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Original article

Effects of the implementation of the dynamic silver code in the emergency department

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ABSTRACT

Background: Older persons accessing the Emergency Department (ED) spend more time and are at increased risk of poor outcomes. The Dynamic Silver Code (DSC), based on administrative data, predicts mortality of 75+ subjects visiting the ED.
Objective: To evaluate the effects of the implementation of the DSC in the ED.
Methods: A pre-post comparison was conducted in the ED of a community hospital in Florence, Italy before and after the DSC was fully implemented. In the post-DSC phase, a clinical decision tree was applied: patients at low-mild risk (DSC class I and II) were assigned to Internal Medicine, those at moderate risk (class III) to Geriatrics, and those at high risk (class IV) required geriatric consultation before assignment. Outcome measures were ED length of stay (LOS) and, in patients admitted to Geriatrics, weight of the Diagnosis Related Groups (DRG), hospital LOS, and mortality.
Results: 7,270 patients were enrolled in the pre-DSC and 4,725 in the post-DSC phase. ED LOS decreased from a median of 380 [206, 958] in the pre-DSC to 318 [178, 655] min in the post-DSC period ($p<0.001$). Class III represented the largest share of admissions to Geriatrics in the post-DSC period (57.7 % vs. 38.3 %; $p<0.001$). In patients admitted to Geriatrics, hospital LOS decreased by one day ($p = 0.006$) between the two study periods, with greater DRG weight and comparable mortality.
Conclusions: Application of the DSC seemed to ease patient flow and to reduce LOS of older patients in the ED and increased appropriateness of admissions to Geriatrics.

1. Introduction

Older patients represent an increasing share of Emergency Department (ED) visitors worldwide [1]. Because of their complex medical and social problems, older patients in the ED require longer clinical evaluation times and increased resources compared to younger adults [2]. For the most vulnerable, ED use represents a destabilizing event, which may be independently associated with suboptimal outcomes [2]. Because of their increased clinical complexity, requiring more diagnostic workout and therapeutic interventions, older adults have longer stays in the ED and experience higher rates of negative health outcomes, such as delirium or adverse drug events [2,3]. Therefore, simple risk

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stratification screening instruments have been proposed to identify vulnerable subjects in the ED setting with the goal of improving patient management and outcomes, while allowing for faster and more focused use of time and resources [3,4]. However, the prognostic accuracy and applicability of these tools have been in general limited [4], with the possible exception of the PROAGE scoring system, that recently showed good accuracy in predicting prolonged LOS and in hospital mortality [6].

In previous studies, we have developed and validated the Dynamic Silver Code (DSC), a prognostic tool that allows automated, real-time identification of patients aged 75+ years accessing the ED, who are at an increased background risk of death at 7 and 30 days and 1 year, independent of the event leading to ED admission. Modeled on a previous tool, which compared well with the well-known Identification of Seniors at Risk [7], the DSC was initially created and tested retrospectively in a large cohort of Italian patients, then it was further validated in a new prospective cohort: according to the tool, patients are assigned to 4 classes of progressively increasing mortality risk, from class I to class IV [8]. The DSC classification predicted also immediate outcomes, such as time spent in the ED and ED disposition, and was associated with previous participant's frailty status, as mainly documented by inability to walk and exhaustion [9]. Furthermore, evidence has been provided that the tool helps identify subsets of patients in whom admission to Geriatrics may be associated with better survival, especially in the presence of specific discharge diagnoses [10].

The DSC has been implemented in software for routine management of ED patients and is now available in real-time across all the hospitals in the healthcare district of Florence, Italy [9]. However, the effects of its implementation have not been reported so far.

This study describes the effects of the DSC implementation that were observed in the Ospedale Santa Maria Annunziata (OSMA), a community-based facility in the metropolitan area of Florence. In particular, ED length of stay (LOS) was compared between patients admitted before and after the implementation of the DSC.

2. Methods

2.1. Study design and setting

This is an ancillary study of the "Anziani in DEA – AIDEA ("Older Persons in the ED") study, sponsored by the Italian Ministry of Health and by the Tuscany Region [8]. Approval by the local Ethics Committee was obtained (976/13_AOUC). To evaluate the effects of the DSC implementation, we used a pre-post comparison of anonymized data, retrospectively collected in all subjects aged 75+ years, accessing the OSMA ED before and after the software for DSC scoring was fully implemented. The period between April 2017 and March 2018 was the pre-DSC phase, whereas the post-DSC phase lasted from April to August 2018.

2.2. Implementation and clinical application of the DSC

As previously described [8], the DSC was obtained using software incorporated into the application routinely used by ED clinicians in all the hospitals of the area. The DSC is applicable to all 75+ residents in the Florence healthcare district accessing the ED of one of the hospitals in the area. As soon as an eligible patient is triaged, the software queries the repository of health care data, links the archives contained in the repository, extracts the information required, and calculates the score. In the pre-DSC phase, the score remained unknown to ED staff, whereas in the second phase it became promptly available onto the computer screen soon after triage, together with the corresponding risk class (class I: score 0–10; class II: score 11–25; class III: score 26–34; class IV: score 35+). Details on the calculation of the score have been previously published and are summarized in the Supplemental Table.

Prior to DSC implementation, admission to Geriatrics vs. Internal Medicine was not rigorously codified, being very broadly based only on an age criterion. In the post-DSC implementation phase, physicians in the ED and in the Internal Medicine and Geriatrics wards in the OSMA were trained on its use and agreed upon its application in a clinical decision tree, limited to patients admitted with conditions not requiring surgery or admission to Intensive Care. Specifically, the evidence from a previous study was valued, that the greatest survival benefit could be expected in class III patients assigned to Geriatrics vs. Internal Medicine, whereas similar mortality rates are expected between the two wards in class I patients [10]. Therefore, following the decision for admission made by the ED physician, patients in class I or II were directly assigned to Internal Medicine and those in class III directly to Geriatrics with no further geriatrics workup, whereas those in class IV would require additional criteria and in-person evaluation by a consulting geriatrician before final assignment (Supplemental Fig.). In both periods, patients were stratified according to the triage color code routinely used in most Italian hospitals, which identifies patients with altered vital functions requiring immediate attention (red), those at risk of altered vital function who need limited wait in a protected area (yellow), those not at risk but with significant discomfort (green), and those not at risk and a low degree of discomfort (white).

2.3. Outcome measures

ED LOS was compared between the pre-DSC and the post-DSC phase as the main outcome measure, in the entire sample as well as in the subsample of patients who were admitted to Internal Medicine or Geriatrics. Furthermore, we also compared the ED LOS between the two time periods in another community hospital (Ospedale San Giovanni di Dio) of the same health district as the OSMA, where the DSC was implemented in the ED software but remained always masked to the staff.

Other outcomes, limited to patients admitted to Geriatrics, were represented by weight of the Diagnosis Related Groups (DRG) on discharge, total hospital LOS, and hospital mortality.

2.4. Analytic procedures

Statistical analysis was performed with SPSS for Mac, version 25 (IBM Corp, Armonk, NY), and Stata, version 15.1 (StataCorp, College Station, TX). Due to non-normal distribution, interval variables were expressed as median and interquartile range, and categorical variables as percentages.

The Mann-Whitney U test was used to compare interval variables and the χ^2 test to compare relative frequencies, considering trends when appropriate. Logistic regression was used to analyze factors associated with binary outcomes, using the "Enter" method to handle variables in the models. The strength of the association was expressed by calculating ORs and their 95 % CIs. The goodness-of-fit was checked with the Hosmer–Lemeshow test.

Protection against type I error was set at alpha level of 0.05.

3. Results

Overall, 7270 75+ year-old patients were enrolled in the pre-DSC phase and 4725 in the post-DSC phase in the OSMA, for a total of 11,995, after exclusion of 17 patients with incomplete data. Technical issues with the informatic procedure for data linkage and DSC calculation occurred during the run-in period of the pre-DSC phase, making the score unavailable at random in some weeks: the monthly median [IQR] number of patients in whom the score was obtained was 633 [288, 921] in the pre-DSC and 914 [903, 1007] in the post-DSC phase ($p = 0.079$). Demographics were comparable between the two periods: median age was 84 [79, 89] and 84 [80, 88] years ($p = 0.510$) and the proportion of men 42 % and 41 % in the pre-DSC and in the post-DSC period, respectively ($p = 0.357$). The distribution across triage color classes

differed significantly, with a lower prevalence of white and green codes in the pre-DSC (white: n = 1040, 14.3 %; green: n = 3230, 44.4 %; yellow: n = 2788, 38.4 %; red: 212, 2.9 %) than in the post-DSC phase (white: n = 824, 17.4 %; green: 2335, 49.4 %; yellow: 1455, 30.8 %; red: 111, 2.4 %; p for trend<0.001). Conversely, no statistically significant difference was observed in the distribution across DSC classes between the pre-DSC (class I: n = 1256, 17.3 %; class II: n = 1992, 27.4 %; class III: 1967, 27.1 %; class IV: 2055, 28.3 %) and the post-DSC phase (class I: n = 775, 16.4 %; class II: 1378, 29.2 %; class III: 1243, 26.3 %; class IV: 1329, 28.1 %; p for trend=0.166).

In the overall sample, the ED LOS decreased from a median of 380 [206, 958] in the pre-DSC to 318 [178, 655] min in the post-DSC period (p<0.001). In a logistic regression model adjusted for triage color code and DSC class, the OR (95 % CI) for an ED LOS below the median was significantly in favor of the post-DSC period (0.73, 0.68–0.78; p<0.001). In the subsample of patients eventually admitted to Internal Medicine or Geriatrics, the decline in the ED LOS was even greater, from a median of 975 [418, 1,419] min in the pre-DSC to 537 [324, 1,166] min in the post-DSC phase (p<0.001). In this subsample, the odds for an ED LOS below the median was again significantly in favor of the post-DSC phase (OR 0.50, 0.42–0.59; p<0.001), adjusting for triage color code and DSC class in a logistic regression model; the fitting of the model was good (p = 0.940). Across the same months, in the other hospital where the DSC had a masked implementation, the ED LOS in patients eventually admitted to Internal Medicine was 1057 [461, 1,520] min in the first period and 659 [380, 1,330] in the second one: no statistically significant difference was observed between the two periods in the odds of LOS above the median in a logistic regression model, adjusting for triage color code (OR 1.09, 0.62–1.56; p = 0.663), again with a good fitting of the model (p = 0.260).

A total of 550 patients in whom the DSC was available were admitted to Geriatrics and 1928 to Internal Medicine across the two periods. As shown in Fig. 1, the distribution of admissions to Geriatrics across DSC classes differed significantly between the two phases: class III covered the largest share of admissions when the DSC-based clinical decision tree was applied in the post-DSC period (57.7 %), compared to only 38.3 % in the pre-DSC phase (p<0.001). In a logistic regression model adjusted for triage color code and length of ED staying, factors independently associated with admission to Geriatrics were DSC and phase of the study

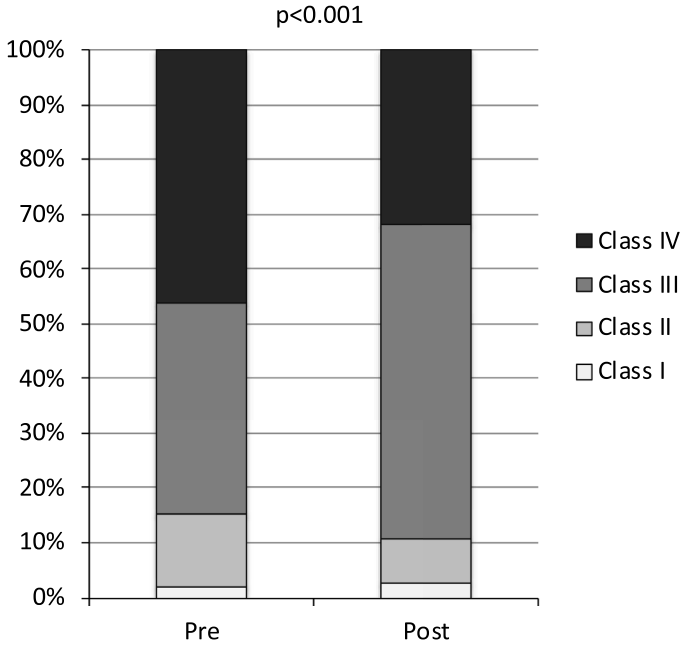

Fig. 1. Comparison of admissions to Geriatrics across the Dynamic Silver Code (DSC) classes between the pre-DSC and the post-DSC phase.

Table 1
Logistic regression model of factors associated with admission to Geriatrics in the two study periods, adjusted for age, color triage code, and ED LOS.

	OR (95 % CI)	p value
Post-DSC vs. pre-DSC study phase	1.99 (1.62–2.45)	<0.001
DSC class III vs. I	3.76 (2.66–5.31)	<0.001
DSC class IV vs. I	1.91 (1.34–2.73)	<0.001

(Table 1), always with a good fitting of the model (p = 0.329). Patients seen in the post-DSC phase were twice as likely to be admitted to Geriatrics as those in the pre-DSC; at the same time, compared to DSC class I, being in DSC class III and IV was associated to an almost four- and two-times greater odds of being admitted to Geriatrics, respectively, independent of age, triage color code, and ED LOS (Table 1).

Two hundred sixty-five patients in whom the DSC was available were admitted to Geriatrics in the pre-DSC and 285 in the post-DSC phase. Among them, hospital LOS decreased by one day, from 7 [5,11] to 6 [5, 9] days (p = 0.006) between the two study periods. The odds of a post-DSC hospital LOS below the median were significant, after adjusting for triage color code (OR 0.67, 0.46–0.98; p = 0.041). At the same time, the weight of the DRG increased slightly but significantly between the pre-DSC and the post-DSC phase (Fig. 2). Fifty patients (19 %) died in-hospital in the pre-DSC and 61 (21 %) in the post-DSC phase (p = 0.459).

4. Discussion

This study shows that the DSC, a prognostic score based on simple administrative data, contributed to improved patient flow and better overall clinical management of older patients in the ED, as suggested by decreased ED LOS, especially in patients eventually admitted to Internal Medicine and Geriatrics wards. Moreover, implementation of the DSC and of a DSC-derived clinical decision tree for assignment to a specific ward appeared to enhance appropriateness of admissions to Geriatrics: in fact, in the post-DSC phase this ward received mostly patients at an intermediate risk (DSC class III), with greater clinical complexity but more chances for improvement and recovery, leading to shorter hospital LOS.

Instruments for risk stratification of older patients in the ED have been developed, but their performance has been in general poor [5]. More recently, the Clinical Frailty Scale (CFS) was validated for use in the ED in patients aged 65+ [11–13], with area under the receiver operating characteristic curve of 0.81 and 0.77 for 30-day and 1-year

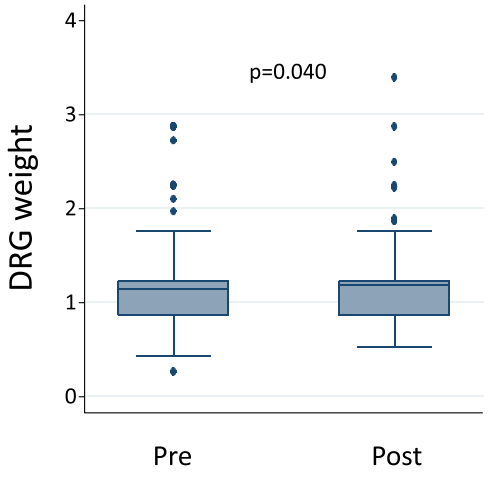

Fig. 2. Comparison of weight of the diagnosis related groups (DRG) between the pre-DSC and the post-DSC phase in patients admitted to Geriatrics. Abbreviation as in Fig. 1.

mortality, respectively [11,12]. However, this tool is complex and requires in-person evaluation, which is difficult to implement because of time constraints and lack of trained personnel in the busy routine of an ED.

Despite their inherent limitations, simple administrative data are an attractive contribution to prognostic assessment of older patients, because they are accurate, objective, easily available at a low cost, and are applicable also in patients unable to communicate [14,15]. These characteristics should be particularly valued in the ED, where extensive application of complex assessment procedures may be challenging [16]. Also, addition of a mobility status as a frailty indicator did not improve the accuracy of a computerized triage system [17]. To our knowledge, the DSC is the only real-time electronic tool for risk stratification of older persons developed for the ED. Our previous studies showed that the DSC is accurate, easily available, and at a low cost. We first reported that it predicts 7-day, 30-day and 1-year mortality [8], then that is associated with measures of pre-existing physical and cognitive impairment [9] and, as ancillary findings in the same publication, that it is able to predict also immediate outcomes, such as ED LOS and hospitalization after the index ED access [9]. However, the effects of its application had never been documented previously. With this study, we provide evidence suggesting that its availability, together with standardized clinical decision rules for assignment to a specific ward, may expedite procedures in the ED, ultimately reducing waiting time and ED LOS. The importance of this finding should be underlined, because older patients stay in the ED longer than younger ones [2,18], and such an increased LOS may by itself contribute to ED-associated complications [2].

Randomized clinical trials (RCTs) and their meta-analyses reported that, compared to Internal Medicine, admission to acute Geriatrics wards may improve survival and functional outcomes of frail older patients requiring hospitalization [19–21], thanks to the delivery of personalized care based on comprehensive geriatric assessment. Participants enrolled in these studies were usually at an intermediate level of clinical severity, whereas those who were too well or too sick were considered unable to draw substantial benefit from admission to a specialized geriatric setting [22]. Our non-randomized intervention study is coherent with the available evidence from RCTs. The clinical decision tree based on the DSC allowed patient selection for direct admission to Geriatrics for those at an intermediate risk (DSC class III), whereas those with low background risk (DSC class I and II) were candidates for Internal Medicine, and an individualized assessment was devised for those at greater risk (class IV). Our findings indicate that this decision tree was indeed correctly applied, therefore improving patient selection and ultimately increasing the efficiency of the Geriatrics ward. In fact, the combination of greater DRG weight and shorter LOS, with unchanged hospital mortality, suggests that patients admitted to Geriatrics in the post-DSC phase could recover faster than those in the pre-DSC phase, even in the face of an increased clinical complexity.

Study limitations must be recognized. We are aware that the pre-post study design is intrinsically weak, as many other variables besides the intervention can modify the outcomes considered. Confounding is better controlled, and causation better ascertained, when a RCT study design is applied. However, this would be difficult, if not impossible, when examining changes affecting the delivery of care in an entire healthcare facility, such a whole hospital. To limit the chances of bias, we adjusted our pre-post comparisons for some indicators of complexity, such as the triage color code and the DSC class. The pre-post groups had indeed comparable demographics and DSC score, but they differed by triage color class: this difference was accounted for by entering triage color class as a covariate in our multivariable models. Other possible sources of variation between the two study periods might be the daily number of accesses and discharges to/from the ED, as well the staffing of the ED and of the wards involved. However, these remained substantially unchanged across the study periods. In addition, adjusting our analyses for triage color class and DSC class, which broadly represent the clinical complexity and the consequent burden on hospital services of our study participants, should have compensated for hypothetical unbalances in these figures. Moreover, we also verified that no differences in ED LOS were observed in another community-based hospital, similar to the OSMA, across the study period. In the pre-DSC phase, availability of the score was erratic and, in fact, the number of patients enrolled monthly was lower, although not significantly, than in the post-DSC phase. For the same reason, patients observed in the Geriatric ward were less in the pre-DSC than in the post-DSC phase, despite longer enrollment period. However, these fluctuations were random and we are, therefore, confident they have not biased our findings. The two study periods had different duration: this was not deliberately chosen, but derived from a combination of different contingent factors, such as limited resource availability and pressure to switch from an investigational to a fully operative phase after DSC implementation. To avoid seasonality, we might have chosen to restrict comparison to a shorter pre-DSC period, but this would have reduced the sample size substantially, and we eventually decided not to follow this option. Variables in the DSC are very simple and cannot convey the whole spectrum of conditions that make an older patient susceptible to poor outcomes. A prognostic assessment based only on administrative data cannot be as accurate and detailed as a clinical one. Nevertheless, our previous studies [8–10] support the predictive validity of the DSC as a population management tool: its simplicity intentionally facilitates its broad application, at least in Italy, where the National Healthcare System warrants universal delivery of services and, at the same time, availability of consistent information to compile the score. This metric and its value need to be tested in ED outside the Italian healthcare system. Only a few indicators (LOS and DRG weight) were available to assess changes in the pre-post comparisons, but these are reliable, important, and easily obtainable from administrative archives. Finally, DRG recorded in the post-DSC phase might have been influenced by a different coding attitude of hospital physicians: however, such a conscious manipulation of DRG coding is unlikely, because physicians were not aware that data, specifically DRG data, were to be collected during this process of clinical practice change.

In conclusion, application of the DSC in the ED of a community hospital was associated with shorter ED LOS of older patients and provided a standardized method identifying older patients most appropriate for admission to a Geriatric inpatient unit. This enhanced the value and efficiency of clinical management of patients admitted to this ward. Further studies should be performed to obtain a more rigorous and extensive assessment of the effects of the implementation of the DSC.

Declaration of Competing Interest

None.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ejim.2023.10.007.

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