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Enhancing Risk Management: Leveraging the Likelihood/Severity Matrix for Effective Risk Assessment and Mitigation in the Electrical and Electronic Sector

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Abstract

This paper presents the basic concept of risk and reviews commonly applied tools and techniques for risk assessment. Generally, risk assessment is a completely experiential decision-making process based on experience and knowledge of risk assistants. This paper emphasises one quantitative/qualitative technique, namely the likelihood/severity matrix approach, which aims to direct the organisation's attention towards risks that have the highest potential to have a negative effect. This paper's main contribution lies in introducing a proposed model that utilises the likelihood/severity matrix approach to categorise risks into 'regions' and subsequently rank them. This process supports risk managers in making informed decisions to reduce risks effectively. A likelihood/severity matrix was examined through a case study belonging to the electrical and electronic sector to find the critical risks that hinder the assembly line of personal computers. Results showed that the 'Breaking parts during assembly', 'Shocking the components from static electricity discharge' and 'Using wrong compatible parts' risks had the maximum risk score, with values of 10–15 as the most critical risks. These results can influence decision makers in developing actions to mitigate these highlighted risks.

Keywords: *likelihood/severity matrix approach; risk assessment; risk log*

1. Introduction

Nowadays, in a business world full of instabilities, industry operations face unexpected challenges. The latest events, such as the Wuhan coronavirus outbreak, have affected many operations worldwide, leading to increased uncontrollable risks. For this, a quick response with the use of data and establishing a strong system is needed [1]. Although the idea of risk is not new with the growth of risk management (RM), some important methods still need to be appraised, such as the likelihood/severity matrix. The likelihood/severity matrix is a definitive technique that can be supportive and perceptive to approve needed decisions as it presents risk data in a brief, graphical and mathematical manner. A likelihood/severity matrix is often colour-coded and utilises qualitative, quantitative and semi-quantitative methods to rank various types of risk based on their levels, enabling the prioritisation of risk mitigation starting from the highest ranks [2]. The purpose of any risk assessment tool/technique is to confirm that the decision-making process is strong, depending on the best knowledge of stakeholders [3,4]. A likelihood/severity matrix manages risks through a matrix approach, which includes identifying the type of damage and the probability of occurrence for each risk. By plotting these values on a matrix, stakeholders and top management can gain a visual representation of the risks, prioritise resource allocation for RM, disclose information about external risks and distribute responsibilities amongst managers [5]. This technique ensures transparency in the analysis process and allows for adaptation to evolving threats, vulnerabilities and assets in the digital economy [6]. This paper delves into the utilisation of the likelihood/severity matrix approach to enhance RM in the electrical and electronic sectors. It introduces a model that classifies risks based on their likelihood and severity, aiding decision makers in prioritising and managing critical risks. In addition, the article delves into the fundamental concepts of risk, engineering RM (ERM), a range of risk assessment tools and techniques and a comprehensive risk assessment model. Ultimately, this model empowers risk managers to make well-informed decisions by targeting high-impact risks for effective risk reduction.

2. Literature Review

2.1. Concept of Risk

The terms likelihood, risk and uncertainty are typically associated with anticipating future events or unknown severities of past events. The main aim of these forecasts is to assist in the decision-making process [7]. Uncertainty refers to the absence of specific knowledge that is deemed essential for making informed decisions [8]. This interconnection between uncertainty and risk is fundamental in the realm of RM. RM emerges as a crucial method for businesses to navigate uncertainties and ensure their survival while striving to achieve their objectives. Risk itself can be defined as the amalgamation of the likelihood and severity of an undesirable event, forming the core of RM science. [9]. A risk has three components: the event, the likelihood of the event and the severity of the event. The two types of severity from uncertain states are risks and opportunities [10,11]. RM strives to understand and control risks that may disturb a project while increasing the chances of positive outcomes [12]. After defining the notion of risk, the combination of risk likelihood and risk severity is called risk score [13,14].

Risk score = (Likelihood) × (Severity) …(1)

Likelihood refers to how often an event occurs and is measured in terms of the number of events per time unit given in percentage. It is described by a discrete distribution. Severity depends on the significance of the occurrences of the events, and it is described by a continuous distribution (e.g. normal distribution, gamma distribution, exponential distribution, and beta distribution) [15].

2.2. ERM

RM is the skill and knowledge of finding, analysing and reporting on risks throughout the life of a project and in the finest awareness of meeting project goals (Schwalbe, 2015). ERM includes the comprehensive management of an engineering system, which is varied and continuous, with the target of guaranteeing the functionality and reliability of the system. As the engineering system will possibly be at risk due to operational and technical factors, an application of the ERM process can decrease the occurrences of such risks [9]. Figure 1 shows the RM processes as defined below (Rose & Hillson, 2004). These processes are applied in an endless cycle of continuously discovering and removing risks.

Fig. 1. RM Processes [16].

2.3. Risk Assessment Tools and Techniques

About 30 risk assessment tools and techniques can be classified in various ways to define and assess risks [17]. Risk assessment approaches help spot and define all risks in the hope of making a clear decision on how to use resources strategically and gainfully to observe and decrease the likelihood and severity of the supposedly undesirable events [18]. Risk assessment methods can be classified into quantitative and qualitative approaches. The quantitative risk assessment approach is a way of quantifying the likelihood and the severity of risks in a project through numerical estimates of its cost and time objectives. Conversely, the qualitative risk assessment approach is the identification, assessment and reduction of prioritised lists of risks on the basis of the insight of the likelihood and severity by stakeholders [19,18]. Table 1 shows the most common risk assessment tools and techniques applied by various references that have been classified into quantitative and qualitative approaches.

Table 1
Risk assessment tools and techniques.

Ref.	Tools/Techniques										Methodology	Classification			Result and Conclusion
	Checklists	Structured Interview and Brainstorming	Root Cause Analysis (Single Loss Analysis)	Delphi Technique	Fault Tree Analysis	Cause-and-Effect Analysis	Failure Mode and Effect Analysis	Risk Register	SWOT Analysis	Monte Carlo Simulation		Qualitative	Quantitative	Semi-quantitative	
[39]									√		A fuzzy analytic hierarchy route examines the stages of the product lifecycle.	√			A new methodology for risk scoring of the production stages of wind turbines
[33]						√					The causes and effects of accidents are analysed using FCM, which depends on three targets and effects of risk factors.		√		Roof falls, gas poisoning and debris with destruction impose high risks on the system. On the contrary, the lowest risk amongst all accidents are collisions and crashes.
[25]			√								Root cause analysis (single loss analysis)		√		The root cause of a reoccurring problem is identified and eliminated depending on previously unknown social and administrative causes.
[24]				√							The initial version of the checklist, composed of 29 items in 9 units, was analysed and assessed by 13 experts.	√			The application of the specification will permit the effective risk valuation of the hygienic and sanitary observations and conditions in food trucks.
[24]		√									Audit firms are required by SAS-altered types to use brainstorming sessions for evaluating risk factors.	√			Information retrieval offered by interactive decision provision and the risk in an audit brainstorming session
[26]			√								Analysis: problem's frequency, notice's time and different error characteristics (cataloguing of the item, where the fault happened, times that occur during the day and week and result)		√		Quality improvement activities have been briefed: structural changes, changes to policies and practices, changes in individual responsibilities and improving workplace culture to counteract underreporting of errors
[34]						√					A method of performing detection actions for a problem and corrective activities for negative effects		√		Presented a literature review about the various methods and applications of FMEA that have been developed until 2018
[31]					√						Focused on how assessors can handle uncertainty based on available evidence		√		Review of previous works, focusing on uncertainty handling in fault tree analysis (FTA) depending on risk assessment
[42]									√		Practised questionnaire survey with the AHP used to the impact and probability scores of risks, and the sensitivity analysis of volatile risk events		√		Developed risk assessment framework applied to a real mining project to demonstrate its application in the mining industry
[29]					√						Analysed the occurrence of top events even in the absence of historic probability data using the FFTA framework		√		Expected helpful results to safety specialists while making decisions related to RM of oil and gas pipeline
[32]						√					Analysed the cause and effect to systematically describe sources of variability with four key in vitro nanobioassays		√		Used four approaches to support the development of a wide variety of nanobioassays
[19]	√										Analysis of modern safety extortions in wireless sensor networks, vehicular ad hoc networks and Internet of Things/industrial Internet of Things	√			Routinely, clearly and sensibly assess the cyber risk for different object sorts in the dynamic digital infrastructures using artificial neural network
[20]	√										Comparison of the agricultural upper-limb assessment, which was developed with existing assessment tools (Ovako working posture investigation system and rapid entire body assessment)	√			Evaluated the danger of various upper-limb carriages using AULA
[27]				√							Three rounds of survey Delphi, one open round and two recording rounds	√			The system summarised 36 items in 6 factors: behaviour factors, general characteristics, physical function, history and environmental factors.

[17]											Simulated the PPV by utilising gene expression programming (GEP) and Monte Carlo simulation techniques				A PPV predictive model was developed using GEP
[18]	√										Comparison of pairwise and survey to create risk scores for different construction accidents	√			The average of safety project performance was at 2.33-sigma 6, which suggests that 228,739 accidents may happen in every million chances
[23]		√									OHSE risk assessment index system utilised the Delphi technique, trapezoidal fuzzy number (TPFN) and set-valued statistics (SVS)	√			Found the difficulties in OHSE RM and applied the corresponding OHSE risk treatments
[37]									√		Reviewed SWOT studies historically, in addition to the analysis of different segments and altered approaches by SWOT	√			Filled the gap in knowledge in the strategic planning context and indicated meaningful implications for managers to help recover strategic decisions
[22]		√									A simple tool for listing risks that need to be considered	√			
[36]								√			A documentation tool presented in a table that identifies possible risks with their probabilities of occurrences and effects	√			Presented different methods to mitigate and reverse the properties of historical and ongoing pressures through restoration measures
[3]								√			Studied the practical costs for daily practice in the guideline-making process and financial features in addition to risk reduction by professionals	√	√	√	The risk matrix method is a helpful tool for assessing impact and probability when determining preventive and investigative interventions.
[35]							√				New integrated fuzzy EVM and fuzzy FMEA approaches that combine fuzzy risk severity (FRS), fuzzy risk priority score (FRPS) and risk rankings		√		Conducted risk investigation through combined fuzzy predictable value technique and proposed risk mitigation measures for critical activities
[40]										√	Monte Carlo simulation		√		The nitrate concentration was relatively high and focused on agriculture and management.

3. Model of Risk Assessments

The model was designed after a wide literature review and consideration by the researchers depending on their experiences. The model, shown in Figure 2, consists of three phases: definition, analysis and review of risks.

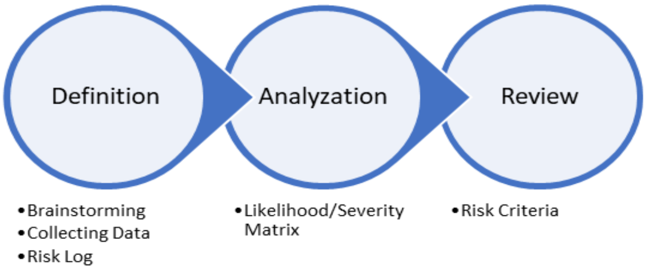

Fig. 2. Risk Assessment Model.

Initially, brainstorming sessions were conducted to estimate the likelihood and severity of the risks to the tasks of a specific project. Risk log is a relatively simple tool that was used in this model to contain and record the needed data for each risk, such as likelihood, severity and score of the risks, together with their calculations. Then, the likelihood/severity matrix was applied based on the already cited concept of risk as a function of its likelihood and severity of occurrence. The four principles to create a likelihood/severity matrix are as follows [20, 21]:

1) Describe the sorts and scales of likelihood and severity levels;
2) Describe the sorts and scales of the output risk index;
3) Create a risk score based on the following formula:

Risk Score = Likelihood Rank × (Severity Group Rank 1 + Severity Group Rank); …(2)

4) Build a depiction graphic of the likelihood/severity matrix.

4. Results and Discussion

The proposed model was applied in an assembly plant of personal computers (PCs) belonging to the electrical and electronic sector in Baghdad, Iraq. The company follows a customised production with a production capacity of 400 PCs/year. The tree diagram of PC components is shown in Figure 3.

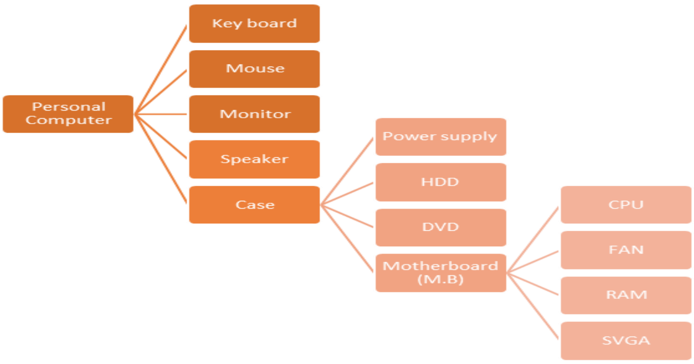

Fig. 3. Tree Diagram of PC Components.

The assembly line consisted of 10 main processes, performed in sequential order as follows: fixing the motherboard (M.B.) and the power supply unit in the case; attaching the fan to the CPU and securing it to the M.B.; fixing the DVD and HDD in the case with screws; inserting SVGA card and RAM on the M.B.; inserting the cover of the case and fixing it with screws; making all necessary cable connections; formatting and installing the Windows system along with the necessary program ID; running the installed system; conducting a quality control test; and packing. As detailed in Table 2, it outlines the ten processes of the assembly PC line, the allocated risks for each process and the likelihood of occurrence percentage.

Table 2
Risk Log.

Process	**Risk**	**Likelihood (%)**
Fix the M.B. and the power supply unit in the case	Shocking the components from static electricity discharge	40
Attach the fan on the CPU and fix it to the M.B.	Not aligning the pins correctly with the socket	45
	Bending the pins while installing the CPU onto the M.B.	60
	Incorrectly installing the CPU and the fan	50
	Initialisation failure due to carelessly handling the CPU	30
Fix the DVD and HDD in the case with screws	Strain, torsion and unneeded pin/pad contact due to over-tightening of screws	35
Insert SVGA card and RAM on the M.B.	Wrongly touching the contacts or interconnects will cause an initialisation failure	40
Insert the cover of the case and fix it with screws	Case bending	10
Cable connections	Error in electrical contacts	25
	Cutting in the wires due to its proximity to the fan	30
	Stopping the fan from working due to wrapping the wire around it	30
Format and install the Windows system and necessary program ID	Wrong selection of Windows system	10
Run the installed system	-	
Quality control test	-	
Packing	-	
	General risk: Breaking parts during assembly	45
	General risk: Using the wrong compatible parts	30

Table 3 presents the data collected through direct observation, documented data and participation in the assembly process. This process was followed by consistent meetings with engineers and line workers, who were considered decision makers, to gain insight into their work environment.

Table 3
Likelihood Occurrence Percentages [22].

Interpretation	Likelihood Range	Likelihood Rank
Very unlikely to happen	0%–10%	1
Unlikely to happen	11%–40%	2
May happen about half of the time	41%–60%	3
Likely to happen	61%–90%	4
Very likely to happen	9%–100%	5

In this paper, the potential risk influence was divided into two groups: likelihood and severity. The likelihood of each risk was specified based on the likelihood scale in Table 3 [22] as the first step of building the risk log. For example, the ‘Wrong selection of Windows system’ risk was conceivable, and possible to occur but never occurred before, and for that 10% was given as a likelihood of occurrence.

In the risk likelihood/severity screening, a 5 × 5-scale dimension is used for the likelihood and severity assignments, comprising five levels (1 =negligible, 2 = low, 3 = medium, 4 = high and 5 = extreme). The interpretation of the 5 × 5 risk likelihood/severity matrix for risk assessment is shown in Figure 4 [23].

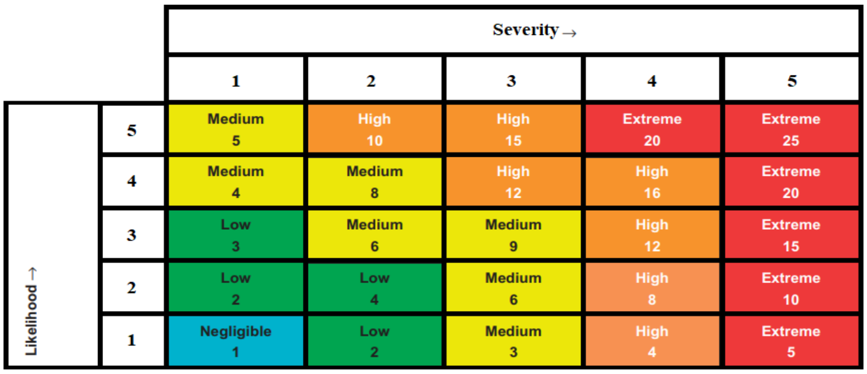

Fig. 4. Likelihood/Severity Matrix [23].

The likelihoods of the identified risks were ranked according to the likelihood ranking scale indicated in Table 3. The ranked likelihoods were added in Table 5 in the ‘Likelihood Rank’ column.

The subsequent step involved ranking the severity of the identified risks based on their potential effects on different groups, as outlined in Table 4. Each company may have its criteria for evaluating risks, and in this study, the data in Table 4 were tailored to the specific company under investigation. The groups identified were categorised into three main areas: employee protection, economic considerations and maintaining a marketable image. A five-point scale was utilised for each group to assess risk severity. Some risks were classified under multiple groups depending on their severity levels, as detailed in Table 5. The risk score for each identified risk was computed using Equation 2, where the two most severe rank groups were designated as Severity Groups 1 and 2, and the corresponding risk scores were incorporated into Table 5.

Table 4,
Severity Ranking.

Risk Severity Group	Severity Description	Severity Rank
Employees' protection	Hardly hurt.	1
	Hurts can be dealt with privately.	2
	Hurts that require medical treatment.	3
	Serious hurts requiring hospital handling.	4
	Several serious hurts.	5
Economic	<0.02% of budget.	1
	<0.05% of the yearly budget.	2
	0.05%–5% of the yearly budget.	3
	>5% of the yearly budget.	4
	>20% of the yearly budget.	5
Marketable image	One local business is affected.	1
	Some local businesses in the state are affected.	2
	Some local businesses in various states are affected.	3
	Local businesses across the country are affected.	4
	International businesses are affected.	5

Table 5,
Risk Score Calculations.

Risk	Probability Rank (1–5)	Severity Rank (1–5)			Risk Score
		Employees' protection	Economic	Marketable Image	
Shocking the components from static electricity discharge	2	4	1	-	10
Not aligning the pins correctly with the socket	3	-	1	1	6
Bending the pins while installing the CPU onto the M.B.	3	-	1	2	9
Incorrectly installed the CPU and the fan	3	-	1	2	9
Initialisation failure due to carelessly handling the CPU	2	-	1	3	8
Strain, torsion and unneeded pin/pad contact due to overtightening of screws	2	-	1	1	4
Wrongly touching the contacts or interconnects will cause an initialisation failure	2	-	1	2	6
Case bending	1	-	1	1	2
Error in electrical contacts	2	1	1	2	6
Cutting in the wires due to its proximity to the fan	2	-	1	2	6
Stopping the fan from working due to wrapping the wire around it	2	-	1	2	6
Wrong selection of Windows system	1	-	-	1	1
Breaking parts during assembly	3	3	2	2	15
Using the wrong compatible parts	2	-	2	3	10

Table 5 displays the outcomes of risk likelihood rank, risk severity rank and risk score for the identified risks. For the review phase of the developed model, the risk scores were positioned in the equivalent cells within the likelihood/severity matrix (Figure 4) to find each risk criterion and control the most serious risks that require further attention and supervision. Risk criteria are 'criteria for assessing the significance of risks' and are 'based on the organisation's objectives and external and internal circumstances'. They 'can be derived from standards, legislation, policy and other requirements' (ISO Guide 73) [24]. The risk criteria and their definition of detection/control that belong to this case are shown in Figure 5. The results from the likelihood/severity matrix were listed in descending order according to their risk score ranks, as shown in Table 6.

Risk Score Level	Detection/control
Negligible	The project team was unable to identify risk response strategies that can detect risk events, control the root causes, and control the consequences of risk events.
Low	The project team identified risk response strategies that are unlikely to detect the risk event, control the root causes, and control the consequences of the risk event.
Medium	The project team identified a medium-likelihood risk response strategy that detects the risk event, controls the root cause, and controls the consequences of the risk event.
High	The project team has identified risk response strategies that are likely to detect the risk event, control the root causes, and control the consequences of the risk event.
Extreme	The project team identified risk response strategies that have historically proven to be highly effective in detecting risk events, controlling root causes, and controlling the consequences of risk events.

Fig. 5. Risk Criteria and Their Definition of Detection/Control.

Table 6
Detected Risk Score and Criteria Colour.

Risk	**Risk Score**	**Risks Criteria Colour**
Breaking parts during assembly	15	
Shocking the components from static electricity discharge	10	
Using the wrong compatible parts	10	
Bending the pins while installing the CPU onto the M.B.	9	
Incorrectly installed the CPU and the fan	9	
Initialisation failure due to carelessly handling the CPU	8	
Wrongly touching the contacts or interconnects will cause an initialisation failure	6	
Error in electrical contacts	6	
Cutting in the wires due to its proximity to the fan	6	
Stopping the fan from working due to wrapping the wire around it	6	
Not aligning the pins correctly with the socket	6	
Strain, torsion and unneeded pin/pad contact due to over-tightening screws	4	
Case bending	2	
Wrong selection of Windows system	1	

Table 6 shows that the 'Breaking parts during assembly', 'Shocking the components from static electricity discharge' and 'Using wrong compatible parts' risks had the highest risk score (i.e. 1015), which were all located in the red region. These risks were followed by eight other risks located in the yellow region with less value of risk score (i.e. 6–9). Risks in the red region required a risk response strategy to control the root causes and severity of these risks. The risks located in the yellow region had a moderate chance of detecting the risk event. Controlling the root causes and controlling the severity of the risk event were required. Two risks were located in the green region, indicating a low chance of detecting the risk event and minimal to no impression. For the risk located in the blue region, its likelihood and severity could be considered little to no effect where no explicit action is required. However, a constant evaluation would be essential for the risks that occur repeatedly or show increasing severity.

5. Conclusion

The conclusion of the article emphasises the significant findings that align with the study's objectives. The proposed risk assessment model was successfully applied in the electrical and electronic sector, specifically in a PC assembly line. Through this application, critical risks were identified and ranked based on their likelihood and severity.

The study revealed that risks such as 'Breaking parts during assembly', 'Shocking the components from static electricity discharge' and 'Using wrong compatible parts' emerged as the most critical, with the highest risk scores ranging from 10 to 15. These findings underscored the urgency and severity of these risks, highlighting the need for immediate mitigation strategies.

Overall, the investigation demonstrated the effectiveness of the likelihood/severity matrix approach in categorising and prioritising risks in the industry. By focusing on these critical risks, decision makers can allocate resources efficiently and implement targeted solutions to reduce the negative effect on operations.

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تعزيز إدارة المخاطر: الاستفادة من مصفوفة الاحتمالية/التأثير لتقييم المخاطر والتخفيف منها في قطاع الكهرباء والإلكترونيات

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المستخلص

تقدم هذه الورقة المفهوم الأساسي للمخاطر وتستعرض الأدوات والتقنيات المطبقة بشكل شائع لتقييم المخاطر. بشكل عام، يعتبر تقييم المخاطر عملية صنع قرار تجريبية تماماً، مستندة إلى خبرة ومعرفة أصحاب القرار. تؤكد هذه الورقة على تقنية كمية/نوعية واحدة وهي نهج مصفوفة الاحتمالية/التأثير. الهدف الرئيسي من مصفوفة الاحتمالية/التأثير هو توجيه انتباه المنظمة نحو المخاطر التي لها أكبر إمكانية للتأثير السلبي. تكمن المساهمة الرئيسية لهذه الورقة في تقديم نموذج مقترح يستخدم نهج مصفوفة الاحتمالية/التأثير لتصنيف المخاطر إلى "مناطق" وترتيبها لاحقًا. يدعم هذا الإجراء مدراء ادارة المخاطر في اتخاذ قرارات مستنيرة للحد من المخاطر بفعالية. تم فحص مصفوفة الاحتمالية/التأثير من خلال دراسة حالة تنتمي إلى قطاع الكهرباء والإلكترونيات لتحديد المخاطر الحرجة التي أعاقت خط تجميع أجهزة الكمبيوتر الشخصية (PC) . أظهرت النتائج أن "كسر الأجزاء أثناء التجميع" و "صدمة المكونات من تفريغ الكهرباء الساكنة" و "استخدام أجزاء متوافقة خاطئة" كانت أكثر المخاطر حرجة بدرجة خطورة تتراوح من "10 إلى 15". أثرت هذه النتائج على متخذي القرار لتطوير إجراءات للتخفيف من هذه المخاطر البارزة.