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The Impact of Law No. 6331 on Work-Related Incidents in Türkiye (2007–2023): Standardization Analysis of City-Level Data for Compulsory Insured Workers

Türkiye'de 6331 Sayılı Kanun'un İş Sağlığı Olaylarına Etkisi (2007–2023): İl Düzeyinde Zorunlu Sigortalı Çalışan Verilerinin Standardizasyon Analizi

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ABSTRACT

Objective: This study examined the effects of the occupational health and safety (OHS) Law No. 6331, enacted in Türkiye in 2013. It analyzed the rates of work-related accidents (WrAs), occupational diseases (ODs), and work-related mortalities (WrMs) among compulsorily insured workers from 2007 to 2023. Additionally, it aimed to reveal the situation prior to the the introduction of compulsory OHS services for public institutions and low-risk workplaces with fewer than 50 workers in 2025. Pre-2025 before became mandatory.

Methods: Using data from Türkiye's social security institution, trends across 81 cities were examined in an epidemiological, observational, descriptive study.The research evaluated trends across 81 provinces usingobtained) withapproach. An indirect standardization technique was applied to adjust for changes in the number of "4-1/a compulsory insured" workers, allowing for comparisons of standardized ($_s$) WrA, $_s$OD, and $_s$WrM ratios between cities.

Results: Between 2007 and 2023, the number of insured workers in Türkiye nearly doubled. Regional disparities became evident, with sWrA ratios higher in western provinces and sWrM ratios elevated in the east. Inequalities $_s$WrAs concentrated, while $_s$WrMs were higher in eastern regions. The cities with the highest ratios of $_s$WrA, $_s$OD, included Zonguldak, Bilecik, Kütahya, Manisa, Bartın, Karabük, and Kocaeli following the after the law's implementation, $_s$WrA rose in the black sea region, while a modest rise in $_s$OD was detected in Marmara. Of Law No. 6331, $_s$WrAs increased significantly, especially. While $_s$ODs remained low nationwide, notable ratio increaserecordedthe region,

ÖZ

Amaç: Bu çalışma, 2013 yılında Türkiye'de yürürlüğe giren iş sağlığı ve güvenliği (İSG) kanunu no. 6331'in etkilerini incelemiştir. Zorunlu sigortalı çalışanlar arasında 2007–2023 yılları arasındaki iş kazası (WrA), meslek hastalığı (OD) ve iş yeri ölüm oranlarını (WrM) analiz etmiştir. Ayrıca, 2025'te kamu kurumları ve 50'den az çalışanı olan düşük riskli iş yerleri için iş sağlığı ve güvenliği hizmetlerinin zorunlu hale gelmesinden önceki durumu ortaya koymayı amaçlamıştır.

Yöntemler: Araştırma, Türkiye Sosyal Güvenlik Kurumu'ndan elde edilen verileri kullanarak 81 ildeki eğilimleri değerlendirmiş, epidemiyolojik, gözlemsel ve tanımlayıcı bir yaklaşım benimsemiştir. "4-1/a zorunlu sigortalı" çalışan sayısındaki değişiklikleri ayarlamak için dolaylı standartizasyon ($_s$) tekniği uygulanmış, böylece iller arasında $_s$WrA, $_s$OD ve $_s$WrM oranlarının karşılaştırılması sağlanmıştır.

Bulgular: 2007–2023 yılları arasında Türkiye'deki sigortalı çalışan sayısı neredeyse iki katına çıkmıştır. Bölgesel eşitsizlikler belirgin hale gelmiş, $_s$WrA oranları batı illerinde yoğunlaşırken, $_s$WrM oranları doğu bölgelerinde daha yüksek olmuştur. $_s$WrA, $_s$OD ve $_s$WrM oranlarının en yüksek olduğu iller arasında Zonguldak, Bilecik, Kütahya, Manisa, Bartın, Karabük ve Kocaeli bulunmaktadır. Kanun no. 6331'n uygulanmasının ardından, özellikle Karadeniz bölgesinde $_s$WrA oranlarında önemli bir artış gözlemlenmiştir. OD oranları ülke genelinde düşük kalırken, Marmara bölgesinde dikkate değer bir artış kaydedilmiş ve Doğu Karadeniz bölgesinde $_s$WrM oranlarında önemli artışlar gözlemlenmiştir.

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ABSTRACT

and significant increases in ˛WrMs werePeaks in ˛WrM occurred in various cities, with clustering observed in the Eastern Black Sea. region

Conclusion: This study provided critical insights into occupational health indicators in Türkiye, highlighting systemic deficiencies and regional disparities. Significant improvements were expected in these data with the upcoming 2025 expansion of Law No. 6331 provides an opportunity for improvement; however, persistent underreporting, limited diagnostic capacity for ODs, and uneven implementation across regions suggest that significant structural gaps remain.6331 in 2025.

Keywords: Work-related accident, work accident, OD, work-related mortality, occupational health and safety, OHS, Türkiye, city, province, region, standardization, 6331

ÖZ

Sonuç: Bu çalışma, Türkiye'deki iş sağlığı göstergeleri hakkında kritik bilgiler sunmuş, sistemik eksiklikleri ve bölgesel farklılıkları vurgulamıştır. 2025'te kanun no. 6331'in kapsamının genişletilmesiyle birlikte bu verilerde önemli iyileşmeler beklenmektedir.

Anahtar Sözcükler: İşle ilgili kaza, iş kazası, OD, işe bağlı mortalite, iş sağlığı ve güvenliği, İSG, Türkiye, şehir, il, bölge, standardizasyon, 6331

INTRODUCTION

In Türkiye's recent history, significant reforms in occupational health and safety (OHS) have been initiated, beginning with the social security reform of 2006. This reform unified previously separate social security institutions (SSI), including those for self-employed individuals and civil servants, under a single framework. As part of this reform, social security Law No. 5510 was enacted, mandating the reporting of all work-related accidents (WrAs) to the SSI. Since 2007, the ministry of labor and social security has made annual statistical data, compiled in accordance with International Labor Organization (ILO) definitions and European Union (EU) sustainability criteria, publicly accessible (1,2) and shared with relevant stakeholders (2).

Despite these advancements, the ILO reported in 2009 that OHS practices remained inadequate in 33 countries, including Türkiye (3). In response, OHS Law No. 6331 was introduced in 2013 (4), which requires employers to appoint occupational safety experts and workplace physicians, conduct risk assessments, provide OHS training, and designate worker representatives. This law also imposes penalties for non-compliance and mandates the preparation of emergency response plans. Following its implementation, reported WrAs tripled in 2013 (5,6), indicating increased awareness and reporting of workplace incidents. However, despite these improvements, the Ministry recognized the need for further interventions to enhance OHS practices (7). In the National OHS Policy Document-III, In response, OHS Law No. 6331, introduced in 2013 (5), requires employers to appoint occupational safety experts and workplace physicians, conduct risk assessments, provide OHS training, and designate worker representatives. Following its implementation, reported WrAs tripled in 2013 (6,7), indicating increased awareness and reporting of workplace incidents. In the National OHS Policy Document-III (8,9), published immediately after this law, OD set a target to achieve a significant increase in diagnosis rates, published immediately after this law, OD set a target for a significant increase in diagnosis rates.

Since its inception, The law was intended to require OHS services for public institutions and low-risk workplaces with fewer than 50 workers. However, due to infrastructural deficiencies, its implementation was postponed until 2025 (10). Following the publication of the 2023 SSI annual statistical data, a comprehensive dataset covering 17 years (2007–2023) is now available online (2), enabling in-depth analysis of long-term trends in OHS.

The purpose of this study is to evaluate the effects of the OHS Law No. 6331, which entered into force in Türkiye in 2013 by analyzing the standardized ratios (s) of WrAs, occupational diseases (ODs), and work-related mortalities (WrMs). Aimsexamineimpactenacted in 2013) among compulsory insured workers from 2007 to 2023. Additionally, it seeks to elucidate the conditions prior to 2025, when OHS services will become compulsory for public institutions and low-risk workplaces employing fewer than 50 workers, thereby informing potential future interventions by the Ministry of Labor and Social Security.

MATERIALS AND METHODS

Research Method

This study was designed as an epidemiological, observational, and descriptive study. The incidence rates of WrAs, ODs, and WrMs were standardized, and the resulting data were utilized for targeted evaluations.

Inclusion and Exclusion Criteria

The study included workers classified under the "4–1/a insurance" status, which refers to individuals employed under a service contract and whose social security contributions are paid by their employer. This group was selected due to their comprehensive and reliable dataset, as well as their higher risk of WrAs and ODs.

This study included workers classified under the "4–1/a insurance" status, as defined by article 4, paragraph 1(a) of the Law No. 5510 (1,11). This category specifically refers to individuals described as "worked by one or more workers under a service contract", for whom social security contributions are paid by their workers. This group was selected because of its comprehensive, reliable dataset, regular workups, and higher risks of WrAs and ODs (11,12).

• Excluded groups include interns, trainees, apprentices, partially insured workers, voluntary insured workers due to their lower exposure to hazardous tasks, and the groups mentioned below.

• Insured in agricultural sector: High levels of informal employment and seasonal work.

• Collective insured: Data unrelated to workplaces in Türkiye.

Furthermore, ODs diagnosed after insurance coverage began were not reported prior to Law No. 6331. Therefore, those reported after enactment of the law were also excluded to maintain consistency. Moreover, these data lacked city-specific information and were therefore excluded from the standardization analysis to maintain comparability and consistency across results.

Data Sources

Data were obtained from all statistical yearbooks published to date by Türkiye's SSI. The analysis covers a 17-year period (2007–2023) and includes data from 81 cities, allowing detailed examination of trends (2). Since the dataset for 2024 has not yet been published, it could not be included in the analysis.

Statistical Analysis

The indirect standardization technique was chosen because it does not require detailed age-specific rates or information on other confounding factors, making it appropriate for datasets in which such information is unavailable (11-13). This method is particularly advantageous for adjusting for variations in the number of insured workers and for ensuring comparability of incidence rates across cities (14,15). This approach adjusted for city-level differences in the number of insured workers, accounted for regional variations, and enabled more accurate comparisons of WrAs, ODs, and WrM incidence rates.

The analysis used the "standardized ratio formula" to compare observed and expected rates. The following formulas were applied to calculate standardized ratios for WrAs, ODs, and WrMs:

• National WrA or OD or WrM (incidence) Rate (only for WrA x 1,000) = Türkiye's observed WrAs/Türkiye's number of workers x 100,000.

• Expected incident = city's number of workers × national WrA or OD or WrM rate.

• Standardized ($_s$) city's WrA or OD or WrM incidence ($_s$WrA or $_s$OD or $_s$WrM) ratio = (city's observed/expected incident) × 100.

Statistical analyses were performed using SPSS 25 (IBM Corp., Armonk, NY, USA) and visualizations were generated using Excel and Flourish Studio (available at https://flourish.studio).

Interpretation of Standardized Ratios

A normal incidence rate is , for example, as the "WrA rate", while a standardized incidence rate is referred to as the "$_s$WrA ratio" and is typically expressed as a percentage. A "$_s$WrA ratio" of 100% represents the national average. For instance, in 2015, Şırnak's $_s$WrM ratio was 1,080%, representing a 9.8-fold increase relative to the national average. This indicates that while 17 fatalities were observed in Şırnak that year, only 2 expected based on the national WrM rate and the number of insured workers in Şırnak.

In other words, large standardized ratios highlight unexpected developments in specific cities during certain years. Identifying and analyzing these deviations can provide critical insights into their underlying causes and help develop targeted solutions.

Presentation Method - Tables

The results of the standardization analyses for WrAs, ODs, and work-related mortality (WrM) are presented in three supplementary tables (Supplementary Tables 1–4), which provide a comprehensive list of all cities and their respective ratios. The effective date of OHS Law No. 6331 is highlighted. Because these tables are extensive, a summary is provided for clarity and emphasis:

• Cities that ranked in the top six for WrAs in any year during the 17-year period are included in Table 1.

• Cities that ranked in the top three for ODs in any year were included in Table 2.

• Cities that ranked first for WrMs in any year are shown in Table 3.

Table 1. Cities appearing in the top six for standardized work-related accident (swra) ratios in any year from 2007 to 2023.

City (%)*	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Zonguldak	565	587	974	970	788	774	340	295	278	252	212	174	221	239	225	211	216
Bilecik	527	416	387	506	514	244	360	350	316	287	293	267	291	283	289	271	258
Karabük	576	614	635	616	607	454	267	252	252	216	198	165	184	183	201	159	149
Manisa	376	532	446	549	501	593	339	312	233	223	208	213	201	196	207	204	205
Karaman	122	94	155	132	153	173	205	217	198	277	354	277	229	243	203	189	146
Kütahya	167	244	288	179	301	262	158	179	155	150	159	156	137	147	148	157	134
Kocaeli	272	145	119	152	207	122	193	202	215	193	185	175	176	183	183	183	178
Eskişehir	201	252	210	270	291	93	203	179	180	172	149	145	145	148	143	140	141
Kayseri	226	243	184	20	227	215	213	204	184	174	165	149	158	171	176	162	159
Bartın	157	146	239	367	362	177	175	145	143	138	125	131	119	126	139	136	133
Denizli	169	216	210	245	248	251	175	161	156	147	136	125	123	125	128	127	115
Bolu	136	121	179	205	194	165	151	149	138	149	135	143	164	176	192	187	173
Yalova	90	106	154	63	97	138	98	114	136	156	164	160	230	253	266	241	251
Bursa	198	197	188	249	162	262	158	154	157	142	125	117	115	112	112	119	118
*Standardized ratio percentage			1st		2nd		3rd		4th		5th		6th		OHS Law No. 6331		

Table 2. Cities appearing in the top three for standardized occupational disease ($_s$OD) ratios in any year from 2007 to 2023.

City (%)*	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Zonguldak	9900	7615	5316	2201	3158	8279	4921	1246	3737	3355	1269	1883	872	706	458	704	302
Kütahya	26	28	0	0	5788	267	231	381	364	434	1508	1601	1334	340	131	511	147
Bilecik	22	52	0	56	169	77	1347	3764	176	625	612	1138	1798	900	334	728	48
Kocaeli	39	5	207	129	9	83	218	366	447	198	384	339	420	330	657	535	0
Çankırı	146	334	1060	102	0	271	1303	0	146	0	104	144	124	69	152	62	0
Bartın	42	0	0	0	0	494	0	189	519	478	272	762	349	0	50	0	0
Yalova	0	0	0	0	0	0	0	0	71	62	307	410	619	384	486	728	0
İzmir	128	242	110	458	31	80	35	61	52	128	116	55	204	91	86	82	612
Sakarya	35	477	100	0	99	0	0	125	85	91	211	205	264	372	299	197	0
Çorum	0	0	0	0	0	0	0	0	251	913	138	297	0	129	49	235	63
Ankara	17	26	199	414	260	187	53	40	140	81	127	102	76	53	39	38	7
Samsun	0	52	0	17	0	0	0	0	23	20	32	0	0	22	8	19	1016
Artvin	0	0	0	0	0	131	0	0	0	0	0	0	61	410	262	292	30
Erzincan	0	195	559	0	0	0	0	0	0	0	261	0	0	0	0	0	0
*Standardized ratio percentage					1st		2nd			3rd					OHS Law No. 6331		

Table 3. Cities ranked first for standardized work-related mortality ($_s$WrM) ratios in any year from 2007 to 2023.

City (%)*	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Şırnak	168	305	93	517	457	124	344	440	1080	331	441	135	201	527	335	403	131
Hakkâri	131	267	255	383	209	444	0	156	153	474	507	347	352	204	0	229	70
Artvin	208	131	86	252	214	348	347	253	134	260	208	257	338	126	422	82	137
Bartın	0	118	211	103	146	196	106	184	116	144	201	168	138	84	147	1622	23
Zonguldak	115	269	122	626	267	278	229	116	211	151	231	147	144	162	192	146	128
Siirt	155	157	220	176	419	344	182	43	190	870	151	28	122	78	35	67	209
Gümüşhane	0	785	277	68	55	240	210	66	223	73	223	122	259	232	149	68	90
Manisa	86	66	80	153	86	107	125	1232	63	105	110	99	68	133	109	122	165
Tunceli	468	0	302	376	110	0	0	138	144	479	111	0	0	132	248	0	365
Karabük	140	131	157	50	128	147	312	202	86	185	138	347	68	67	180	194	113
Batman	36	112	129	185	468	304	139	158	89	101	60	142	179	124	127	118	130
Nevşehir	202	177	90	338	124	47	394	86	55	55	115	161	118	252	73	130	116
Bingöl	110	0	354	99	341	359	95	0	220	130	63	166	239	82	187	0	77
Bayburt	388	0	0	0	125	223	0	0	0	144	98	111	462	0	247	119	113
*Standardized ratio percentage							1st								OHS Law No. 6331		

This approach limits each table to 14 cities, ensuring a concise presentation while effectively conveying key patterns and trends in the data.

Presentation Method - Figures

To present the extensive dataset simply and effectively, the results of the standardization analysis were visualized using figures. The visualization process followed a hierarchical approach, starting with national-level analyses and progressively focusing on specific city-level trends. The Figures 1–8 were structured as follows:

Figure 1

This figure illustrates the annual changes in the number of workers, workplaces, WrAs, ODs, and WrMs across Türkiye. It emphasizes trends at the national level and highlights the effective date of OHS Law No. 6331. This figure is particularly significant as it visualizes the five key work-related risk parameters in a single graph. To achieve this, two Y-axes were utilized: parameters marked with an asterisk (*) correspond to the left Y-axis, while those represented with dashed lines correspond to the right Y-axis, which uses a logarithmic scale. This dual-axis approach ensures clarity and allows for the simultaneous presentation of multiple parameters within a single figure.

Figure 2

This figure illustrates the "National WrA, OD, and WrM Rates" over a 17-year period, with the effective date of Law No. 6331 highlighted.

Figures 3–5

This heatmaps of Türkiye were created to visualize the 17-year standardization analyses, illustrating the average standardized ratio percentages for 81 cities over the study period. In the top left corner of the figures, there is a scale for the standardized work incidence ratio range (%), along with a second scale indicating the percentage increase represented by the upward arrows. These arrows highlight cities that exhibited an increasing trend in these ratios following Law No. 6331, effectively representing both the magnitude and direction of the correlation (Spearman). This approach was limited to the highest 14 cities in order to attract attention.

Figures 6–8

These figures provide detailed analyses of the top 7 cities with the highest standardized ratio percentages of WrAs, ODs, and WrMs over the 17-year period, particularly in the context of the implementation of Law No. 6331. This approach allows for a closer examination of specific cities while maintaining the general-to-specific flow of the study. Figures 6–8 utilize a logarithmic scale on the Y-axis but presenting values in their original. This method effectively displays both small and large standardization ratios, ensuring that variations across the dataset are clearly visible and comparable.

RESULTS

National Level

Between 2007 and 2023, the number of 4-1/a compulsorily insured workers in Türkiye increased from 8,505,390 to 16,406,420; the number of workplaces rose from 1,116,638 to 2,179,123; WrA cases increased from 80,602 to 681,401; OD diagnoses decreased from 1,208 to 945; and WrM cases rose from 1,043 to 1,966 (Figure 1).

The number of WrAs nearly tripled within one year of the implementation of Law No. 6331, and this increase continued steadily in subsequent years.WrA In contrast, the number of ODs exhibited a delayed response, showing a consistent upward trend one year after the law's enactment. This trend persisted until the onset of the COVID-19 pandemic, when the ratios fluctuated. Conversely, WrM cases followed a fluctuating pattern; however, when averaged over time, they demonstrated a stable trajectory (Figure 1).

Examination of the National Incidence Rates (Figure 2), which are more reliable than the numbers in Figure 1, showed that although no difference in the WrA trajectory was detected that would alter the interpretation, the increase observed in OD rates in Figure 1 was, in fact, minimal. Furthermore, while no significant difference in WrM rates was observed before and after the implementation of the law in Figure 1, a notable decrease in these rates was recorded in the period following the law's enactment, in Figure 2.

Region Level

WrA reports were predominantly located in the western half of the country. However, when examined the 14 cities that experienced the most significant increase in sWrAs (range: 70%-96.4%) as a result of Law No. 6331, a clustering pattern of this upward trend was identified in the black sea region (Figure 3).

In terms of sODs, consistently high percentages and ranking positions were notable in cities such as Zonguldak, Kütahya, and Bilecik. Additionally, when examined the 14 cities with the largest increase in OD diagnoses (range: 61.5%-96.1%) as a result of Law No. 6331, a clustering pattern was identified in the marmara region (Figure 4).

In contrast to ODs, high sWrM ratios were not confined to a limited area but were widespread across the country. When the 14 cities with the highest sWrMs (range: 35.5%–58.2%) that resulted from Law No. 6331 were examined, it was evident that these high rates were concentrated in the Eastern Black Sea region (Figure 5).

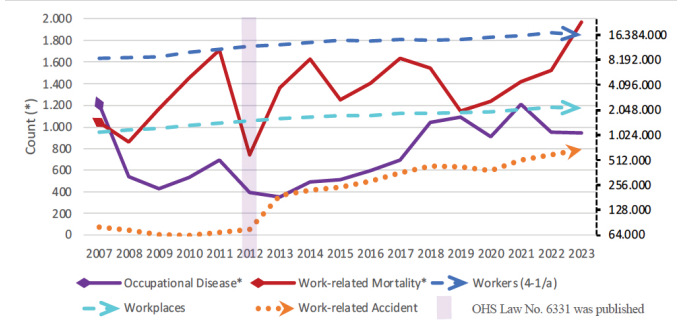

Figure 1. The count of workers, workplaces and work-related incidents in Türkiye (2007–2023).

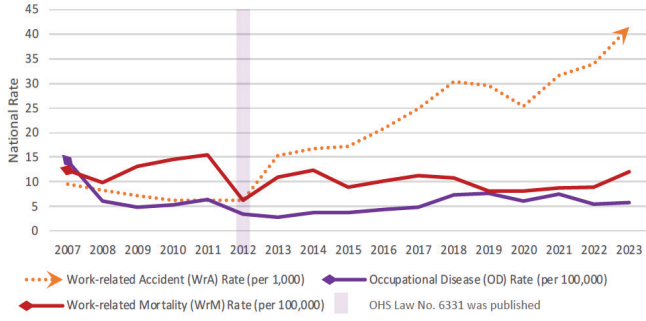

Figure 2. National Work-Related Incidence Rates in Türkiye (2007–2023).

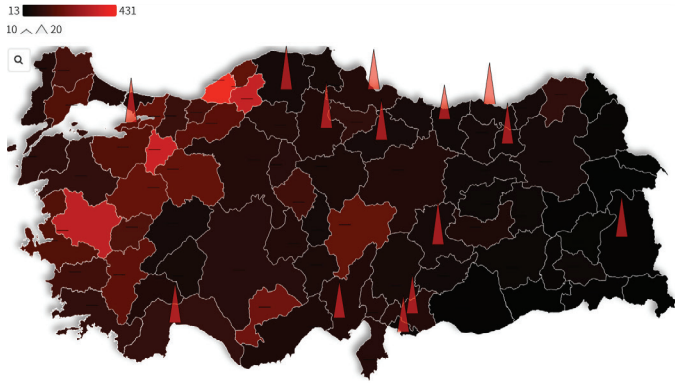

Figure 3: Heatmap of standardized work-related accident ($_s$WrA) ratios (%) by city (2007–2023).

City Level

The top seven cities with the highest overall ratios of sWrA, sOD, and sWrM were as follows: Zonguldak, Bilecik, Kütahya, Manisa, Bartın, Karabük, and Kocaeli. Notably, the top six cities consistently ranked at the forefront both before and after the implementation of Law No. 6331. When their locations on the map were examined, they were observed to be aligned nearly in a straight line along the north-south axis. In top-ranked cities, a noticeable decline in sWrA was observed following the implementation of Law No. 6331. While irregularities and wide fluctuations dominate sOD trends, a slight downward trend is evident in the maximum observed rates after the enactment of Law No. 6331. In contrast, sWrMs exhibit more frequent peaks and troughs and show no discernible pattern associated with Law No. 6331 (Figures 6–8).

Work-Related Accidents

Prior to the implementation of Law No. 6331, sWrA reached as high as 900% in some cities; however, no city subsequently recorded a rate exceeding 500% (Table 1, Figure 6). Specifically;

• Zonguldak: The sWrA ratio, which was 565% in 2007, decreased to 216% in 2023.

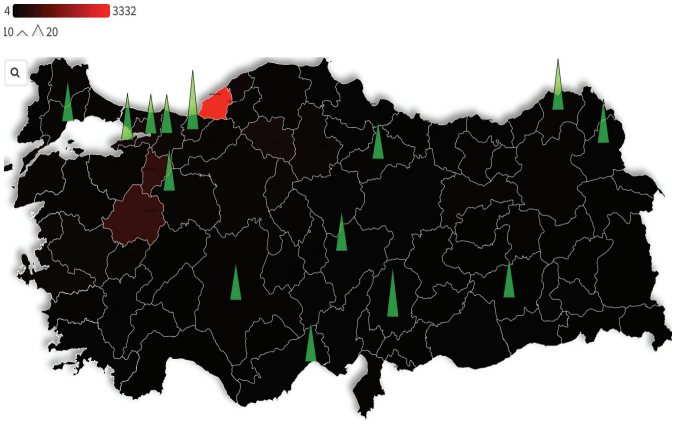

Figure 4. Heatmap of standardized occupational disease ($_s$OD) ratios (%) by city (2007–2023).

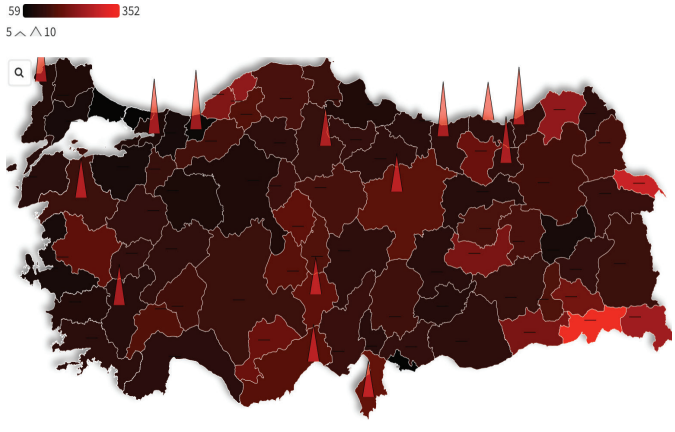

Figure 5. Heatmap of standardized work-related mortality ($_s$WrM) ratios (%) by city (2007–2023).

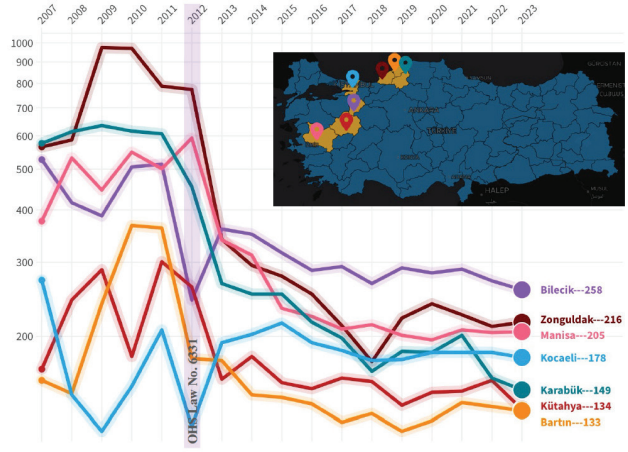

Figure 6. Trends in standardized ratios (%) of work-related accidents (WrA) in the top 7 cities (2007–2023).

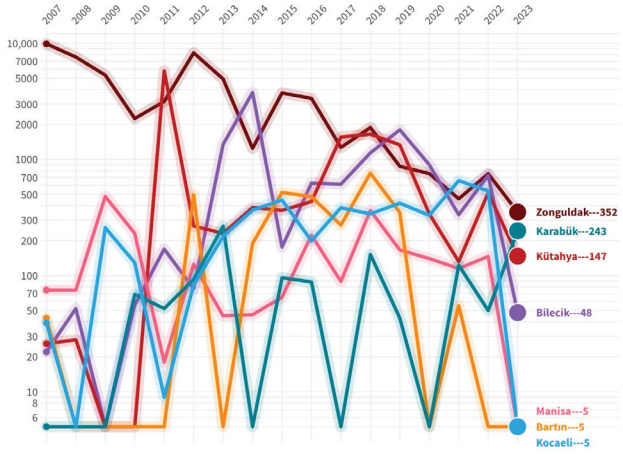

Figure 7. Trends in standardized ratios (%) of occupational diseases (OD) in the top 7 cities (2007–2023).

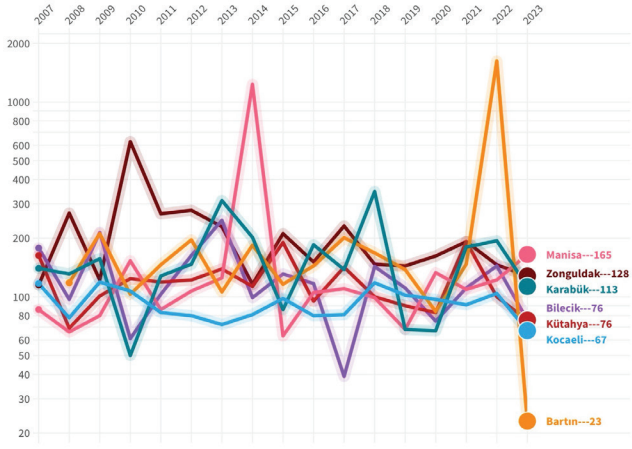

Figure 8. Trends in standardized ratios (%) of work-related mortality (WrM) in the top 7 cities (2007–2023).

• Bilecik and Karabük: In Bilecik, the ratio was 527% in 2007 and dropped to 258% in 2023, while in Karabük, the ratio decreased from 576% in 2007 to 149% in 2023.

• Manisa: The sWrA peaked at 593% in 2013 but showed a steady decline in subsequent years, reaching 205% in 2023.

• Bartın: In 2011, Bartın had a high sWrA ratio of 367%, which decreased to 133% in 2023.

Occupational Diseases

Prior to the implementation of Law No. 6331, excessively high sOD ratios were recorded in some cities, reaching 10,000%. In 2007, Zonguldak stood out with a ratio of 9,900%. Following the enactment of Law No. 6331, a significant decline in $_{s}$OD ratios was observed, with maximum rates decreasing to approximately 4,000% by 2016. For instance, Bilecik recorded a notable rate of 3,764% in 2013. During 2017–2019, sOD ratios further declined to approximately 1,000%, with cities such as Zonguldak (1,269%) and Kütahya (1,508%) maintaining relatively high ratios. From 2020 onwards, a trend toward lower sOD ratios was observed, with ratios above 500% becoming rare, and most cities reporting ratios in the range of 100–300%. However, the 2023 sOD ratio of 1,016% in Samsun is an exception to this general trend (Table 2, Figure 7). Specifically;

• Zonguldak had an exceptionally high $_{s}$OD ratio of 9,900% in 2007, which decreased to 302% in 2023.

• Bilecik experienced a notable spike in 2013 with a $_{s}$OD ratio of 3,764%, but this ratio dropped to 48% in 2023.

• Kütahya recorded one of the highest sOD ratios in 2011at 5,788%, which declined to 147% in 2023.

• Bartın had a high sOD ratio of 519% in 2015, but by 2023 the sOD ratio had dropped to zero.

Work-Related Mortalities

Regarding WrMs, no discernible pattern associated with Law No. 6331 is evident; the cities with the highest ratios vary significantly across years. Unlike the WrA and OD tables (Tables 1 and 2), where certain cities consistently rank at the top, the sWrM ratios exhibit sudden spikes in certain years. Cities experiencing spikes often have ratios exceeding the 200–300 level in multiple other years. However, cities such as Manisa (2014) and Bartın (2022) are exceptions to this generalization. In these cities, the rates typically remained low but then suddenly rose to very high levels. For example:

• Bartın exhibited a marked increase in 2022, with a sWrM ratio of 1,622%; however, this ratio declined to 23% in 2023.

• Manisa experienced a notable increase in 2014, reaching an sWrM ratio of 1,232%.

• Şırnak had one of the highest sWrM ratios in 2015, at 1,080%, but this ratio decreased to 131% in 2023.

• Zonguldak had a high $_{s}$WrM ratio of 626% in 2010, which dropped to 128% in 2023.

• Karabük reached an sWrM ratio of 312% in 2013, but this ratio fell to 113% in 2023.

These data indicate significant variations in sWrM ratios across cities and reveal sudden spikes in certain years (Table 3, Figure 8).

DISCUSSION

This study examined the effects of the OHS Law No. 6331, which came into force in Türkiye in 2013, through the standardization of data related to WrA, OD, and WrM. Analysis of data published by the SSI for all available years revealed a significant increase in sWrAs following the implementation of Law No. 6331, a slight increase in sOD ratios, and no significant change in sWrMs.reveals while has been observedhas occurred. Additionally, when examining the highest increases, all work-related incidences exhibited clustering in specific regions, and the highest standardized ratios declined over time.examined foralso.

The best indicators of occupational health are work-related incidence rates. Figure 1 provides a general overview by presenting the annual raw numbers of WrAs, ODs, and WrMs. Although the total number of WrMs appears largely stable in Figure 1, Figure 2 reveals a downward trend in WrM rates over time. Therefore, standardized incidence rates—as shown in Figure 2—provide a more reliable and meaningful basis for assessing actual risk levels and should be prioritized when interpreting the findings.

Typically, even in countries with the most advanced OHS systems, it is estimated that there are reporting deficiencies (including WrM) (16,17). Nevertheless, we believe that the most effective assessment can be achieved through a comparison with the official data of Germany, a country with a similar population and a strong OHS system.

Into provide a comparative general perspective, in terms of WrAs, while 870,000 WrAs were reported in Germany in 2019 (18), this number was below 430,000 in Türkiye (Figure 1). Normally, preventing WrA is an indicator of the effective functioning of OHS. However, Türkiye's significantly lower reporting of WrA compared to Germany indicates the opposite. This is because one of the main issues in Türkiye is the underreporting and lack of recording of WrAs (16).

This situation stemmed from the inadequacy of the OHS system prior to 2013. The ministry observed this situation and enacted Law No. 6331, which has had a positive impact on WrA reporting (Figure 2). Moreover, the effect of making OHS services compulsory in 2025 for public institutions and low-risk workplaces with fewer than 50 workers have yet to be seen, and it is anticipated that the situation will improve further. However, Despite the years that have passed since the law came into effect, our WrA counts were still half of those in Germany. The existing problem is likely due to the inadequate implementation of the OHS system and the lack of an established OHS culture in Türkiye. Therefore, any increase in WrAs in a specific location in Türkiye should be interpreted as an indication that the OHS system is beginning to take hold in that region. The concentration of cities in the black sea region that experienced the greatest increase in sOD diagnoses following the enactment of Law No. 6331 should be interpreted in this context (Figure 3).

The situation concerning OD in Türkiye is particularly striking. The expected increase in OD diagnoses began—perhaps unexpectedly—only in 2014, one year after Law No. 6331 was enacted. This rise showed a steady upward trend until fluctuations during the COVID-19 pandemic (Figure 2). As of 2022, the number of OD diagnoses in

Türkiye has only reached around 1,000 (Figure 1). In contrast, during the same period, the number in Germany was 200,000 (18,19). Part of this significant difference is due to Germany's recognition of COVID-19 cases as OD under certain circumstances. However, the situations in Türkiye and Germany did not differ substantially even before the pandemic. Moreover, the COVID-19 pandemic may provide a more accurate comparison, as the differing approaches to recognizing COVID-19 as an OD highlight the stark differences in the OHS culture (19). This disparity is not only present between Germany and Türkiye but also exists with many other countries (5).

The seriousness of missed diagnoses in OD is clearly observed in the complex trends depicted in the relevant graphs and the differences in the heat map (Figures 4 and 7). Authorities acknowledge that the number of OD diagnoses in Türkiye was quite low (6,8,20). Six hundred twenty following the enactment of Law No. 6331, the cities experiencing the highest increase in OD diagnoses were concentrated in the Marmara Region, the most developed area of Türkiye. This situation suggests that the infrastructure and awareness for identifying OD may be stronger in more industrialized and economically developed regions. In summary, a high reporting rate of OHS incidents in a region of Türkiye does not indicate poor workplace management; rather, it demonstrates that OHS systems are functioning effectively and that their existence is a positive aspect.

In 2014, the rate of WrM per 100,000 workers was recorded as 1.27 in EU countries (21), while in Türkiye, this rate was determined to be 12.2 (Figure 2) (21). Contrary to the issues of underreporting in WrAs and ODs, the problem concerning WrMs are the very high rates themselves, which is understandably concerning. Even if there is underreporting, it appears to be at much lower levels compared to WrA and OD. This is due to the fact that a concrete and extremely serious outcome, such as fatality, cannot be overlooked (22,23). It is evident that there are Significant deficiencies in OHS measures in Türkiye (3,24,27). The literature indicated that the prognosis of reported incidents in Türkiye is more severe compared to other countries (5,6). For all these reasons, we consider WrM data like a gold standard when evaluating the indicators of occupational health in Türkiye.

In our study, despite many developments following the enactment of Law No. 6331, the average WrM rate has not changed (Figure 2). This suggests that underreporting is not prevalent and that without fundamental changes and lasting cultural gains, this rate is unlikely to decrease. Additionally, we observed that the reporting ratios of sWrA were significantly lower in Türkiye's eastern regions compared to the west (Figure 3), whereas sWrM ratios were considerably higher (Figure 5). This indicates that the inadequacy of the OHS system in Türkiye is likely to be even more pronounced in the eastern regions.

Unfortunately, an ineffective OHS system can lead to disasters that result in the deaths of many workers. We have confirmed the effects of such incidents in our sWrM-specific outputs, allowing us to approach this data like a gold standard. In our study, we were able to observe the impacts of incidents that gained media attention and became public knowledge (25), such as the one in Kilimli (Zonguldak) in 2010, in our graphs, which underscores the consistency of the data.(25) According to the ILO accident hierarchy pyramid, expected fatalities can typically be predicted based on the quantity and quality of WrA (26). However, in the Turkish context, it is clear that there is a lack of reporting regarding WrA; therefore, it is clear that strong predictions cannot be made. When we examine the 14 cities with the highest sWrM ratios, we find that, with the exception of two cities, these locations had already reached sWrMs of 200-300 prior to major incidents (Table 3, Figure 8). This indicates that these cities exhibited significant risks for major accidents and displayed clear warning signs even before such catastrophic events occurred. Consequently, in the case of Türkiye, this situation may suggest the potential for catastrophic events prevention if focused interventions are implemented in these high-risk cities.

Generally, the cities with the highest ratios of $_{s}$WrA, $_{s}$OD, and $_{s}$WrM included Zonguldak, Bilecik, Kütahya, Manisa, Bartın, Karabük, and Kocaeli (Tables 1–3). Mining activities were predominant in all of these cities except for Kocaeli, which was an industrial center. Furthermore, these mining cities consistently ranked at the top both before and after the enactment of Law No. 6331. This is also evident in Issever's research on industrial sectors (27). However, the pattern of decreasing peak values observed in previous years for sWrA and sOD was also evident in these cities over time (Figures 6, 7). The underlying reason for this may be the improvements in OHS practices in other cities following the enactment of Law No. 6331 and the resulting increase in work-related incidence rates, which has led to the growth of denominator in the standardization formula. Lastly, no direct or clear impact of COVID-19 had been observed in these cities.

Additionally, an analysis of $_{s}$WrMs in these cities revealed a direct association with specific catastrophic events. For instance, the 2010 Kilimli and 2013 Kozlu mining accidents in Zonguldak significantly increased the city's $_{s}$WrMs. Similarly, the 2014 Soma mining disaster in Manisa, which resulted in the fatalities of 301 workers, caused the city's sWrM ratio to spike to 1,232%. Another notable incident was the 2014 Ermenek mining accident in Karaman, which also contributed to elevated sWrM. More recently, the 2022 Amasra mining disaster in Bartın led to an extraordinary increase in the city's $_{s}$WrM, reaching 1,622% (Table 3, Figure 8).

Study Limitations

This study has several limitations that should be acknowledged. While the SSI presents work-related incidents by considering all individuals under the 4-1/a category collectively, our research specifically focused on compulsory insured individuals within the 4–1/a group, which we believe represents the primary risk group. This focus may have led to a slight overestimation of the rates during the standardization process. It would be beneficial for the annual statistical reports to provide detailed data on work-related incidents specifically for compulsory insured individuals under the 4–1/a category. Although expected incidents, standard deviations, errors, confidence intervals and inter-city/regional comparisons were calculated, they were excluded due to space constraints. standard thesenot included in the article Additionally, the study did not account for the severity of WrAs, which could have provided a more nuanced analysis (28). The absence of detailed sectoral data and international comparisons limits the broader applicability of the findings. Finally, the analysis could not consider the hazard levels of workplaces where the workers were employed.

CONCLUSION

This study provides critical insights into the state and deficiencies of the OHS system, particularly analyzing the period immediately preceding the expansion of the scope of Law No. 6331 in 2025. It elucidates the effects of the implementation of the law in 2013 on occupational health indicators. During this period, cities with the highest standardized ratios of WrA, OD, and WrM were predominantly those with intensive mining activities, including Zonguldak, Bilecik, Kütahya, Manisa, Bartın, Karabük, and Kocaeli.

Our findings reveal substantial disparities across regions, with eastern provinces showing lower reporting of WrAs and higher WrM rates, suggesting serious underreporting except in fatal cases. highlight systemic deficiencies in OHS practices, particularly in the regions. The combination of $_{s}$WrA$_{s}$WrM ratios in these areas suggests that WrAs are often underreported unless they result in severe outcomes. Nationwide, $_{s}$ODs remained notably low, with a relative increase observed in the Marmara Region, likely due to improved infrastructure and heightened awareness. Nevertheless, the declining peak values in $_{s}$WrAs and $_{s}$ODs over time indicate gradual improvements in reporting and compliance are evident from the decline in extreme peak values. The OHS system, as well as increased. The expansion of the scope of Law No. 6331 in 2025 is expected to play a crucial role in addressing these systemic deficiencies and fostering a safer, more sustainable working environment in Türkiye.

Ethics

Ethics Committee Approval: Ethical approval was not required, as the study utilized publicly available, anonymized data in compliance with the Declaration of Helsinki.

Informed Consent: Informed consent was obtained.

Footnotes

Authorship Contributions

Surgical and Medical Practices:O.F.B., H.İ.,Concept: O.F.B., H.İ., Design: O.F.B., H.İ., Data Collection or Processing: O.F.B., Analysis or Interpretation: O.F.B., Literature Search: O.F.B., Writing: O.F.B.

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