Published in final edited form as:
J Biomed Inform. 2014 June ; 0: 292–299. doi:10.1016/j.jbi.2014.02.017.

Time Motion Studies in Healthcare: What are we talking about?

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Abstract

Time motion studies were first described in the early 20th century in industrial engineering, referring to a quantitative data collection method where an external observer captured detailed data on the duration and movements required to accomplish a specific task, coupled with an analysis focused on improving efficiency. Since then, they have been broadly adopted by biomedical researchers and have become a focus of attention due to the current interest in clinical workflow related factors. However, attempts to aggregate results from these studies have been difficult, resulting from a significant variability in the implementation and reporting of methods. While efforts have been made to standardize the reporting of such data and findings, a lack of common understanding on what "time motion studies" are remains, which not only hinders reviews, but could also partially explain the methodological variability in the domain literature (duration of the observations, number of tasks, multitasking, training rigor and reliability assessments) caused by an attempt to cluster dissimilar sub-techniques. A crucial milestone towards the standardization and validation of time motion studies corresponds to a common understanding, accompanied by a proper recognition of the distinct techniques it encompasses. Towards this goal, we conducted a review of the literature aiming at identifying what is being referred to as "time motion studies". We provide a detailed description of the distinct methods used in articles referenced or classified as "time motion studies", and conclude that currently it is used not only to define the original technique, but also to describe a broad spectrum of studies whose only common factor is the capture and/or analysis of the duration of one or more events. To maintain alignment with the existing broad scope of the term, we propose a disambiguation approach by preserving the expanded conception, while recommending the use of a specific qualifier "continuous observation time motion studies" to refer to variations of the original method (the use of an external observer recording data continuously). In addition, we present a more granular naming for sub-techniques within continuous observation time motion studies, expecting to reduce the methodological variability within each sub-technique and facilitate future results aggregation.

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Keywords

Time and Motion Studies; methods; standardization

1. Introduction

In the early 20th century, special interest was devoted to the study of industrial processes driven by the global concern related to inefficiencies and waste on material resources[1]. Frederick Taylor (1856–1915) devoted his research to this issue, proposing that the biggest loss due to inefficiencies was not material, but indeed a waste of human effort. He contributed to the emerging "scientific management" field with his Time Study method aiming at reducing processes' times. At a very basic level, time studies were described as detailed observations of workers using a stop-watch to determine the time required to accomplish specific tasks (e.g. time required to swing the shovel backward and then throw the load for a given horizontal distance, accompanied by a given height [1]). This method was later expanded by Taylor's disciples, Frank and Lilian Gilbreth, who focused on motion[2]. The Motion Study method sought to make processes more efficient by reducing the motions involved. These two techniques, time studies and motion studies, became integrated into a widely accepted method in scientific management referred to as Time Motion Studies (TMS).

Taylor's time study method was originally presented to the American Society of Mechanical Engineers and emphasized that the same principles could be applied to all kinds of human activities. In 1914, the Gilbreths began the application of their motion study techniques to healthcare and life sciences by assessing inefficiencies in the healthcare industry[3]. Since this time, TMS have been adopted by hospital managers and researchers, who initially applied these methods to study costs and inefficiencies in healthcare delivery and then rapidly expanded the focus of their studies towards patient safety and quality. More recently, an increase in adoption of informatics and information technology systems in healthcare and life sciences, associated with the inherent potential to cause a major impact on quality, efficiency and costs of healthcare[4][5], has triggered the need to study and evaluate the adoption of such systems. Since the observation that increased time for documentation is one of the most commonly stated barriers to successful implementation of electronic health records[6], the evaluation of time efficiency in documentation and other workflow related factors have become a common research aim, positioning Time Motion Studies in a protagonist role.

A century after the introduction of scientific management methods to the healthcare arena, there is genuine interest in aggregating results from these TMS to generate knowledge in healthcare workflow, inefficiencies, patient safety and quality, and lately, to support decision making on the acquisition and implementation of health information technologies. Regrettably, attempts to aggregate results conclude that the design, conduct, and data reporting of existing TMS varied considerably, making study comparison impossible[7]. Efforts to summarize findings across TMS are frustrated due to dissimilar activity categorizations and a lack of methodological standardization [8].

A first step towards standardizing the method was published by Zheng et al. who, after analyzing a sub set of twenty four “time and motion studies” specifically assessing health IT implementations, proposed a checklist aiming at standardizing the reporting of such studies’ methods. [7]. Although this is an important first contribution, it did not address the persistent lack of common understanding concerning the definition of what are (or are not) “time motion studies”, persisting two major gaps in knowledge and practice as follows:

A. The lack of common understanding hinders reviews and any further methodological standardization efforts. In order to apply and take advantage of Zheng’s reporting checklist for “time motion studies”, authors must first correctly identify what a time motion study encompasses, which doesn’t seem to be the case: in the previously mentioned review, 40% of the exclusion was due to articles failing to conform to a working definition presented by the authors (“independent and continuous observation of clinician’s’ work to record the time required to perform a series of clinical or non-clinical activities”) [7].

B. Also, the inability to identify and distinguish distinct variations of the original technique could partially explain the methodological variability described (duration of the observations, number of tasks, multitasking, training rigor and reliability assessments) caused by an attempt to cluster dissimilar sub-techniques.

As such, a crucial step towards the standardization and validation of time motion studies in the biomedical domain corresponds to establishing a common understanding, accompanied by a proper identification of the distinct techniques it encompasses.

1.1 Objective

In response to the aforementioned gaps in knowledge and challenges surrounding TMS methodologies, our objective in this report is to contribute to the standardization of time motion studies by providing a disambiguation based on a broad understanding on what the concept “Time Motion Studies” currently embraces in the biomedical literature. Specifically, we aim to:

a. Review a broad sample of the biomedical literature being referenced or classified as pertaining to “time motion studies” in order to identify the current scope of the method.

b. Provide a detailed description of the distinct methods used in those articles; and

c. Present a disambiguation schema for the term “time motion studies”.

2. Methods

Our goal was not to conduct a survey on every quantitative data collection method used in workflow research (thoroughly discussed by Unertl et al. [9]), but to identify what the term “Time Motion Studies” currently refers to in the biomedical literature, particularly in healthcare. Thus we selected PubMed/MEDLINE as the bibliographic database, and searched for empirical studies published in English that contained the strings “time motion study” or “time and motion study” in the title/abstract. The PubMed search engine treats dashes as spaces[10], thus the results did not change when adding “time-motion studies” to the query. With this search strategy, we expected to retrieve those articles where the author actively, either in the title and/or in the abstract, declared having conducted a time motion study. Moreover, in addition to assessing and classifying what researchers consider to be focused upon “time motion studies,” we also evaluated what MeSH classifies as time motion studies. To maintain efficiency while expanding the scope of the review, we selected the “Time and Motion Studies” MeSH major topic. This allowed us to assess a convenience sample spanning 10 years of studies where either “Time and Motion Studies [MeSH]” was one of the main topics discussed in the article or “time motion study” was declared in the title/abstract. We restricted the search to journal articles only, and as we were interested in time motion study methods in empirical studies, we excluded editorial, comments and review publication types from the query. The final search strategy resulted in: ("Time and Motion Studies"[Majr] OR "time and motion study"[Title/Abstract] OR "time motion study"[Title/Abstract]) AND "Health Care Category"[Mesh] AND English[lang] AND "2003/01/01"[PDAT] : "2013/01/01"[PDAT] AND Journal Article[ptyp] NOT Editorial[ptyp] NOT Review[ptyp] NOT Comment[ptyp].

The query was run in May 2013, and retrieved 285 citations. No extra exclusion criteria were used: we aimed to assess every empirical study either classified by MeSH or by the authors as TMS. Twenty-two articles corresponding to article types that were missed by our query exclusion criteria (reviews, comments or editorials) were discarded, leaving 263 articles for full assessment. With very few exceptions and only if no doubt existed on the method being reported, the assessment was performed on the full article.

An initial assessment of the sample revealed that our query, besides encountering the original method or variations of the original method (i.e. the use of independent external observers recording time data continuously), also returned a broad spectrum of distinct quantitative data capture methodologies referred to as “time motion studies”. Since the only common theme corresponded to the capture and/or analysis of the time required to complete one or more events, and supported by literature reporting differences on data quality depending on the data collection method [11][12][13], we grouped the distinct methods encountered by major data capture procedures. Once we identified the method(s) in an article, we clustered them by similarities regarding how, by whom and when the time motion data was collected, provided a detailed description, and finally reported a relative prevalence of each method. In addition, we analyzed changes in the relative prevalence of methods over time. Last, we assessed discrepancies in the scope of “time motion studies” between “time motion studies’ authors” and “mesh indexers”, analyzing the overlap of citations when executing specific queries and assessing the distribution of the TMS methods used by both groups.

Data extraction was conducted by a medical doctor and validated by a nurse/PhD with training in biomedical informatics, both of whom had extensive experience designing and conducting *continuous observation* time motion studies. An initial annotation of 20% of the articles was performed independently, and discrepancies were discussed and solved by mutual agreement. Once complete agreement was achieved for the annotation process, the first reviewer completed the remaining 80% of the sample. For each of the 263 articles, the method(s) reported to collect the time motion data were carefully assessed and extracted.

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3. Results

3.1 Time motion data produced by external observers

In this group, the burden of collecting the time motion data relies on an external observer. It can be performed asynchronously by having the observer analyze video recordings of the subject behavior in the work environment (also called “time-action analysis”[14][15]), but it is mostly conducted by directly observing and following the subject in real-time. Subjects might feel disturbed, and sometimes an improvement in performance can be evidenced by the presence of an external observer: a phenomenon known as the Hawthorne effect[1]. Two methods were identified within this category: continuous observation and work sampling.

In continuous observation, the external observer maintains the attention on the subject and continuously records the time taken to perform one or multiple tasks, implying that the action of recording is triggered by an action performed by the subject. It is a useful approach to collect data for non-centralized tasks, sensible for short tasks and provides granular and detailed field data, but usually requires a 1:1 subject to observer ratio.

Unlike continuous observation, which measures the elapsed time for a task, work sampling identifies the task being performed at a given instant[16], repeating the measure at predefined fixed or random intervals during the observation. It relies on the repetitive nature of work and assumes the probabilistic generalization of the sampling findings to describe how workers spend their time. One of the major benefits compared to continuous observation, is that the observer can focus on multiple subjects during a single observation period. Work sampling has been reported to be efficient for studies classifying the subjects’ activities into fewer categories: with more categories describing less frequent tasks, the required number of observations increases [11], losing the advantages afforded by this method. Strictly speaking, work sampling estimates the proportion of time given to an activity based on random observations [17]. The temporality of the sampling methodology has been debated in the literature, concluding that systematic work sampling is a flawed biased estimate, and random work sampling is the recommended approach [18]. However, one of the pioneer researchers in TMS argues that the reduction in bias provided by randomization is overweighed by the complexities in scheduling the observations, advocating in favor of fixed periodic intervals[19]. We observed this issue in our review: all the studies conducting work sampling with an external observer used a systematic fixed time interval: i.e. 1 minute[20], 5 min[21]. A high frequency work sampling method was identified and referred to as “Davis observation code”[22], sampling every 15 seconds. Under optimal circumstances, work sampling has been proposed as a useful and efficient methodology for analyzing the distribution of staff work activities in relation to the types of activities they perform[23], but falls short for questions related to specific task durations, occurrences or workflow studies. A highly cited paper concludes that work sampling may not provide an acceptably precise approximation of the results that would be obtained by continuous observation time motion studies.[11]

[1]This was first reported in Chicago during the 1920s, when after studying methods of increasing productivity it was found that regardless of the change introduced in the working environment, the result was always an increase in productivity. It is now explained as “an increase in worker productivity produced by the psychological stimulus of being singled out and made to feel important”[57].

3.2 Time motion data produced by the subject(s) being studied

In this group, the subjects provide the time-related data themselves. Although self-report can be a low cost method for measuring work activities, perceptual differences among the self-reporters can lead to discrepancies in how activities are categorized [24]. Also, subjects may either lie about what they are doing or change normal routine in order to represent data they believe are in some sense more desirable.[11] This has been proven outside TMS when comparing self-report and observation for dentists providing preventive services: self-report frequencies systematically exceeded observed frequencies[12]. Self-reports are also considered unreliable because they over-estimate contact time with patients and under-estimate the non-productive clinician time, compared to work sampling using an external observer[25]. Anecdotally, one study comparing the number of duty-hours violations among residents encountered no difference between self-reports and computerized system time-stamps[26]; however instead of reporting the agreement between the two measures, they compared if a threshold of work hours was exceeded, and not the specific durations.

Four major methods were identified in this group, which can also be classified as synchronous or asynchronous. On the asynchronous side of the spectrum we found interview/focus groups and surveys. There, the subject is asked to answer questions regarding the time it takes him to perform different steps of a process. Asynchronous self-report methods are considered limited due to the participant’s subjective evaluation of their workflow and working conditions[27], and poor estimators of durations. For example, when comparing physician recall of events duration in the operating room, surveys over-estimated the duration by 30 minutes on average, from a few minutes up to two hours, when compared to times extracted from the surgery log[28]. On the synchronous side of the spectrum, we identified active tracking and self-reported work sampling, which have been proved burdensome by nurses attempting to record activities while conducting clinical duties[24]. In active tracking, the subjects complete some kind of log with the time motion data, either after completing the task, or by the end of the work day. Self-reported work sampling involves the repeated recording of the activity taking place at pre-determined systematic or random intervals, but in this case, the subject himself is required to record the data. As previously discussed, random intervals recording are feasible and more common in this setting [29], usually using some sort of electronic device that reminds the subject in random intervals to record the data. In a comparison of self-reported work sampling and traditional work sampling for measuring nursing tasks[30], the self-report work sampling technique was found to be an unreliable method for obtaining an accurate reflection of the work tasks of ward-based nurses. Also, nurses preferred the use of an external observer. Despite that, one of the largest scale TMS corresponds to self-report work sampling by nurses in 36 hospitals[31].

3.3 Time motion data produced automatically by computerized systems

In this group, timestamps and durations of tasks are automatically generated by computerized systems when the subjects perform pre-defined tasks. Usually the movement of the subjects triggers the record of the time motion data on the systems, providing a rich “motion” dimension of the data. It is important to highlight that the name doesn’t make reference to the use of electronic tools to collect the data (such as an external observer using a tablet pc to timestamp events), but to the fact that the time stamp is being created automatically, observer-independent and without an active intention of data recording by the subject. This group includes a broad range of systems, spanning from indoor or global positioning systems, accelerometers, electrodes, radio frequency identification and diverse sensors. From the subject's perspective, this can be considered a passive tracking method that records time motion data automatically while the subject performs their usual workflow. Examples include position-tracking devices that create time-stamps when the user approaches sensors, the time-stamping log of user-interface events on the screen of an electronic health record or sensor movements on a laparoscopic surgery training module. Although for electronic motion sensors time is a reliable variable captured[32], time-stamped logs from software usage have to be interpreted carefully. If the variable of interest is the duration of interactions with the system (i.e. charting time) it could be considered an accurate measure. However, when the variable of interest is deduced from the automated EHR timestamp as a proxy (i.e. time of patient transfer to another unit) it might not be an accurate measure. For example, a TMS conducted in the emergency department compared continuous observation and time extracted from EHR timestamps, concluding that durations extracted from the EHR were recorded 2 minutes before they were actually observed (median, interquartile range 31 min before to 3 min after)[13].

3.4 Special case: Logged time on charts/documents/databases

A large portion of the articles (21%) conducted the time analysis on logged time from databases, chart reviews or existing documents. Although this could represent a standalone group of studies, it actually embraces two possible means of time data capture: a first scenario where the subject actively records a time or a duration in the system/record, and a second scenario where the logged time data is being automatically recorded in the system by other actions performed by the user (the user does not actively input time data on to the record). Thus, the first scenario corresponds to a subset of the active tracking self-report group, while the second scenario corresponds to a subset of the UI timestamps from the computerized systems group. Due to the previously presented evidence that emphasizes the subjectivity of the self-reported data, this distinction is not minor. Although we could assume that most of the data in this group came from active tracking self-report, this wasn't systematically reported. Thus, we decided to represent these studies in a standalone category, while encouraging future researchers to report the data source of their logs and databases. An interesting discussion arises from the assumption that this group represents a distinct scenario from self-report active tracking: a scenario where the action of self-registering times/ durations is actually part of the routine workflow of the subjects. However, the transition from being a prolonged self-report study to collecting time data as part of the routine workflow is unclear and the effect on data accuracy has not been studied.

3.5 Other studies

Seven articles returned by our query did not collect or analyze any task/event time duration. The articles corresponded to two time-series studies[33][34] (where time is an independent variable), an interview to assess why a delay existed[35], two work-load calculation models for the emergency department[36][37], a qualitative participant observation with no quantitative time motion data captured[38], and a survey to validate time-related vocabulary[39]. One article did not provide any details on the method used to collect the data, and was left unclassified. An interesting highlight is that these seven studies were classified as TMS by MeSH, but not by the authors (not mentioned in the title or the abstract).

3.6 MeSH vs. authors: discrepancies

We iteratively combined Boolean operators in our query to identify articles retrievable by the "Time Motion Studies" [Majr], "time motion study" or "time and motion study" string on the title/abstract, or both, and compared the number of results. By using MeSH [Majr], 216 articles were returned, compared to 99 returned by the string on the title/abstract. At first, we thought this might be due to a difference in sensitivity (one being a subset of the other), but when we studied the intersections and union of the groups, a different set of articles were retrieved [Figure 1]: MeSH and the authors seem to have a different understanding of time motion studies. We compared the relative prevalence of the different identified methods [Figure 2]. Authors mentioning time motion study in the title/abstract mostly refer to methods using an external observer, while MeSH noticeably extends the scope in databases/chart reviews and in asynchronous self-report methods (surveys/interviews). Continuous observation represented the 32.4% of the TMS articles indexed by mesh and 77.1% of the self-reported TMS articles.

4. Discussion

4.1 Time Motion Studies: what are we talking about?

The original use of the term time motion study (combining the work of Taylor and the Gilbreths) refers to a method for improving efficiency and establishing employee productivity standards in which a task is broken into steps, the sequence of movements performed by the subject to accomplish those steps is observed to detect redundant motion, and precise time taken for each movement is measured. However, our query results returned a broad spectrum of distinct methodologies referred to as "time motion studies". They ranged from surveys, patient records reviews, self-reports and work-sampling. There is an evident misunderstanding and contradictory definitions that need to be clarified.

Based on our results, we present a disambiguation schema. Currently "time motion studies" is used to refer to:

A. The conglomeration of studies using a broad spectrum of dissimilar methods whose only common factor is the capture and/or analysis of the time required to complete one or more events[2]. An important fact to highlight is that this "least common denominator" leans towards the time study portion of time motions studies. Although most automated timestamps consider motion at a very granular level, data produced by external observers only sometimes considers motion, and usually at a high level by recording the subject location. Self-reported data rarely considers

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[2]A confusion might arise with time-series studies. The gathering of time-series data is a common practice in the social sciences, but unlike time-motion studies, time-series studies assess the effect of time (specifically dates) over other factors. We thought to make the clarification since one of the articles returned by MeSH as a time motion study corresponded to a time-series study comparing changes in attitudes of persons over time[33].

motion. This emphasis on the time study side of time motion studies can also be evidenced when assessing the entry terms for “Time and Motion Studies” in the MeSH hierarchy: “Time Studies”, “Studies, Time”, “Time Study” and “Study, Time”[40].

B. The use of an external observer capturing data continuously (no work-sampling). Although not unanimous, the majority (77.1%) of the articles containing “time motion study” in the title/abstract referred to the use of an external observer doing continuous data capture, which makes sense historically since it correlates more to the original 1900s’ time motion method.

We believe that it would be more scientifically and historically accurate to use “time motion studies” to refer to the uses of external observer capturing data continuously. However, the fact that it only represents 32.4% of the “Time motion studies” [Majr] indexed articles, the broad use of this conception and the influence of work sampling supporters, present as an impediment for trying to rectify the definition. Instead, we believe that maintaining compliance with the expanded conception and establishing the clear specification “continuous[3] observation time motion studies” will allow a better understanding. This premise, accompanied by the present review of methods embraced by TMS will allow future researchers to properly identify and refer to a desired method. We encourage TMS researchers to thoroughly describe their methodologies and identify the method being used [Figure 3]. If the method selected is continuous observation TMS, we suggest to follow the checklist proposed by Zheng[7] to describe the details of the implementation of the method.

4.3 Expanding Continuous Observation Time Motion Studies and future work in TMS standardization

Continuous observation time motion studies represented the majority (42.2%) of the articles classified as time motion studies in our 10 year-span review. When analyzing the trend of methods over time, despite a year to year variability in the distribution, a clear trend towards continuous observation was observed: 35% of the methods used in 2003–2007 corresponded to continuous observation, compared to 48% in 2008–2012. This supports the theory of continuous observation being considered the gold standard methods: the research community accepts them as the method of preference to collect time/duration data in healthcare. Thus, standardization efforts should keep focusing on this method. Based on our findings, two clarifications will further contribute to the common understanding of TMS methodologies, specifically continuous observation TMS.

First, among methods based on external observers, the distinction between work sampling and continuous observation is not universally understood. For example, one article using continuous observation[41] provided evidence as to why the method used was superior (participant observation of time allocation with continuous task duration recording) by citing an article that examined work-sampling[25]. The distinction between triggering the recording by an action from the subject (continuous observation) versus triggering the

[3]We emphasize that continuous refers to the fact that the observer is continuously recording data as it occurs, and not the fact that he is continuously present in the field: technically when conducting work sampling every 5 minutes the observer is also continuously in the field, but records data intermittently.

recording of data by a time interval (work sampling) gets even more confusing when variation of the methods are poorly described. For example, some studies using continuous observation with paper-based tools record the start and stop times of observed tasks with a detail of minutes, not seconds (easier for the observer, but produces a loss of detail and accuracy of the observation, thus losing the ability to track tasks fragmentation and quick task switching). This scenario can be easily confused with a systematic one-minute interval work sampling approach, where the observer records the current activity every elapsed minute. A rare, more complex sub-type of work sampling is particularly confusing: a one minute interval work sampling approach where the observer, instead of recording the current activity, recorded the activity that most represented the physician's action during the previous minute[42]. We suggest naming this "task predominance work sampling".

Second, we believe that a more granular description of continuous observation TMS will help distinguish sub techniques, which in turn might explain some of the variability previously described. Within continuous observation, we encountered three distinct data schemas naming them "single duration measurement", "milestones timing" and "workflow time study", corresponding to 19.7%, 18.8% and 61.5% of continuous observation TMS respectively.

In single duration measurement, the external observer measures the duration of a single event, i.e. the observer only records the subjects' time spent in the bathroom[43] or the time required to walk 50 feet[44]. Zheng et al. differentiated this group from the rest of continuous observation methods, excluding it from his review and referring to it as "efficiency studies on isolated events, such as workaround times". We believe that a further specification can be declared within the remaining group, identifying two distinct sub-techniques. In one approach, researchers interpret and model qualitative data onto theoretical activity diagrams a-priori[45], and then enrich the abstracted workflow with time-data[46] by having observers record the duration of expected ordered milestones[47]. We named this approach "milestones timing", which is the most similar to the original method described by Taylor. Examples include measuring six vaccination steps[48], timing the duration of five stages in a esophageal manometry[49], or developing an idealized medication administration flowchart and time the duration of each predicted step[50],[51]. While "single duration measurement" and "milestones timing" provide a relatively simple framework for the observers, it has been broadly reported that the nature of clinical work is unpredictable[52][53], with an unusual number of imponderables, nonstandard environments and equipment, caring for distinct variable patients. This non-linear and interruptive nature of clinical work encourages researchers to use a more granular approach[54] provided by the third sub-technique identified, which we named "workflow time study". In this more comprehensive schema, the observer records the occurrence and duration of unpredicted instances of tasks, producing a data schema of time-stamped tasks, which accounts for task fragmentation, interruptions and work variability. This proposed differentiation is not trivial, since it might partially explain the methodological variability previously reported in continuous observation TMS. For example, the number of tasks being observed will certainly be lower for milestones timing than workflow time studies, or the hours of training will significantly differ if the observer has to focus on a single event duration v/s identifying and timing a set of tasks. Also, humans have been proven to be good time keepers in single duration measurements compared to electronic sensors[55], and reliable for tracking simple movement patterns compared to GPS[56]. However, for more complex scenarios like workflow time studies, reliability becomes a major concern. Assessing inter-observer reliability for each sub-technique will differ: single duration measurement and milestones timing will focus on the duration of the pre-specified interval(s), while workflow time studies require a multidimensional inter-observer reliability assessments to compare the naming, count and duration of the tasks identified. Differences are also expected for the duration of the observations and the unit of observation, etc…

We believe this detailed description will help better understand the variability among these methods. With a common understanding, future efforts on standardizing continuous observation TMS can be aligned and potentiate collaborations in pending issues such as how to record multi-tasking accurately, best approaches for recording interruptions, a proper inter-observer reliability assessment and tasks definitions concerns.

4.4 Limitations

The use of a single database (PubMed) might have limited the scope of the articles retrieved and only represents the indexing trend of MEDLINE, which might differ with other biomedical bibliographic databases, or business/management literature. Also, these findings only reflect time motion studies from the biomedical domain, specifically healthcare, therefore these findings might not apply to other fields concerning these studies (i.e. industrial engineering).

5. Conclusions

Our review revealed a common and reoccurring misunderstanding regarding the definition and scope of time motion studies. It is currently being used in two ways: at a high level, referring to the conglomeration of studies on which the duration of an event is one of the variables of interest, and at a more granular level, making reference to the use of an external observer recording time data continuously. To maintain compliance with the existing scope of the term, we propose to preserve the expanded conception and recommend the use of a specific qualifier "continuous observation time motion studies" for referring to the use of an external observer recording data continuously. We hereby provided a review of all the methods covered by the current global conception of TMS, aiming at empowering TMS researchers and reviewers to understand the differences among them. Future efforts in this series are focused on the standardization of continuous observation time motion studies: we encourage researchers to adopt Zheng's methodological reporting checklist for this group, thoroughly describing the implementation of the selected method, thus facilitating further research assessing discrepancies on multi-tasking recording, definitions of interruptions, observers training and inter-observer reliability assessments, a unified clinical time motion study task ontology, finally leading to a comprehensive time motion driven workflow analysis methodology.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Funding source

This publication was supported in part by an Institutional Clinical and Translational Science Award, NIH/NCRR Grant Number UL1-RR025755-04.

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Highlights

- We evidenced the discrepancies regarding the meaning of "Time Motion Studies" (TMS)
- A detailed description of methods classified as TMS is delivered
- We present a disambiguation for "Time Motion Studies"
- Specific descriptor "continuous observation TMS" is proposed

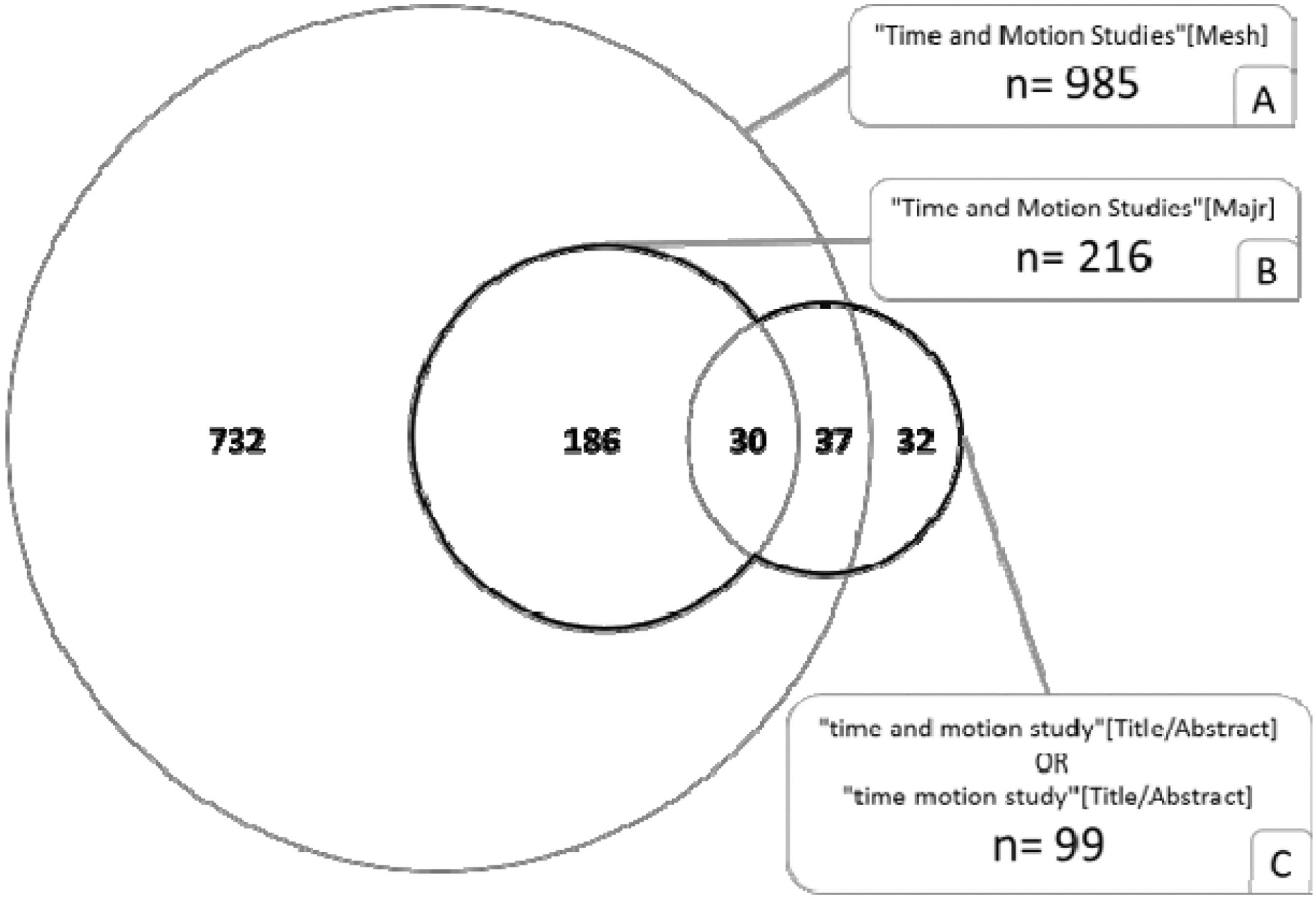

Figure 1.

Venn diagram showing the union and intersections of the distinct sub-queries. The thicker borders represent the set of articles reviewed in our study (the union of B and C). C is not entirely a sub-set of B, nor A, possibly indicating a discrepancy of the definitions of TMS for authors and for the indexer organism.

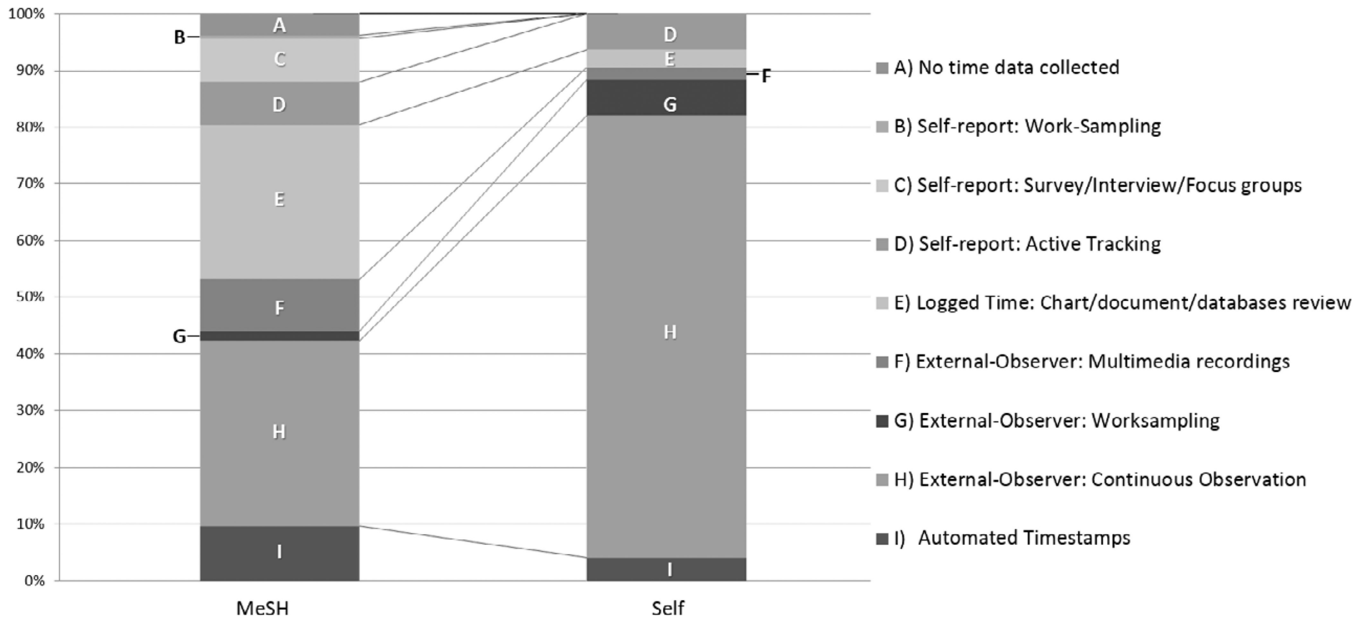

Figure 2.

Stacked columns representing the relative prevalence of the distinct methods referred to as "time motion studies". A clear difference in the distributions can be visualized between the articles indexed by "Time motion studies" [Majr] (left) vs. the presence of "time motion study"/"time and motion study" in the title/abstract (right).

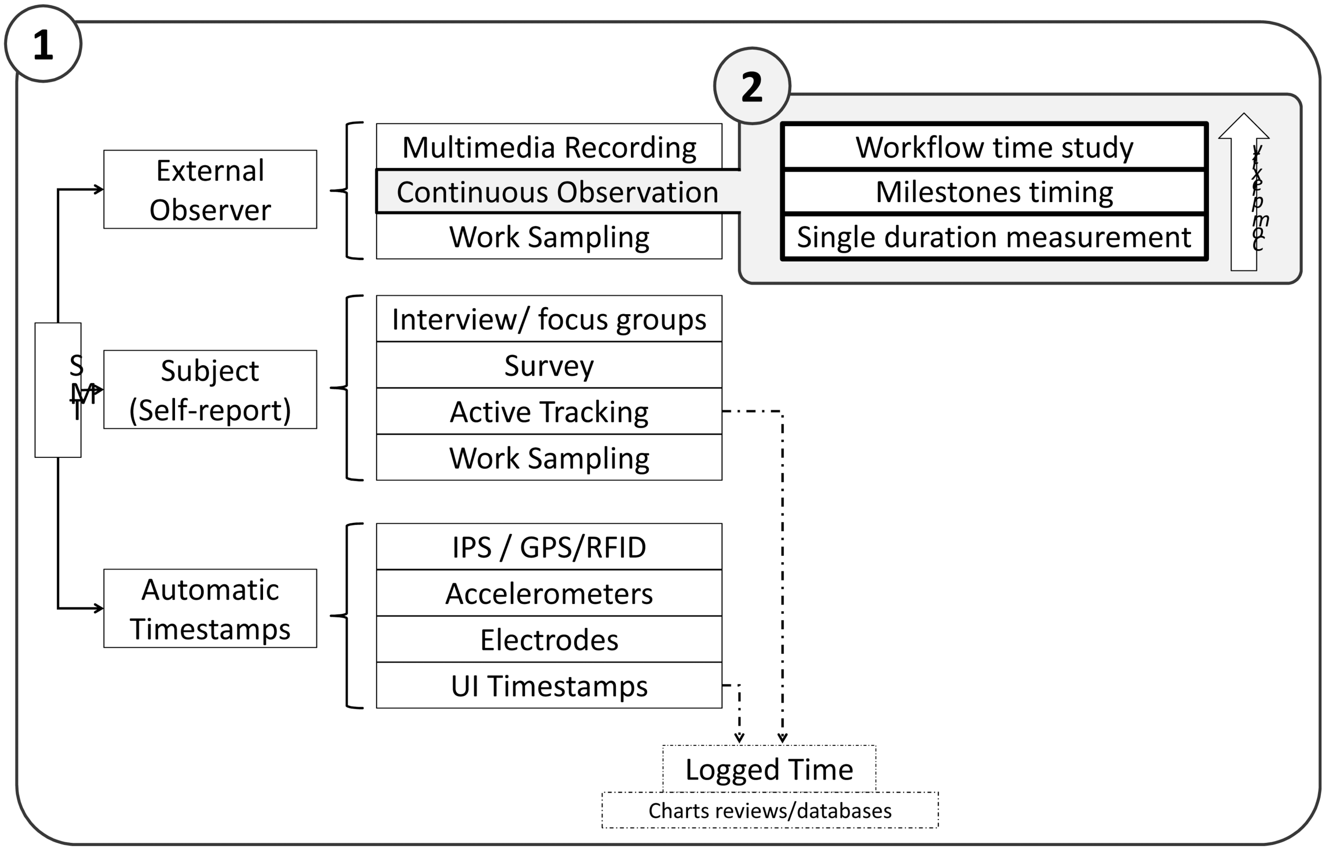

Figure 3.
Methods described in the reviewed articles. We can concluded that the term “Time Motion Studies” is currently being used in two ways:

- #1 at a high level, referring to the conglomeration of studies on which the duration of an event is one of the variables of interest. This includes methods on which data collection is based on external observers, self-reports and/or automatic time-stamps. Each encompasses distinct data collection techniques, with advantages and disadvantages (see results section). “Logged Time” presents an artifact of our review due to the lack of details regarding the data source: it can represent data actively recorded by subjects, or passively time-stamped by electronic systems, which should be interpreted differently.
- #2 at a more granular level, referring to the use of an external observer recording time data continuously (Continuous Observation TMS). We identified three distinct sub-techniques and named them accordingly.

Table 1

Time motion data capture methodology distribution of the reviewed articles and relative prevalence.

Group	Method	n	%
External-Observer	Continuous Observation	111	42.2%
	Work sampling	8	3.0%
	Multimedia recordings(Indirect)	18	6.8%
Self-Report	Active Tracking	19	7.2%
	Survey/Interview/Focus groups	14	5.3%
	Work sampling	1	0.4%
Automatic Timestamps	IPS/GPS/RFID/other	20	7.6%
*	Logged Time: documents/databases review	51	19.4%
Combination of methods		13	4.9%
Unspecified		1	0.4%
No time data collected		7	2.7%
Total		263	100.00%