency response unit or emergency phone receives 119 reports but does not have command or control, so the report is transferred by messenger, so it is clear that the processing time will increase beyond 15 minutes. Therefore, the installation standard for this should be presented.

The types and number of reporting lines installed in the emergency call GSR and fire stations in each city and province across the country are as shown in Table 5.

Table 5: Status of installation of emergency call GSR and emergency call lines at fire stations nationwide

Division	**Total**	**GSR line**				**Fire Department Line**		
		Sub total	Main line	Standby line	Emergency reception line	Sub total	line	Emergency reception line
Total	6,176	4,586	3,360	882	344	1590	723	867
Seoul	720	480	480	-	-	240	240	-
Busan	218	198	180	-	18	20	-	20
Daegu	150	120	120	-	-	30	30	-
Incheon	260	160	120	23	17	100	-	100
Gwangju	137	127	120	-	7	10	-	10
Daejeon	261	261	240	-	21	-	-	-
Ulsan	136	136	60	60	16	-	-	-
Sejong	102	67	60	-	7	35	30	5
Southern Gyeonggi	960	600	540	-	60	360	-	360
Northern Gyeonggi	825	660	420	180	60	165	-	165
Gangwon	295	259	240	19	-	36	-	36
Chungbuk	260	250	120	120	10	10	-	10
Chungnam	190	139	120	-	19	51	-	51
Jeonbuk	195	135	60	60	15	60	36	24

The emergency line installed in the 119 GSR is used when 119 call reception is blocked due to a failure in the telephone communication line or the report reception system. In other words, it is a line that switches from the main line to the emergency line to receive 119 reports in the event of a telephone communication line or system failure. The three 119 Integrated Situation Rooms in Seoul, Daegu, and Gangwon did not have emergency lines, and Seoul and Daegu maintained separate 119 lines at their fire stations. Gangwon had emergency reception lines at each fire station to prevent 119 call reception from being interrupted due to a failure.

The number of emergency reception lines was 344 lines, which is about 10% of the main lines. Busan, Daejeon, Chungcheongbuk-do, and Jeju have fewer emergency reception lines compared to the number of reporting desks and emergency phones installed. This makes it difficult to respond when

communication line or system failures and a surge of reports occur at the same time, and installing emergency phones is also meaningless.

3. EMERGENCY CALL REPORT CONGESTION

3.1 Emergency call Report Reception System

Looking at the steps of the emergency call report reception in the Fire Service Basic Act, in normal times, the report is received in a three-step process from the telecommunications company to the emergency call GSR, the report that comes into the situation room goes through the CTI (report distribution machine), and then the report receiver receives it. In cases where there are a lot of reports, they go to the waiting report before going to the CTI (report distribution machine), and then go through the IVR (ARS) in a four-step process [7].

Table 6 shows the procedure according to the report overload. It is done by M1, M2 classification according to the number of reports in the telecommunications company column of Table 6. The second is to respond like I1, I2 of Table 6 according to the number of ARS waiting reports in the emergency call GSR, and if a certain standard of waiting reports occur, the report is transferred to another city/province emergency call integrated situation room or fire station. In this case, whether or not to transfer should be decided when a certain level of waiting reports occur through the real-time report control system between the Fire Department and the city/province emergency call GSR.

Table 6: Procedure of report congestion

News agency	Situation	IVR (ARS)	Situation	CTI	Receipt	Dispatch order	Control
			↑ Waiting start	Full	Full	Full	Full
			↑ 60% or less*S1 (Good)	Calculate processing time Determining the ARS transfer criteria(26%)			Normally Included
		⇐ Transfer start *I1	Surge (61% or more)	Full	Full	Full	Full
		⇏ Stop transfer *I2	↧ 60% or less(Good)	Full	Full	Full	Full
⇐ Transfer start*M1	Surge	Full	100%reached	Full	Full	Full	Full
⇏ Stop transfer *M2		Not Full	↧ 80% or less (Prevent re-run)	Calculate processing time Trunk transfer suspension criteria determined(80%)Full			Full
Reporter's choice, waiver		Reduce ARS stay time(Reporter's choice, waiver)		Fast processing of applications		Quick command	

3.2 Type of Reporting Congestion

On October 5, 2022, the number of 119 calls received at the Gyeongnam emergency call GSR increased from 3:00 AM due to the surge in 119 calls caused by Typhoon Chaba. Before the typhoon made landfall, the Korea Meteorological Administration issued a typhoon watch and warning, so the 119 GSR was aware of the increase in 119 calls and was preparing for it.

The graph of the form in which the surge in reports occurred is as shown in Fig. 1. Here, if we take the standard of 200% of the number of reports received during normal times, which can be responded to

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through emergency reports, it lasted for 6 hours from 7 AM to 1 PM, and if we look at the time when the number of reports exceeded 400% of the number of reports received during normal times, when there is a high risk of missing reports and lost homes, it lasted for 3 hours from 9 AM to 12 PM.

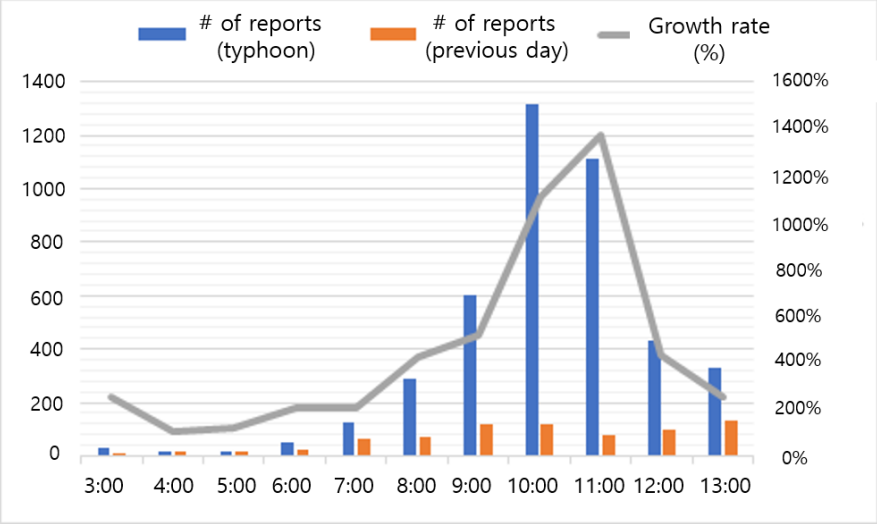

Figure 1: Emergency call surge due to typhoon 'Chaba'.

As another example, the number of emergency calls increased from 6 a.m. due to the surge in emergency calls caused by Typhoon Sanba in 2021.

The status of emergency calls received is shown in Fig. 2. As of 10 a.m., when the typhoon hit and damage began to occur, the number of calls increased by 516% from the previous day, and the emergency call center began to experience a surge in calls that made it impossible to process all calls. The number of calls received increased further, reaching a maximum of 1,042 calls at 11 a.m., with a 508% increase in the number of calls at that time, and a 565% increase at 12 p.m. compared to the previous day. Afterwards, it gradually decreased, and at 4 p.m., the surge in calls ended with 142 calls, a 177% increase compared to the previous day.

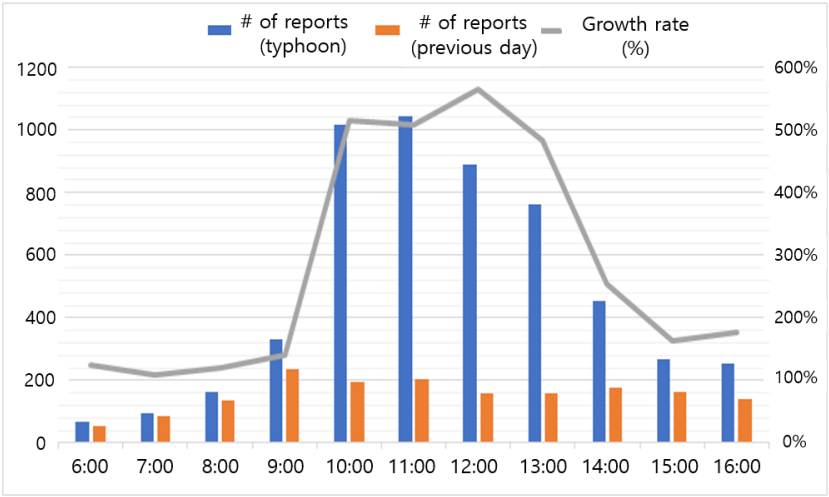

Figure 2: Emergency call surge due to typhoon 'Sanba'.

On September 17, 2021, the number of emergency calls increased from 5 a.m. at the Gyeongnam emergency call GSR due to a surge in emergency calls caused by heavy rain. Before the heavy rain occurred, the Korea Meteorological Administration had issued heavy rain advisories and warnings, so the emergency GSR was aware of the increase in emergency calls and was preparing for it.

The form in which the surge in reports occurred is shown in Fig. 3. Here, if we consider the number of reports received during normal times as 200% of the number that can be responded to through emergency reports, it lasted for 4 hours from 5 AM to 9 AM, and if we consider the time when the number of reports exceeded 400% of the number of reports received during normal times, when there is a high risk of missing reports and lost homes, it lasted for 2 hours from 6 AM to 8 AM.

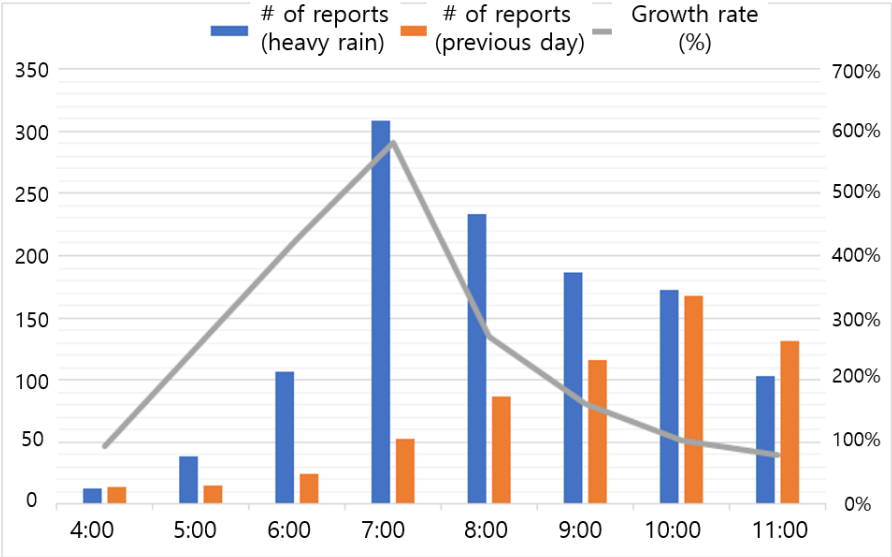

Figure 3: Emergency call surge due to heavy rain in Gyeongnam in 2021.

3.3 Problems and countermeasures of emergency call report congestion

1) Problems caused by the surge in emergency call reports

On the evening of July 23, 2020, due to heavy rain in the Busan area, there was a surge of reports to the Busan emergency call GSR, and 3,139 reports were received in one hour from 10 p.m. This was a 3,737% increase from the average number of 119 reports received in Busan per hour, which was 84 cases from 2018 to 2020, and the fire department was unable to respond to the reports received by the emergency call GSR. In addition, due to heavy rain in the Gwangju area on Saturday, August 8, 2020, the number of 119 reports received at the Gwangju emergency call GSR increased by 6 times compared to normal times to 4,655. Despite the expansion of report reception capacity such as the number of emergency call report receivers and report reception desks, there were limits to the processing of reports. In addition, the delay or non-reception of emergency reports related to rescue efforts made it difficult to respond on-site to actual firefighting demands.

As in the two cases above, when an earthquake, a summer typhoon, or heavy rain occurs, it affects a wider area than other accidents, and when damage occurs, many people are involved and many people report to call center, so the emergency call GSR experiences a flood of reports. When there is a flood of emergency call reports, emergency call reports cannot be received smoothly, resulting in delays in receiving reports or failure to report. However, since call reports are for emergency reports, delays in receiving reports or failure to report other emergency reports can lead to loss of life.

2) Countermeasures for the surge of emergency calls

A surge of emergency calls is a situation where emergency calls are concentrated in a short period of time and reports cannot be received smoothly. When categorizing the types of occurrence, there are predictable surges of reports such as typhoons and heavy rains in the summer, and unexpected surges of reports such as earthquakes and large-scale fires. In addition, the problem of the surge of emergency calls is that there are delays in receiving emergency calls or failure to report, but most importantly, there is a possibility that other emergency calls may not be received, which may result in loss of life.

Therefore, the emergency call center nationwide is establishing and implementing various measures to prevent delays in receiving emergency calls or failure to report due to the surge of emergency calls.

The measures being implemented by the emergency call center nationwide to respond to the surge of emergency calls can be broadly divided into three categories: the first is to increase the maximum report reception capacity by instantly expanding the emergency call reception capacity, the second is to block non-emergency calls in advance to reduce the number of emergency calls, and the third is to quickly confirm and respond to emergency calls. Measures to increase the maximum report reception capacity by instantly expanding the emergency call reception capacity include expanding the number of emergency call reception staff and increasing the number of report reception desks. Measures to block non-emergency reports in advance include responding to the same report, responding to ARS, guiding to multimedia reports, requesting public broadcasting to broadcast disaster guidance, and requesting local governments to send short disaster guidance messages. In addition, measures to confirm and respond to emergency reports include installing hotlines for joint responses with other organizations and confirming unreceived reports.

4. CONCLUSION

In this paper, we conducted a study on the emergency response system through regional analysis in response to the surge in emergency call reports, and the following conclusions were drawn.

Emergency call-in personnel should be designated in response to the surge in reports. In other words, in the case of emergency call-in of situation management personnel, there is no problem in receiving reports, but in the case of office workers receiving reports, report reception may not be smooth, so as a countermeasure, it is necessary to give priority to those with experience as situation workers among office workers.

Tasks should be assigned to emergency personnel who are called in due to a surge in reports. Personnel called in due to an emergency call surge are usually doing work that is not their original job, so their level of understanding and skill are low, and their ability to receive reports and perform corresponding work is low. Therefore, a task division table for each stage of emergency response due to a surge in reports that clearly distinguishes the tasks of each person in charge should be prepared and posted.

It is necessary to secure additional locations for emergency reception desks due to a surge in reports. Emergency reception desks or emergency phones installed as emergency response measures due to a surge in emergency phone calls are not normally used, so they are stored in other locations and no installation locations have been secured. Therefore, in order to install and use emergency reception desks or emergency phones in the event of a surge in reports, space and communication lines appropriate for the number of installations must be secured.

Separate training is required for operating the emergency reception desk. The emergency reception desk or emergency phone, which is installed as an emergency response measure in response to a surge of emergency phone calls, is a device that receives only reports that cannot be commanded or controlled differently from the report reception desk in normal times, and is also a device that is not used by situation management personnel who receive reports in normal times. Therefore, periodic training on how to operate the emergency reception desk and the transfer procedure to control is required.

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