보건학석사 학위논문

Analysis of Factors related to Occurrence of Traffic Accidents and Laboratory Accidents on a University Campus in South Korea for 10 years

일개 종합대학의 10년간 캠퍼스 내 교통사고와 실험실 안전사고 발생 실태 및 관련 요인 분석

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서울대학교 보건대학원

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이 논문을 보건학석사 학위논문으로 제출함

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김 민 정의 보건학석사 학위논문을 인준함

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ABSTRACT

Analysis of Factors related to Occurrence of Traffic Accidents and Laboratory Accidents on a University Campus in South Korea for 10 years.

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A university campus is both a living and an occupational environment for its members (e.g., student, faculty, and staff). In a university campus, the incidence rate of road traffic and laboratory accidents was unabated. Hence, this study aims to analyze the trend of road traffic and laboratory accidents for 10 years in a university campus in South Korea, with specific areas (e.g., street parking lot, parking lot, and

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roads) as a driver distraction factor. Moreover, seasons were considered a causal factor of campus road traffic accidents, and human/machine/environment and semester–vacation was explored as a temporal factor related to campus laboratory accidents.

After obtaining approval from Institutional Review Board (IRB), descriptive data forms of road traffic accidents from 2010 to 2019 were gathered from the Campus Management Division. These data were coded into parameters that might affect the occurrence of road traffic accidents. The frequency cross-tabulation for the data and Fisher's exact test, chi-square test, and logistic regression with driver distraction as the dependent parameter were performed using SPSS 26. For spatial distribution of red spots, number of victims and equivalent property damage only(EPDO) for 5 years (2015–2019) were used. Map visualization was performed using Google Maps. A total of 680 road traffic accidents for 10 years was analyzed. The incidence rates of road traffic accidents had decreased for the last two years (2018–2019). Accidents related to the car–car type (n = 319, 46.9%), offender of visitors (n = 363, 53.4%), areas with no traffic lights (n = 593, 87.2%), and street parking lots (n = 167, 24.6%) have the higher frequency. Comparing the incidence of 2016–2017 and 2018–2019, visitor offender was the highest frequency in 2016–2017 (55.6%), but it has decreased in 2018–2019 (52.8%) and member offender has increased from 33.3% to 42.6%. Further, driver distraction, which was the major cause analyzed through logistic regression, was determined to be the main causal factor for the accidents. Seasonal

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factor was also considered. Driver distraction has several causal factors, which differ per season.

The same university was also investigated for laboratory accidents. After obtaining approval from IRB, descriptive data forms of laboratory accidents from 2010 to 2019 were gathered from the Institute of Environmental Protection and Safety. The data were coded into parameters that might affect the occurrence of laboratory accidents. Frequency tabulation for related factors was performed using SPSS 26. A total of 199 laboratory accidents for 10 years was analyzed. The incidence rates of laboratory accidents had increased for the last two years (2018–2019). Laboratory accidents are typically due to chemicals (n = 106, 53.3%), equipment failure (n = 44, 22.1%), injury/bleeding (n = 37, 18.6%), and hand injury (n = 24, 12.1%). Other factors are during Mondays (n = 52, 26.1%), human causal factor (60.9%), and the college of engineering (n = 52, 26.1%). For the semester–vacation temporal factor, the number of incidents in semester that occurred during Saturdays was the same as those in vacation.

This study determined the trends of accident characteristics in road traffic and laboratory accidents for 10 years. To ensure health protection and safety in the campus, red spots should be identified and one must be careful when turning left or right specifically at the street parking lot and crossway. Transportation safety education is also necessary as the cases of member offender have increased recently. Further, regular inspection to ensure that vehicles are not parked illegally, which might obstruct the driver's field of vision and threat pedestrians' safety, should be

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strictly implemented. Meanwhile, regular inspection of machines and being careful during Mondays must be practiced to prevent laboratory accidents.

Keyword:	Campus accidents, Campus road traffic accidents, Campus laboratory accidents, University accidents, Chemical incidents, School accidents, Logistic regression
Student number:	**2019-26382**

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CHAPTER I.

Background

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I-1. University campus incidents and previous studies

A university campus is not only a work environment for faculty and staff but also a living and educational environment for university students. Each member in this environment has various groups and different living styles (Yoo, 2009). In addition to its members, visitors, including community residents who visit for a walk or go for hiking or participate in various programs from extension, regularly enter and leave the campus (Park, 2006). Considering this crowded environment, members of university campuses have high potential to be exposed to various types of safety accidents (Park, 2009).

Due to the occurrence of the Sewol ferry disaster in 2014, the importance of school safety has been raised (Han, 2014). As a variety of safety accidents occur in school, it is vital to ensure that students acquire education in a safe environment (Han, 2014). According to Lee (2012), “School safety accident means the events both inside and outside of school which occurred the result as an injury or death of students and staff.” However, currently universities are not covered by the Act on the Prevention of and Compensation Against Safety Accidents in Schools (MoE, 2019).

Safety accidents continue to occur in university campuses every year. According to a survey from the Korean Ministry of Education (MoE) in 2019, road traffic and laboratory accidents have continuously increased, from 191 and 134 cases in 2014 to 262 and 258 cases in 2018, respectively (Lee, 2019). Victims of these accidents could

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be slightly or severely injured, which could threaten one's life. These accidents should be prevented by implementing safety measures.

As an aspect of policy level, among those campus safety accidents, related laws exist, but safety in university campuses is still not within the scope. Roads in campuses are not considered actual roads generally, according to Road Traffic Act in Korea (MoIS, 2020; Kim, 2018). Further, these road areas are not officially aggregated in the statistic of National Police Agency (Kim, 2018). Any other government authorities have no control over the campus road traffic accidents. For laboratory accidents, due to the death of three students and one student in a doctoral program in 1999 and 2003, respectively, the Act on the Establishment of Safe Laboratory Environment has been established in 2005 in Korea (Bae, 2009; Ministry of Science and ICT, 2020). With the establishment of this act, there have been increasing number of concerns; however situations of sites, such as university campuses, are not covered when conducting management processes and the occurrence of laboratory accidents were unabated (Inha University, 2017).

With regard to safety issues in university campuses, only a few studies have been conducted about cognition and systems of safety management of campus accidents, such as road traffic and laboratory. Among these accidents, the major conclusions are as follows. College students' awareness and practice behavior of safety had significant correlation ($r = .595$. $p < .01$) (Kim, 2015). The satisfaction level of living safely in university campuses for students was lower than that of the staff (Bae, 2009).

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Showing past laboratory incidents to young scientists in college enables them to have higher accident perception level (coeff = 9.08, $p < .001$) (Kim, 2013).

Although university campus accidents constantly occur, there have been few incident analysis studies based on realistic incident data globally thus far. One study analyzed the victim cases from the university health center for 2 years with the help of undergraduate students, graduate students, and staff (Park & Wie, 1992). However, they did not investigate other safety accidents in the university and limited the temporal range to 2 years only. Kim (2019) conducted a core system analysis using value, institution, leadership, and several campus road traffic accidents cases . However, this study did not focus on the real condition of campus road traffic accidents. Another study conducted frequency analysis of laboratory incidents globally based on newspaper articles from 2012 to 2015 (Gopalaswami & Han, 2020), but they only included the opened cases. A study was conducted on biological safety cabinet explosion of a real case (Al-Dahhan et al., 2016), but it only focused on one case.

In particular, research on the university campus accidents is limited. Owing to the limited accessibility of real raw data on campus accidents, studies related to university campus accidents could not represent the results of entire campus accidents in general. Specifically, only opened partial cases from universities were the object of previous studies. However, those opened cases lack of information on minor accidents. Further, the characteristics of campus road traffic accidents and their

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related factors were not considered, as well as those of campus laboratory accidents, which also include minor accidents, and their related factors.

Therefore, accidents in university campuses should be analyzed based on the actual raw data.

I-2. Objectives and study design

The objectives of this study were (1) to identify the trend of campus road traffic accidents for 10 years and the influencing factors, such as specific areas, driver distraction, and seasons (Chapter 2); and (2) to identify the trend of campus laboratory accidents for 10 years and the causal factors, including human/machine/environment, and temporal factor specifically semester–vacation as influencing factor (Chapter 3).

(1) Chapter 1. University campus incidents and previous studies (Backgrounds)

(2) Chapter 2. Trend of campus road traffic accidents for 10 years and specific areas, driver distraction, and seasons as influencing factors

(3) Chapter 3. Trend of campus laboratory accidents for 10 years and causal factors (including human, machine, and environment) and temporal factor specifically semester–vacation as influencing factors

(4) Chapter 4. Summery and conclusions

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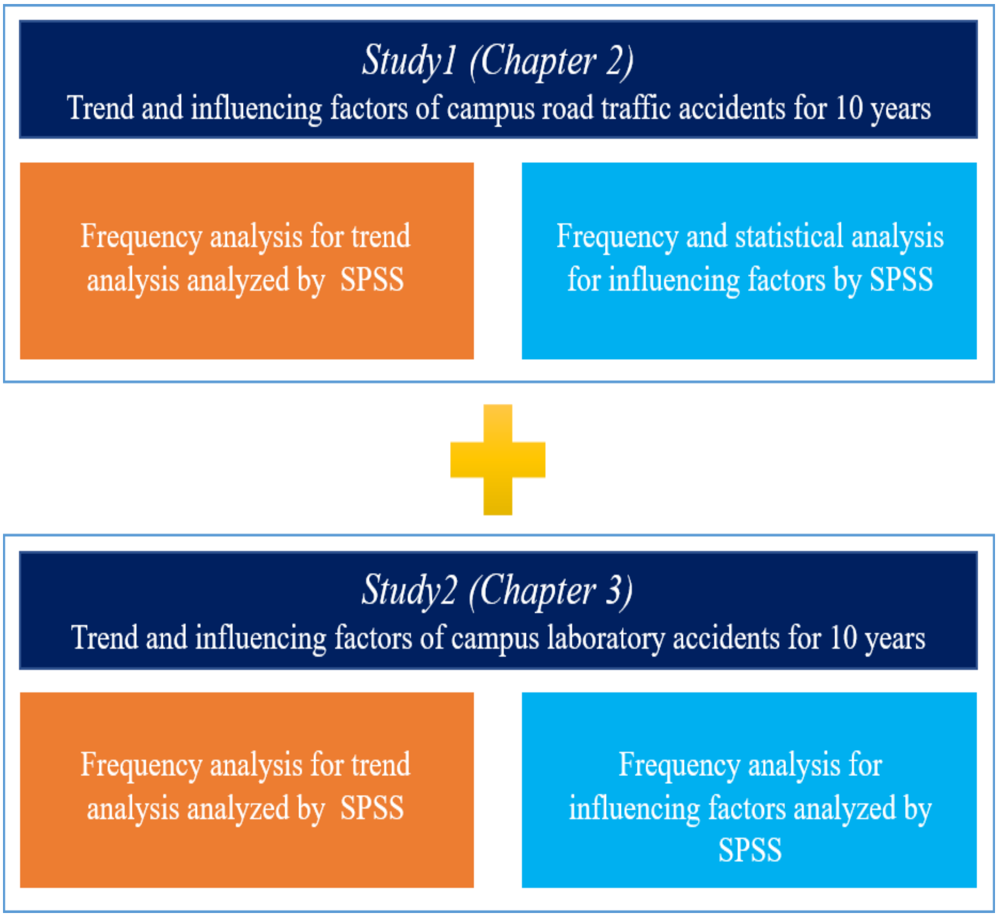

Figure I- 1. Framework of this study

CHAPTER II.

Trend of campus road traffic accidents for 10 years and specific areas, driver distraction, and seasons as influencing factor

II-1. Introduction

Due to the occurrence of Sewol ferry accident in 2014, the importance of school safety has been raised (Han, 2014). As a variety of safety accidents occurred in school, it is vital to ensure that students acquire education in safe environment (Han, 2014). According to Lee (2012), "School safety accident means the events both inside and outside of school which occurred the result as an injury or death of students and staff." However, currently universities are not covered by the Act on the Prevention of and Compensation Against Safety Accidents in Schools (MoE, 2019).

These safety accidents continue to occur in university campuses yearly. According to a survey from Korean Ministry of Education (MoE) in 2019, the road traffic accidents continuously increased from 191 cases in 2014 to 262 cases in 2018 (Lee, 2019).However, road traffic accidents in university campuses were not covered by laws. The campus roads are not considered roads in general, according to Road Traffic Act in Korea (MoIS, 2020; Kim, 2018), and these non-road areas are not officially aggregated in the statistics of National Police Agency (Kim, 2018).

As safety accidents lead to injuries or threaten life, they are closely related to public health. However, school safety accident analysis of most studies focused mainly on primary, middle, and high schools in Korea. These studies also focused on cognition or safety education (Kim et al., 1999; Jung et al., 2000; Cho et al., 2015; Choi et al., 2016), whereas some previous studies performed analysis on actual data (Lee, 2012).

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Unlike these schools, universities have different features. According to healthy campus-related study, "University campus is bigger than primary school, middle school and high school as its scale. And having a diverse age group and a style of living" (Yoo, 2009). Moreover, it is both a learning environment for students and an occupational environment for staff and faculty. The university campus could be a decision factor that affects the health and life of the members of a university campus, including student, staff, and faculty (Dooris, 2006). Considering these dissimilar features, studies on safety accidents in university campus should be conducted.

In the field of accident prevention and industrial safety, there is theory of Heinrich about an accident occurrence (Collins, 2011). This theory states that one major injury is the result of minor injuries in 29 cases, and there are 300 cases of accidents without injury involved before the occurrence of minor injuries (Collins, 2011). According to a previous study, record of previous incidents increased the recognition of the risk involved in an accident (Kim, 2013). Therefore, every minor accident should be recorded and analyzes concretely to determine its causes to help prevent major accidents from happening (Lee et al., 2019).

In an instance of road traffic accidents, determining their major causes is important to help decrease the number of accidents (Choi et al., 2014). According to a theory of accident causation, components of man and/or worker and environment and machine are closely related to possibility on accident occurrence, and they interact with each other (Chazireni, 2018). In particular, road traffic accidents typically involve road

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user (human), vehicle (machine), and road environment (Sul et al, 2013). Previous studies revealed that the major causes of accidents are human factors, especially for major accidents (Dan et al., 2017; Hellman et al., 1986; Petersen, 1981; Skogdalen et al., 2011). For road traffic accidents particularly, driver distraction (i.e., not focusing on the road) was the major human factor in Korea, among all the factors (Han et al, 2017; TAAS, 2020). However, research emphasizing that driver distraction, that is, not paying attention to the road, does not exist, unlike other human factors (Ha et al., 2019). To prevent road traffic accidents, a previous study proposed that an accident black spot should be set and regularly managed to improve traffic safety (Jo et al, 2018).

Meanwhile, traffic accidents are related to seasons (Park et al., 2013; Satterthwaite, 1976) as these accidents mostly occur in fall (Lee, 2013), and season was the influencing factor for a driver's behavior (Hwang Bo, 2007). There has been evidence about the influencing factor of seasons to an industrial accident of a worker, which was also happened to traffic accident in the industrial accidents (Occupational Safety and Health Research Institute, 2010).

However, studies related to accidents in university campuses globally were limited. There was a previous study about campus road traffic accidents, but it only focused on an motorcycle accident (Umebese & Okukpo, 2001). Real raw data and detailed data such as those of minor accidents, domestic and international, are not available owing to accessibility difficulties.

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Thus, this study aimed to explore the trend of campus road traffic accidents for 10 years and the specific areas, driver distraction, and seasons as influencing factors of campus road traffic accidents.

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II-2. Methods

II-2-1. Study design

One university in Seoul, Korea, was selected for this study considering that data can be acquired. Before obtaining the required data from the university, approval of Institutional Review Board (IRB) was obtained first to ensure protection of personal information. Thereafter, the data of 693 cases of road traffic accidents were obtained from the Campus Management Division. The temporal range was from 2010 to 2019, which is about 10 years. Repeated six cases, two cases that occurred outside of the university, and five cases of unknown type were excluded from the analysis. Therefore, 680 cases of campus road traffic accidents were analyzed in this study.

The campus road traffic accidents were coded as parameters to be used for the statistical analysis considering the availability and accessibility of information. For spatial distribution for 5 years (2015–2019) in this study, the estimated property distribution only (EPDO) method and the number of victims were used (**Figure II-1**).

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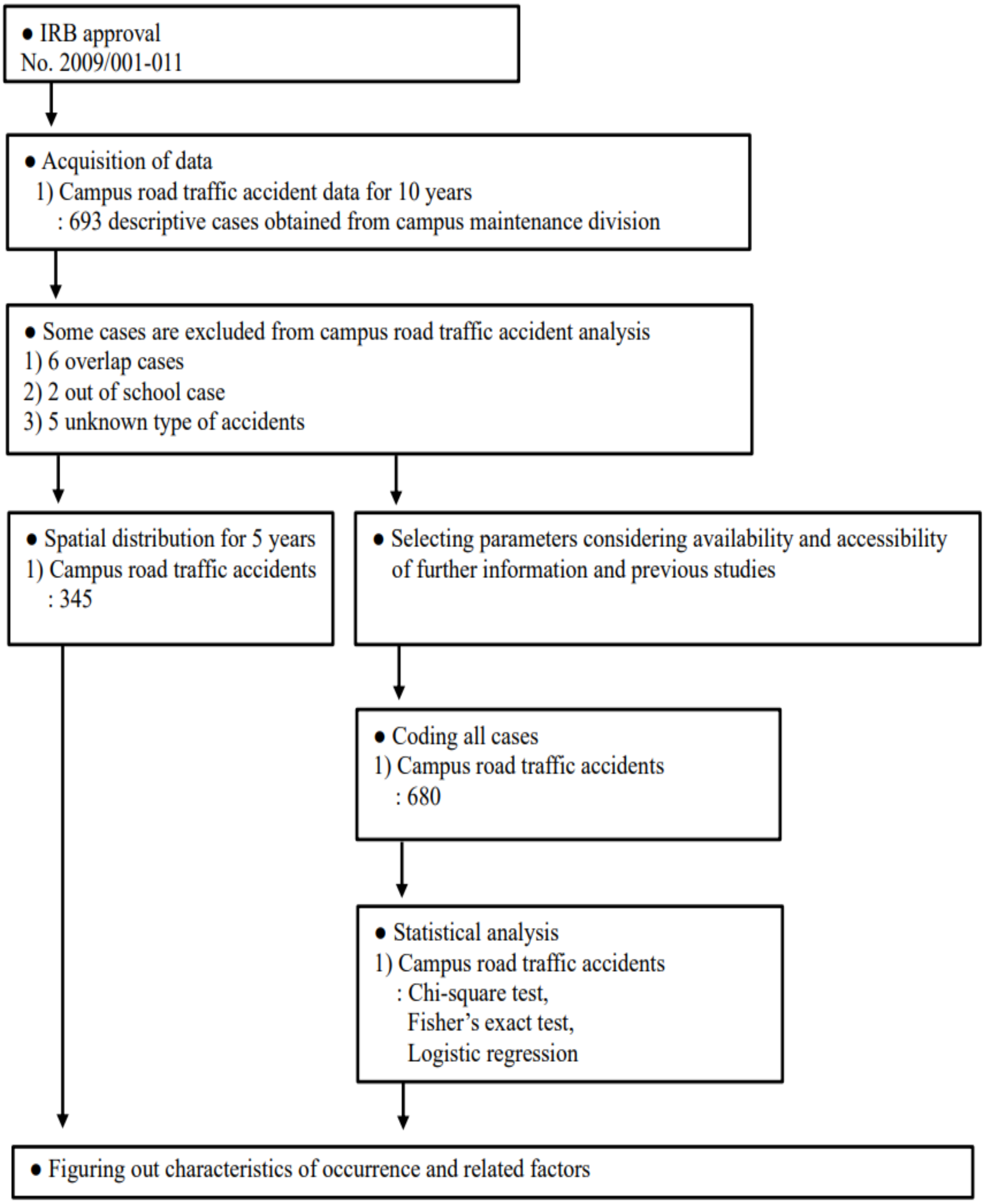

Figure II- 1. Diagram of the overall study design for campus road traffic accidents

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II-2-2. Selection of parameters and coding

The data form style from the university was a descriptive case style, and each case was recorded by the campus police. Given that the campus police does not have any investigational rights, information is limited, compared to the data from the National Police Agency. Further, some of cases were able to identify only part of the contents due to conditions of the original records.

Table II-1 presents all the parameters and their operational definition, which were coded to be used for the statistical analysis. To determine the temporal variation, years (2010–2019), months, seasons, and days of week were coded.

Regarding road conditions based on the weather, weather details of the 680 cases were collected from the website of Korea Meteorological Administration (Meteorological Agency, 2020). The weather of the city where the university is located was used. One previous analysis of road traffic accidents from the Road Traffic Authority in Korea used similar weather condition (i.e., clear, cloudy rainy, foggy, snowy; Road Traffic Authority, 2014).

The accident- area was categorized into six considering the structural characteristics of the university arbitrarily: main gate, rear gate, other gates, crossway without gates, street parking lot, and others. The main gate includes two toll gate offices located at the crossway. The rear gate is one of toll gate offices that was not at the crossway road. Other gates indicate the crossing gate, excluding the main and rear

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gates. As there are many crossways in the university, crossways without gates were considered to distinguish it from the crossway with gates that includes the main and other gates. Further, the university had a number of street parking lots, so the street parking lot was considered as parameters. Finally, other one-way roads were categorized as “others.”

To determine the effects of traffic lights on road traffic accidents, presence of traffic lights was considered as parameters. There were 11 traffic lights and were taken place in eight places in the university campus as spatial range based on the inside main gate and the rear gate. However, part of the university campus is also located outside of both the main and rear gates. Two more traffic lights were installed outside the main and rear gates. This area outside the main and rear gates was considered in this study as the regional range of the university campus. As spatial characteristics, traffic lights were also considered. In this paper, traffic lights include the three colored traffic lights and yellow blinkers. Most of these traffic lights were yellow blinkers, and the number of yellow blinkers were 10 out of 13. It should be noted that effects based on the colors of traffic lights were not analyzed in this study.

The types of accidents was categorized into car–person, car–car, and car only, in accordance with the format followed by the Road Traffic Authority (2014), and it was subdivided per case, and, for the detailed type, the format of Lee (2019) was followed.

The cause of accidents was categorized into eight, which was based on the format of Sul et al. (2013). These are personal factor, vehicle defect, road environment,

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personal factor + vehicle defect, personal factor + road environment, vehicle defect + road environment, personal factor + vehicle defect + road environment, and unknown. The Haddon Matrix from Sul et al. (2012) was referred to classify these causes. The factors from Jeong (2007) were referred for the personal factor. In particular, inexperienced driver was limited to cases when the campus police recorded the cause as “inexperienced driver.” If not, the assumed cause was driver distraction. The case of driver distraction included when the driver did not pay attention on the front/right/left side of the road and not yielding when he or she turned right or left at the crossway. Keeping not safe distance included when the rear car crush happened when the rear car was following on and crushed due to keeping narrow distance.

In addition to those parameters, the offender was coded. Offenders were categorized as visitors, members, hit and run, and cannot be distinguished. The cannot-be-distinguished case is when information is insufficient to distinguish the offender. Road Traffic Act and Casebook of deliberation on car accident dispute of proportion of mistake from General Insurance Association of Korea was used as the basis to classify the offender (MoIS, 2020; General Insurance Association of Korea, 2020). In this article, the roads inside the university were regarded as “road” in the Road Traffic Act when classifying the offenders. Because the university has many barriers but there are no restraints to enter the university. So visitors enter university easily even if there are crossing barrier. And there had similar judicial precedent of other university in the same city with the university in this article (**Table II-1**).

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Table II- 1. Formation of coded parameters and its operational definition of campus road traffic accidents

Coded parameters	Operational definition
Years	Occurred year : 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019
Seasons	Occurred seasons : Spring(3,4,5), Summer(6,7,8), Fall(9,10,11), Winter(12,1,2)
Month	Occurred month :1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
Days of week	Occurred days of week. :Mon, Tues, Wed, Thurs, Fri, Sat, Sun
Time slot	Analyzed the occurred time as 30minute unit.
Weather	The weather of the day of accident occurred. : Clear, Snowy, Rainy, Cloudy/Hazy, Yellow dust
Type	The relation type of accidents. 5 unknown cases were excluded for analysis. : Car-Person, Car-Car, Car only
Accident place	The accident place of accident occurred. : Main gate, Back gate, Other gates, Crossway without gates, Street parking lot, The others
Traffic lights	Whether the spot of accident occurred had traffic lights or not. : With traffic lights, No traffic lights
Cause1	The cause of occurred accidents. : Personal factor, Vehicle defect, Road environment, Personal factor + Vehicle defect, Personal factor + Road environment, Vehicle defect + Road environment, Personal factor + Vehicle defect + Road environment
Cause2	Specific cause of single cause(personal factor, vehicle defect, road environment) from Cause1. : Driver distraction, Inexperienced driver/Driver inattention, Speeding, Drunk driving, Faulty passing, Failure to maintain safe distance, Jaywalking, Condition of the road/slope way, Non-operating of crossing barrier, Infringement of animal, Damaged goods, Defect of brakes, Sudden unintended acceleration/ Defect of starting device, Defect of tires
Offender	Whether the offender was visitors or not. : Visitors, Members, Hit and run, Cannot-be-distinguished

II-2-3. Statistical analysis

All the statistical analysis of this article was performed using SPSS software v.26 (IBM Corp., USA). Thereafter, the basic frequency analysis of the number of accidents and victims was performed. This analysis was also used when analyzing the specific areas (such as street parking lot) as a factor.

To identify the differences among parameters based on seasons, a chi-square test was conducted. The Fisher's exact test was used in the case of the expected frequency for each cell in the 2*2 table was less than 5 and the number of cases was more than 25% of the total. The approximate chi-square distribution is assumed to be a sufficient number of sample (Park, 2001). Meanwhile, the logistic regression was used to determine the causal relevance factor of parameters to the independent variable of driver distraction related to seasons.

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II-2-4. Spatial distribution analysis

As shown in **Figure II-1**, all 338 cases for 5 years were presented on the map for clustering per area. During this process, due to the lack of accurate location information for mapping, only 7 cases among the 345 cases were not visualized. Hence, 338 cases were used for selecting accident red spot of campus road accidents and were clustered to 105 areas.

In this study, two methods of severity were used to determine the severity-based spatial distribution: EPDO and the number of victims. For both methods, two parameters were coded as the number of victims per case and the number of material damage per case (**Table II-2**).

According to Ma et al. (2016), EPDO has been adopted in the field of transportation security for some time (Harkey, 1999; Hunter et al., 2001; PIARC et al., 2004; Campbell and Knapp, 2005; HRPDC, 2006; Holt, 2008; Rifaat et al., 2010; Oh et al., 2010; Montella, 2010; UMassSafe, 2011; Boudreau, 2014; Washington et al., 2014, Ma et al; 2016 recited). Its first application is assumed to be before 1973 (Pigman & Cornette, 1973). EPDO is one of severity methods, which are a form of crash severity reflected measures (Manepalli & Bham, 2016). To execute plans for the improvement of safety measures, counts of EPCO values in each case had been used, but explanation regarding the severity of accidents is lacking. Thus, the EPDO was used to address this problem (Oh & Lee, 2015). The weighted values for each death, injury, and property damage were used to

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reflect the severity of each accident. According to Lim et al. (2016) and Oh and Lee (2015), differences in the weighted values were found in EPDO of both Korea and the USA. In this study, the weighted values of Korea were used, in accordance with the Road Traffic Authority (2013) and Oh & Lee (2015). EPDO was calculated using following equation:

EPDO = (Number of death per case ・12) + (Number of victims who had injuries per case ・3) + (Number of material damage per case ・1)

After the calculation of EPDO for each of the 338 cases, the values were summed as 105 clustered areas.

Sections of the degree of risk are set in accordance with both distribution of EPDO quotients and the number of victims in the university, as well as the reference about the section of EPDO risk from Korea Road Traffic Authority (Korea Road Traffic Authority, 2015). To obtain information of each of the 105 clustered areas, the longitudes and latitudes were obtained by using Google Map (Google Corp., USA). Further, Google Map Application Programming Interface (Google Corp., USA) was used to visualize on the map.

The number of victims was added to the total number of victims in one clustered area. Originally the number of deaths is also considered to calculate the severity of accidents. However, based on the data on the university campus road traffic accidents for 10 years, no death cases due to road traffic accidents were recorded.

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Table II- 2. Formation of coded parameters for spatial distribution of campus road traffic accidents

Coded parameters	Operational definition
The counts of victims by each cases	Victim means person who got any injury from the road traffic accidents. Even pain and bruising were regarded as a victim. The case when the person is taken to hospital and there are any references about getting back due to “all clear” for the person’s status, it is regarded as occurrence of victims.
The counts of material damage by each cases	Whether the material damage occurred or not. If any materials got scratch, it was regarded as presence of material damage. It included that even the material is the university’s property.

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II-3. Results

II-3-1. Details of the university

The details of the university, which was the object of the study, are presented in **Table II-3**. University members are composed of faculty, staff, and students, with a total of 6665, 3375, and 42,680, respectively. Student members had the highest proportion (i.e., 81.0%). These numbers were from the 2019 data only; it could have changed currently.

For the spatial extent, the university has three campuses in Korea. Campus A has the largest area, among the three campuses, and majority of the students are living in campus A. Thus, campus A was the source of campus road traffic accidents data because the Campus Management Division focus on collecting the data of campus A. However, campuses of A, B, and C were all the sources of campus laboratory accidents for the spatial range, in addition to the other two areas in other cities that have laboratories. These areas are also subject for laboratory accidents according to the Institute of Environmental Protection and Safety in the university, which will be discussed in **Chapter III**.

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Table II- 3. Details of the surveyed university

Parameter		Conditions *N(%)*
The number of members[1]		
	Faculty	6,665(12.6)
	Staff	3,375(6.4)
	Student	42,680(81.0)
Area (1,000 m^2)		
	Campus A[2]	4,109
	Campus B	91
	Campus C	1,189
The total number of accident cases in university campus (2010-2019)		
	Road traffic accidents	680
	Laboratory accidents	199

[1] The number of member was version of 2019 (Jeon, 2020).
[2] Campus A was the object area of campus road traffic accidents.

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II-3-2. General characteristics of the parameters

For 10 years, there were 680 cases of campus road traffic accidents. The incidence rates for the selected years are presented in **Table II-4**. The denominator was the number of cars entering the campus through the main and rear gates, and the number of incidents were the numerator. The incidents rates from 2011 to 2017 cannot be calculated due to lack of information from the university. Data of cars entering the campus through the main and rear gates were only from March to December 2017. For 2010, 2018, and 2019, the incidence rates might decrease as time passes. In particular, 0.0032% in 2010 has decreased to 0.0015% in 2018 and 0.0010% in 2019. **Figure A-1** presents the number of cases and victims for 10 years. A sharp decrease was existed in the number of cases in 2018, and additional analysis of this phenomenon will be treated behind in this part. **Figure A-2** presents the severity controlled trend of the campus road traffic accidents by EPDO for 5 years (2015–2019). Except for 2015, the increasing and decreasing trends in 2015–2019 (**Figures A-1** and **A-2)** were similar.

The monthly incidence rates of car accidents for 4 years (i.e., 2010, 2017, 2018, and 2019) were presented in **Table A-1** of the Appendices. The monthly number of entering cars in 2019 was doubled in 2010. However, from March to December 2010, it has decreased to more than half, except for January and February in 2010 and 2019. For the yearly case, in 2010, the incidence rates in

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March (0.0044%) and September (0.0030%) has increased, compared to the previous months (i.e., February, 0.0008%, and August, 0.0025%). However, in 2019, the incidence rate in February (0.0015%) was higher than that in March (0.0011), but the incidence rates of July, August, and September were consistent (0.0006%). Moreover, the highest incidence rate in 2019 was in January (0.0028%).

The number of incidents and victims for the general characteristics of coded parameters is summarized in **Table II-5**. Here, month, season, days of week, weather, type of accidents, offender type, presence of traffic lights, and accident-prone places were presented. For month, October (74) and May (68) have the highest frequency in the cases. The highest number of victims per month was in October (32) and March (23).

Fall (189) has the highest incidence rate among the seasons, followed by spring (184), winter (163), and summer (144) from 2010 to 2019. For the seasonal features of campus road accidents, the incident number of both spring (184) and fall (189) was higher than both summer (144) and winter (163) in general. Fall (68) has also the highest number for victims among the seasons, followed by spring (62), summer (47), and winter (40) (**Table II-5**).

Among the days of week, the number of incidents and proportion of victims were higher on Thursdays (124, 18.2%, respectively) and Mondays (120, 17.6%, respectively) than the other days (**Table II-5**).

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The total counts of days by weather for 10 years are presented in **Table A-2**. To compare this table with **Table II-5**, the campus road traffic accidents had high occurrence for snowy (10.4%), clear (29.1%), and yellow dust (1.8%) weather, compared with the 10-year weather data for snowy (7.3%), clear (28.8%), and yellow dust (0.6%).

The accident type showed that each incident number of car-only (316) and car–car (319) type of accidents were about seven times higher than that of the car–person (45) type. Offenders were mostly visitors (363, 53.4%). The specific accident types are summarized in **Table A-3**. For the car–person accident type, accidents in crosswalks were common for 20 cases. For the car–car accident type, broadside collision was the most frequent for 199 cases. For the car-only type, collision with the parked and/or stopped car was the most frequent accident for 134 cases.

For the offender type, visitor offenders had the largest frequency of incidents case number (363, 53.4%) and the number of victims (112, 51.6%), followed by member offenders (231, 34.0%, respectively) and (87, 40.1%, respectively), hit and run (18, 2.6%, respectively), and cannot be determined (1, 0.5%, respectively) (**Table II-5**).

For spatial features, accidents mostly occurred on the street parking lot (167). Most of these accidents usually occurred when the driver attempts to enter the main road from the street parking lot. The second highest value of the incident case was other gates (159). In this case, the accidents occurred when the driver

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attempts to enter the main road or attempts to went through the gate. All of the "other gates" were located in T-shaped crossway. The rear gate has the least frequency of both incident cases and number of victims (19 and 9, respectively).

II-3-3. Characteristics by specific areas

The characteristics of the specific area of street parking lot (outside), parking lot (inside), and others (i.e., roads) for 10 years are presented in **Table A-5**. Among these areas, the proportion of others (road) has the highest incidence rate for cases (69.1%) and victims (75.1%), followed by street parking lot (24.6% for cases, 24.4% for victims) and parking lot (6.3% for cases, 0.46% for victims). Regarding seasons, three areas had different highest proportions of occurrence frequency. In fall, cases of street parking lot (51, 30.5%) and victims of others (54, 33.1%) have the highest proportion. In summer, cases of parking lot (13, 30.2%) and victims of street parking lot (15, 28.3%) have the highest proportion. In spring, cases of others have the highest proportion of occurrence (130, 27.7%). In street parking lot, Monday (19.8% for cases, 24.5% for victims) has the highest incidence rate. In parking lot, Thursday (39.5% for cases) has the highest incidence rate. In others, Friday (18.3% for cases, 19.6% for victims) has the highest incidence rate. In terms of weather, both cases of street parking lot (32.9%) and parking lot (37.2%) have the highest incidence rate during rainy days. Others have the highest incidence rate at clear weather (30.4%). In terms of the offender type, the difference between visitors (43.7%) and members (40.1%) is minimal in street parking lot. Conversely, members have the highest incidence rate (46.5%) in parking lot. For others, the proportion of visitors (58.5%) was approximately two times higher than the one of members (30.6%).

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For the cause, driver distraction was the major cause. Driver distraction has the highest incidence rate in street parking lot (55.7%) and in others (62.8%), and the proportion had a significant difference with other causes. However, in parking lot, the proportion of driver distraction (32.6%) and inexperienced driver/inattention (30.2%) had little difference.

The sharp decrease in 2018, as shown in **Table II-4,** was also compared based on the characteristics of a specific area, namely, street parking lot (outside), parking lot (outside) and others (roads), between 2016–2017 and 2018–2019 (**Table A-4**). The percentage of each place per year of accidents that occurred in street parking lot was almost same as 24.0% and 24.1% for those that occurred in parking lot increased from 5.8% to 8.3%, whereas those that occurred in others slightly decreased from 70.2% to 67.6%. For the months, the percentage of total incident cases in January (8.2%–13.0%), February (4.7%–11.1%), March (8.8%–10.2%), April (6.4%–12.0%), August (4.7%–5.6%), and December (8.8%–9.3%) has increased in 2018–2019, compared to the months in 2016–2017. Conversely, the percentage for the months of others (i.e., May, June, July, September, and October) has decreased. For the seasons, the percentage for spring (26.3%–31.5%) and winter (21.6%–33.3%) has increased. The percentage of all of the three places during winter has increased, but in spring only parking lot (inside) has increased and others have decreased. Meanwhile, the percentage in summer and fall has decreased. For the days of week, the percentage in Mondays (17.5%–20.4%), Tuesdays (13.5%–18.5%),

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Thursdays (18.7%–19.4%), Saturdays (6.4%–8.3%), and Sundays (2.9%–7.4%) has increased. In particular, the percentage in Mondays, Tuesdays, and Thursdays has mostly increased in parking lot (inside), whereas that in Saturdays and Sundays has mostly increased in street parking lot and parking lot (inside). For the weather, the percentage of snowy (11.7%–14.8%) and clear (25.7%–30.6%) weather has increased, and each of them has increased at the street parking lot, parking lot (inside), and others. For the accident type, the percentage of car–car accident has increased from 42.7% to 51.9%, as well as in street parking lot and others. For the offender type, the percentage of members has increased from 33.3% to 42.6%, and the percentage of all the places has increased (**Table A-4)**. For the cause, the percentage of driver distraction has increased from 60.8% to 65.7%, as well as in street parking lot and others.

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Table II- 4. Yearly incidence rates of car accidents for selected years

Parameter	Year									
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
The number of victims of road traffic accidents yearly (N)	19	23	24	16	17	29	28	22	26	13
The number of road traffic accidents yearly[2] (N)	64	59	75	82	58	63	83	88	65	43
The number of entering cars through main and rear gate yearly (N)	1,977,146	-*	-	-	-	-	-	-	4,263,779	4,201,680
Incident rate of car accidents[1] (%)	0.0032	-	-	-	-	-	-	-	0.0015	0.0010

[1] The incident rate of car accidents were calculated by the methods below.
(Yearly number of road traffic accidents)/(Yearly total number of entering cars through main gate and rear gate)*100

[2] The total number of incident cases for 10 years were 680.

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Table II- 5. General characteristics of campus road traffic accidents

General characteristics		**The number of accidents(cases)**	**The number of victims(persons)**
Total		680(100.0)	217(100.0)
Month	1	59(8.7)	12(5.5)
	2	36(5.3)	12(5.5)
	3	55(8.1)	23(10.6)
	4	61(9.0)	22(10.1)
	5	68(10.0)	17(7.8)
	6	50(7.4)	16(7.4)
	7	45(6.6)	15(6.9)
	8	49(7.2)	16(7.4)
	9	62(9.1)	20(9.2)
	10	74(10.9)	32(14.7)
	11	53(7.8)	16(7.4)
	12	68(10.0)	16(7.4)
Season	Spring(3,4,5)	184(27.1)	62(28.6)
	Summer(6,7,8)	144(21.2)	47(21.7)
	Fall(9,10,11)	189(27.8)	68(31.3)
	Winter(12,1,2)	163(24.0)	40(18.4)
Days of week	Monday	120(17.6)	43(19.8)
	Tuesday	115(16.9)	41(18.9)
	Wednesday	114(16.8)	32(14.7)
	Thursday	124(18.2)	40(18.4)
	Friday	111(16.3)	38(17.5)
	Saturday	57(8.4)	14(6.5)
	Sunday	39(5.7)	9(4.1)
Weather	Yellow dust	12(1.8)	4(1.8)
	Cloudy/hazy	201(29.6)	71(32.7)
	Rainy	198(29.1)	65(30.0)
	Snowy	71(10.4)	20(9.2)
	Clear	198(29.1)	57(26.3)
Type of accidents[1]	Car-car	319(46.9)	114(52.5)
	Car-person	45(6.6)	43(19.8)
	Car only	316(46.5)	60(27.6)
Offender	Visitors	363(53.4)	112(51.6)
	Members	231(34.0)	87(40.1)
	Hit and run	18(2.6)	1(0.5)
	Cannot-be-distinguished	68(10.0)	17(7.8)
Traffic lights	With traffic lights	87(12.8)	35(16.1)

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	No traffic lights	593(87.2)	182(83.9)
Accident place	Main gate	114(16.8)	29(13.4)
	Rear gate	19(2.8)	9(4.1)
	Other gate	159(23.4)	56(25.8)
	Crossway without gates	114(16.8)	48(22.1)
	Street parking lot	167(24.6)	53(24.4)
	The others	107(15.7)	22(10.1)

[1] In type of accidents, 5 unknown cases were excluded in this study due to lack of information(2) or crushes caused by facility fracture(2) or crushed caused by natural wind(1). The specific factors in type of accidents were presented in appendices table A-3.

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II-3-4. Spatial distribution analysis via number of victims and EPDO

For the spatial distribution of campus road traffic accidents, data from 2015 to 2019 were used. **Figures II-2** and **II-3** show the spatial distribution of the number of victims and EPDO quotients. A total of 105 accident places and some facilities, including toll gates (3), bus stations (43), crosswalks (74), other gates (23), and traffic lights (10) have been presented in the figures. The facilities were based on the 2018 road view pictures from Kakao map shown in **Figures II-2** and **II-3**. The severity was classified into four. Red is the most severe place in the maps, followed by orange, green, and blue. In **Figure II-2,** red includes the number of victims (3–7 persons), orange includes the number of victims (2 persons), green includes the number of victims (1 person), and blue includes cases without victims. The number of colors was 17 for red, 12 for orange, 28 for green ,and 48 for blue.

In **Figure II-3,** red includes the value of EPDO quotient (from 18 to 56), orange includes the value of EPDO quotient (from 9 to 17), green includes the value of EPDO quotient (from 5 to 8), and blue includes the value of EPDO quotient (from no values to 4). The number of colors was 12 for red, 21 for orange, 22 for green, and 50 for blue .

The most severe was in red, and 10 accident places were in common in **Figures II-2** and **II-3**, as shown in **Figure A-3**. Among the 10 accident places,

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the most severe place (D) through both maps was at the crossway, which was located in front of the gate and the bus station, without crosswalks. The total number of places with crossway, in front of the gate, bus station, and crosswalk was 11. An extra three would be added if the places with facilities stated above and traffic lights are included.

For those 10 accident places, onsite investigation (2020) was conducted, and achievable maps through the Kakao map (2010, 2011, 2014, and 2018) and Google map (2020) were compared as a road view picture (**Table A-6**). Further, other unavailable pictures existed due to no data. There was no large difference from 2010 to 2020 overall, except for place J where traffic lights were installed and bus station was moved to another place and for place H where speed bump-shaped stones were installed.

Based on the onsite investigation of the 10 places, these issues were found. First, buses tended to stop on the first lane even if the bus station is at the second lane of the road because the front and rear sections of the bus station were street parking lot where cars were parked; hence, the entrance to the bus station would be inconvenient for bus driver. Moreover, most of the opposite lane has only one lane. This sometimes triggered the rear car to overtake the busof the bus when the bus stopped at the first lane as going to drive backwards by using the opposite lane, and this could cause collision accidents. Second, the street parking lot has many cars, and in front and rear of the area was usually no parking area, but drivers ignore the sign that no parking lot is available and

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eventually park their cars. This illegal parking interrupts the driver's view when turning left or right at the crossway. Third, in front of some crosswalks has stop line, but others do not have. However, many cars do not stop immediately at the stop line even if a person is about to cross the crosswalk. Fourth, most drivers do not yield and are not careful enough when turning right or left or when crossing the crossway. Finally, at the entrance, drivers did not keep safety distances between cars.

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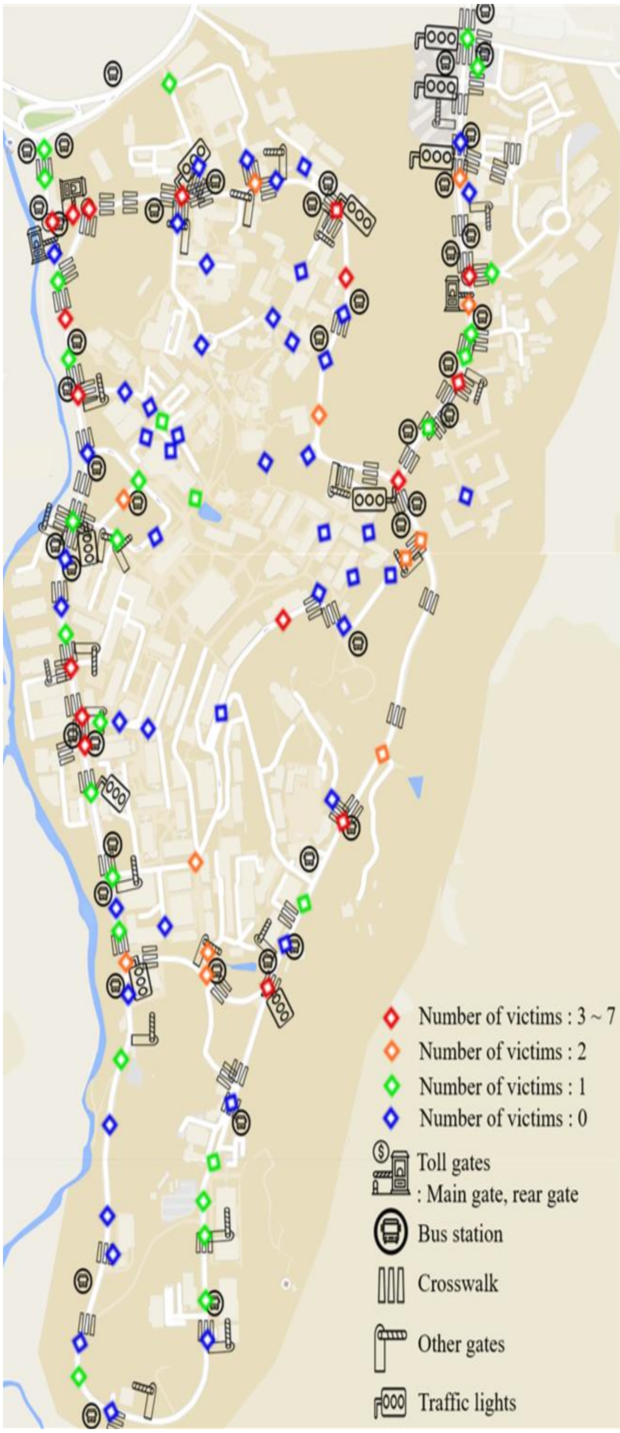

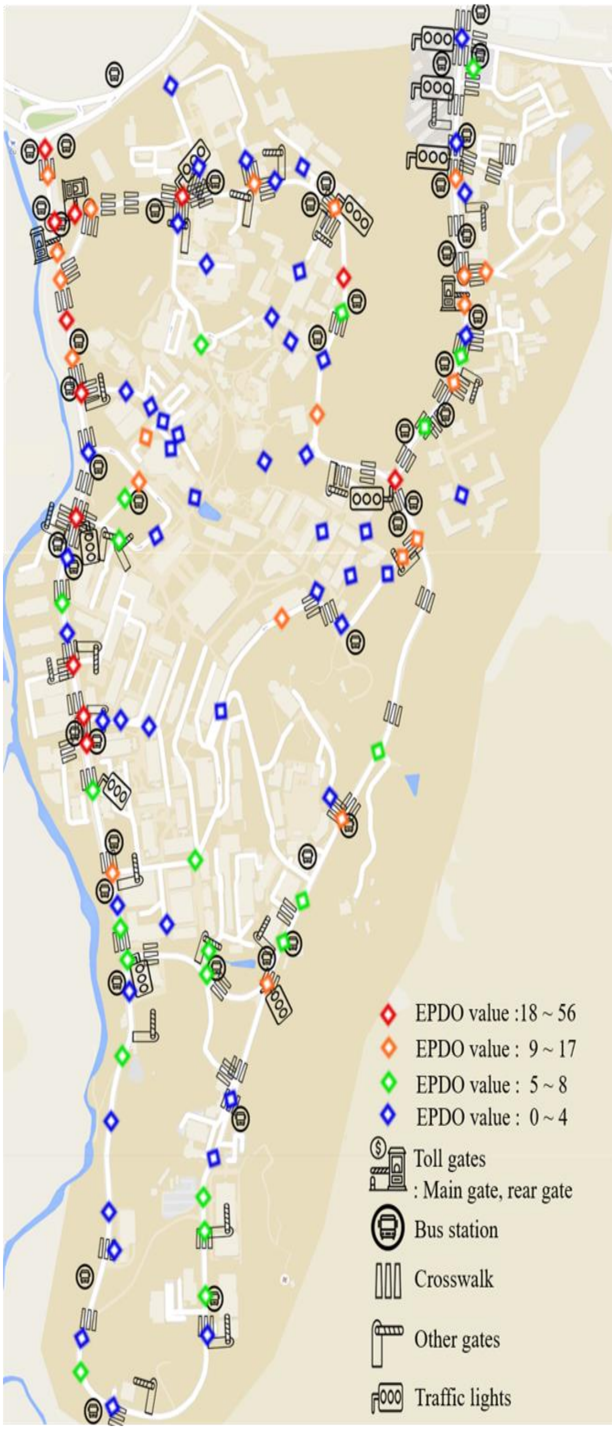

Figure II- 2. Spatial distribution for victims(left)
Figure II- 3. Spatial distribution for EPDO(right)

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II-3-5. Differences in characteristics with driver distraction as a causal factor

Table II-6 shows the significant difference of the frequency and percentage of driver distraction and other causal factors. The difference between driver distraction and other causes were significant based on the accident type ($p < 0.001$). Among the accident types, the car–car type had the largest percentage of driver distraction of 244 (76.5%), whereas the car-only type had higher percentage of other factors of 189 (59.8%).

Among the accident places, the difference between driver distraction and other factors was statistically significant ($p < 0.01$). Driver distraction occurred mostly at the main gate of 77 (67.5%), whereas other factors occurred mostly at the others compared to other spots of 63 (58.9%) .

It was also statistically significant of the difference between both causes for offender ($p < 0.001$). Visitor offenders had high driver distraction of 234 (64.5%), and the cannot-be-distinguished cases had other factors of 49 (72.1%). The difference between both factors was statistically significant in years ($p < 0.01$). Specifically, 2016 has the large amount of driver distraction of 61 (73.5%), and 2013 has 44 (53.7%) for large amount of other factors (**Table II-6**).

The causal factors of road traffic accidents were categorized into four: personal factor, vehicle defect factor, road environmental factor, and complex

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factors, which was a combination of more than one of four factors. Driver distraction was 77.6% (402 cases) among the personal factors, and the personal factor was 76.2% (518 cases) among the causal factors (**Table II-7**).

The personal factor presented in **Table II-7** was the causal factor of the offender of accidents, when the cause of the accidents was only a personal factor.

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Table II- 6. Difference via causal factors by each parameters of road traffic accidents for 10 years

Parameters		Causal factors		x^2
		Driver distraction *N*(%)	Other factors *N*(%)	
Total	680(100.0)	402(59.1)	278(40.9)	
Type of accident	Car-Person	31(68.9)	14(31.1)	88.45****
	Car-Car	244(76.5)	75(23.5)	
	Car only	127(40.2)	189(59.8)	
Accident place	Main gate	77(67.5)	37(32.5)	21.88***
	Rear gate	12(63.2)	7(36.8)	
	Other gates	102(64.2)	57(35.8)	
	Crossway without gates	74(64.9)	40(35.1)	
	Street parking lot	93(55.7)	74(44.3)	
	The others	44(41.1)	63(58.9)	
Offender	Visitors	234(64.5)	129(35.5)	33.59****
	Members	141(61.0)	90(39.0)	
	Hit and run	8(44.4)	10(55.6)	
	Unable to distinguish	19(27.9)	49(72.1)	
Years	2010	33(51.6)	31(48.4)	25.26***
	2011	31(52.5)	28(47.5)	
	2012	44(58.7)	31(41.3)	
	2013	38(46.3)	44(53.7)	
	2014	39(67.2)	19(32.8)	
	2015	42(66.7)	21(33.3)	
	2016	61(73.5)	22(26.5)	
	2017	43(48.9)	45(51.1)	
	2018	40(61.5)	25(38.5)	
	2019	31(72.1)	12(27.9)	

p *** <.01 p **** <.001

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Table II- 7. Number of driver distraction among personal factors and driver distraction among total factor of road traffic accidents for 10 years

Causal factors	Parameter The number of cases *N*(%)
Personal factors	518(76.2)
Driver distraction[1]	402(77.6)
Inexperienced driver/Driver inattention[2]	44(8.5)
Speeding	4(0.8)
Drunk driving	8(1.5)
Faulty passing	7(1.4)
Failure to maintain safe distance	24(4.6)
Jaywalking	4(0.8)
Unknown	25(4.8)
Subtotal	518(100.0)
Vehicle defect	14(2.1)
Road environment	14(2.1)
Complex factors	134(19.6)
Personal factor + vehicle defect	1(0.1)
Personal factor + road environment	66(9.7)
Vehicle defect + road environment	7(1.0)
Personal factor + vehicle defect + road environment	1(0.1)
Unknown	59(8.7)
Total	680(100.0)

Reformulated by the table in 32p of (Sul et al., 2013)
[1] Driver distraction included the cases of negligence in keeping eyes forward, not paying attention to road.
[2] Inexperienced driver/Driver inattention included cases of inattention of operating cars especially steering wheel, accelerator due to inexperience or inattention.

II-3-6. Difference in characteristics by seasons

Table II-8 shows the statistically significant differences of seasons for each parameter. The difference between seasons were statistically significant for accident places ($p < 0.05$). In spring, the main gate had higher occurrence for 41 (36.0%). In summer, street parking lot had higher occurrence for 44 (26.3%). In fall, the rear gate had higher occurrence of 9 (47.4%). In winter, the crossway without gates had higher occurrence for 39 (34.2%).

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Table II- 8. Significant difference via seasons by accident place of road traffic accidents for 10 years

Parameter		Seasons				x^2
		Spring *N*(%)	Summer *N*(%)	Fall *N*(%)	Winter *N*(%)	
Accident place	Main gate	41(36.0)	19(16.7)	26(22.8)	28(24.6)	28.24 **
	Rear gate	4(21.1)	1(5.3)	9(47.4)	5(26.3)	
	Other gates	41(25.8)	39(24.5)	46(28.9)	33(20.8)	
	Crossway without gate	29(25.4)	18(15.8)	28(24.6)	39(34.2)	
	Street parking lot	45(26.9)	44(26.3)	51(30.5)	27(16.2)	
	The others	24(22.4)	23(21.5)	29(27.1)	31(29.0)	
Total		184(27.1)	144(21.2)	189(27.8)	163(24.0)	

p ** <.05 p **** <.001

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II-3-7. Result of logistic regression analysis of driver distraction

Table II-9 shows the result of logistic regression analysis when driver distraction is used as the dependent variable. As the significance probability of the Hosmer–Lemeshow test was 0.342 ($p > 0.05$), the model for logistic regression was well predictable. The possibility of driver distraction for cannot-be-distinguished offenders was 0.174 times lower than that of visitor offenders ($p < 0.001$). The possibility of driver distraction for the car-only accident type was 0.293 times lower than that of the car–person type ($p < 0.01$). For year, 2019 has 1.065 times higher possibilities of driver distraction compared to 2010 ($p < 0.1$). For spots, the others had 0.554 times lower possibilities of driver distraction than that of the main gate ($p < 0.1$).

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Table II- 9. Result of logistic regression analysis of driver distraction of campus road traffic accidents for 10 years

Parameters	p-value	EXP(B)
Offender-visitors	0.000	
Offender-members	0.446	0.861
Hit and run	0.413	0.651
Unavailable of distinguish offender	0.000****	0.174
Car-person	0.000	
Car-car	0.301	1.463
Car only	0.001***	0.293
Year(2010~2019)	0.059*	1.065
Spot- main gate	0.538	
Spot- back gate	0.970	1.022
Spot- other gates	0.427	0.791
Spot- crossway without gate	0.619	0.849
Spot- street parking lot	0.535	0.834
Spot- the others	0.064*	0.554
Season-spring	0.181	
Season-summer	0.163	1.482
Season-fall	0.148	1.575
Season-winter	0.645	0.878
Month(1~12)	0.454	0.975
Weather-Clear	0.457	
Weather-Snowy	0.243	0.663
Weather-Rainy	0.108	0.681
Weather-Cloudy/Hazy	0.571	0.875
Weather-Yellow dust	0.419	0.586
Day-Monday	0.877	
Day-Tuesday	0.253	0.707
Day-Wednesday	0.688	0.883
Day-Thursday	0.255	0.712
Day-Friday	0.855	0.945
Day-Saturday	0.543	0.582
Day-Sunday	0.603	0.624
Holiday	0.851	1.165
Working hours	0.338	0.831

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Traffic light	0.828	1.065
Constant term	0.012	4.002

p * <.1 p *** <.01 p **** <.001
The significance probability of Hosmer and Lemeshow was 0.342(p>0.05).
R^2 of Cox and Snell was 0.194 and R^2 of Nagelkerke was 0.262.

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II-3-8. Result of logistic regression analysis of driver distraction by seasons

Table II-10 shows the result of logistic regression analysis when driver distraction is used as the dependent variable by each of the seasons. As the significance probability of the Hosmer–Lemeshow test results was 0.842 for spring, 0.524 for summer, 0.722 for fall, and 0.706 for winter ($p > 0.05$), the model for logistic regression was well predictable. Tuesdays had 0.265 times lower possibilities for driver distraction than Mondays ($p < 0.05$), and the other spots had 0.279 times lower possibilities for driver distraction than in the main gate ($p < 0.05$). Further, cannot-be-distinguished offender has 0.284 times lower possibilities of driver distraction than visitor offender ($p < 0.1$).

In summer, the car-only accident type has 0.089 times lower possibility of driver distraction than the car–person type ($p < 0.05$). Moreover, the cannot-be-distinguished offender had 0.115 times lower possibility of driver distraction than the visitor offender ($p < 0.01$).

In fall, the second half of the year has 1.526 times higher possibility of driver distraction than the first half ($p < 0.1$). Tuesdays and Wednesdays have 0.242 and 0.252 times, respectively, lower possibilities of driver distraction than Mondays ($p < 0.05$; $p < 0.05$, respectively). The car-only type of accidents has 0.161 times lower possibilities of negligence than the car–person type ($p < 0.05$), which was statistically significant. Finally, the cannot-be-distinguished offender has 0.054 times lower

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possibilities of negligence than the visitor offender ($p < 0.001$).

For winter, 2019 has 1.437 times higher possibilities of driver distraction than 2010 ($p < 0.001$). Fridays have 0.182 times lower possibilities than Mondays ($p < 0.05$), and the car-only type of accidents has 0.161 times lower possibilities than the car–person type ($p < 0.1$). Meanwhile, street parking lot has 0.230 times lower possibilities than the main gate ($p < 0.1$). The unknown and cannot-be-distinguished offender each has 0.040 and 0.156 times lower possibilities than the visitor offender ($p < 0.1$ and $p < 0.05$, respectively).

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Table II- 10. Result of logistic regression analysis of driver distraction by each season of campus road traffic accidents for 10 years

Parameters	Spring		Summer		Fall		Winter	
	p-value	EXP (B)	p-value	EXP (B)	p-value	EXP (B)	p-value	EXP (B)
Year	0.842	1.014	0.411	1.087	0.142	0.898	0.000 ****	1.437
Month	0.830	1.051	0.423	0.795	0.095 *	1.526	0.670	1.020
Monday	0.456		0.539		0.127		0.181	
Tuesday	0.035**	0.265	0.125	3.652	0.029 **	0.242	0.561	1.609
Wednesday	0.675	0.740	0.546	1.573	0.044 **	0.252	0.734	1.285
Thursday	0.280	0.527	0.586	0.643	0.230	0.469	0.489	0.567
Friday	0.636	0.749	0.479	1.829	0.775	1.237	0.038 **	0.182
Saturday	0.999	0.000	0.713	0.509	0.579	0.363	1.000	0.000
Sunday	0.999	0.000	0.909	1.209	0.514	0.249	1.000	0.000
Car-person	0.027		0.000		0.011		0.000	
Car-Car	0.249	2.413	0.526	1.803	0.523	0.600	0.385	2.431
Car only	0.665	0.723	0.011 **	0.089	0.044 **	0.208	0.069 *	0.161
Main gate	0.430		0.829		0.440		0.525	
Back gate	0.866	1.268	1.000	0.000	0.673	0.649	0.706	0.570
Other gates	0.938	0.957	0.362	1.994	0.905	0.925	0.125	0.281
Crossway without gate	0.453	0.619	0.980	0.978	0.657	1.393	0.122	0.289
Street parking lot	0.384	0.630	0.305	2.205	0.932	1.056	0.072 *	0.230
The others	0.046**	0.279	0.819	1.217	0.123	0.318	0.362	0.492
Visitors	0.303		0.038		0.001		0.044	
Member	0.594	1.237	0.140	0.459	0.835	0.918	0.471	0.681
Unknown	0.746	0.680	0.999	0.000	0.111	0.175	0.094 *	0.040
Unavailable	0.096*	0.284	0.005	0.115	0.000	0.054	0.018	0.156

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of distinguish offender			***		****		**	
Holiday	0.999	0.000	0.678	1.860	0.590	2.401	1.000	0.000
Working hours	0.370	0.701	0.613	1.305	0.344	1.469	0.161	0.504
Traffic light	0.956	1.032	0.550	1.599	0.265	0.535	0.537	1.659
Clear	0.628	-	0.592	-	0.622		0.464	
Snowy	0.530	2.753	0.842	1.124	0.704	0.656	0.642	0.760
Rainy	0.201	0.538	0.446	0.587	0.121	0.471	0.435	1.942
Cloudy/Hazy	0.643	0.798	-	-	0.482	0.723	0.389	1.701
Yellow dust	0.443	0.520	-	-	0.490	0.371	-	-
Constant term	0.370	3.341	0.337	10.584	0.820	0.548	0.925	1.138

p * <.1 p ** <.05 p *** <.01 p **** <.001

The significance probability of each seasons of Hosmer and Lemeshow was 0.842(spring), 0.524(summer), 0.722 (fall), 0.706(winter)($p>0.05$).

R^2 of Cox and Snell was 0.189(spring), 0.345(summer), 0.267(fall), 0.410(winter) and R^2 of Nagelkerke was 0.257(spring), 0.465(summer), 0.363(fall), 0.548(winter).

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II-4. Discussion

In this study, the trends of road traffic accidents in a university campus for 10 years and the related factors, such as specific areas including street parking lot/parking lot/others, driver distraction, and seasons, were analyzed.

The first hypothesis was that the incidence rate would increase as years pass owing to the increase in traffic volumes. However, the number of incident cases per year decreases as years pass. Second, others would have higher incidence rate among the areas, such as street parking lot and parking lot. In this study, others (i.e., roads) had the highest incidence rate. The aim for selecting red spots through spatial distribution was achieved by selecting the most severe area in the university campus for 5 years. The third hypothesis was of which significant differences would exist in parameters depending on whether the cause is driver distraction. In addition, type of accident, accident place, offender type, and year are the several parameters that had significant differences between driver distraction and other factors. The final hypothesis was there would have differences in the parameters due to seasons, and accident places had a difference due to seasons as well.

This study found that the number of cars entering in the campus through the main and rear gates in both 2018 and 2019 has increased, at least two times higher than that of 2010 (**Table II-4**). However, the incidence rates of road traffic accidents have decreased as time passes. This could imply that the university is well-managed.

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However, effort to decrease the accident rates as low as possible is necessary, and reporting minor accidents should be the practice to prevent major accidents. From the results, the car–car (46.9%) and car-only (46.5%) type of accidents had higher incidence rates, and the majority of offenders were visitors (53.4%). Moreover, the main cause of accidents was driver distraction (59.1%), and the accident-prone area was street parking lot (24.6%) (**Table II-5**). Based on these frequency analyses, when the car enters the main gates or rear gate, the driver should pay attention at street parking lot, or caution facilities are needed in the area.

For the spatial distribution of red spots, the most severe place was at the crossway and crosswalk in front of the gate and bus station. The cause of accidents for a total of 17 cases (94.44%) in these areas was personal factors. As 13 of the 17 cases were due to driver distraction, a driver should be pay attention when turning right or left or going straight to the area. However, not only these road traffic accidents could occur in a campus but also lab accidents, which are life threatening. Therefore, to protect health and ensure safety, past accident data must be analyzed and disseminated (**Figures II-2** and **II-3**).

A total of 10 places are in red spots, where the number of victims and EPDO are high. Onsite investigation was implemented and found that the problem was that drivers did not yield to the opposite lane in the crossway and many cars have illegally parked at the corner of the crossway that could obstruct a driver's field of vision.

For the spatial characteristics of specific areas, others (roads) had higher incidence

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rate (69.1%) for 10 years. For seasons, accidents in each area had occurred in different seasons. Street parking lot had the highest incidence rate in fall (30.5%), parking lot in summer (30.2%), and others (roads) in spring (27.7%). For days of week, parking lot had the highest accident occurrence during Thursdays (39.5%), Mondays (19.8%) for street parking lot, and Fridays (18.3%) for others, but the percentage was almost similar to other weekdays. For the weather, street parking lot and parking lot had higher incidence rate during rainy weather (32.9% and 37.2%, respectively), whereas others (roads) had higher incidence during clear days (30.4%) (**Table A-5**). These percentages were higher than the weather percentages for 10 years (**Table A-2**). Visitor offender (58.5%) had almost two times higher incidence rate than member offender (30.6%) at others (roads). In parking lot, the percentage of driver distraction (32.6%) and inexperienced driver/driver inattention (30.2%) were almost equal.

In winter, it had 1.437 times higher occurrence of driver distraction in the university campus (**Table II-10**). In this connection, Park et al. (2013) had the same result in that driver distraction had higher occurrence in summer and winter at freeways. Driver distraction could be explained due to an increase in speed during winter season from a previous study; the object of that study was industrial accidents, but driving during work hours were also included (Occupational Safety and Health Research Institute, 2010).

The differences in days of week had existed depending on the season. In spring, driver distraction possibilities are 0.265 times lower in Mondays than in Tuesdays. In

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fall, driver distraction possibilities are 0.029 times and 0.044 times lower in Tuesdays and Wednesdays than in Mondays. In winter, driver distraction possibilities were 0.182 times lower in Fridays than in Mondays. These results indicate that driver distraction possibilities are higher in Mondays if accidents occurred in spring, fall, and winter. According to the National Police Agency, the most frequent traffic accident occurred in Saturdays, followed by Fridays and Mondays. Further, the Agency revealed that there had frequent accidents before and after the weekends and the most common causes of these accidents were driver distraction (KN News, 2011). In the university campus, it is cautiously judged that it would be the influence of before and after weekends for the frequent accidents on Mondays (**Table II-10**).

There are several limitations of this study. First, cognitive factors were not surveyed in this study. Psychological aspects could often be the cause of incidents (Gopalaswami & Han, 2020). Hence, a collaboration study on real data analysis and psychological analysis is required in the future to explain this phenomenon. Second, the descriptive raw data of campus road accident analysis were recorded only by campus police. Thus, there might be subjective judgment. Third, for coding each case, the offender type for road traffic accidents for each case was difficult classify because the precisely accurate information about fault ratio(offender-victim) of campus road traffic accidents and whether safety rules are followed were not suggested in the records. However, safety rules were not found in the given data. This limited information leads to classification constraints. However, this study has determined

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the accident trends for 10 years of campus road traffic accidents using these data as minor cases were also recorded.

To our knowledge, this is the first study to present the fundamental characteristics of campus road traffic accidents and their related factors, including driver distraction as causal factor. Further, there were only a few studies that analyzed road traffic accidents. In particular, driver distraction mainly occurred when entering roads from "T" shaped road or street parking lot and in areas without traffic lights. Overall, to prevent road traffic accidents in the university, the driver should be cautious and yield in crossway, and nearby street parking lot is required. For crossways without traffic lights, previous study has suggested a standby lane after left turn to decrease the number of such accidents (Son et al., 2009).

For the required information of incident database in the future, accurate manual for classifying the causes of accidents is also necessary. To ensure accurate accident classification, a variety of information is required, such as driving experience (career), whether this is the first accident committed by the driver, and whether the driver pays attention on the road (including the front and sides of the car) to explain the accident well and to determine the possible cause. In addition, currently the specific injured parts of a victim's body and the severity of the injury during campus road traffic accidents are difficult to determine precisely. Hence, to classify disease code, more information is needed. As suggested in a previous study of Song, Kim, Choi, Chun & Lee (2018) on other types of university accidents, the classification of disease code

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should be based on the Korean Standard Classification of Disease and Cause of Death. It could also corresponded and applied to road traffic accidents in universities. Accidents may occur during working hours and days. Considering that the university campus is a living and working environment, accidents should be analyzed to ensure safety of its members. Currently, the unexpected break out of COVID-19 has affected the volume of traffic. Specifically, it increased the volume of bus traffic and taxi traffic from 12% to 32% and from 10% to 32%, respectively, compared with before the occurrence of COVID-19 (Jang et al., 2020). As taxis and buses have free access to the university areas, these areas can be considered a public road. Thus, the occurrence rates of accidents now and in the future may increase. Therefore, the university should also prepare for this case by controlling traffic in the main gate. In addition, owing to the commercializing of personal mobility (PM), many students have been started using PM on the university campus. However, the related regulations regarding speed or protective device are not available currently. As PM accidents have occurred in the university for 10 years, related regulations in the campus is necessary.

This study not only provides information regarding managing the safety of campuses but also provides accident data to protect members' health and safety as well as visitors.

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II-5. Conclusion

The trends of road traffic accidents for 10 years and its related factors, such as specific areas, driver distraction, and seasons, were analyzed. Further, the most severe places were determined using a map based on the number of victims and EPDO for 5 years.

We found that the total number of campus road accident cases was 680 for 10 years, and the incidence rate has decreased for the last 2 years. The major type of accidents was the car–car type, which mainly occurred in street parking lot. These accidents were mainly cause by driver distraction when the car enters the main road or passes straight to the street parking lot. To decrease the number of accidents in the crossway, being cautious when entering the road, yielding to the other person, and recognizing the accident red spots are necessary. Although the majority of offenders were visitors, as recently (2018–2019) the incidence rates by member offender have increased, transportation safety education is also required.

In the aspect of living and working environments, road traffic accidents should be prevented by analyzing past accidents to ensure health and safety for all the members of the campus.

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CHAPTER III.

Trend of campus laboratory accidents for 10 years and causal and temporal factors specifically semester-vacation as influencing factors

III-1. Introduction

With the occurrence of Sewol ferry accident in 2014, the importance of school safety has been raised (Han, 2014). As a variety of safety accidents occur in schools, it is vital to ensure that students acquire education in a safe environment (Han, 2014). According to a related study, "School safety accident means the events both inside and outside of school which occurred the result as an injury or death of students and staff" (Lee, 2012). However, currently universities are not covered by the Act on the Prevention of and Compensation Against Safety Accidents in Schools (MoE, 2019).

Safety accidents continue to occur in university campuses yearly. According to a survey from Korean Ministry of Education (MoE) in 2019, laboratory accidents have continuously increased from 134 cases in 2014 to 258 cases in 2018 (Lee, 2019). However, laboratory accidents in university campuses were not covered by laws. Owing to the frequency of laboratory accidents, the Act on the Establishment of Safe Laboratory Environment has been established in 2005 in Korea (Ministry of Science and ICT, 2020). With the establishment of the act, there have been increasing number of concerns; however situations of sites, such as university campuses, are not covered when conducting management processes and the occurrence of the laboratory accident was unabated (Inha University, 2017).

As these accidents might lead to injuries or threaten one's life, these safety accidents are closely related to public health. However, most studies on school safety accident

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analysis focused on mainly on primary, middle, and high schools in Korea. These studies have focused on cognition or safety education (Kim et al., 1999; Jung et al., 2000; Choi et al., 2016), whereas some previous studies were only on the analysis of actual data (Lee, 2012).

Universities have different features compared to these schools. According to a healthy campus-related study, " University campus is bigger than primary school, middle school and high school as its scale. And having a diverse age group and a style of living" (Yoo, 2009). Moreover, a university is a learning environment for students and an occupational environment for staff and faculty. The university campus could be decision factor that might affect the health and life of its members, including students, staff, and faculty (Dooris, 2006). Considering these dissimilar features, studies on safety accidents in university campuses are required.

In the field of prevention of accident and industrial safety, there is theory of Heinrich which is about an accident occurrence (Collins, 2011). This theory states that major injuries in one case are the result of minor injuries in 29 cases, and there are 300 cases of accidents without injury involved before 29 cases of minor injuries (Collins, 2011). According to a previous study, record of previous incidents increased the recognition of the risk involved in an accident (Kim, 2013). Therefore, every minor accident should be recorded and analyzes concretely to determine its causes to help prevent major accidents from happening (Lee et al., 2019).

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In an instance of road traffic accidents, determining their major causes is important to help decrease the number of accidents (Choi et al., 2014). According to a theory of accident causation, components of man and/or worker and environment and machine are closely related to possibility of accident occurrence, and they interact with each other (Chazireni, 2018). Previous studies revealed that the major causes of accidents are human factors, especially for major accidents (Dan et al., 2017; Hellman et al., 1986; Petersen, 1981; Skogdalen et al., 2011). Therefore, investigating human factors is also important in an accident analysis.

Meanwhile, season-related results have been reported that cause major university laboratory accidents that occurred in fall (Lee, 2012). However, its influence with seasons is difficult to determine. Therefore, to reflect characteristics of the university, rather than determining the seasonal influence, the influence of temporal factor specifically semester–vacation was considered in this study.

Studies related to accidents in university campuses were only limited globally. However, analysis on laboratory accidents is rare (Gopalaswami & Han, 2020; Hellman et al., 1986; Kim, 2013; Choi & Lee, 2012; Lee & Lee, 2012), but most of the laboratory accidents-related studies were generally about safety management during the occurrence of laboratory accidents (Gibson, Schröder, & Wayne, 2014). Real raw data and detailed data, including minor accidents, domestic and international, are limited owing to accessibility difficulties.

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Thus, this study aimed to explore the trend of campus laboratory accidents for 10 years and the causal factors, including human/machine/environment, and temporal factor specifically semester–vacation, which was explored as an influencing factor of campus laboratory accidents.

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III-2. Methods

III-2-1. Study design

One university in Seoul, Korea, was selected for this study considering that data can be acquired. Before obtaining the required data from the university, approval of Institutional Review Board (IRB) was obtained first to ensure protection of personal information.

Thereafter, the data of 199 cases of campus laboratory accidents were obtained from division of Institute of Environmental Protection & Safety. The temporal range was from 2010 to 2019, which is about 10 years.

The campus laboratory accidents were coded as parameters to be used for the statistical analysis considering the availability and accessibility of information (**Figure III-1**).

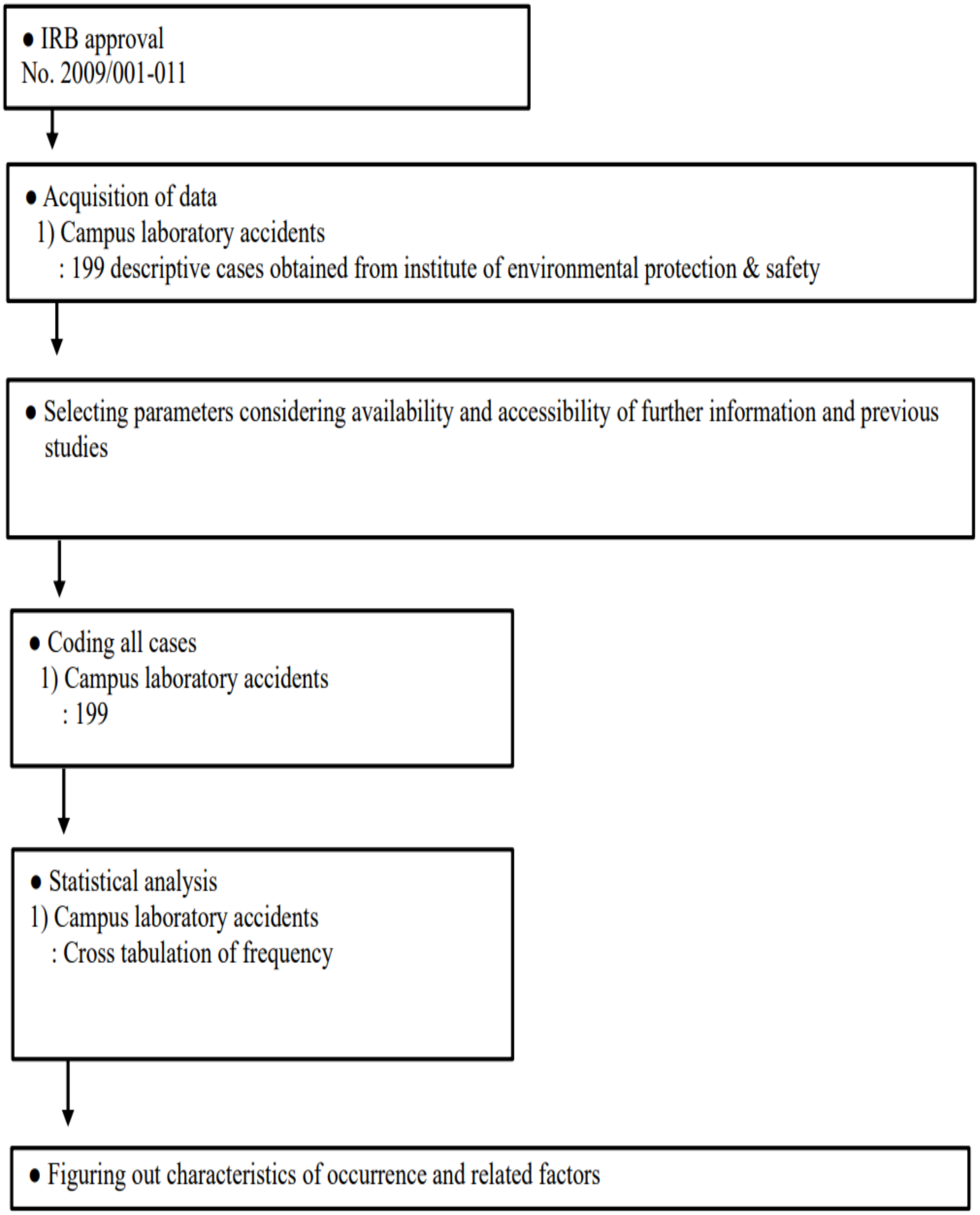

Figure III- 1. Diagram of the overall study design for campus laboratory accidents

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III-2-2. Selection of parameters and coding

The data form style from the university was a descriptive case style, and each case was recorded by the campus police. Given that the campus police does not have any investigational rights, information is limited, compared to the data from the National Police Agency. Further, some of cases were able to identify only part of the contents.

The parameters are coded, as presented in **Table III-1**. For the specific accident type, accident types in the manual of accident response established by the Korea National Research Safety Information System were used (Ministry of Science and ICT, 2014). The examples on their website were used as the basis to categorize cases into accident types.

The injured part cannot be categorized as disease code as mentioned in a previous study (Song et al., 2018) that also analyzed laboratory accidents from institutes and universities. Injury type was referred to the mentioned manual and other related studies (Ministry of Science and ICT, 2014; Park, 2016; Song et al., 2018). The cause of laboratory accidents was referred to a related study and its supplementary data, which were categorized into laboratory accident cases (Gopalaswami & Han, 2020).

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Table III- 1. Formation of coded parameters and its operational definition of campus laboratory accidents.

Coded parameters	Operational definition
Years	Occurred year : 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019
Victims	The number of victims. The person who inhaled hazardous vapor or gas was also regarded as victims.
Semester/Vacation	Semester included the 3,4,5,6,9,10,11,12. The vacation was 1,2,7,8.
Month	Occurred month : 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
Days of week	Occurred days of week. : Mon, Tues, Wed, Thurs, Fri, Sat, Sun
Time slot	Analyzed the occurred time as 1 hours unit.
Accident type	The type of laboratory accidents. : Chemical, gas, electricity, biology, machinery, the others
Specific accident type	The type of specific laboratory accidents : Leak/ contact of chemical substance, Fire and explosion of chemical, Combustible gas, Toxic gas, Non-combustible and non-toxic gas, Unknown, Electric shock, Fire from electricity, Leak of pathogenic substances, Bite from animal/ Injuries from needle, Pinch/ cut, Broken, Error in function, Fire, Burns/scalds, Wound/bleeding, Contact with harmful rays, Hurts of Musculoskeletal system
Damage extent	Damage included pain and damage of laboratory equipment. : Human + Property, Only human damage, Only property damage, No damage
Injury parts	This parameter included single part of injury : Eyes, Legs, Head, Foot, Hands, Shoulders, Face, Arms, Lung, Waist, Multiple parts, Unknown
Injury type	In injury type, inhalation of hazardous vapor or gas was also classified as inhalation : Injury/Bleeding, Burn/Scald, Infection, Inhalation, Musculoskeletal disease, Contact with hazardous rays, Unknown
Cause	This included the cause of the accidents. : Improper storage & handling, Equipment failure, Runaway reaction, Lack of training, Procedure violation, Lack of PPE, Careless, Unknown

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III-2-3. Statistical analysis

All the statistical analysis of this article was performed by using SPSS software v.26 (IBM Corp., USA). Thereafter, the basic frequency analysis of the number of incidents and victims were analyzed. In particular, the frequency analysis for the cross-tabulated laboratory accidents per semester and vacation was also performed.

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III-3. Results

III-3-1. General characteristics of campus laboratory accidents

The total cases of campus laboratory incidents were 199 cases for 10 years. However, when calculating only the incidence rate for these accidents, one laboratory case was excluded as it was a corporate laboratory, not university-associated laboratory because the university did not consider it as a laboratory. The total number of victims of campus laboratory incidents for 10 years were 86 persons. The yearly incidence rates are presented in the **Table III-2**. The incidence rates of 2019 (2.27%) has six times more than that of 2010 (0.37%). As starting point of 2014 (0.44%), the incidence rates started to increase until 2019 (2.27%). The last three years (i.e., 2017, 2018, and 2019) has the highest incidence rate for 10 years (**Table III-2**). The time trend on the number of cases and victims of lab accidents yearly is shown in **Figure A-4**. The severity controlled occurrence of accidents for 10 years is shown in **Figure A-5** using the EPDO method, which was used in **Chapter II**. The increasing and decreasing trend was almost similar except for 2013 and 2019. The frequency of cases was 14 for 2011, 11 for 2013, 54 for 2018, and 44 for 2019 (**Figure A-4**). However, it was different when severity was controlled. The EPDO values are 12 for 2011, 38 for 2013, 77 for 2018, and 82 for 2019 (**Figure A-5**). The yearly trend of the damage type is shown in **Figure A-6**.

Table III-3 presents the number of cases and victims for 10 years of

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semester–vacation, month, days of week, type, cause, college and lab, damage scale, injury type, and injured parts. The time slot per 1 hour is provided in **Table A-7.** The accident (139) cases and victims (69) in the semester was more than two times higher than those during vacation with 60 and 25, respectively. For the month, September has the highest frequency among the incident cases of 26. Among the days of week, Mondays have the highest with 52 cases. However, Fridays have the highest number of victims with 24 persons. For the type of accidents, chemical accidents have an overwhelming frequency with 106 cases. The number of victims of chemical accidents was also higher among the types with 27 persons to the next of type of the others. Meanwhile, equipment failure was the most frequent cause of incidents with 44 cases, followed by improper storage and handling and carelessness with 41 cases. For the category of college and laboratories, college of engineering has the highest frequency with 52 cases, followed by natural sciences (36), agriculture (30), medicine (22), and pharmacy (18). Conversely, the other labs or colleges have less than 10 cases. For the damage scale, human-only damage has the highest frequency with 71 cases, followed by property only (62), no damage (51), and human + property (15). For injury types, injury/bleeding (37) and burn/scald (27) have higher frequency. For injured part, hand (24) and face (8) were the commonly injured, except for multiple parts (14) or unknown (15) cases (**Table III-3**).

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Table III- 2. Incidence rates of laboratory accidents

Parameter	Year										Total
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	*N*(%)
The number of victims of laboratory yearly (*N*)	3 (3.2)	5 (5.3)	7 (7.4)	11 (11.7)	0 (0.0)	2 (2.1)	6 (6.4)	10 (10.6)	25 (26.6)	25 (26.6)	94(100.0)
The number of laboratory accidents yearly (*N*)	5 (2.5)	14 (6.6)	12 (6.1)	11 (5.6)	6 (3.0)	9 (4.6)	11 (5.6)	32[a] (16.2)	54 (27.4)	44 (22.3)	198(100.0)
The number of laboratory yearly[1] (*N*)	1,362	1,253	1,082	1,181	1,368	1,108	1,299	1,427	1,453	1,938	-*
Incident rate of laboratory accidents[2] (%)	0.37	1.04	1.11	0.93	0.44	0.81	0.85	2.24	3.72	2.27	-**

[a] The yearly lab accident of 2017 was totally 33 cases but 1 case was excluded when calculating incident rate of lab accidents because the case has occurred in corporate which located in the university. Yearly number of lab of 2017 also did not reflect the corporate laboratory.
[1] The yearly accessing car included entering cars from main gate and rear gate.
[2] The incident rate of lab accidents were calculated by the methods below.
(Yearly number of lab accident)/(Yearly number of lab in the university)*100

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Table III- 3. General characteristics of incident cases and victims of campus laboratory accidents via parameters

General characteristics		Frequency	
		Accidents(cases) *N*(%)	Victims(persons) *N*(%)
Total		199(100.0)	94(100.0)
Semester/ Vacation	Semester[6]	139(69.8)	69(73.4)
	Vacation	60(30.2)	25(26.6)
Month	1	13(6.5)	8(8.5)
	2	7(3.5)	2(2.1)
	3	19(9.5)	6(6.4)
	4	15(7.5)	15(16.0)
	5	11(5.5)	7(7.4)
	6	17(8.5)	9(9.6)
	7	17(8.5)	5(5.3)
	8	23(11.6)	10(10.6)
	9	26(13.1)	7(7.4)
	10	17(8.5)	8(8.5)
	11	20(10.1)	8(8.5)
	12	14(7.0)	9(9.6)
Days of week	Monday	52(26.1)	20(21.3)
	Tuesday	26(13.1)	11(11.7)
	Wednesday	34(17.1)	12(12.8)
	Thursday	36(18.1)	18(19.1)
	Friday	34(17.1)	24(25.5)
	Saturday	8(4.0)	4(4.3)
	Sunday	9(4.5)	5(5.3)
Type	Chemical	106(53.3)	27(28.7))
	Gas	15(7.5)	5(5.3)
	Electricity	13(6.5)	1(1.1)
	Biology	13(6.5)	19(20.2)
	Machinery	13(6.5)	5(5.3)
	The others	39(19.6)	37(39.4)
Cause	Improper storage& handling	41(20.6)	12(12.8)
	Equipment failure	44(22.1)	5(5.3)
	Runaway reaction	22(11.1)	9(9.6)
	Lack of training	6(3.0)	5(5.3)
	Procedure violation	4(2.0)	3(3.2)
	Lack of PPE[1]	11(5.5)	11(11.7)
	Careless	41(20.6)	41(43.6)
	Unknown	30(15.1)	8(8.5)
College & lab	Engineering	52(26.1)	17(18.1)

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	Natural science	36(18.1)	16(17.0)
	Agriculture	30(15.1)	10(10.6)
	Medicine	22(11.1)	19(20.2)
	Pharmacy	18(9.0)	4(4.3)
	Dentistry	8(4.0)	6(6.4)
	Veterinary medicine	7(3.5)	3(3.2)
	Human ecology	5(2.5)	1(1.1)
	Public health	3(1.5)	3(3.2)
	Fine arts	1(0.5)	7(7.4)
	Education	1(0.5)	1(1.1)
	Other laboratories[2]	15(7.5)	7(7.4)
	Not included in university	1(0.5)	0(0.0)
Damage scale	Human + property	16(8.0)	18(19.1)
	Human only[3]	70(35.2)	76(80.9)
	Property only[4]	65(32.7)	0(0.0)
	No damage	48(24.1)	0(0.0)
Injury type[5]	Injury/Bleeding	37(18.6)	37(39.4)
	Burn/Scald	27(13.6)	28(29.8)
	Musculoskeletal disease	9(4.5)	9(9.6)
	Inhalation	5(2.5)	5(5.3)
	Contact with harmful rays	2(1.0)	2(2.1)
	Infection	1(0.5)	1(1.1)
	Unknown	5(2.5)	12(12.8)
Injury parts[5]	Hands	24(12.1)	24(25.5)
	Face	8(4.0)	8(8.5)
	Waist	6(3.0)	6(6.4)
	Foot	6(3.0)	6(6.4)
	Arms	3(1.5)	3(3.2)
	Lung	3(1.5)	3(3.2)
	Legs	3(1.5)	3(3.2)
	Eyes	2(1.0)	2(2.1)
	Head	1(0.5)	1(1.1)
	Shoulders	1(0.5)	1(1.1)
	Multiple parts	14(7.0)	15(16.0)
	Unknown	15(7.5)	22(23.4)

[1] The PPE means Personal Protective Equipment.

[2] The other laboratories included national center for inter-university research facilities, inter-university semiconductor research center, research institute of advanced materials, automation and systems research institute, institute of advanced machines and design, institute of chemical processes.

[3] Only human damage included cases which the person got at least pain such as headache or pain from inhalation of chemical substances and if there was no property damage.

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[4] Only property damage included cases of damage of every property such as gas/ chemical container, floor stain.
[5] The cases with no injury were 113 cases(56.8%).
[6] Semester included the month of 3,4,5,6,9,10,11,12.

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III-3-2. Characteristics by causal factors

Table III-3 presents the causal factors including human, machine, and environment, as shown in **Table A-9**. A proportion of each causal factor had the highest incidence rate in human factors (60.9%), followed by machine (26.0%) and environment (13.0%). The environmental factor had the highest incidence rate in March (27.3%). Both human and machine factors had the highest incidence rate in September with 13.6% and 20.5%, respectively. Both of them had the highest incidence rate during Mondays with 29.1% and 27.3%, respectively. However, the environmental factor had the highest incidence rate during Fridays. For the accident type, all of the human, machine, and environmental factors had high incidence rate in chemical with 44.7%, 36.4%, and 95.5%, respectively. For college and laboratories, natural science (21.4%), engineering (18.4%), and medicine (18.4%) had higher incidence rate for the human factor. For machine and environmental factors, engineering had the highest incidence rate with 29.5% and 50.0%, respectively. For the injury type, injury/bleeding (44.3%) had the highest proportion for the human factor, and burn/scald (66.7%) had the highest proportion for environment. For the injured parts, hands (31.4%) were the highest incidence rate of human factor, and multiple parts (55.6%) were the highest incidence rate in the environmental factor.

As shown in **Table III-2**, the number of accidents has started to increase in

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2017. Thus, specific years, including 2015–2016 and 2018–2019, were analyzed additionally (**Table A-8**). Year divisions have the highest proportion of human factor among the total cases but decreased from 77.8% to 65.9%, and the environmental factor decreased from 11.1% to 9.8%. However, machine factor increased recently from 11.1% to 25.6%. The proportion of incidence increased in semester from 61.1% to 79.3%, and the incidence proportion in September increased from 5.6% to 18.3%. November has decreased from 22.2% to 6.1%. Mondays have the highest incidence rate in 2015–2016 (55.6%), but decreased to 19.5%, whereas Thursdays have increased from 11.1% to 20.7% and have the highest incidence rate in 2018–2019. There were no incidence on weekends in 2015–2016, but it was recorded in 2018–2019. For the type, both of year divisions had chemical as the main cause of accidents, but it has decreased from 55.6% to 40.2%. Engineering college has the highest incidence rate in 2015–2016 (44.4%), but it decreased to 15.9%. Meanwhile, medicine college has increased from 11.1% to 20.7% and has the highest incidence rate in 2018–2019. For the damage, human only has increased from 38.9% to 53.7% and has the highest incidence rate in 2018–2019. For the injury type, year division had injury/bleeding as the highest incidence rate, but it decreased from 50.0% to 44.9%. For the injured parts, hands have the highest incidence rate in both year division also, but it decreased from 37.5% to 32.7%.

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III-3-3. Characteristics by semester and vacation

The differences between semester and vacation is shown in **Tables III-4** and **III-5**. **Table III-4** presents the cross-tabulation of days of week and semester–vacation. Most of the days of week had tendency of occurring mainly in semester. However, Sundays have the same frequency for both vacation and semester with 4 cases. Similarly, Sunday has only one case of difference between vacation and semester. Hence, semester was a little higher with 1 case (**Table III-4**).

The differences between semester and vacation based on injury type are presented in **Table III-5**. Most injuries in semester, including injury/bleeding (29), burn/scald (18), inhalation (5), and musculoskeletal disease (7), were higher than those during vacation with 8, 9, 0, and 2 cases, respectively. However, infection (1) and unknown (3) injuries during vacation was higher than those in semester with 0 and 1 case, respectively. The frequency of contact with harmful rays (1) case in vacation was the same as that in semester.

Other parameters, such as cause, specific type, damage type, college type, and injured parts in vacation and semester, are shown in **Table A-10**. Most of the factors in each parameter had higher frequency in semester than during vacation.

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Table III- 4. Days of week by semester and vacation of campus laboratory accidents

Days of week	Monthly division		Total
	Vacation[1]	Semester[2]	
	N(%)	*N*(%)	*N*(%)
Monday	18(34.6)	34(65.4)	52(100.0)
Tuesday	7(26.9)	19(73.1)	26(100.0)
Wednesday	9(26.5)	25(73.5)	34(100.0)
Thursday	12(33.3)	24(66.7)	36(100.0)
Friday	6(17.6)	28(82.4)	34(100.0)
Saturday	4(50.0)	4(50.0)	8(100.0)
Sunday	4(44.4)	5(55.6)	9(100.0)
Total *N*(%)	60(30.2)	139(69.8)	199(100.0)

[1] Vacation included month of January, February, July, August.
[2] Semester included month of March, April, May, June, September, October, November, December.

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Table III- 5. Injury type by semester and vacation of campus laboratory accidents

Injury type	**Monthly division**		**Total**
	Vacation[1] *N*(%)	Semester[2] *N*(%)	*N*(%)
Injury/Bleeding	8(21.6)	29(78.4)	37(100.0)
Burn/Scald	9(33.3)	18(66.7)	27(100.0)
Infection	1(100.0)	0(0.0)	1(100.0)
Inhalation	0(0.0)	5(100.0)	5(100.0)
Musculoskeletal disease	2(22.2)	7(77.8)	9(100.0)
Contact with harmful rays	1(50.0)	1(50.0)	2(100.0)
Unknown	3(60.0)	2(40.0)	5(100.0)
Total *N*(%)	24(27.9)	62(72.1)	86(100.0) [a]

[1] Vacation included month of January, February, July, August.

[2] Semester included month of March, April, May, June, September, October, November, December.

[a] The total damage cases were 86 cases which were the sum of human damage(human + property damage and only human damage) among total cases.

III-4. Discussion

In this study, the occurrence trends of laboratory accidents in a university campus for 10 years and the related factors, causal factors (e.g., human, machine, and environment), and temporal factors specifically for semester and vacation of lab accidents were analyzed.

The first hypothesis was that the frequency rate would decrease as years pass when laboratory safety education is implemented. However, the number of cases per year increases as years pass. The second hypothesis was that human factors would have the highest incidence rate among the total cases as a causal factor. Through this study, the major causal factor was found to human factors. The third hypothesis was that all of the parameters would have higher incidence in semester than during vacation. However, on Saturdays, the incidence frequency of both semester and vacation are equal, as well as the contact with harmful rays of injury type.

For the methodology, most previous studies (Song, Kim, Choi, Chun, & Lee, 2018; Gopalaswami & Han, 2020) that used real accident cases analyzed the general frequency of causes, injury parts, and so on. However, the severity of cases per year was not considered. In this study, the EPDO method, which had been used in the field of transportation safety, was utilized to reflect the severity. However, the weighted values were used for car accidents; hence, the weighted values for laboratory accidents should be developed in the future.

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This study found that the trends of laboratory accidents are increasing based on year 2017 (32, 16.2%). The incidence rates in 2015 and 2016 were 9 (4.6%) and 11 (5.6%), respectively, whereas the incidence rates in 2018 and 2019 were 54 (27.4%) and 44 (22.3%), respectively. The comparison of the year division 2015–2016 and 2018–2019 via causal factors except for unknown causes is shown in **Table A-8**. However, the specific reason for the sharp increase could not be concluded through this study. It could be judged that these findings are related to the increased cognition of safety due to continuous laboratory safety education and reporting the accidents despite its small cases. However, victims in 2018 (25) and 2019 (25) also increased.

For the aim of figuring out the characteristics of frequency, chemical accidents were over the half of total accident type. For the cause of accidents, equipment failure was the highest (22.1%), followed by improper storage and handling (20.6%) and carelessness (20.6%). However, a previous study reported that improper storage and handling was 40%, followed by equipment failure (14%) and runaway reaction (12%) (Gopalaswami & Han, 2020). For the injured parts, hands (12.1%) were the most frequently injured parts, followed by face (4.0) and waist (3.0). the injured part was compared to a previous study of Song, Kim, Choi, Chun, & Lee (2018) that reported that skin was the frequently injured parts (7%), followed by face and hands (5%), face (5%), and lungs (5%) (**Table III-3**).

Further, this study has found that the major causal factor for laboratory

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accidents for 10 years was human factor with 60.9% (**Table A-9**). Despite the decrease in the incidence proportion of human factor in 2015–2016 (77.8%) to 65.9% in 2018–2019, it remained the highest incidence rate among the causal factors in 2018–2019 (**Table A-8**). As the incidence proportion was the highest in September (14, 13.6%), it is interpreted as affection of freshman in graduate school who started to use laboratory a moment ago. Moreover, Mondays (30, 29.1%) have the highest incidence rate for laboratory accidents. The percentage of Mondays through the total causal factors was 52 for cases and 26.1% for victims (**Table III-3**). This result was similar to that of a previous study that had investigated the chemical accident cases at specific places in Korea (Lee, Jo, Park, Heo, & Im, 2019).

For semester and vacation factors, this study found that most of the lab accidents have occurred in semester. However, the occurrence frequency during Saturdays was same for both factors with 5 cases. For the injury type factor, contact with harmful rays was same for semester and vacation factors with 1 case, and infection had occurred only in vacation with 1 case, but it is not noticeable as this was only one case.

There are several limitations of this study. First, cognitive factors were not surveyed in this study. Psychological aspects could often be the cause of incidents (Gopalaswami & Han, 2020). Hence, a collaboration study on real data analysis and psychological analysis is required in the future to explain this phenomenon. Second, the descriptive raw data were recorded by staff. Hence,

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there might be subjective judgment involved. Third, classifying each case that causes laboratory accidents was difficult as the safety rules and work periods of campus laboratory accidents were not available in the given data. This limited information leads to classification constraints Fourth, the number and variety of chemical substances were not considered in this study owing to data uniaxiality as the gathered data were only from 2020. However, this study has determined the accident trends for 10 years of laboratory accidents by using only data wherein minor cases were also recorded. This suggests a methodology by using the severity method and by analyzing both causal factors and semester and vacation factors.

To our knowledge, this is a first study to present the fundamental characteristics of campus laboratory accidents and related factors, including human, machine, and environment as the causal factors and semester as a related factor. Moreover, there were only few previous studies that analyzed the campus laboratory accidents by using real raw incident cases. With the increasing diversifications of substances in a laboratory, the laboratory should be managed systematically.

For the required information of incident database in the future, accurate manual classification of causes of accidents is also required. To perform accurate classification, a variety of information is required, such as work period, to provide sufficient explanation about the accident. Currently, determining the injured parts of a victim's body due to laboratory accidents is challenging;

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Hence, for the classification of the injured parts, more information is required, and a previous study suggested to use the Korean standard classification of disease and cause of death (Song et al., 2018). Further, accidents may occur during working hours or days. Considering that the university campus is a living environment and working environment, accidents should be evaluated to ensure health and safety of campus members.

Currently, the unexpected break out of COVID-19 has affected young scientists. Specifically, wearing dust or general mask is mandatory. Hence, wearing gas mask could protect one's health from gas substances or organic compounds. In reality, according to a previous study that investigated wearing respirator in university laboratories, the percentage of objective labs had higher proportion (35.7%) for organic compounds and for gas (18.9%) as treating substances (Kang, 2019). Prior to the spread of COVID-19, the percentages of misuse of dust mask and general mask, instead of wearing gas mask, were 35.5% and 38.6%, respectively (Kang, 2019). Therefore, methods for choosing an appropriate mask and wearing mask should be supplemented as a safety education. This study not only provides information regarding managing the safety of campuses but also provides accident data to protect the health and safety of its members as well as visitors.

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III-5. Conclusion

The trends of laboratory accidents for 10 years and the causal factors (i.e., human, machine, environment) and related factors of semester were analyzed.

We found that the total number of campus laboratory accidents is was 199 case for 10 years and the incidence rate has increased for last 3 years. Further, the major type of accidents was chemical accidents, which mostly occurred in the college of engineering, and the main cause is equipment failure. Majority of injury type was injury/bleeding, and injury of the hand was high. Human factor was the major causal factor. Among human factors, hand injury, Mondays, chemical, and September had the highest incidence rates. Hence, regular inspection of machine and being cautious during Mondays should be the practice to prevent laboratory accidents.

The university campus comprises various members, including student, staff, and faculty. Recognizing the importance of the campus as a living environment and a working environment, these accidents should be minimized by analyzing the data of past accidents to protect health and ensure safety of the campus members.

CHAPTER IV.

Summary

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The university campus safety accidents were one of the worst incidents occurred in a campus, which is not only an educational environment but also a working environment. This study used real descriptive campus road traffic accident and campus laboratory accident cases that had occurred in the university campus for 10 years. This study aimed to identify the trend of campus road traffic accidents for 10 years and specific areas, driver distraction, and seasons as influencing factors and to identify the trend of campus laboratory accidents for 10 years and the causal factors (i.e., human, machine, and environment) and temporal factor (specifically semester–vacation as influencing factors).

First, the general characteristics of parameters and the specific areas, including street parking lot, parking lot, and others and driver distraction and seasonal factors were evaluated. The trends of incidence had a sharp decrease in 2018, and these incidence rates has decreased continuously. For specific areas, others (i.e., roads) had the highest incidence rate (69.1%) for 10 years. They have decreased in frequency from 68.0% in 2016–2017 to 67.6% in 2018–2019, but increased in the number of victims from 68.0% to 76.9%. The incidence rate in fall (30.4%) was the highest in 2016–2017, but it decreased. Meanwhile, winter (33.3%) has the highest incidence rate in 2018–2019. Further, the highest incidence rate in 2016–2017 was Wednesdays (22.8%), and it had changed to Mondays (20.4%) in 2018–2019. Visitor offenders have the highest incidence rate in 2016–2017 (55.6%), but it slightly decreased to 52.8%, whereas member offenders increased to 42.6%. For the spatial distribution,

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crosswalk, crossway, bus station, and gates were the most severe. Driver distraction had the highest percentage (59.1%) among the causal factors. There has been significant differences between driver distraction and other factors on the type of accident ($p < .001$), accident place ($p < .01$), offender type ($p < .001$), and years ($p < .01$). For the seasons, there has been differences between seasons on accident places ($p < .05$). Road traffic accidents were more likely to occur continuously in winter ($p < .001$).

Second, the general characteristics of parameters and the causal factors (human, machine, and environment) and temporal factors as semester and vacation were analyzed. The trends of incidence had a sharp increase in 2018. The incidence rates in in September, during Mondays, and chemical accidents were higher in 2018–2019 than in 2015–2016. The human factors had the highest incidence rate among the causal factors. Most of accidents occurred in semester. However, the incidence rate on Saturdays and the injury type of contact with harmful rays were equal for semester and vacation.

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APPENDICES

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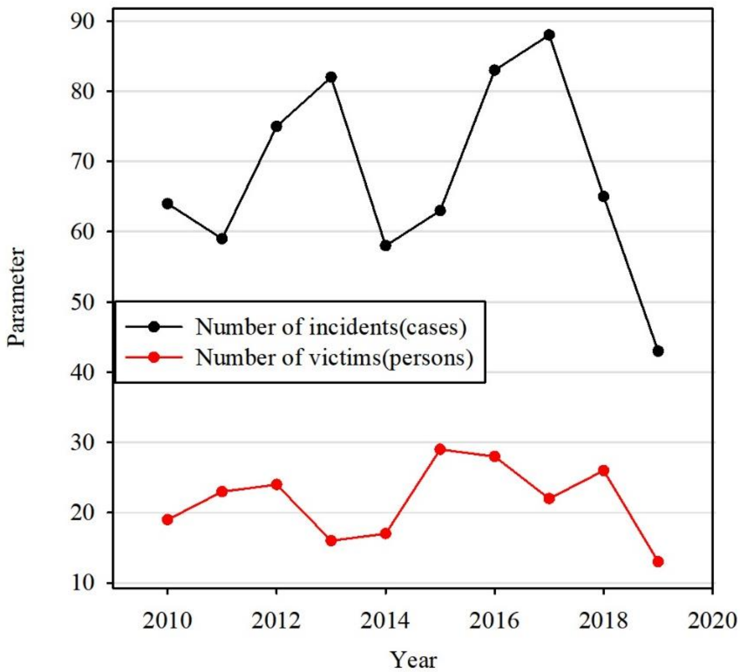

(Reformulation of the format of a figure in (Road Traffic Authority, 2020) 21p with campus road traffic accident data)

Figure A-1. Number of campus road traffic accidents and victims by year

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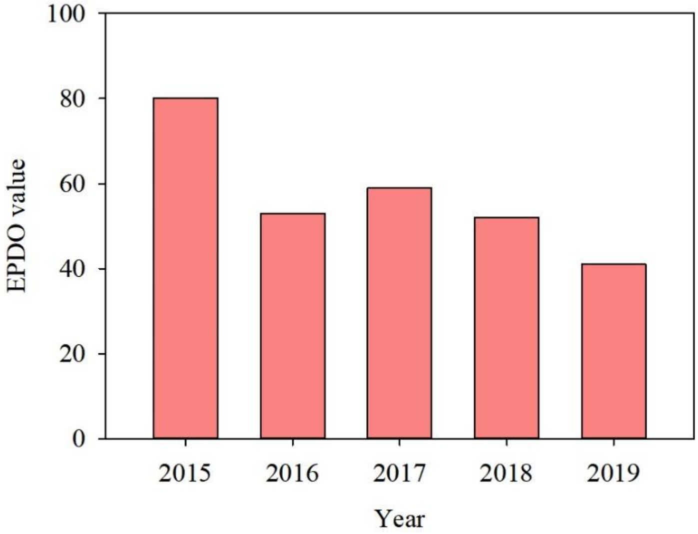

Figure A-2. Severity controlled trend of campus road traffic accidents for 5 years (2015 - 2019) via over 90% of total EPDO values of each cases

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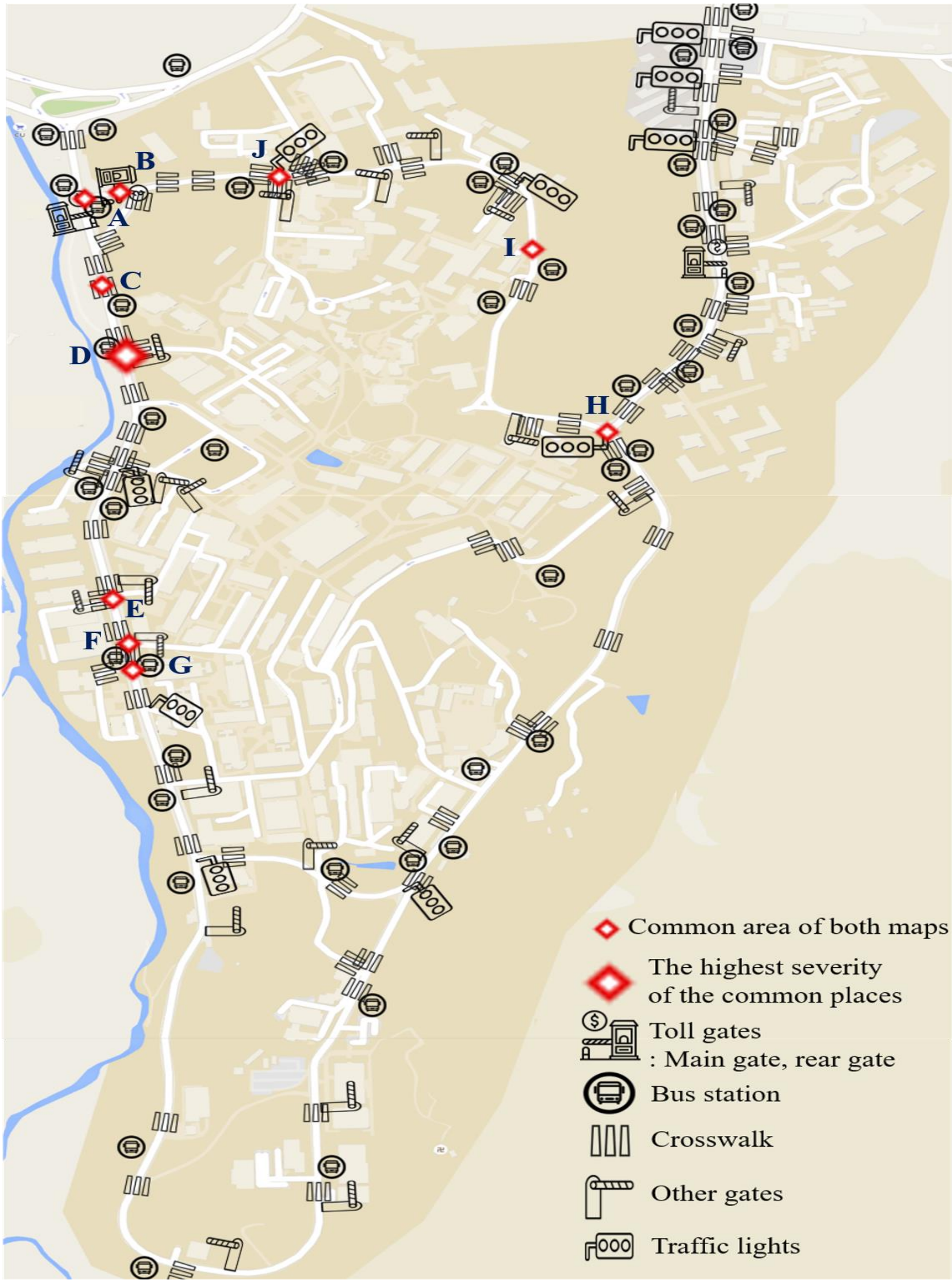

Figure A-3. Spatial distribution of common 10 places between counts of victims and EPDO

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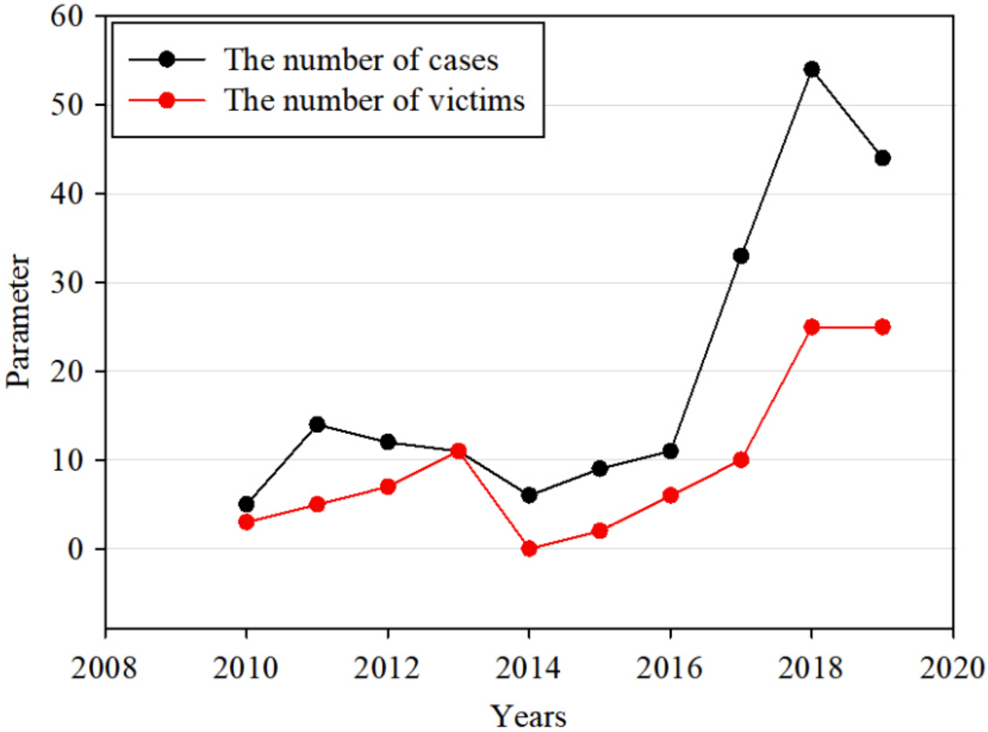

(Reformulation of the format of a figure in (Road Traffic Authority, 2020) 21p with campus laboratory accident data)

Figure A-4. Number of campus laboratory accidents and victims by year

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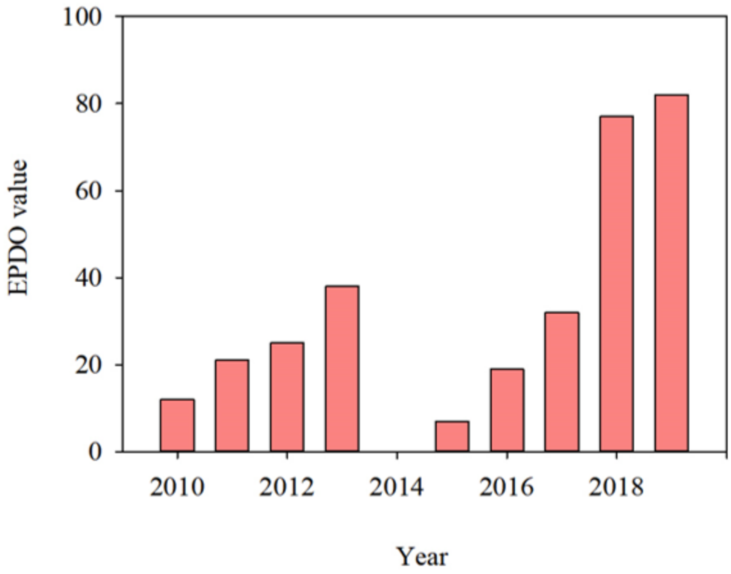

Figure A-5. Severity controlled trend of campus laboratory accidents for 10 years (2010 - 2019) via over 60% of total EPDO values of each cases

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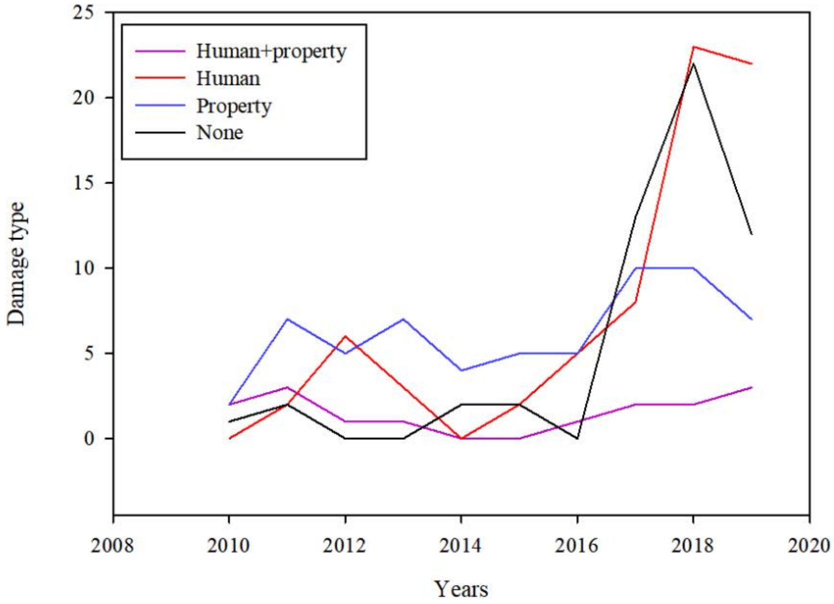

Figure A-6. Time trends of damages extent of campus laboratory accidents for 10 years

Table A-1. Monthly incidence rates of car accidents for 4 years

Parameter	Month											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Monthly accidents[1] in 2010 (*N*)	1	1	7	5	4	3	5	4	5	13	5	11
Monthly entering cars[2] in 2010 (*N*)	168293	127059	160875	168543	177649	162965	155349	160100	168197	185094	176368	166654
Monthly incident rate[3] in 2010 (%)	0.0006	0.0008	0.0044	0.0030	0.0023	0.0018	0.0032	0.0025	0.0030	0.0070	0.0028	0.0066
Monthly accidents in 2017 (*N*)	-*	-	6	6	8	6	7	3	13	9	11	7
Monthly entering cars in 2017 (*N*)	-	-	408953	398194	401144	373075	338999	340680	395428	355213	386037	350990
Monthly incident rate in 2017 (%)	-	-	0.0015	0.0015	0.0020	0.0016	0.0021	0.0009	0.0033	0.0025	0.0028	0.0020
Monthly accidents in 2018 (*N*)	5	8	7	9	6	6	4	4	3	4	2	7
Monthly entering cars	310975	274154	390094	390025	400214	358149	341306	325986	339438	399731	394662	339045

in 2018 (*N*)												
Monthly incident rate in 2018 (%)	0.0016	0.0029	0.0018	0.0023	0.0015	0.0017	0.0012	0.0012	0.0009	0.0010	0.0005	0.0021
Monthly accidents in 2019 (*N*)	9	4	4	4	4	3	2	2	2	5	1	3
Monthly entering cars in 2019 (*N*)	326810	263780	375013	389997	385300	343896	338282	322726	352345	385365	381091	337075
Monthly incident rate in 2019 (%)	0.0028	0.0015	0.0011	0.0010	0.0010	0.0009	0.0006	0.0006	0.0006	0.0013	0.0003	0.0009

[1] The monthly accidents included the number of accidents in each year monthly.
[2] The monthly entering cars included the number of cars which enters through main gate and rear gate of the university campus
[3] The monthly incident rate included the incident rate by month via each year.
[*] The bar included unknown data which did not exist in the university as time goes on.

Table A- 2. Counts of days by weather for 10 years

Weather	Counts of days by weather for 10 years *N*(%)
Yellow dust	21(0.6)
Cloudy/hazy	1156(31.7)
Rainy	1158(31.7)
Snowy	266(7.3)
Clear	1051(28.8)
Total	3652(100.0)

Table A-3. Total frequency of road traffic accident in a campus determined via accident type and its detailed type for 10 years

Accident type	Parameters		
	Detailed type	**The number of cases** *N*(%)	**The number of victims** *N*(%)
Car[1] - Person[2]	Crosswalk	20(2.9)	22(10.1)
	Roadway	9(1.3)	6(2.8)
	Edge of road	1(0.1)	0(0.0)
	Unknown area	14(2.0)	15(6.9)
	Not collision[3]	1(0.1)	0(0.0)
	Subtotal	45(6.6)	43(19.8)
Car-Car	Head on collision	4(0.6)	6(2.8)
	Broadside collision	199(29.1)	71(32.7)
	Rear-end collision	57(8.3)	19(8.8)
	Rear-end collision of backward state	19(2.8)	1(0.5)
	Unknown collision	27(3.9)	11(5.1)
	Not collision[3]	13(1.9)	6(2.8)
	Subtotal	319(46.6)	114(52.5)
Car only	Structure/building collision	118(17.2)	5(2.3)
	Deviate from road	23(3.4)	2(0.9)
	Collision with parked/stopped car	134(19.6)	17(7.8)
	Roll – Over	36(5.3)	36(16.6)
	Others[4]	5(0.7)	0(0.0)
	Subtotal	316(46.1)	60(27.6)
Unknown[5]		5(0.7)	0(0.0)
Total		685(100.0)	217(100.0)

[1] Car included car, motorcycle, bicycle, personal mobility.
[2] Person included pedestrian and a person in a wheelchair.
[3] Not collision included not collided but damaged case.
[4] Others included both cases which damaged someone's belongings and waiting on the road due to breakdown.
[5] Unknown included cases with insufficiency of information and cases which facility such as tree damaged cars or fell down of cars by itself.

Table A-4. General characteristics of road traffic accidents via specific years

		2016~2017						Total		2018~2019						Total	
		Street parking lot(outside)		Parking lot(inside)		The others (roads)				Street parking lot(outside)		Parking lot(inside)		The others (roads)			
General characteristics		Cases *N*(%)	Victims *N*(%)	Cases *N*(%)	Victims *N*(%)	Cases *N*(%)	Victims *N*(%)	Case *N*	Victim *N*	Cases N(%)	Victims N(%)	Cases N(%)	Victims N(%)	Cases N(%)	Victims N(%)	Case *N*	Victim *N*
Total		41 (100.0)	15 (100.0)	10 (100.0)	1 (100.0)	120 (100.0)	34 (100.0)	171 (100.0)	50 (100.0)	26 (100.0)	9 (100.0)	9 (100.0)	0 (100.0)	73 (100.0)	30 (100.0)	108 (100.0)	39 (100.0)
		(24.0)	(30.0)	(5.8)	(2.0)	(70.2)	(68.0)	(100.0)	(100.0)	(24.1)	(23.1)	(8.3)	(0.0)	(67.6)	(76.9)	(100.0)	(100.0)
Month	1	2(4.9)	2(13.3)	0(0.0)	0(0.0)	12(10.0)	1(2.9)	14 (8.2)	3(6.0)	4(15.4)	2(22.2)	3(33.3)	0(0.0)	7(9.6)	0(0.0)	14(13.0)	2(5.1)
	2	1(2.4)	1(6.7)	0(0.0)	0(0.0)	7(5.8)	2(5.9)	8 (4.7)	3(6.0)	1(3.8)	0(0.0)	0(0.0)	0(0.0)	11(15.1)	4(13.3)	12(11.1)	4(10.3)
	3	4(9.8)	4(26.7)	0(0.0)	0(0.0)	11(9.2)	3(8.8)	15 (8.8)	7(14.0)	2(7.7)	1(11.1)	1(11.1)	0(0.0)	8(11.0)	4(13.3)	11(10.2)	5(12.8)
	4	2(4.9)	1(6.7)	0(0.0)	0(0.0)	9(7.5)	5(14.7)	11 (6.4)	6(12.0)	2(7.7)	0(0.0)	2(22.2)	0(0.0)	9(12.3)	5(16.7)	13(12.0)	5(12.8)
	5	6(14.6)	2(13.3)	2(20.0)	0(0.0)	11(9.2)	3(8.8)	19(11.1)	5(10.0)	2(7.7)	0(0.0)	2(22.2)	0(0.0)	6(8.2)	3(10.0)	10(9.3)	3(7.7)
	6	5(15.2)	1(2.4)	2(20.0)	0(0.0)	9(7.5)	3(8.8)	16 (9.4)	4(8.0)	2(7.7)	1(11.1)	1(11.1)	0(0.0)	6(8.2)	0(0.0)	9(8.3)	1(2.6)
	7	5(15.2)	1(2.4)	0(0.0)	0(0.0)	8(6.7)	4(11.8)	13 (7.6)	5(10.0)	4(15.4)	1(11.1)	0(0.0)	0(0.0)	2(2.7)	2(6.7)	6(5.6)	3(7.7)
	8	4(9.8)	1(2.4)	1(10.0)	0(0.0)	3(2.5)	0(0.0)	8(4.	1(2.	2(7.7)	2(22.2)	0(0.0)	0(0.0)	4(5.5)	0(0.0)	6(5.	2(5.

								7)	0)							6)	1)
	9	1(2.4)	0(0.0)	0(0.0)	0(0.0)	18(15.0)	8(23.5)	19(11.1)	8(16.0)	3(11.5)	1(11.1)	0(0.0)	0(0.0)	2(2.7)	1(3.3)	5(4.6)	2(5.1)
	10	4(9.8)	0(0.0)	2(20.0)	0(0.0)	10(8.3)	1(2.9)	16(9.4)	1(2.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	9(12.3)	6(20.0)	9(8.3)	6(15.4)
	11	4(9.8)	2(1.3)	3(30.0)	1(100.0)	10(8.3)	1(2.9)	17(9.9)	4(8.0)	2(7.7)	1(11.1)	0(0.0)	0(0.0)	1(1.4)	1(3.3)	3(2.8)	2(5.1)
	12	3(7.3)	0(0.0)	0(0.0)	0(0.0)	12(10.0)	3(8.8)	15(8.8)	3(6.0)	2(7.7)	0(0.0)	0(0.0)	0(0.0)	8(11.0)	4(13.3)	10(9.3)	4(10.3)
Season	Spring 3,4,5	12 (29.3)	7(46.7)	2(20.0)	0(0.0)	31(25.8)	11(32.4)	45(26.3)	18(36.0)	6(23.1)	1(11.1)	5(55.6)	0(0.0)	23(31.5)	12(40.0)	34(31.5)	13(33.3)
	Summer 6,7,8	14 (34.1)	3(20.0)	3(30.0)	0(0.0)	20(16.7)	7(20.6)	37(21.6)	10(20.0)	8(30.8)	4(44.4)	1(11.1)	0(0.0)	12(16.4)	2(6.7)	21(19.4)	6(15.4)
	Fall 9,10,11	9(22.0)	2(13.3)	5(50.0)	1(100.0)	38(31.7)	10(29.4)	52(30.4)	13(26.0)	5(19.2)	2(22.2)	0(0.0)	0(0.0)	12(16.4)	8(26.7)	17(15.7)	10(25.6)
	Winter 12,1,2	6 (14.6)	3(20.0)	0(0.0)	0(0.0)	31(25.8)	6(17.6)	37(21.6)	9(18.0)	7(26.9)	2(22.2)	3(33.3)	0(0.0)	26(35.6)	8(26.7)	36(33.3)	10(25.6)
Days of week	Mon	10(24.4)	6(40.0)	2(20.0)	0(0.0)	18(15.0)	4(11.8)	30(17.5)	10(20.0)	6(23.1)	1(11.1)	2(22.2)	0(0.0)	14(19.2)	10(33.3)	22(20.4)	11(28.2)
	Tues	5(12.2)	0(0.0)	1(10.0)	0(0.0)	17(14.2)	6(17.6)	23(13.5)	6(12.0)	2(7.7)	0(0.0)	0(0.0)	0(0.0)	18(24.7)	7(23.3)	20(18.5)	7(17.9)
	Wed	10(24.4)	4(26.7)	1(10.0)	0(0.0)	28(23.3)	9(26.5)	39(22.8)	13(26.0)	4(15.4)	0(0.0)	0(0.0)	0(0.0)	13(17.8)	2(6.7)	17(15.7)	2(5.1)
	Thurs	8(19.5)	4(26.7)	3(30.0)	0(0.0)	21(17.5)	4(11.8)	32(18.7)	8(16.0)	5(19.2)	3(33.3)	4(44.4)	0(0.0)	12(16.4)	5(16.7)	21(19.4)	8(20.5)
	Fri	4(9.8)	1(6.7)	0(0.0)	0(0.0)	27(22.5)	8(23.5)	31(18.1)	9(18.0)	3(11.5)	2(22.2)	0(0.0)	0(0.0)	8(11.0)	4(13.3)	11(10.2)	6(15.4)
	Sat	3(7.3)	0(0.0)	2(20.0)	1(100.0)	6(5.0)	3(8.8)	11(6.4)	4(8.0)	3(11.5)	2(22.2)	2(22.2)	0(0.0)	4(5.5)	0(0.0)	9(8.3)	2(5.1)
	Sun	1(2.4)	0(0.0)	1(10.0)	0(0.0)	3(2.5)	0(0.0)	5(2.9)	0(0.0)	3(11.5)	1(11.1)	1(11.1)	0(0.0)	4(5.5)	2(6.7)	8(7.4)	3(7.7)

Weather	Yellow dust	3(7.3)	1(6.7)	0(0.0)	0(0.0)	1(0.8)	1(2.9)	4 (2.3)	2(4.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(1.4)	0(0.0)	1 (0.9)	0 (0.0)
	Cloudy /hazy	13(31.7)	4(26.7)	4(40.0)	1(100.0)	38(31.7)	11(32.4)	55(32.2)	16(32.0)	9(34.6)	3(33.3)	1(11.1)	0(0.0)	24(32.9)	8(26.7)	34(31.5)	11(28.2)
	Rainy	17(41.5)	7(46.7)	3(30.0)	0(0.0)	28(23.3)	14(41.2)	48(28.1)	21(42.0)	5(19.2)	3(33.3)	3(33.3)	0(0.0)	16(21.9)	6(20.0)	24(22.2)	9(23.1)
	Snowy	3(7.3)	1(6.7)	0(0.0)	0(0.0)	17(14.2)	4(11.8)	20(11.7)	5(10.0)	4(15.4)	2(22.2)	1(11.1)	0(0.0)	11(15.1)	5(16.7)	16(14.8)	7(17.9)
	Clear	5(12.2)	2(13.3)	3(30.0)	0(0.0)	36(30.0)	4(11.8)	44(25.7)	6(12.0)	8(30.8)	1(11.1)	4(44.4)	0(0.0)	21(28.8)	11(36.7)	33(30.6)	12(30.8)
Type [1]	Car-car	14 (34.1)	9(60.0)	3(30.0)	0(0.0)	56(46.7)	12(35.3)	73(42.7)	21(42.0)	11(42.3)	6(66.7)	1(11.1)	0(0.0)	44(60.3)	15(50.0)	56(51.9)	21(53.8)
	Car-person	1(2.4)	1(6.7)	0(0.0)	0(0.0)	8(6.7)	7(20.6)	9 (5.3)	8(16.0)	1(3.8)	1(11.1)	0(0.0)	0(0.0)	5(6.8)	5(16.7)	6(5.6)	6(15.4)
	Car only	26 (63.4)	5(33.3)	7(70.0)	1(100.0)	56(46.7)	15(44.1)	89(52.0)	21(42.0)	14(53.8)	2(22.2)	8(88.9)	0(0.0)	24(32.9)	10(33.3)	46(42.6)	12(30.8)
Offender	Visitors	22(53.7)	9(60.0)	3(30.0)	0(0.0)	70(58.3)	18(52.9)	95(55.6)	27(54.0)	10(38.5)	1(11.1)	2(22.2)	0(0.0)	45(61.6)	18(60.0)	57(52.8)	19(48.7)
	Members	16(39.0)	6(40.0)	5(50.0)	1(100.0)	36(30.0)	13(38.2)	57(33.3)	20(40.0)	15(57.7)	8(88.9)	5(55.6)	0(0.0)	26(35.6)	12(40.0)	46(42.6)	20(51.3)
	Hit and run	1(2.4)	0(0.0)	1(10.0)	0(0.0)	4(3.3)	0(0.0)	6 (3.5)	0(0.0)	1(3.8)	0(0.0)	1(11.1)	0(0.0)	2(2.7)	0(0.0)	4(3.7)	0(0.0)
	Unable to distinguish	2(4.9)	0(0.0)	1(10.0)	0(0.0)	10(8.3)	3(8.8)	13 (7.6)	3(6.0)	0(0.0)	0(0.0)	1(11.1)	0(0.0)	0(0.0)	0(0.0)	1(0.9)	0(0.0)
Traffic lights	With traffic lights	3(7.3)	4(26.7)	0(0.0)	0(0.0)	16(13.3)	6(17.6)	19 (11.1)	10(20.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	9(12.3)	7(23.3)	9 (8.3)	7 (17.9)
	No traffic	38(92.7)	11(73.3)	10(100.0)	1(100.0)	104(86.7)	28(82.4)	152 (88.	40(80.0)	26(100.0)	9(100.0)	9(100.0)	0(0.0)	64(87.7)	23(76.7)	99 (91.	32 (82.

	lights							9)								7)	1)
Cause	Driver distraction	23(56.1)	7(46.7)	3(30.0)	0(0.0)	78(65.0)	20(58.8)	104 (60.8)	27 (54.0)	16(61.5)	6(66.7)	2(22.2)	0(0.0)	53(72.6)	21(70.0)	71 (65.7)	27 (69.2)
	Inexperienced driver/ Driver inattention	5(12.2)	2(13.3)	4(40.0)	0(0.0)	3(2.5)	0(0.0)	12 (7.0)	2 (4.0)	1(3.8)	0(0.0)	4(44.4)	0(0.0)	3(4.1)	1(3.3)	8 (7.4)	1 (2.6)
	Speeding	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0 (0.0)	0 (0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(1.4)	1(3.3)	1(0.9)	1(2.6)
	Drunk driving	1(2.4)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1 (0.6)	0 (0.0)	1(3.8)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(0.9)	0(0.0)
	Faulty passing	2(4.9)	3(20.0)	0(0.0)	0(0.0)	1(0.8)	0(0.0)	3 (1.8)	3 (6.0)	1(3.8)	1(11.1)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(0.9)	1(2.6)
	Failure to maintain safe distance	3(7.3)	2(13.3)	0(0.0)	0(0.0)	3(2.5)	1(2.9)	6 (3.5)	3 (6.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	3(4.1)	1(3.3)	3(2.8)	1(2.6)
	Jaywalking	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0 (0.0)	0 (0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(1.4)	1(3.3)	1(0.9)	1(2.6)
	Specifically unknown case among personal factor	0(0.0)	0(0.0)	0(0.0)	0(0.0)	6(5.0)	3(8.8)	6 (3.5)	3 (6.0)	1(3.8)	0(0.0)	1(11.1)	0(0.0)	3(4.1)	2(6.7)	5(4.6)	2(5.1)
	Condition of road	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(0.8)	1(2.9)	1 (0.6)	1 (2.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0 (0.0)	0 (0.0)

Error of gate barrier	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0 (0.0)	0 (0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0 (0.0)	0 (0.0)
Invasion of animal	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0 (0.0)	0 (0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0 (0.0)	0 (0.0)
Broken facilities	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(0.8)	0(0.0)	1 (0.6)	0 (0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0 (0.0)	0 (0.0)
Defect of brake	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2(1.7)	3(8.8)	2 (1.2)	3 (6.0)	1(3.8)	1(11.1)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1 (0.9)	1 (2.6)
Sudden unintended acceleration	0(0.0)	0(0.0)	1(10.0)	1(100.0)	0(0.0)	0(0.0)	1 (0.6)	1 (2.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0 (0.0)	0 (0.0)
Defect of tires	1(2.4)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1 (0.6)	0 (0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0 (0.0)	0 (0.0)
Complex factors	2(4.9)	1(6.7)	0(0.0)	0(0.0)	13(10.8)	4(11.8)	15 (8.8)	5 (10.0)	4(15.4)	1(11.1)	1(11.1)	0(0.0)	9(12.3)	3(10.0)	14 (13.0)	4 (10.3)
Unknown	4(9.8)	0(0.0)	2(20.0)	0(0.0)	12(10.0)	2(5.9)	18 (10.5)	2 (4.0)	1(3.8)	0(0.0)	1(11.1)	0(0.0)	0(0.0)	0(0.0)	2 (1.9)	0 (0.0)

[1] In type of accidents, 5 unknown cases were excluded in this study due to lack of information(2) or crushes caused by facility fracture(2) or crushed caused by natural wind(1). The specific factors in type of accidents were presented in appendices table A-5.

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Table A-5. General characteristics of road traffic accidents for 10 years via spots

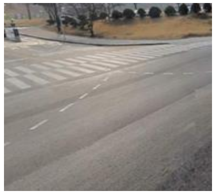
General characteristics	Specific spots	Street parking lot(outside)		Parking lot(inside)		The others(roads)	
		Accidents cases N(%)	**Victims** N(%)	**Accidents cases** N(%)	**Victims** N(%)	**Accidents cases** N(%)	**Victims** N(%)
Total		167(100.0) (24.6)	53(100.0) (24.4)	43(100.0) (6.3)	1(100.0) (0.5)	470(100.0) (69.1)	163(100.0) (75.1)
Month	1	11(6.6)	5(9.4)	6(14.0)	0(0.0)	42(8.9)	7(4.3)
	2	3(1.8)	2(3.8)	0(0.0)	0(0.0)	33(7.0)	10(6.1)
	3	15(9.0)	9(17.0)	2(4.7)	0(0.0)	38(8.1)	14(8.6)
	4	14(8.4)	3(5.7)	2(4.7)	0(0.0)	45(9.6)	19(11.7)
	5	16(9.6)	2(1.2)	5(11.6)	0(0.0)	47(10.0)	15(9.2)
	6	14(8.4)	6(11.3)	6(14.0)	0(0.0)	30(6.4)	10(6.1)
	7	14(8.4)	4(7.5)	6(14.0)	0(0.0)	25(5.3)	11(6.7)
	8	16(9.6)	5(9.4)	1(2.3)	0(0.0)	32(6.8)	11(6.7)
	9	16(9.6)	3(5.7)	1(2.3)	0(0.0)	45(9.6)	17(10.4)
	10	20(12.0)	5(9.4)	3(7.0)	0(0.0)	51(10.9)	27(16.6)
	11	15(7.6)	5(9.4)	7(16.3)	1(100.0)	31(6.6)	10(6.1)
	12	13(7.8)	4(7.5)	4(9.3)	0(0.0)	51(10.9)	12(7.4)
Season	Spring(3,4,5)	45(26.9)	14(26.4)	9(20.9)	0(0.0)	130(27.7)	48(29.4)
	Summer(6,7,8)	44(26.3)	15(28.3)	13(30.2)	0(0.0)	87(18.5)	32(19.6)

	Fall(9,10,11)	51(30.5)	13(24.5)	11(25.6)	1(100.0)	127(27.0)	54(33.1)
	Winter(12,1,2)	27(16.2)	11(20.8)	10(23.3)	0(0.0)	126(26.8)	29(17.8)
Days of week	Monday	33(19.8)	13(24.5)	6(14.0)	0(0.0)	81(17.2)	30(18.4)
	Tuesday	29(17.4)	10(18.9)	5(11.6)	0(0.0)	81(17.2)	31(19.0)
	Wednesday	27(16.2)	8(15.1)	3(7.0)	0(0.0)	84(17.9)	24(14.7)
	Thursday	30(18.0)	11(20.8)	17(39.5)	0(0.0)	77(16.4)	29(17.8)
	Friday	23(13.8)	6(11.3)	2(4.7)	0(0.0)	86(18.3)	32(19.6)
	Saturday	14(8.4)	3(5.7)	7(16.3)	1(100.0)	36(7.7)	10(6.1)
	Sunday	11(6.6)	2(3.8)	3(7.0)	0(0.0)	25(5.3)	7(4.3)
Weather	Yellow dust	3(1.8)	1(1.9)	0(0.0)	0(0.0)	9(1.9)	3(1.8)
	Cloudy/hazy	51(30.5)	17(32.1)	10(23.3)	1(100.0)	140(29.8)	53(32.5)
	Rainy	55(32.9)	19(35.8)	16(37.2)	0(0.0)	127(27.0)	46(28.2)
	Snowy	17(10.2)	6(11.3)	3(7.0)	0(0.0)	51(10.9)	14(8.6)
	Clear	41(24.6)	10(18.9)	14(32.6)	0(0.0)	143(30.4)	47(28.8)
Type of accidents[1]	Car-car	65(38.9)	33(62.3)	7(16.3)	0(0.0)	247(52.6)	81(49.7)
	Car-person	7(4.2)	8(15.1)	0(0.0)	0(0.0)	38(8.1)	35(21.5)
	Car only	95(56.9)	12(22.6)	36(83.7)	1(100.0)	185(39.4)	47(28.8)
Offender	Visitors	73(43.7)	23(43.4)	15(34.9)	0(0.0)	275(58.5)	89(54.6)
	Members	67(40.1)	27(50.9)	20(46.5)	1(100.0)	144(30.6)	59(36.2)
	Hit and run	5(3.0)	1(1.9)	3(7.0)	0(0.0)	10(2.1)	0(0.0)
	Unable to distinguish	22(13.2)	2(3.8)	5(11.6)	0(0.0)	41(8.7)	15(9.2)
Traffic lights	With traffic lights	12(7.2)	7(13.2)	0(0.0)	0(0.0)	75(16.0)	28(17.2)
	No traffic lights	155(92.8)	46(86.8)	43(100.0)	1(100.0)	395(84.0)	135(82.8)
Cause	Driver distraction	93(55.7)	33(62.3)	14(32.6)	0(0.0)	295(62.8)	107(65.6)

	Inexperienced driver/Driver inattention	13(7.8)	3(5.7)	13(30.2)	0(0.0)	18(3.8)	4(2.5)
	Speeding	0(0.0)	0(0.0)	0(0.0)	0(0.0)	4(0.9)	3(1.8)
	Drunk driving	2(1.2)	0(0.0)	0(0.0)	0(0.0)	6(1.3)	3(1.8)
	Faulty passing	4(2.4)	4(2.4)	0(0.0)	0(0.0)	3(0.6)	0(0.0)
	Failure to maintain safe distance	5(3.0)	3(5.7)	0(0.0)	0(0.0)	19(4.0)	4(2.5)
	Jaywalking	1(0.6)	1(1.9)	0(0.0)	0(0.0)	3(0.6)	2(1.2)
	Specifically unknown case among personal factor	3(1.8)	0(0.0)	3(7.0)	0(0.0)	19(4.0)	7(4.3)
	Condition of road	0(0.0)	0(0.0)	0(0.0)	0(0.0)	11(2.3)	1(0.6)
	Error of gate barrier	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(0.2)	1(0.6)
	Invasion of animal	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(0.2)	1(0.6)
	Broken facilities	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(0.2)	0(0.0)
	Defect of brake	1(0.6)	1(1.9)	1(2.3)	0(0.0)	4(0.9)	4(2.5)
	Sudden unintended acceleration	0(0.0)	0(0.0)	4(9.3)	1(100.0)	2(0.4)	1(0.6)
	Defect of tires	1(0.6)	0(0.0)	0(0.0)	0(0.0)	1(0.2)	2(1.2)
	Complex factors	20(12.0)	8(15.1)	3(7.0)	0(0.0)	52(11.1)	17(10.4)
	Unknown	24(14.4)	0(0.0)	5(11.6)	0(0.0)	30(6.4)	6(3.7)

[1] In type of accidents, 5 unknown cases were excluded in this study due to lack of information(2) or crushes caused by facility fracture(2) or crushed caused by natural wind(1). The specific factors in type of accidents were presented in appendices table A-5.

Table A-6. Comparing road safety facilities via specific 6 years

	Spatial differences via years					
Place	2010	2011	2014	2018	2019	2020
A EPDO : 47 Victim : 7	 Road sign in front of gate	 Road sign in front of gate	 Deleted road sign	 Deleted road sign	 Deleted road sign	 Deleted road sign
	 Partially existed of white guideline on the road	 Fully existed white guideline on the road	 Fully existed white guideline on the road	 Fully existed white guideline on the road	 Fully existed white guideline on the road	 Fully existed white guideline on the road

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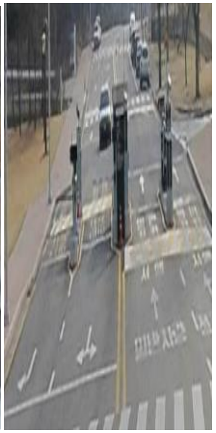
	Spatial differences via years					
Place	2010	2011	2014	2018	2019	2020
B EPDO : 24 Victim : 4						
	Construction for pedestrian road was in progress.	No difference	No difference	No difference	No difference	No difference

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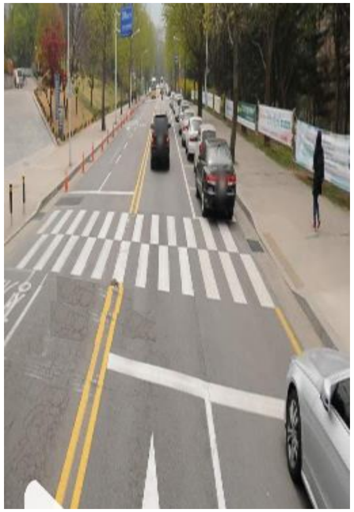
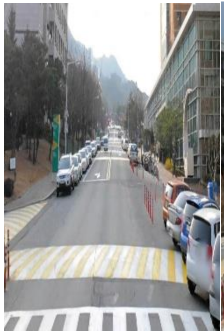
Place	Spatial differences via years					
	2010	2011	2014	2018	2019	2020
C EPDO : 18 Victim : 3						
	There were street parking lot both sides of the road. Full left side and half of right side which started from upper side of the crosswalk.	Same with the one of 2010.	The street parking lot on left side was deleted. And the half of right side which started from bottom side of the crosswalk was used as street parking lot even though it was not the official street parking lot.	Same with the one of 2014.	Same with the one of 2018.	There were no differences compared to 2018.

	Spatial differences via years					
Place	2010	2011	2014	2018	2019	2020
D EPDO : 56 Victim : 9					-	
	White painted guideline was on the road.	Same with the one of 2010.	Same with the one of 2011.	The white guideline was deleted.	The picture of road view was unavailable.	Same with the one of 2018.

Place	Spatial differences via years					
	2010	2011	2014	2018	2019	2020
E EPDO : 35 Victim : 5						
	There were unofficial street parking lot on the right side of the crosswalk	There were no cars on the unofficial street parking lot from 2011.	Yellow-black barrier and parking funnel were installed to prevent parking on the crosswalk or speedbump.	Same with the one of 2014.	Same with the one of 2018.	Same with the one of 2019.

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	There was a speed bump under the gate barrier.	Same with the one of 2010.	Same with the one of 2011.	The speed bump at the gate was deleted.	Same with the one of 2018.	Same with the one of 2019.

	Spatial differences via years					
Place	2010	2011	2014	2018	2019	2020
F EPDO : 19 Victim : 3					-	
		Same with the one of 2010.	The parking funnels were installed on the edge of the crosswalk.	The sign of ban on parking was painted at the left side of gate entrance as yellow color on the road.	The picture of road view was unavailable.	Same with the one of 2018 but the cars existed on the sign of ban on parking still.

	Spatial differences via years					
Place	2010	2011	2014	2018	2019	2020
G EPDO : 18 Victim : 3						
		The were no differences between 2010 and 2011.	There were no differences as well.	There were no differences as well.	There were no differences as well.	There were no differences as well.

Place	Spatial differences via years					
	2010	2011	2014	2018	2019	2020
H EPDO : 36 Victim : 7					-	
	The traffic lights were installed at the center of crossway.	The traffic lights moved to the edge of the road. Triangle shaped facilities are installed on the road.	No differences compared to the one of 2011.	No differences compared to the one of 2014.	The picture of the road view was unavailable.	No differences compared to the one of 2018.

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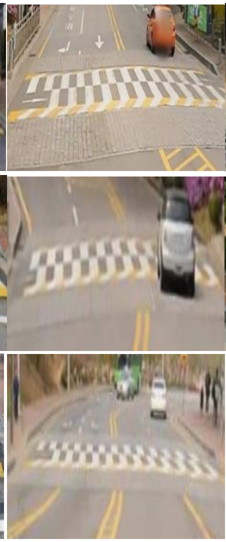
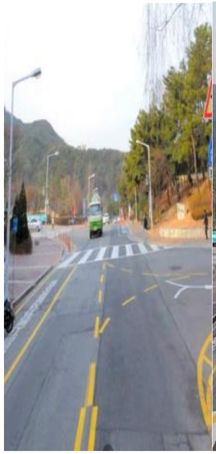
There were three white painted guidelines on the road.	One of the white painted guideline was deleted.	Same with the one of 2011.	Same with the one of 2014.	The picture of the road view was unavailable.	The one of white painted guideline was added like the one of 2010.

				-	
There were white painted crosswalks at the three sides of the three way intersection.	The two white painted crosswalk were added with white and yellow color like speed bump.	Many stones were installed in front and rear of crosswalk.	Same with the one of 2014.	The picture of the road view was unavailable.	Same with the one of 2018.

	Spatial differences via years					
Place	2010	2011	2014	2018	2019	2020
I EPDO : 26 Victim : 5					-	
	There was one of the reflector on right side in the picture.	Same with the one of 2010.	The building was constructed(left side) and one of the reflector was added.	Same with the one of 2014.	The picture of the road view was unavailable.	Same with the one of 2018.

	Spatial differences via years					
Place	2010	2011	2014	2018	2019	2020
J EPDO : 32 Victim : 5	 There was a crosswalk on the road.	 One of the crosswalk was deleted. Traffic lights were installed	 The deleted crosswalk was painted again.	 Same with the one of 2014.	- The picture of the road view was unavailable.	 The sign of 'immediately stop' was painted on the road in front of crosswalk.

 There was a bus stop and crosswalk in front of the gate.	 The bus stop was moved to other place. Traffic lights and one of the crosswalk was added.	 Same with the one of 2011.	 Same with the one of 2014.	- The picture of the road view was unavailable.	 The sign of 'immediately stop' was painted on the road in front of crosswalk.

Table A-7. Total number of laboratory accident frequency and its percentage in a campus determined via 1hour time slot for 10 years

Time slot	Number of cases[1] *N*(%)
00:00~00:59	1(0.6)
1:00~1:59	0(0.0)
2:00~2:59	1(0.6)
3:00~3:59	0(0.0)
4:00~4:59	1(0.6)
5:00~5:59	1(0.6)
6:00~6:59	2(1.1)
7:00~7:59	1(0.6)
8:00~8:59	2(1.1)
9:00~9:59	8(4.5)
10:00~10:59	14(8.0)
11:00~11:59	7(4.0)
12:00~12:59	9(5.1)
13:00~13:59	11(6.3)
14:00~14:59	17(9.7)
15:00~15:59	24(13.6)
16:00~16:59	22(12.5)
17:00~17:59	19(10.8)
18:00~18:59	11(6.3)
19:00~19:59	6(3.4)
20:00~20:59	5(2.8)
21:00~21:59	6(3.4)
22:00~22:59	7(4.0)
23:00~23:59	1(0.6)

[1] The cases which time is unwritten(23, 11.6% of total cases) were excluded

Table A-8. General characteristics of laboratory accidents via specific years

General characteristics		2015-2016						Total[4]		2018-2019						Total[5]	
		Human[1]		Machine[2]		Environment[3]				Human		Machine		Environment			
		Cases *N*(%)	Victims *N*(%)	Cases *N*(%)	Victims *N*(%)	Cases *N*(%)	Victims *N*(%)	Cases *N*(%)	Victims *N*(%)	Cases *N*(%)	Victims *N*(%)	Cases *N*(%)	Victims *N*(%)	Cases *N*(%)	Victims *N*(%)	Cases *N*(%)	Victims *N*(%)
Total		14 (100.0)	8 (100.0)	2 (100.0)	0 (100.0)	2 (100.0)	0 (100.0)	18 (100.0)	8 (100.0)	53 (100.0)	43 (100.0)	21 (100.0)	3 (100.0)	8 (100.0)	3 (100.0)	82 (100.0)	49 (100.0)
		(77.8)	(100.0)	(11.1)	(0.0)	(11.1)	(0.0)	(100.0)	(100.0)	(64.6)	(87.8)	(25.6)	(6.1)	(9.8)	(6.1)	(100.0)	(100.0)
Semester/ Vacation[6]	Semester	10 (71.4)	5 (62.5)	0(0.0)	0(0.0)	1 (50.0)	0(0.0)	11 (61.1)	5 (62.5)	40 (75.5)	32 (74.4)	18 (85.7)	3 (100.0)	7 (87.5)	3 (100.0)	65 (79.3)	38 (77.6)
	Vacation	4 (28.6)	3 (37.5)	2 (100.0)	0(0.0)	1 (50.0)	0(0.0)	7 (38.9)	3 (37.5)	13 (24.5)	11 (25.6)	3 (14.3)	0 (0.0)	1 (12.5)	0 (0.0)	17 (20.7)	11 (22.4)
Month	1	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	7(13.2)	6(14.0)	2(9.5)	0(0.0)	0(0.0)	0(0.0)	9(11.0)	6(12.2)
	2	0(0.0)	0(0.0)	1(50.0)	0(0.0)	0(0.0)	0(0.0)	1(5.6)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(12.5)	0(0.0)	1(1.2)	0(0.0)
	3	1(7.1)	1(12.5)	0(0.0)	0(0.0)	1(50.0)	0(0.0)	2(11.1)	1(12.5)	2(3.8)	2(4.7)	3(14.3)	0(0.0)	4(50.0)	1(33.3)	9(11.0)	3(6.1)
	4	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	6(11.3)	5(11.6)	1(4.8)	0(0.0)	1(12.5)	1(33.3)	8(9.8)	6(12.2)
	5	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	3(5.7)	3(7.0)	3(14.3)	0(0.0)	0(0.0)	0(0.0)	6(7.3)	3(6.1)
	6	1(7.1)	1(12.5)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(5.6)	1(12.	7(13.	6(14.0)	0(0.0)	0(0.0)	1(12.	0(0.0)	8(9.8)	6(12.

									5)	2)				5)			2)
	7	1(7.1)	1(12.5)	1(50.0)	0(0.0)	1(50.0)	0(0.0)	3(16.7)	1(12.5)	2(3.8)	2(4.7)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2(2.4)	2(4.1)
	8	3(21.4)	2(25.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	3(16.7)	2(25.0)	4(7.5)	3(7.0)	1(4.8)	0(0.0)	0(0.0)	0(0.0)	5(6.1)	3(6.1)
	9	1(7.1)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(5.6)	0(0.0)	8(15.1)	4(9.3)	6(28.6)	0(0.0)	1(12.5)	1(33.3)	15(18.3)	5(10.2)
	10	2(14.3)	2(25.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2(11.1)	2(25.0)	6(11.3)	4(9.3)	2(9.5)	1(33.3)	0(0.0)	0(0.0)	8(9.8)	5(10.2)
	11	4(28.6)	1(12.5)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	4(22.2)	1(12.5)	2(3.8)	2(4.7)	3(14.3)	2(66.7)	0(0.0)	0(0.0)	5(6.1)	4(8.2)
	12	1(7.1)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(5.6)	0(0.0)	6(11.3)	6(14.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	6(7.3)	6(12.2)
Days of week	Mon	9 (64.3)	5 (62.5)	0(0.0)	0(0.0)	1 (50.0)	0(0.0)	10 (55.6)	5 (62.5)	10(18.9)	8(18.6)	5(23.8)	0(0.0)	1(12.5)	0(0.0)	16(19.5)	8(16.3)
	Tues	1 (7.1)	1 (12.5)	0(0.0)	0(0.0)	1 (50.0)	0(0.0)	2(11.1)	1 (12.5)	9(17.0)	6(14.0)	3(14.3)	1(33.3)	0(0.0)	0(0.0)	12(14.6)	7(14.3)
	Wed	1 (7.1)	0 (0.0)	1(50.0)	0(0.0)	0(0.0)	0(0.0)	2(11.1)	0(0.0)	9(17.0)	6(14.0)	5(23.8)	0(0.0)	1(12.5)	0(0.0)	15(18.3)	6(12.2)
	Thurs	2(14.3)	1(12.5)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2(11.1)	1 (12.5)	13(24.5)	12(27.9)	2(9.5)	0(0.0)	2(25.0)	1(33.3)	17(20.7)	13(26.5)
	Fri	1(7.1)	1(12.5)	1(50.0)	0(0.0)	0(0.0)	0(0.0)	2(11.1)	1 (12.5)	9(17.0)	8(18.6)	3(14.3)	1(33.3)	2(25.0)	1(33.3)	14(17.1)	10(20.4)
	Sat	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2(3.8)	2(4.7)	2(9.5)	1(33.3)	1(12.5)	0(0.0)	5(6.1)	3(6.1)
	Sun	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(1.9)	1(2.3)	1(4.8)	0(0.0)	1(12.5)	1(33.3)	3(3.7)	2(4.1)
Type	Chemical	8(57.	3(37.5)	0(0.0)	0(0.0)	2(100.0	0(0.0)	10	3	18(34	9(20.9)	8(38.	1(33.3)	7(87.	2(66.5)	33(40	12(24

		1)				)		(55.6)	(37.5)	.0)		1)		5)		.2)	.5)
	Gas	1(7.1)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(5.6)	0(0.0)	1(1.9)	1(2.3)	6(28.6)	1(33.3)	0(0.0)	0(0.0)	7(8.5)	2(4.1)
	Electricity	0(0.0)	0(0.0)	2(100.0)	0(0.0)	0(0.0)	0(0.0)	2(11.1)	0(0.0)	1(1.9)	1(2.3)	1(4.8)	0(0.0)	0(0.0)	0(0.0)	2(2.4)	1(2.0)
	Biology	1(7.1)	1(12.5)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(5.6)	1(12.5)	10 (18.9)	10 (23.3)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	10(12.2)	10(20.4)
	Machinery	1(7.1)	1(12.5)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(5.6)	1(12.5)	1(1.9)	1(2.3)	5(23.8)	0(0.0)	0(0.0)	0(0.0)	6(7.3)	1(2.0)
	The others	3(21.4)	3(37.5)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	3(16.7)	3(37.5)	22 (41.5)	21 (48.8)	1(4.8)	1(33.3)	1(12.5)	1(33.3)	24(29.3)	23(46.9)
College & lab	Engineering	6(42.9)	3(37.5)	1(50.0)	0(0.0)	1(50.0)	0(0.0)	8(44.4)	3(37.5)	4(7.5)	3(7.0)	6(28.6)	0(0.0)	3(37.5)	2(66.7)	13(15.9)	5(10.2)
	Natural science	1(7.1)	1(12.5)	1(50.0)	0(0.0)	0(0.0)	0(0.0)	2(11.1)	1(12.5)	12(22.6)	9(20.9)	2(9.5)	0(0.0)	1(12.5)	0(0.0)	15(18.3)	9(18.4)
	Agriculture	1(7.1)	1(12.5)	0(0.0)	0(0.0)	1(50.0)	0(0.0)	2(11.1)	1(12.5)	3(5.7)	3(7.0)	2(9.5)	0(0.0)	2(25.0)	0(0.0)	7(8.5)	3(6.1)
	Medicine	2(14.3)	1(12.5)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2(11.1)	1(12.5)	14(26.4)	13(30.2)	3(14.3)	2(66.7)	0(0.0)	0(0.0)	17(20.7)	15(30.6)
	Pharmacy	1(7.1)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(5.6)	0(0.0)	7(13.2)	4(9.3)	3(14.3)	0(0.0)	0(0.0)	0(0.0)	10(12.2)	4(8.2)
	Dentistry	2(14.3)	2(25.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2(11.1)	2(25.0)	2(3.8)	2(4.7)	1(4.8)	0(0.0)	1(12.5)	1(33.3)	4(4.9)	3(6.1)
	Veterinary medicine	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	3(5.7)	2(4.7)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	3(3.7)	2(4.1)
	Human ecology	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(1.9)	1(2.3)	1(4.8)	0(0.0)	0(0.0)	0(0.0)	2(2.4)	1(2.0)

	Public health	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	3(5.7)	3(7.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	3(3.7)	3(6.1)
	Fine arts	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	Education	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(1.9)	1(2.3)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(1.2)	1(2.0)
	Other laboratories[7]	1(7.1)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(5.6)	0(0.0)	3(5.7)	2(4.7)	3(14.3)	1(33.3)	1(12.5)	0(0.0)	7(8.5)	3(6.1)
	Not included in university	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Damage scale	Human+ property	1(7.1)	1(12.5)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(5.6)	1(12.5)	3(5.7)	3(7.0)	1(4.8)	1(33.3)	1(12.5)	1(33.3)	5(6.1)	5 (10.2)
	Human only[8]	7(50.0)	7(87.5)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	7 (38.9)	7 (87.5)	40 (75.5)	40 (93.0)	2(9.5)	2(66.7)	2 (25.0)	2(66.7)	44 (53.7)	44 (89.8)
	Property only[9]	4(28.6)	0(0.0)	2(100.0)	0(0.0)	2(100.0)	0(0.0)	8 (44.4)	0(0.0)	4(7.5)	0(0.0)	9 (42.9)	0(0.0)	3 (37.5)	0(0.0)	16 (19.5)	0(0.0)
	No damage	2(14.3)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2 (11.1)	0(0.0)	6 (11.3)	0(0.0)	9 (42.9)	0(0.0)	2 (25.0)	0(0.0)	17 (20.7)	0(0.0)
Injury type[10]	Injury/Bleeding	4(50.0)	4(50.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	4 (50.0)	4 (50.0)	21 (48.8)	21 (48.8)	1(33.3)	1(33.3)	0(0.0)	0(0.0)	22 (44.9)	22 (44.9)
	Burn/Scald	1(12.5)	1(12.5)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1 (12.5)	1 (12.5)	12 (27.9)	12 (27.9)	0(0.0)	0(0.0)	3(100.0)	3(100.0)	15 (30.6)	15 (30.6)
	Musculoskeletal disease	1(12.5)	1(12.5)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1 (12.5)	1 (12.5)	5 (11.6)	5 (11.6)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	5(10.2)	5(10.2)

	Inhalation	1(12.5)	1(12.5)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1 (12.5)	1 (12.5)	2(4.7)	2(4.7)	2 (66.7)	2 (66.7)	0(0.0)	0(0.0)	4(8.2)	4(8.2)
	Contact with harmful rays	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2(4.7)	2(4.7)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2(4.1)	2(4.1)
	Infection	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	Unknown	1(12.5)	1(12.5)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(12.5)	1(12.5)	1(2.3)	1(2.3)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(2.0)	1(2.0)
Injury parts[10]	Hands	3(37.5)	3(37.5)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	3(37.5)	3(37.5)	14 (32.6)	14 (32.6)	1 (33.3)	1 (33.3)	1 (33.3)	1 (33.3)	16 (32.7)	16 (32.7)
	Face	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	4(9.3)	4(9.3)	0(0.0)	0(0.0)	1 (33.3)	1 (33.3)	5 (10.2)	5 (10.2)
	Waist	1(12.5)	1(12.5)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(12.5)	1(12.5)	4(9.3)	4(9.3)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	4 (8.2)	4 (8.2)
	Foot	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	4(9.3)	4(9.3)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	4(8.2)	4(8.2)
	Arms	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(2.3)	1(2.3)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(2.0)	1(2.0)
	Lung	1(12.5)	1(12.5)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(12.5)	1(12.5)	2(4.7)	2(4.7)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2(4.1)	2(4.1)
	Legs	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2(4.7)	2(4.7)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2(4.1)	2(4.1)
	Eyes	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2(4.7)	2(4.7)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2(4.1)	2(4.1)
	Head	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1 (33.3)	1 (33.3)	0(0.0)	0(0.0)	1(2.0)	1(2.0)
	Shoulders	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	Multiple parts	1 (12.5)	1(12.5)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1 (12.5)	1 (12.5)	3(7.0)	3(7.0)	0(0.0)	0(0.0)	1 (33.3)	1 (33.3)	4(8.2)	4(8.2)
	Unknow	2	2(25.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2	2	7	7	1	1	0(0.0)	0(0.0)	8	8

n	(25.0)						(25.0)	(25.0)	(16.3)	(16.3)	(33.3)	(33.3)			(16.3)	(16.3)

[1] The factor of human included improper storage &handling, lack of training, procedure violation, lack of PPE, careless among cause of laboratory accidents.
[2] The factor of machine included equipment failure among cause of laboratory accidents.
[3] The factor of environment included runaway reaction among cause of laboratory accidents.
[4] The total case of 2015-2016 included the factor of human, machine, environment of 2015-2016. The 2 cases of ‘unknown’ factor were excluded in this table.
[5] The total case of 2018-2019 included the factor of human, machine, environment of 2018-2019. The 16 cases of ‘unknown’ factor were excluded in this table.
[6] The semester included March, April, May, June, September, October, November, December. And the vacation included January, February, July, August.
[7] The other laboratories included national center for inter-university research facilities, inter-university semiconductor research center, research institute of advanced materials, automation and systems research institute, institute of advanced machines and design, institute of chemical processes.
[8] Only human damage included cases which the person got at least pain such as headache or pain from inhalation of chemical substances and if there was no property damage.
[9] Only property damage included cases of damage of every property such as gas/ chemical container, floor stain.
[10] The total number of cases of injury type and injury parts have differences with others because those were confined to cases which victim occurred. The total number of cases and victims in 2015-2016 were each of 8 and 8. The number of cases and victims of human factors in 2015-2016 were each of 8 and 8. The number of cases and victims of other factors including machine and environment were all zero in the same period. And the total number of cases and victims in 2018-2019 were each of 49 and 49. The number of cases and victims of human factors in 2018-2019 were each of 43 and 43.The number of cases and victims of other factors including machine and environment were each of 3 and 3 in the same period.

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Table A-9. General characteristics of laboratory accidents via causal factors for 10 years

General characteristics		Specific factors[1]					
		Human[2]		Machine[3]		Environment[4]	
		Cases N(%)	Victims N(%)	Cases N(%)	Victims N(%)	Cases N(%)	Victims N(%)
Total		103(100.0)	72(100.0)	44(100.0)	5(100.0)	22(100.0)	9(100.0)
		(60.9)	(83.7)	(26.0)	(5.81)	(13.0)	(10.5)
Semester/ Vacation[5]	Semester	74(71.8)	49(68.1)	32(72.7)	5(100.0)	15(68.2)	7(77.8)
	Vacation	29(28.2)	23(31.9)	12(27.3)	0(0.0)	7(31.8)	2(22.2)
Month	1	9(8.7)	8(11.1)	2(4.5)	0(0.0)	0(0.0)	0(0.0)
	2	2(1.9)	1(1.4)	2(4.5)	0(0.0)	3(13.6)	1(11.1)
	3	5(4.9)	4(5.6)	4(9.1)	0(0.0)	6(27.3)	2(22.2)
	4	11(10.7)	7(9.7)	1(2.3)	0(0.0)	1(4.5)	1(11.1)
	5	5(4.9)	5(6.9)	5(11.4)	1(20.0)	0(0.0)	0(0.0)
	6	12(11.7)	9(12.5)	3(6.8)	0(0.0)	1(4.5)	0(0.0)
	7	6(5.8)	5(6.9)	2(4.5)	0(0.0)	1(4.5)	0(0.0)
	8	12(11.7)	9(12.5)	6(13.6)	0(0.0)	3(13.6)	1(11.1)
	9	14(13.6)	6(8.3)	9(20.5)	0(0.0)	1(4.5)	1(11.1)
	10	9(8.7)	6(8.3)	5(11.4)	2(40.0)	0(0.0)	0(0.0)
	11	8(7.8)	4(5.6)	3(6.8)	2(40.0)	5(22.7)	2(22.2)
	12	10(9.7)	8(11.1)	2(4.5)	0(0.0)	1(4.5)	1(11.1)
Days of week	Mon	30(29.1)	18(25.0)	12(27.3)	1(20.0)	4(18.2)	1(11.1)
	Tues	14(13.6)	9(12.5)	6(13.6)	1(20.0)	4(18.2)	1(11.1)
	Wed	15(14.6)	10(13.9)	7(15.9)	0(0.0)	4(18.2)	2(22.2)

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	Thurs	20(19.4)	15(20.8)	7(15.9)	1(20.0)	3(13.6)	2(22.2)
	Fri	18(17.5)	14(19.4)	7(15.9)	1(20.0)	5(22.7)	2(22.2)
	Sat	3(2.9)	3(4.2)	2(4.5)	1(20.0)	1(4.5)	0(0.0)
	Sun	3(2.9)	3(2.4)	3(6.8)	0(0.0)	1(4.5)	1(11.1)
Type	Chemical	46(44.7)	18(25.0)	16(36.4)	1(20.0)	21(95.5)	8(88.9)
	Gas	5(4.9)	4(5.6)	9(20.5)	1(20.0)	0(0.0)	0(0.0)
	Electricity	2(1.9)	1(1.4)	8(18.2)	0(0.0)	0(0.0)	0(0.0)
	Biology	12(11.7)	12(16.7)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	Machinery	4(3.9)	4(5.6)	9(20.5)	1(20.0)	0(0.0)	0(0.0)
	The others	34(33.0)	33(45.8)	2(4.5)	2(40.0)	1(4.5)	1(11.1)
College & lab	Engineering	19(18.4)	11(15.3)	13(29.5)	0(0.0)	11(50.0)	6(66.7)
	Natural science	22(21.4)	16(22.2)	9(20.5)	0(0.0)	2(9.1)	0(0.0)
	Agriculture	11(10.7)	8(11.1)	7(15.9)	1(20.0)	4(18.2)	1(11.1)
	Medicine	19(18.4)	17(23.6)	3(6.8)	2(40.0)	0(0.0)	0(0.0)
	Pharmacy	10(9.7)	4(5.6)	5(11.4)	0(0.0)	1(4.5)	0(0.0)
	Dentistry	6(5.8)	5(6.9)	1(2.3)	0(0.0)	1(4.5)	1(11.1)
	Veterinary medicine	3(2.9)	2(2.8)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	Human ecology	2(1.9)	1(1.4)	1(2.3)	0(0.0)	1(4.5)	0(0.0)
	Public health	3(2.9)	3(4.2)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	Fine arts	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	Education	1(1.0)	1(1.4)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	Other laboratories[6]	7(6.8)	4(5.6)	4(9.1)	2(40.0)	2(9.1)	1(11.1)
	Not included in	0(0.0)	0(0.0)	1(2.3)	0(0.0)	0(0.0)	0(0.0)

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	university						
Damage scale	Human+property	7(6.8)	9(12.5)	3(6.8)	3(60.0)	5(22.7)	5(55.6)
	Human only[7]	63(61.2)	63(87.5)	2(4.5)	2(40.0)	4(18.2)	4(44.4)
	Property only[8]	20(19.4)	0(0.0)	28(63.6)	0(0.0)	9(40.9)	0(0.0)
	No damage	13(12.6)	0(0.0)	11(25.0)	0(0.0)	4(18.2)	0(0.0)
Injury type[9]	Injury/Bleeding	31(44.3)	31(43.1)	2(40.0)	2(40.0)	3(33.3)	3(33.3)
	Burn/Scald	20(28.6)	21(29.2)	1(20.0)	1(20.0)	6(66.7)	6(66.7)
	Musculoskeletal disease	9(12.9)	9(12.5)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	Inhalation	3(4.3)	3(4.2)	2(40.0)	2(40.0)	0(0.0)	0(0.0)
	Contact with harmful rays	2(2.9)	2(2.8)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	Infection	1(1.4)	1(1.4)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	Unknown	4(5.7)	5(6.9)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Injury parts[9]	Hands	22(31.4)	22(30.6)	1(20.0)	1(20.0)	1(11.1)	1(11.1)
	Face	6(8.6)	6(8.3)	0(0.0)	0(0.0)	1(11.1)	1(11.1)
	Waist	6(8.6)	6(8.3)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	Foot	6(8.6)	6(8.3)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	Arms	2(2.9)	2(2.8)	1(20.0)	1(20.0)	0(0.0)	0(0.0)
	Lung	3(4.3)	3(4.2)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	Legs	3(4.3)	3(4.2)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	Eyes	2(2.9)	2(2.8)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	Head	0(0.0)	0(0.0)	1(20.0)	1(20.0)	0(0.0)	0(0.0)
	Shoulders	1(1.4)	1(1.4)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
	Multiple parts	8(11.4)	9(12.5)	1(20.0)	1(20.0)	5(55.6)	5(55.6)

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Unknown	11(15.7)	12(16.7)	1(20.0)	1(20.0)	2(22.2)	2(22.2)

[1] The specific factors included factors of human, machine and environment. The 30 cases of 'unknown' factor were excluded in this table.

[2] The factor of human included improper storage &handling, lack of training, procedure violation, lack of PPE, careless among cause of laboratory accidents.

[3] The factor of machine included equipment failure among cause of laboratory accidents.

[4] The factor of environment included runaway reaction among cause of laboratory accidents.

[5] The semester included March, April, May, June, September, October, November, December. And the vacation included January, February, July, August.

[6] The other laboratories included national center for inter-university research facilities, inter-university semiconductor research center, research institute of advanced materials, automation and systems research institute, institute of advanced machines and design, institute of chemical processes.

[7] Only human damage included cases which the person got at least pain such as headache or pain from inhalation of chemical substances and if there was no property damage.

[8] Only property damage included cases of damage of every property such as gas/ chemical container, floor stain.

[9] The total number of cases of injury type and injury parts have differences with others because those were confined to cases which victim occurred. The total number of cases and victims for 10 years were each of 84 and 86. The number of cases and victims of human factors for 10 years were each of 70 and 72. The number of cases and victims of machine factors were each of 5 and 5. The one of environmental factor were each of 9 and 9 for the same period.

Table A-10. Total number of laboratory accident frequency and its percentage via semester for 10 years

Parameters			Frequency		Total
			Vacation N(%)	Semester N(%)	N(%)
Cause	Improper storage & handling		12(29.3)	29(70.7)	41(100.0)
	Equipment failure		12(27.3)	32(72.7)	44(100.0)
	Runaway reaction		7(31.8)	15(68.2)	22(100.0)
	Lack of training		2(33.3)	4(66.7)	6(100.0)
	Procedure violation		0(0.0)	4(100.0)	4(100.0)
	Lack of PPE		4(36.4)	7(63.6)	11(100.0)
	Careless		11(26.8)	30(73.2)	41(100.0)
	Unknown		12(40.0)	18(60.0)	30(100.0)
Type	Chemical	Leak/ contact of chemical substance	27 (34.2)	52 (65.8)	79 (100.0)
		Fire and explosion	9 (33.3)	18 (66.7)	27 (100.0)
	Gas (leak/explosion)	Combustible gas	1 (16.7)	5 (83.3)	6(100.0)
		Toxic gas	1(25.0)	3(75.0)	4(100.0)
		Non-combustible and non-toxic gas	1(33.3)	2(66.7)	3(100.0)
		Unknown	1(50.0)	1(50.0)	2(100.0)
	Electricity	Electric shock	0(0.0)	1(100.0)	1(100.0)
		Fire	4(33.3)	8(66.7)	12(100.0)
	Biology	Leak of pathogenic substances	0 (0.0)	1 (100.0)	1(100.0)
		Bite from animal/ Injuries from needle	3 (25.0)	9 (75.0)	12(100.0)
	Machinery	Pinch/ cut[1]	1(25.0)	3(75.0)	4(100.0)
		Broken[2]	0(0.0)	1(100.0)	1(100.0)
		Error in function[3]	3(37.5)	5(62.5)	8(100.0)
	The others	Fire	0(0.0)	2(100.0)	2(100.0)
		Burns/scalds	2(22.2)	7(77.8)	9(100.0)
		Wound/bleeding	4(22.2)	14(77.8)	18(100.0)
		Contact with harmful rays	1(50.0)	1(50.0)	2(100.0)
		Hurts of Musculoskeletal	2(25.0)	6(75.0)	8(100.0)

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	system			
Damage	Human + Property damage	5(33.3)	10(66.7)	15(100.0)
	Only human damage[4]	19(26.8)	52(73.2)	71(100.0)
	Only property damage[5]	17(27.4)	45(72.6)	62(100.0)
	No damage	19(37.3)	32(62.7)	51(100.0)
College& lab	Engineering	20(38.5)	32(61.5)	52(100.0)
	Natural science	11(30.6)	25(69.4)	36(100.0)
	Agriculture	10(33.3)	20(66.7)	30(100.0)
	Medicine	4(18.2)	18(81.8)	22(100.0)
	Pharmacy	6(33.3)	12(66.7)	18(100.0)
	Dentistry	1(12.5)	7(87.5)	8(100.0)
	Veterinary medicine	3(42.9)	4(57.1)	7(100.0)
	Human ecology	2(40.0)	3(60.0)	5(100.0)
	Public health	0(0.0)	3(100.0)	3(100.0)
	Fine arts	0(0.0)	1(100.0)	1(100.0)
	Education	0(0.0)	1(100.0)	1(100.0)
	Other laboratories[2]	3(20.0)	12(80.0)	15(100.0)
	Not included in university	0(0.0)	1(100.0)	1(100.0)
Injury parts	Eyes	1(50.0)	1(50.0)	2(100.0)
	Legs	1(33.3)	2(66.7)	3(100.0)
	Head	0(0.0)	1(100.0)	1(100.0)
	Foot	2(33.3)	4(66.7)	6(100.0)
	Hands	6(25.0)	18(75.0)	24(100.0)
	Shoulders	1(100.0)	0(0.0)	1(100.0)
	Face	2(25.0)	6(75.0)	8(100.0)
	Arms	0(0.0)	3(100.0)	3(100.0)
	Lung	0(0.0)	3(100.0)	3(100.0)
	Waist	1(16.7)	5(83.3)	6(100.0)
	Multiple parts	3(21.4)	11(78.6)	14(100.0)
	Unknown	7(46.7)	8(53.3)	15(100.0)
	Subtotal [a]	24(27.9)	62(72.1)	86(100.0)
	Total	60(30.2)	139(69.8)	199(100.0)

[1] Pinch/cut included the injury outcome from treating lab glasses or machine.
[2] Broken included fracture or broken of lab glasses or machine due to its flaw.
[3] Error in function included operation of wrong buzzer, leak of ventilation, wrong function of drainage.
[4] Only human damage included cases which the person got at least pain such as headache or pain from inhalation of chemical substances and if there was no property damage.
[5] Only property damage included cases of damage of every property such as gas/ chemical container, floor stain.
[a] The total damage cases were 86 cases which is the sum of human + property

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damage and only human damage of the table.

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국문초록

일개 종합대학의 10년간 캠퍼스 내 교통사고와 실험실 안전사고 발생 실태 및 관련요인 분석

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대학 캠퍼스는 그의 구성원인 학생, 교원, 직원에게 있어서 생활환경일 뿐만 아니라 직업환경이기도 하다. 이러한 대학교 캠퍼스 내에서 교통사고와 실험실 안전사고가 끊이지 않고 있다. 따라서,본 연구의 목적은 10년간 일개 종합대학 캠퍼스 내 교통사고 및 실험실 안전사고의 트렌드 파악하고 교통사고의 장소적 요인(노상주차장/주차장/그 외 도로), 원인적 요인인 주시태만과 계절요인 및 실험실 안전사고의 원인적 요인(인간/기계/환경)과 관련 요인인 학기 중/방학 중 시간적요인을 분석함에 있다.

연구대상은 한국의 일개 종합대학 캠퍼스로 하였다. 캠퍼스 내 교

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통사고를 분석하기 위해 생명윤리위원회(IRB)의 승인을 받은 후 사례 기술형 자료를 해당 대학의 캠퍼스 관리 부서로부터 받아 진행하였다. 자료의 시간적 범위는 2010년부터 2019년까지 총 10년치 자료였다. 자료의 구득성을 고려하여 교통사고 발생에 영향을 줄 수 있는 변수들로 코딩하여 분석하였다. 모든 분석은 SPSS 26버전으로 진행되었다. 변수의 일반적 특성에 빈도분석 및 관련요인들을 피셔의 정확검정, 카이 제곱 검정을 통해 살펴보았으며 주시태만 여부를 종속변수로 하여 로지스틱 회귀분석을 실시하였다. 사고다발지의 장소적 분포로는 부상자수와 대물피해환산법(EPDO)이 사용되었으며 자료 중 최근 5년(2015-2019) 자료로 진행하였다. 시각화로는 Google Maps JavaScript Application Programming Interface이 사용되었다. 총 680건의 캠퍼스 교통사고 분석결과 발생율은 최근 2년간(2018-2019) 감소하였다. 차대차(n=319, 46.9%), 외부인 가해자(n=363, 53.4%), 신호등이 없는 지역(n=592, 87.1%), 노상주차장(n=167, 24.6%)이 최다 빈도였다. 최근 2년(2018-2019)과 그 이전의 2년(2016-2017)을 비교분석한 결과 이전에 최다 빈도였던 외부인 가해자가 최근에 감소(52.8%)하고 내부인 가해자(42.6%)가 증가하였다. 교통사고의 주원인인 주시태만은 로지스틱 회귀분석에서 종속변수로서 분석되었다. 그 결과, 주시태만의 원인 요인들이 존재하였고 그것은 계절별로 상이하였다.

실험실 안전사고 역시 생명윤리위원회(IRB)의 승인을 받고, 그 이후 사례기술형 자료를 해당 대학교의 환경안전원으로부터 받아 진행하였다. 자료의 시간적 범위는 2010년부터 2019년까지 총 10년치 자료였다. 자료의 구득성과 실험실 안전사고 발생에 영향을 줄 수 있는

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변수들을 고려하여 코딩 및 분석하였다. 관련요인 분석을 위해 교차빈도 분석이 사용되었으며 SPSS 26버전이 사용되었다. 총 199건의 실험실 안전사고가 분석되었으며, 사고의 발생율은 최근 2년(2018-2019) 사이에 증가하였다. 실험실 안전사고에서는 화학 사고(n=106, 53.3%), 공과대학(n=52, 26.1%), 기계고장(n=44, 22.1%), 출혈/부상(n=37, 18.6%) , 손 부상(n=24, 12.1%), 월요일(n=52, 26.1%), 인적요인(60.9%)이 각각 최다 빈도였다. 학기 중/방학 중으로 비교해보았을 때 학기 중 토요일에 발생한 빈도와 방학 중 토요일에 발생하는 빈도에 차이가 없었다.

본 연구에서 10년간 캠퍼스 내에서 발생한 교통사고와 실험실 안전사고의 사고 특성 트렌드를 확인하였다. 건강을 보호하고 안전한 캠퍼스가 되기 위하여 다음의 사항들이 필요하다. 사고다발지를 확인하여 해당 지역에서 특히 노상주차장 및 교차로에서는 좌회전, 우회전 진입 시 혹은 직진진행시 주의와 양보가 필요하며 최근 2년간 내부인 가해자가 증가하였고 교내에 교통안전관련 교육은 없기에 내부적인 교통안전교육도 필요하다. 또한 운전자의 시야를 방해하고 보행자의 안전을 위협하는 불법주차에 대한 단속이 필요하다. 실험실 사고에서는 정기적인 기계 검사가 필요하며 휴일이 끝나고 복귀하는 월요일에 사고가 많이 발생하므로 보다 경각심을 가져야 한다.

주요어: 캠퍼스사고, 캠퍼스 교통사고, 캠퍼스 실험실 안전사고, 대학교사고, 화학사고, 학교안전사고, 로지스틱 회귀분석

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