Software Development Models for Computer Based Workplace Attendance Management System

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Abstract

This paper establishes that: a formally instituted and consistently applied attendance management system significantly reduces absence levels. It further establishes that: the effectiveness of an attendance management system depends largely on the monitoring, recording, measuring, and reporting of attendance statistics. The paper then affirms that: computer based technologies will be suitable for implementing such systems, since they possess the capacity for effectively performing the listed tasks, as well as producing information for making prompt, informed, and consistent decisions across organisational units. However, the paper discovers that generalizable standards for building these systems are lacking in the literature, due to the obscuring of the internal logic of the existing systems, which are also strategically organisation-centric. The paper therefore, emphasises the need to shift from organisation-centric to process-centric (inter-organisational) approaches. Consequently, it introduces a set of systematic drivers (algorithms, flowcharts, structure chart, and mathematical models), for building new systems, rather than discussing the features of a black-box oriented system that may not have complied adequately with the software engineering best practices. This paper is thus, providing opportunities for broader scientific evaluations, development of sound evidence-based guidelines, and rational framework for on-going modification and refinement in the future. It will therefore, lead to the implementation of

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systems that serve as benchmarks for producing data, which is valid, reliable, subject to scrutiny, modifiable, and generalizable to the needs of the global stakeholders.

1 Introduction

The results of the study in [1] indicate that, a formally instituted and consistently applied attendance management policy significantly reduces absence levels. This position is supported by [2], who confirms that absence rate increased sharply when a policy requiring uniform standards across an organisation, was replaced with the one that allowed supervisors to use their discretions.

However, [3] posits that the effectiveness of an attendance policy, regardless of its form and content, depends largely on accurate and detailed monitoring, recording and quantitative measuring of absence statistics. The author further indicates that, managing attendance should be carried out within a clearly defined policy, which sets out the roles and responsibilities of the employers, employees, as well as the procedures to be adhered to. In agreement with the above positions, [4] identifies the use of computer based data mining technologies as an effective means of aggregating, analysing, and reporting of attendance behavioural records.

The above prescriptions motivate the objective of this paper, which is to introduce a set of systematic drivers for the development of computer based attendance management systems, so as to: (i) create opportunities for wider scientific evaluations, (ii) assist in the development of sound evidence-based guidelines, and (iii) create a more rational framework for on-going modification and refinement in the future. The paper will therefore, lead to the implementation of systems that serve as benchmarks, by producing data, which are valid, reliable and generalizable to the wider population.

The inspiration for this study derives from [3], who indicates that:

> *There is little evidence that organisations are currently carrying out or publishing systematic evaluations of their attendance management policies, which would be of use to other organisations. Where agencies have carried out surveys of current practice, these are methodologically weak and consequently provide only limited information. The importance is emphasisedof developing a system, which is: (i) based on the identified needs of the organisation and (ii) congruent with that of other organisations with whose data the data might need to be compared.*

The literature, in affirming the above position, reveals the existence of thousands of black-box oriented attendance management systems, whose internal logic cannot be inspected. Majority of the documentations, as found in [5], [6], [7], [8], and [9] are opinions or comments directed at the determinants of absence, and interventions attempting to address those determinants, but few possess any scientific strategy. This paucity of strategic evidence is largely responsible for the concern raised in [10] relating to the existence of much ambiguity in meanings and uses of absence management mechanism-based thinking in the literature.

The current widespread uses of black-box approaches in the implementation of attendance management systems therefore, raise some concerns. However, the major concern emanates from

the fact that, black-box oriented systems obscure their internal logic from being tested, so as to determine the level of compliance with software engineering best practices [11]. This makes it difficult for independent experts to explain how and why such programs work (or fail to work) in different contexts and for different stakeholders [12]. Consequently, such programs could be implemented and operated with undetected faulty logic, which increases the cost of maintaining the system [13].

This paper therefore, makes its contributions towards ameliorating these challenges, by way of providing open-source strategic evidence for the development of computer based workplace attendance management systems. To achieve the set objectives, the paper: (i) provides a systematic analysis of an operational workplace attendance policy, (ii) identifies and resolves any knowledge gaps on the feasibility of software implementations, (iii) formulates software development tools (algorithms, flowcharts, and structure chart), describing the procedures to be adhered to, and (iv) creates mathematical models for generating the rate of attendance and punctuality statistics.

2 Materials and Methods

Bevan in [8] advocates the use of three approaches in managing attendance, including: (i) policy, (ii) Preventive actions, and (iii) Rewarding attendance

This paper utilises the instrumentality of (i) and (iii), while insisting that the implementation of these two aspects will greatly achieve the intentions for (ii). The policy aspect is presented in this section, while that of reward is presented in section 4.

The tool to be analysed is the operational workplace attendance policy, contained in the Public Service Rules of the Federal Republic of Nigeria Official Gazette, No. 57, Vol. 96 of 25th August, 2009 [14]. The document states in its preamble that, the "Public Service Rules shall be reviewed every five years to update its provisions". Consequently, as at the time of writing this paper, it is the subsisting policy document guiding employees' behaviours and outcomes in the Nigerian Public Service.

We will endeavour to retain the words used in the policy to avoid misinterpretations in the formulations that follow. We have also presented the statements in a sequence that will portray a vivid picture of the intentions of the policy formulators.

Each rule has been given a number containing six digits. The first two of the digits represent the Chapter; the next two, the Section; and the last two, the Rule Number. For example, 010503 implies: Chapter 01; Section 05; and Rule 03. We use this numbering system in representing the relevant rules as presented in the remaining part of this section, as follows:

010101 These Public Service Rules apply to all employees except where they conflict with specific terms approved by the Federal Government and written into the contract of employment or letters of appointment.

160103 Ministries, Agencies, and Departments are to retain and improve existing rules, procedures and practices in their establishments and ensure that there are no deviations from the

general principles contained in the Public Service Rules. However in the absence of internal rules and regulations on any matter, the relevant provisions of the Public Service Rules shall apply.

100101 Leave is the authorised absence of an employee from duty for a specific period of time.

030402(e) Absence from duty without leave is an act of serious misconduct.

030401 Serious misconduct is defined as a specific act of very serious wrongdoing and improper behaviour which is inimical to the image of the service and which can be investigated and if proven, may lead to dismissal.

030413 Any employee who absents himself/herself from duty without leave renders himself/herself liable to be dismissed from the service and the onus shall rest on him/her, to show that the circumstances do not justify the imposition of the full penalty.

070301 If an employee is ill and unable to report for duty, he/she shall notify his/her Ministry/Agency in writing or by any other means of communication. Any prolonged absence from duty on ground of illness should be supported with any of the following documents:

  (a) Excuse Duty Certificate;
  (b) Light Duty Certificate;
  (c) Medical Certificate of Treatment duly authorised by the

The period of excuse or light duty entered on the first certificate issued shall not exceed three days unless the Healthcare Provider has examined the patient, in which case the period may be for up to seven days. Each period of extension, thereto, shall not exceed seven days and not more than a total of forty-two calendar days sick leave may be allowed on such extension. If the employee is still not fit for duty after forty-three calendar days sick leave, he/she shall be examined by a Medical Board. This shall also apply to an employee admitted to a Specialist Hospital on the recommendation of a Healthcare Provider.

070316 (i) The maximum aggregate sick leave which can be allowed an employee, who is not hospitalised, during any period of twelve months shall be forty-two (42) calendar days. Where such an employee has been absent from duty on the ground of ill-health for an aggregate period in excess of forty-two (42) calendar days within twelve calendar months, the employee should be made to appear before a Medical Board with a view to ascertain whether he/she should be invalidated from service.

070318 Sick leave for a period up to three months in the first instance may be allowed on the certificate of an approved HealthCare Provider to an employee who is hospitalised. If at the end of that period the employee is still hospitalised, his Permanent Secretary/Head of Extra-Ministerial Office must make an arrangement for him to be examined by a Medical Board with a view to ascertaining whether he should be invalidated from the service or allowed further paid sick leave.

100203 Annual Leave shall be granted to an employee in accordance with his grade level as shown. This is presented as part of Table 1.

100214 Casual Leave is the absence of an employee from duty for a short period not exceeding an aggregate of 5 working days within a leave year as may be authorised by a superior employee.

The casual leave shall only be granted after an employee has exhausted his/her annual leave. Casual leave is deductible in advance or arrears of earned leave.

100215 A maximum of seven days casual leave shall be granted in any leave year. Casual leave in excess of seven days in any leave year may be granted only by the Permanent Secretary/Head of Extra-Ministerial Office.

100218 A female staff that is pregnant is entitled to 16 weeks maternity leave at a stretch beginning not less than 4 weeks from the expected date of delivery with full pay. A medical certificate showing the expected date of confinement must be presented not less than two months before that date. The annual leave for that year will, however, be regarded as part of the maternity leave. Where this annual leave has already been enjoyed before the grant of maternity leave, the part of the maternity leave equivalent to the annual leave will be without pay.

100221 An employee may be allowed Examination leave with full pay to take an examination, the passing of which is not a condition of his/her current appointment.

100222 Sabbatical leave is the absence of an employee on GL. 15 or equivalent and above from duty, for the purpose of research either within or outside Nigeria. The Employee on sabbatical leave shall be qualified to undertake properly organised study in areas relevant to the interest of the service or national development for a period of twelve months once in five years.

100223 Study Leave is the leave granted to a confirmed serving employee to undertake an approved course of study within or outside the country.

100230 An employee may be allowed special leave from duty on full pay on compassionate ground for a period up to two weeks for burial of spouse/child/parents/parents of spouse.

100231 Leave-of-Absence is absence of an employee from duty authorised on grounds of public policy. All such leave shall be approved by the Head of Civil Service of the Federation, on the recommendation of the Permanent Secretary or Head of Ministerial Office.

100242 Annual vacation leave shall be based on calendar days only.

100243 The period of any other leave such as casual leave, sick leave, maternity leave etc. granted under these rules shall be inclusive of Saturdays, Sundays and Public Holidays occurring therein.

2.1 Analysis of the Existing System

In this section, we address the first two of the activities set out for this paper, as stated in the last paragraph of section 1. To facilitate these, the analysis process attempts to address two specific questions: (i) Are the objectives of the policy clear? (ii) How feasible is the implementation of the policy?

2.1.1 Are the objectives of policy clear?

In order to have a clear understanding of the specifications of the features of the system under study, we restructure the policy data presented in the preceding section. This abstraction is shown in Table 1.

Table 1. Types and terms of leaves in the policy framework

S/N	Type of leave	Period of time	Maximum annual cumulative	In excess	Enforcement rule no.
1	Sick Leave without Hospitalisation	7 days	$42^{\pm}$ days	Absent	070316 (i)
2	Sick Leave with Hospitalisation	90 days	$90^{\pm}$ days	Absent	070318
3	Annual Leave Grade 07 and above	30 days	30 days	Absent	100203
4	Annual Leave Grade Level 04-06	21 days	21 days	Absent	100203
5	Annual Leave Grade Level 03 and below	14 days	14 days	Absent	100203
6	Casual Leave	7 days	7 days	Absent	100215
7	Maternity Leave	112 days	$112^{\dagger}$ days	Absent	100218
8	Examination Leave	14 days	14 days	Absent	100221
9	Sabbatical Leave for Grade Level 15 and above	1 Year	1 Year	Absent	100222
10	Study Leave	Depending on the programme	‡Depending on the programme	Absent	100223
11	Burial of Spouse/Child/ Parents/Parents of Spouse Leave	14 days	Open	Absent	100230
12	Leave of Absence	Depending on the Appointment	†Depending on the Appointment	Absent	100231

$^{\pm}$: *Appear before a Medical Board after exceeding the maximum number of days allowed*
†: *Annual Leave is calculated as part of the Maternity Leave*
‡: *"Depending on the programme" is not a computer based implementable specification. Therefore, we formulate the specifications in Table 2 to represent the period of time allocation for Study Leave.*
†: *"Depending on the Appointment" is not also a computer based implementable specification. Therefore, we formulate the specifications in Table 3 to represent the period of time allocation for Leave of Absence.*

Result: The above symbols represent areas of the policy without specific definitions. It is safe therefore, to state that, because it contains ambiguities, it is not clearly defined.

2.1.2 How feasible is the implementation of the policy?

Spurgeon in [3] indicates that wherever the objectives of an attendance management policy are not clearly defined, the results emanating there from are frequently unpredictable, with unintended consequences. It is therefore, safe to state that, because the policy is not clearly defined, it is not feasible for software implementation.

2.2 Discussion

It is clear that the analysed instrument could produce unpredictable results, with unintended consequences. One of the consequences is the interpretation of the clauses of the policy with different meanings. Therefore, at the level of enforcement, this weakness delegates attendance control to the latitude of the supervisors on a flexible case-by-case basis. In other words, the policy can be inequitably enforced across the Decision Making Units (DMU) by the supervisors.

This tendency is detrimental to the well-being of any organisation, as employees under some supervisors could feel that they have been treated unfairly, as they perceive employees under some other supervisors getting away with such misconducts.

The authors in [15] assert that this weakness makes a policy lose its effectiveness, have a negative impact on workers' productivity, and further lead to industrial disputations. The obvious sign of an ineffective workplace attendance management policy is that absenteeism rate persists [2]. Furthermore, the Australasian Faculty of Occupational Medicine in [6] lists the implications of this weakness to include: lower morale, increased workloads, frustrated managers and supervisors, loss of productivity, non-achievement of objectives, reduced provision of services, decreased product quality, increased training costs and loss of key skills and personnel, adverse public perception and confidence, and adverse effects on consumers.

In view of these negative implications on the well-being of the organisation, we see the need for the adoption of a systematic approach that will minimise the discrepancies and inconsistencies, and ensure that the employees are treated equitably no matter who their supervisor is.

In the next section, we develop software development tools to mitigate these weaknesses.

3 Model Development

We begin this section with the creation of tables that will remove the ambiguities identified in the existing system. Referring to Table 1, the ambiguities relate to "Study Leave" and "Leave of Absence" found in serial nos. 10 and 12 respectively. Table 2 allocates time periods for Study Leave, while Table 3 allocates time periods for Leave of Absence. These tables will be applied in formulating the software development tools later in this section. These time allocations give clear definitions to the components, and as such, make them software implementable.

Table 2. Time allocation for study leave

S/N	Type of programme	Period of time
1	Certificate	6 months
2	National Diploma	2 years
3	Higher National Diploma	2 years
4	Bachelor's Degree	4 Years
5	Post Graduate Diploma	1 Year
6	Master's Degree	2 Years
7	PhD Degree	4 Years

Table 3. Time allocation for leave of absence

S/N	Type of appointment	Period of Time
1	To join spouse on course of instruction	1 Year
2	To join spouse on grounds of Public Policy	4 Years
3	For Technical Aid Programme	2 Years
4	For Special/Personal Assistant on Public Policy	2 Years
5	For spouse of Presidents, Vice Presidents, Governors, and Deputy Governors	4 Years

In the formulations that follow, we posit that "absent with leave" has duration, and an employee is expected to resume work at the expiration of approved leave period. Therefore, when an employee's leave duration expires, and he/she does not report to work, he/she is considered to be "absent without leave". We are interested in keeping count of the number of days and time of reporting for duty. We will also keep count of the leave status of every employee at all times, so as to be able to determine the number of days in which an employee is "absent without leave" in a defined period. We will then compare this value with the level of compliance with the organisational policy requirements. In other words, we will formulate a "rate of attendance" model to determine the percentage of attendance within a defined period. We will further formulate a "rate of punctuality" model to determine the percentage of punctuality within a defined period of time.

The high level program structure-chart for the proposed system is presented in Fig. 1.
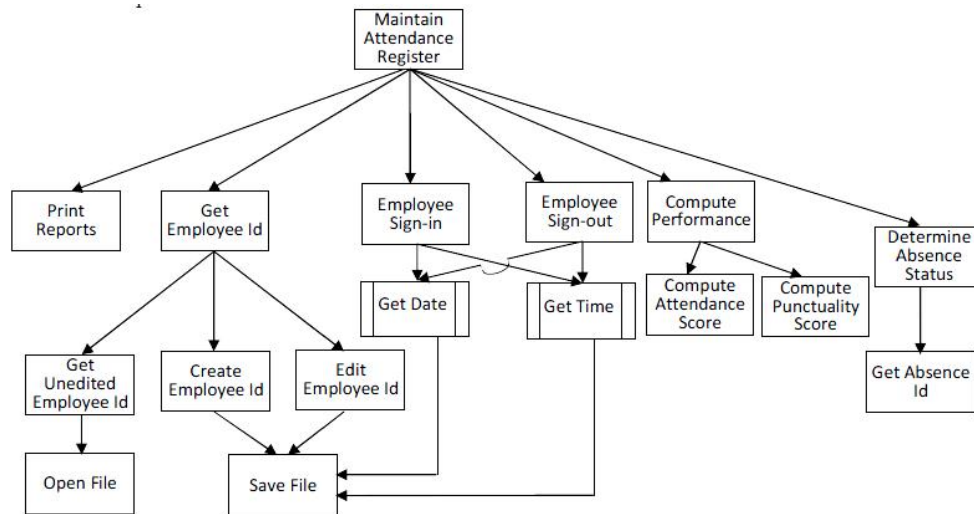
Fig. 1. Program structure-chart for developing attendance register system

Fig. 2 is an algorithm representing the significant modules in Fig. 1 that require further clarifications. Fig. 2 is used to obtain each employee's daily attendance and punctuality scores.

```
If in attendance
Do Employee-Sign-in procedure
Else
Do Determine-Absence-Status procedure
Endif
```

Fig. 2. Algorithm to obtain employee's daily attendance and punctuality scores

In order to successfully implement the procedures in Fig. 2, a program should create an electronic Attendance Register to automatically record the date and time an employee signs in. Every record in the Attendance Register should have a minimum of four fields including: Date, Employee-ID,

Attendance-Value-Date, and Punctuality-Value-Date. While the Date field relies on the system's date, the Punctuality-Value is a function of the system's time. It is therefore, imperative that the system hosting the software should be date and time sensitive. More so, the system should provide security measures to ensure that the operators do not deliberately tamper with these important features of the system.

The next stage is to present the structures of the procedures referenced in Fig. 2. The Employee-Sign-in procedure awards a score of 1 to a variable called Attendance-Value. The Attendance-Value for every employee at the start of every working day is automatically initialised to 0. This value is also automatically changed to 1 whenever an employee signs in into the register. The system does not allow for multiple Sign-in entries in one day. If an employee attempts to sign in after the first-time entry for the day, the system presents a message to indicate its rejection. Consequently, each employee can only score a maximum of 1 in attendance for a day. However, there is a module for Sign-out, where the employees indicate their time of departure. Fig. 3 is a flowchart representing the process of generating the Attendance-Value in the Employee-Sign-in procedure.
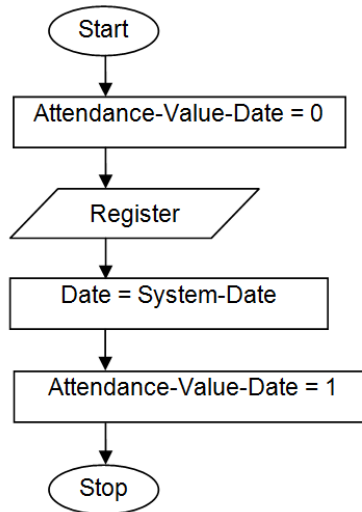

Fig. 3. Program flowchart for generating attendance value

Furthermore, the Punctuality-Value holds the punctuality score of an employee who signs into the attendance register. This variable is also automatically initialised to 0 for every employee at the start of every working day. The Punctuality-Value remains unaltered at 0 for any day that the employee does not sign in or signs in later than the approved reporting time. Since the Attendance-Value in a day cannot be more than 1, it then implies that each employee can only score a maximum of 1 in punctuality for a day as well. Fig. 4 is a flowchart representing the process of generating the Punctuality-Value in the Employee-Sign-in procedure.

The Determine-Absence-Status procedure in Fig. 2 searches through the attendance register and keeps track of all those whose Attendance-Value in the Employee-Sign-in procedure is 0. However, there exists a category of employees whose Attendance-Value could be 0 but they have

official authorisation to be absent. For this set of employees, it is pertinent to keep track of the period for which the authorisation subsists. Consequently, while an employee is on leave, his/her attendance record is isolated and exempted for the purpose of computing the attendance rates.
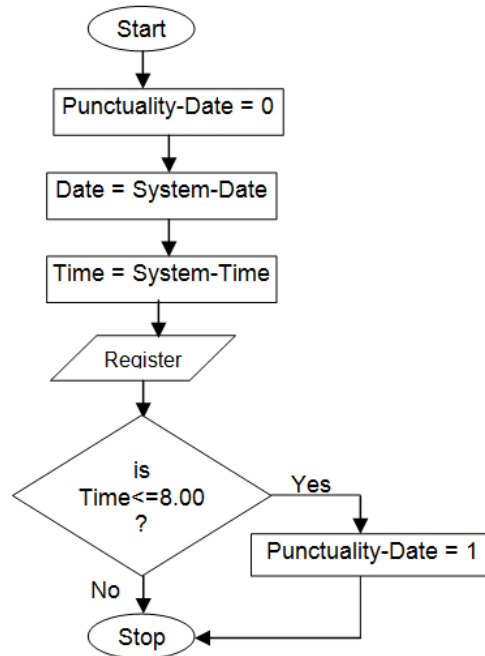

Fig. 4. Program flowchart for generating punctuality value

Combining the information in Tables 1, 2, and 3, we present the sketches of what should constitute the Determine-Absence-Status procedure presented in Fig. 2. These are presented in Figs. 5, 6, and 7. Finally, the algorithm to Report Leave Status is also presented in Fig. 8.

Please note that the "Type of Leave" is represented with their serial nos. in Table 1. For example, "Sick Leave without Hospitalisation" is represented with 0.01, while "Maternity Leave" is represented with 0.07.
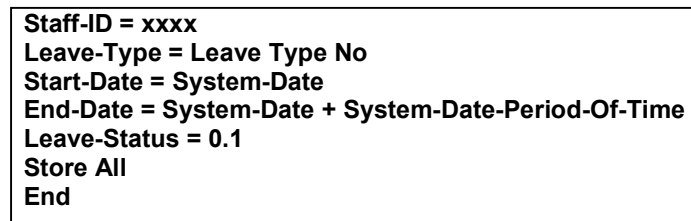

Fig. 5. Algorithm to create new leave status

```
Staff-ID = xxxx
Check the End-Date Value in the Database
If End-Date<System-Date
Leave-Status = 0.0
Else
Leave-Status = 0.1
        Endif
Return Leave-Status
End
```

Fig. 6. Algorithm to modify leave status

```
Leave-Value = Modify-Leave-Status (Leave-Status)
If Leave-Value = 0
Attendance-Value-Date = 0
Else
Do Report-Leave-Status
Endif
Return Leave-Value
End
```

Fig. 7. Algorithm to determine leave value

```
Staff-ID = xxxx
Check the Leave-Type Value in the Database
Report on the Leave Type
End
```

Fig. 8. Algorithm to report leave status

4 Computing the Attendance and Punctuality Rates

We adopt the Data Envelopment Analysis (DEA) principle to obtain the attendance and punctuality measures. The DEA principle establishes the standard to guide the Decision Making Units (DMUs) in arriving at informed decisions. The DEA determines the performance of the best performing object, with the belief that if the conditions were possible for the best performer, then it will be possible for others in the same Department/Unit to replicate the same performance. This measure of the best performer is then used as the standard by the DMUs to define the performance level of others in their units.

The DEA principle therefore, sets out the best performers as role models and standard bearers. Rewarding the best performers will thus, motivate other workers towards improved Workplace Attendance [16]. Eisenberger et al. in [17] also indicate that performance would increase with the expectation that high effort will lead to desired performance and that such performance will be rewarded

Equation 1 is the measure for determining the attendance rate.

$$\text{Attendance rate} = \frac{\text{Work days attended} * 100\%}{\text{Working days available}} \tag{1}$$

where, "work days attended", is the total number of days the employee signed into the electronics register, while "working days available", refers to the maximum number of days associated with any employee in the same Department/Unit in the register.

The same principle is also applied to determine the measure for Punctuality rate as shown in Equation 2

$$\text{Punctuality rate} = \frac{\text{Work days attended on time} * 100\%}{\text{Working days available}} \tag{2}$$

where, "work days attended on time", is the total number of days the employee signed into the electronics register on/before the daily work resumption time, while "working days available", refers to the maximum total number of days associated with any employee in the same Department/Unit in the register.

5 Conclusions

Computer based technologies possess effective means of monitoring, recording, measuring, and reporting of workplace absence behaviours. Utilising computer based technologies in the development of workplace attendance management systems will facilitate the production of information suitable for making prompt, informed, and consistent decisions across organisational units, which has been established as a panacea for significantly reducing absence levels.

So much ambiguity exists in meanings and uses of absence management mechanism-based thinking, due to the obscuring of the internal logic of the available systems. The importance is emphasised of developing systems, which are: (i) based on identified needs of an organisation and (ii) congruent with that of other organisations with whose data the data might need to be compared.

A set of systematic drivers for the development of computer based attendance management systems is created to: (i) provide opportunities for wider scientific evaluations, (ii) assist in the development of sound evidence-based guidelines, and (iii) provide a more rational framework for on-going modification and refinement in the future.

A platform is therefore, initiated for the implementation of systems that serve as benchmarks, for producing data, which is valid, reliable, subject to scrutiny, modifiable, and generalizable to the wider population.

Competing Interests

Authors have declared that no competing interests exist.

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