

ELECTRONIC PERFORMANCE MONITORING AT THE WORKPLACE: A SURVEY TO DIAGNOSE ENGINEER'S AWARENESS

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Abstract

The electronic performance monitoring (EPM) of human resources using new technologies increases current control methods while introducing ethics and moral concerns. In chasing EPM deployments, a survey was conducted to diagnose the perception of workers and students. The engineers were elected as core participants in EPM due to their knowledge of both the technology and the field of application. Surprisingly, 69% of the 261 respondents were unaware of the topic. Results indicate a 56% acceptance level (95% confidence level and 6.3% error). The research points out the most accepted and rejected aspects of EPM, illustrating scenarios and alternatives for implementation.

Introduction

The industry has been applying numerous innovations in electronic devices and wearables to monitor workers' performance. Institutions seek to use electronic monitoring of human resources to increase their financial results (Alder, 2001). Electronic Performance Monitoring is about the use of hardware, software, and techniques to access and evaluate human resources job performance (Alder & Tompkins, 1997; Lund, 1992; Oz et al., 1999; Panina & Aiello, 2005). The great challenge to electronic monitoring is related to trust and security in sharing data between workers and employers (Calvetti et al., 2020; Calvetti, Mêda, et al., 2021; European Commission. Directorate General for Research and Innovation., 2021; Kelly, 2018; *Use of Wearables in the Workplace Is Halted by Lack of Trust – PwC Research - Press Room*, n.d.). Perceiving the people's reaction to monitoring is a fundamental part of achieving success in implementing technological innovation projects (Bhave, 2013; Holland et al., 2015; Panina & Aiello, 2005; Stanton & Julian, 2002). Industrial sectors, such as construction, whose financial result is strongly linked to the physical performance of human resources, seek to improve their control tools in safety, health, productivity and quality of services (Calvetti et al., 2022; Calvetti, Gonçalves, et al., 2021). A worker away from work due to accidents or work-related illnesses has a negative impact on the performance of companies. Work activities with a great need for human physical effort and little repeatability have significant

variability in productivity rates and demand numerous processes to control the quality of services.

In addition to current control methods such as using computers (email, internet, etc.), access control by badges, and monitoring the use of equipment and machines. Electronic monitoring advances in analysing location, movements, gestures, and the physiological state of workers. Tracking the location of each worker in near real-time provides, in addition to the analysis of their productive occupation, the diagnosis of permanence in areas with safety hazards and routes with the risk of being run over by machinery and equipment (Bangaru, Wang, & Aghazadeh, 2020; Duan et al., 2022; Igwe et al., 2022; Jung & Chi, 2020; Ryu et al., 2020). The detailed assessment of workers' movements and gestures allows for a precise ergonomic analysis, which helps analyse occupational health, safety and productivity (Bangaru, Wang, Zhou, et al., 2020; Yang et al., 2019; Zhang et al., 2019). Collecting data regarding the workers' physical state (cerebral electrical activity, temperature, pressure, heart rate, etc.) makes it possible to assess the physiological state (tiredness, fatigue, stress, tension, etc.), which also allows for the assessment of performance in health, safety and productivity (Ahn et al., 2019; Choi et al., 2019; Costa et al., 2019; Jebelli et al., 2018; Wang et al., 2019).

However, current technological advances allow for a new and vast field of investigation regarding human resources performance. Nevertheless, legal paradigms and restrictions regarding electronic monitoring must be confronted. Realising workers' reactions to electronic monitoring is a crucial element in achieving successful technological innovations in the workplace (Ahn et al., 2019; Maurice et al., 2019; Ryu et al., 2019; Yan et al., 2018). Because of that, a survey was conducted to understand better peoples' reactions to electronic monitoring at work.

Survey sample

A total of 8914 people received the questionnaire, which 8478 - Students of the Faculty of Engineering of the University of Porto (FEUP), 16 - Professors of FEUP, and 420 - People from the authors' network (mainly from LinkedIn social network). A total of 261 people answered the questionnaire, which determined a response rate of 2.93%. Based on the population (8478) and sample (261), within a confidence level of

95% ($P = 0.5$), the accuracy of the responses reached an index of $\pm 6.3\%$ (Dupont et al., 2017).

The collected data were tabulated in MS Excel for analysis and graphical development. Furthermore, the IBM SPSS system was used for the univariate and multivariate statistical analysis. Finally, the results were discussed by comparing similar research conducted by the insurance company AIG (American International Group, Inc.) in nine countries with 400 employees and 250 entrepreneurs in the year 2016 (Mike Abbott, 2017).

Young Portuguese students gave the most significant number of answers from Engineering in Information Technology and Computers, Civil Engineering, Mechanics, Metallurgy and Materials Engineering. Concerning the education level, 67% of respondents are students, and 13% study and work; in effect, 80% of the sample is currently a student. It is worth noting that the vast majority of these, 58%, attend the integrated master's degree, followed by 16% to develop degrees, 15% for doctorates and 10% for master's degrees.

Regarding the field of activity (academic/professional), it was identified that most of the respondents are from technology and computing fields, with 43%, followed by 24% of civil engineering, mechanics, metallurgical, and materials.

As for gender, there was 64% of males, 35% of females, and 1% of respondents chose not to be identified by a specific gender. Moreover, as seen previously, the more representative public sampled are students who are predominantly young, with 34% between 16 and 21 years old and 33% between 22 and 25 years old. However, the sample represents the perception of future engineers who are going to enter the labour market in the coming years. Finally, 87% of the respondents live in Portugal, and 10% are Brazilian residents, among other countries with 3%.

Results and discussions

In order to conduct the respondents for real situations about the application of electronic performance monitoring at work, fourteen situational questions were applied. Moreover, two questions sat the respondents in the position of the employer and twelve as workers. Besides, interviewees' personal view-positioning was observed in two questions about believing that monitoring their own work is essential to improve performance and if the government should regulate EPM. Finally, to identify whether the respondents already had any knowledge about the EPM subject, one question was asked. The results of these seventeen questions are presented and discussed in the exact order developed in the survey.

Questions 1 and 3-8 were the types of yes/no answers with room for alternative/free opinions. Question 2 presents different options to agree/disagree as well as with room to write a distinguished option.

Question 1: Do you believe that monitoring the progress of activities developed during the workday is important for improving your performance?

Result: Yes 209 (80%), No 52 (20%). It is noticed that the great majority understand that monitoring is a relevant tool for the improvement of their own performance.

Question 2: By placing yourself in the position of EMPLOYER, you would want to use technological innovations to monitor. Alternatives: The safety of workers; The health of workers; The productivity of workers; The quality of services performed by workers; Other (field for text insertion).

Results: As shown in Figure 1, it is perceived that respondents would be more interested in monitoring order: Safety of workers 200 (77%); The productivity of workers 185 (71%); The quality of services performed by employees 182 (70%); Workers' health 155 (59%); Do not monitor 5 (2%). The values in safety, productivity, and quality are close, and health monitoring is significantly below, with still fewer responses contrary to any form of monitoring. Compared to the survey carried out by AIG (Mike Abbott, 2017), it is observed that the population responding has higher interest levels, as for security (77%) compared to (59% AIG), productivity (71%) versus (55% AIG), and health (59%) versus (55% AIG).

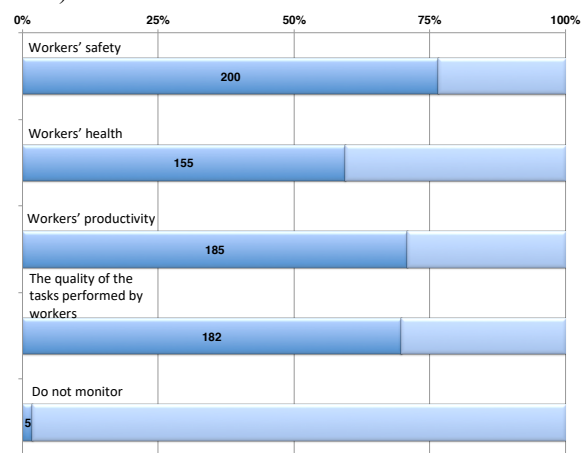


Figure 1: Subjects of interest to be monitored

Question 3: By placing yourself in the position of EMPLOYER, do you believe that in the case of applying the monitoring, you should share this data collected with the employees?

Result: No (this information must be exclusive to the company) 47 (18%), Yes (I must allow workers access to information) 214 (82%). It is noticed that in the vast majority, people understand it necessary to share the data collected with the workers. The study conducted by AIG (Mike Abbott, 2017), evaluated the intention to share data of employees and employers, where per country:

- Japan - employees (80%), employers (65%)

- United States of America - employees (75%), employers (65%)
- Australia - employees (74%), employers (65%)
- Singapore - employees (76%), employers (69%)
- United Kingdom - employees (74%), employers (68%)
- Italy - employees (87%), employers (85%)
- Germany - employees (70%), employers (70%)
- China - employees (93%), employers (97%)
- France - employees (66%), employers (76%)

There is an alignment of the sample surveyed regarding the sharing of data, mainly countries with higher indexes of intention to share, such as Japan and Italy.

Question 4: Do you believe that the GOVERNMENT should regulate electronic monitoring at work?

Result: Yes, 141 (54%), No 107 (41%), Depends on the level of monitoring 4 (2%), I have no opinion 4 (2%), Other responses 5 (2%). Compared with the results of AIG's survey (Mike Abbott, 2017), which indicated that 89% of employers and 87% of employees understand that there should be legal regulation of monitoring (Mike Abbott, 2017), the rate of only 54% seems low. Because the survey sample is predominantly of young students (still out of the job market), two hypotheses can be assumed for such a low value. Firstly, students still do not know/fear the possible persuasive use of EPM. Secondly, young people accept electronic monitoring more naturally than older generations (employees and employers).

Question 5: By placing yourself in the position of EMPLOYEE, would you allow the mapping of your location in real-time by the employer?

Result: Yes, 111 (43%), No 150 (57%). At this point in the survey, respondents are confronted with more frontal questions about electronic monitoring methods at work. Of effect, it can perceive some greater reactivity from the respondents regarding EPM, in this specific case of allowing the mapping location in real-time.

Question 6: By placing yourself in the position of EMPLOYEE, would you allow the mapping of your movements/motions (trunk, legs, arms, and hands) by the employer?

Result: Yes, 86 (33%), No 175 (67%). Within the same analysis performed previously, and specifically regarding the monitoring of the movements and gestures, the respondents' significant reactivity was identified. This sentiment is aligned, for example, with the journalistic material published on CNN Tech, regarding the controversial patent application by the Amazon company with the intention of monitoring the workers' arms motions (Kelly, 2018).

Question 7: By placing yourself in the position of EMPLOYEE, would you allow the mapping of your physical conditions (electrical activity of the brain,

temperature, pressure, heart rate, etc.) by the employer?

Result: Yes, 138 (53%), No 123 (47%). Given the two previous answers, the monitoring of physical conditions reached a higher rate of acceptance. One possible hypothesis is that the respondents connect the monitoring of physical conditions to health issues, and in the opposite, the two before productivity issues. However, it should be noted that monitoring these physiological aspects could undoubtedly be used to assess productivity.

Question 8: By placing yourself in the position of EMPLOYEE, would you feel safe sharing the data collected by wearable electronic devices with the employer?

Result: Yes, 143 (55%), No 118 (45%). It is identified that more than half of the respondents would trust their data to the employer. However, the survey carried out by AIG regarding the employees' intention to share the data indicates higher indexes of the order of 66% to 93% (Mike Abbott, 2017).

Questions 9, 10, and 11 requested a situational opinion, as employees, if they were prone to allow the monitoring to receive some rewards. Meanwhile, questions 12 and 13 try to perceive awareness about safety and health in the workplace. Smartphone data collection/analysis is a current issue. Questions 14 and 15 asked if they would share data from their own device and in case of that device was from the company. Question 16 puts respondents against the wall, asking if their job depends on the acceptance of EPM if they would allow it. Finally, in the last question, 17 asked if they knew, before that survey, about those EPM methods at the workplace.

Question 9: Regarding the monitoring by means of electronic devices and wearables, by placing yourself in the position of EMPLOYEE in these situations: "I would allow monitoring as long as I received financial compensation."

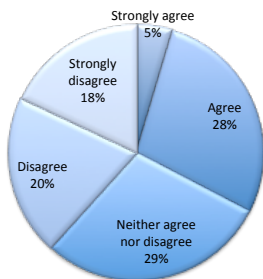
Question 10: Regarding the monitoring by means of electronic devices and wearables, by placing yourself in the position of EMPLOYEE in these situations: "I would allow monitoring as long as I received more days off as a benefit."

Question 11: Regarding the monitoring by means of electronic devices and wearables, by placing yourself in the position of EMPLOYEE in these situations: "I would allow monitoring as long as this would help my hierarchical progression in the company."

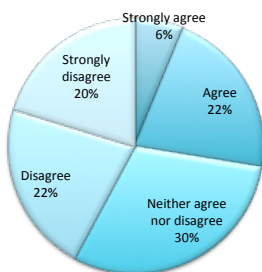
It is noticed that the respondents value more the professional career concerning other rewards such as financial benefits and days off. The hypothesis that can be inferred is that the young public of the sample aims to enter the job market and to have professional success, not yet realise the relevance of the financial benefits and times of rest; see Figure 2, where it is highlighted: 33% agree, or strongly agree to allow monitoring through financial compensation; 28% agree, or strongly agree to allow monitoring by

receiving more days off; 44% agree, or strongly agree to allow monitoring through a hierarchical progression in the company.

I would allow monitoring as long as I received financial compensation



I would allow monitoring as long as I received more days off as a benefit



I would allow monitoring as long as this would help my hierarchical progression in the company

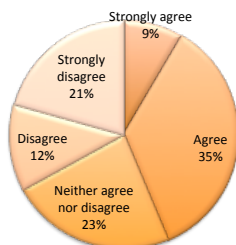


Figure 2: Situation of enabling monitoring in exchange for benefits

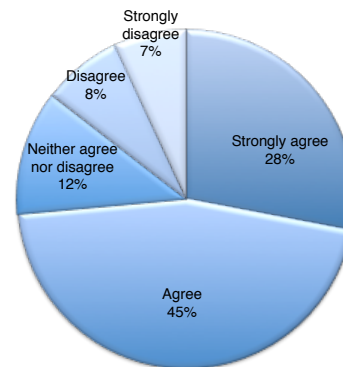
Question 12: Regarding the monitoring by means of electronic devices and wearables, by placing yourself in the position of EMPLOYEE in these situations: "I would allow monitoring only for my physical safety during the workday."

Question 13: Regarding the monitoring by means of electronic devices and wearables, by placing yourself in the position of EMPLOYEE in these situations: "I would allow monitoring only in the concern to improve my physical health during the workday."

Figure 3 presents the results. It can be identified that the respondents have great motivation to accept monitoring for their own safety and health, where 74% agree or strongly agree to allow monitoring in the pursuit of improving physical safety during the workday; 68% agree or strongly agree to allow

monitoring in the quest to improve physical health during the workday.

I would allow monitoring only for my physical safety during the work day



I would allow monitoring only in the concern to improve my physical health during the work day

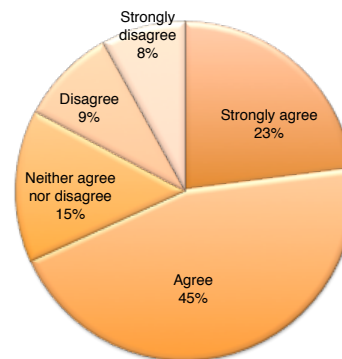


Figure 3: Situation of allowing monitoring for greater safety and health during the workday

Question 14: Regarding the monitoring by means of electronic devices and wearables, by placing yourself in the position of EMPLOYEE in these situations: "I would allow monitoring of data from my own smartphone."

Question 15: Regarding the monitoring by means of electronic devices and wearables, by placing yourself in the position of EMPLOYEE in these situations: "I would only allow monitoring data from a smartphone provided by the company."

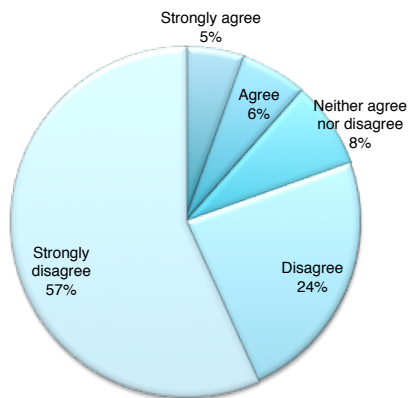
Figure 4 presents the results. It is noticed that the respondents strongly reject the idea of allowing the availability of data on their own smartphones. However, when the hypothesis of the smartphone was provided by the employer, there was a significant tendency of acceptance to share data, where it is highlighted that 11% agree or strongly agree to allow monitoring of data from the smartphone itself; 50% agree, or strongly agree to allow the monitoring of smartphone data provided by the company.

The study carried out by AIG (Mike Abbott, 2017) highlights the favourable position of employees in using a device provided by the employer, by country as forward presented:

- Germany (29%)
- Japan (36%)
- United States of America and Australia (38%)
- United Kingdom and France (40%)
- Italy, Singapore and China (56%)

The indices identified in this survey of 50% are above the position of several countries, being close to Italy, Singapore, and China (56%), countries with more favourable indexes.

I would allow monitoring of data from my own smartphone



I would only allow monitoring data from a smartphone provided by the company

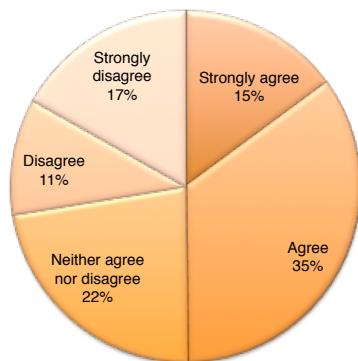


Figure 4: Situation of allowing monitoring for greater safety and health during the workday

Question 16: Regarding the monitoring by means of electronic devices and wearables, by placing yourself in the position of EMPLOYEE in these situations: "I would never allow monitoring, even if that would be a prerogative to get the job."

It should be noted that 55% disagree or strongly disagree with the proposed statement, which indicates that these respondents in the postulated case would accept the monitoring to access/guarantee a job vacancy. Only 14% responded by indicating that they would withdraw from the job if there were the prerogative of monitoring, where the result points out that: Strongly agree (7%); Agree (7%); Neither agree

nor disagree (31%); Disagree (28%); Strongly disagree (26%).

Question 17: Have you had contact or knowledge of the use of electronic monitoring systems in the workplace?

Surprisingly, a large part of the respondents (69%) only has known about the subject of electronic monitoring at work through this survey. In practice, only 7% had real-life experience with EPM, and 24% knew some piece of information from some news. Where the options presented were: No. "I did not know the matter." 180 (69%); Yes. "I've followed or participated in projects of this type." 19 (7%); Yes. "I had already obtained information on the subject (internet, videos, lectures, etc.)." 62 (24%)

An EPM level of acceptance is possible by quantifying the answers. The questions with answers of type "yes" or "no" were quantified on a binary scale, been by unfavourable added zero (0), and most favourable to the monitoring one (1), where: Question: 1; Yes (1), No (0); Question 3; No (1), Yes (0); Question 4; Yes (0), No (1), Depends on the level of monitoring (0), I have no opinion (0), Other answers (0); Questions 5-8; Yes (1), No (0).

As a criterion for the question of multiple choices (question 2), one value (1) was established for each selected item. Given a value of zero (0) to the indications of not monitoring. In this question, the values have variables from zero (not monitor) to four (selection of all items), where the safety of workers (1), Workers' health (1), The productivity of workers (1), The quality of services performed by workers (1); Do not monitor (0).

For situational questions with five alternatives (questions 9-15), according to the favourable or unfavourable sense of monitoring, the following values were assigned: Strongly agree (1); Agree (0,5); Neither agree nor disagree (0); Disagree (-0,5); Strongly disagree (-1).

Specifically for question 16, which has an otherwise sense of agreement, the values were: Strongly agree (-1); Agree (-0,5); Neither agree nor disagree (0); Disagree (0,5); Strongly disagree (1).

With this, based on the above-detailed quantification, the maximum attainable value (all favourable responses) is "19 values"; in counterpoint, the lowest possible value (all unfavourable responses) is "-8 values". Based on the responses and values, a value level was determined for each respondent, see Figure 5.

Proportionally, the total spectrum was divided into four quartiles. The first is with an index between 0-25% (Q0), the second between 25-50% (Q25), the third between 50-75% (Q50), and finally, the fourth quartile between 75-100% (Q75).

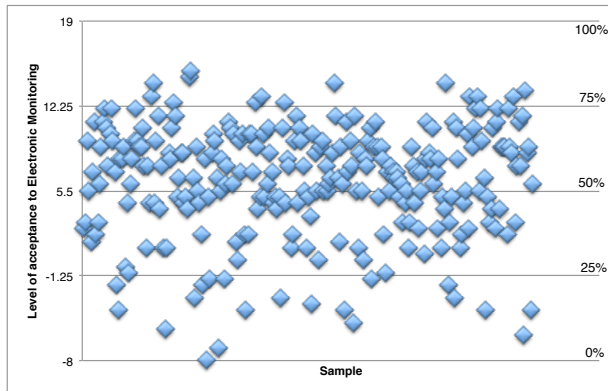


Figure 5: Acceptance level for electronic sample monitoring

It is observed that 60% of the sample (156 respondents) is in the Q50 (between 50-75%) of acceptance to the EPM. In the top quadrant, Q75, with an acceptable level greater than 75%, there are 14 respondents (5%). In this sense, it is highlighted a trend of sixty-five per cent favourable to EPM by these populations under analysis. Within Q25 (25-50%), there are 71 respondents (27%). Furthermore, at the lower end, positions totally contrary to EPM, only 20 respondents (8%) were found.

Employing the SPSS software, the values and histogram graph, see Figure 6, of the total sample were determined statistically. It is observed that the average (6.3180) and the median (7.0000) have approximate values. The kurtosis value (0.3630) is below 0.5, indicating the normality of the distribution. However, the marked asymmetry (-0.7500) and the mode value (9.0000) accept the values' distribution as expected. The value that most represents the population under analysis is the median (7.0000). Other values are Standard deviation (4.4411), Variance (19.7230), Minimum (-8,0000), and Maximum (15,0000).

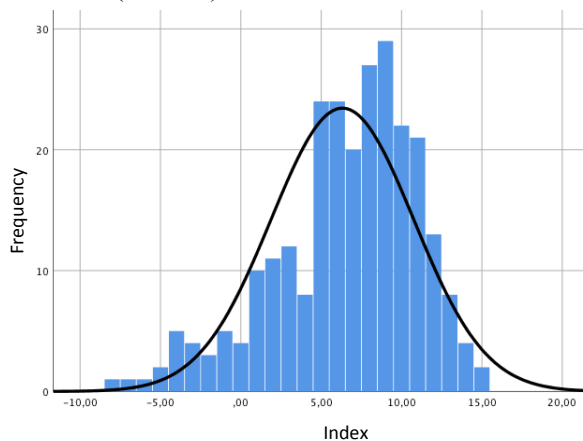


Figure 6: Samples' histogram distribution of the statistical analysis

With this, a level of 56% acceptance is determined for the electronic monitoring of the population under analysis. Within a 95% confidence level ($P = 0.5$), the

accuracy of the responses reached an index of $\pm 6.3\%$ (Dupont et al., 2017).

Accounting for the quartiles (Q0 - Q25 - Q50 - Q75) and the proportion of their population, Table 1, which indicates a higher or lower level of acceptance to EPM, it is possible to identify whether parameters for the sample characteristics (e.g., age, gender, etc.) can guide clusters of individuals. In this sense, multivariate statistical analysis was performed through SPSS-IBM to cluster the individuals. However, no characteristic of the sample was identified that was guiding the formation of groups of individuals, "more or less" favourable to the monitoring. The results and cross-analysis of sample characteristics and responses within the four quartiles (Q0 - Q25 - Q50 - Q75) are presented below. It should be noted that all values were determined to vary according to the statistical error of $\pm 6.3\%$; see exemplification in Table 1.

Table 1: Acceptance levels for electronic performance monitoring

Quartile	Total	%	Lower limit	Upper limit
Q0	20	8%	1%	14%
Q25	71	27%	21%	34%
Q50	156	60%	53%	66%
Q75	14	5%	-1%	12%
Total	261			

Conclusions

The applied survey allowed a very detailed view of a population predominantly of engineers (students and workers) regarding EPM at work. Surprisingly 69% of the respondents first knew about EPM through the survey. The population under analysis is more predisposed to accept monitoring to increase safety and evaluate health. Also, reward systems (financial, days off, and hierarchical advancement) are detected as factors that may facilitate acceptance of EPM. Raising people's awareness that monitoring makes it possible to improve performance can be a facilitating method for implementing EPM at work. However, the EPM projects' success needs to guarantee data sharing security and provide devices for the workers.

An expressive level of 56% EPM acceptance was determined. Within a 95% confidence level ($P=0.5$), the accuracy of the responses reached an index of $\pm 6.3\%$, thus delimiting the determined level in the range of 49.7% to 62.3%. It is observed that 60% of the sample (156 respondents) is in Q50 (between 50% and 75%) from reception to monitoring. And that still is in the maximum quadrant, Q75, with an acceptance

level greater than 75%, 14 respondents (5%). In this sense, there is a tendency (65%) in favour of electronic monitoring by the population under analysis. By how much, at lower levels, within Q25 (25% to 50%), there are 71 respondents (27%). And, with a completely opposite position (a level below 25%) to electronic monitoring, only 20 respondents (8%) were monitored.

Most respondents, 180 (69%), had, for the first time, knowledge about electronic monitoring at work through the survey in question. The population under analysis is more predisposed to accept monitoring when it aims to increase safety and assess health. Also, benefit systems (financial and days off) and opportunities for hierarchical advancement in companies are factors that facilitate the monitoring of electronic monitoring.

Raising people's awareness that monitoring enables performance improvement can be a facilitating method for including electronic monitoring at work. However, it is accompanied by the success of implementing transparent information monitoring and investment in processes that transmit security to workers regarding data sharing.

Acknowledgments

This work was financially supported by: Base Funding - UIDB/04708/2020 with DOI 10.54499/UIDB/04708/2020 (<https://doi.org/10.54499/UIDB/04708/2020>) of the CONSTRUCT - Instituto de I&D em Estruturas e Construções - funded by national funds through the FCT/MCTES (PIDDAC).

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