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The evaluation of occupational accident with sequential pattern mining

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ABSTRACT

Accidents in manufacturing systems greatly affect productivity and efficiency, which are well known performance indicaters in practice. Therefore, it is very important to know the sequential patterns among the accidents to avode possible losses decrasing performance of the manufacturing systems. In order to reduce accidents, it is necessary to determine the patterns that cause the accident first. The associations among the causes of the occurrence of accidents is rarely investigated in the literature. To fill this gap, the patterns of causes among the accidents in the manufacturing system are revealed by using sequential pattern mining in this study. The most important contribution of this study is the discovery of sequential patterns formed by accident characteristics of pre-accident, moment of accident and post-accident stages unlike traditional accident investigation methods. Additionally, knowing the patterns of causes among the accidents can help decision makers to prepare a more proactive security program in real life. The CloFast algorithm is performed to go into the details of accidents in manufacturing systems. Accident records induding data between 2013 and 2019 are used to discover the sequential patterns. The results of this study showed that each accidents has its own sequential accident patterns and it is also posible to prevent possible accidents and reduce losses due to accidents considering sequential patterns in real life. Safety engineers and occupational safety specialists should take into account the sequential patterns among the accidents to avoid similar accident in the near future.

1. Introduction

73.27% of companies that fall under manufacturing industry's scope are classified as dangerous, while 20.92% are classified as highly dangerous (Workplace Hazard Classes Notification on OHS, 2012). The manufacturing as a whole includes 73.27% of dangerous enterprises and 20.92% of very dangerous enterprises (SSI annual statistical report 2013-2018). However, occupational accidents affected about 4% of the compulsorily insured workers in the manufacturing sector between 2013 and 2018 (SSI annual statistical report 2013-2018). Unwanted events including personal injury or death, environmental harm, property damage, and reputational damage may come from workplace accidents (Kjellen and Albrechtsen 2017, p.59). Occupational accidents and occupational injuries can have a macro-scale impact on the economic development and development of the country negatively at the macro level (Pereira et al., 2015; Mahmoudi et al., 2020; Yang et al., 2019; Seo and Yoon, 2012; Rundmo and Söderqvist, 1994). In a firm, occupational accidents and occupational injuries cause decrease in production efficiency, loss of trained workforce, loss of work days, recovery costs at the micro level. In a study conducted in the Korean manufacturing industry, it was found that the increase in occupational accidents statistically significantly reduced sales per employee, operating profit per employee, the ratio of operating profit to sales and sales growth rate (Kim and Park, 2021). In addition, increase in accident magnitude has the effect of increasing employe turnover (Yang et al., 2019) and reducing employee productivity (Eom et al., 2022). Ivascu and Cioca (2019) suggested that occupational safety specialists conduct statistical analyses of fatal and non-fatal incidents to assess the efficacy of rules, guidelines, and checklist procedures in order to increase safety. This study has been organized by taking into account the micro and macro effects of occupational accidents and the safety statistics in the Turkish manufacturing industry. The research question of this study is "how does the association pattern between occupational accidents in the manufacturing industry occur sequentially?" In order to answer this question, accident sequences consisting of direct causes and contributing causes in safety-related occupational accident records are analyzed with the sequential pattern mining approach.

A study of the occupational accident problem reveals causes at three

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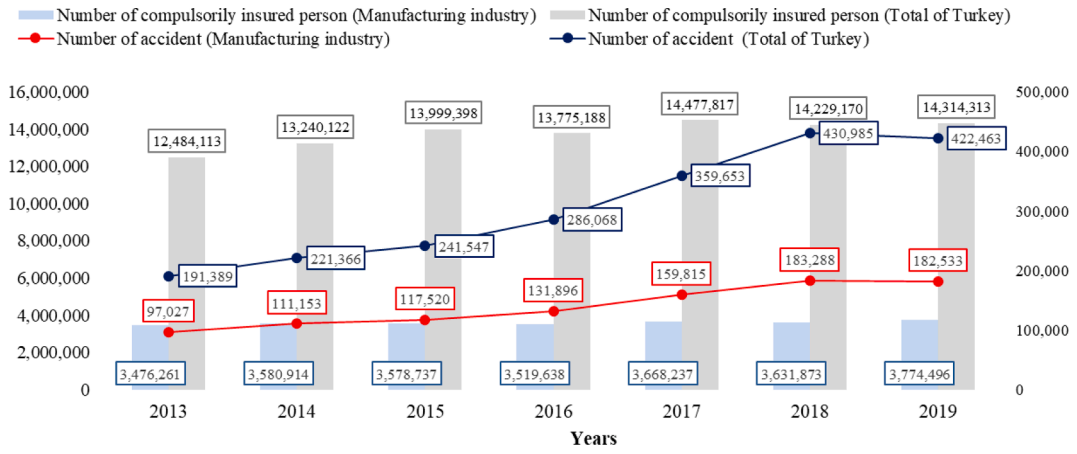

Fig. 1. The number of compulsory insured and accident numbers in Turkey for the manufacturing industry and all sectors by year (SSI annual statistical report 2013-2018 2019).

Table 1
Approaches about work accidents.

Author(s)(year)	Approach
Bird and Germain (1985)	International Loss Control Institute's (ILCI) loss causation
Hendrick and Benner (1986)	Sequential Timed Event Plotting (STEP)
Hudson et al. (1994)	Tripod-delta
Van der Want (1996)	Tripod
Doran et al. (1996)	Tripod beta
Reason (1997)	Swiss cheese model (SCM)
Shappell and Wiegmann, (2001)	Human Factors Analysis And Classificaiton Systems (HFACS)
Svedung and Rasmussen (2002)	AcciMap
Hollnagel (2004)	Functional Rezonance Accident Model (FRAM)
Leveson (2011)	Systems-Theoretic Accident Model and Processes (STAMP)
Fu et al. (2020)	24Model
Kang et al. (2021)	Root causes-effect model

levels: direct causes (energy sources, hazardous materails), indirect causes (unsafe act and conditions), basic causes or root causes (management policies, personal or environmental factors) (Reese, 2011, p.46, 64). Direct causes are sufficient for the accident to occur, while indirect causes alone do not cause the accident, but indirect causes increase the probability of the accident. The factors called basic causes, which also called root causes, are poor security management, procedures, decisions and policies. Inadequate controls, along with unsafe working conditions, reveal personal and work-related factors (McKinnon, 2019). Inadequate controls, along with unsafe working conditions, reveal personal and work-related factors (McKinnon, 2019). These eventually cause contact, property damage and/or injury. We present "checkpoints" to the attention of safety experts in terms of the sequential occupational accident patterns obtained for this study. In this way, safety experts will be able to control the strengths and weaknesses in their workplaces, and they will have the opportunity to develop their weaknesses.

Despite the frequent occupational injuries in the industry, Turkey's manufacturing industry plays a vital role in the expansion of the nation's economy in terms of employment and foreign commerce (Polat, 2011). The Social Security Institution (SSI) statistics on workplace and insured persons from 2013 to 2019 indicate that the manufacturing industry is responsible to around 26.17% of all compulsory insurance policyholders (SSI annual statistical report 2013-2018 2019, See Fig. 1). The terms of trade for the manufacturing industry tended to rise between 1995 and 2012, according to Aysun's (2015) research. According to Beşer and Uurlu (2020), a considerable part of the Turkish manufacturing industry's foreign trade intensity increases in the nation's economy. Preventing occupational accidents that result in financial and social losses appears to be crucial for upholding the manufacturing industries sustainable.

Accident models are prominent in the analysis of occupational accidents. Accident models are logical tools that aid in understanding how accidents happen (Kjellen and Albrechtsen 2017, p.26). The goal of accident analysis is to show the variables that influence the outcome of an accident in terms of a defined accident outcome. More effective accident prevention measures can be implemented this manner, and the effectiveness of current measures can be evaluated. The causal-sequence model, or the earliest and simplest accident model, known as the domino theory, contends that an incident can be avoided by removing one or more of the causes (Hudson, 2012). The process models describe an accident as a sequence of events that occurred over period (Kjellen and Larsson, 1981). "Energy models": analyses of accidents that consider the transfer of energy to the body at a level over the threshold for injury and

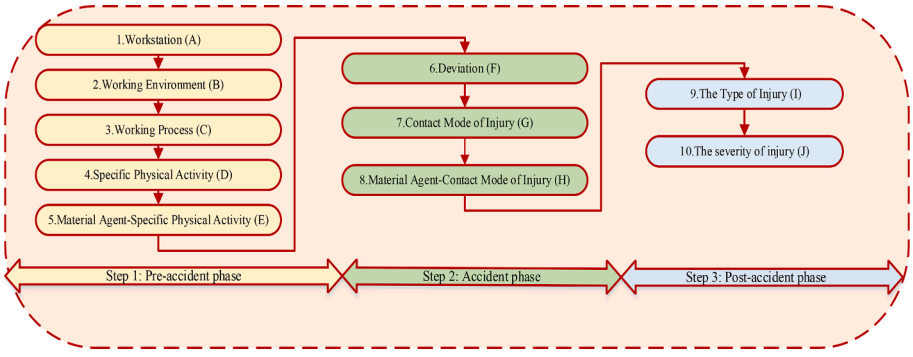

Fig. 2. The accident sequence, phases, and items.

Table 2
The absolute frequency and percentage values of occupational accidents in the manufacturing industry.

Section	Division (NACE Rev.2 code)	Description	Absolute frequnence ($n_{others\ included}$)	%	Absolute frequnence ($n_{others\ excluded}$)	%
CA	Dvs_1: 10	Manufacture of food products	115,928	11.65	25,859	8.41
	Dvs_2: 11	Manufacture of beverages	2,979	0.30	758	0.25
	Dvs_3: 12	Manufacture of tobacco products	788	0.08	185	0.06
CB	Dvs_4: 13	Manufacture of textiles	105,569	10.60	33,354	10.84
	Dvs_5: 14	Manufacture of wearing apparel	28,887	2.90	7,349	2.39
	Dvs_6: 15	Manufacture of leather and related products	4,636	0.47	1,337	0.43
CC	Dvs_7: 16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	20,192	2.03	6,537	2.13
	Dvs_8: 17	Manufacture of paper and paper products	19,062	1.91	5,552	1.80
	Dvs_9: 18	Printing and reproduction of recorded media	6,199	0.62	1,737	0.56
CD	Dvs_{10}: 19	Manufacture of coke and refined petroleum products	1,080	0.11	350	0.11
CE	Dvs_{11}: 20	Manufacture of chemicals and chemical products	18,073	1.82	4,936	1.60
CF	Dvs_{12}: 21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	3,861	0.39	741	0.24
CG	Dvs_{13}: 22	Manufacture of rubber and plastic products	69,569	6.99	22,339	7.26
	Dvs_{14}: 23	Manufacture of other non-metallic mineral products	86,976	8.74	22,243	7.23
CH	Dvs_{15}: 24	Manufacture of basic metals	99,178	9.96	33,965	11.04
	Dvs_{16}: 25	Manufacture of fabricated metal products, except machinery and equipment	144,667	14.53	48,487	15.76
CI	Dvs_{17}: 26	Manufacture of computer, electronic and optical products	7,301	0.73	2,412	0.78
CJ	Dvs_{18}: 27	Manufacture of electrical equipment	48,241	4.85	17,352	5.64
CK	Dvs_{19}: 28	Manufacture of machinery and equipment n.e.c.	50,874	5.11	18,908	6.15
CL	Dvs_{20}: 29	Manufacture of motor vehicles, trailers and semi-trailers	68,614	6.89	26,341	8.56
	Dvs_{21}: 30	Manufacture of other transport equipmenT	22,753	2.29	7,497	2.44
CM	Dvs_{22}: 31	Manufacture of furniture	39,574	3.98	12,226	3.97
	Dvs_{23}: 32	Other manufacturing	5.268	0.53	1,656	0.54
	Dvs_{24}: 33	Repair and installation of machinery and equipment	25,234	2.53	5,473	1.78
Total			995,503	100	307,594	100

Table 3
The descriptive statistics, the absolute frequency and % of occupational accidents in the manufacturing industry ($n_{others\ included}$ = 995,503).

Experience	Absolute frequnence	%	Experience	Absolute frequnence	%
Exp_1: [0,2)	617,903	62.07	Exp_9: [16,18)	3,213	0.32
Exp_2: [2,4)	167,957	16.87	Exp_{10}: [18,20)	2,006	0.20
Exp_3: [4,6)	81,265	8.16	Exp_{11}: [20,22)	1,539	0.15
Exp_4: [6,8)	44,892	4.51	Exp_{12}: [22,24)	1,851	0.19
Exp_5: [8,10)	27,133	2.73	Exp_{13}: [24,26)	2,229	0.22
Exp_6: [10,12)	17,871	1.80	Exp_{14}: [26, 28)	2,363	0.24
Exp_7: [12,14)	11,161	1.12	Exp_{15}: [28,	7,794	0.78
Exp_8: [14,16)	6,326	0.64			
Age	**Absolute frequnence**	**%**	**Marital Status**	**Absolute frequnence**	**%**
Age_1: 0–14	111	0.01	Ms_1: Single	294,555	29.589
Age_2: 15–24	192,358	19.32	Ms_2: No information	3,701	0.372
Age_3: 25–34	376,760	37.85	Ms_3: Divorced	38,063	3.823
Age_4: 35–44	294,620	29.60	Ms_4: Widowed	2,622	0.263
Age_5: 45–54	116,192	11.67	Ms_5: Married	656,545	65.951
Age_6: 55-	15,462	1.55	Ms_6: Marriage termination	17	0.002
Years	**Absolute frequnence**	**%**	**Day**	**Absolute frequnence**	**%**
Y_1: 2013	97,841	9.83	D_1: Monday	43,827	4.40
Y_2: 2014	114,098	11.46	D_2: Tuesday	166,269	16.70
Y_3: 2015	121,917	12.25	D_3: Wednesday	169,208	17.00
Y_4: 2016	134,955	13.56	D_4: Thursday	172,006	17.28
Y_5: 2017	160,877	16.16	D_5: Friday	170,505	17.13
Y_6: 2018	183,580	18.44	D_6: Saturday	163,076	16.38
Y_7: 2019	182,235	18.31	D_7: Sunday	110,612	11.11
Working Hour	**Absolute frequnence**	**%**	**Working Hour**	**Absolute frequnence**	**%**
Wh_1: 00:00 to 00:59	97,162	9.76	Wh_{13}: 12:00 to 12:59	4,619	0.46
Wh_2: 01:00 to 01:59	118,115	11.86	Wh_{14}: 13:00 to 13:59	2,889	0.29
Wh_3: 02:00 to 02:59	121,892	12.24	Wh_{15}: 14:00 to 14:59	2,054	0.21
Wh_4: 03:00 to 03:59	121,595	12.21	Wh_{16}: 15:00 to 15:59	2,129	0.21
Wh_5: 04:00 to 04:59	78,281	7.86	Wh_{17}: 16:00 to 16:59	2,163	0.22
Wh_6: 05:00 to 05:59	91,600	9.20	Wh_{18}: 17:00 to 17:59	2,363	0.24
Wh_7: 06:00 to 06:59	105,033	10.55	Wh_{19}: 18:00 to 18:59	2,290	0.23
Wh_8: 07:00 to 07:59	102,498	10.30	Wh_{19}: 19:00 to 19:59	1,882	0.19
Wh_9: 08:00 to 08:59	56,698	5.70	Wh_{20}: 20:00 to 20:59	1,614	0.16
Wh_{10}: 09:00 to 09:59	36,864	3.70	Wh_{21}: 21:00 to 21:59	1,619	0.16
Wh_{11}: 10:00 to 10:59	14,954	1.50	Wh_{22}: 22:00 to 22:59	2,727	0.27
Wh_{12}: 11:00 to 11:59	9,753	0.98	Wh_{23}: 23:00 to 23:59	14,709	1.48
Gender	**Absolute frequnence**	**%**			
F: Female	142,035	14.27			
M: Male	853,468	85.73			

Table 4
The descriptive statistics, the absolute frequency and % of occupational accidents in the manufacturing industry ($n_{others\ included} = 995{,}503$).

Working Hour	Absolute frequnence	%	Working Hour	Absolute frequnence	%
Hd_1: 00:00 to 00:59	18,376	1.85	**Hd_{13}**: 12:00 to 12:59	47,543	4.78
Hd_2: 01:00 to 01:59	21,135	2.12	**Hd_{14}**: 13:00 to 13:59	58,325	5.86
Hd_3: 02:00 to 02:59	19,963	2.01	**Hd_{15}**: 14:00 to 14:59	78,522	7.89
Hd_4: 03:00 to 03:59	17,941	1.80	**Hd_{16}**: 15:00 to 15:59	75,165	7.55
Hd_5: 04:00 to 04:59	15,982	1.61	**Hd_{17}**: 16:00 to 16:59	64,092	6.44
Hd_6: 05:00 to 05:59	15,981	1.61	**Hd_{18}**: 17:00 to 17:59	55,508	5.58
Hd_7: 06:00 to 06:59	16,118	1.62	**Hd_{19}**: 18:00 to 18:59	31,006	3.11
Hd_8: 07:00 to 07:59	25,556	2.57	**Hd_{19}**: 19:00 to 19:59	24,931	2.50
Hd_9: 08:00 to 08:59	54,835	5.51	**Hd_{20}**: 20:00 to 20:59	21,769	2.19
Hd_{10}: 09:00 to 09:59	82,523	8.29	**Hd_{21}**: 21:00 to 21:59	22,881	2.30
Hd_{11}: 10:00 to 10:59	88,187	8.86	**Hd_{22}**: 22:00 to 22:59	22,108	2.22
Hd_{12}: 11:00 to 11:59	95,756	9.62	**Hd_{23}**: 23:00 to 23:59	21,300	2.14
Workplace status	**Absolute frequnence**	**%**	**Seasons**	**Absolute frequnence**	**%**
St_1: Permanent workplaces of the official sector	14,700	1.48	**$Seas_1$**: March-April-May	247,051	24.82
St_2: Permanent workplaces of the private sector	970,785	97.52	**$Seas_2$**: June-July-August	258,879	26.00
St_3: Temporary or seasonal workplaces of the official sector	195	0.02	**$Seas_3$**: September-October-November	260,961	26.21
St_4: Temporary or seasonal workplaces of the private sector	9,823	0.99	**$Seas_4$**: December-January-Febuary	228,612	22.96
Educational backround	**Absolute frequnence**	**%**	**Days lost (day)**	**Absolute frequnence**	**%**
Eb_1: No information	277	0.03	**Dl_0**: 0	394,835	39.66
Eb_2: Illiterate	2,480	0.25	**Dl_1**: 1–9	479,409	48.16
Eb_3: Literate	54,513	5.48	**Dl_2**: 10–19	86,468	8.69
Eb_4: Primary school graduate	110,563	11.11	**Dl_3**: 20–29	11,616	1.17
Eb_5: Primary school	264,169	26.54	**Dl_4**: 30–39	15,083	1.52
Eb_6: Junior high school	177,024	17.78	**Dl_5**: 40–49	4,511	0.45
Eb_7: High school	234,577	23.56	**Dl_6**: 50–59	583	0.06
Eb_8: Vocational high School	97,246	9.77	**Dl_7**: 60–69	1,747	0.18
Eb_9: College	36,982	3.71	**Dl_8**: 70–79	189	0.02
Eb_{10}: University	16,949	1.70	**Dl_9**: 80–89	104	0.01
Eb_{11}: Master, high engineering etc.	638	0.06	**Dl_{10}**: 90-	958	0.10
Eb_{12}: Doctorate	85	0.01			
OHS training	**Absolute frequnence**	**%**	**Professional training**	**Absolute frequnence**	**%**
OHS_1: Yes	957,458	96.18	**Pt_1:** Yes	780,768	78.43
OHS_2: No	37,991	3.82	**Pt_2:** No	214,303	21.53
OHS_3: No information	54	0.01	**Pt_3:** No information	432	0.04

Table 5
The descriptive statistics, the absolute frequency and % of occupational accidents in the manufacturing industry ($n_{others\ excluded} = 307{,}594$).

Experience	Absolute frequnence	%	Experience	Absolute frequnence	%
Exp_1: [0,2)	187,228	60.87	**Exp_9**: [16,18)	1,075	0.35
Exp_2: [2,4)	52,360	17.02	**Exp_{10}**: [18,20)	675	0.22
Exp_3: [4,6)	25,729	8.36	**Exp_{11}**: [20,22)	525	0.17
Exp_4: [6,8)	14,794	4.81	**Exp_{12}**: [22,24)	656	0.21
Exp_5: [8,10)	8,919	2.90	**Exp_{13}**: [24,26)	786	0.26
Exp_6: [10,12)	5,931	1.93	**Exp_{14}**: [26, 28)	860	0.28
Exp_7: [12,14)	3,801	1.24	**Exp_{15}**: [28,	2,162	0.70
Exp_8: [14,16)	2,093	0.68			
Age	**Absolute frequnence**	**%**	**Marital Status**	**Absolute frequnence**	**%**
Age_1: 0–14	29	0.01	**Ms_1**: Single	93,488	30.393
Age_2: 15–24	61,150	19.88	**Ms_2**: No information	399	0.130
Age_3: 25–34	117,800	38.30	**Ms_3**: Divorced	11,105	3.610
Age_4: 35–44	90,414	29.39	**Ms_4**: Widowed	728	0.237
Age_5: 45–54	33,950	11.04	**Ms_5**: Married	201,872	65.629
Age_6: 55-	4,251	1.38	**Ms_6**: Marriage termination	2	0.001
Years	**Absolute frequnence**	**%**	**Day**	**Absolute frequnence**	**%**
Y_1: 2013	29,609	9.63	**D_1**: Monday	13,262	4.31
Y_2: 2014	33,787	10.98	**D_2**: Tuesday	51,686	16.80
Y_3: 2015	37,280	12.12	**D_3**: Wednesday	52,629	17.11
Y_4: 2016	41,080	13.36	**D_4**: Thursday	53,322	17.34
Y_5: 2017	49,753	16.17	**D_5**: Friday	52,858	17.18
Y_6: 2018	58,654	19.07	**D_6**: Saturday	49,757	16.18
Y_7: 2019	57,431	18.67	**D_7**: Sunday	34,080	11.08
Working Hour	**Absolute frequnence**	**%**	**Working Hour**	**Absolute frequnence**	**%**
Wh_1: 00:00 to 00:59	29,547	9.61	**Wh_{13}**: 12:00 to 12:59	1,299	0.42
Wh_2: 01:00 to 01:59	37,865	12.31	**Wh_{14}**: 13:00 to 13:59	797	0.26
Wh_3: 02:00 to 02:59	38,427	12.49	**Wh_{15}**: 14:00 to 14:59	560	0.18
Wh_4: 03:00 to 03:59	38,495	12.51	**Wh_{16}**: 15:00 to 15:59	555	0.18
Wh_5: 04:00 to 04:59	23,515	7.64	**Wh_{17}**: 16:00 to 16:59	609	0.20
Wh_6: 05:00 to 05:59	28,771	9.35	**Wh_{18}**: 17:00 to 17:59	776	0.25
Wh_7: 06:00 to 06:59	33,599	10.92	**Wh_{19}**: 18:00 to 18:59	668	0.22

(*continued on next page*)

Table 5 (*continued*)

Experience	Absolute frequnence	%	Experience	Absolute frequnence	%
Wh_8: 07:00 to 07:59	32,544	10.58	**Wh_{19}**: 19:00 to 19:59	533	0.17
Wh_9: 08:00 to 08:59	17,069	5.55	**Wh_{20}**: 20:00 to 20:59	499	0.16
Wh_{10}: 09:00 to 09:59	11,442	3.72	**Wh_{21}**: 21:00 to 21:59	422	0.14
Wh_{11}: 10:00 to 10:59	4,169	1.36	**Wh_{22}**: 22:00 to 22:59	547	0.18
Wh_{12}: 11:00 to 11:59	3,042	0.99	**Wh_{23}**: 23:00 to 23:59	1,844	0.60
Gender	**Absolute frequnence**	**%**			
F: Female	37,256	12.11			
M: Male	270,338	87.89			

the consequent injury, "Logic tree models": determining the causes of accidents based on the logical connections between the events and conditions in the system in question, Technical and organizational "system models" by considering how different components interact, it analyzes accidents. "Cognitive models": study accidents as a result of human errors as a result of cognitive function failures, and make it possible for cognitive factors to identify how accidents occur (Kjellen and Albrechtsen, 2017, p.27). A small number of studies have considered the accident sequence model, despite the fact that there are studies in the literature that undertake accident analysis with a manufacturing industry focus. (exp: Berhan, 2020a; Yang et al., 2019; Dhalmahapatra et al., 2019; Yang and Jeong, 2019). The approaches about work accidents is given Table 1.

The American National Standards Institute advised keeping records for accident sequence in accident classification: accident (accident type, agency of accident), hazardous condition (unguarded, defective tools, unsafe design, etc.), unsafe act (failure to source, operating at unsafe speed etc.). To generate benefits for the construction industry by conducting studies that implement the European Occupational Accident Statistics (ESAW) Project (Heimonen et al., 2023; Hoła and Szóstak, 2019; Hoła and Szóstak, 2017; Hoła and Szóstak, 2014; Palamara et al., 2011). It was used in our study to develop an accident sequence that included ESAW and the American National Standards Institute's accident sequence variables for the manufacturing industry. Accidents can only be avoided by reducing unsafe behaviors and conditions (Kjellén, 2000, p.32). To obtain information to help prevent accidents, sequential accident patterns were determined by analyzing occupational accident records from the Turkish manufacturing industry from 2013 to 2019. The sections of the study that follow are organized as follows. Section 2 is a literature review, Section 3 is an accident sequence model, Section 4 is a method and material, Section 5 is results, and Section 6 is discussion, and Section 7 is conclusion.

2. Literature review

Previous studies were conducted in which information was collected from employees who had an accident in the manufacturing industry sectors using questionnaires (Berhan, 2020a; Berhan, 2020b;

Table 6
The descriptive statistics, the absolute frequency and % of occupational accidents in the manufacturing industry ($n_{others\ excluded} = 307{,}594$).

Working Hour	Absolute frequnence	%	Working Hour	Absolute frequnence	%
Hd_1: 00:00 to 00:59	5,397	1.75	**Hd_{13}**: 12:00 to 12:59	13,694	4.45
Hd_2: 01:00 to 01:59	6,890	2.24	**Hd_{14}**: 13:00 to 13:59	17,974	5.84
Hd_3: 02:00 to 02:59	6,513	2.12	**Hd_{15}**: 14:00 to 14:59	24,734	8.04
Hd_4: 03:00 to 03:59	5,683	1.85	**Hd_{16}**: 15:00 to 15:59	23,403	7.61
Hd_5: 04:00 to 04:59	5,147	1.67	**Hd_{17}**: 16:00 to 16:59	20,017	6.51
Hd_6: 05:00 to 05:59	5,185	1.69	**Hd_{18}**: 17:00 to 17:59	17,395	5.66
Hd_7: 06:00 to 06:59	4,895	1.59	**Hd_{19}**: 18:00 to 18:59	9,278	3.02
Hd_8: 07:00 to 07:59	6,279	2.04	**Hd_{19}**: 19:00 to 19:59	7,600	2.47
Hd_9: 08:00 to 08:59	16,174	5.26	**Hd_{20}**: 20:00 to 20:59	6,830	2.22
Hd_{10}: 09:00 to 09:59	26,075	8.48	**Hd_{21}**: 21:00 to 21:59	7,320	2.38
Hd_{11}: 10:00 to 10:59	27,280	8.87	**Hd_{22}**: 22:00 to 22:59	6,820	2.22
Hd_{12}: 11:00 to 11:59	30,395	9.88	**Hd_{23}**: 23:00 to 23:59	6,616	2.15
Workplace status	**Absolute frequnence**	**%**	**Seasons**	**Absolute frequnence**	**%**
St_1: Permanent workplaces of the official sector	4,869	1.58	**$Seas_1$**: March-April-May	76,504	24.87
St_2: Permanent workplaces of the private sector	299,855	97.48	**$Seas_2$**: June-July-August	79,794	25.94
St_3: Temporary or seasonal workplaces of the official sector	40	0.01	**$Seas_3$**: September-October-November	80,783	26.26
St_4: Temporary or seasonal workplaces of the private sector	2,830	0.92	**$Seas_4$**: December-January-Febuary	70,513	22.92
Educational backround	**Absolute frequnence**	**%**	**Days lost (day)**	**Absolute frequnence**	**%**
Eb_1: No information	79	0.03	**Dl_0**: 0	123,047	40.00
Eb_2: Illiterate	572	0.19	**Dl_1**: 1–9	143,496	46.65
Eb_3: Literate	12,621	4.10	**Dl_2**: 10–19	29,227	9.50
Eb_4: Primary school graduate	34,712	11.29	**Dl_3**: 20–29	4,039	1.31
Eb_5: Primary school	77,743	25.27	**Dl_4**: 30–39	5,201	1.69
Eb_6: Junior high school	56,079	18.23	**Dl_5**: 40–49	1,453	0.47
Eb_7: High school	73,755	23.98	**Dl_6**: 50–59	182	0.06
Eb_8: Vocational high School	35,430	11.52	**Dl_7**: 60–69	592	0.19
Eb_9: College	12,165	3.95	**Dl_8**: 70–79	61	0.02
Eb_{10}: University	4,231	1.38	**Dl_9**: 80–89	21	0.01
Eb_{11}: Master, high engineering etc.	187	0.06	**Dl_{10}**: 90-	275	0.09
Eb_{12}: Doctorate	20	0.01			
OHS training	**Absolute frequnence**	**%**	**Professional training**	**Absolute frequnence**	**%**
OHS_1: Yes	297,340	96.67	**Pt_1:** Yes	240,488	78.18
OHS_2: No	10,232	3.33	**Pt_2:** No	66,993	21.78
OHS_3: No information	22	0.01	**Pt_3:** No information	113	0.04

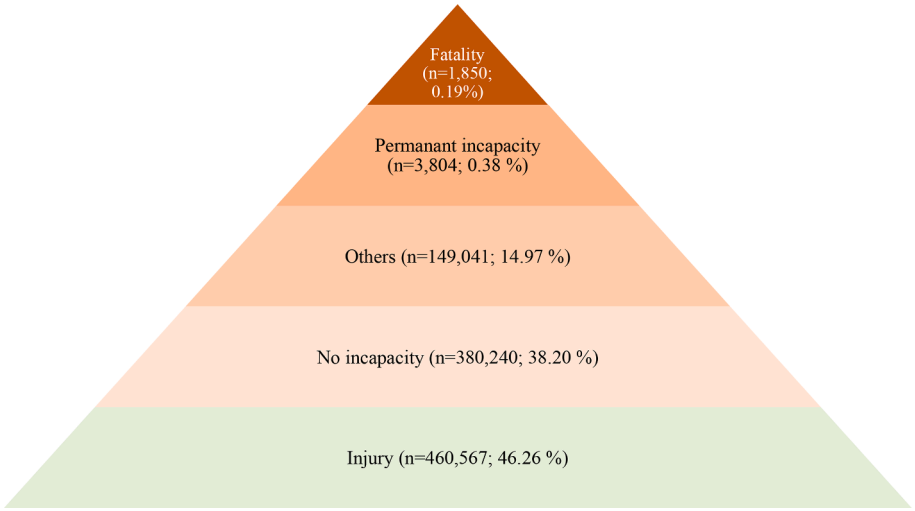

Fig. 3. Employee post-accident status distribution in the Turkish manufacturing industry from 2013 to 2019 ($n_{others\ included}$ = 995,503).

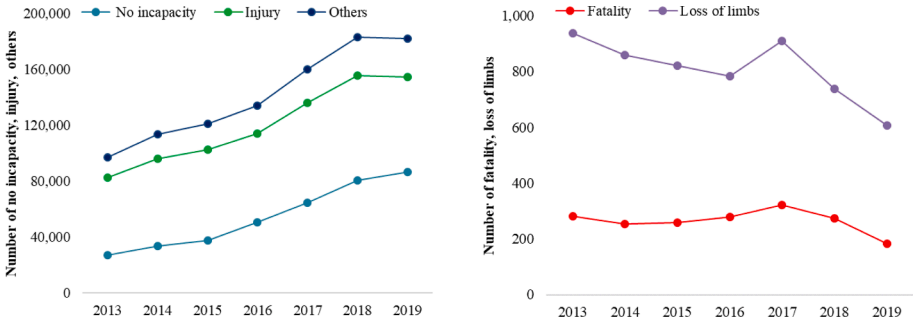

Fig. 4. Changes in the severity level of accidents in the Turkish manufacturing industry from 2013 to 2019 ($n_{others\ excluded}$ = 995.503).

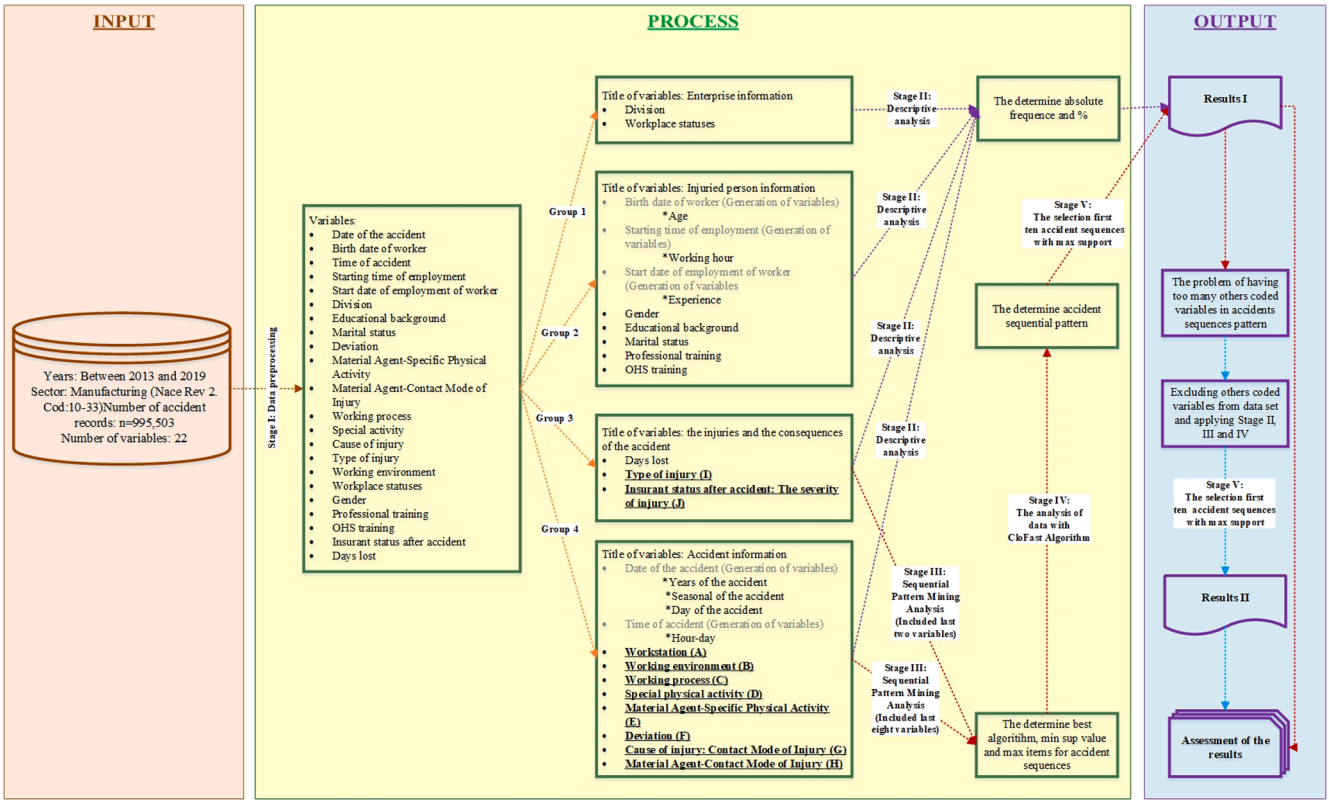

Fig. 5. Workflow of study.

Table 7
Example sequences expressing four occupational accident cases with five items.

SID	Sequences
S_1	$\{a_{01}\}, \{b_{011}\}, \{c_{11}\}, \{d_{62}\}, \{e_{02.03}\}$
S_2	$\{a_{01}\}, \{b_{011}\}, \{c_{11}\}, \{d_{13}\},\{e_{14.10}\}$
S_3	$\{a_{01}\}, \{b_{063}\}, \{c_{11}\}, \{d_{21}\}, \{e_{07.02}\}$
S_4	$\{a_{01}\}, \{b_{011}\}, \{c_{11}\}, \{d_{11}\}, \{e_{14.02}\}$

Table 8
Output for Table 7 by the CloFast algorithm.

ID	Closed sequential pattern	Support
S_1	$\{a_{01}\},\{c_{11}\}$	100%
S_2	$\{a_{01}\},\{b_{011}\},\{c_{11}\}$	75%

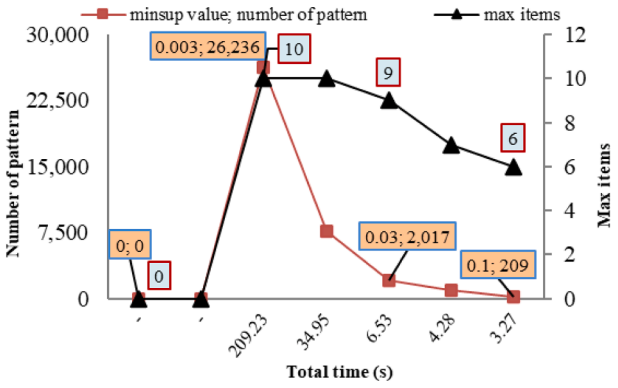

Fig. 6. The determination of best minsup value for "Section CA: Total of Nace Rev.2: 10, 11 and 12" ($n_{others\ excluded}$ = 26,802). Note: out of memory error for minsup = 0.

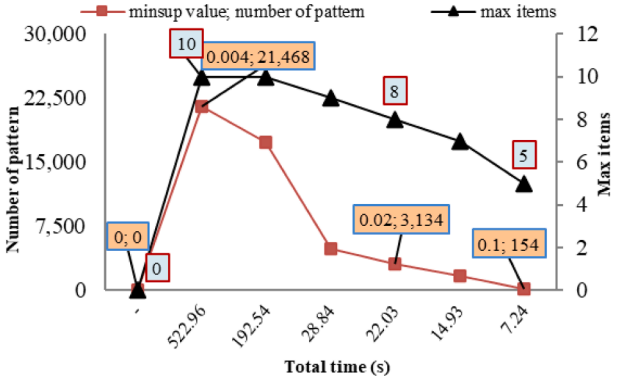

Fig. 7. The determination of best minsup value for "Sectio CB: Total of Nace Rev.2: 13, 14 and 15" $n_{others\ excluded}$ = 42,040). Note: out of memory error for minsup = 0.

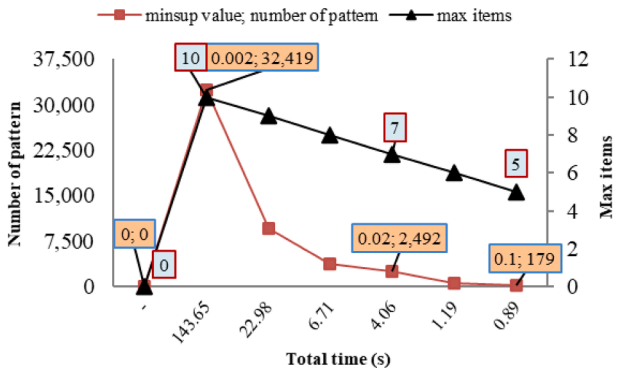

Fig. 8. The determination of best minsup value for "Sectio CC: Total of Nace Rev.2: 16, 17 and 18" ($n_{others\ excluded}$ = 13,826). Note: out of memory error for minsup = 0.

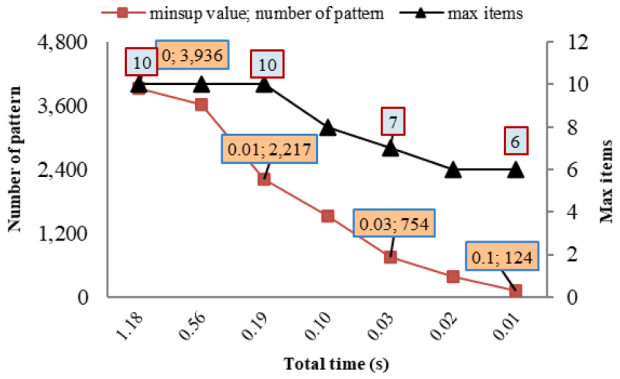

Fig. 9. The determination of best minsup value for "Sectio CD: Total of Nace Rev.2: 19" ($n_{others\ excluded}$ = 350).

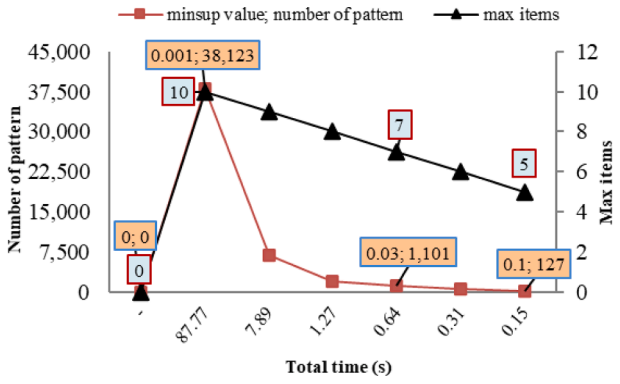

Fig. 10. The determination of best minsup value for "Sectio CE: Total of Nace Rev.2: 20" ($n_{others\ excluded}$ = 4,936). Note: out of memory error for minsup = 0.

Ratnasingam et al., 2012), work accidents were analyzed using statistical methods, and high-risk factors that were effective on accidents were determined. Studies that analyzed information gathered via the questionnaire method indicated Management commitments (MCs) are one of the most important factors in ensuring occupational safety (Berhan, 2020b), in Addis Abeba, Ethiopia, production workers in the iron, steel, and metal fabrication industries are most vulnerable to fracture, dislocation, abrasion, suffocation, and burn injuries; small businesses are especially vulnerable to accidents (Berhan, 2020a), OHSAS18001-certified manufacturing companies in Iran have lower accident rates (Ghahramani and Salminen, 2019), according to research conducted in the Chinese manufacturing industry, employees play a critical role in pressuring employers to improve occupational health and safety (Yang et al., 2019) and according to a study conducted in the wooden furniture industry in Malaysia, Thailand, Indonesia, and Vietnam, contract workers have fewer accidents and a more positive attitude toward their work than local workers (Ratnasingam et al., 2012).

There were also studies that looked at occupational accident cases in the manufacturing industry. Takahashi and Miura (2016) has included the manufacturing and construction industries in the high-risk sectors group in its study, which examines the risk group of sectors while taking the age of the victim and the type of accident into account. Berhan (2020a) emphasized the importance of both employee awareness and policymaker intervention in reducing occupational accidents and

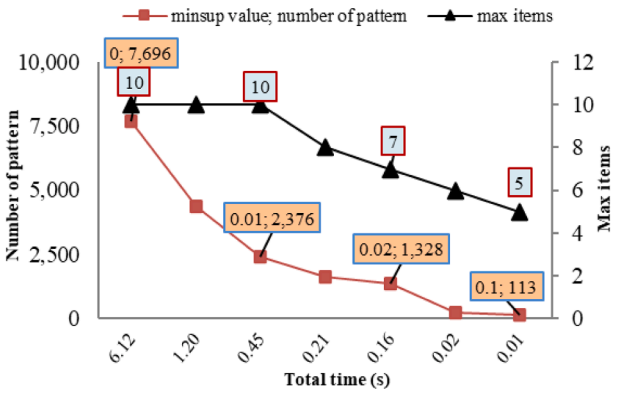

Fig. 11. The determination of best minsup value for "Sectio CF: Total of Nace Rev.2: 21" ($n_{others\ excluded}$ = 741).

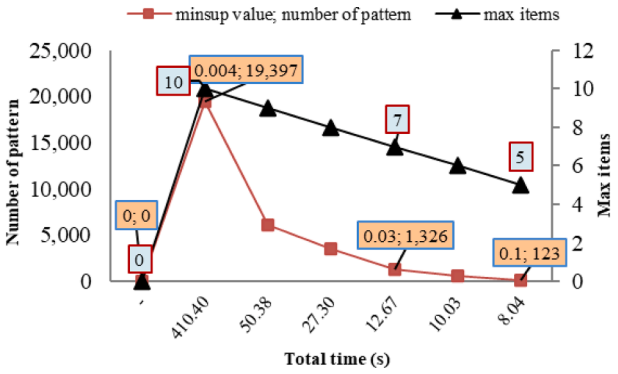

Fig. 12. The determination of best minsup value for "Sectio CG: Total of Nace Rev.2: 22 and 23" ($n_{others\ excluded}$ = 44,582). Note: out of memory error for minsup = 0.

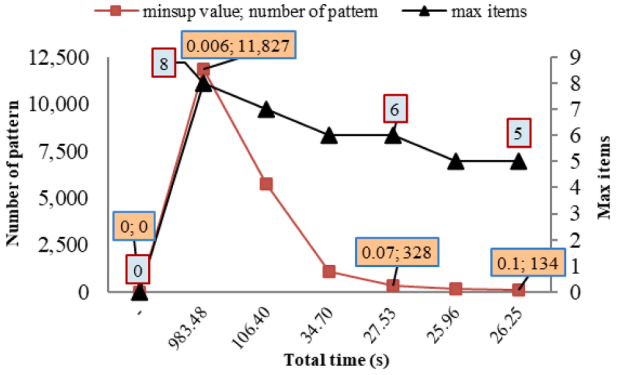

Fig. 13. The determination of best minsup value for "Sectio CH: Total of Nace Rev.2: 24 and 25" ($n_{others\ excluded}$ = 82,452). Note: out of memory error for minsup = 0.

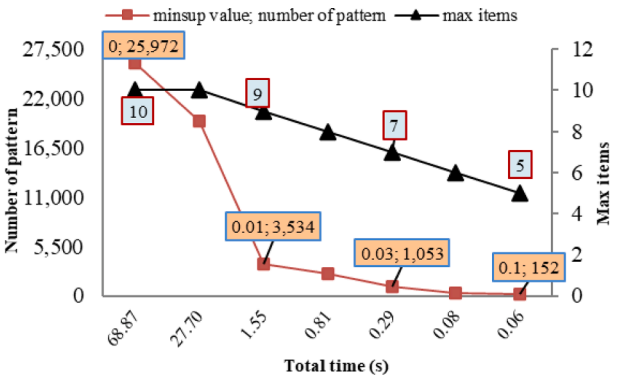

Fig. 14. The determination of best minsup value for "CI: Total of Nace Rev.2: 26" ($n_{others\ excluded}$ = 2,412).

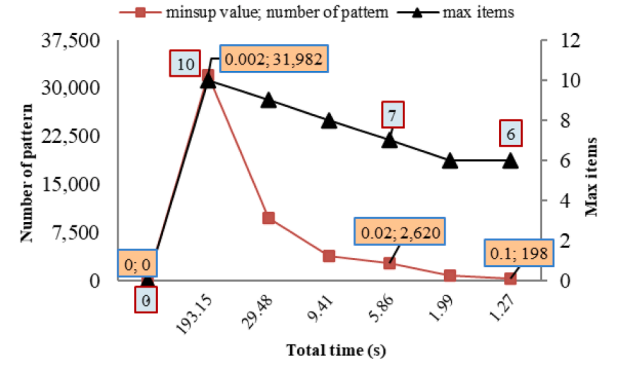

Fig. 15. The determination of best minsup value for "Sectio CJ: Total of Nace Rev.2: 27" ($n_{others\ excluded}$ = 17,352). Note: out of memory error for minsup = 0.

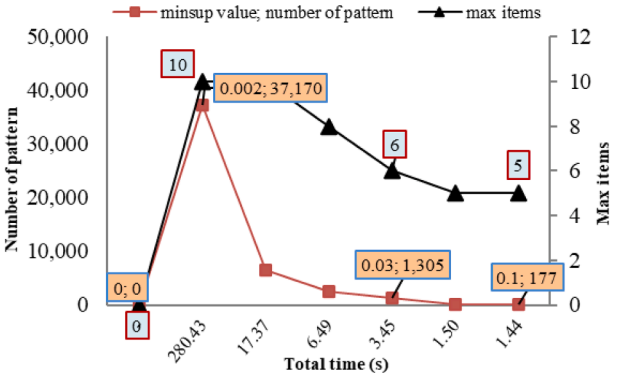

Fig. 16. The determination of best minsup value for "CK: Total of Nace Rev.2: 28" ($n_{others\ excluded}$ = 18,908). Note: out of memory error for minsup = 0.

injuries in the iron, steel, and metal fabrication industry. Yang and Jeong (2019) examined 1,530 occupational accidents in the automobile industry in South Korea and the United States and discovered that 17.7% of the accidents occurred in manual materials handling (MMH) jobs and 82.3% in non-MMH jobs and MMH jobs. Furthermore, compared to non-MHM, revealed that types of sprain and herniated discs, as well as in the injured part of the trunk/back, leg/foot, and shoulder injuries were more common. Yang et al. (2019) examined 120 safety accidents in the Chinese manufacturing industry from 2009 to 2016 and found that the magnitude of the accident decreased as the company's technical innovation initiatives within the scope of R&D increased, and the employee did not show any quit behavior. As a result, investments made to improve occupational safety support employee safety and contribute to the development of occupational safety. Lezama et al. (2018) used multivariate statistics and generalized linear models methods on work accidents in the electric power production, cement production, and oil refining sectors. In another study, Katsakiori et al. (2010) used LISREL structural equation modeling to analyze 40 occupational accidents in the 9 divisions of the manufacturing industry in the EastAttica region of Greece between 2000 and 2008, confirming the relationship between work design and training as well as the provision of unsafe equipment and determining that the employee was involved. Concurrently, Katsakiori et al. (2010) discovered that workers in the 26–35 age group (42.5%) and workers in the worker status (57.5%) were the most vulnerable to occupational accidents. Heinrich (1986) determined that

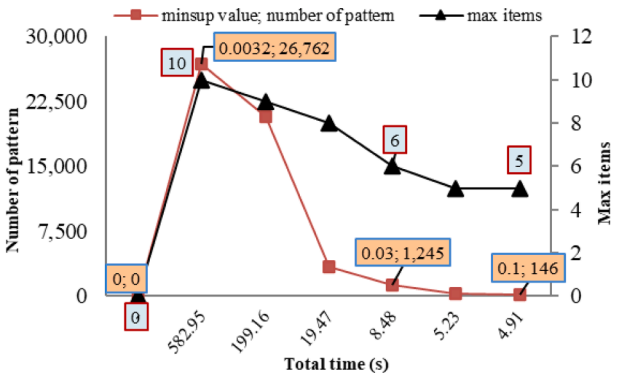

Fig. 17. The determination of best minsup value for "CL: Total of Nace Rev.2: 29 and 30" ($n_{others\ excluded}$ = 33,838). Note: out of memory error for minsup = 0.

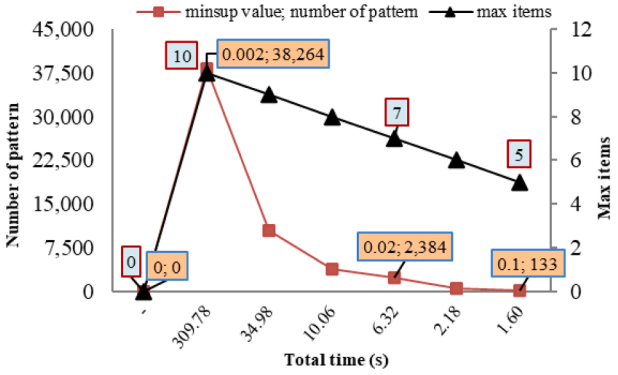

Fig. 18. The determination of best minsup value for "CM: Total of Nace Rev.2: 31, 32 and 33" ($n_{others\ excluded}$ = 19,355). Note: out of memory error for minsup = 0.

88% of accidents were caused by dangerous behaviors since analyzing accident statistics. Employees are more likely to engage in risky behavior in the workplace due to the complexity of human–machine interaction (Dhalmahapatra et al., 2019). According to the accident involvement theory, people who are prone to accidents should not be employed in dangerous work (Kjellén, 2000, p.32).

It is vital to use data mining approaches to discover the association, relationship, valuable information, and rules of data that can help make the right decisions in the development of a health, safety, and environmental management system (Wu et al., 2019). Data mining approaches have also been used in the analysis of occupational accidents in the manufacturing industry, as according research. Singh and Maiti (2020) proposed a new data mining approach for determining high-risk accident paths based on 612 accident records from the steel manufacturing industry. Mutlu and Altuntas (2019) used data mining approaches to analyze 242,537 occupational accident records in the Turkish manufacturing industry from 2013 to 2016 and discovered five factors that had a 92.40% effect on the accident type: material (the equipment used during the accident), special activity, general activity, place (department where the accident occurred), and profession. Dhalmahapatra et al. (2019) used the decision tree (DT) to analyze the accidents that occurred in Electrical Overhead Traveling (EOT) cranes in manufacturing industries between 2014 and 2016, and discovered that the majority of the accidents occurred during the weekend (Saturday, Sunday), construction and maintenance activities. Altunkaynak (2018) applied attribute evaluater and association rule mining approaches to analyze 37,735 occupational accident cases in the Turkish manufacturing industry in 2012, and found that the five most influential factors on the type of accident were sector, size, age, experience, and hour day. According to Palamara et al. (2011), using the Kohonen's Self-Organizing Map and the k-means clustering algorithm approaches to analyze 1,207 accident records from 2002 to 2004 in the wood industry operating in Italy, the most common accident in the wood industry working with tools/"loss of control/contact with sharp/pointed/abrasive parts" has determined that accidents occur due to incorrect movement deviation while working with machines, and due to loss of control deviation. Haibo and Zhi (2019) proposed an intelligent early-warning method based on the DBSCAN clustering method, one of the data mining approaches used in the oil and gas industry to prevent drilling overflow accidents, and achieved successful results in preventing accidents. Fernandes and Garcia (2012, November) used the association rules approach to analyze accident records in the petroleum industry. Bevilacqua et al. (2008) used the CART (Classification And Regression Trees) method to analyze 200 accident cases in the API refinery from 1994 to 2004 and made rules induction including ergonomic, management, and operational parameters that cause high accident risk.

Studies in the manufacturing industry where accident theories are applied focused on problems such as accident investigation and increasing the efficiency of the production system. Alayyannur et al. (2022) examined relation between OHS policy and individual commitment using ILCI loss causation model in informal metal industry. Hosseinpouri et al. (2022) used Tripod beta ve Tripod delta to ecamine aciddents in a manufacturing compony. In addition, Shafiei et al. (2021) performed Tripod beta method to examine occupational accidents for a vehicle manufacturing company. Ahmadi et al. (2021) utilized Tripod method based on swiss cheese model to examine occupational accidents for oil and gas industries. In another study, Baldissone et al. (2019) examined occupational accidents occured in automotive production using Human Factors Analysis And Classificaiton Systems (HFACS). Sousa et al. (2017) benefited from lean philosophy and system Theoretic Accident Model And Processes (STAMP) to obtain information that helps increase the efficiency of the production system.

The number of studies in the literature that consider the sequence of events leading up to the accident's occurrence is extremely limited. In fact, the manufacturing industry contains 24 divisions by code Nace Rev 2. The division examined in the literature is also small in number and

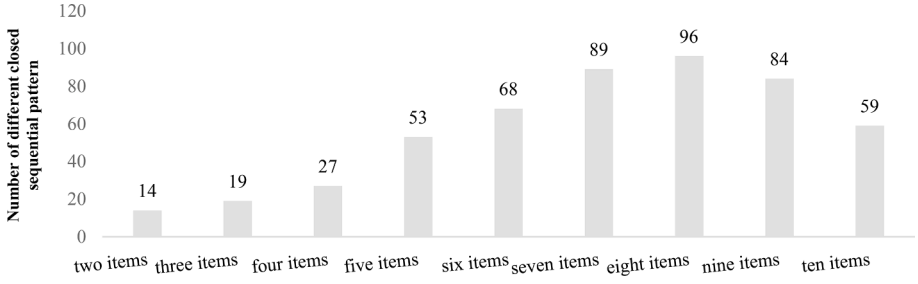

Fig. 19. Number of different accident closed sequential pattern with two, three, four, five, six, seven, eight, nine and ten items in the first ten accident closed sequential pattern of each one section ($n_{others\ excluded}$ = 307,594).

Table 9
The first three accident sequences pattern with two, three, four, five, six and seven items for each section: support ($n_{others\ excluded}$ = 307,594).

Sequences	Support value												
	CA[a]	CB[b]	CC[c]	CD[d]	CE[e]	CF[f]	CG[g]	CH[h]	CI[i]	CJ[j]	CK[k]	CL[l]	CM[m]
a_{01}-b_{011}	84.69%	92.95%	89.50%	84.00%	86.57%	83.94%	87.56%	90.84%	90.80%	93.29%	91.72%	88.21%	75.88%
a_{01}-c_{11}	80.37%	86.82%	81.72%	71.14%	77.80%	73.14%	81.54%	85.68%	83.54%	89.75%	87.44%	86.75%	75.07%
b_{011}-c_{11}	76.46%	86.45%	80.46%	71.43%	76.11%	72.60%	80.88%	85.27%	82.09%	89.55%	88.30%	83.87%	71.58%
a_{01}-b_{011}-c_{11}	74.97%	85.23%	79.43%	68.57%	74.96%	71.39%	79.44%	83.64%	81.47%	88.37%	86.04%	82.35%	69.67%
a_{01}-b_{011}-1_{011}	47.85%	60.83%	–	–	–	53.71%	51.84%	–	–	59.27%	56.65%	54.78%	49.00%
a_{01}-c_{11}-1_{011}	46.73%	57.79%	–	–	–	–	–	–	–	57.56%	–	–	48.81%
a_{01}-b_{011}-j_{20}	–	–	59.18%	48.29%	60.03%	48.45%	54.70%	64.54%	–	–	58.93%	54.12%	–
a_{01}-c_{11}-j_{20}	–	–	54.18%	39.43%	54.48%	–	–	60.78%	–	–	–	–	–
a_{01}-b_{011}-j_{00}	–	–	–	–	–	–	–	–	67.79%	–	–	–	–
a_{01}-c_{11}-j_{00}	–	–	–	–	–	–	–	–	62.11%	–	–	–	–
a_{01}-b_{011}-c_{11}-1_{011}	42.94%	56.81%	47.22%	26.00%	44.41%	46.96%	47.62%	51.73%	43.20%	56.67%	53.79%	51.65%	45.65%
a_{01}-b_{011}-c_{11}-j_{00}	41.34%	39.48%	–	31.43%	–	28.21%	–	–	60.78%	49.52%	–	–	–
a_{01}-b_{011}-c_{11}-j_{20}	33.20%	45.44%	52.86%	37.14%	52.43%	42.78%	49.52%	59.43%	–	38.53%	54.96%	50.50%	42.90%
a_{01}-b_{011}-1_{011}-j_{20}	–	–	33.49%	–	34.28%	–	31.16%	37.58%	–	–	34.13%	32.40%	28.55%
a_{01}-b_{011}-1_{011}-j_{00}	–	–	–	–	–	–	–	–	34.58%	–	–	–	–
a_{01}-b_{011}-c_{11}-1_{011}-j_{00}	25.04%	28.51%	17.06%	–	13.96%	22.94%	18.97%	16.49%	31.51%	33.09%	21.44%	20.98%	18.92%
a_{01}-b_{011}-c_{11}-1_{011}-j_{20}	17.85%	28.24%	30.09%	–	30.43%	24.02%	28.60%	35.16%	–	23.54%	32.26%	30.63%	26.70%
a_{01}-c_{11}-$e_{06.02}$-g_{51}-$h_{06.02}$	11.34%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-f_{64}-1_{011}	–	12.15%	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-g_{63}-j_{20}	–	–	11.65%	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-$h_{00.01}$	–	–	–	16.86%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-j_{00}	–	–	–	15.14%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$h_{00.01}$-j_{00}	–	–	–	14.86%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-j_{20}	–	–	–	–	9.58%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.16}$-$h_{10.16}$	–	–	–	–	–	12.01%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-g_{51}-1_{011}	–	–	–	–	–	–	10.00%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-g_{53}-1_{011}	–	–	–	–	–	–	–	12.09%	–	–	–	10.80%	–
a_{01}-b_{011}-c_{11}-1_{032}-j_{00}	–	–	–	–	–	–	–	–	19.32%	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-j_{00}	–	–	–	–	–	–	–	–	18.03%	14.33%	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-j_{20}	–	–	–	–	–	–	–	–	–	–	11.57%	–	–
a_{01}-b_{011}-c_{11}-f_{43}-1_{011}	–	–	–	–	–	–	–	–	–	–	–	–	12.69%
a_{01}-b_{011}-c_{11}-$e_{06.02}$-g_{51}-$h_{06.02}$	10.05%	6.63%	–	–	–	–	–	–	–	–	–	–	–
a_{01}-c_{11}-$e_{06.02}$-g_{51}-$h_{06.02}$-1_{011}	7.58%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-c_{11}-d_{21}-$e_{06.02}$-g_{51}-$h_{06.02}$	7.16%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-f_{64}-1_{011}-j_{20}	–	6.31%	–	–	6.62%	–	5.34%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-g_{51}-1_{011}-j_{00}	–	6.03%	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-g_{51}-1_{011}-j_{20}	–	–	6.91%	–	–	–	6.04%	–	–	–	–	–	6.84%
a_{01}-b_{011}-c_{11}-g_{63}-1_{011}-j_{20}	–	–	6.34%	–	–	–	4.93%	5.25%	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.06}$-$h_{10.06}$-j_{20}	–	–	5.83%	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-$h_{00.01}$-j_{00}	–	–	–	13.14%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}- $e_{00.01}$- $h_{00.01}$-1_{011}	–	–	–	5.71%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}- $e_{00.01}$-1_{011}-j_{00}	–	–	–	5.71%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{11}-1_{011}-j_{20}	–	–	–	–	5.35%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-1_{011}-j_{20}	–	–	–	–	5.35%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.16}$-$h_{10.16}$-1_{011}	–	–	–	–	–	9.18%	–	–	–	–	–	–	–

[a]Support value for minsup = 0.003, [b]Support value for minsup = 0.004, [c]Support value for minsup = 0.002, [d]Support value for minsup = 0.000, [e]Support value for minsup = 0.001, [f]Support value for minsup = 0.000, [g]Support value for minsup = 0.004, [h]Support value for minsup = 0.006, [i]Support value for minsup = 0.000, [j]Support value for minsup = 0.002, [k]Support value for minsup = 0.002, [l]Support value for minsup = 0.0032, [m]Support value for minsup = 0.002.

provides little information about the field. To help fill this gap in the literature, we used occupational accident records from 24 divisions in the Turkish manufacturing industry from 2013 to 2019. The most common sequential accident patterns have been obtained using the sequential pattern mining approach based on the CloFast algorithm, taking into account the sequence of events that caused the accident to occur. The findings are thought to provide an opportunity for occupational safety professionals to review and improve precautionary measures.

3. The accident sequences model

Accident models are essential in accident investigations and in gathering information for the design of the safety management system (Kjellen and Albrechtsen, 2017, p.25). Furthermore, accident models are important for risk assessment in terms of preventing dangerous deviations that lead to accidents and similar accidents in the future, as well as assisting in the identification of the risks causing the accident (Leveson, 2004). Kjellen and Albrechtsen (2017, p.27) classified accident models into six categories: causal-sequence models, process models, energy models, logic tree models, system models, and cognitive models. In this study, accident records were converted into accident sequence using the European Statistics on Accident at Work (ESAW) occupational accident model, which takes the form of a three-phase accident chain, as in Hola and Szóstak's (2019) study (Eurostat European Commission, 2013). Fig. 2 shows the accident chain and the variables it includes. Phase 1: Pre-accident phase includes five variables that make up the accident chain, Phase 2: Accident phase includes three variables that make up the second phase of the accident chain, and Phase 3: Post-accident phase includes two variables that make up the third part of the accident chain. The variables that contain the accident sequence are as follows:

- **Workstation:** usual or, alternatively, occasional nature of the job /post the victim held at the time of the accident.

Table 10
The first three accident sequences pattern with six, seven, eight and nine items for each section: support ($n_{others\ excluded} = 307{,}594$).

Sequences	Support value												
	CA[a]	CB[b]	CC[c]	CD[d]	CE[e]	CF[f]	CG[g]	CH[h]	CI[i]	CJ[j]	CK[k]	CL[l]	CM[m]
a_{01}-b_{011}-c_{11}-$e_{10.16}$-$h_{10.16}$-j_{20}	–	–	–	–	–	6.34%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.16}$-$h_{10.16}$-j_{00}	–	–	–	–	–	5.67%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-g_{53}-i_{011}-j_{20}	–	–	–	–	–	–	–	7.81%	–	–	6.74%	6.60%	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-i_{011}-j_{20}	–	–	–	–	–	–	–	5.23%	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-i_{011}-j_{00}	–	–	–	–	–	–	–	–	9.16%	10.13%	–	–	–
a_{01}-b_{011}-c_{11}-$e_{14.05}$-$h_{14.05}$-j_{00}	–	–	–	–	–	–	–	–	8.87%	–	–	–	–
a_{01}-b_{011}-c_{11}-f_{44}-i_{011}-j_{00}	–	–	–	–	–	–	–	–	7.09%	8.82%	–	–	–
a_{01}-b_{011}-c_{11}-g_{53}-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	7.39%	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-i_{011}-j_{20}	–	–	–	–	–	–	–	–	–	–	7.05%	5.78%	5.95%
a_{01}-b_{011}-c_{11}-f_{43}-i_{011}-j_{20}	–	–	–	–	–	–	–	–	–	–	6.60%	5.28%	7.04%
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-g_{51}-$h_{06.02}$	6.67%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{06.02}$-g_{51}-$h_{06.02}$-i_{011}	6.42%	5.06%	2.56%	–	3.40%	–	3.29%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$	6.11%	3.81%	–	–	–	–	2.88%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{06.02}$-g_{51}-$h_{06.02}$-j_{20}	–	3.45%	2.50%	–	2.86%	–	2.93%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.06}$-$h_{10.06}$-i_{011}-j_{20}	–	–	3.50%	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-f_{64}-$h_{00.01}$-j_{00}	–	–	–	4.57%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-$h_{00.01}$-i_{011}-j_{00}	–	–	–	4.29%	–	–	–	–	–	–	–	2.75%	–
a_{01}-b_{011}-c_{11}-d_{61}-$e_{00.01}$-$h_{00.01}$-j_{00}	–	–	–	3.43%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{09.99}$-$h_{09.99}$-i_{011}-j_{20}	–	–	–	–	2.78%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.16}$-$h_{10.16}$-i_{011}-j_{00}	–	–	–	–	–	5.26%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.16}$-$h_{10.16}$-i_{011}-j_{20}	–	–	–	–	–	3.91%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{13}-$e_{10.16}$-$h_{10.16}$-i_{011}	–	–	–	–	–	3.64%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-$h_{00.01}$-i_{011}-j_{20}	–	–	–	–	–	–	–	2.89%	–	–	2.34%	–	–
a_{01}-b_{011}-c_{11}-$e_{14.99}$-$h_{14.99}$-i_{011}-j_{20}	–	–	–	–	–	–	–	2.41%	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{14.03}$-$h_{14.03}$-i_{011}-j_{20}	–	–	–	–	–	–	–	1.75%	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{14.05}$-$h_{14.05}$-i_{032}-j_{00}	–	–	–	–	–	–	–	–	5.22%	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.05}$-$h_{14.05}$-j_{00}	–	–	–	–	–	–	–	–	3.90%	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-f_{44}-i_{011}-j_{00}	–	–	–	–	–	–	–	–	3.52%	4.01%	–	–	–
a_{01}-b_{011}-c_{11}-$e_{14.05}$-$h_{14.05}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	3.26%	–	–	–
a_{01}-b_{011}-c_{11}-$e_{14.12}$-$h_{14.12}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	3.26%	2.42%	–	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{00.01}$-f_{71}-$h_{00.01}$	–	–	–	–	–	–	–	–	–	–	–	2.51%	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{00.01}$-$h_{00.01}$-j_{00}	–	–	–	–	–	–	–	–	–	–	–	2.44%	–
a_{01}-b_{011}-c_{11}-d_{21}-f_{43}-i_{011}-j_{20}	–	–	–	–	–	–	–	–	–	–	2.98%	–	3.22%
a_{01}-b_{011}-c_{11}-d_{21}-f_{43}-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	–	–	–	2.69%
a_{01}-b_{011}-c_{11}-f_{43}-g_{51}-i_{011}-j_{20}	–	–	–	–	–	–	–	–	–	–	–	–	2.51%
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$	4.53%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-g_{51}-$h_{06.02}$-i_{011}	4.50%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-g_{51}-$h_{06.02}$-j_{00}	4.22%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-i_{011}	–	2.86%	1.42%	–	1.92%	–	1.84%	–	–	–	–	–	1.42%
a_{01}-b_{011}-c_{11}-$e_{06.02}$-g_{51}-$h_{06.02}$-i_{011}-j_{00}	–	2.60%	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{06.02}$-g_{51}-$h_{06.02}$-i_{011}-j_{20}	–	2.45%	1.84%	–	2.13%	–	2.01%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-j_{20}	–	–	1.47%	–	–	–	1.71%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-f_{51}-$h_{00.01}$-i_{011}-j_{00}	–	–	–	2.00%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{61}-$e_{00.01}$-f_{64}-$h_{00.01}$-j_{00}	–	–	–	1.71%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{70}-g_{15}-$h_{00.01}$-i_{071}-j_{00}	–	–	–	1.71%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{09.99}$-$h_{09.99}$-i_{011}-j_{20}	–	–	–	–	1.99%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{13}-$e_{10.16}$-g_{63}-$h_{10.16}$-j_{20}	–	–	–	–	–	1.89%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{13}-$e_{10.16}$-$h_{10.16}$-i_{011}-j_{20}	–	–	–	–	–	1.89%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{13}-$e_{10.16}$-$h_{10.16}$-i_{011}-j_{00}	–	–	–	–	–	1.75%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{14.99}$-f_{44}-$h_{14.99}$-i_{011}-j_{20}	–	–	–	–	–	–	–	0.82%	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{14.99}$-g_{53}-$h_{14.99}$-i_{011}-j_{20}	–	–	–	–	–	–	–	0.80%	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-f_{64}-$h_{00.01}$-i_{011}-j_{20}	–	–	–	–	–	–	–	0.76%	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.05}$-$h_{14.05}$-i_{032}-j_{00}	–	–	–	–	–	–	–	–	2.20%	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.05}$-$h_{14.05}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	1.62%	1.98%	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.12}$-$h_{14.12}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	1.62%	1.80%	2.04%	–	–
a_{01}-b_{011}-c_{11}-$e_{14.05}$-g_{51}-$h_{14.05}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	1.65%	–	–	–
a_{01}-b_{011}-c_{11}-$e_{14.12}$-g_{51}-$h_{14.12}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	–	1.99%	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.12}$-g_{51}-$h_{14.12}$-i_{011}	–	–	–	–	–	–	–	–	–	–	1.93%	–	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{00.01}$-f_{71}-$h_{00.01}$-j_{00}	–	–	–	–	–	–	–	–	–	–	–	2.18%	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{00.01}$-$h_{00.01}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	–	–	1.27%	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{00.01}$-f_{71}-$h_{00.01}$-i_{011}	–	–	–	–	–	–	–	–	–	–	–	1.22%	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.06}$-f_{43}-$h_{06.06}$-i_{011}	–	–	–	–	–	–	–	–	–	–	–	–	1.64%
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.06}$-g_{52}-$h_{06.06}$-i_{011}	–	–	–	–	–	–	–	–	–	–	–	–	1.44%
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-i_{011}	3.12%	1.46%	0.79%	–	0.95%	–	–	–	–	–	–	–	0.91%
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-g_{51}-$h_{06.02}$-i_{011}-j_{00}	2.97%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-j_{00}	2.88%	–	–	–	–	–	–	–	–	–	–	–	–

[a]Support value for minsup = 0.003, [b]Support value for minsup = 0.004, [c]Support value for minsup = 0.002, [d]Support value for minsup = 0.000, [e]Support value for minsup = 0.001, [f]Support value for minsup = 0.000, [g]Support value for minsup = 0.004, [h]Support value for minsup = 0.006, [i]Support value for minsup = 0.000, [j]Support value for minsup = 0.002, [k]Support value for minsup = 0.002, [l]Support value for minsup = 0.0032, [m]Support value for minsup = 0.002.

Table 11
The first three accident sequences pattern with nine and ten items for each section: support ($n_{others\ excluded} = 307{,}594$).

Sequences	Support value												
	CA[a]	CB[b]	CC[c]	CD[d]	CE[e]	CF[f]	CG[g]	CH[h]	CI[i]	CJ[j]	CK[k]	CL[l]	CM[m]
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.99}$-f_{49}-$h_{06.99}$-i_{011}-j_{00}	–	1.76%	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-i_{011}-j_{20}	–	1.44%	1.04%	–	1.18%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-g_{51}-$h_{06.02}$-i_{011}-j_{20}	–	–	0.88%	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{00}-$e_{00.01}$-f_{51}-g_{00}-$h_{00.01}$-i_{011}	–	–	–	1.14%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{61}-$e_{00.01}$-f_{51}-g_{31}-i_{011}-j_{00}	–	–	–	1.14%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{00}-f_{14}-g_{23}-$h_{04.01}$-i_{079}-j_{20}	–	–	–	0.86%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{09.99}$-f_{49}-$h_{09.99}$-i_{011}-j_{20}	–	–	–	–	1.52%	–	–	–	–	–	–	–	–
a_{01}-b_{012}-c_{24}-d_{70}-$e_{00.01}$-f_{14}-g_{23}-i_{000}-j_{00}	–	–	–	–	–	1.21%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{13}-$e_{10.16}$-f_{41}-g_{63}-$h_{10.16}$-j_{20}	–	–	–	–	–	0.94%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{13}-$e_{10.16}$-g_{63}-$h_{10.16}$-i_{011}-j_{20}	–	–	–	–	–	0.81%	–	–	–	–	–	–	–
a_{01}-c_{11}-d_{21}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-i_{011}-j_{20}	–	–	–	–	–	–	0.63%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-i_{012}	–	–	–	–	–	–	0.57%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-i_{012}-j_{20}	–	–	–	–	–	–	0.61%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{14.03}$-f_{44}-g_{53}-$h_{14.03}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	1.24%	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.03}$-g_{53}-$h_{14.03}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	1.00%	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.03}$-f_{44}-$h_{14.03}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	0.91%	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.05}$-g_{51}-$h_{14.05}$-i_{011}-k_{00}	–	–	–	–	–	–	–	–	–	1.17%	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.12}$-f_{44}-$h_{14.12}$-i_{011}-k_{00}	–	–	–	–	–	–	–	–	–	0.93%	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.12}$-g_{51}-$h_{14.12}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	0.89%	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.12}$-f_{44}-$h_{14.12}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	–	1.85%	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.12}$-f_{44}-$h_{14.12}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	–	1.64%	–	–
a_{01}-b_{011}-c_{11}-$e_{14.12}$-f_{44}-g_{51}-$h_{14.12}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	–	1.63%	–	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{00.01}$-f_{71}-$h_{00.01}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	–	–	1.07%	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{00.01}$-f_{71}-$h_{00.01}$-i_{032}-j_{00}	–	–	–	–	–	–	–	–	–	–	–	0.72%	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{0.02}$-f_{43}-g_{51}-$h_{06.02}$-i_{011}	–	–	–	–	–	–	–	–	–	–	–	0.56%	0.00%
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.06}$-f_{43}-g_{52}-$h_{06.06}$-i_{011}	–	–	–	–	–	–	–	–	–	–	–	–	1.12%
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.06}$-f_{43}-$h_{06.06}$-i_{011}-j_{20}	–	–	–	–	–	–	–	–	–	–	–	–	0.89%
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-i_{011}-j_{00}	2.15%	0.71%	–	–	0.43%	–	0.45%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-i_{011}-j_{20}	0.97%	0.74%	0.54%	–	0.53%	–	0.62%	–	–	–	0.21%	0.35%	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-i_{012}-j_{00}	0.70%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{13}-$e_{10.15}$-f_{41}-g_{52}-$h_{10.15}$-i_{011}-j_{00}	–	0.53%	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.06}$-f_{43}-g_{52}-$h_{06.06}$-i_{011}-j_{20}	–	–	0.26%	–	–	–	–	–	–	–	–	–	0.58%
a_{01}-b_{011}-c_{11}-d_{11}-$e_{10.06}$-f_{41}-g_{63}-$h_{10.06}$-i_{011}-j_{20}	–	–	0.25%	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{70}-$e_{15.02}$-f_{24}-g_{15}-$h_{00.01}$-i_{071}-j_{00}	–	–	–	1.14%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{00}-d_{00}-$e_{00.02}$-f_{13}-g_{13}-$h_{15.04}$-i_{062}-j_{20}	–	–	–	0.86%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{00}-$e_{00.01}$-f_{51}-g_{00}-$h_{00.01}$-i_{011}-j_{00}	–	–	–	0.86%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{09.99}$-f_{49}-g_{63}-$h_{09.99}$-i_{011}-j_{20}	–	–	–	–	0.59%	–	–	–	–	–	–	–	–
a_{01}-b_{012}-c_{24}-d_{70}-$e_{00.01}$-f_{14}-g_{23}-$h_{00.01}$-i_{000}-j_{00}	–	–	–	–	–	1.08%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{12}-$e_{10.16}$-f_{41}-g_{63}-$h_{10.16}$-i_{011}-j_{00}	–	–	–	–	–	0.54%	–	–	–	–	–	–	–
a_{02}-b_{061}-c_{61}-d_{70}-$e_{12.02}$-f_{42}-g_{45}-$h_{12.02}$-i_{011}-j_{20}	–	–	–	–	–	0.54%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.03}$-f_{44}-g_{53}-$h_{14.03}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	0.87%	0.39%	–	–	–
a_{01}-b_{011}-c_{11}-d_{51}-$e_{14.05}$-f_{71}-g_{71}-$h_{14.05}$-i_{032}-j_{00}	–	–	–	–	–	–	–	–	0.66%	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.05}$-f_{72}-g_{51}-$h_{14.05}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	0.33%	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{42}-$e_{14.01}$-f_{44}-g_{53}-$h_{14.01}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	0.49%	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.05}$-f_{44}-g_{51}-$h_{14.05}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	0.31%	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.12}$-f_{44}-g_{51}-$h_{14.12}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	–	1.52%	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.06}$-f_{43}-g_{53}-$h_{06.06}$-i_{011}-j_{20}	–	–	–	–	–	–	–	–	–	–	0.37%	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-i_{011}-j_{20}	–	–	–	–	–	–	–	–	–	–	–	–	0.57%
a_{01}-b_{011}-c_{11}-d_{22}-$e_{07.06}$-f_{43}-g_{52}-$h_{07.06}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	–	–	–	0.55%

[a]Support value for minsup = 0.003, [b]Support value for minsup = 0.004, [c]Support value for minsup = 0.002, [d]Support value for minsup = 0.000, [e]Support value for minsup = 0.001, [f]Support value for minsup = 0.000, [g]Support value for minsup = 0.004, [h]Support value for minsup = 0.006, [i]Support value for minsup = 0.000, [j]Support value for minsup = 0.002, [k]Support value for minsup = 0.002, [l]Support value for minsup = 0.0032, [m]Support value for minsup = 0.002.

- **Working Environment:** the workplace, work premises or general environment where the accident happened.
- **Working Process:** main type of work or task (general activity) being performed by the victim at the time of the accident.
- **Special Physical Activity:** the victim's exact 'Specific Physical Activity' at the instant of the accident, i.e. what exactly the victim was doing at the exact time of the accident.
- **Material Agent-Specific Physical Activity:** the tool, object, or instrument being used by the victim when the accident happened, just before the accident.
- **Material Agent-Contact Mode of Injury:** the object, tool or instrument with which the victim came into contact or the psychological mode of injury.
- **Deviation:** last event differing from the norm and leading to the accident.
- **Contact Mode of Injury:** the contact that injured the victim.
- **Type of injury:** 'physical consequences for the victim' e.g. bone fracture, wounds etc.
- **The severity of injury:** accident severity type.

Tables 14-19 in the appendix provide detailed information on the variables. Furthermore, it was discovered in our study that the Turkish manufacturing industry determined material (material agent-special physical activity and material agent-contact mode of injury), special activity (special physical activity), general activity (working process), and place (working environment), which are all accident sequence components. It has a significant impact on the type of workplace accident that occurs (Mutlu and Altuntas, 2019).

Table 12
The most common accident patterns and sections with two to ten items.

Section	Accident sequences pattern with two items	Support value
CJ: manufacture of electrical equipment	***Workstation-working enviroment:*** usual workstation or within the usual local unit of work-production area, factory, workshop	93.29%
	Accident sequences pattern with three items	**Support value**
	Workstation-working enviroment-working process: usual workstation or within the usual local unit of work-production area, factory, workshop-Production, manufacturing, processing (all types)	88.37%
	Accident sequences pattern with five items	**Support value**
	Workstation-working enviroment -working process-type of injury-the severity of injury: usual workstation or within the usual local unit of work-production area, factory, workshop-Production, manufacturing, processing (all types)-superficial injuries-no incapacity	33.09%
Section	**Accident sequences pattern with four items**	**Support value**
CB: manufacture of textiles, apparel, leather and related products	***Workstation-working enviroment -working process- type of injury:*** usual workstation or within the usual local unit of work-production area, factory, workshop-production, manufacturing, processing (all types)-superficial injuries	56.81%
Section	**Accident sequences pattern with six items**	**Support value**
CA: manufacture of food products, beverages and tobacco products	***Workstation-working enviroment -working process-material agent (specific physical activity)-contact mode of injury-material agent (contact mode of injury):*** usual workstation or within the usual local unit of work-production area, factory, workshop-production, manufacturing, processing/all types-hand tools, not powered/for cutting, separating (including scissors, shears, secateurs)-contact with sharp material agent (knife, blade etc.)-hand tools, not powered/for cutting, separating (including scissors, shears, secateurs)	10.05%
	Accident sequences pattern with seven items	**Support value**
	Workstation-working enviroment -working process-specific physical activity- material agent (specific physical activity)-contact mode of injury-material agent (contact mode of injury): usual workstation or within the usual local unit of work-production area, factory, workshop- production, manufacturing, processing/all types -held tools (manual)-hand tools, not powered/for cutting, separating (including scissors, shears, secateurs)-contact with sharp material agent (knife, blade etc.)-hand tools, not powere/for cutting, separating (including scissors, shears, secateurs)	6.68%
	Accident sequences pattern with eight items	**Support value**
	Workstation-working enviroment-working process-specific physical activity- material agent (specific physical activity)-deviation- contact mode of injury-material agent (contact mode of injury): usual workstation or within the usual local unit of work-production area, factory, workshop-production, manufacturing, processing–all types-Working with hand-held tools (manual)- hand tools, not powered -for cutting, separating (including scissors, shears, secateurs)-loss of control (total or partial) of hand/held tool (motorised or not) or of the material being worked by the tool- contact with sharp material agent (knife, blade etc.)- hand tools, not powered -for cutting, separating (including scissors, shears, secateurs)-superficial injuries	4.50%
	Accident sequences pattern with nine items	**Support value**
	Workstation-working enviroment -working process-specific physical activity- material agent (specific physical activity)-deviation- contact mode of injury-material agent (contact mode of injury)-type of injury: usual workstation or within the usual local unit of work-production area, factory, workshop-production, manufacturing, processing(all types)- working with hand-held tools (manual)- hand tools, not powered for cutting, separating (including scissors, shears, secateurs)-loss of control (total or partial) of hand/held tool (motorised or not) or of the material being worked by the tool- contact with sharp material agent (knife, blade etc.)- hand tools, not powered for cutting, separating (including scissors, shears, secateurs)-superficial injuries.	3.12%
	Accident sequences pattern with ten items	**Support value**
	Workstation-working enviroment -working process-specific physical activity- material agent (specific physical activity)-deviation-contact mode of injury-material agent (contact mode of injury)-type of injury-the severity of injury: usual workstation or within the usual local unit of work-production area, factory, workshop-production, manufacturing, processing (all types)- working with hand-held tools (manual)- hand tools, not powered for cutting, separating (including scissors, shears, secateurs)-loss of control (total or partial) of hand/held tool (motorised or not) or of the material being worked by the tool- contact with sharp material agent (knife, blade etc.)- hand tools, not powered for cutting, separating (including scissors, shears, secateurs)-superficial injuries-no incapacity.	2.15%

Table 13
The most common sequential accident patterns and sections resulting in injury.

Section	Accident sequences pattern with two items	Support value
CH: Manufacture of basic metals and fabricated metal products, except machinery and equipment	***Workstation-the severity of injury:*** usual workstation or within the usual local unit of work-injury.	67.78%
	Accident sequences pattern with three items	
	Workstation-working enviroment-the severity of injury usual workstation or within the usual local unit of work- production area, factory, workshop-injury.	64.54%
	Accident sequences pattern with four items	
	Workstation-working enviroment-type of injury-the severity of injury: usual workstation or within the usual local unit of work- production area, factory, workshop-superficial injuries-injury.	37.58%
	Accident sequences pattern with five items	
	Workstation-working enviroment -working process-type of injury-the severity of injury: usual workstation or within the usual local unit of work- production area, factory, workshop-production, manufacturing, processing (all types)-superficial injuries-injury.	35.16%
Section	**Accident sequences pattern with six items**	**Support value**
CE: manufacture of chemicals and chemical products	***Workstation-working enviroment -working process-deviation-type of injury-the severity of injury:*** usual workstation or within the usual local unit of work- production area, factory, workshop-production, manufacturing, processing (all types)-uncoordinated movements, spurious or untimely actions-uncoordinated movements, spurious or untimely actions-superficial injuries-injury.	6.62%
Section	**Accident sequences pattern with seven items**	**Support value**
CC: manufacture of wood and paper products, and printing	***Workstation-working enviroment -working process- material agent-specific physical activity- material agent-contact mode of injury-type of injury-the severity of injury:*** usual workstation or within the usual local unit of work- production area, factory, workshop-production, manufacturing, processing (all types)-machines for processing materials (other processes) -machines for processing materials (other processes)-superficial injuries-injury.	3.50%
Section	**Accident sequences pattern with eight items**	**Support value**
CB: manufacture of textiles, apparel, leather and related products	***Workstation-working enviroment -working process-material agent-specific physical activity- contact mode of injury-material agent contact mode of injury-type of injury-the severity of injury:*** usual workstation or within the usual local unit of work-production area, factory, workshop-production, manufacturing, processing (all types)-hand tools, not powered for cutting, separating (including scissors, shears, secateurs)-contact with sharp material agent (knife, blade etc.)- hand tools, not powered for cutting, separating (including scissors, shears, secateurs)-superficial injuries-injury.	2.45%
Section	**Accident sequences pattern with nine items**	**Support value**
CK: manufacture of machinery and equipment n.e.c	***Workstation-working enviroment-working process-specific physical activity-material agent-specific physical activity-deviation-material agent-contact mode of injury-type of injury-the severity of injury***: usual workstation or within the usual local unit of work- Production area, factory, workshop-production, manufacturing, processing (all types)-working with hand-held tools - manual -hand tools, not powered (for nailing, riveting stapling)-Loss of control (total or partial)-of hand-held tool (motorised or not) or of the material being worked by the tool -hand tools, not powered (for nailing, riveting stapling)-superficial injuries-injury.	6.63%
	Accident sequences pattern with ten items	**Support value**
	Workstation-working enviroment-working process-specific physical activity-material agent-specific physical activity-deviation-contact mode of injury- material agent-contact mode of injury-type of injury-the severity of injury: usual workstation or within the usual local unit of work- production area, factory, workshop-production, manufacturing, processing (all types)- working with hand/held tools (manual) -hand tools, not powered for nailing, riveting staplin- loss of control (total or partial) of hand-held tool (motorised or not) or of the material being worked by the tool-contact with hard or rough material agent- hand tools, not powered for nailing, riveting stapling -superficial injuries-injury.	2.90%

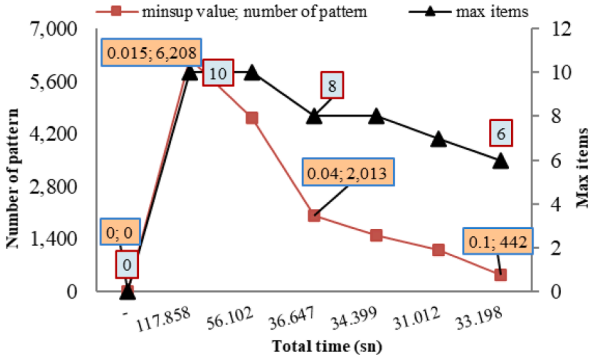

Fig. 20. The determination of best minsup value for "CA: Total of Nace Rev.2: 10, 11 and 12" ($n_{others\ included}$ = 119,695). Note: out of memory error for minsup = 0.

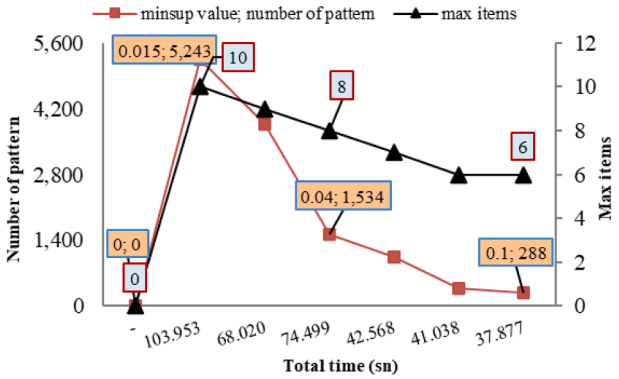

Fig. 21. The determination of best minsup value for "CB: Total of Nace Rev.2: 13, 14 and 15" ($n_{others\ included}$ = 139,092). Note: out of memory error for minsup = 0.

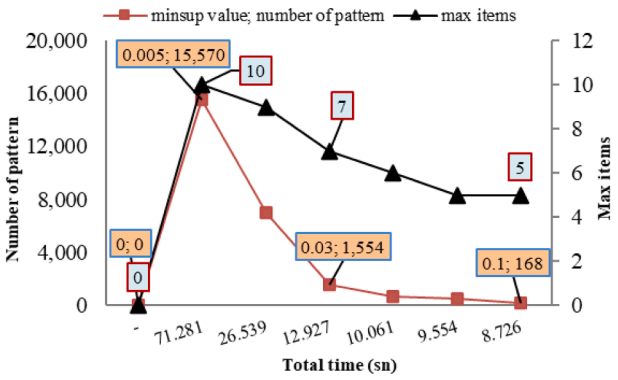

Fig. 22. The determination of best minsup value for "CC: Total of Nace Rev.2: 16, 17 and 18" ($n_{others\ included}$ = 45,453). Note: out of memory error for minsup = 0.

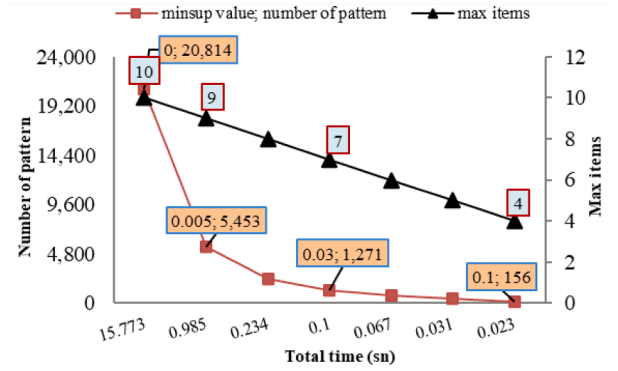

Fig. 23. The determination of best minsup value for "CD: Total of Nace Rev.2: 19" ($n_{others\ included}$ = 1,080).

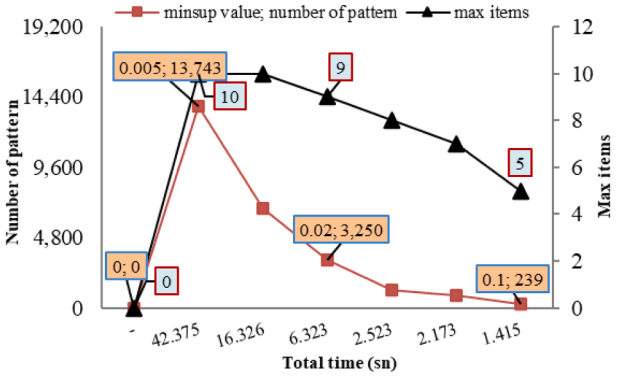

Fig. 24. The determination of best minsup value for "CE: Total of Nace Rev.2: 20" ($n_{others\ included}$ = 18,073). Note: out of memory error for minsup = 0.

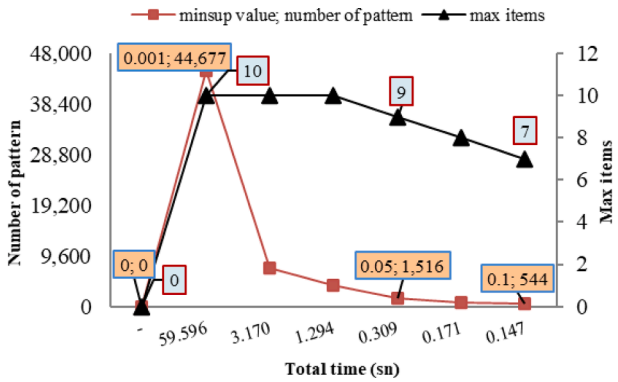

Fig. 25. The determination of best minsup value for "CF: Total of Nace Rev.2: 21" ($n_{others\ included}$ = 3,861). Note: out of memory error for minsup = 0.

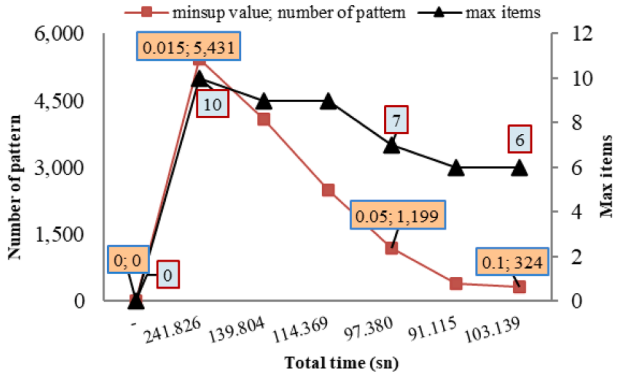

Fig. 26. The determination of best minsup value for "CG: Total of Nace Rev.2: 22 and 23" ($n_{others\ included}$ = 156,545). Note: out of memory error for minsup = 0.

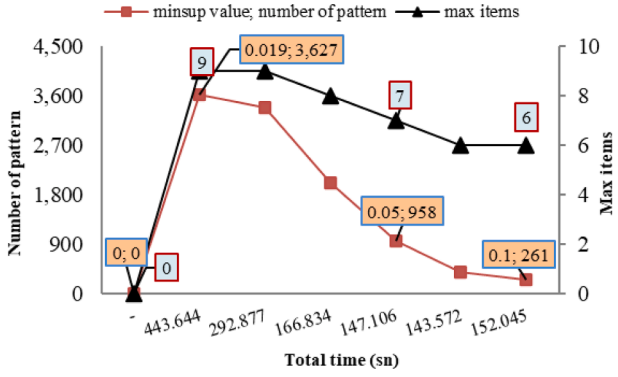

Fig. 27. The determination of best minsup value for "CH: Total of Nace Rev.2: 24 and 25" ($n_{others\ included}$ = 243,845). Note: out of memory error for minsup = 0.

4. Method and material

4.1. Work accidents data

The process proposed for the accident investigation paradigm by Huang et al. (2018) is considered in this study. According to the process, the first step is data acquisition, recording, and classification. In the first step, data obtained from various sources should be classified as text data, audio data, and video data. In the second step, unstructured data is cleaned for data extraction, and annotation. In the third step, data is analyzed with appropriate methods to reveal insights from security-related data within the scope of data modeling and analysis. The research depended on occupational data. Occupational accident records were obtained from Turkey Republic Social Security Institution (SSI) in 2020 through a special agreement. This study considered a number 995,503 occupational accident records defined by 22 observable variables experienced in the Turkish manufacturing industry between 2013 and 2019. According to Eurostat (2008), the accident records analyzed in the study cover 24 divisions and 13 sections of the manufacturing industry (see Table 2). The accident sequence shown in Fig. 1 was generated using the variables in Fig. 2. The input-process-output workflow of the study is given in Fig. 5. The input of this research is the occupational accident records. Data preprocessing, descriptive analysis, and sequential pattern mining are applied to occupational

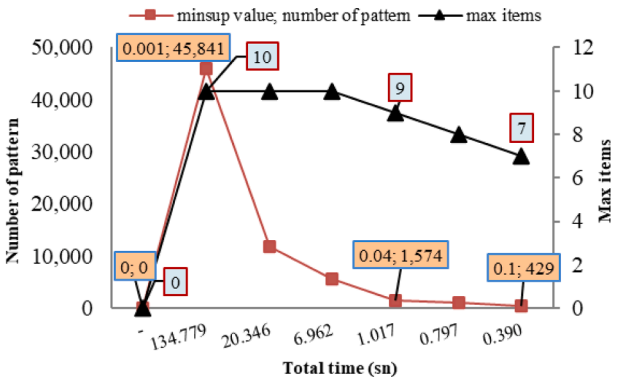

Fig. 28. The determination of best minsup value for "CI: Total of Nace Rev.2: 26" ($n_{others\ included}$ = 7,301). Note: out of memory error for minsup = 0.

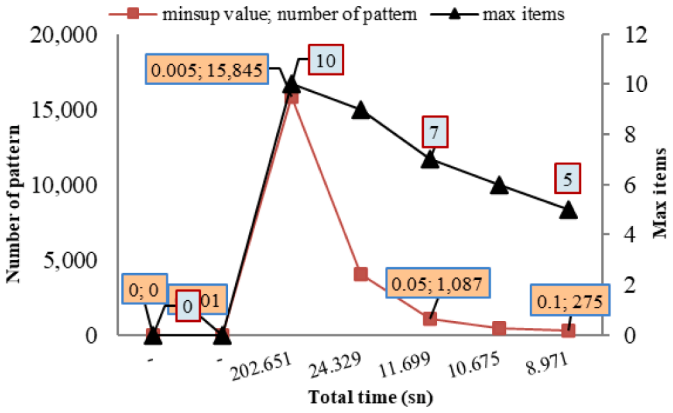

Fig. 29. The determination of best minsup value for "CJ: Total of Nace Rev.2: 27" ($n_{others\ included}$ = 48,241). Note: out of memory error for minsup = 0 and 0.001.

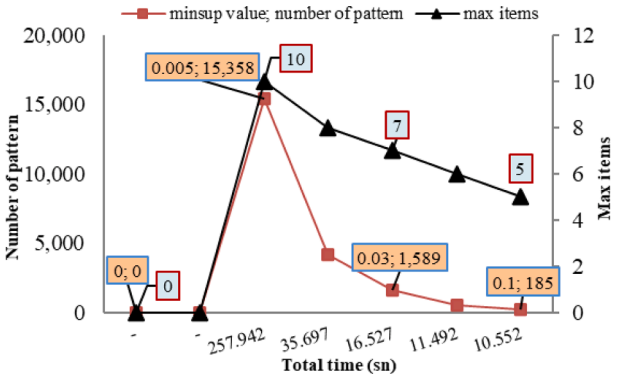

Fig. 30. The determination of best minsup value for "CK: Total of Nace Rev.2: 28" ($n_{others\ included}$ = 50,874). Note: out of memory error for minsup = 0 and 0.003.

accident records. The output of the study is the final stage in which the results are provided to answer to the research question. In addition, descriptive statistics about victims information, enterprise information and accident information are also presented in this study.The absolute frequency and percentage values of occupational accidents in each division and section are given in Table 2, descriptive statistics obtained after the data pre-processing process for other accident variables is reached, in Table 3-4 for $n_{others\ included}$ = 995,503, and in Table 5-6 for $n_{others\ excluded}$ = 307,594. The purpose of this research is to provide useful information to safety professionals in order to improve

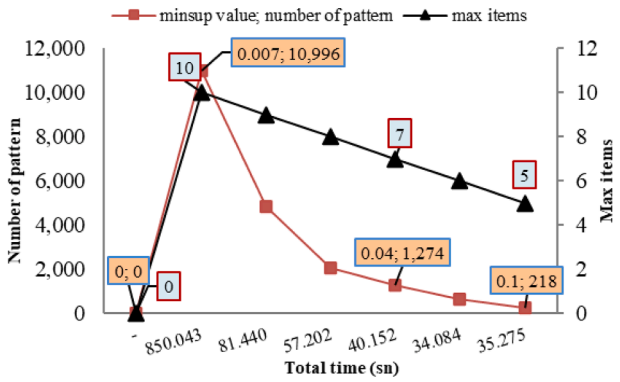

Fig. 31. The determination of best minsup value for "CL: Total of Nace Rev.2: 29 and 30" ($n_{others\ included}$ = 91,367). Note: out of memory error for minsup = 0.

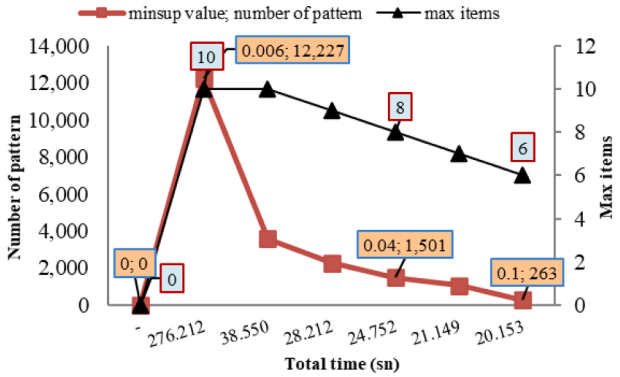

Fig. 32. The determination of best minsup value for "CM: Total of Nace Rev.2: 31, 32 and 33" ($n_{others\ included}$ = 70,076). Note: out of memory error for minsup = 0.

occupational health and safety by determining the sequence pattern in manufacturing industry accidents, which is expressed in 13 sections. To that end, the accident sequences generated by the ESAW methodology were analyzed using the sequential pattern mining approach, which is one of the data mining approaches that considers the sequence of the factors in the data set. The CloFast algorithm, whose confirmability has been demonstrated in a range of fields, was used for analysis.

4.1.1. *Data preprocessing and descriptive analysis*

The 22 variables covered by the occupational accident data were analyzed using five main stages (see Fig. 5). First and primarily, **Stage I:** Data preprocessing was applied to 22 variables that represented accident records. The information is divided into four categories: enterprise information, injured person information, accident consequences information, and accident information (see Fig. 5).

- The victim's work experience was calculated using the accident date and the victim's starting date of work and was expressed in 15 groups (Exp_a; a={1, 2, …15}).
- The age of the victim was calculated using the date of birth and the date of the accident and was divided into six categories (Age_b; b={1, 2,.0.6}).
- Working hour until the accident was calculated and defined in 24 groups using the accident time information and the accident day starting time information (Wh_c; c={1, 2, …24}).
- The time period during which the accident occurred during the day was expressed in 24 groups using the accident time information (Hd_d; d={1, 2, …24})
- By using the accident date information, the day of the accident is divided into 7 groups (D_e; e={1, 2,…7}), the season in which the

Table 14
The variables in the accident sequence.

Workstation: A={ a_i; i = 00, 01, 02, 09}			
a_{00}	Not specified	a_{02}	Occasional or mobile workstation or in a journey on behalf of the employer
a_{01}	Usual workstation or within the usual local unit of work	a_{09}	**Other workstation**
Working Environment: B={b_j; j = 000, 011,…,999}			
b_{000}	No information	b_{051}	Health establishment, private hospital, hospital, nursing home
b_{011}	Production area, factory, workshop	b_{059}	Other group 050 type Working Environments not listed above
b_{012}	Maintenance area, repair workshop	b_{061}	Area permanently open to public thoroughfare – (highways, byways, parking areas, station or airport waiting rooms etc.)
b_{013}	Area used principally for storage, loading, unloading	b_{062}	Means of transport - by land or rail – private or public (all kinds: train, bus, car etc.)
b_{019}	Other group 010 type Working Environments not listed above	b_{063}	Zone attached to public places but with access restricted to authorised personnel: railway line, airport apron, motorway hard shoulder
b_{021}	Construction site -building being constructed	b_{069}	Other group 060 type Working Environments not listed above
b_{022}	Construction site - building being demolished, repaired, maintained	b_{071}	Private home
b_{023}	Opencast quarry, opencast mine, excavation, trench (including opencast mines and w	b_{072}	Communal parts of a building, annexes, private family garden
b_{025}	Construction site - on / over water	b_{079}	Other group 070 type Working Environments not listed above
b_{029}	Other group 020 type Working Environments not listed above	b_{081}	Indoor sports area – sports hall, gymnasium, indoor swimming pool
b_{031}	Breeding area	b_{082}	Outdoor sports area – sports ground, outdoor swimming pool, skiing piste
b_{032}	Farming area - ground crop	b_{089}	Other group 080 type Working Environments not listed above
b_{033}	Farming area - tree or bush crop	b_{091}	Elevated – on a fixed level (roof, terrace, etc.)
b_{034}	Forestry zone	b_{092}	Elevated – mast, pylon, suspended platform
b_{035}	Fish farming zone, fishing, aquaculture (not on a vessel)	b_{093}	In the air - aboard aircraft
b_{036}	Garden, park, botanical garden, zoological garden	b_{099}	Other group 090 type Working Environments not listed above, excluding construction sites
b_{039}	Other group 030 type Working Environments not listed above	b_{109}	Other group 100 type Working Environments not listed above, excluding construction sites
b_{041}	Office, meeting room, library etc.	b_{119}	Other group 110 type Working Environments not listed above, excluding construction sites
b_{042}	Teaching establishment, school, secondary school, college, university, crèche, day nursey	b_{121}	In a high pressure environment – underwater (e.g. diving)
b_{043}	Small or large sales area (including street commerce)	b_{129}	Other group 120 type Working Environments not listed above, excluding construction site
b_{044}	Restaurant, recreational area, temporary accommodation (including museums, auditoriums, stadiums, fairs etc.)	b_{999}	**Other Working Environments not listed in the classification**
b_{049}	Other group 040 type Working Environments not listed above		

Table 15
The variables in the accident sequence (continue).

Working Process: C={c_k; k = 00,11,…99}					
c_{00}	No information	c_{31}	Agricultural type work - working the land	c_{51}	Setting up, preparation, installation, mounting, disassembling, dismantling
c_{11}	Production, manufacturing, processing – all types	c_{32}	Agricultural type work- with vegetables, horticultural	c_{52}	Maintenance, repair, tuning, adjustment
c_{12}	Storing - all types	c_{33}	Agricultural type work - with live animals	c_{53}	Cleaning working areas, machines - industrial or manual
c_{19}	Other group 10 type Working Processes not listed above	c_{34}	Forestry type work	c_{54}	Waste management, disposal, waste treatment of all kinds
c_{21}	Excavation	c_{35}	Fish farming, fishing	c_{55}	Monitoring, inspection of manufacturing procedures, working areas, means of transport, equipment - with or without monitoring equipment
c_{22}	New construction - building	c_{39}	Other group 30 type Working Processes not listed above	c_{59}	Other group 50 type Working Processes not listed above
c_{23}	New construction - civil engineering, infrastructures, roads, bridges, dams, ports	c_{41}	Service, care, assistance, to the general public	c_{61}	Movement, including aboard means of transport
c_{24}	Remodelling, repairing, extending, building maintenance - all types of constructions	c_{42}	Intellectual work - teaching, training, data processing, office work, organising, managing	c_{62}	Sport, artistic activity
c_{25}	Demolition - all types of construction	c_{43}	Commercial activity - buying, selling and associated services	c_{69}	Other group 60 type Working Processes not listed above
c_{29}	Other group 20 type Working Processes not listed above	c_{49}	Other group 40 type Working Processes not listed above	c_{99}	**Other group 60 type Working Processes not listed above**
Special Physical Activity: D={ d_l; l = 00, 11…,99}					
d_{00}	No information	d_{46}	Pouring, pouring into, filling up, watering, spraying, emptying, baling out		
d_{11}	Starting the machine, stopping the machine	d_{47}	Opening (a drawer), pushing (a warehouse/office /cupboard door)		
d_{12}	Feeding the machine, unloading the machine	d_{49}	Other group 40 type Specific Physical Activities not listed above		
d_{13}	Monitoring the machine, operating or driving the machine	d_{51}	Carrying vertically - lifting, raising, lowering an object		
d_{19}	Other group 10 type Specific Physical Activities not listed above	d_{52}	Carrying horizontally - pulling, pushing, rolling an object		
d_{21}	Working with hand-held tools - manual	d_{53}	Transporting a load - carried by a person		
d_{22}	Working with hand-held tools - motorised	d_{59}	Other group 50 type Specific Physical Activities not listed above		
d_{29}	Other group 20 type Specific Physical Activities not listed above	d_{61}	Walking, running, going up, going down, etc		

(*continued on next page*)

Table 15 (*continued*)

Working Process: C={c_k; k = 00,11,…99}			
d_{31}	Driving a means of transport or handling equipment - mobile and motorised	**d_{62}**	Getting in or out
d_{32}	Driving a means of transport or handling equipment - mobile and non-motorised	**d_{63}**	Jumping, hopping, etc.
d_{33}	Being a passenger on board a means of transport	**d_{64}**	Crawling, climbing, etc.
d_{39}	Other group 30 type Specific Physical Activities not listed above	**d_{65}**	Getting up, sitting down
d_{41}	Manually taking hold of, grasping, seizing, holding, placing - on a horizontal level	**d_{66}**	Swimming, diving
d_{42}	Tying, binding, tearing off, undoing, squeezing, unscrewing, screwing, turning	**d_{67}**	Movements on the spot
d_{43}	Fastening, hanging up, raising, putting up - on a vertical level	**d_{69}**	Other group 60 type Specific Physical Activities not listed above
d_{44}	Throwing, flinging away	**d_{70}**	Presence - Not specified
d_{45}	Opening, closing (box, package, parcel)	**d_{99}**	**Other Specific Physical Activities not listed in this classification**

accident occurred is divided into four categories ($Seas_f$; f={1, 2, 3, 4}), The year is listed with seven variables (Y_g; g={1, 2,…7}).
- Economic activities defined by Nace Rev.2 codes are expressed using 24 different codes (Dvs_h; h={1, 2,…24}).
- Workplace statuses are classified into four categories (St_t; t={1, 2, 3, 4}).
- Days lost due to a workplace accident are listed into 11 categories (Dl_w; w={0, 1,…10}).
- Two codes define the victim's gender (Female: F, Male: M).
- The victim's educational status is defined by 12 codes (Eb_y; y={1, 2, …12}).
- The casualty's marital status is expressed using five codes (Ms_z; z={1, 2, …5})
- Three codes were used to express the victim's occupational health and safety training status (OHS_v; v={1, 2, 3}) and vocational training status (Pt_r; r={1, 2, 3}).

Stage II: In the second stage of the study, descriptive statistical analysis was performed to better understand the data, and accident variables were expressed as absolute frequency and percentage.

The majority of the occupational incidents included in the study had injury ($n_{others\ included}$ = 460,567; 43.26 %), with a fatality rate of 0.19% ($n_{others\ included}$ = 1,850, see Fig. 3). Between 2013 and 2019, the number of permanent incapacities caused by accidents decreased, accidents resulting in no incapacity increased continuously, and fatal accidents decreased after 2017 (see Fig. 4). While the majority of casualties are male ($n_{others\ included}$ = 853,468; 85.73%, $n_{others\ excluded}$ = 270,338; 87.89%), their work experience is [0,2) years ($n_{others\ included}$ = 617,903; 62.07%; $n_{others\ excluded}$ = 187,228; 60.87%), the age group most exposed to accidents is Age_3: 25–34 ($n_{others\ included}$ = 376,760; 37.85%, $n_{others\ excluded}$ = 117,800; 38.30%), the most occupational accidents occurred Wh_3: 02:00 to 02:59 after starting work ($n_{others\ included}$ = 121,892; 12.24%, $n_{others\ excluded}$ = 38,425; 12.49%), and accidents occurred mostly between Hd_{12}: 11:00 to 11:59 days ($n_{others\ included}$ = 95,756; 9.62%, $n_{others\ excluded}$ = 30,395; 9.88%) (see Table 3-6). The sections that follow present explanations for stages 3, 4, and 5.

4.2. The sequential pattern mining (SPM) approach

The procedures of discovering hidden patterns in large data sets is known as data mining (Liu and Wang, 2005, p.1). Furthermore, data mining helps to understand the data and obtain the information required to make decisions (Fournier-Viger et al., 2017). Agrawal and Srikant's (1995, March) Sequential Pattern Mining is one of the data mining approaches with a broad range of applications (Chang, 2011). Data sequences are a collection of sequences used as input data for sequential pattern mining. Each data sequence is made up of an ordered list of transactions, each of which is made up of a set of literals (Fumarola et al., 2016). When item and itemset ordering is important in data sets, a sequential pattern mining approach is used (Febrer-Hernández and Hernández-Palancar, 2012). The discovery of interesting, useful, and unexpected patterns in databases is made possible by sequential pattern mining (Gan et al., 2019). Major, medical treatment (exp: Baralis et al., 2010; Cheng and Ren, 2016, November; Ou-Yang et al., 2018), and telecommunications (exp: Hidri et al., 2020; Li et al., 2019; Mijumbi et al., 2019, July), music (exp: Wassi et al., 2018; Luo, 2018; Ren et al., 2010), and text mining (exp: Maylawati et al., 2019, December; Alias et al., 2018) are used to discover sequential pattern patterns in data obtained for various fields.

Occupational accidents are also based on the sequence in which the events that caused the accident occurred (Eurostat European Commission, 2013; Palamara et al., 2011). In our study, we used the Sequential Pattern Mining (SPM) Approach for the first time to discover patterns in accident sequences (see Fig. 5, **Stage III**).

4.2.1. The CloFast algorithm

Fumarola et al. (2016) CloFAST algorithm was used in the scope of **Stage IV** of the study's workflow. CloFast is a fast pattern-growth algorithm that finds closed sequential patterns in sequence databases. A sequential pattern is a subsequence found in multiple sequences. Display the sequences in question using database sequences database SDB. A single id uniquely identifies each sequential sequence (sequences-id or SID). Each SID contains a sequence of transactions, each of which is identified by a unique transaction-id or TID. The SDB's size is proportional to the number of sequences in the sequence database (in this study, the number of employees who had an accident). The CloFast algorithm application steps are described in (Fumarola et al., 2016).

- It begins by scanning the database and discovering both frequent itemsets and creating sparse id lists (SID). It finds closed frequent itemsets while also creating a sparse id list. It constructs a closed itemset enumeration tree (CIET) at the same time, which is a modified version of the marking and pruning strategy used in the Fast algorithm (Salvemini et al. 2011).
- A Closed Sequence Enumeration Tree (CSET) is produced from the closed sequential item sets provided by CIET. While CSET continues forward building, it prunes non-closed sequences as part of backward closure checking using the vertical id list (VIL) data structure. It completes all tasks listed simultaneously. Find all SDB closed sequential patterns with support values greater than or equal to the minimum support criterion (min sup). Details on CloFast algorithm specifics can be found in Fumarola et al. (2016).

For example, the SDB in Table 7 is composed of four clusters (|SDB|= 4), with the first cluster containing five transactions, the second cluster containing five, and the third and fourth clusters containing five. The

Table 16
The variables in the accident sequence (continue).

Material Agent-Specific Physical Activity: E={e_m; m = 00.01, 00.02, …0.99.00}, Material Agent-Contact Mode of Injury: H={*h_n; n = 00.01, 00.02, …0.99.00}	
$e_{00.01}$	No material agent
$e_{00.02}$	No information
$e_{00.99}$	Other known group 00 situation not listed above
$e_{01.01}$	Building components, structural components - doors, walls, partitions etc. and intentional obstacles (windows, etc.)
$e_{01.02}$	Surfaces at ground level - ground and floors (indoor or outdoor, farmland, sports fields, slippery floors, cluttered floors, plank with nails in)
$e_{01.03}$	Surfaces at ground level - floating
$e_{01.99}$	Other known buildings, structures and surfaces, - at same level, in group 01 but not listed above
$e_{02.01}$	Parts of building, above ground level - fixed (roofs, terraces, doors and windows, stairs, quays)
$e_{02.02}$	Structures, surfaces, above ground level - fixed (including gangways, fixed ladders, pylons)
$e_{02.03}$	Structures, surfaces, above ground level - mobile (including scaffolding, mobile ladders, cradles, elevating platforms)
$e_{02.04}$	Structures, surfaces, above ground level - temporary (including temporary scaffolding, harnesses, swings)
$e_{02.05}$	Structures, surfaces, above ground level - floating (including drilling platforms, scaffolding on barges)
$e_{02.99}$	Other known buildings, structures, surfaces - above ground level, in group 02 but not listed above
$e_{03.01}$	Excavations, trenches, wells, pits, escarpments, garage pits
$e_{03.02}$	Underground areas, tunnels
$e_{03.03}$	Underwater environments
$e_{03.99}$	Other known buildings, structures, surfaces - below ground level, in group 03 but not listed above
$e_{04.01}$	Systems for the supply and distribution of materials, pipe networks - fixed - for gas, air, liquids, solids - including hoppers
$e_{04.02}$	Systems for the supply and distribution of materials, pipe networks - mobile
$e_{04.03}$	Sewers, drains
$e_{04.99}$	Other known systems for the supply and distribution of materials, pipe networks, in group 04 but not listed above
$e_{05.01}$	Motors, power generators (thermal, electric, radiation)
$e_{05.02}$	Systems for energy transmission and storage (mechanical, pneumatic, hydraulic, electric, including batteries and accumulators)
$e_{05.99}$	Other known motors, systems for energy transmission and storage, in group 05 but not listed above
$e_{06.01}$	Hand tools, not powered - for sawing
$e_{06.02}$	Hand tools, not powered - for cutting, separating (including scissors, shears, secateurs)
$e_{06.03}$	Hand tools, not powered - for carving, slotting, chiselling, trimming, clipping, shearing
$e_{06.04}$	Hand tools, not powered - for scraping, polishing, buffing
$e_{06.05}$	Hand tools, not powered - for drilling, turning, screwing
$e_{06.06}$	Hand tools, not powered - for nailing, riveting stapling
$e_{06.07}$	Hand tools, not powered - for sewing, knitting
$e_{06.08}$	Hand tools, not powered - for welding, gluing
$e_{06.09}$	Hand tools, not powered - for extracting materials and working the ground (including farming tools)
$e_{06.10}$	Hand tools, not powered - for waxing, lubricating, washing, cleaning
$e_{06.11}$	Hand tools, not powered - for painting
$e_{06.12}$	Hand tools, not powered - for holding in place, grasping
$e_{06.13}$	Hand tools, not powered - for kitchen work (except knives)
$e_{06.14}$	Hand tools, not powered - for medical and surgical work - sharp, cutting
$e_{06.15}$	Hand tools, not powered - for medical and surgical work - non-cutting, others
$e_{06.99}$	Other known hand tools, not powered, in group 06 but not listed above
$e_{07.01}$	Mechanical hand tools - for sawing
$e_{07.02}$	Mechanical hand tools - for cutting, separating (including scissors, shears, secateurs)
$e_{07.03}$	Mechanical hand tools - for carving, slotting, chiselling, (hedge cutting see 09.02) trimming, clipping, shearing
$e_{07.04}$	Mechanical hand tools - for scraping, polishing, buffing (including disc cutters)
$e_{07.05}$	Mechanical hand tools - for drilling, turning, screwing
$e_{07.06}$	Mechanical hand tools - for nailing, riveting, stapling
$e_{07.07}$	Mechanical hand tools - for sewing, knitting
$e_{07.08}$	Mechanical hand tools - for welding, gluing
$e_{07.09}$	Mechanical hand tools - for extracting materials and working the ground (including farming tools, concrete breakers)
$e_{07.10}$	Mechanical hand tools - for waxing, lubricating, washing, cleaning (including high-pressure vacuum cleaner)
$e_{07.11}$	Mechanical hand tools - for painting
$e_{07.12}$	Mechanical hand tools - for holding in place, grasping
$e_{07.13}$	Mechanical hand tools - for kitchen work (except knives)
$e_{07.14}$	Mechanical hand tools - for heating (including driers, flame guns, irons)
$e_{07.15}$	Mechanical hand tools - for medical and surgical work - sharp, cutting
$e_{07.16}$	Mechanical hand tools - for medical and surgical work - non-cutting, others
$e_{07.17}$	Pneumatic guns (without specification of tool)
$e_{07.99}$	Other known hand-held or hand-guided mechanical tools, in group 07 but not listed above
$e_{08.01}$	Hand tools, without specification of power source - for sawing
$e_{08.02}$	Hand tools, without specification of power source - for cutting, separating (including scissors, shears, secateurs)
$e_{08.03}$	Hand tools, without specification of power source - for carving, slotting, chiselling, trimming, clipping, shearing
$e_{08.04}$	Hand tools, without specification of power source - for scraping, polishing, buffing
$e_{08.05}$	Hand tools, without specification of power source - for drilling, turning, screwing
$e_{08.06}$	Hand tools, without specification of power source - for nailing, riveting stapling
$e_{08.07}$	Hand tools, without specification of power source - for sewing, knitting
$e_{08.08}$	Hand tools, without specification of power source - for welding, gluing
$e_{08.09}$	Hand tools, without specification of power source - for extracting materials and working the ground (including farming tools)
$e_{08.10}$	Hand tools, without specification of power source - for waxing, lubricating, washing, cleaning
$e_{08.11}$	Hand tools, without specification of power source - for painting
$e_{08.12}$	Hand tools, without specification of power source - for holding in place, grasping
$e_{08.13}$	Hand tools, without specification of power source - for kitchen work (except knives)
$e_{08.14}$	Hand tools, without specification of power source - for medical and surgical work - sharp, cutting
$e_{08.15}$	Hand tools, without specification of power source - for medical and surgical work - non-cutting, others
$e_{08.99}$	Other known hand tools, without specification of power source, in group 08 but not listed above

*In here, hn = em.

Table 17
The variables in the accident sequence (continue).

Material Agent-Specific Physical Activity: E={e_m; m = 00.01, 00.02, ….$_{99}$.00}, Material Agent-Contact Mode of Injury: H={*h_n; n = 00.01, 00.02, …0.99.00}			
$e_{09.01}$	Portable or mobile machines – for extracting materials or working the ground – mines, quarries and plant for building and civil engineering works	$e_{12.04}$	Other land vehicles: skis, roller-skates
$e_{09.02}$	Portable or mobile machines – for working the ground, farming	$e_{12.99}$	Other known land vehicles in group $_{12}$ but not listed above
$e_{09.03}$	Portable or mobile machines (not for working the ground) – for construction sites	$e_{13.01}$	Vehicles – on rails, including suspended monorails: goods
$e_{09.04}$	Mobile floor cleaning machines	$e_{13.02}$	Vehicles – on rails, including suspended monorails: passengers
$e_{09.99}$	Other known portable or mobile machines and equipment in group 09 but not listed above	$e_{13.03}$	Vehicles – nautical: goods
$e_{10.01}$	Fixed machines for extracting materials or working the ground	$e_{13.04}$	Vehicles – nautical: passengers
$e_{10.02}$	Machines for preparing materials, crushing, pulverising, filtering, separating, mixing, blending	$e_{13.05}$	Vehicles – nautical: fishing
$e_{10.03}$	Machines for processing materials – chemical processes (reactive, fermenting processes)	$e_{13.06}$	Vehicles – aerial: goods
$e_{10.04}$	Machines for processing materials – hot processes (ovens, driers, kilns)	$e_{13.07}$	Vehicles – aerial: passenger
$e_{10.05}$	Machines for processing materials – cold processes (production of cold)	$e_{13.99}$	Other known transport vehicles in group $_{13}$ but not listed above
$e_{10.06}$	Machines for processing materials – other processes	$e_{14.01}$	Building materials – large and small: prefabricated shells, formwork, girders, beams, bricks, tiles, etc.
$e_{10.07}$	Forming machines – by pressing, crushing	$e_{14.02}$	Machine components, vehicle components: chassis, crankcase, levers, wheels, etc.
$e_{10.08}$	Forming machines – by calendering, rolling, cylinder presses (including paper presses)	$e_{14.03}$	Machined parts or components, machine tools (including fragments and chips from these material agents)
$e_{10.09}$	Forming machines – by injection, extrusion, blowing, spinning, moulding, melting, casting	$e_{14.04}$	Joining devices: nuts, bolts, screws, nails, etc.
$e_{10.10}$	Machine tools – for planning, milling, surface treatment, grinding, polishing, turning, drilling	$e_{14.05}$	Particles, dust, splinters, fragments, splashes, shards, other debris
$e_{10.11}$	Machine tools – for sawing	$e_{14.06}$	Farm products (including seeds, straw, other farm products)
$e_{10.12}$	Machine tools – for cutting, splitting, clipping (including die cutters, shearing machines, clippers, oxygen cutting equipment)	$e_{14.07}$	Products for use in farming and breeding (including fertilisers, animal feeds)
$e_{10.13}$	Machines for surface treatment – cleaning, washing, drying, painting, printing	$e_{14.08}$	Stored products – including objects and packaging in storage areas
$e_{10.14}$	Machines for surface treatment – galvanising, electrolytic surface treatment	$e_{14.09}$	Stored products – in rolls, coils
$e_{10.15}$	Assembling machines (welding, gluing, nailing, screwing, riveting, spinning, wiring, sewing, stapling)	$e_{14.10}$	Loads – transported by a mechanical handling or conveying device
$e_{10.16}$	Packing machines, wrapping machines (filling, labelling, closing…)	$e_{14.11}$	Loads – suspended from a hoisting device, a crane
$e_{10.17}$	Other machines for specific industries (miscellaneous monitoring and testing machines	$e_{14.12}$	Loads – handled by hand
$e_{10.18}$	Specific machines used in farming which are not included with the above machines	$e_{14.99}$	Other known materials, objects, products, machine components in group 14 but not listed above
$e_{10.99}$	Other known fixed machines and equipment in group 10 but not listed above	$e_{15.01}$	Substances – caustic, corrosive (solid, liquid or gaseous)
$e_{11.01}$	Fixed conveyors, continuous handling equipment and systems – belts, escalators, cableways, conveyors, etc.)	$e_{15.02}$	Substances – harmful, toxic (solid, liquid or gaseous)
$e_{11.02}$	Elevators, lifts – hoists, bucket elevators, jacks, etc.	$e_{15.03}$	Substances – flammables (solid, liquid or gaseous)
$e_{11.03}$	Fixed cranes, mobile cranes, vehicle-mounted cranes, overhead travelling cranes, hoisting devices with suspended load	$e_{15.04}$	Substances – explosive, reactive (solid, liquid or gaseous)
$e_{11.04}$	Mobile handling devices, handling trucks (powered or not) – barrows, pallet trucks, etc.	$e_{15.05}$	Gases, vapours with no specific effects (inert for life forms, suffocating)
$e_{11.05}$	Lifting equipment, securing, gripping and miscellaneous handling devices (including slings, hooks, ropes…)	$e_{15.06}$	Substances – radioactive
$e_{11.06}$	Storage systems, packaging equipment, containers (silos, tanks) – fixed – tanks, vats, containers, etc.	$e_{15.07}$	Substances – biological
$e_{11.07}$	Storage systems, packaging equipment, containers – mobile	$e_{15.08}$	Substances, materials – with no specific risk (water, inert materials…)
$e_{11.08}$	Storage accessories, shelving, pallet racks, pallets	$e_{15.99}$	Other known chemical, explosive, radioactive, biological substances in group 15 but not listed above
$e_{11.09}$	Miscellaneous packaging, small and medium-sized, mobile (skips, miscellaneous containers, bottles, crates, extinguishers…)	$e_{16.01}$	Safety devices – on machines
$e_{11.99}$	Other known conveying, transport and storage systems in group 11 but not listed above	$e_{16.02}$	Protective devices – individual
$e_{12.01}$	Vehicles – heavy: lorries, buses, coaches (passenger transport)	$e_{16.03}$	Emergency devices and equipment
$e_{12.02}$	Vehicles – light: goods or passengers	$e_{16.99}$	Other known safety devices and equipment in group 16 but not listed above
$e_{12.03}$	Vehicles – two or three wheels, powered or not	$e_{17.01}$	Furniture

* In here, $h_n = e_m$.

meaning of S_1 sequence is that a01 is followed by b_{011}, then c_{11}, and finally d_{62}, resulting in $e_{02.03}$. It is assumed that each item appears only once in the item set and does not seem to once more.

Let I be a set of $I = \{i_1, i_2, \cdots, i_n\}$ different items. A work-related accident sequence is S is a transaction list, $S = \langle t_1, t_2, \cdots, t_m \rangle$. Each $t_j \subseteq I$ is jth here represents an event/situation encountered during the transaction/accident. The sequences α's size is $|\alpha|$the number of item sets in the sequences. The number of item sets in the sequence α is represented by the array size, $|\alpha|$. A sequence $\alpha = \langle a_1, a_2, \cdots, a_m \rangle$, $\beta = \langle b_1, b_2, \cdots, b_n \rangle$ is an ordered sequence, if this sequence is integers then $i_1, i_2, \cdots, i_m$, $1 \leq i_1 < i_2 < \cdots < i_m \leq n$ ve $a_1 \subseteq b_{i1}$, $a_2 \subseteq b_{i2}$, …., $a_m \subseteq b_{im}$. From here, β is a sequence containing α (Fumarola et al., 2016). The number of sequences where the pattern occurs divided by the total number of sequences in the database is the support of a sequential pattern. A frequent sequential pattern is one that has a support that is greater than the minimum support (minsup) parameter specified by the user. A closed sequential pattern is one that is not strictly included in another pattern that has the same support. The CloFast algorithm has two significant advantages (Fumarola et al., 2016):

- It can be shown that the set of closed sequential patterns is generally much smaller than the set of sequential patterns and that no information small.
- Moreover, finding closed sequential patterns is often much more efficient than discovering all patterns.

Table 18
The variables in the accident sequence (continue).

Material Agent-Specific Physical Activity: E={e_m; m = 00.01, 00.02, …0.99.00}	
Material Agent-Contact Mode of Injury: H={*h_n; n = 00.01, 00.02, …0.99.00}	
$e_{17.02}$ Equipment – computer, office automation, reprographic, communications	$e_{18.05}$ Infectious viral agents
$e_{17.03}$ Equipment – for teaching, writing, drawing – including typewriters, stamping machines, enlargers, time-recorders	$e_{18.06}$ Humans
$e_{17.04}$ Items and equipment for sports and games	$e_{18.99}$ Other known living organisms and human-beings in group 18 but not listed above
$e_{17.05}$ Weapons	$e_{19.01}$ Bulk waste - from raw materials, products, materials, objects
$e_{17.06}$ Personal items, clothing	$e_{19.02}$ Bulk waste - from chemicals
$e_{17.07}$ Musical instruments	$e_{19.03}$ Bulk waste - from biological substances, plants, animals
$e_{17.08}$ Domestic-type equipment, tools, objects, linen (professional use)	$e_{19.99}$ Other known bulk waste in group 19 but not listed above
$e_{17.99}$ Other known office equipment, personal equipment, sports equipment, weapons in group 17 but not listed above	$e_{20.01}$ Physical phenomena - noise, natural radiation, light, light arcs, pressurisation, depressurisation, pressure
$e_{18.01}$ Trees, plants, crops	$e_{20.02}$ Natural and atmospheric elements (including stretches of water, mud, rain, hail, snow, ice, wind, etc,)
$e_{18.02}$ Animals - domestic and for breeding	$e_{20.03}$ Natural disasters (including floods, volcanic eruptions, earthquakes, tidal waves, fire, conflagration)
$e_{18.03}$ Animals – wild animals, insects, snakes	$e_{20.99}$ Other known physical phenomena and elements in group 20 but not listed above
$e_{18.04}$ Micro-organisms	$e_{99.00}$ **Other material agents not listed in this classification**
Deviation: F={f_o; o = 00, 11, …0.99}	
f_{00} No information	f_{49} Other group 40 type Deviations not listed above
f_{11} Electrical problem due to equipment failure - leading to indirect contact	f_{51} Fall of person - to a lower level
f_{12} Electrical problem - leading to direct contact	f_{52} Slipping - Stumbling and falling - Fall of person - on the same level
f_{13} Explosion	f_{59} Other group 50 type Deviations not listed above
f_{14} Fire, flare up	f_{61} Walking on a sharp object
f_{19} Other group 10 type Deviations not listed above	f_{62} Kneeling on, sitting on, leaning against
f_{21} Solid state - overflowing, overturning	f_{63} Being caught or carried away, by something or by momentum
f_{22} Liquid state - leaking, oozing, flowing, splashing, spraying	f_{64} Uncoordinated movements, spurious or untimely actions
f_{23} Gaseous state - vaporisation, aerosol formation, gas formation	f_{69} Other group 60 type Deviations not listed above
f_{24} Pulverulent material - smoke generation, dust/particles in suspension/ emission of	f_{71} Lifting, carrying, standing up
f_{29} Other group 20 type Deviations not listed above	f_{72} Pushing, pulling
f_{31} Breakage of material - at joint, at seams	f_{73} Putting down, bending down
f_{32} Breakage, bursting - causing splinters (wood, glass, metal, stone, plastic, others)	f_{74} Twisting, turning
f_{33} Slip, fall, collapse of Material Agent - from above (falling on the victim)	f_{75} Treading badly, twisting leg or ankle, slipping without falling
f_{34} Slip, fall, collapse of Material Agent - from below (dragging the victim down)	f_{79} Other group 70 type Deviations not listed above
f_{35} Slip, fall, collapse of Material Agent - on the same level	f_{81} Shock, fright
f_{39} Other group 30 type Deviations not listed above	f_{82} Violence, aggression, threat - between company employees subjected to the employer's authority
f_{41} Loss of control (total or partial) - of machine (including unwanted start-up) or of the material being worked by the machine	f_{83} Violence, aggression, threat - from people external to the company towards victims performing their duties (bank holdup, bus drivers, etc.)
f_{42} Loss of control (total or partial) - of means of transport or handling equipment, (motorised or not)	f_{84} Aggression, jostle - by animal
f_{43} Loss of control (total or partial) - of hand-held tool (motorised or not) or of the material being worked by the tool	f_{85} Presence of the victim or of a third person in itself creating a danger for oneself and possibly others
f_{44} Loss of control (total or partial) - of object (being carried, moved, handled, etc.)	f_{89} Other group 80 type Deviations not listed above
f_{45} Loss of control (total or partial) - of animal	f_{99} **Other Deviations not listed above in this classification**.
Contact Mode of Injury: G={g_p; p = 00, 11, …0.99}	
g_{00} No information	g_{16} Contact with hazardous substances - on/through skin or eyes
g_{11} Indirect contact with a welding arc, spark, lightning (passive)	g_{17} Contact with hazardous substances - through the digestive system by swallowing or eating
g_{12} Direct contact with electricity, receipt of electrical charge in the body	g_{19} Other group 10 type Contacts -Modes of Injury not listed above
g_{13} Contact with naked flame or a hot or burning object or environment	g_{21} Drowned in liquid
g_{14} Contact with a cold or frozen object or environment	g_{22} Buried under solid
g_{15} Contact with hazardous substances - through nose, mouth via inhalation	g_{23} Enveloped in, surrounded by gas or airborne particles

* In here, $h_n = e_m$.

Table 19
The variables in the accident sequence (continue).

Contact Mode of Injury: G={g_p; p = 00, 11, ...0.99}			
g_{29}	Other group 20 type Contacts -Modes of Injury not listed above	g_{61}	Trapped, crushed - in
g_{31}	Vertical motion, crash on or against (resulting from a fall)	g_{62}	Trapped, crushed - under
g_{32}	Horizontal motion, crash on or against	g_{63}	Trapped, crushed - between
g_{39}	Other group 30 type Contacts -Modes of Injury not listed above	g_{64}	Limb, hand or finger torn or cut off
g_{41}	Struck - by flying object	g_{69}	Other group 60 type Contacts -Modes of Injury not listed above
g_{42}	Struck - by falling object	g_{71}	Physical stress - on the musculoskeletal system
g_{43}	Struck - by swinging object	g_{72}	Physical stress - due to radiation, noise, light or pressure
g_{44}	Struck - by rotating, moving, transported object, including vehicles	g_{73}	Mental stress or shock
g_{45}	Collision with an object, including vehicles - collision with a person (the victim is moving)	g_{79}	Other group 70 type Contacts -Modes of Injury not listed above
g_{49}	Other group 40 type Contacts -Modes of Injury not listed above	g_{81}	Bite
g_{51}	Contact with sharp Material Agent (knife, blade etc.)	g_{82}	Sting from insect or fish
g_{52}	Contact with pointed Material Agent (nail, sharp tool etc.)	g_{83}	Blow, kick, head butt, strangulation
g_{53}	Contact with hard or rough Material Agent	g_{89}	Other group 80 type Contacts -Modes of Injury not listed above
g_{59}	Other group 50 type Contacts -Modes of Injury not listed above	g_{99}	**Other Contacts - Modes of Injury not listed in this classification**
Type of injury: I={$ı_r$; r = 000, 011, ...0.999}			
$ı_{000}$	Unknown injury	$ı_{071}$	Acute poisonings
$ı_{011}$	Superficial injuries	$ı_{072}$	Acute infections
$ı_{012}$	Open wounds	$ı_{079}$	Other types of poisonings and infections
$ı_{019}$	Other types of wounds and superficial injuries	$ı_{081}$	Asphyxiation
$ı_{021}$	Closed fractures	$ı_{082}$	Drownings or nonfatal submersions
$ı_{022}$	Open fractures	$ı_{089}$	Other types of drowning and asphyxiation
$ı_{029}$	Other types of bone fractures	$ı_{091}$	Acute hearing losses
$ı_{031}$	Dislocations and subluxations	$ı_{092}$	Effects of pressure (barotrauma)
$ı_{032}$	Sprains and strains	$ı_{099}$	Other acute effects of sound, vibration and pressure
$ı_{039}$	Other types of dislocations sprains and strains	$ı_{101}$	Heat and sunstroke
$ı_{040}$	Traumatic amputations (Loss of body parts)	$ı_{102}$	Effects of radiation (non-thermal)
$ı_{051}$	Concussions and intracranial injuries	$ı_{103}$	Effects of reduced temperature
$ı_{052}$	Internal injuries	$ı_{109}$	Other effects of temperature extremes, light and radiation
$ı_{059}$	Other types of concussion and internal injuries	$ı_{111}$	Shocks after aggressions and threats
$ı_{061}$	Burns, scalds (thermal)	$ı_{112}$	Traumatic shocks
$ı_{062}$	Chemical burns (corrosions)	$ı_{119}$	Other types of shock
$ı_{063}$	Frostbites	$ı_{120}$	Multiple injuries
$ı_{069}$	Other types of burns, scalds and frostbite	$ı_{999}$	**Other specified injuries not included under other headings**
The severity of injury: J={j_s; s = 00, 11, 20, 21, 90}			
j_{00}	No incapacity	j_{21}	Permanent incapacity
j_{11}	Fatality	j_{90}	**Others**
j_{20}	Injury		

To run the CloFast algorithm, a sequential database must enter a minsup value in the range [0,1] into the software. A sequenced database is a collection of sequenced items in the form of an ordered list of items. The result in Table 8 is obtained when the minsup value of 50% is entered for the data set in Table 7 and the CloFast algorithm is run. The support value is 100% in this case because the pattern (a_{01}),(c_{11}) appears in all sequences (S_1, S_2, S_3, and S_4) in Table 7, indicating that there is a closed sequential pattern seen in all accidents.

4.3. The application

In the Turkish manufacturing industry from 2013 to 2019, there are 995,503 occupational accident records in the SPMF open-source data mining library (Fournier-Viger et al., 2016 September), and Fumarola et al. (2016) was analyzed using the CloFast algorithm. Each work accident data set includes ten items: "workstation," "working environment," "working process," "special physical activity," "material agent-special physical activity," "deviation," "cause of injury," "material agent contect mode of injury," "type of injury," and "insurant status after accident" (Hola and Szóstak, 2019; Eurostat European Commission, 2013). The accident sequence is made up of ordered itemsets of these items (see Fig. 1). Each employee has their own set of accident data. The computer used to analysis the sequential accident sequences has 16 GB of RAM and an Intel(R) Core(TM) i7-9750H CPU@2.60 GHz processor.

It is important that the large sequence's itemsets have a minsup value (Agrawal and Srikant, 1995). According to Yao et al. (2020), the minimum support value in a data mining algorithm is the threshold that affects the accuracy of the mining result, and he determined the optimum support value and conducted his analysis. Considering the aforementioned issue, in the **Stage III** of our study, the optimum support value, where the number of sequential patterns and the number of items in the sequential pattern (where the sequence length is max), is determined for each section of the manufacturing industry using the CloFast algorithm and various minsup values (See, Figs. 6-18 for $n_{others\ excluded}$ = 307,594 and Figs. 20-32 for $n_{others\ included}$ = 995,503). In Fig. 6, for CA section with occupational accident number 26,502, 209 sequence patterns were obtained when minsup = 0.1, 2,017 sequence patterns when minsup = 0.03, and 26,236 sequence patterns when minsup = 0.003. The number of obtained sequence patterns decreases as the minsup value increases. The optimum minsup value for the CA section was determined to be 0.003. Number of different accident closed sequential pattern with two, three, four, five, six, seven, eight, nine and ten items in the first ten accident closed sequential pattern of each one section ($n_{others\ excluded}$ = 307,594) is given Fig. 19.

In the **Stage IV** of the study, accident data were analyzed with the CloFast algorithm using the optimum support values determined for each section. Within the scope of **Stage V** specified in the study's workflow, the top ten patterns with the highest support value among the sequential accident patterns with two, three, four, five, six, seven, eight, nine, and ten items are given in the Appendix (Table 20-28 for $n_{others\ excluded}$ = 307,594, Table 29-35 for $n_{others\ included}$ = 995,503).

According to the sequential accident pattern results obtained for $n_{others\ included}$ = 995,503, according to the variable descriptions expressed in Table 14-19, in most of the sequential patterns, others coded "a_{09}, b_{999}, c_{99}, d_{99}, $h_{99.00}$, $e_{99.00}$, f_{99}, g_{99}, 1_{99}, j_{90}" contain variables. For example, according to the accident sequence given below, with 6 items and a support value of 13.20%, it is nearly impossible to understand the area to focus on and take specific occupational safety

Table 20
The first ten accident sequences pattern with two, three and four items for each section: support ($n_{others\ excluded} = 307{,}594$).

Sequences	Support value												
	CA[a]	CB[b]	CC[c]	CD[d]	CE[e]	CF[f]	CG[g]	CH[h]	CI[i]	CJ[j]	CK[k]	CL[l]	CM[m]
a_{01}-b_{011}	84.69%	92.95%	89.50%	84.00%	86.57%	83.94%	87.56%	90.84%	90.80%	**93.29%**	91.72%	88.21%	75.88%
a_{01}-c_{11}	80.37%	86.82%	81.72%	71.14%	77.80%	73.14%	81.54%	85.68%	83.54%	89.75%	87.44%	86.75%	75.07%
b_{011}-c_{11}	76.47%	86.45%	80.46%	71.43%	76.11%	72.60%	80.88%	85.27%	82.09%	89.55%	88.30%	83.87%	71.58%
a_{01}-$ı_{011}$	54.52%	63.17%	56.47%	33.43%	55.15%	57.76%	55.18%	58.01%	49.92%	61.27%	58.31%	58.89%	56.56%
a_{01}-j_{00}	52.49%	44.87%	–	39.43%	–	39.54%	34.86%	–	72.39%	53.60%	–	37.41%	–
b_{011}-$ı_{011}$	48.82%	61.82%	53.56%	–	51.70%	54.66%	52.77%	56.57%	47.97%	60.17%	58.12%	55.87%	50.51%
c_{11}-$ı_{011}$	47.67%	58.69%	49.29%	–	46.84%	48.58%	50.23%	54.18%	44.90%	58.42%	56.09%	55.40%	51.04%
b_{011}-j_{00}	47.17%	–	–	37.14%	–	–	–	–	68.53%	52.73%	–	–	–
c_{11}-j_{00}	45.74%	–	–	32.86%	–	–	–	–	62.77%	50.79%	–	–	–
a_{01}-j_{20}	43.18%	52.12%	63.24%	54.57%	66.94%	53.85%	58.62%	67.78%	–	42.90%	61.24%	58.27%	54.98%
b_{011}-j_{20}	–	50.66%	60.04%	50.00%	61.02%	48.99%	55.87%	65.87%	–	–	60.64%	55.27%	48.16%
c_{11}-j_{20}	–	46.97%	55.16%	41.43%	55.27%	43.86%	52.35%	62.26%	–	–	57.83%	53.94%	48.60%
$ı_{011}$-j_{20}	–	–	36.46%	–	38.51%	–	–	40.49%	–	–	33.28%	–	35.08%
$ı_{011}$-j_{00}	–	–	–	–	–	–	–	–	37.60%	–	–	–	–
a_{01}-b_{011}-c_{11}	74.97%	85.23%	79.43%	68.57%	74.96%	71.39%	79.44%	83.64%	81.47%	**88.37%**	86.04%	82.35%	71.55%
a_{01}-b_{011}-$ı_{011}$	47.85%	60.83%	52.79%	29.14%	50.89%	53.71%	51.84%	55.45%	47.18%	59.27%	56.65%	54.78%	49.00%
a_{01}-c_{11}-$ı_{011}$	46.73%	57.79%	48.47%	27.71%	46.13%	47.77%	48.99%	52.88%	44.20%	57.56%	54.53%	54.10%	48.81%
a_{01}-b_{011}-j_{00}	46.28%	–	–	35.71%	–	35.09%	32.38%	–	67.79%	52.03%	–	33.78%	–
a_{01}-c_{11}-j_{00}	44.85%	40.29%	–	31.71%	–	29.28%	–	–	62.11%	50.07%	–	33.88%	–
b_{011}-c_{11}-$ı_{011}$	43.71%	57.64%	47.77%	–	44.98%	47.77%	48.41%	52.68%	43.62%	57.40%	55.05%	52.63%	46.84%
b_{011}-c_{11}-j_{00}	42.04%	40.05%	–	32.57%	–	–	–	–	61.19%	50.10%	–	–	–
a_{01}-b_{011}-j_{20}	37.93%	49.84%	59.18%	48.29%	60.03%	48.45%	54.70%	64.54%	–	40.92%	58.93%	54.12%	46.60%
a_{01}-c_{11}-j_{20}	35.07%	46.23%	54.18%	39.43%	54.48%	43.45%	50.89%	60.78%	–	39.34%	55.97%	52.56%	46.24%
b_{011}-c_{11}-j_{20}	34.00%	46.10%	53.50%	38.86%	53.04%	43.18%	50.29%	54.44%	–	39.12%	56.39%	51.47%	44.01%
a_{011}-b_{011}-j_{00}	–	42.77%	–	–	–	–	–	–	–	–	–	–	–
a_{01}-$ı_{011}$-j_{20}	–	–	35.51%	–	37.78%	29.15%	33.06%	39.21%	–	–	35.21%	34.33%	32.61%
b_{011}-$ı_{011}$-j_{20}	–	–	33.95%	–	34.62%	–	31.73%	38.30%	–	–	34.96%	–	29.40%
c_{11}-$ı_{011}$- j_{20}	–	–	31.27%	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-$e_{00\cdot01}$	–	–	–	27.71%	–	–	–	–	–	–	–	–	–
c_{11}-$ı_{011}$-j_{20}	–	–	–	–	31.95%	–	–	36.69%	–	–	33.67%	–	29.73%
a_{01}-$ı_{011}$-j_{00}	–	–	–	–	–	–	–	–	36.73%	–	–	–	–
b_{011}-$ı_{011}$-j_{00}	–	–	–	–	–	–	–	–	35.12%	–	–	–	–
c_{11}-$ı_{011}$-j_{00}	–	–	–	–	–	–	–	–	32.75%	–	–	–	–
a_{01}-b_{011}-c_{11}-$ı_{011}$	42.94%	56.81%	47.22%	26.00%	44.41%	46.96%	47.62%	51.73%	43.20%	56.67%	53.79%	51.65%	45.65%
a_{01}-b_{011}-c_{11}-j_{00}	41.35%	39.48%	25.94%	31.43%	22.06%	28.21%	29.65%	23.68%	60.78%	49.52%	30.62%	31.56%	26.18%
a_{01}-b_{011}-c_{11}-j_{20}	33.20%	45.44%	52.86%	37.14%	52.43%	42.78%	49.36%	59.43%	20.40%	38.53%	54.96%	50.50%	42.90%
a_{01}-c_{11}-$ı_{011}$-j_{00}	27.86%	29.06%	17.64%	–	14.47%	23.35%	19.57%	16.91%	32.26%	33.41%	21.68%	22.42%	20.24%
a_{01}-b_{011}-$ı_{011}$-j_{00}	27.82%	30.43%	19.22%	–	16.59%	26.72%	20.63%	17.79%	34.58%	34.41%	22.44%	22.33%	20.40%
b_{011}-c_{11}-$ı_{011}$-j_{00}	25.40%	28.93%	17.27%	–	14.28%	23.62%	19.27%	16.83%	31.80%	33.48%	21.97%	21.36%	19.44%
a_{01}-b_{011}-$ı_{011}$-j_{20}	19.98%	30.34%	33.49%	–	34.28%	26.99%	31.16%	37.58%	–	24.82%	34.13%	32.40%	28.55%
a_{01}-c_{11}-$ı_{011}$-j_{20}	18.82%	28.68%	30.77%	–	31.65%	24.43%	29.38%	35.89%	–	24.10%	32.76%	31.63%	28.54%
b_{011}-c_{11}-$ı_{011}$-j_{20}	18.26%	23.90%	30.43%	–	30.67%	24.16%	29.09%	35.77%	–	23.87%	32.99%	31.22%	27.36%
a_{01}-b_{011}-c_{11}-g_{51}	15.67%	–	15.43%	–	–	–	14.20%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-f_{64}	–	16.56%	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00\cdot01}$	–	–	–	23.71%	13.55%	–	–	–	–	–	–	15.88%	–
a_{01}-b_{011}-c_{11}-$h_{00\cdot01}$	–	–	–	19.43%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-$e_{00\cdot01}$-$h_{00\cdot01}$	–	–	–	18.29%	–	–	–	–	–	–	–	–	–
a_{01}-c_{11}-$e_{00\cdot01}$-$h_{00\cdot01}$	–	–	–	17.14%	–	–	–	–	–	–	–	–	–
b_{011}-c_{11}-$e_{00\cdot01}$-$h_{00\cdot01}$	–	–	–	17.14%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-$e_{00\cdot01}$-j_{00}	–	–	–	16.29%	–	–	–	–	–	–	–	–	–
b_{011}-c_{11}-$e_{00\cdot01}$-j_{00}	–	–	–	15.71%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-g_{63}	–	–	–	–	–	16.46%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-g_{53}	–	–	–	–	–	–	–	17.13%	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$ı_{032}$	–	–	–	–	–	–	–	–	22.93%	–	–	–	–
a_{01}-b_{011}-$ı_{032}$-j_{00}	–	–	–	–	–	–	–	–	21.23%	–	–	–	–
a_{01}-c_{11}-$ı_{032}$-j_{00}	–	–	–	–	–	–	–	–	19.53%	–	–	–	–
b_{011}-c_{11}-$ı_{032}$-j_{00}	–	–	–	–	–	–	–	–	19.40%	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}	–	–	–	–	–	–	–	–	–	18.87%	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}	–	–	–	–	–	–	–	–	–	–	17.88%	–	–
a_{01}-b_{011}-c_{11}-f_{43}	–	–	–	–	–	–	–	–	–	–	–	–	17.03%

[a]Support value for minsup = 0.003, [b]Support value for minsup = 0.004, [c]Support value for minsup = 0.002, [d]Support value for minsup = 0.000, [e]Support value for minsup = 0.001, [f]Support value for minsup = 0.000, [g]Support value for minsup = 0.004, [h]Support value for minsup = 0.006, [ı]Support value for minsup = 0.000, [j]Support value for minsup = 0.002, [k]Support value for minsup = 0.002, [l]Support value for minsup = 0.0032, [m]Support value for minsup = 0.002.

Table 21
The first ten accident sequences pattern with five items for each section: support value ($n_{others\ excluded}$ = 307,594).

Sequences	Support value												
	CA[a]	CB[b]	CC[c]	CD[d]	CE[e]	CF[f]	CG[g]	CH[h]	CI[i]	CJ[j]	CK[k]	CL[l]	CM[m]
a_{01}-b_{011}-c_{11}-1_{011}-j_{00}	25.04%	28.51%	17.06%	13.71%	13.96%	22.94%	18.97%	16.49%	31.51%	33.09%	21.44%	20.98%	18.92%
a_{01}-b_{011}-c_{11}-1_{011}-j_{20}	17.85%	28.24%	30.09%	12.29%	21.31%	24.02%	28.60%	35.16%	11.69%	23.54%	32.26%	30.63%	26.70%
a_{01}-c_{11}-$e_{06.02}$-g_{51}-$h_{06.02}$	11.34%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-g_{51}-$h_{06.02}$	10.72%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{06.02}$-$h_{06.02}$	10.61%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-$e_{06.02}$-g_{51}-$h_{06.02}$	10.28%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{06.02}$-g_{51}	10.27%	–	–	–	–	–	–	–	–	–	–	–	–
b_{011}-c_{11}-$e_{06.02}$-g_{51}-$h_{06.02}$	10.15%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-1_{011}	10.08%	9.10%	–	–	–	–	–	–	–	–	11.56%	9.13%	10.75%
a_{01}-b_{011}-c_{11}-g_{51}-1_{011}	9.93%	12.02%	10.05%	–	7.64%	–	10.00%	–	–	10.57%	8.43%	–	10.92%
a_{01}-b_{011}-c_{11}-f_{64}-1_{011}	–	12.15%	9.08%	–	8.14%	–	9.15%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{13}-1_{011}	–	10.10%	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-g_{63}-j_{20}	–	9.04%	11.65%	–	8.65%	11.07%	8.99%	9.64%	–	–	–	–	–
a_{01}-b_{011}-c_{11}-f_{43}-1_{011}	–	8.99%	–	–	–	–	–	–	–	–	10.28%	8.45%	12.69%
a_{01}-b_{011}-c_{11}-g_{63}-1_{011}	–	8.96%	8.59%	–	–	10.53%	7.29%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-f_{41}-1_{011}	–	8.94%	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-g_{51}-j_{20}	–	–	10.81%	–	–	–	8.90%	–	–	–	–	–	10.64%
a_{01}-b_{011}-c_{11}-f_{64}-j_{20}	–	–	8.83%	–	8.23%	–	8.17%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.06}$-$h_{10.06}$	–	–	8.82%	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{13}-j_{20}	–	–	8.41%	–	7.90%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-$h_{00.01}$	–	–	–	16.86%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-j_{00}	–	–	–	15.14%	–	–	–	–	11.19%	–	–	8.06%	–
a_{01}-b_{011}-c_{11}-$h_{00.01}$-j_{00}	–	–	–	14.86%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-$e_{00.01}$-$h_{00.01}$-j_{00}	–	–	–	13.43%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-j_{20}	–	–	–	8.57%	9.58%	–	8.08%	9.00%	–	–	7.89%	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-1_{011}	–	–	–	8.57%	7.56%	–	–	–	–	–	–	8.40%	–
a_{01}-b_{011}-c_{11}-1_{032}-j_{20}	–	–	–	6.57%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-f_{64}	–	–	–	6.29%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{11}-j_{20}	–	–	–	–	7.84%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.16}$-$h_{10.16}$	–	–	–	–	–	12.01%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$h_{10.16}$-1_{011}	–	–	–	–	–	9.58%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.16}$-1_{011}	–	–	–	–	–	9.45%	–	–	–	–	–	–	–
b_{011}-c_{11}-$e_{10.16}$-$h_{10.16}$-1_{011}	–	–	–	–	–	9.45%	–	–	–	–	–	–	–
a_{01}-b_{011}-$e_{10.16}$-$h_{10.16}$-1_{011}	–	–	–	–	–	9.31%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{13}-j_{20}	–	–	–	–	–	9.04%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-g_{53}-1_{011}	–	–	–	–	–	–	8.25%	12.09%	–	12.09%	11.09%	10.80%	–
a_{01}-b_{011}-c_{11}-g_{53}-j_{20}	–	–	–	–	–	–	–	11.70%	–	–	10.34%	9.34%	–
a_{01}-b_{011}-g_{53}-1_{011}-j_{20}	–	–	–	–	–	–	–	8.19%	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-j_{20}	–	–	–	–	–	–	–	8.15%	–	–	11.57%	8.49%	8.68%
a_{01}-c_{11}-g_{53}-1_{011}-j_{20}	–	–	–	–	–	–	–	7.95%	–	–	–	–	–
b_{011}-c_{11}-g_{53}-1_{011}-j_{20}	–	–	–	–	–	–	–	7.93%	–	–	–	–	–
a_{01}-b_{011}-c_{11}-1_{032}-j_{00}	–	–	–	–	–	–	–	–	19.32%	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-j_{00}	–	–	–	–	–	–	–	–	18.03%	14.33%	–	–	–
a_{01}-b_{011}-c_{11}-f_{44}-j_{00}	–	–	–	–	–	–	–	–	11.15%	11.64%	–	–	–
a_{01}-b_{011}-c_{11}-$e_{14.05}$-j_{00}	–	–	–	–	–	–	–	–	10.03%	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-1_{011}	–	–	–	–	–	–	–	–	9.99%	13.10%	–	–	–
a_{01}-b_{011}-c_{11}-$h_{14.05}$-j_{00}	–	–	–	–	–	–	–	–	9.83%	–	–	–	–
a_{01}-b_{011}-d_{41}-1_{011}-j_{00}	–	–	–	–	–	–	–	–	9.58%	10.21%	–	–	–
a_{01}-c_{11}-d_{41}-1_{011}-j_{00}	–	–	–	–	–	–	–	–	–	10.21%	–	–	–
a_{01}-b_{011}-c_{11}-f_{44}-1_{011}	–	–	–	–	–	–	–	–	–	11.74%	–	8.43%	–
a_{01}-b_{011}-c_{11}-f_{43}-j_{20}	–	–	–	–	–	–	–	–	–	–	10.77%	–	10.07%
a_{01}-b_{011}-c_{11}-d_{22}-1_{011}	–	–	–	–	–	–	–	–	–	–	–	–	7.69%
a_{01}-b_{011}-c_{11}-d_{21}-f_{43}	–	–	–	–	–	–	–	–	–	–	–	–	7.61%

[a]Support value for minsup = 0.003, [b]Support value for minsup = 0.004, [c]Support value for minsup = 0.002, [d]Support value for minsup = 0.000, [e]Support value for minsup = 0.001, [f]Support value for minsup = 0.000, [g]Support value for minsup = 0.004, [h]Support value for minsup = 0.006, [i]Support value for minsup = 0.000, [j]Support value for minsup = 0.002, [k]Support value for minsup = 0.002, [l]Support value for minsup = 0.0032, [m]Support value for minsup = 0.002.

measures. More meaningful results are required before making decisions on occupational safety measures. As a result, others were $n_{others\ excluded}$ = 307,594 operational accident data deemed suitable for analysis. We are interested in the findings of the accident record analysis.

$\langle b_{011} - d_{99} - e_{99.00} - f_{99} - g_{99} - h_{99.00} \rangle$

: ⟨production area, factory, workshop

– other specific physical Activities not listed in this classification

– other material agents not listed in this classification – other deviations

– other material agents ⟩

Stages II, III, IV, and V were repeated for the data set in which the variables coded with Others were excluded. Working with various support values to determine the minimum support value for 307,594 occupational accident records revealed optimal minsup values (see Figs. 6-18). The optimal minimum support values obtained for data sets including and excluding variables coded with Others varied due to the different data pattern and the number of data in each section. The CloFast algorithm was used to rerun the newly determined optimum minsup values. The first three sequential accident patterns with the highest support value are given in Table 9-11, and the first ten are given in Table 20-28, which is given as Appendix. Here, specific information about the sequential events that led to the accident could be obtained

Table 22
The first ten accident sequences pattern with six items for each section: support value (Others excluded data: n = 307,594).

Sequences	Support value												
	CA[a]	CB[b]	CC[c]	CD[d]	CE[e]	CF[f]	CG[g]	CH[h]	CI[i]	CJ[j]	CK[k]	CL[l]	CM[m]
a_{01}-b_{011}-c_{11}-$e_{06.02}$-g_{51}-$h_{06.02}$	10.05%	6.63%	–	–	4.56%	–	4.71%	–	–	–	–	–	–
a_{01}-c_{11}-$e_{06.02}$-g_{51}-$h_{06.02}$-i_{011}	7.58%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-c_{11}-d_{21}-$e_{06.02}$-g_{51}-$h_{06.02}$	7.16%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-c_{11}-$e_{06.02}$-g_{51}-$h_{06.02}$-j_{00}	7.08%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-c_{11}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$	7.03%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-$h_{06.02}$	7.00%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-g_{51}-$h_{06.02}$	6.88%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-g_{51}	6.84%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{06.02}$-$h_{06.02}$-i_{011}	6.81%	5.64%	–	–	–	–	3.71%	–	–	–	–	–	–
a_{01}-b_{011}-d_{21}-$e_{06.02}$-g_{51}-$h_{06.02}$	6.79%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-f_{64}-i_{011}-j_{20}	–	6.31%	5.39%	–	6.62%	–	5.34%	5.11%	–	5.31%	–	–	–
a_{01}-b_{011}-c_{11}-g_{51}-i_{011}-j_{00}	–	6.03%	–	–	–	–	3.94%	–	5.22%	6.29%	4.33%	–	–
a_{01}-b_{011}-c_{11}-g_{51}-i_{011}-j_{20}	–	5.98%	6.91%	–	5.06%	–	6.04%	–	–	–	–	3.99%	6.84%
a_{01}-b_{011}-c_{11}-f_{64}-i_{011}-j_{00}	–	5.83%	–	–	0.00%	–	3.80%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-g_{51}-$h_{06.02}$-i_{011}	–	5.74%	–	–	3.81%	–	3.64%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-i_{011}-j_{00}	–	5.45%	–	–	–	–	–	–	–	–	4.47%	–	4.80%
a_{01}-b_{011}-c_{11}-g_{63}-i_{011}-j_{20}	–	5.33%	6.34%	–	5.19%	5.67%	4.93%	5.25%	–	–	–	3.81%	–
a_{01}-b_{011}-c_{11}-$e_{06.02}$-g_{51}-i_{011}	–	5.24%	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.06}$-$h_{10.06}$-j_{20}	–	–	5.83%	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.06}$-$h_{10.06}$-i_{011}	–	–	5.29%	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{11}-i_{011}-j_{20}	–	–	4.86%	–	5.35%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-f_{43}-i_{011}-j_{20}	–	–	4.83%	–	–	–	–	4.36%	–	–	6.60%	5.28%	7.04%
a_{01}-b_{011}-c_{11}-d_{13}-i_{011}-j_{20}	–	–	4.61%	–	5.09%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-f_{41}-i_{011}-j_{20}	–	–	4.48%	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$h_{10.06}$-i_{011}-j_{20}	–	–	4.19%	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-$h_{00.01}$-j_{00}	–	–	–	13.14%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-$h_{00.01}$-i_{011}	–	–	–	5.71%	–	–	–	4.34%	–	–	–	4.65%	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-i_{011}-j_{00}	–	–	–	5.71%	–	–	–	–	4.89%	5.62%	–	4.59%	–
a_{01}-b_{011}-c_{11}- $e_{00.01}$-f_{64}-$h_{00.01}$	–	–	–	5.14%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-f_{64}-$h_{00.01}$-j_{00}	–	–	–	4.86%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{61}-$e_{00.01}$-$h_{00.01}$	–	–	–	4.57%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$h_{00.01}$-i_{011}-j_{00}	–	–	–	4.57%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{61}-$e_{00.01}$-j_{00}	–	–	–	4.00%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{70}-$h_{00.01}$-j_{00}	–	–	–	4.00%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-$h_{00.01}$-j_{20}	–	–	–	3.71%	–	–	–	4.78%	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-i_{011}-j_{20}	–	–	–	–	5.35%	–	–	5.23%	–	–	4.50%	–	–
a_{01}-b_{011}-c_{11}-g_{53}-i_{011}-j_{20}	–	–	–	–	5.27%	–	4.72%	7.81%	–	–	6.74%	6.60%	–
a_{01}-b_{011}-c_{11}-d_{21}-i_{011}-j_{20}	–	–	–	–	4.01%	–	–	4.90%	–	–	7.05%	5.78%	5.95%
a_{01}-b_{011}-c_{11}-$e_{10.16}$-$h_{10.16}$-i_{011}	–	–	–	–	–	9.18%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.16}$-$h_{10.16}$-j_{00}	–	–	–	–	–	6.34%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.16}$-i_{011}-j_{00}	–	–	–	–	–	5.67%	–	–	–	–	–	–	–
b_{011}-c_{11}-$e_{10.16}$-$h_{10.16}$-i_{011}-j_{00}	–	–	–	–	–	5.53%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$h_{10.16}$-i_{011}-j_{00}	–	–	–	–	–	5.53%	–	–	–	–	–	–	–
a_{01}-b_{011}-$e_{10.16}$-$h_{10.16}$-i_{011}-j_{00}	–	–	–	–	–	5.40%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.16}$-g_{63}-$h_{10.16}$	–	–	–	–	–	5.40%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{13}-$e_{10.16}$-$h_{10.16}$	–	–	–	–	–	5.26%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-i_{011}-j_{20}	–	–	–	–	–	5.13%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-f_{44}-i_{011}-j_{20}	–	–	–	–	–	–	4.17%	5.23%	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-i_{011}-j_{00}	–	–	–	–	–	–	–	4.92%	–	–	–	4.89%	–
a_{01}-b_{011}-c_{11}-$e_{14.05}$-$h_{14.05}$-j_{00}	–	–	–	–	–	–	–	–	9.16%	10.13%	–	–	–
a_{01}-b_{011}-c_{11}-f_{44}-i_{011}-j_{00}	–	–	–	–	–	–	–	–	8.87%	5.75%	–	–	–
a_{01}-b_{011}-c_{11}-f_{44}-i_{011}-j_{00}	–	–	–	–	–	–	–	–	7.09%	8.82%	–	–	–
a_{01}-b_{011}-c_{11}-$e_{14.05}$-i_{032}-j_{00}	–	–	–	–	–	–	–	–	6.18%	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-i_{032}-j_{00}	–	–	–	–	–	–	–	–	6.05%	–	–	–	–
a_{01}-b_{011}-c_{11}-$h_{14.05}$-i_{032}-j_{00}	–	–	–	–	–	–	–	–	5.72%	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-f_{44}-j_{00}	–	–	–	–	–	–	–	–	5.60%	5.07%	–	–	–
a_{01}-b_{011}-$e_{14.05}$-$h_{14.05}$-i_{032}-j_{00}	–	–	–	–	–	–	–	–	5.31%	–	–	–	–
a_{01}-b_{011}-c_{11}-g_{53}-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	7.39%	–	–	–
a_{01}-b_{011}-c_{11}-$h_{14.99}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	4.82%	–	–	–
a_{01}-b_{011}-c_{11}-$e_{14.12}$-$h_{14.12}$-j_{00}	–	–	–	–	–	–	–	–	–	4.75%	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-f_{43}-j_{20}	–	–	–	–	–	–	–	–	–	–	4.75%	–	4.42%

[a]Support value for minsup = 0.003, [b]Support value for minsup = 0.004, [c]Support value for minsup = 0.002, [d]Support value for minsup = 0.000, [e]Support value for minsup = 0.001, [f]Support value for minsup = 0.000, [g]Support value for minsup = 0.004, [h]Support value for minsup = 0.006, [i]Support value for minsup = 0.000, [j]Support value for minsup = 0.002, [k]Support value for minsup = 0.002, [l]Support value for minsup = 0.0032, [m]Support value for minsup = 0.002.

Table 23
The first ten accident sequences pattern with six and seven items for each section: support value (Others excluded data: n = 307,594).

Sequences	Support value												
	CA[a]	CB[b]	CC[c]	CD[d]	CE[e]	CF[f]	CG[g]	CH[h]	CI[i]	CJ[j]	CK[k]	CL[l]	CM[m]
a_{01}-b_{011}-c_{11}-d_{22}-$\imath_{011}$-j_{20}	–	–	–	–	–	–	–	–	–	–	4.72%	–	4.14%
a_{01}-b_{011}-c_{11}-d_{21}-f_{43}-$\imath_{011}$	–	–	–	–	–	–	–	–	–	–	4.63%	–	5.91%
a_{01}-b_{011}-c_{11}-g_{53}-$\imath_{011}$-j_{00}	–	–	–	–	–	–	–	–	–	–	4.34%	–	7.32%
a_{01}-b_{011}-c_{11}-$e_{00.01}$-$h_{00.01}$-j_{00}	–	–	–	–	–	–	–	–	–	–	–	4.68%	–
a_{01}-b_{011}-c_{11}-g_{53}-$\imath_{011}$-j_{00}	–	–	–	–	–	–	–	–	–	–	–	4.19%	–
a_{01}-b_{011}-c_{11}-f_{43}-$\imath_{011}$-j_{00}	–	–	–	–	–	–	–	–	–	–	–	–	5.65%
a_{01}-b_{011}-c_{11}-f_{43}-g_{52}-$\imath_{011}$	–	–	–	–	–	–	–	–	–	–	–	–	4.53%
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-g_{51}-$h_{06.02}$	6.68%	2.96%	–	–	–	–	2.35%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{06.02}$-g_{51}-$h_{06.02}$-$\imath_{011}$	6.43%	5.06%	2.56%	–	3.40%	–	3.29%	–	–	–	–	–	2.21%
a_{01}-b_{011}-c_{11}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$	6.11%	3.81%	2.03%	–	2.69%	–	2.88%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{06.02}$-g_{51}-$h_{06.02}$-j_{00}	6.10%	3.18%	–	–	–	–	–	–	–	–	–	–	–
a_{01}-c_{11}-d_{21}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$	4.91%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-c_{11}-d_{21}-$e_{06.02}$-g_{51}-$h_{06.02}$-$\imath_{011}$	4.88%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-c_{11}-$e_{06.02}$-g_{51}-$h_{06.02}$-$\imath_{011}$-j_{00}	4.87%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-$h_{06.02}$-$\imath_{011}$	4.73%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-c_{11}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-$\imath_{011}$	4.69%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-f_{43}-$h_{06.02}$	4.67%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{06.02}$-g_{51}-$h_{06.02}$-j_{20}	–	3.45%	2.50%	–	2.86%	–	2.93%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{07.07}$-$h_{07.07}$-$\imath_{011}$-j_{00}	–	3.20%	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-f_{43}-g_{51}-$h_{06.02}$-$\imath_{011}$	–	3.20%	–	–	–	–	2.04%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{06.02}$-f_{43}-$h_{06.02}$-$\imath_{011}$	–	3.09%	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-g_{51}-$h_{06.02}$-$\imath_{011}$-j_{00}	–	2.94%	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{06.02}$-f_{43}-g_{51}-$\imath_{011}$	–	2.94%	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.06}$-$h_{10.06}$-$\imath_{011}$-j_{20}	–	–	3.50%	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.06}$-f_{41}-$h_{10.06}$-j_{20}	–	–	2.34%	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-f_{43}-g_{51}-$\imath_{011}$-j_{20}	–	–	2.12%	–	–	–	–	–	–	–	–	–	2.51%
a_{01}-b_{011}-c_{11}-$e_{10.06}$-g_{63}-$h_{10.06}$-j_{20}	–	–	2.03%	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-g_{51}-$h_{06.02}$-$\imath_{011}$-j_{20}	–	–	2.03%	–	2.37%	–	2.23%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.06}$-f_{41}-$h_{10.06}$-$\imath_{011}$	–	–	2.00%	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{06.02}$-$h_{06.02}$-$\imath_{011}$-j_{20}	–	–	1.95%	–	2.39%	–	2.26%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-f_{64}-$h_{00.01}$-j_{00}	–	–	–	4.57%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-$h_{00.01}$-$\imath_{011}$-j_{00}	–	–	–	4.29%	–	–	–	1.44%	–	–	–	2.75%	–
a_{01}-b_{011}-c_{11}-d_{61}-$e_{00.01}$-$h_{00.01}$-j_{00}	–	–	–	3.43%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-$h_{00.01}$-$\imath_{061}$-j_{00}	–	–	–	3.43%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{70}-$e_{00.01}$-$h_{00.01}$-j_{00}	–	–	–	2.86%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-g_{16}-$h_{00.01}$-j_{00}	–	–	–	2.57%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-g_{32}-$h_{00.01}$-j_{00}	–	–	–	2.57%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{61}-$e_{00.01}$-f_{64}-$h_{00.01}$	–	–	–	2.29%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-f_{51}-$h_{00.01}$-j_{00}	–	–	–	2.29%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-f_{51}-$h_{00.01}$-j_{00}	–	–	–	2.29%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-f_{51}-$h_{00.01}$-$\imath_{011}$	–	–	–	2.29%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{09.99}$-$h_{09.99}$-$\imath_{011}$-j_{20}:	–	–	–	–	2.78%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{09.99}$-$h_{09.99}$-$\imath_{011}$	–	–	–	–	2.41%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-f_{64}-g_{53}-$\imath_{011}$-j_{20}	–	–	–	–	2.35%	–	–	1.74%	–	–	–	–	–
a_{01}-b_{011}-$e_{06.02}$-g_{51}-$h_{06.02}$-$\imath_{011}$-j_{20}	–	–	–	–	2.23%	–	2.06%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-f_{64}-$\imath_{011}$-j_{20}	–	–	–	–	2.21%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.16}$-$h_{10.16}$-$\imath_{011}$-j_{00}	–	–	–	–	–	5.26%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.16}$-$h_{10.16}$-$\imath_{011}$-j_{20}	–	–	–	–	–	3.91%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{13}-$e_{10.16}$-$h_{10.16}$-$\imath_{011}$	–	–	–	–	–	3.64%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.16}$-g_{63}-$h_{10.16}$-j_{20}	–	–	–	–	–	3.37%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.16}$-g_{63}-$h_{10.16}$-$\imath_{011}$	–	–	–	–	–	3.37%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{13}-$e_{10.16}$-$h_{10.16}$-j_{20}	–	–	–	–	–	3.10%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.16}$-f_{41}-$h_{10.16}$-j_{20}	–	–	–	–	–	2.83%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.16}$-f_{41}-$h_{10.16}$-$\imath_{011}$	–	–	–	–	–	2.83%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{13}-$e_{10.16}$-g_{63}-$h_{10.16}$	–	–	–	–	–	2.70%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.16}$-f_{41}-g_{63}-$h_{10.16}$	–	–	–	–	–	2.56%	–	–	–	–	–	–	–
b_{011}-c_{11}-$e_{06.02}$-g_{51}-$h_{06.02}$-$\imath_{011}$-j_{20}	–	–	–	–	–	–	2.04%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{06.02}$-g_{51}-$\imath_{011}$-j_{20}	–	–	–	–	–	–	2.10%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-$h_{00.01}$-$\imath_{011}$-j_{20}	–	–	–	–	–	–	–	2.89%	–	–	2.34%	–	–
a_{01}-b_{011}-c_{11}-$e_{14.99}$-$h_{14.99}$-$\imath_{011}$-j_{20}	–	–	–	–	–	–	–	2.41%	–	–	–	–	–

[a]Support value for minsup = 0.003, [b]Support value for minsup = 0.004, [c]Support value for minsup = 0.002, [d]Support value for minsup = 0.000, [e]Support value for minsup = 0.001, [f]Support value for minsup = 0.000, [g]Support value for minsup = 0.004, [h]Support value for minsup = 0.006, [i]Support value for minsup = 0.000, [j]Support value for minsup = 0.002, [k]Support value for minsup = 0.002, [l]Support value for minsup = 0.0032, [m]Support value for minsup = 0.002.

Table 24
The first ten accident sequences pattern with seven and eight items for each section: support value (Others excluded data: n = 307,594).

Sequences	Support value												
	CA[a]	CB[b]	CC[c]	CD[d]	CE[e]	CF[f]	CG[g]	CH[h]	CI[i]	CJ[j]	CK[k]	CL[l]	CM[m]
a_{01}-b_{011}-c_{11}-$e_{14.03}$-$h_{14\cdot03}$-$\imath_{011}$-j_{20}	–	–	–	–	–	–	–	1.75%	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-f_{43}-$\imath_{011}$-j_{20}	–	–	–	–	–	–	–	1.54%	–	–	2.98%	2.24%	3.22%
a_{01}-b_{011}-c_{11}-$e_{10.12}$-$h_{10.12}$-$\imath_{011}$-j_{20}	–	–	–	–	–	–	–	1.30%	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{22}-f_{43}-$\imath_{011}$-j_{20}	–	–	–	–	–	–	–	1.27%	–	–	–	–	2.10%
a_{01}-b_{011}-c_{11}-$e_{14.99}$-f_{44}-$h_{14.99}$-j_{20}	–	–	–	–	–	–	–	1.21%	–	–	–	–	–
a_{01}-b_{011}-c_{11}-f_{44}-g_{53}-$\imath_{011}$-j_{20}	–	–	–	–	–	–	–	1.19%	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{14.05}$-$h_{14.05}$-$\imath_{032}$-j_{00}	–	–	–	–	–	–	–	–	5.22%	2.37%	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.05}$-$h_{14.05}$-j_{00}	–	–	–	–	–	–	–	–	3.90%	3.24%	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-f_{44}-$\imath_{011}$-j_{00}	–	–	–	–	–	–	–	–	3.52%	4.01%	2.12%	–	–
a_{01}-b_{011}-c_{11}-$e_{14.05}$-$h_{14.05}$-$\imath_{011}$-j_{00}	–	–	–	–	–	–	–	–	3.44%	3.26%	0.00%	–	–
a_{01}-b_{011}-c_{11}-$e_{14.12}$-$h_{14.12}$-$\imath_{011}$-j_{00}	–	–	–	–	–	–	–	–	2.78%	3.26%	2.42%	–	–
a_{01}-b_{011}-c_{11}-$e_{14.99}$-$h_{14.99}$-$\imath_{011}$-j_{00}	–	–	–	–	–	–	–	–	2.53%	2.92%	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.05}$-$\imath_{032}$-j_{00}	–	–	–	–	–	–	–	–	2.45%	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.12}$-$h_{14.12}$-j_{00}	–	–	–	–	–	–	–	–	2.40%	2.26%	2.09%	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$h_{14.05}$-$\imath_{032}$-j_{00}	–	–	–	–	–	–	–	–	2.36%	–	–	–	–
a_{01}-b_{011}-c_{11}-f_{44}-g_{53}-$\imath_{011}$-j_{00}	–	–	–	–	–	–	–	–	2.24%	3.07%	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-g_{51}-$\imath_{011}$-j_{00}	–	–	–	–	–	–	–	–	–	2.58%	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$h_{14.05}$-$\imath_{011}$-j_{00}	–	–	–	–	–	–	–	–	–	2.29%	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.06}$-f_{43}-$h_{06.06}$	–	–	–	–	–	–	–	–	–	–	2.30%	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.12}$-$h_{14.12}$-$\imath_{011}$	–	–	–	–	–	–	–	–	–	–	2.23%	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.06}$-$h_{06.06}$-$\imath_{011}$	–	–	–	–	–	–	–	–	–	–	2.21%	–	2.19%
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.06}$-$h_{06.06}$-j_{20}	–	–	–	–	–	–	–	–	–	–	2.18%	–	–
a_{01}-b_{011}-c_{11}-$e_{14.12}$-g_{51}-$h_{14.12}$-$\imath_{011}$	–	–	–	–	–	–	–	–	–	–	2.13%	–	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{00.01}$-f_{71}-$h_{00.01}$	–	–	–	–	–	–	–	–	–	–	–	2.51%	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{00.01}$-$h_{00.01}$-j_{00}	–	–	–	–	–	–	–	–	–	–	–	2.44%	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-f_{71}-$h_{00.01}$-j_{00}	–	–	–	–	–	–	–	–	–	–	–	2.27%	–
a_{01}-b_{011}-c_{11}-d_{11}-f_{71}-$h_{00.01}$-j_{00}	–	–	–	–	–	–	–	–	–	–	–	2.20%	–
b_{011}-c_{11}-d_{11}-$e_{00.01}$-f_{71}-$h_{00.01}$-j_{00}	–	–	–	–	–	–	–	–	–	–	–	2.20%	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{00.01}$-f_{71}-j_{00}	–	–	–	–	–	–	–	–	–	–	–	2.19%	–
a_{01}-b_{011}-d_{11}-$e_{00.01}$-f_{71}-$h_{00.01}$-j_{00}	–	–	–	–	–	–	–	–	–	–	–	2.18%	–
a_{01}-c_{11}-d_{11}-$e_{00.01}$-f_{71}-$h_{00.01}$-j_{00}	–	–	–	–	–	–	–	–	–	–	–	2.18%	–
a_{01}-b_{011}-c_{11}-d_{21}-f_{43}-$\imath_{011}$-j_{00}	–	–	–	–	–	–	–	–	–	–	–	–	2.69%
a_{01}-b_{011}-c_{11}-d_{21}-f_{43}-g_{52}-$\imath_{011}$	–	–	–	–	–	–	–	–	–	–	–	–	2.50%
a_{01}-b_{011}-c_{11}-f_{43}-g_{52}-$\imath_{011}$-j_{00}	–	–	–	–	–	–	–	–	–	–	–	–	2.31%
a_{01}-b_{011}-c_{11}-f_{43}-g_{52}-$\imath_{011}$-j_{20}	–	–	–	–	–	–	–	–	–	–	–	–	2.22%
a_{01}-b_{011}-c_{11}-d_{21}-f_{43}-g_{51}-$\imath_{011}$	–	–	–	–	–	–	–	–	–	–	–	–	1.93%
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$	4.53%	1.92%	–	–	–	–	1.67%	–	–	–	–	0.84%	1.29%
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-g_{51}-$h_{06.02}$-$\imath_{011}$	4.50%	2.30%	1.26%	–	–	–	1.58%	–	–	–	–	–	1.34%
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-g_{51}-$h_{06.02}$-j_{00}	4.22%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{06.02}$-g_{51}-$h_{06.02}$-$\imath_{011}$-j_{00}	3.94%	2.60%	–	–	–	–	1.68%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-j_{00}	3.90%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-$\imath_{011}$	3.85%	2.86%	1.42%	–	1.92%	–	1.84%	–	–	–	–	–	1.42%
a_{01}-c_{11}-d_{21}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-$\imath_{011}$	3.43%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-c_{11}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-$\imath_{011}$-j_{00}	3.24%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-f_{43}-$h_{06.02}$-$\imath_{011}$	3.23%	–	–	–	–	–	1.18%	–	–	–	–	–	–
a_{01}-c_{11}-d_{21}-$e_{06.02}$-g_{51}-$h_{06.02}$-$\imath_{011}$-j_{00}	3.21%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{06.02}$-g_{51}-$h_{06.02}$-$\imath_{011}$-j_{20}	–	2.45%	1.84%	–	2.13%	–	2.01%	–	–	–	–	–	1.28%
a_{01}-b_{011}-c_{11}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-j_{20}	–	2.06%	1.47%	–	1.64%	–	1.71%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.99}$-$h_{06.99}$-$\imath_{011}$-j_{00}	–	1.90%	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{07.07}$-g_{52}-$h_{07.07}$-$\imath_{011}$-j_{00}	–	1.86%	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.99}$-f_{49}-$h_{06.99}$-$\imath_{011}$	–	1.85%	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.99}$-f_{49}-$h_{06.99}$-j_{00}	–	1.77%	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.06}$-f_{41}-$h_{10.06}$-$\imath_{011}$-j_{20}	–	–	1.42%	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.06}$-g_{63}-$h_{10.06}$-$\imath_{011}$-j_{20}:	–	–	1.23%	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{10.06}$-$h_{10.06}$-$\imath_{011}$-j_{20}	–	–	1.18%	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-f_{43}-g_{51}-$h_{06.02}$-$\imath_{011}$-j_{20}	–	–	1.14%	–	–	–	1.20%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{06.02}$-f_{43}-g_{51}-$\imath_{011}$-j_{20}	–	–	1.09%	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-g_{51}-$h_{06.02}$-j_{20}	–	–	1.08%	–	–	–	1.39%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-f_{51}-$h_{00.01}$-$\imath_{011}$-j_{00}	–	–	–	2.00%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{61}-$e_{00.01}$-f_{64}-$h_{00.01}$-j_{00}	–	–	–	1.71%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{70}-g_{15}-$h_{00.01}$-$\imath_{071}$-j_{00}	–	–	–	1.71%	–	–	–	–	–	–	–	–	–

[a]Support value for minsup = 0.003, [b]Support value for minsup = 0.004, [c]Support value for minsup = 0.002, [d]Support value for minsup = 0.000, [e]Support value for minsup = 0.001, [f]Support value for minsup = 0.000, [g]Support value for minsup = 0.004, [h]Support value for minsup = 0.006, [i]Support value for minsup = 0.000, [j]Support value for minsup = 0.002, [k]Support value for minsup = 0.002, [l]Support value for minsup = 0.0032, [m]Support value for minsup = 0.002.

Table 25
The first ten accident sequences pattern with eight items for each section: support value ($n_{others\ excluded}$ = 307,594).

Sequences	Support value												
	CA[a]	CB[b]	CC[c]	CD[d]	CE[e]	CF[f]	CG[g]	CH[h]	CI[i]	CJ[j]	CK[k]	CL[l]	CM[m]
a_{01}-b_{011}-c_{11}-$e_{00.01}$-f_{64}-$h_{00.01}$-i_{061}-j_{00}	–	–	–	1.71%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{00}-$e_{00.01}$-g_{00}-$h_{00.01}$-j_{00}	–	–	–	1.43%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{61}-$e_{00.01}$-g_{32}-$h_{00.01}$-j_{00}	–	–	–	1.43%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{61}-$e_{00.01}$-$h_{00.01}$-i_{011}-j_{00}	–	–	–	1.43%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{61}-$e_{00.01}$-$h_{00.01}$-i_{061}-j_{00}	–	–	–	1.43%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{70}-$e_{00.01}$-f_{23}-$h_{00.01}$-j_{00}	–	–	–	1.43%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{70}-$e_{15.02}$-g_{15}-i_{071}-j_{00}	–	–	–	2.29%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{09.99}$-$h_{09.99}$-i_{011}-j_{20}	–	–	–	–	1.99%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{09.99}$-f_{49}-$h_{09.99}$-i_{011}	–	–	–	–	1.74%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{09.99}$-f_{49}-$h_{09.99}$-i_{011}-j_{20}	–	–	–	–	1.66%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{09.99}$-f_{49}-$h_{09.99}$-j_{20}	–	–	–	–	1.64%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{09.99}$-f_{49}-i_{011}-j_{20}	–	–	–	–	1.56%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{11}-f_{49}-$h_{09.99}$-i_{011}-j_{20}	–	–	–	–	1.54%	–	–	–	–	–	–	–	–
a_{01}-c_{11}-d_{11}-$e_{09.99}$-f_{49}-$h_{09.99}$-i_{011}-j_{20}	–	–	–	–	1.54%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{13}-$e_{10.16}$-g_{63}-$h_{10.16}$-j_{20}	–	–	–	–	–	1.89%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{13}-$e_{10.16}$-$h_{10.16}$-i_{011}-j_{20}	–	–	–	–	–	1.89%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{13}-$e_{10.16}$-$h_{10.16}$-i_{011}-j_{00}	–	–	–	–	–	1.75%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.16}$-g_{63}-$h_{10.16}$-i_{011}-j_{20}	–	–	–	–	–	1.75%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.16}$-f_{41}-g_{63}-$h_{10.16}$-j_{20}	–	–	–	–	–	1.62%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.16}$-f_{41}-$h_{10.16}$-i_{011}-j_{20}	–	–	–	–	–	1.62%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.16}$-f_{64}-$h_{10.16}$-i_{011}-j_{00}	–	–	–	–	–	1.62%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.16}$-g_{63}-$h_{10.16}$-i_{011}-j_{00}	–	–	–	–	–	1.62%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{12}-$e_{10.16}$-$h_{10.16}$-i_{011}-j_{00}	–	–	–	–	–	1.48%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{13}-$e_{10.16}$-f_{41}-$h_{10.16}$-j_{20}	–	–	–	–	–	1.48%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{06.02}$-g_{51}-$h_{06.02}$-i_{011}-j_{00}	–	–	–	–	–	–	1.28%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{14.99}$-f_{44}-$h_{14.99}$-i_{011}-j_{20}	–	–	–	–	–	–	–	0.82%	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{14.99}$-g_{53}-$h_{14.99}$-i_{011}-j_{20}	–	–	–	–	–	–	–	0.80%	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-f_{64}-$h_{00.01}$-i_{011}-j_{20}	–	–	–	–	–	–	–	0.76%	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$- g_{53}-$h_{00.01}$-i_{011}-j_{20}	–	–	–	–	–	–	–	0.67%	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.06}$-f_{43}-$h_{06.02}$- j_{20}	–	–	–	–	–	–	–	0.67%	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{14.03}$-f_{44}-$h_{14.03}$-i_{011}-j_{20}	–	–	–	–	–	–	–	0.64%	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{10.12}$-f_{41}-$h_{10.12}$-j_{20}	–	–	–	–	–	–	–	0.62%	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.05}$-$h_{14.05}$-i_{032}-j_{00}	–	–	–	–	–	–	–	–	2.20%	1.23%	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.05}$-$h_{14.05}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	1.62%	1.98%	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.12}$-$h_{14.12}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	1.62%	1.80%	2.04%	–	–
a_{01}-b_{011}-c_{11}-$e_{14.05}$-g_{51}-$h_{14.05}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	1.53%	1.65%	–	–	–
a_{01}-b_{011}-c_{11}-$e_{14.03}$-g_{53}-h1$_{4.03}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	1.49%	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{14.05}$-g_{71}-$h_{14.05}$-i_{032}-j_{00}	–	–	–	–	–	–	–	–	1.45%	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{14.03}$-f_{44}-$h_{14.03}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	1.41%	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{14.05}$-f_{71}-$h_{14.05}$-i_{032}-j_{00}	–	–	–	–	–	–	–	–	1.37%	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{14.12}$-g_{71}-$h_{14.12}$-i_{032}-j_{00}	–	–	–	–	–	–	–	–	1.33%	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{14.03}$-f_{44}-g_{53}-i_{011}-j_{00}	–	–	–	–	–	–	–	–	1.29%	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{14.12}$-f_{44}-$h_{14.12}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	1.45%	1.79%	–	–
a_{01}-b_{011}-c_{11}-d_{41}-g_{51}-$h_{14.05}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	1.36%	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.05}$-g_{51}-$h_{14.05}$-j_{00}	–	–	–	–	–	–	–	–	–	1.23%	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-f_{44}-g_{53}-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	1.23%	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.05}$-g_{51}-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	1.19%	–	–	–
b_{011}-c_{11}-d_{41}-$e_{14.05}$-g_{51}-$h_{14.05}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	1.19%	–	–	–
a_{01}-b_{011}-c_{11}-$e_{14.12}$-g_{51}-$h_{14.12}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	–	1.99%	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.12}$-g_{51}-$h_{14.12}$-i_{011}	–	–	–	–	–	–	–	–	–	–	1.93%	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.12}$-g_{51}-$h_{14.12}$-j_{00}	–	–	–	–	–	–	–	–	–	–	1.87%	–	–
a_{01}-b_{011}-c_{11}-d_{41}-g_{51}-$h_{14.12}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	–	1.86%	–	–
b_{011}-c_{11}-d_{41}-$e_{14.12}$-g_{51}-$h_{14.12}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	–	1.86%	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.12}$-f_{44}-$h_{14.12}$-i_{011}	–	–	–	–	–	–	–	–	–	–	1.72%	–	–
a_{01}-b_{011}-c_{11}-$e_{14.12}$-f_{44}-g_{51}-$h_{14.12}$-i_{011}	–	–	–	–	–	–	–	–	–	–	1.69%	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.12}$-f_{44}-$h_{14.12}$-j_{00}	–	–	–	–	–	–	–	–	–	–	1.67%	–	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{00.01}$-f_{71}-$h_{00.01}$-j_{00}	–	–	–	–	–	–	–	–	–	–	–	2.18%	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{00.01}$-$h_{00.01}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	–	–	1.27%	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-f_{71}-$h_{00.01}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	–	–	1.22%	–
a_{01}-b_{011}-c_{11}-d_{11}-f_{71}-$h_{00.01}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	–	–	1.11%	–

[a]Support value for minsup = 0.003, [b]Support value for minsup = 0.004, [c]Support value for minsup = 0.002, [d]Support value for minsup = 0.000, [e]Support value for minsup = 0.001, [f]Support value for minsup = 0.000, [g]Support value for minsup = 0.004, [h]Support value for minsup = 0.006, [i]Support value for minsup = 0.000, [j]Support value for minsup = 0.002, [k]Support value for minsup = 0.002, [l]Support value for minsup = 0.0032, [m]Support value for minsup = 0.002.

using the following sequential accident pattern with 6 items and a support value of 7.16%, which is expressed in Table 9 and only seen in the CA section. This means that the accident sequence a_{01}-c_{11}-d_{21}-$e_{06.02}$-g_{51}-$h_{06.02}$ is seen in 7.16% of the accidents in the CA section. It is critical that the sequential accident patterns in question support safety managers' decision-making in order to prevent the repetition of similar accidents and potential accidents.

$\langle a_{011} - c_{11} - d_{21} - e_{06.02} - g_{51} - h_{06.02} \rangle$:
⟨Usual workstation or within the usual local unit of work − production, manufacturing, processing (all types) −working with hand −held tools (manual) −hand tools, not powered/for cutting, separating (including scissors, shears, secateurs) − contact with sharp material agent (knife, blade etc.) − hand tools, not powered/for cutting, separating (including scissors, shears, secateurs)⟩.

Table 26
The first ten accident sequences pattern with eight and nine items for each section: support value ($n_{others\ excluded} = 307{,}594$).

Sequences	Support value												
	CA[a]	CB[b]	CC[c]	CD[d]	CE[e]	CF[f]	CG[g]	CH[h]	CI[i]	CJ[j]	CK[k]	CL[l]	CM[m]
b_{011}-c_{11}-d_{11}-$e_{00.01}$-f_{71}-$h_{00.01}$-$\imath_{011}$-j_{00}	–	–	–	–	–	–	–	–	–	–	–	1.08%	–
a_{01}-b_{011}-c_{11}-d_{11}-f_{71}-$h_{00.01}$-$\imath_{011}$-j_{00}	–	–	–	–	–	–	–	–	–	–	–	1.08%	–
a_{01}-b_{011}-d_{11}-$e_{00.01}$-f_{71}-$h_{00.01}$-$\imath_{011}$-j_{00}	–	–	–	–	–	–	–	–	–	–	–	1.07%	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{00.01}$-f_{71}-$h_{00.01}$-$\imath_{032}$	–	–	–	–	–	–	–	–	–	–	–	0.82%	–
a_{01}-b_{011}-c_{11}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-$\imath_{011}$	–	–	–	–	–	–	–	–	–	–	–	0.82%	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.06}$-f_{43}-$h_{06.06}$-$\imath_{011}$	–	–	–	–	–	–	–	–	–	–	–	–	1.64%
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.06}$-g_{52}-$h_{06.06}$-$\imath_{011}$	–	–	–	–	–	–	–	–	–	–	–	–	1.44%
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.06}$-f_{43}-g_{52}-$\imath_{011}$	–	–	–	–	–	–	–	–	–	–	–	–	1.25%
a_{01}-b_{011}-c_{11}-d_{21}-f_{43}-g_{52}-$\imath_{011}$-j_{00}	–	–	–	–	–	–	–	–	–	–	–	–	1.25%
a_{01}-b_{011}-c_{11}-d_{21}-f_{43}-g_{52}-$\imath_{011}$-j_{20}	–	–	–	–	–	–	–	–	–	–	–	–	1.25%
a_{01}-b_{011}-c_{11}-$e_{06.06}$-f_{43}-g_{52}-$h_{06.06}$-$\imath_{011}$	–	–	–	–	–	–	–	–	–	–	–	–	1.25%
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-$\imath_{011}$	3.12%	1.46%	0.79%	–	0.95%	–	–	–	–	–	–	1.01%	0.52%
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-g_{51}-$h_{06.02}$-$\imath_{011}$-j_{00}	2.97%	1.21%	–	–	0.63%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-j_{00}	2.88%	0.88%	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-$\imath_{011}$-j_{00}	2.57%	1.41%	–	–	0.75%	–	–	–	–	–	–	–	–
a_{01}-c_{11}-d_{21}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-$\imath_{011}$-j_{00}	2.36%	–	–	–	–	–	0.45%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-f_{43}-$h_{06.02}$-$\imath_{011}$-j_{00}	2.20%	0.79%	–	–	–	–	0.49%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-f_{43}-g_{51}-$\imath_{011}$-j_{00}	2.20%	–	–	–	–	–	0.47%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-f_{43}-g_{51}-$h_{06.02}$-$\imath_{011}$-j_{00}	2.20%	–	–	–	–	–	0.48%	–	–	–	–	–	–
a_{01}-b_{011}-d_{21}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-$\imath_{011}$-j_{00}	2.18%	–	–	–	–	–	0.46%	–	–	–	–	–	–
b_{011}-c_{11}-d_{21}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-$\imath_{011}$-j_{00}	2.17%	–	–	–	–	–	0.45%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.99}$-f_{49}-$h_{06.99}$-$\imath_{011}$-j_{00}	–	1.76%	–	–	0.00%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-$\imath_{011}$-j_{20}	–	1.44%	1.04%	–	1.18%	–	–	–	–	–	–	0.89%	0.49%
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-g_{51}-$h_{06.02}$-$\imath_{011}$-j_{20}	–	1.08%	0.88%	–	0.83%	–	–	–	–	–	–	0.88%	0.46%
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-j_{20}	–	1.03%	0.67%	–	0.63%	–	–	–	–	–	–	0.97%	0.47%
a_{01}-b_{011}-c_{11}-$e_{07.07}$-f_{41}-g_{52}-$h_{07.07}$-$\imath_{011}$-j_{00}	–	0.85%	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{10.06}$-f_{41}-$h_{10.06}$-$\imath_{011}$-j_{20}	–	–	0.67%	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-f_{43}-g_{51}-$h_{06.02}$-$\imath_{011}$-j_{20}	–	–	0.59%	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.06}$-f_{41}-g_{63}-$h_{10.06}$-$\imath_{011}$-j_{20}	–	–	0.58%	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-f_{43}-$h_{06.02}$-$\imath_{011}$-j_{20}	–	–	0.57%	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-f_{43}-g_{51}-$\imath_{011}$-j_{20}	–	–	0.56%	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-d_{21}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-$\imath_{011}$-j_{20}	–	–	0.56%	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{00}-$e_{00.01}$-f_{51}-g_{00}-$h_{00.01}$-$\imath_{011}$	–	–	–	1.14%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{61}-$e_{00.01}$-f_{51}-g_{31}-$\imath_{011}$-j_{00}	–	–	–	1.14%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{00}-f_{14}-g_{23}-$h_{04.01}$-$\imath_{079}$-j_{20}	–	–	–	0.86%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{00.01}$-g_{16}-$h_{00.01}$-$\imath_{000}$-j_{00}	–	–	–	0.86%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{61}-$e_{00.01}$-f_{64}-g_{32}-$h_{00.01}$-j_{00}	–	–	–	0.86%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{61}-$e_{00.01}$-f_{64}-$h_{00.01}$-$\imath_{061}$-j_{00}	–	–	–	0.86%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{61}-$e_{00.01}$-g_{32}-$h_{00.01}$-$\imath_{061}$-j_{00}	–	–	–	0.86%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{61}-$e_{02.02}$-f_{52}-$h_{02.02}$-$\imath_{011}$-j_{20}	–	–	–	0.86%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{70}-$e_{00.01}$-f_{23}-g_{15}-$h_{00.01}$-$\imath_{071}$	–	–	–	0.86%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-f_{64}-g_{13}-$h_{00.01}$-$\imath_{061}$-j_{00}	–	–	–	0.86%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{09.99}$-f_{49}-$h_{09.99}$-$\imath_{011}$-j_{20}	–	–	–	–	1.52%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{09.99}$-f_{49}-g_{63}-$h_{09.99}$-$\imath_{011}$	–	–	–	–	0.71%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{09.99}$-f_{49}-g_{63}-$h_{09.99}$-j_{20}	–	–	–	–	0.69%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{09.99}$-f_{49}-g_{63}-$h_{09.99}$-$\imath_{011}$-j_{20}	–	–	–	–	0.67%	–	–	–	–	–	–	–	–
a_{01}-b_{012}-c_{24}-d_{70}-$e_{00.01}$-f_{14}-g_{23}-$\imath_{000}$-j_{00}	–	–	–	–	–	1.21%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{13}-$e_{10.16}$-f_{41}-g_{63}-$h_{10.16}$-j_{20}	–	–	–	–	–	0.94%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{13}-$e_{10.16}$-g_{63}-$h_{10.16}$-$\imath_{011}$-j_{20}	–	–	–	–	–	0.81%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{10.16}$-f_{41}-g_{63}-$h_{10.16}$-$\imath_{011}$-j_{00}	–	–	–	–	–	0.81%	–	–	–	–	–	–	–
a_{02}-b_{061}-c_{61}-$e_{12.02}$-f_{42}-g_{45}-$h_{12.02}$-$\imath_{011}$-j_{20}	–	–	–	–	–	0.81%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{12}-$e_{10.16}$-f_{41}-g_{63}-$h_{10.16}$-j_{00}	–	–	–	–	–	0.67%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{12}-$e_{10.16}$-f_{41}-g_{63}-$h_{10.16}$-$\imath_{011}$	–	–	–	–	–	0.67%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{12}-$e_{10.16}$-g_{63}-$h_{10.16}$-$\imath_{011}$-j_{00}	–	–	–	–	–	0.67%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{13}-$e_{10.16}$-f_{41}-$h_{10.16}$-$\imath_{011}$-j_{20}	–	–	–	–	–	0.67%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{13}-$e_{10.16}$-g_{63}-$h_{10.16}$-$\imath_{011}$-j_{00}	–	–	–	–	–	0.67%	–	–	–	–	–	–	–
a_{01}-c_{11}-d_{21}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-$\imath_{011}$-j_{20}	–	–	–	–	–	–	0.63%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-$\imath_{012}$-j_{20}	–	–	–	–	–	–	0.61%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-$\imath_{012}$	–	–	–	–	–	–	0.57%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-g_{51}-$h_{06.02}$-$\imath_{012}$-j_{20}	–	–	–	–	–	–	0.45%	–	–	–	–	–	–

[a]Support value for minsup = 0.003, [b]Support value for minsup = 0.004, [c]Support value for minsup = 0.002, [d]Support value for minsup = 0.000, [e]Support value for minsup = 0.001, [f]Support value for minsup = 0.000, [g]Support value for minsup = 0.004, [h]Support value for minsup = 0.006, [i]Support value for minsup = 0.000, [j]Support value for minsup = 0.002, [k]Support value for minsup = 0.002, [l]Support value for minsup = 0.0032, [m]Support value for minsup = 0.002.

Table 27
The first ten accident sequences pattern with nine and ten items for each section: support value ($n_{others\ excluded} = 307{,}594$).

Sequences	Support value											
	CA[a]	CB[b]	CC[c]	CD[d]	CE[e]	CF[f]	CG[g]	CI[i]	CJ[j]	CK[k]	CL[l]	CM[m]
a_{01}-b_{011}-c_{11}-$e_{14.03}$-f_{44}-g_{53}-$h_{14.03}$-i_{011}-j_{00}	–	–	–	–	–	–	–	0.14%	0.14%	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.03}$-g_{53}-$h_{14.03}$-i_{011}-j_{00}	–	–	–	–	–	–	–	0.03%	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.03}$-f_{44}-$h_{14.03}$-i_{011}-j_{00}	–	–	–	–	–	–	–	0.03%	0.12%	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.05}$-g_{51}-$h_{14.05}$-i_{011}-j_{00}	–	–	–	–	–	–	–	0.03%	0.25%	–	–	–
a_{01}-b_{011}-c_{11}-$e_{14.05}$-f_{71}-g_{71}-$h_{14.05}$-i_{032}-j_{00}	–	–	–	–	–	–	–	0.03%	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{51}-$e_{14.05}$-g_{71}-$h_{14.05}$-i_{032}-j_{00}	–	–	–	–	–	–	–	0.02%	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{51}-$e_{14.05}$-f_{71}-$h_{14.05}$-i_{032}-j_{00}	–	–	–	–	–	–	–	0.02%	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.12}$-f_{44}-$h_{14.12}$-i_{011}-j_{00}	–	–	–	–	–	–	–	0.02%	0.20%	12.89%	–	–
a_{01}-b_{011}-c_{11}-d_{51}-$e_{14.05}$-f_{71}-g_{71}-$h_{14.05}$-j_{00}	–	–	–	–	–	–	–	0.02%	–	–	–	–
a_{01}-b_{011}-d_{51}-$e_{14.05}$-f_{71}-g_{71}-$h_{14.05}$-i_{032}-j_{00}	–	–	–	–	–	–	–	0.02%	0.00%	–	–	–
a_{01}-b_{011}-c_{11}-$e_{14.01}$-f_{44}-g_{53}-$h_{14.01}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	0.19%	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.05}$-f_{44}-$h_{14.05}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	0.13%	–	–	–
a_{01}-b_{011}-c_{11}-d_{42}-$e_{14.01}$-g_{53}-$h_{14.01}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	0.12%	–	–	–
a_{01}-b_{011}-c_{11}-d_{42}-$e_{14.01}$-f_{44}-g_{53}-i_{011}-j_{00}	–	–	–	–	–	–	–	–	0.11%	–	–	–
a_{01}-b_{011}-c_{11}-d_{42}-$e_{14.01}$-f_{44}-$h_{14.01}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	0.11%	–	–	–
a_{01}-b_{011}-c_{11}-d_{42}-f_{44}-g_{53}-$h_{14.01}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	0.11%	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.12}$-g_{51}-$h_{14.12}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	14.47%	–	–
a_{01}-b_{011}-c_{11}-$e_{14.12}$-f_{44}-g_{51}-$h_{14.12}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	12.77%	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.12}$-f_{44}-g_{51}-$h_{14.12}$-i_{011}	–	–	–	–	–	–	–	–	–	12.35%	–	–
b_{011}-c_{11}-d_{41}-$e_{14.12}$-f_{44}-g_{51}-$h_{14.12}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	12.02%	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.12}$-f_{44}-g_{51}-$h_{14.12}$-j_{00}	–	–	–	–	–	–	–	–	–	11.98%	–	–
a_{01}-b_{011}-c_{11}-d_{41}-f_{44}-g_{51}-$h_{14.12}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	11.98%	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.06}$-f_{43}-$h_{06.06}$-i_{011}-j_{20}	–	–	–	–	–	–	–	–	–	6.63%	0.82%	0.91%
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.06}$-f_{43}-g_{53}-$h_{06.06}$-j_{20}	–	–	–	–	–	–	–	–	–	5.22%	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.06}$-g_{53}-$h_{06.06}$-i_{011}-j_{20}	–	–	–	–	–	–	–	–	–	4.39%	–	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{00.01}$-f_{71}-$h_{00.01}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	–	2.09%	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{00.01}$-f_{71}-$h_{00.01}$-i_{032}-j_{00}	–	–	–	–	–	–	–	–	–	–	1.41%	–
a_{01}-b_{011}-c_{11}-d_{13}-$e_{10.15}$-f_{64}-g_{51}-$h_{14.12}$-i_{012}	–	–	–	–	–	–	–	–	–	–	1.00%	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{00.01}$-f_{71}-g_{00}-$h_{00.01}$-j_{00}	–	–	–	–	–	–	–	–	–	–	0.93%	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{00.01}$-f_{71}-g_{31}-$h_{00.01}$-j_{00}	–	–	–	–	–	–	–	–	–	–	0.86%	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.06}$-f_{43}-g_{52}-$h_{06.06}$-i_{011}	–	–	–	–	–	–	–	–	–	–	–	1.15%
a_{01}-b_{011}-c_{11}-d_{22}-$e_{07.06}$-f_{43}-g_{52}-$h_{07.06}$-i_{011}	–	–	–	–	–	–	–	–	–	–	–	0.88%
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.06}$-g_{52}-$h_{06.06}$-i_{011}-j_{20}	–	–	–	–	–	–	–	–	–	–	–	0.80%
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.06}$-f_{43}-$h_{06.06}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	–	–	0.77%
a_{01}-b_{011}-c_{11}-$e_{07.06}$-f_{43}-g_{52}-$h_{07.06}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	–	–	0.70%
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-i_{011}-j_{00}	2.15%	0.71%	0.25%	–	0.43%	–	0.45%	0.04%	0.04%	–	–	0.35%
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-i_{011}-j_{20}	0.97%	0.74%	0.54%	–	0.53%	0.40%	0.62%	–	–	–	0.69%	0.58%
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-i_{012}-j_{00}	0.70%	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-i_{012}-j_{20}	0.66%	–	–	–	–	–	–	–	–	–	–	0.26%
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-f_{64}-g_{51}-$h_{06.02}$-i_{011}-j_{00}	0.50%	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.13}$-f_{43}-g_{53}-$h_{06.13}$-i_{011}-j_{00}	0.49%	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{035}-c_{11}-d_{41}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-i_{011}-j_{00}	0.42%	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-f_{64}-g_{51}-$h_{06.02}$-i_{012}-j_{00}	0.38%	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{06.02}$-f_{43}-g_{51}-$h_{06.02}$-i_{012}-j_{00}	0.33%	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{61}-$e_{00.01}$-f_{52}-g_{31}-$h_{02.02}$-i_{011}-j_{00}	0.31%	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{13}-$e_{10.15}$-f_{41}-g_{52}-$h_{10.15}$-i_{011}-j_{00}	–	0.53%	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{07.07}$-f_{41}-g_{52}-$h_{07.07}$-i_{011}-j_{00}	–	0.47%	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{22}-$e_{08.07}$-f_{64}-g_{52}-$h_{08.07}$-i_{011}-j_{20}	–	0.46%	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.06}$-f_{43}-g_{52}-$h_{06.06}$-i_{011}-j_{20}	–	–	0.26%	–	–	–	–	–	–	–	–	0.60%
a_{01}-b_{011}-c_{11}-d_{21}-$e_{10.06}$-f_{41}-g_{63}-$h_{10.06}$-i_{011}-j_{20}	–	–	0.25%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{22}-$e_{07.06}$-f_{43}-g_{52}-$h_{07.06}$-i_{011}-j_{20}	–	–	0.22%	–	–	–	–	–	–	–	–	0.32%
a_{01}-b_{011}-c_{11}-d_{13}-$e_{10.06}$-f_{41}-g_{63}-$h_{10.06}$-i_{011}-j_{20}	–	–	0.20%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{70}-$e_{15.02}$-f_{24}-g_{15}-$h_{00.01}$-i_{071}-j_{00}	–	–	–	1.14%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{00}-d_{00}-$e_{00.02}$-f_{13}-g_{13}-$h_{15.04}$-i_{062}-j_{20}	–	–	–	0.86%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{00}-$e_{00.01}$-f_{51}-g_{00}-$h_{00.01}$-i_{011}-j_{00}	–	–	–	0.86%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{61}-$e_{00.01}$-f_{51}-g_{31}-$h_{00.01}$-i_{011}-j_{00}	–	–	–	0.86%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{00}-$e_{00.01}$-f_{14}-g_{23}-$h_{04.01}$-i_{079}-j_{20}	–	–	–	0.57%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{10.13}$-f_{43}-g_{43}-$h_{07.10}$-i_{011}-j_{00}	–	–	–	0.57%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{00.01}$-f_{22}-g_{16}-$h_{00.01}$-i_{000}-j_{00}	–	–	–	0.57%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{02.02}$-f_{43}-g_{53}-$h_{02.02}$-i_{011}-j_{00}	–	–	–	0.57%	–	–	–	–	–	–	–	–

[a]Support value for minsup = 0.003, [b]Support value for minsup = 0.004, [c]Support value for minsup = 0.002, [d]Support value for minsup = 0.000, [e]Support value for minsup = 0.001, [f]Support value for minsup = 0.000, [g]Support value for minsup = 0.004, [h]Support value for minsup = 0.006, [i]Support value for minsup = 0.000, [j]Support value for minsup = 0.002, [k]Support value for minsup = 0.002, [l]Support value for minsup = 0.0032, [m]Support value for minsup = 0.002.

Table 28
The first ten accident sequences pattern with ten items for each section: support value ($n_{others\ excluded}$ = 307,594).

Sequences	Support value											
	CA[a]	CB[b]	CC[c]	CD[d]	CE[e]	CF[f]	CG[g]	CI[i]	CJ[j]	CK[k]	CL[l]	CM[m]
a_{01}-b_{011}-c_{11}-d_{21}-$e_{10.03}$-f_{23}-g_{16}-$h_{10.03}$-i_{011}-j_{00}	–	–	–	0.57%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{06.12}$-f_{35}-g_{13}-$h_{06.12}$-i_{061}-j_{20}	–	–	–	0.57%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{09.99}$-f_{49}-g_{63}-$h_{09.99}$-i_{011}-j_{20}	–	–	–	–	0.59%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{09.99}$-f_{49}-g_{44}-$h_{09.99}$-i_{011}-j_{20}	–	–	–	–	0.38%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{13}-$e_{00.01}$-f_{64}-g_{53}-$h_{10.99}$-i_{011}-j_{20}	–	–	–	–	0.28%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{69}-d_{61}-$e_{00.01}$-f_{23}-g_{15}-$h_{00.01}$-i_{071}-j_{20}	–	–	–	–	0.18%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{09.09}$-f_{49}-g_{49}-$h_{09.09}$-i_{011}-j_{20}	–	–	–	–	0.16%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{09.09}$-f_{49}-g_{42}-$h_{09.09}$-i_{011}-j_{20}	–	–	–	–	0.14%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{11}-$e_{10.16}$-f_{41}-g_{63}-$h_{10.16}$-i_{011}-j_{20}	–	–	–	–	0.14%	0.27%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{13}-$e_{10.16}$-f_{41}-g_{51}-$h_{10.16}$-i_{011}-j_{20}	–	–	–	–	0.14%	–	–	–	–	–	–	–
a_{01}-b_{012}-c_{24}-d_{70}-$e_{00.01}$-f_{14}-g_{23}-$h_{00.01}$-i_{000}-j_{00}	–	–	–	–	–	1.08%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{12}-$e_{10.16}$-f_{41}-g_{63}-$h_{10.16}$-i_{011}-j_{00}	–	–	–	–	–	0.54%	–	–	–	–	–	–
a_{02}-b_{061}-c_{61}-d_{70}-$e_{12.02}$-f_{42}-g_{45}-$h_{12.02}$-i_{011}-j_{20}	–	–	–	–	–	0.54%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{13}-$e_{10.16}$-f_{41}-g_{63}-$h_{10.16}$-i_{032}-j_{20}	–	–	–	–	–	0.40%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{00.01}$-f_{32}-g_{51}-$h_{00.01}$-i_{011}-j_{00}	–	–	–	–	–	0.40%	–	–	–	–	–	–
a_{01}-b_{011}-c_{00}-d_{00}-$e_{00.02}$-f_{52}-g_{00}-$h_{00.02}$-i_{000}-j_{00}	–	–	–	–	–	0.27%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{00}-$e_{00.02}$-f_{32}-g_{16}-$h_{14.99}$-i_{062}-j_{00}	–	–	–	–	–	0.27%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{12}-$e_{10.02}$-f_{41}-g_{63}-$h_{10.02}$-i_{011}-j_{20}	–	–	–	–	–	0.27%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.03}$-f_{44}-g_{53}-$h_{14.03}$-i_{011}-j_{00}	–	–	–	–	–	–	–	0.03%	0.08%	–	–	–
a_{01}-b_{011}-c_{11}-d_{51}-$e_{14.05}$-f_{71}-g_{71}-$h_{14.05}$-i_{032}-j_{00}	–	–	–	–	–	–	–	0.02%	0.05%	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.05}$-f_{72}-g_{51}-$h_{14.05}$-i_{011}-j_{00}	–	–	–	–	–	–	–	0.01%	0.04%	–	–	–
a_{01}-b_{011}-c_{11}-d_{51}-$e_{00.01}$-f_{71}-g_{71}-$h_{14.12}$-i_{039}-j_{00}	–	–	–	–	–	–	–	0.01%	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{51}-$e_{14.12}$-f_{71}-g_{71}-$h_{14.12}$-i_{032}-j_{00}	–	–	–	–	–	–	–	0.01%	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{61}-$e_{01.01}$-f_{52}-g_{31}-$h_{01.01}$-i_{032}-j_{00}	–	–	–	–	–	–	–	0.01%	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{13}-$e_{10.06}$-f_{64}-g_{63}-$h_{10.06}$-i_{011}-j_{00}	–	–	–	–	–	–	–	0.01%	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.12}$-f_{44}-g_{32}-$h_{14.12}$-i_{011}-j_{00}	–	–	–	–	–	–	–	0.01%	0.06%	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.12}$-f_{71}-g_{71}-$h_{14.12}$-i_{032}-j_{00}	–	–	–	–	–	–	–	0.01%	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.12}$-f_{44}-g_{51}-$h_{14.12}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	11.94%	–	–
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.06}$-f_{43}-g_{53}-$h_{06.06}$-i_{011}-j_{20}	–	–	–	–	–	–	–	–	–	2.90%	–	–
a_{01}-b_{011}-c_{11}-d_{22}-$e_{07.06}$-f_{43}-g_{52}-$h_{07.06}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	1.62%	–	0.56%
a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.06}$-f_{43}-g_{52}-$h_{06.06}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	–	–	0.55%
a_{01}-b_{000}-c_{00}-d_{00}-$e_{00.01}$-f_{00}-g_{00}-$h_{00.01}$-i_{000}-j_{20}	–	–	–	–	–	–	–	–	–	–	–	0.34%
a_{01}-b_{011}-c_{11}-d_{22}-$e_{07.02}$-f_{43}-g_{51}-$h_{07.02}$-i_{011}-j_{20}	–	–	–	–	–	–	–	–	–	–	–	0.31%
a_{01}-b_{011}-c_{11}-d_{21}-$e_{08.06}$-f_{43}-g_{52}-$h_{08.06}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	–	–	0.21%

[a]Support value for minsup = 0.003, [b]Support value for minsup = 0.004, [c]Support value for minsup = 0.002, [d]Support value for minsup = 0.000, [e]Support value for minsup = 0.001, [f]Support value for minsup = 0.000, [g]Support value for minsup = 0.004, [h]Support value for minsup = 0.006, [i]Support value for minsup = 0.000, [j]Support value for minsup = 0.002, [k]Support value for minsup = 0.002, [l]Support value for minsup = 0.0032, [m]Support value for minsup = 0.002.

5. Results

This study examined 995,503 occupational accident records from the Turkish manufacturing industry between 2013 and 2019. The data were analyzed using the CloFast algorithm as part of a mining approach called sequential pattern mining. In terms of the data pattern used, the analysis method, and the results obtained, the study makes an important contribution to the literature. The main findings obtained are summarized below.

- Within the manufacturing industry, "CH: manufacture of basic metals and fabricated metal products, except machinery and equipment section" had the most accidents at work ($n_{others\ included}$ = 243,845; 24.49%, $n_{others\ excluded}$ = 82,452; 26.81%). Katsakiori et al. (2010) discovered in their study that section CH has the highest rate of occupational accidents (20%).
- The majority of the victims were men ($n_{others\ included}$ = 853,468; 85.73%, $n_{others\ excluded}$ = 270,338; 87.89%) with [0, 2) years of work experience ($n_{others\ included}$ = 617,903; 62.07%; $n_{others\ excluded}$ = 187,228; 60.87%).
- The Age_3: 25–34 age group has the highest number of accidents ($n_{others\ included}$ = 376,760; 37.85%, $n_{others\ excluded}$=117,800; 3.30%). Katsakiori et al. (2010) showed that nearly half (42.5%) of the victims in the manufacturing industry were between the ages of 26 and 35.
- The majority of workplace accidents occurred between Wh_3:02:00 and 02:59 after beginning work ($n_{others\ included}$ = 121,892; 12,24%, $n_{others\ excluded}$ = 38,425; 12,49%). During the day, the most accidents occurred between Hd_{12}:11:00 and 11:59 ($n_{others\ included}$ = 95,756; 9.62%, $n_{others\ excluded}$ = 30,395; 9.88%, see Table 3-6).

Workplace accident that occurred in the manufacturing industry from the records, others included variables were coded as including $n_{others\ included}$ = 999,503 obtained with two-ten items, sequential accident patterns in Table 29-35, others in the coded variables are $n_{others\ excluded}$ = 307,594 obtained with two-ten items, sequential accident patterns are given in Table 20-28. The accident sequence patterns obtained in this study for $n_{others\ included}$ = 999,503 could not provide meaningful information that aids in the development of measures to predict accidents because the others contain too many encoded values. However, specific information has been discovered that the sequential accident patterns obtained for $n_{others\ excluded}$ = 307,594 might help prevent similar accidents. With a data set of $n_{others\ excluded}$ = 307,594, the behavior patterns common to the sequential accident patterns obtained for each section from CA to CM were determined (see, Table 20-28).

Table 12 lists the most common accident patterns and sections with two to ten items. The most common sequential accident patterns and sections resulting in injury are summarized in Table 13. It has been defined that the majority of accidents in the manufacturing industry occur at "workstation: usual workstation or within the usual local unit of work, working environment: production area, factory, workshop, and working process: production, manufacturing, processing - all types.".

According to Palamara et al. (2011), the most common five-item sequential accident sequence in the wood industry operating in Italy is "working with tools/loss of control/contact with sharp/pointed/

Table 29
The first ten accident sequences pattern with two, three and four items for each section: Support value ($n_{others\ included}$ = 995,503).

Sequences	Support value												
	CA[ax]	CB[bx]	CC[cx]	CD[dx]	CE[ex]	CF[fx]	CG[gx]	CH[hx]	CI[ix]	CJ[jx]	CK[kx]	CL[lx]	CM[mx]
a_{01}-b_{011}	61.76%	77.30%	75.16%	70.28%	73.19%	65.40%	72.08%	82.34%	82.62%	81.24%	81.72%	76.36%	54.79%
a_{01}-c_{11}	55.51%	64.96%	65.59%	47.13%	57.31%	49.96%	60.11%	69.34%	69.07%	72.35%	72.11%	68.65%	51.99%
b_{011}-c_{11}	54.92%	62.53%	60.95%	46.39%	56.18%	47.94%	58.06%	68.32%	67.52%	71.05%	71.85%	65.84%	45.52%
a_{01}-j_{00}	34.39%	38.94%	–	30.65%	30.66%	38.36%	–	–	63.35%	42.90%	30.19%	–	30.26%
$e_{99.00}$-$h_{99.00}$	37.65%	–	–	–	–	35.38%	–	–	–	–	–	–	–
b_{011}-j_{00}	36.26%	35.36%	–	26.48%	–	–	–	–	60.22%	40.62%	–	–	–
a_{01}-g_{99}	34.62%	34.65%	33.77%	33.06%	37.75%	41.10%	35.21%	–	36.00%	–	–	–	32.14%
g_{99}-$h_{99.00}$	33.21%	–	–	–	–	–	–	–	–	–	–	–	–
f_{99}-g_{99}	33.21%	–	–	–	–	–	–	–	–	–	–	–	–
c_{11}-j_{00}	32.67%	–	–	–	–	–	–	–	49.72%	35.56%	–	–	–
a_{01}-$\imath_{011}$	–	40.70%	39.65%	–	32.63%	–	37.95%	43.73%	44.57%	43.50%	43.67%	43.08%	37.11%
b_{011}-$\imath_{011}$	–	38.41%	35.30%	–	29.82%	–	34.71%	42.05%	42.80%	41.81%	43.02%	39.65%	29.06%
a_{01}-j_{20}	–	36.70%	46.68%	41.02%	41.18%	33.26%	42.20%	50.99%	–	33.84%	46.98%	43.92%	36.98%
a_{01}-f_{99}	–	34.05%	–	–	–	38.62%	32.67%	34.02%	–	–	–	–	29.85%
b_{011}-j_{20}	–	–	40.58%	38.06%	36.86%	–	38.06%	48.53%	–	–	45.27%	39.78%	–
c_{11}-j_{20}	–	–	36.46%	26.02%	–	–	32.25%	41.28%	–	–	40.26%	36.06%	–
b_{011}-g_{99}	–	–	–	29.91%	33.50%	–	–	–	–	–	–	–	–
c_{11}-$\imath_{011}$	–	–	32.63%	–	–	–	–	36.48%	36.72%	38.71%	39.14%	36.80%	28.40%
a_{01}-$e_{99.00}$	–	–	–	–	–	33.98%	–	–	–	–	–	32.89%	–
a_{01}-$h_{99.00}$	–	–	–	–	–	33.85%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}	48.42%	61.03%	59.58%	43.89%	54.42%	46.44%	56.05%	66.51%	66.51%	69.68%	69.48%	64.15%	43.98%
a_{01}-b_{011}-j_{00}	31.32%	33.72%	24.33%	24.54%	25.86%	28.00%	25.48%	–	58.79%	39.65%	27.75%	27.29%	20.79%
$e_{99.00}$-g_{99}-$h_{99.00}$	30.70%	–	–	–	–	28.02%	–	–	–	–	–	–	21.30%
$e_{99.00}$-f_{99}-$h_{99.00}$	28.70%	–	–	–	–	–	–	–	–	–	–	–	19.80%
b_{011}-c_{11}-j_{00}	28.57%	–	–	17.41%	–	–	–	–	48.05%	34.44%	–	–	–
a_{01}-c_{11}-j_{00}	28.07%	28.22%	–	–	–	–	–	–	48.76%	34.78%	–	24.98%	–
d_{99}-$e_{99.00}$-$h_{99.00}$	27.67%	–	–	–	–	–	–	–	–	–	–	–	–
f_{99}-g_{99}-$h_{99.00}$	25.86%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-$\imath_{011}$	25.81%	37.32%	34.50%	19.17%	28.63%	29.68%	33.57%	40.86%	41.61%	40.89%	41.39%	38.55%	27.79%
$e_{99.00}$-f_{99}-g_{99}	25.55%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-c_{11}-$\imath_{011}$	–	33.29%	30.89%	–	23.49%	–	29.48%	35.43%	36.02%	37.93%	37.73%	35.74%	27.11%
b_{011}-c_{11}-$\imath_{011}$	–	32.33%	29.10%	–	23.03%	–	28.52%	35.06%	35.31%	37.48%	37.87%	34.68%	24.53%
a_{01}-b_{011}-j_{20}	–	32.26%	39.43%	34.91%	35.20%	27.25%	36.60%	46.88%	–	30.31%	43.39%	38.45%	26.03%
a_{01}-b_{011}-g_{99}	–	28.27%	26.63%	26.76%	31.23%	27.58%	28.22%	29.65%	32.76%	–	26.25%	–	–
a_{01}-c_{11}-j_{20}	–	0.03%	0.04%	24.63%	0.03%	–	0.03%	0.04%	–	0.03%	0.04%	0.03%	0.03%
a_{01}-b_{011}-f_{99}	–	0.03%	0.02%	18.15%	0.02%	–	0.03%	0.03%	–	0.03%	0.03%	0.03%	–
b_{011}-c_{11}-j_{20}	–	–	0.03%	23.98%	0.03%	–	0.03%	0.04%	–	–	0.04%	0.03%	0.02%
a_{01}-b_{011}-$e_{00.01}$	–	–	–	19.91%	–	–	–	–	–	–	–	–	–
a_{01}-$e_{99.00}$-$h_{99.00}$	–	–	–	–	–	0.03%	–	–	–	–	–	–	–
a_{01}-g_{99}-$h_{99.00}$	–	–	–	–	–	0.03%	–	–	–	–	–	–	–
a_{01}-f_{99}-g_{99}	–	–	–	–	–	25.43%	–	–	–	–	–	–	–
a_{01}-$e_{99.00}$-g_{99}	–	–	–	–	–	25.43%	–	–	–	–	–	–	–
a_{01}-$\imath_{011}$-j_{20}	–	–	–	–	–	–	–	0.03%	–	–	–	–	–
a_{01}-$\imath_{011}$-j_{00}	–	–	–	–	–	–	–	–	0.03%	–	–	–	–
b_{011}-$\imath_{011}$-j_{00}	–	–	–	–	–	–	–	–	0.03%	–	–	–	–
d_{99}-$e_{99.00}$-g_{99}-$h_{99.00}$	24.73%	–	–	–	–	20.54%	19.24%	–	–	–	–	–	17.44%
$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$	24.68%	16.41%	–	–	14.24%	22.09%	19.98%	–	–	16.73%	–	–	17.29%
a_{01}-b_{011}-c_{11}-j_{00}	24.60%	26.66%	18.60%	16.30%	18.53%	–	19.72%	18.06%	47.40%	33.89%	23.73%	22.95%	16.08%
d_{99}-$e_{99.00}$-f_{99}-$h_{99.00}$	23.90%	–	–	–	–	18.86%	18.69%	–	–	–	–	–	16.58%
d_{99}-$e_{99.00}$-f_{99}-g_{99}	21.93%	–	–	–	–	19.22%	17.70%	–	–	–	–	–	15.74%
d_{99}-f_{99}-g_{99}-$h_{99.00}$	22.10%	–	–	–	–	–	17.71%	–	–	–	–	–	15.66%
a_{01}-b_{011}-c_{11}-$\imath_{011}$	21.32%	31.69%	28.59%	13.52%	22.48%	22.77%	27.80%	34.26%	34.82%	36.86%	36.77%	33.90%	23.86%
b_{011}-$e_{99.00}$-g_{99}-$h_{99.00}$	19.29%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-g_{99}	18.43%	19.49%	19.60%	12.13%	21.49%	–	18.82%	21.20%	23.78%	21.10%	20.37%	18.25%	–
a_{01}-$e_{99.00}$-g_{99}-$h_{99.00}$	18.32%	16.97%	–	–	14.71%	23.65%	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-j_{20}	–	26.28%	32.22%	22.96%	27.25%	20.46%	28.90%	38.45%	–	26.45%	37.29%	33.00%	21.91%
a_{01}-b_{011}-c_{11}-f_{99}	–	19.43%	18.48%	–	15.38%	–	–	21.04%	22.07%	21.07%	20.05%	19.34%	–

[ax]Support value for minsup = 0.015, [bx]Support value for minsup = 0.015, [cx]Support value for minsup = 0.005, [dx]Support value for minsup = 0.000, [ex]Support value for minsup = 0.005, [fx]Support value for minsup = 0.000, [gx]Support value for minsup = 0.015, [hx]Support value for minsup = 0.019, [ix]Support value for minsup = 0.001, [jx]Support value for minsup = 0.005, [kx]Support value for minsup = 0.005, [lx]Support value for minsup = 0.007, [mx]Support value for minsup = 0.006.

Table 30
The first ten accident sequences pattern with four and five items for each section: Support value ($n_{others\ included} = 995{,}503$).

Sequences	Support value												
	CA[ax]	CB[bx]	CC[cx]	CD[dx]	CE[ex]	CF[fx]	CG[gx]	CH[hx]	CI[ix]	CJ[jx]	CK[kx]	CL[lx]	CM[mx]
a_{01}-b_{011}-$\imath_{011}$-j_{00}	–	17.53%	–	–	–	–	–	–	31.24%	21.63%	15.89%	14.72%	–
a_{01}-b_{011}-$e_{99.00}$-$e_{99.00}$	–	17.43%	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-$\imath_{011}$-j_{20}	–	17.35%	20.22%	–	16.36%	–	18.13%	24.92%	–	16.81%	22.73%	21.19%	–
a_{01}-c_{11}-$\imath_{011}$-j_{20}	–	–	18.38%	–	–	–	–	21.75%	–	–	20.79%	19.65%	–
b_{011}-c_{11}-$\imath_{011}$-j_{20}	–	–	17.29%	–	–	–	–	21.53%	–	–	20.79%	19.30%	–
a_{01}-b_{011}-f_{99}-g_{99}	–	–	13.84%	11.67%	15.20%	–	–	18.21%	–	–	–	14.87%	–
a_{01}-b_{011}-$e_{99.00}$-$h_{99.00}$	–	–	11.98%	–	15.14%	–	–	15.73%	20.50%	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$	–	–	–	13.06%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-$e_{00.01}$-$h_{00.01}$	–	–	–	11.76%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-g_{99}-$h_{99.00}$	–	–	–	11.30%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-g_{99}-j_{20}	–	–	–	11.20%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-d_{99}-g_{99}	–	–	–	10.09%	–	–	–	–	–	–	–	–	–
a_{01}-$e_{99.00}$-f_{99}-$h_{99.00}$	–	–	–	–	–	20.75%	–	–	–	–	–	–	–
a_{01}-f_{99}-g_{99}-$h_{99.00}$	–	–	–	–	–	19.79%	–	–	–	–	–	–	–
a_{01}-$e_{99.00}$-f_{99}-g_{99}	–	–	–	–	–	19.30%	–	–	–	–	–	–	–
a_{01}-c_{11}-$\imath_{011}$-j_{00}	–	–	–	–	–	–	–	–	26.72%	20.45%	–	–	–
b_{011}-c_{11}-$\imath_{011}$-j_{00}	–	–	–	–	–	–	–	–	26.38%	19.99%	14.65%	–	–
a_{01}-b_{011}-g_{99}-j_{00}	–	–	–	–	–	–	–	–	24.17%	–	–	–	–
a_{01}-b_{011}-f_{99}-j_{00}	–	–	–	–	–	–	–	–	22.05%	–	–	–	–
c_{99}-$e_{99.00}$-g_{99}-$h_{99.00}$	–	–	–	–	–	–	–	–	–	–	–	–	14.41%
c_{99}-d_{99}-$e_{99.00}$-$h_{99.00}$	–	–	–	–	–	–	–	–	–	–	–	–	14.25%
d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$	21.68%	13.71%	8.09%	–	11.63%	17.79%	17.25%	12.32%	–	14.05%	8.37%	12.52%	15.19%
b_{011}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$	15.29%	–	–	–	–	–	–	–	–	–	–	–	–
b_{011}-d_{99}-$e_{99.00}$-g_{99}-$h_{99.00}$	15.06%	–	–	–	–	–	–	–	–	–	–	–	–
b_{011}-d_{99}-$e_{99.00}$-f_{99}-$h_{99.00}$	14.88%	–	–	–	–	–	–	–	–	–	–	–	–
$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-j_{00}	14.18%	–	–	–	–	–	–	–	–	–	–	–	–
d_{99}-$e_{99.00}$-g_{99}-$h_{99.00}$-j_{00}	13.98%	–	–	–	–	–	–	–	–	–	–	–	–
d_{99}-$e_{99.00}$-f_{99}-$h_{99.00}$-j_{00}	13.79%	–	–	–	–	–	–	–	–	–	–	–	–
b_{011}-d_{99}-$e_{99.00}$-f_{99}-g_{99}	13.49%	–	–	–	–	–	–	–	–	–	–	–	–
b_{011}-c_{11}-$e_{99.00}$-g_{99}-$h_{99.00}$	13.47%	–	–	–	–	–	–	–	–	–	–	–	–
b_{011}-d_{99}-f_{99}-g_{99}-$h_{99.00}$	13.44%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$\imath_{011}$-j_{00}	–	14.94%	9.61%	–	–	–	–	–	26.02%	19.71%	14.19%	12.90%	–
a_{01}-b_{011}-c_{11}-$\imath_{011}$-j_{20}	–	14.70%	17.00%	6.94%	13.24%	–	15.16%	21.07%	–	15.00%	20.23%	18.85%	12.40%
a_{01}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$	–	13.35%	8.08%	–	10.78%	18.44%	13.99%	11.82%	–	12.14%	–	11.23%	11.14%
a_{01}-b_{011}-$e_{99.00}$-g_{99}-$h_{99.00}$	–	13.10%	8.49%	7.41%	11.65%	–	13.24%	12.09%	15.74%	11.85%	8.73%	–	–
a_{01}-d_{99}-$e_{99.00}$-g_{99}-$h_{99.00}$	–	12.51%	–	–	10.50%	16.86%	13.17%	11.33%	–	–	–	10.77%	10.93%
a_{01}-b_{011}-$e_{99.00}$-f_{99}-$h_{99.00}$	–	12.40%	–	–	10.05%	–	12.71%	11.85%	15.00%	11.81%	8.23%	9.09%	–
a_{01}-d_{99}-$e_{99.00}$-f_{99}-$h_{99.00}$	–	12.00%	–	–	9.56%	15.38%	12.96%	11.24%	–	10.64%	–	10.96%	–
a_{01}-d_{99}-$e_{99.00}$-f_{99}-g_{99}	–	11.25%	–	–	–	15.07%	–	–	–	–	–	10.04%	–
a_{01}-d_{99}-f_{99}-g_{99}-$h_{99.00}$	–	11.18%	–	–	–	14.94%	–	–	–	–	–	10.03%	–
a_{01}-b_{011}-c_{11}-f_{99}-g_{99}	–	–	9.94%	–	9.54%	–	–	11.96%	–	11.54%	10.56%	10.47%	–
a_{01}-b_{011}-c_{11}-f_{99}-j_{20}	–	–	9.21%	–	–	–	–	–	–	–	9.17%	–	–
a_{01}-b_{011}-c_{11}-g_{99}-j_{20}	–	–	8.80%	–	–	–	–	–	–	–	9.18%	–	–
a_{01}-b_{011}-c_{11}-f_{99}-$\imath_{011}$	–	–	7.99%	–	–	–	–	–	–	–	9.62%	–	–
a_{01}-b_{011}-c_{11}-$e_{99.00}$-$h_{99.00}$	–	–	7.73%	–	–	–	–	–	13.68%	10.80%	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-$h_{00.01}$	–	–	–	8.43%	–	–	–	–	–	–	–	–	–
c_{99}-d_{99}-$e_{99.00}$-g_{99}-$h_{99.00}$	–	–	–	7.50%	–	15.23%	13.31%	–	–	–	–	–	13.27%
a_{01}-b_{011}-c_{99}-f_{99}-g_{99}	–	–	–	7.13%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-$e_{00.01}$-$h_{00.01}$-j_{00}	–	–	–	7.04%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{99}-d_{99}-g_{99}	–	–	–	6.85%	–	–	–	–	–	–	–	–	–
a_{01}-c_{99}-d_{99}-f_{99}-g_{99}	–	–	–	6.85%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-d_{99}-f_{99}-g_{99}	–	–	–	6.76%	–	–	–	11.54%	–	–	–	–	–
a_{01}-b_{011}-f_{99}-g_{99}-$h_{99.00}$	–	–	–	6.48%	9.30%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-d_{99}-$e_{99.00}$-$h_{99.00}$	–	–	–	–	9.59%	–	–	10.92%	–	–	–	–	–
c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}	–	–	–	–	–	14.71%	–	–	–	–	–	–	12.07%
$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-$\imath_{999}$	–	–	–	–	–	15.07%	–	–	–	10.87%	–	–	–
c_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$	–	–	–	–	–	14.43%	12.77%	–	–	–	–	–	12.33%

[ax]Support value for minsup = 0.015, [bx]Support value for minsup = 0.015, [cx]Support value for minsup = 0.005, [dx]Support value for minsup = 0.000, [ex]Support value for minsup = 0.005, [fx]Support value for minsup = 0.000, [gx]Support value for minsup = 0.015, [hx]Support value for minsup = 0.019, [ix]Support value for minsup = 0.001, [jx]Support value for minsup = 0.005, [kx]Support value for minsup = 0.005, [lx]Support value for minsup = 0.007, [mx]Support value for minsup = 0.006.

Table 31
The first ten accident sequences pattern with five and six items for each section: Support value ($n_{others\ included}$ = 995,503).

Sequences	Support value												
	CA[ax]	CB[bx]	CC[cx]	CD[dx]	CE[ex]	CF[fx]	CG[gx]	CH[hx]	CI[ix]	CJ[jx]	CK[kx]	CL[lx]	CM[mx]
c_{99}-d_{99}-$e_{99.00}$-f_{99}-$h_{99.00}$	–	–	–	–	–	–	12.85%	–	–	–	–	–	12.37%
a_{01}-b_{011}-c_{11}-g_{99}-j_{00}	–	–	–	–	–	–	–	–	17.41%	–	–	–	–
a_{01}-b_{011}-$e_{99.00}$-$h_{99.00}$-j_{00}	–	–	–	–	–	–	–	–	16.68%	–	–	–	–
a_{01}-b_{011}-c_{11}-f_{99}-j_{00}	–	–	–	–	–	–	–	–	15.96%	–	–	–	–
a_{01}-b_{011}-f_{99}-g_{99}-j_{00}	–	–	–	–	–	–	–	–	14.92%	–	–	–	–
a_{01}-b_{011}-g_{99}-$e_{99.00}$-j_{00}	–	–	–	–	–	–	–	–	13.70%	–	–	–	–
a_{01}-$e_{99.00}$-g_{99}-$h_{99.00}$-j_{00}	–	–	–	–	–	–	–	–	13.46%	–	–	–	–
a_{01}-b_{011}-c_{11}-g_{99}-1_{011}	–	–	–	–	–	–	–	–	–	–	8.40%	–	–
c_{99}-d_{99}-f_{99}-g_{99}-$h_{99.00}$	–	–	–	–	–	–	–	–	–	–	–	–	12.01%
d_{99}-$e_{99.00}$-g_{99}-$h_{99.00}$-1_{999}	–	–	–	–	–	–	–	–	–	–	–	–	10.66%
b_{011}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$	13.20%	8.93%	–	–	7.19%	–	9.82%	8.80%	–	8.30%	5.47%	6.17%	–
d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-j_{00}	11.82%	–	–	–	–	–	–	–	–	–	–	–	8.17%
c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$	11.80%	8.67%	5.46%	5.28%	7.33%	13.65%	12.31%	7.51%	–	2.32%	–	7.75%	11.73%
d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-1_{999}	11.01%	8.86%	4.77%	–	7.99%	13.18%	–	–	–	–	4.98%	7.95%	9.73%
a_{01}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$	10.82%	10.90%	5.86%	–	8.52%	14.56%	11.65%	10.00%	11.00%	9.66%	6.51%	9.75%	9.47%
b_{011}-c_{11}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$	10.45%	–	–	–	–	–	–	–	–	–	–	–	–
a_{09}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$	10.41%	–	–	–	–	–	–	–	–	–	–	–	–
b_{011}-c_{11}-d_{99}-$e_{99.00}$-g_{99}-$h_{99.00}$	10.14%	–	–	–	–	–	–	–	–	–	–	–	–
b_{011}-c_{11}-d_{99}-$e_{99.00}$-f_{99}-$h_{99.00}$	10.11%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$	9.66%	10.19%	5.83%	4.44%	8.48%	–	10.50%	9.84%	12.19%	9.85%	6.41%	7.07%	–
a_{01}-b_{011}-d_{99}-$e_{99.00}$-g_{99}-$h_{99.00}$	–	9.30%	5.11%	4.63%	8.16%	–	9.69%	9.34%	11.35%	8.69%	6.08%	6.57%	–
a_{01}-b_{011}-d_{99}-$e_{99.00}$-f_{99}-$h_{99.00}$	–	9.05%	4.77%	–	7.51%	–	9.65%	9.35%	12.09%	8.79%	6.15%	7.01%	–
a_{01}-b_{011}-d_{99}-$e_{99.00}$-f_{99}-g_{99}	–	8.40%	–	–	7.07%	–	8.85%	8.61%	–	8.12%	5.34%	6.12%	–
a_{01}-b_{011}-d_{99}-f_{99}-g_{99}-$h_{99.00}$	–	8.33%	–	4.17%	6.87%	–	8.90%	8.53%	–	8.15%	5.36%	–	–
a_{01}-b_{011}-c_{11}-$e_{99.00}$-g_{99}-$h_{99.00}$	–	7.79%	5.23%	–	6.73%	–	–	6.88%	–	–	5.46%	–	–
a_{01}-b_{011}-c_{11}-f_{99}-1_{011}-j_{20}	–	–	4.82%	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{99.00}$-f_{99}-$h_{99.00}$	–	–	4.66%	–	–	–	–	6.82%	–	7.89%	5.21%	–	–
a_{01}-b_{011}-c_{11}-f_{99}-g_{99}-j_{20}	–	–	4.38%	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{99}-d_{99}-f_{99}-g_{99}	–	–	–	5.37%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{00.01}$-$h_{00.01}$-j_{00}	–	–	–	5.28%	–	–	–	–	–	–	–	–	–
a_{01}-c_{99}-d_{99}-$e_{99.00}$-g_{99}-$h_{99.00}$	–	–	–	4.81%	–	12.07%	–	–	–	–	–	6.20%	–
a_{01}-b_{011}-c_{99}-f_{99}-g_{99}-$h_{99.00}$	–	–	–	4.54%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{99}-d_{99}-g_{99}-$h_{99.00}$	–	–	–	4.54%	–	–	–	–	–	–	–	–	–
a_{01}-c_{99}-d_{99}-f_{99}-g_{99}-$h_{99.00}$	–	–	–	4.26%	–	–	–	–	–	–	–	–	–
a_{01}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-1_{999}	–	–	–	–	–	12.43%	–	–	–	–	–	6.16%	–
a_{01}-d_{99}-$e_{99.00}$-g_{99}-$h_{99.00}$-1_{999}	–	–	–	–	–	11.76%	–	–	–	–	–	–	–
c_{99}-d_{99}-$e_{99.00}$-g_{99}-$h_{99.00}$-1_{999}	–	–	–	–	–	11.73%	–	–	–	–	–	–	–
c_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-1_{999}	–	–	–	–	–	11.63%	–	–	–	–	–	–	8.01%
c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-1_{999}	–	–	–	–	–	11.60%	–	–	–	–	–	–	–
a_{01}-c_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$	–	–	–	–	–	11.42%	–	–	–	–	–	–	–
d_{99}-$e_{99.00}$-f_{99}-g_{99}-$e_{99.00}$-1_{999}	–	–	–	–	–	–	9.89%	–	–	9.95%	–	–	–
c_{99}-d_{99}-$e_{99.00}$-g_{99}-$e_{99.00}$-1_{999}	–	–	–	–	–	–	8.58%	–	–	–	–	–	8.44%
a_{01}-b_{011}-$e_{99.00}$-g_{99}-$h_{99.00}$-j_{00}	–	–	–	–	–	–	–	–	12.92%	–	–	–	–
a_{01}-b_{011}-$e_{99.00}$-f_{99}-$h_{99.00}$-j_{00}	–	–	–	–	–	–	–	–	12.70%	–	–	–	–
a_{01}-b_{011}-d_{99}-$e_{99.00}$-$h_{99.00}$-j_{00}	–	–	–	–	–	–	–	–	11.60%	–	–	–	–
b_{011}-d_{99}-$e_{99.00}$-f_{99}-$h_{99.00}$-j_{00}	–	–	–	–	–	–	–	–	11.15%	–	–	–	–
a_{01}-d_{99}-$e_{99.00}$-f_{99}-$h_{99.00}$-j_{00}	–	–	–	–	–	–	–	–	11.15%	–	–	–	–
a_{01}-b_{011}-d_{99}-$e_{99.00}$-f_{99}-j_{00}	–	–	–	–	–	–	–	–	10.92%	–	–	–	–
b_{999}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$	–	–	–	–	–	–	–	–	–	–	–	–	8.72%
b_{999}-c_{99}-d_{99}-$e_{99.00}$-g_{99}-$h_{99.00}$	–	–	–	–	–	–	–	–	–	–	–	–	8.45%
c_{99}-d_{99}-$e_{99.00}$-f_{99}-$h_{99.00}$-1_{999}	–	–	–	–	–	–	–	–	–	–	–	–	7.95%
b_{999}-c_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$	–	–	–	–	–	–	–	–	–	–	–	–	7.93%

[ax]Support value for minsup = 0.015, [bx]Support value for minsup = 0.015, [cx]Support value for minsup = 0.005, [dx]Support value for minsup = 0.000, [ex]Support value for minsup = 0.005, [fx]Support value for minsup = 0.000, [gx]Support value for minsup = 0.015, [hx]Support value for minsup = 0.019, [ix]Support value for minsup = 0.001, [jx]Support value for minsup = 0.005, [kx]Support value for minsup = 0.005, [lx]Support value for minsup = 0.007, [mx]Support value for minsup = 0.006.

abrasive parts." In our study, in the 7-item sequential accident sequence shown in Table 9, 3.50% of the accidents in the wood industry resulted in superficial injuries/injury, and the material agent used during the specific physical activity that caused the injury and also causing the injury was used in packing machines (filling, labeling, and closing).

6. Discussion

In the literature, studies has been carried out to prevent accidents and reduce losses. Studies examining accidents in the manufacturing industry have also been carried out frequently. Among these studies, Berhan (2019) examined the accidents in the iron, steel and metal manufacturing industries operating in Ethiopian. Additionally, Kim et al. (2021), Dhalmahapatra et al. (2019), and Yang and Jeong (2019) focused on occupational accidents. Hovewer, these studies are studies aimed at understanding the accident mechanism and its effects, without adopting the understanding of accident theory or model. The studies represent the results of local data far from big data analytics. Studies in the literature have not been conducted to reveal the sequential accident sequence. It is possible to say that the findings obtained from these studies are related to the working environment, special physical activity, and individual and organizational policies and practices that contribute to the accident. On the other hand, the number of studies in the manufacturing industry, in which accident investigations are carried out systematically based on accident theories, is also limited. Theories about work accidents in the manufacturing industry are summarized in Table 1. Studies given in Table 1 did not focus on the associations among factors leads to occupational accidents. Findings of these draw attention

Table 32
The first ten accident sequences pattern with seven items for each section: Support value ($n_{others\ included}$ = 995,503).

Sequences	Support value												
	CA[ax]	CB[bx]	CC[cx]	CD[dx]	CE[ex]	CF[fx]	CG[gx]	CH[hx]	CI[ix]	CJ[jx]	CK[kx]	CL[lx]	CM[mx]
b_{011}-c_{11}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$	8.80%	–	–	–	–	–	–	–	–	–	–	–	–
c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}	8.11%	5.94%	3.49%	–	5.34%	11.16%	8.16%	–	–	6.73%	3.23%	5.23%	7.76%
b_{011}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-j_{00}	7.86%	–	–	–	–	–	–	–	9.49%	–	–	–	–
a_{01}-b_{011}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$	7.75%	8.11%	4.03%	2.96%	6.63%	–	8.61%	8.25%	10.27%	7.93%	5.13%	5.88%	–
b_{999}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$	7.10%	–	3.04%	–	–	9.97%	5.95%	–	–	5.10%	–	4.64%	7.60%
c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-j_{00}	6.64%	–	–	–	–	–	5.61%	–	–	–	–	–	7.04%
a_{09}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-j_{00}	6.43%	–	–	–	–	–	–	–	–	–	–	–	5.65%
d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{00}	6.49%	–	–	–	4.75%	–	–	–	–	–	–	–	–
b_{011}-c_{11}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-j_{00}	6.37%	–	–	–	–	–	–	–	–	–	–	–	–
b_{011}-c_{11}-d_{99}-$e_{99.00}$-f_{99}-$h_{99.00}$-j_{00}	6.16%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}	–	6.76%	3.10%	–	5.37%	10.75%	5.40%	4.46%	–	5.96%	3.49%	5.65%	–
a_{01}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$	–	6.11%	3.48%	3.52%	4.61%	10.85%	7.32%	5.49%	–	–	3.47%	5.75%	6.28%
a_{01}-b_{011}-c_{11}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$	–	5.90%	3.44%	–	4.73%	–	–	5.33%	–	6.33%	3.79%	4.27%	–
a_{01}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-j_{00}	–	5.83%	2.63%	–	4.78%	8.99%	–	–	9.51%	–	–	4.26%	–
a_{01}-b_{011}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}	–	5.64%	2.65%	–	4.80%	–	–	–	–	5.27%	2.93%	–	–
b_{011}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}	–	5.49%	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-j_{00}	–	5.41%	2.55%	–	4.64%	–	–	–	10.38%	–	–	–	–
a_{01}-b_{011}-d_{99}-$e_{99.00}$-g_{99}-$h_{99.00}$-i_{999}	–	5.31%	–	–	4.55%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{99}-$e_{99.00}$-g_{99}-$h_{99.00}$	–	–	2.56%	–	–	–	0.00%	4.67%	–	5.21%	3.31%	–	–
a_{01}-b_{011}-c_{99}-d_{99}-$e_{99.00}$-g_{99}-$h_{99.00}$	–	–	–	3.52%	–	–	5.28%	–	–	–	–	–	–
a_{01}-b_{011}-c_{99}-d_{99}-f_{99}-g_{99}-$h_{99.00}$	–	–	–	3.33%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$	–	–	–	3.15%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-$h_{99.00}$	–	–	–	2.78%	–	–	5.23%	–	–	–	–	–	–
b_{011}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$	–	–	–	2.69%	–	–	5.72%	–	–	–	–	–	–
a_{01}-b_{011}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}	–	–	–	2.69%	–	–	–	–	–	–	–	–	–
c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-j_{90}	–	–	–	2.59%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{99}-d_{99}-f_{99}-g_{99}-j_{00}	–	–	–	2.41%	–	–	–	–	–	–	–	–	–
a_{01}-c_{99}-d_{99}-$e_{99.00}$-g_{99}-$h_{99.00}$-i_{999}	–	–	–	–	–	9.45%	–	–	–	–	–	–	–
a_{01}-c_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}	–	–	–	–	–	9.30%	–	–	–	–	–	–	–
a_{01}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-$h_{99.00}$-i_{999}	–	–	–	–	–	9.09%	–	–	–	–	–	–	–
a_{01}-c_{99}-d_{99}-f_{99}-g_{99}-$h_{99.00}$-i_{999}	–	–	–	–	–	9.07%	–	–	–	–	–	–	–
a_{01}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-i_{999}	–	–	–	–	–	9.07%	–	–	–	–	–	–	–
b_{999}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}	–	–	–	–	–	–	5.20%	–	–	4.95%	–	4.58%	6.37%
a_{01}-b_{011}-c_{11}-d_{99}-$e_{99.00}$-f_{99}-$h_{99.00}$	–	–	–	–	–	–	–	4.79%	–	5.34%	3.46%	4.25%	–
a_{01}-b_{011}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-j_{20}	–	–	–	–	–	–	–	4.57%	–	–	–	–	–
a_{01}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-j_{20}	–	–	–	–	–	–	–	4.51%	–	–	–	–	–
a_{01}-b_{011}-d_{99}-$e_{99.00}$-f_{99}-$h_{99.00}$-j_{20}	–	–	–	–	–	–	–	4.46%	–	–	–	–	–
a_{01}-b_{011}-d_{99}-$e_{99.00}$-g_{99}-$h_{99.00}$-j_{20}	–	–	–	–	–	–	–	4.44%	–	–	–	–	–
a_{01}-b_{011}-d_{99}-$e_{99.00}$-f_{99}-$h_{99.00}$-j_{00}	–	–	–	–	–	–	–	–	10.78%	–	–	–	–
a_{01}-b_{011}-d_{99}-$e_{99.00}$-g_{99}-$h_{99.00}$-j_{00}	–	–	–	–	–	–	–	–	9.77%	–	–	–	–
a_{01}-b_{011}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-j_{00}	–	–	–	–	–	–	–	–	9.26%	–	–	–	–
a_{01}-b_{011}-d_{99}-f_{99}-g_{99}-$h_{99.00}$-j_{00}	–	–	–	–	–	–	–	–	9.25%	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{99.00}$-f_{99}-$h_{99.00}$-j_{00}	–	–	–	–	–	–	–	–	7.88%	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{99.00}$-g_{99}-$h_{99.00}$-j_{00}	–	–	–	–	–	–	–	–	7.74%	–	–	–	–
a_{01}-c_{11}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$	–	–	–	–	–	–	–	–	–	4.94%	2.89%	–	–
a_{01}-b_{011}-c_{11}-d_{99}-f_{99}-g_{99}-$h_{99.00}$	–	–	–	–	–	–	–	–	–	–	2.87%	–	–
a_{01}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-j_{00}	–	–	–	–	–	–	–	–	–	–	–	4.20%	–
b_{999}-c_{99}-d_{99}-$e_{99.00}$-g_{99}-$h_{99.00}$-i_{999}	–	–	–	–	–	–	–	–	–	–	–	–	5.91%
b_{999}-c_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}	–	–	–	–	–	–	–	–	–	–	–	–	5.61%
b_{999}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-i_{999}	–	–	–	–	–	–	–	–	–	–	–	–	5.58%
b_{999}-c_{99}-d_{99}-f_{99}-g_{99}-$h_{99.00}$-i_{999}	–	–	–	–	–	–	–	–	–	–	–	–	5.57%

[ax]Support value for minsup = 0.015, [bx]Support value for minsup = 0.015, [cx]Support value for minsup = 0.005, [dx]Support value for minsup = 0.000, [ex]Support value for minsup = 0.005, [fx]Support value for minsup = 0.000, [gx]Support value for minsup = 0.015, [hx]Support value for minsup = 0.019, [ix]Support value for minsup = 0.001, [jx]Support value for minsup = 0.005, [kx]Support value for minsup = 0.005, [lx]Support value for minsup = 0.007, [mx]Support value for minsup = 0.006.

in the focus of organization and OHS management, especially as root causes, rather than accident results.

In our study, the accident sequences are created by considering the factors that indirectly and directly contribute to the accident for the entire manufacturing industry. In addition, to best of our knowledge, this is the first study that applies sequential pattern mining to accident data for the manufacturing industry. According to the occupational accident research unit (OARU) model proposed by Kjellén (1984), the pre accident phase-accident phase-post accident phase model is created using ESAW variables in the current study. By analyzing the generated accident sequences with the CloFast algorithm, the sequential patterns created by the accident factors within the scope of each accident stage are presented in this study. Accident sequence models, which are concluded by taking into account the pre-accident and post-accident situations, are presented in detail. These models provide specific information for businesses operating within the manufacturing industry in order to prevent repetitive accidents and reduce losses.

7. Conclusions

Occupational accidents are one of the major issues threatening the Turkish manufacturing industry's survival. In this study, a data mining application was used to analysis occupational accident data from the Turkish manufacturing industry from 2013 to 2019. One of the sequential pattern mining algorithms is the CloFast algorithm. The nature of the sequential accident patterns obtained for each section-

Table 33
The first ten accident sequences pattern with eight items for each section: Support value ($n_{others\ included}$ = 995,503).

Sequences	Support value												
	CA^{ax}	CB^{bx}	CC^{cx}	CD^{dx}	CE^{ex}	CF^{fx}	CG^{gx}	CH^{hx}	CI^{ix}	CJ^{jx}	CK^{kx}	CL^{lx}	CM^{mx}
b_{999}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}	5,51%	–	2,20%	–	2,93%	8,47%	4,94%	–	–	4,75%	1,86%	3,67%	5,48%
b_{011}-c_{11}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-j_{00}	5,44%	–	–	–	–	–	–	–	5,08%	–	–	–	–
c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{00}	4,86%	3,22%	–	–	3,05%	6,92%	–	–	–	–	–	2,63%	4,98%
a_{09}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999} 4,00%	4,78%	–	1,40%	–	–	–		4,01%	–	–	3,66%	–	–
a_{09}-b_{999}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$	4,72%	–	1,51%	–	–	–	3,84%	–	–	3,65%	–	–	4,31%
a_{01}-b_{011}-c_{11}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$	4,56%	4,21%	1,92%	–	3,34%	–	–	4,02%	5,85%	4,70%	2,70%	3,38%	–
a_{01}-b_{011}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-j_{00}	4,38%	4,51%	1,90%	–	3,81%	–	3,73%	2,80%	9,16%	4,01%	1,88%	–	–
a_{09}-b_{011}-c_{11}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$	4,15%	–	–	–	–	–	–	–	–	–	–	–	–
b_{999}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-j_{00}	4,05%	–	–	–	–	–	–	–	–	–	–	–	4,67%
a_{09}-b_{999}-c_{99}-d_{99}-$e_{99.00}$-99-$h_{99.00}$-i_{999}	4,00%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}	–	4,91%	2,00%	–	4,03%	–	3,79%	3,25%	–	4,62%	2,43%	2,80%	–
a_{01}-c_{99}-d_{99}-$e_{99.00}$-f_{99}.g_{99}-$h_{99.00}$-i_{999}	–	3,99%	1,93%	–	3,00%	8,99%	3,96%	2,57%	–	–	2,01%	3,61%	–
a_{01}-d_{99}-$e_{99.00}$-f_{99}.g_{99}-$h_{99.00}$-i_{999}-j_{00}	–	3,89%	–	–	3,28%	–	–	–	–	–	–	2,82%	–
a_{01}-b_{011}-c_{99}-d_{99}-$e_{99.00}$-f_{99}.g_{99}-$h_{99.00}$	–	3,67%	1,97%	2,59%	3,04%	–	4,94%	4,06%	–	–	2,31%	–	–
b_{011}-d_{99}-$e_{99.00}$.f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{00}	–	3,31%	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-$e_{99.00}$-f_{99}.g_{99}-$h_{99.00}$-i_{999}-j_{00}	–	3,23%	–	–	2,93%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{99.00}$-f_{99}.g_{99}-$h_{99.00}$-j_{00}	–	3,23%	–	–	–	–	–	–	5,97%	–	–	–	–
a_{01}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-j_{00}	–	–	1,66%	1,48%	–	–	–	–	–	–	–	2,55%	–
a_{01}-b_{011}-c_{11}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}	–	–	1,48%	–	–	–	–	–	–	–	1,74%	–	–
a_{01}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-j_{90}	–	–	–	1,67%	–	–	–	–	–	–	–	–	–
a_{01}.b_{011}.c_{99}.d_{99}.f_{99}.g_{99}.$h_{99.00}$.j_{90}	–	–	–	1,57%	–	–	–	–	–	–	–	–	–
a_{01}.b_{011}.c_{99}.d_{99}.$e_{99.00}$.g_{99}.$h_{99.00}$.j_{90}	–	–	–	1,48%	–	–	–	–	–	–	–	–	–
a_{01}.b_{011}.c_{99}.d_{99}.$e_{99.00}$.g_{99}.$h_{99.00}$.j_{00}	–	–	–	1,48%	–	–	–	–	–	–	–	–	–
a_{01}.b_{011}.c_{99}.$e_{99.00}$.f_{99}.g_{99}.$h_{99.00}$.j_{90}	–	–	–	1,48%	–	–	–	–	–	–	–	–	–
a_{01}.b_{011}.d_{99}.$e_{99.00}$.f_{99}.g_{99}.$h_{99.00}$.j_{90}	–	–	–	1,39%	–	–	–	–	–	–	–	–	–
a_{01}.b_{011}.c_{99}.d_{99}.$e_{99.00}$.f_{99}.$h_{99.00}$.j_{90}	–	–	–	1,39%	–	–	–	–	–	–	–	–	–
a_{01}.b_{011}.c_{99}.$e_{99.00}$.f_{99}.g_{99}.$h_{99.00}$.j_{00}	–	–	–	1,39%	–	–	–	–	–	–	–	–	–
a_{01}.b_{011}.d_{99}.$e_{99.00}$.g_{99}.$h_{99.00}$-i_{999}.j_{00}	–	–	–	–	2,83%	–	–	–	–	–	–	–	–
a_{01}.b_{999}.c_{99}.d_{99}.$e_{99.00}$.f_{99}.g_{99}.$h_{99.00}$	–	–	–	–	–	8,03%	–	–	–	–	–	2,98%	–
a_{01}.b_{999}.d_{99}.$e_{99.00}$.f_{99}.g_{99}.$h_{99.00}$.i_{999}	–	–	–	–	–	7,23%	–	–	–	–	–	2,57%	–
a_{01}.b_{999}-c_{99}-d_{99}.$e_{99.00}$-g_{99}-$h_{99.00}$-i_{999}	–	–	–	–	–	7,23%	–	–	–	–	–	–	–
a_{01}.b_{999}-c_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}	–	–	–	–	–	7,15%	–	–	–	–	–	–	–
a_{01}.b_{999}-c_{99}-d_{99}-f_{99}-g_{99}-$h_{99.00}$-i_{999}	–	–	–	–	–	6,99%	–	–	–	–	–	–	–
a_{01}.b_{999}-c_{99}-d_{99}.$e_{99.00}$-f_{99}-g_{99}-i_{999}	–	–	–	–	–	6,97%	–	–	–	–	–	–	–
a_{01}.b_{999}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-$h_{99.00}$-i_{999}	–	–	–	–	–	6,97%	–	–	–	–	–	–	–
a_{09}-b_{999}-c_{99}-d_{99}-$e_{99.00}$-g_{99}-$h_{99.00}$-i_{999}	–	–	–	–	–	–	3,76%	–	–	3,63%	–	–	3,97%
a_{09}-b_{999}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}	–	–	–	–	–	–	3,74%	–	–	3,62%	–	–	3,84%
a_{09}-b_{999}-c_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}	–	–	–	–	–	–	3,69%	–	–	–	–	–	3,82%
a_{01}-b_{011}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-j_{20}	–	–	–	–	–	–	–	3,88%	–	–	2,12%	–	–
a_{01}-b_{011}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{011}	–	–	–	–	–	–	–	3,11%	–	–	1,55%	–	–
a_{01}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-j_{20}	–	–	–	–	–	–	–	2,58%	–	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-j_{20}	–	–	–	–	–	–	–	2,29%	–	–	1,51%	–	–
b_{011}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-j_{20}	–	–	–	–	–	–	–	2,27%	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{99}-$e_{99.00}$.f_{99}-$h_{99.00}$.j_{00}	–	–	–	–	–	–	–	–	6,30%	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{99}-$e_{99.00}$.g_{99}-$h_{99.00}$.j_{00}	–	–	–	–	–	–	–	–	5,34%	–	–	–	–
a_{01}-c_{11}-d_{99}-$e_{99.00}$.f_{99}-g_{99}-$h_{99.00}$.j_{00}	–	–	–	–	–	–	–	–	5,08%	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{99}-$e_{99.00}$.f_{99}-g_{99}-j_{00}	–	–	–	–	–	–	–	–	5,04%	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{99}-f_{99}-g_{99}-$h_{99.00}$.j_{00}	–	–	–	–	–	–	–	–	5,03%	–	–	–	–
a_{01}-b_{011}-d_{99}-$e_{99.00}$.f_{99}-$h_{99.00}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	4,96%	–	–	–	–
a_{09}-b_{999}-c_{99}-d_{99}-$e_{99.00}$.f_{99}-g_{99}-i_{999}	–	–	–	–	–	–	–	–	–	3,58%	–	–	3,75%
a_{09}-b_{999}-c_{99}-d_{99}-f_{99}-g_{99}-$h_{99.00}$-i_{999}	–	–	–	–	–	–	–	–	–	3,58%	–	–	–
b_{999}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{00}	–	–	–	–	–	–	–	–	–	–	–	2,52%	–
a_{09}-b_{999}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-i_{999}	–	–	–	–	–	–	–	–	–	–	–	–	3,82%

specific hazard was different (see Table 9-11).

Considering the descriptive data obtained in this study (see Tables 3, 4, 5, and 6), it can be recommended that workers aged 25–34 not be employed in jobs that require attention, and that special occupational health and safety training programs be implemented for these workers. Morover, after work break plans Wh_3: 02:00 to 02:59 time before you can work during the day and in the days of experiencing accidents are the most common time interval Hd_{12}: 11:00 to 11:59 information may be beneficial in terms of preventing accidents considering reorganization.

Sequential patterns were discovered in terms of accident contributing causes, direct causes and accident severity behind work accidents in the Turkish manufacturing industry. The causes that threaten security differ due to the nature of each section in the industry. Results about workstation, working environment, working process, specific physical activity and deviation as direct causes, contact mode of injury and material agent-contact mode of injury specific to each section are presented in this study. Measures to reduce the probability of an accident for the aforementioned causes can be restructured. Measures to reduce the severity of the damage should be developed within the scope of the hazard control hierarchy (Morris and Cannady, 2019).

The most common patterns among the ten items selected for sequential accident patterns are presented respectfully. The pattern that emerged only in thes section CA "a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.02}$-f_{64}-g_{51}-$h_{06.02}$-

Table 34
The first ten accident sequences pattern with nine items for each section: Support value ($n_{others\ included} = 995{,}503$).

Sequences	Support value												
	CA[ax]	CB[bx]	CC[cx]	CD[dx]	CE[ex]	CF[fx]	CG[gx]	CH[hx]	CI[ix]	CJ[jx]	CK[kx]	CL[lx]	CM[mx]
a_{01}-b_{999}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}	3.84%	–	0.85%	–	–	6.94%	–	–	–	–	0.86%	2.25%	–
b_{999}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{00}	3.34%	–	–	–	1.65%	5.49%	2.49%	–	–	1.98%	–	1.94%	3.43%
a_{09}-b_{011}-c_{11}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-j_{00}	2.91%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{00}	2.89%	2.14%	0.86%	–	1.73%	5.41%	–	–	–	1.83%	–	1.84%	–
a_{09}-b_{999}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-j_{00}	2.82%	–	–	–	–	–	1.99%	–	–	–	–	–	2.86%
a_{01}-b_{011}-c_{11}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-j_{00}	2.48%	2.49%	–	–	1.95%	–	–	–	4.97%	1.84%	1.05%	1.33%	–
a_{09}-b_{999}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{00}	2.47%	–	–	–	–	–	1.96%	–	–	–	–	–	2.60%
a_{01}-b_{999}-c_{99}-d_{99}-$e_{99.00}$-g_{99}-$h_{99.00}$-i_{999}-j_{00}	2.46%	–	–	–	–	4.56%	–	–	–	–	–	1.26%	–
a_{01}-b_{999}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-$h_{99.00}$-i_{999}-j_{00}	2.42%	–	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{999}-c_{99}-d_{99}-f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{00}	2.42%	–	–	–	–	4.48%	–	–	–	–	–	–	–
a_{01}-b_{011}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{00}	–	2.90%	0.90%	–	2.57%	–	–	–	–	2.19%	1.00%	–	–
a_{01}-b_{011}-c_{11}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}	–	2.47%	0.94%	–	2.01%	–	–	–	–	2.74%	1.30%	1.61%	–
a_{01}-b_{011}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}	–	2.34%	1.01%	–	1.88%	–	2.59%	–	–	–	1.09%	–	–
a_{01}-b_{011}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-j_{00}	–	1.89%	1.06%	1.11%	1.71%	–	2.16%	–	4.05%	2.10%	–	–	–
a_{01}-b_{011}-c_{11}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{00}	–	1.85%	–	–	1.59%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{99}-$e_{99.00}$-g_{99}-$h_{99.00}$-i_{999}-j_{00}	–	1.69%	–	–	1.51%	–	–	–	–	–	–	–	–
a_{01}-c_{11}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{00}	–	1.66%	–	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{99}-$e_{99.00}$-f_{99}-$h_{99.00}$-i_{999}-j_{00}	–	1.65%	–	–	–	–	–	–	–	–	–	–	–
a_{09}-b_{999}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}	–	–	1.24%	–	1.92%	–	3.37%	–	–	3.56%	0.94%	1.26%	3.77%
a_{01}-b_{011}-c_{11}-d_{13}-$e_{10.02}$-f_{99}-g_{99}-$h_{10.02}$-j_{20}	–	–	0.95%	–	–	–	–	–	–	–	–	–	–
b_{999}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{20}	–	–	0.83%	–	–	–	–	–	–	1.95%	–	–	–
a_{01}-b_{011}-c_{11}-d_{13}-$e_{10.02}$-f_{99}-g_{99}-$h_{10.02}$-i_{011}	–	–	0.80%	–	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-j_{90}	–	–	–	1.30%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{99}-d_{99}-$e_{00.01}$-f_{99}-g_{99}-$h_{00.01}$-j_{00}	–	–	–	1.02%	–	–	–	–	–	–	–	–	–
a_{01}-c_{99}-d_{99}-$e_{00.01}$-f_{99}-g_{99}-$h_{00.01}$-i_{071}-j_{00}	–	–	–	1.02%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{011}	–	–	–	0.83%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{99}-$e_{01.02}$-f_{99}-g_{99}-$h_{01.02}$-i_{032}-j_{90}	–	–	–	0.65%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{011}-j_{00}	–	–	–	0.56%	–	–	–	–	3.51%	–	–	–	–
a_{01}-b_{011}-c_{99}-d_{99}-$e_{99.00}$-g_{99}-$h_{99.00}$-i_{011}-j_{00}	–	–	–	0.56%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{032}	–	–	–	0.56%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{011}-j_{00}	–	–	–	0.56%	–	–	–	–	–	–	–	–	–
a_{01}-b_{999}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-j_{00}	–	–	–	–	–	5.21%	–	–	–	–	–	1.48%	–
a_{01}-b_{999}-c_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{00}	–	–	–	–	–	4.64%	–	–	–	–	–	–	–
a_{01}-b_{999}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{00}	–	–	–	–	–	4.58%	–	–	–	–	–	1.47%	–
a_{01}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{90}	–	–	–	–	–	2,20%	–	–	–	–	–	–	–
b_{999}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{90}	–	–	–	–	–	2,18%	–	–	–	–	–	–	–
a_{09}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{00}	–	–	–	–	–	–	2,03%	–	–	–	–	–	2,73%
a_{01}-b_{011}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-j_{20}	–	–	–	–	–	–	2,00%	2,08%	–	–	0,95%	–	–
a_{09}-b_{999}-c_{99}-d_{99}-$e_{99.00}$-g_{99}-$h_{99.00}$-i_{999}-j_{00}	–	–	–	–	–	–	1,96%	–	–	–	–	–	2,66%
a_{09}-b_{999}-c_{99}-d_{99}-f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{00}	–	–	–	–	–	–	1,94%	–	–	–	–	–	2,60%
a_{01}-b_{011}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{071}-j_{00}	–	–	–	–	–	–	–	–	4,73%	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{99}-$e_{99.00}$-f_{99}-$h_{99.00}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	3,22%	–	–	–	–
a_{01}-b_{011}-c_{11}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	2,63%	–	–	–	–
a_{01}-c_{11}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{071}-j_{00}	–	–	–	–	–	–	–	–	2,40%	–	–	–	–
a_{01}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{071}-j_{00}	–	–	–	–	–	–	–	–	2,38%	–	–	–	–
a_{01}-b_{011}-c_{99}-d_{99}-f_{99}-g_{99}-$h_{99.00}$-i_{071}-j_{00}	–	–	–	–	–	–	–	–	2,34%	–	–	–	–
a_{01}-b_{011}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{071}	–	–	–	–	–	–	–	–	2,34%	–	–	–	–
a_{01}-b_{011}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{90}	–	–	–	–	–	–	–	–	–	1,83%	–	–	–
a_{01}-b_{011}-c_{11}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-j_{90}	–	–	–	–	–	–	–	–	–	1,80%	–	–	–
a_{01}-b_{011}-c_{11}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-j_{20}	–	–	–	–	–	–	–	–	–	–	1,12%	1,33%	–
a_{01}-b_{011}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{20}	–	–	–	–	–	–	–	–	–	–	0,87%	–	–
a_{01}-b_{011}-c_{11}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{011}	–	–	–	–	–	–	–	–	–	–	0,86%	–	–
a_{09}-b_{999}-c_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{00}	–	–	–	–	–	–	–	–	–	–	–	–	2,61%
a_{09}-b_{999}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-i_{999}-j_{00}	–	–	–	–	–	–	–	–	–	–	–	–	2,60%
a_{09}-b_{999}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-$h_{99.00}$-i_{999}-j_{00}	–	–	–	–	–	–	–	–	–	–	–	–	2,60%

[ax]Support value for minsup = 0.015, [bx]Support value for minsup = 0.015, [cx]Support value for minsup = 0.005, [dx]Support value for minsup = 0.000, [ex]Support value for minsup = 0.005, [fx]Support value for minsup = 0.000, [gx]Support value for minsup = 0.015, [hx]Support value for minsup = 0.019, [ix]Support value for minsup = 0.001, [jx]Support value for minsup = 0.005, [kx]Support value for minsup = 0.005, [lx]Support value for minsup = 0.007, [mx]Support value for minsup = 0.006.

i_{011}-j_{00}", only in section CB "a_{01}-b_{011}-c_{11}-d_{21}-$e_{10.06}$-f_{41}-g_{63}-$h_{10.06}$-i_{011}-j_{20}", only in section CC "a_{01}-b_{011}-c_{11}-d_{21}-$e_{10.06}$-f_{41}-g_{63}-$h_{10.06}$-i_{011}-j_{20}", only in section CD "a_{01}-b_{011}-c_{11}-d_{70}-$e_{15.02}$-f_{24}-g_{15}-$h_{00.01}$-i_{071}-j_{00}", only in section CE "a_{01}-b_{011}-c_{11}-d_{11}-$e_{09.99}$-f_{49}-g_{63}-$h_{09.99}$-i_{011}-j_{20}", only in section CF "a_{01}-b_{012}-c_{24}-d_{70}-$e_{00.01}$-f_{14}-g_{23}-$h_{00.01}$-i_{000}-j_{00}", only in section CI "a_{01}-b_{011}-c_{11}-d_{51}-$e_{00.01}$-f_{71}-g_{71}-$h_{14.12}$-i_{039}-j_{00}", only in section CK "a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.12}$-f_{44}-g_{51}-$h_{14.12}$-i_{011}-j_{00}", only in section CM "a_{01}-b_{011}-c_{11}-d_{21}-$e_{06.06}$-f_{43}-g_{52}-$h_{06.06}$-i_{011}-j_{00}". However, there are partial patterns that are same in the accident sequence patterns obtained for relevant sections. In addition, similar sequential accident patterns are obtained in different sections. In here, each one successive item that forms the sequential accident series should be evaluated as a risk factor by occupational safety professionals.

One of the most significant limitations of the study is the large number of variables coded as others in the data set. As a result, analyses were performed by excluding 687,909 occupational accident records from the data set. However, occupational accident records only include employees who have compulsory insurance.

In this study, sequential accident patterns resulting in the most common no incapacity and injury were discovered in each section. It is suggested that future research be conducted to discover sequential accident sequences in accidents that result in fewer fatalities and

Table 35
The first ten accident sequences pattern with ten items for each section: Support value ($n_{others\ included} = 995{,}503$).

Sequences	Support value											
	CA[ax]	CB[bx]	CC[cx]	CD[dx]	CE[ex]	CF[fx]	CG[gx]	CI[ix]	CJ[jx]	CK[kx]	CL[lx]	CM[mx]
a_{09}-b_{999}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{00}	2.41%	–	–	–	1.11%	0.88%	1.92%	–	1.35%	–	–	–
a_{01}-b_{011}-c_{11}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{00}	–	1.58%	–	–	1.35%	0.91%	–	0.27%	0.93%	0.56%	0.71%	–
a_{01}-b_{011}-c_{11}-d_{13}-$e_{10.02}$-f_{99}-g_{99}-$h_{10.02}$-i_{011}-j_{20}	–	–	0.77%	–	–	–	–	–	–	–	–	–
a_{09}-b_{999}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{20}	–	–	0.56%	–	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{99}-d_{99}-$e_{00.01}$-f_{99}-g_{99}-$h_{00.01}$-i_{071}-j_{00}	–	–	–	0.93%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{011}-j_{00}	–	–	–	0.46%	–	–	–	1.44%	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{70}-$e_{15.02}$-f_{24}-g_{15}-$h_{00.01}$-i_{071}-j_{00}	–	–	–	0.37%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{011}-j_{90}	–	–	–	0.37%	–	–	–	–	–	–	–	–
a_{01}-b_{999}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{00}	–	–	–	0.28%	0.51%	4.45%	–	–	0.57%	–	1.24%	0.74%
a_{01}-b_{011}-c_{00}-d_{00}-$e_{01.02}$-f_{13}-g_{13}-$h_{15.04}$-i_{062}-j_{20}	–	–	–	0.28%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{00}-$e_{00.01}$-f_{51}-g_{00}-$h_{00.01}$-i_{011}-j_{00}	–	–	–	0.28%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{61}-$e_{00.01}$-f_{51}-g_{31}-$h_{00.01}$-i_{011}-j_{00}	–	–	–	0.28%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{99}-d_{00}-$e_{01.02}$-f_{99}-g_{99}-$h_{01.02}$-i_{032}-j_{90}	–	–	–	0.28%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{99}-d_{70}-$e_{00.01}$-f_{14}-g_{99}-$h_{10.04}$-i_{069}-j_{00}	–	–	–	0.28%	–	–	–	–	–	–	–	–
a_{01}-b_{011}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{00}	–	–	–	–	1.13%	0.91%	–	–	1.23%	–	–	1.16%
a_{09}-b_{999}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{90}	–	–	–	–	0.50%	–	–	–	0.62%	–	–	0.64%
a_{01}-b_{999}-c_{99}-d_{999}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{90}	–	–	–	–	–	1.84%	–	–	–	–	–	–
a_{01}-b_{011}-c_{00}-d_{00}-$e_{01.02}$-f_{99}-g_{00}-$h_{01.02}$-i_{000}-j_{00}	–	–	–	–	–	1.24%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{011}-j_{00}	–	–	–	–	–	0.75%	–	1.97%	–	–	–	–
a_{01}-b_{011}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{20}	–	–	–	–	–	0.70%	–	–	–	–	–	–
a_{01}-b_{999}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{20}	–	–	–	–	–	0.65%	–	–	–	–	–	–
a_{01}-b_{000}-c_{00}-d_{00}-$e_{01.02}$-f_{99}-g_{00}-$h_{01.02}$-i_{000}-j_{00}	–	–	–	–	–	0.57%	–	–	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{071}-j_{00}	–	–	–	–	–	–	–	2.37%	–	–	–	–
a_{01}-b_{011}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{071}-j_{00}	–	–	–	–	–	–	–	2.33%	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{99}-$e_{99.00}$-f_{99}-g_{53}-$h_{99.00}$-i_{011}-j_{00}	–	–	–	–	–	–	–	0.58%	–	–	–	–
a_{00}-b_{00}-c_{00}-d_{00}-$e_{00.02}$-f_{99}-g_{00}-$h_{00.02}$-i_{000}-j_{00}	–	–	–	–	–	–	–	0.37%	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.03}$-f_{44}-g_{53}-$h_{14.03}$-i_{011}-j_{00}	–	–	–	–	–	–	–	0.29%	–	–	–	–
a_{00}-b_{00}-c_{00}-d_{70}-$e_{00.02}$-f_{99}-g_{00}-$h_{12.01}$-i_{000}-j_{00}	–	–	–	–	–	–	–	0.27%	–	–	–	–
a_{01}-b_{011}-c_{11}-d_{99}-$e_{99.00}$-f_{99}-g_{63}-$h_{99.00}$-i_{011}-j_{00}	–	–	–	–	–	–	–	0.27%	–	–	–	–
a_{09}-b_{999}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{20}	–	–	–	–	–	–	–	–	1.58%	–	–	–
a_{01}-b_{011}-c_{11}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{90}	–	–	–	–	–	–	–	–	1.50%	–	–	–
a_{01}-b_{011}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{079}-j_{00}	–	–	–	–	–	–	–	–	0.60%	–	–	–
a_{01}-b_{011}-c_{11}-d_{41}-$e_{14.12}$-f_{44}-g_{51}-$h_{14.12}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	0.57%	–	–
a_{00}-b_{999}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{00}	–	–	–	–	–	–	–	–	–	–	–	2.58%
a_{01}-b_{999}-c_{99}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{011}-j_{00}	–	–	–	–	–	–	–	–	–	–	–	0.73%
a_{01}-b_{999}-c_{11}-d_{99}-$e_{99.00}$-f_{99}-g_{99}-$h_{99.00}$-i_{999}-j_{90}	–	–	–	–	–	–	–	–	–	–	–	0.72%

permanent incapacity than others. It is hoped that by doing so, information will be gathered to aid in the prevention of fatal and permanent incapacity accidents.

CRediT authorship contribution statement

Nazli Gulum Mutlu: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Serkan Altuntas:** Supervision, Methodology, Conceptualization, Writing - original draft, Writing – review & editing. **Turkay Dereli:** Data curation, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

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

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Appendix A

(See Figs. 20-32 and Tables 14-35).

References

Agrawal, R., & Srikant, R. (1995, March). Mining sequential patterns. In Proceedings of the eleventh international conference on data engineering (pp. 3-14). IEEE.
Ahmadi, O., Mortazavi, S.B., Asilian Mahabadi, H., 2021. Application and modification of the Tripod Beta method for analyzing the causes of oil and gas industry accidents. Int. J. Occup. Saf. Ergon. 27 (3), 928–937.
Alayyannur, P.A., Paskarini, I., Ufiana, A., 2022. Analysis of work accidents in packaging workers using ILCI Theory in the informal metal industry. Malaysian J. Med. Health Sciences 18, 21–29.
Alias, S., Mohammad, S.K., Hoon, G.K., Ping, T.T., 2018. A text representation model using Sequential Pattern-Growth method. Pattern Anal. Appl. 21 (1), 233–247.
Altunkaynak, B., 2018. A statistical study of occupational accidents in the manufacturing industry in Turkey. Int. J. Ind. Ergon. 66, 101–109.
Aysun, Ö.Z.E.N., 2015. Analysis of turkish manufacturing industry with selected indicators. Nevsehir Hacı Bektas Veli University J. ISS 5 (1), 140–162.
Baldissone, G., Demichela, M., Comberti, L., Murè, S., 2019. Occupational accident-precursors data collection and analysis according to human factors analysis and classification system (HFACS) taxonomy. Data Brief 26, 104479.
Baralis, E., Bruno, G., Chiusano, S., Domenici, V.C., Mahoto, N.A., Petrigni, C., 2010, September. Analysis of medical pathways by means of frequent closed sequences. In: International Conference on Knowledge-Based and Intelligent Information and Engineering Systems. Springer, Berlin, Heidelberg, pp. 418–425.
Berhan, E., 2020a. Prevalence of occupational accident; and injuries and their associated factors in iron, steel and metal manufacturing industries in Addis Ababa. Cogent Eng. 7 (1), 1723211.
Berhan, E., 2020b. Management commitment and its impact on occupational health and safety improvement: a case of iron, steel and metal manufacturing industries. Int. J. Workplace Health Manag. 13 (4), 427–444.
Beşer, N.Ö., Uğurlu, S., 2020. The effects of manufacturing and industry sector on current accounts balance in Turkey (1974–2017). J. Administrative Sciences 18 (35), 77–90.
Bevilacqua, M., Ciarapica, F.E., Giacchetta, G., 2008. Industrial and occupational ergonomics in the petrochemical process industry: A regression trees approach. Accid. Anal. Prev. 40 (4), 1468–1479.
Bird, F.E.J., Germain, G.L., 1985. Practical loss control leadership. International Loss Control Institute, Loganville, Geogia.

Chang, J.H., 2011. Mining weighted sequential patterns in a sequence database with a time-interval weight. Knowl.-Based Syst. 24 (1), 1–9.
Cheng, Q., Ren, X., 2016. Medical insurance data mining using SPAM algorithm. In: International Conference on Geo-Informatics in Resource Management and Sustainable Ecosystem. Springer, Singapore, pp. 100–108.
Dhalmahapatra, K., Singh, K., Jain, Y., Maiti, J., 2019. Exploring causes of crane accidents from incident reports using decision tree. In: Information and Communication Technology for Intelligent Systems. Springer, Singapore, pp. 175–183.
Doran, J.A., Van Der Graaf, G.C., 1996, June. Tripod-BETA: incident investigation and analysis. SPE Health, Safety and Environment in Oil and Gas Exploration and Production Conference. OnePetro.
Eom, G., Been, S., Byeon, H., 2022. ICF-based job performance predictors for south korean industrial accident workers: population-based 3-year longitudinal analysis. int. J. Environ. Res. Public Health 19 (13), 7822.
Eurostat European Commission, 2013. European statistics on accident at work (ESAW). summary methodology. Eurostat Methodologies&Working Paper.
Eurostat, N. A. C. E. 2008. Rev. 2–statistical classification of economic activities in the european community. Office for Official Publications of the European Communities, Luxemburg.
Febrer-Hernández, J.K., Hernández-Palancar, J., 2012. Sequential pattern mining algorithms review. Intell. Data Anal. 16 (3), 451–466.
Fernandes, L.A., García, A.C.B., 2012, November. Association rule visualization and pruning through response-style data organization and clustering. In: Ibero-American Conference on Artificial Intelligence. Springer, Berlin, Heidelberg, pp. 71–80.
Fournier-Viger, P., Lin, J.C.W., Gomariz, A., Gueniche, T., Soltani, A., Deng, Z., Lam, H. T., 2016. The SPMF open-source data mining library version 2. In: Joint European conference on machine learning and knowledge discovery in databases. Springer, Cham, pp. 36–40.
Fournier-Viger, P., Lin, J.C.W., Kiran, R.U., Koh, Y.S., Thomas, R., 2017. A survey of sequential pattern mining. Data Science and Pattern Recognition 1 (1), 54–77.
Fu, G., Xie, X., Jia, Q., Li, Z., Chen, P., Ge, Y., 2020. The development history of accident causation models in the past 100 years: 24Model, a more modern accident causation model. Process Saf. Environ. Prot. 134, 47–82.
Fumarola, F., Lanotte, P.F., Ceci, M., Malerba, D., 2016. CloFAST: closed sequential pattern mining using sparse and vertical id-lists. Knowl. Inf. Syst. 48 (2), 429–463.
Gan, W., Lin, J.C.W., Fournier-Viger, P., Chao, H.C., Yu, P.S., 2019. A survey of parallel sequential pattern mining. ACM Trans. Knowledge Discovery from Data (TKDD) 13 (3), 1–34.
Ghahramani, A., Salminen, S., 2019. Evaluating effectiveness of OHSAS 18001 on safety performance in manufacturing companies in Iran. Saf. Sci. 112, 206–212.
Haibo, L., Zhi, W., 2019. Application of an intelligent early-warning method based on DBSCAN clustering for drilling overflow accident. Clust. Comput. 22 (5), 12599–12608.
Heimonen, A., Nousiainen, K., Lassila, H., et al., 2023. Work-related head injury and industry sectors in Finland: causes and circumstances. Int. Arch. Occup. Environ. Health 96, 577–586.
Hendrick, K., Benner, L., 1986. Investigating accident with STEP. CRC Press.
Hidri, A., Selmi, A., Hidri, M.S., 2020. Discovery of frequent patterns of episodes within a time window for alarm management systems. IEEE Access 8, 11061–11073.
Hoła, B., Szóstak, M., 2014. Analysis of the development of accident situations in the construction industry. Procedia Eng. 91, 429–434.
Hoła, B., Szóstak, M., 2017. Methodology of analysing the accident rate in the construction industry. Procedia Eng. 172, 355–362.
Hoła, B., Szóstak, M., 2019. Modeling of the accidentality phenomenon in the construction industry. Appl. Sci. 9 (9), 1878.
Hollnagel, E., 2004. Barriers and accident prevention. Ashgate, Aldershot.
Hosseinpouri, M., Majarshin, V.M., Sheikhmozafari, M.J., Ahmadi, O., 2022. Methodology for quantitatively monitoring basic risk factors of accidents: a case study on manufacturing companies. Work Preprint 1–12.
Huang, L., Wu, C., Wang, B., Ouyang, Q., 2018. A new paradigm for accident investigation and analysis in the era of big data. Process Saf. Prog. 37 (1), 42–48.
Hudson, P., 2012, September. Why is Achieving Zero Accidents so Difficult? In: *International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production*. OnePetro.SPE-157369-MS.
Hudson, P.T.W., Reason, J.T., Bentley, P.D., Primrose, M., 1994. Tripod delta: proactive approach to enhanced safety. J. Petrol. Tech. 46 (01), 58–62.
Ivascu, L., Cioca, L.I., 2019. Occupational accidents assessment by field of activity and investigation model for prevention and control. Safety 5(1), 12, 1–23.
Kang, Y., Yang, S., Patterson, P., 2021. Modern cause and effect model by factors of root cause for accident prevention in small to medium sized enterprises. Saf. Health Work 12 (4), 505–510.
Katsakiori, P., Kavvathas, A., Athanassiou, G., Goutsos, S., Manatakis, E., 2010. Workplace and organizational accident causation factors in the manufacturing industry. Hum. Factors Ergon. Manuf. Serv. Ind. 20 (1), 2–9.
Kim, S., Lee, J., Kang, C., 2021. Analysis of industrial accidents causing through jamming or crushing accidental deaths in the manufacturing industry in South Korea: focus on non-routine work on machinery. Saf. Sci. 133, 104998.
Kim, D.K., Park, S., 2021. An analysis of the effects of occupational accidents on corporate management performance. Saf. Sci. 138, 105228.
Kjellén, U., 1984. The role of deviations in accident causation and control. J. Occup. Accid. 6 (1–3), 117–126.
Kjellén, U., 2000. Prevention of accidents through experience feedback. CRC Press.
Kjellen, U., Albrechtsen, E., 2017. Prevention of accidents and unwanted occurrences: theory, methods, and tools in safety management. CRC Press.
Kjellen, U., Larsson, T.J., 1981. Investigating accidents and reducing risks–A dynamic approach. J. Occup. Accid. 3 (2), 129–140.
Leveson, N., 2004. A new accident model for engineering safer systems. Saf. Sci. 42 (4), 237–270.
Leveson, N.G., 2011. Engineering a safer world: systems thinking applied to safety. The MIT Press.
Lezama, O. B. P., Varela Izquierdo, N., Pérez Fernández, D., Gómez Dorta, R. L., Viloria Silva, A. J., & Romero Marín, L. (2018). Models of multivariate regression for labor accidents in different production sectors: Comparative study.
Li, H., Peng, S., Li, J., Li, J., Cui, J., Ma, J., 2019. Counting the frequency of time-constrained serial episodes in a streaming sequence. Inf. Sci. 505, 422–439.
Liu, J., Wang, W., Yang, J., 2005. Mining sequential patterns from large data sets. Adv. Database Systems 18.
Luo, X., 2018. Research on the construction of an intelligent music auxiliary composing and arranging system based on bayesian network. J. Adv. Oxidation Technol. 21 (2).
Mahmoudi, D., Alizadeh, S.S., Rasoulzadeh, Y., Jafarabadi, M.A., 2020. Prioritizing the thirteenth dimensions of Organizational Resilience in dealing with crises and major accidents. Iran Occupational Health 17, 62.
Maylawati, D.S., Kumar, Y.J., Kasmin, F.B., Ramdhani, M.A., 2019. An idea based on sequential pattern mining and deep learning for text summarization. J. Phys.: Conf. Ser. 1402 (7), 077013.
McKinnon, R.C., 2019. Cause, effect, and control of accidental loss with accident investigation kit. CRC Press.
Mijumbi, R., Asthana, A., Bernal, C., & Castejon, M. 2019, July. MAYOR: Machine Learning and Analytics for Automated Operations and Recovery. In 2019 28th International Conference on Computer Communication and Networks (ICCCN) (pp. 1-9). IEEE.
Morris, G.A., Cannady, R., 2019. Proper use of the hierarchy of controls. Prof. Saf. 64 (08), 37–40.
Mutlu, N.G., Altuntas, S., 2019. Assessment of occupational risks In Turkish manufacturing systems with data-driven models. J. Manuf. Syst. 53, 169–182.
Ou-Yang, C., Wulandari, C.P., Hariadi, R.A.R., Wang, H.C., Chen, C., 2018. Applying sequential pattern mining to investigate cerebrovascular health outpatients' re-visit patterns. PeerJ 6, e5183.
Palamara, F., Piglione, F., Piccinini, N., 2011. Self-organizing map and clustering algorithms for the analysis of occupational accident databases. Saf. Sci. 49 (8–9), 1215–1230.
Pereira, J.C., Bordeaux, R., Zotes, L.P., Lima, G.B., Quelhas, O.L.G., 2015. Probabilistic risk analysis of safety management system failure and impact on economic performance: the case of jet engine manufacturing. Int. J. Manag. Decis. Mak. 14 (4), 345–372.
Polat, H., 2011. Manufacturing industry in economy of Turkey. Dicle University Journal of Economics and Administrative Sciences 1 (2), 24–39.
Ratnasingam, J., Ioras, F., Abrudan, I.V., 2012. An evaluation of occupational accidents in the wooden furniture industry–a regional study in South East Asia. Saf. Sci. 50 (5), 1190–1195.
Reason, J., 1997. Managing the risks of organizational accidents. Ashgate, England.
Reese, C.D., 2011. Accident/incident prevention techniques. CRC Press, p. 46.
Ren, J.M., Chen, Z.S., Jang, J.S.R., 2010, March. On the use of sequential patterns mining as temporal features for music genre classification. In: In 2010 IEEE International Conference on Acoustics, Speech and Signal Processing. IEEE, pp. 2294–2297.
Rundmo, T., Söderqvist, A., 1994. Economic assessment of occupational injuries in furniture industries. Saf. Sci. 18 (1), 33–43.
Salvemini, E., Fumarola, F., Malerba, D., Han, J., 2011, June. Fast sequence mining based on sparse id-lists. In: International Symposium on Methodologies for Intelligent Systems. Springer, Berlin, Heidelberg, pp. 316–325.
Seo, K.K., Yoon, S., 2012. Development of the EHS management system as SaaS for small and medium manufacturing firms. In: In 2012 6th International Conference on New Trends in Information Science, Service Science and Data Mining (ISSDM2012). IEEE, pp. 231–234.
Shafiei, P., Jabbari, M., Tehrani, M.M.E., 2021. Investigation of root cause of work-related accidents in a vehicle manufacturing company using Tripod-Beta method. J. Health and Safety at Work 11 (2), 309–326.
Shappell, S.A., Wiegmann, D.A., 2001. Applying Reason: the human factors analysis and classification system (HFACS). Human Factors and Aerospace Safety.
Singh, K., Maiti, J., 2020. A novel data mining approach for analysis of accident paths and performance assessment of risk control systems. Reliab. Eng. Syst. Saf. 202, 107041.
Sousa, M.S.D., Torres, F.M., Jorge, A.B., 2017. Application of STAMP methodology in one complex manufacturing system. Int. J. Ind. Syst. Eng. 27 (3), 311–339.
SSI annual statistical report 2013. The social security institution (SSI) annual statistical report. http://www.sgk.gov.tr/wps/portal/sgk/tr/kurumsal/istatistik/sgk_istatistik_yilliklari. Accessed 05 July 2020.
SSI annual statistical report 2014. The social security institution (SSI) annual statistical report. http://www.sgk.gov.tr/wps/portal/sgk/tr/kurumsal/istatistik/sgk_istatistik_yilliklari. Accessed 05 July 2020.
SSI annual statistical report 2015. The social security institution (SSI) annual statistical report. http://www.sgk.gov.tr/wps/portal/sgk/tr/kurumsal/istatistik/sgk_istatistik_yilliklari. Accessed 05 July 2020.
SSI annual statistical report 2016. The social security institution (SSI) annual statistical report. http://www.sgk.gov.tr/wps/portal/sgk/tr/kurumsal/istatistik/sgk_istatistik_yilliklari. Accessed 05 July 2020.
SSI annual statistical report 2017. The social security institution (SSI) annual statistical report. http://www.sgk.gov.tr/wps/portal/sgk/tr/kurumsal/istatistik/sgk_istatistik_yilliklari. Accessed 05 July 2020.

SSI annual statistical report 2018. The social security institution (SSI) annual statistical report. http://www.sgk.gov.tr/wps/portal/sgk/tr/kurumsal/istatistik/sgk_istatistik_yilliklari. Accessed 05 July 2020.

Svedung, I., Rasmussen, J., 2002. Graphic representation of accident scenarios: mapping system structure and the causation of accidents. Saf. Sci. 40 (5), 397–417.

Takahashi, A., Miura, T., 2016. At what age is the occupational accident risk high? analysis of the occurrence rate of occupational accidents by age. In: Advances in Safety Management and Human Factors. Springer, Cham, pp. 3–10.

Van der Want, P. G. D. (1996, October). Tripod incident analysis methodology. In Safety Performance Measurement. Conf (pp. 99-109). European Process Safety Centre Paris.

Wassi, G., Iloga, S., Romain, O., Granado, B., Tchuenté, M., 2018. FPGA-based simultaneous multichannel audio processor for musical genre indexing applications in broadcast band. J. Parallel Distrib. Comput. 119, 146–161.

Workplace Hazard Classes Notıfıcatıon on OHS, 2012. Workplace Hazard Classes Notification on Occupatıonal Health And Safety, Resmi Gazete Tarihi 26.12.2012, Government newspaper number: 28509, https://www.mevzuat.gov.tr/mevzuat?MevzuatNo=16909&MevzuatTur=9&MevzuatTertip=5. Accessed 22 July 2020.

Wu, T., Mao, Y., & Zhao, G. (2019, March). A Model Designed for HSE Big Data Analysis in Petroleum Industry. In International Petroleum Technology Conference. International Petroleum Technology Conference.

Yang, S.T., Jeong, B.Y., 2019. Comparison of accident characteristics between manual materials handling (MMH) and non-MMH works in the automobile parts manufacturing industry: Based on South Korea and the US. Work 62 (2), 197–203.

Yang, R., Zhu, W., Marinova, D., Wei, J., 2019. Time to take corporate innovation initiatives: the consequence of safety accidents in China's manufacturing industry. Career Dev. Int. 24 (5), 404–419.

Yao, L., Huang, H., Chen, S.H., 2020. Product quality detection through manufacturing process based on sequential patterns considering deep semantic learning and process rules. Processes 8 (7), 751.