ARTICLE IN PRESS

JAMDA xxx (2021) 1–5

JAMDA

journal homepage: www.jamda.com

Original Study

Estimating Prognosis and Frailty in Persons Aged ≥75 Years in the Emergency Department: Further Validation of Dynamic Silver Code

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Keywords:
Prognostic assessment
elderly
frailty
emergency department
dynamic silver code
administrative data

A B S T R A C T

Objectives: To assess concurrent validity of the Dynamic Silver Code (DSC), a tool based on administrative data that predicts prognosis in older adults accessing the emergency department (ED), in terms of association with markers of poor functional and cognitive status.
Design: Cross-sectional.
Setting and Participants: Data were obtained in the AIDEA study, which enrolled a cohort of ≥75-year-old patients, accessing the ED of 2 hospitals in Florence, Italy.
Methods: The DSC score and classes (I to IV, corresponding to an increasing risk of death) were obtained from administrative data. Information on health and functional status prior to ED access were collected from face-to-face, direct, or proxy interviews. The 4AT test was administered to screen for possible delirium. Bivariate comparisons of the prevalence of each functional and cognitive marker across 4 DSC classes were performed. Multinomial logistic regression was used to assess the multivariable risk of being in II, III, or IV DSC class vs I.
Results: Among 3358 participants (mean age 83 years, men 44%), 32.9%, 30.3%, 19.5%, and 17.2% were in DSC class I, II, III, and IV. Preadmission abnormal functional and cognitive conditions, and delirium in the ED, were increasingly more common from DSC class I through IV ($P < .001$). In particular, the prevalence of total inability to walk increased from 2.9% (class I) to 23.4% (class IV). In multivariable analyses, this was the strongest predictor of being in progressively worse DSC classes, whereas feeling of exhaustion, reporting of serious falls, weight loss, and severe memory loss or diagnosis of dementia gave some contribution.
Conclusions and Implications: The ability of the DSC to predict survival in older persons appears to rely on its prevailing association with markers of functional impairment. These results may support clinical use of the tool.

The “Anziani in DEA” study was jointly funded by the Italian Ministry of Health and by the Tuscany Region (RF-2010-2321801). The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript. All the authors were independent from funders, had access to all of the data, and can take responsibility for the integrity of the data and the accuracy of the data analysis.

The authors declare no conflicts of interest.

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https://doi.org/10.1016/j.jamda.2021.05.024

Recent literature reports several non–disease-specific prognostic indices predicting the risk of death in older adults, to be used in different clinical settings.[1,2] These tools have been developed to ground clinical decision making on scientific evidence, rather than on arbitrary age cutoffs. For example, it has been suggested that among older persons needing hospitalization, those who may benefit the most from admission to a geriatric care setting are those at an intermediate risk,[3,4] whereas patients who are too well or too sick are considered unlikely to take advantage from a specialized setting.

The Dynamic Silver Code (DSC) was recently proposed to evaluate, in patients aged ≥75 years accessing the emergency department (ED), the individual background risk of death at 7 and 30 days and 1 year, irrespective of the event leading to ED admission. Being based only on simple administrative health data, the DSC does not require human resources to collect data via personal interview and can be obtained also in non-collaborating patients. According to the DSC, patients are assigned to 4 classes of progressively increasing mortality risk, from class I to class IV.[5]

Although important, the predictive validity of a prognostic score may not be sufficient to advocate its application in clinical practice. Indeed, patients with similar prognosis may exhibit diverse features, suggesting prevalent physical frailty or cognitive impairment: although tightly interconnected and often coexisting, these conditions require different care approaches, within the overarching geriatric approach of comprehensive geriatric assessment (CGA).[6] Thus, comparing the characteristics of patients across the DSC classes, that is, assessing the concurrent validity of the tool against those features characterizing the geriatric patient, would be an important complement and a further stimulus to its application. This represents the primary aim of this study. Accessorily, we examined whether time spent in the ED and subsequent disposition differed across DSC classes, as these 2 immediate outcomes had not been reported in previous DSC studies. To these purposes, we analyzed data collected in the Anziani in DEA (AIDEA) study, standing for "Older Persons in the ED," where the predictive validity of the tool has been already ascertained.[5]

Methods

Study Design and Data Source

The AIDEA project was sponsored by the Italian Ministry of Health and by the Tuscany Region.[5] After approval by the local Ethics Committee (976/13_AOUC), the study was conducted in 2 hospitals in Florence (Italy), the Azienda Ospedaliero-Universitaria Careggi (AOUC), an academic tertiary hospital, and the Ospedale Santa Maria Annunziata (OSMA), a community hospital. Data were collected between June and August 2016 and again between February and March 2017 in the AOUC, and between August and September 2016 in the OSMA, for a total of 22 weeks. In these separate time windows, all patients aged ≥75 years accessing the ED of the participating hospitals were consecutively enrolled, with the only exclusion of those residing outside the Florence metropolitan area, or seeking care only because of ophthalmologic problems. For the purpose of this study, in the case of repeated ED access, only the first one was considered.

As previously described,[5] the DSC was obtained with a software incorporated into the application routinely used by ED clinicians, which has now been definitively implemented in all the hospitals in the Azienda Sanitaria Toscana Centro area and in the AOUC. 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, which is then shown onto the computer screen 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[5] and are summarized in Supplementary Table 1. Briefly, a score, obtained from Cox regression analysis predicting 1-year mortality, is assigned to age, gender, number of drugs prescribed in the previous 3 months, days from previous hospital admission, and its associated main diagnostic group. The DSC is then calculated by summation. The lag time between occurrence of events contributing to the DSC and their registration in the health care data repository is approximately 2 weeks.

As detailed below, face-to-face, direct or proxy interviews were conducted with participants signing the informed consent by the AIDEA project's staff, which included trained health care workers and physicians fellows of the School of Geriatrics. Interview data and DSC classification were compared in a cross-sectional study design, whereas ED length of stay and disposition were considered as possible outcomes of the DSC classification, according to a short-term cohort study design.

Variables

Variables abstracted from the ED clinical records included time of access, DSC class, presence of a proxy, arrival by ambulance, triage color code, time spent in the ED, and disposition, dichotomized as discharge vs death or hospitalization.

The interview, based on the principles of CGA, focused on health and functional status prior to the index event leading to ED access, investigating symptoms of physical frailty (inability to walk 400 m, complete inability to walk, history of falls, and unintentional weight loss of ≥4.5 kg in the previous year) and cognitive decline (severe memory loss in the previous 5 years and previous diagnosis of dementia, referred by the proxy). The Identification of Senior at Risk (ISAR) score[7] was also applied, which classifies as at-risk patients scoring 2 or more. The 4AT, a screening test for cognitive disorders and delirium,[8] was administered to the participant to detect the possible presence of delirium, indicated by a score of 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). Interval variables were expressed as mean ± standard error (SEM) or median and interquartile range, depending on the distribution, and categorical variables as percentages.

The Student *t* and the Mann-Whitney *U* tests were used to compare normally and non-normally distributed interval variables, and the χ^2 test to compare relative frequencies, between individuals included and not included in the study. To assess concurrent validity, bivariate comparisons across the 4 DSC risk classes of each interview variable (with exclusion of age, gender, previous hospitalization, and number of drugs, directly related to the generation of the DSC itself) were conducted with the χ^2 test for trend. The same test was applied to analyze differences in the proportion of participants being hospitalized or dying in the ED, whereas the Kruskal-Wallis test was used to compare the non-normally distributed duration of ED stay, always across the DSC classes.

A multinomial logistic regression model was then built, to assess the risk of being in DSC class II vs I, III vs I, and IV vs I, as odds ratio (OR) and 95% confidence interval (CI), on the basis of all the variables that, at bivariate comparisons, differed across the 4 classes. Although this approach does not account for the ordinal structure of the data, it was chosen because it allows to overcome violation of the proportionality assumption,[9,10] which was indeed revealed for some independent variables by the Brant test ($P < .001$). Being a nursing home resident and having an abnormal ISAR score were not included in this analysis, because these were considered as summary variables, more than descriptors of specific clinical abnormalities. The variable "inability to walk 400 meters" was not included in this analysis, given its potential collinearity with the variable “total inability to walk.” We also excluded the presence of possible delirium, as indicated by the 4AT score, because we focused on conditions preceding ED access, whereas the time of onset of delirium could not be ascertained.

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

Results

The study flowchart is reported in Supplementary Figure 1. Of a total of 6743 records of patients aged ≥75 years accessing the 2 EDs in the time periods considered, 565 were excluded because they referred to repeated ED access. An additional 544 patients were excluded because they resided outside the Azienda Sanitaria Toscana Centro area, 679 because they accessed the ED only for ophthalmologic problems, and 303 because the triage code or the DSC were unavailable because of temporary software problems. Of the remaining 4652 patients, 3439 consented to the interview and were potentially eligible. Another 81 patients were excluded because of missing data in key variables (disposition after ED access, ISAR score, ability to walk 400 m, report of exhaustion, unintentional weight loss, severe loss of memory), leaving a final sample of 3358 AIDEA participants for the present study.

Patients who were or were not included had comparable mean age (83.2 ± 0.10 vs 84.0 ± 0.68; $P = .197$) and gender distribution (proportion of men among those included 44.1%, vs 43.2% among those not included; $P = .873$). The 2 subgroups had comparable distribution by DSC class (Supplementary Figure 2) and median (interquartile range) ED length of stay [included: 356 (222, 807) vs not included: 330 (213, 486) minutes; $P = .277$], but differed in terms of triage color code (Supplementary Figure 3).

Characteristics of the Sample, As a Whole and by DSC Classes

Of the 3358 participants, 1034 (30.8%) were younger than 80 years and 1326 (39.5%) were aged ≥85 years. More than 40% of the interviews were conducted with a proxy. The DSC score ranged from 0 to 84, with a median (interquartile range) of 23 (8, 29) and a mean of 21.8 ± 0.30. A total of 1106 participants (32.9%) were in DSC class I, 1019 (30.3%) in class II, 656 (19.5%) in class III, and 577 (17.2%) in class IV. Most participants were triaged with green (n = 1471, 43.8%) or yellow code (n = 1524, 45.4%), whereas only few of them were assigned white (n = 275, 8.2%) and red (n = 88, 2.6%) codes. The distribution of color triage codes differed across the DSC risk classes ($P < .001$), with participants triaged with white or green code prevailing in DSC class I and being less represented in class IV (Figure 1).

Overall, 111 participants (3.3%) were nursing home residents, 348 (10.7% of the 3249 in whom this information was available) had 24-hour home assistance by salaried personnel, and 2194 (65.3%) arrived at the ED by ambulance. According to several markers, functional status prior to ED access was moderately to severely impaired: 1838 participants (54.7%) reported feeling of exhaustion, 1874 (55.8%) had an ISAR score of 2 or greater, 1554 (46.4%) could not walk 400 m, 359 (10.7%) were completely unable to walk; finally, 1009 participants (30.0%) reported significant unintentional weight loss and 508 (15.1%) 1 or more falls requiring ED access in the previous year.

According to their proxy informant, 716 (21.3%) study participants had substantial memory loss or a formal diagnosis of dementia in the previous 5 years. A score of 4 + at the 4AT test, administered during ED stay to 3188 participants, suggested the presence of possible delirium in 422 participants (13.2%).

As shown in Table 1, the prevalence of preadmission abnormal functional and cognitive conditions, as well as that of delirium, increased progressively across DSC classes. In particular, an almost 10-fold increase was observed, from class I to class IV, in the prevalence of total inability to walk. Table 2 reports findings from the multinomial

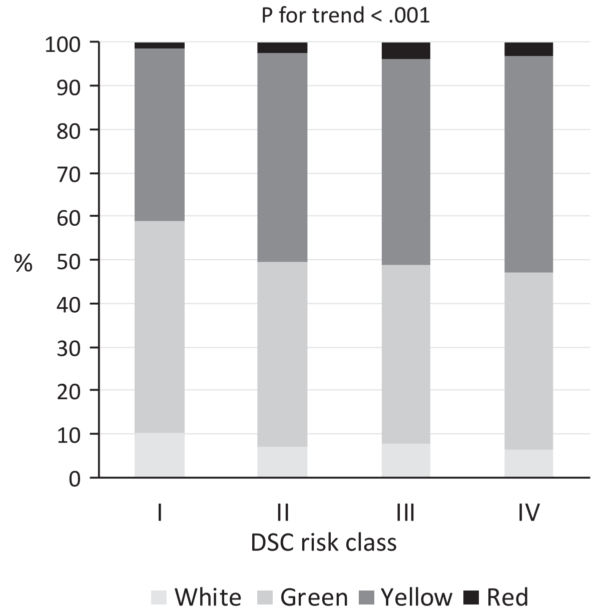

Fig. 1. Distribution of the study participants across triage color codes, by DSC risk classes. Cutoff scores for DSC classes were I: 0-10, II: 11-25, III: 26-34, and IV: 35+.

logistic regression model, where DSC classes II, III, and IV were contrasted to DSC class I as far as variables primarily representing preadmission functional and cognitive impairments. In this model, the ORs for being in a higher DSC class were greater for the variable “total inability to walk” than for the other variables, and increased from the first (class II vs class I) through the last (class IV vs class I) comparison; thus, this variable was the strongest predictor of being in progressively worse DSC classes. The variable “exhaustion” increased the risk of being in a higher class almost homogeneously for all comparisons. Reporting of an ED-requiring fall contributed only to assignment to classes II and III vs class I, whereas the variable “weight loss” contributed only to assignment to class IV vs class I. Finally, the presence of severe memory loss or a diagnosis of dementia gave a significant contribution only to being in class II vs class I.

Short-Term Outcomes

The time spent in the ED increased significantly across the DSC risk classes (Figure 2, top panel). Overall, 1059 participants (31.5%) were

Table 1
Comparison of Study Participants’ Characteristics Across DSC Risk Classes

Characteristic	Class I (n = 1106)	Class II (n = 1019)	Class III (n = 656)	Class IV (n = 577)	*P* for Trend
Nursing home resident	17 (1.5)	33 (3.3)	32 (4.9)	29 (5.1)	<.001
Self-report of exhaustion	515 (46.6)	566 (55.6)	371 (56.6)	386 (66.9)	<.001
ISAR score 2+	389 (35.2)	578 (56.7)	414 (63.1)	493 (85.4)	<.001
Unable to walk 400 m	440 (39.8)	580 (56.9)	371 (56.6)	413 (71.6)	<.001
Totally unable to walk	32 (2.9)	106 (10.4)	86 (13.1)	135 (23.4)	<.001
Weight loss ≥4.5 kg in previous year	255 (23.1)	272 (26.7)	194 (29.6)	288 (49.9)	<.001
Fall with ED access in previous year	119 (10.8)	137 (13.4)	106 (16.2)	146 (25.3)	<.001
Severe memory loss and diagnosis of dementia	158 (14.3)	245 (24.0)	165 (25.2)	148 (25.6)	<.001
Probable delirium, 4AT score 4+	81 (7.5)	140 (14.6)	103 (16.5)	98 (18.6)	<.001

Data are n (%).

Table 2
Multinomial Logistic Regression Model Testing the Multivariable Association Between DSC Class and Selected Markers of Physical Frailty and Cognitive Decline

Marker	Or (95% CI)		
	Class II vs I	Class III vs I	Class IV vs I
Self-report of exhaustion	1.28 (1.08, 1.53)	1.29 (1.05, 1.57)	1.67 (1.34, 2.09)
Totally unable to walk	3.03 (1.99, 4.6)	3.90 (2.53, 6.03)	7.45 (4.88, 11.38)
Weight loss ≥4.5 kg in previous year	1.08 (0.88, 1.32)	1.21 (0.96, 1.51)	2.61 (2.09, 3.27)
Fall with ED access in previous year	1.18 (0.91, 1.54)	1.45 (1.09, 1.94)	2.39 (1.80, 3.17)
Severe memory loss or diagnosis of dementia	1.52 (1.20, 1.92)	1.48 (1.14, 1.92)	1.05 (0.79, 1.39)

hospitalized and 11 (0.3%) died in the ED. The proportion of hospitalizations or deaths in the ED increased substantially across the 4 DSC risk classes (Figure 2, bottom panel).

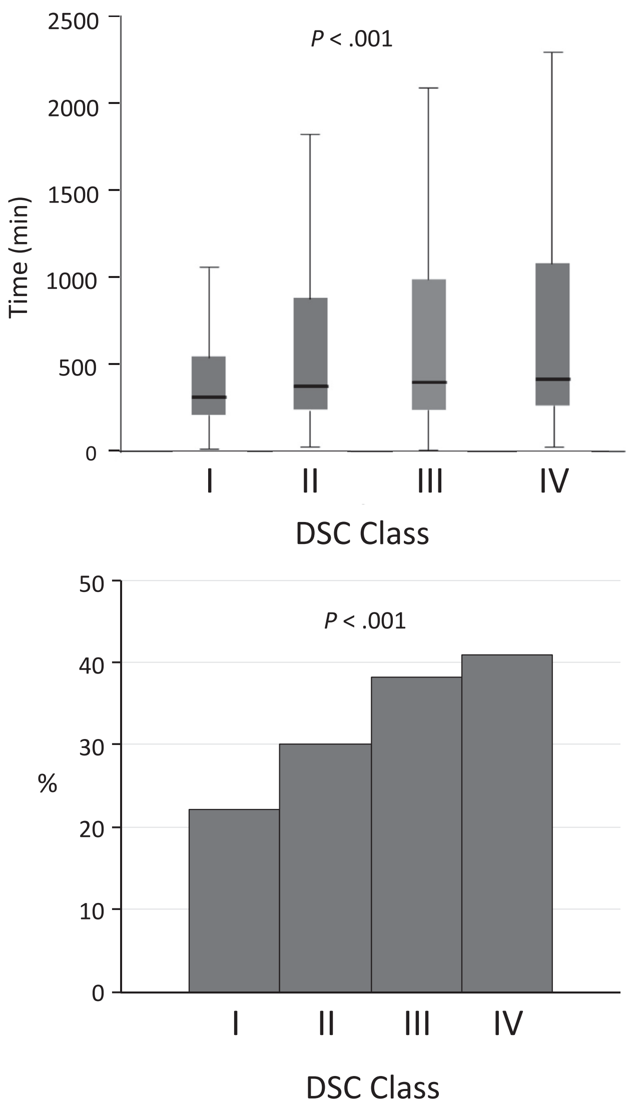

Fig. 2. Time spent in the ED (top panel) and proportion of participants admitted to the hospital or dying in the ED (bottom panel), across DSC risk classes.

Discussion

In this large cohort of older adults admitted to the ED, the definition of the risk status provided by the DSC was associated with previous participant's frailty status, as documented by several indicators, whose prevalence, as well as that of delirium, increased progressively across DSC classes. In particular, inability to walk and, with weaker associations, exhaustion were the 2 variables that more consistently predicted assignment to progressively worse DSC classes. Other markers of poor physical status and the presence of cognitive impairment contributed to this outcome, although to a lesser extent.

It has been previously shown that the DSC could identify older patients at an increased risk of death, independent of the acute condition leading to ED access.[5,11] However, those studies could not indicate which features distinguished patients across risk classes. This study fills this knowledge gap, demonstrating that the higher the DSC risk class, the greater the prevalence of 2 summary markers of preexisting vulnerability, such as living in a nursing home and having an ISAR score of 2 or higher, of some of Fried's hallmarks of physical frailty,[12] and of cognitive impairment. Thus, the DSC is associated with well-known aspects of age-related functional and cognitive decline, which often remain undetected in the busy routine of the ED. Notably, its strong association with inability to walk is consistent with previous studies, showing that walking speed is a major predictor of death in older persons.[13]

Assessment of pre-existing functional status must be part of prognostic judgment in older patients. When this background information is ignored, grim consequences may derive in the 2 opposite directions of futility and undertreatment: many older patients with a limited disability-free life expectancy receive therapies of questionable appropriateness,[14] whereas others with a reasonably good prognosis are denied effective treatments because they are considered too old.[15] Previous investigations where simple administrative data were assembled to predict survival in older persons[16–21] usually did not explore associations with Fried's markers of frailty.[12] The only exception is probably represented by the Hospital Frailty Risk Score (HFRS), which was developed to predict 30-day mortality using a clustering of diagnoses.[18] Unfortunately, agreement of the HFRS with Fried's frailty phenotype, but also with Rockwood cumulative deficit model,[22] was disappointingly low, as shown by kappa statistics of 0.22 and 0.30, respectively.[18] Thus, we believe that our study offers a positive contribution on an issue that, to our knowledge, remained unsolved in previous studies.

Cognitive impairment may severely compromise personal independence and life expectancy in old age.[23,24] Accordingly, in our bivariate comparisons, the proportion of patients with severe memory loss or diagnosis of dementia increased from DCS class I to IV. However, such a diagnosis was only marginally associated with worsening DSC risk classification in the multinomial model. This may possibly reflect the limited accuracy of our diagnostic criteria for cognitive impairment, or it may suggest that, as a prognostic marker, cognitive impairment has some independent value in older individuals whose overall health status and function is still preserved, whereas it is largely surpassed by measures of functional status in the presence of poor health and reduced life expectancy.

A few other findings deserve comments. First, the DSC classes were also associated with triage color codes, with participants triaged as white or green codes prevailing in DCS class I and being less represented in class IV. The statistical significance of such an association should not obscure that, in fact, the 2 classification systems resulted in markedly different distributions: indeed, the study sample was fairly homogeneously distributed across the 4 DSC classes, whereas it was almost completely concentrated in the 2 intermediate color code classes. Thus, in spite of the statistically significant association, the 2 tools convey quite different information. Second, the study shows that also the prevalence of delirium increased progressively across DSC classes. This may simply reflect the association with previous cognitive impairment, discussed above: as a screening test, indeed, the 4AT tool might not discriminate completely delirium from pre-existing dementia.[8,25] On the other hand, this association may be due to the frequent occurrence of delirium in frail older persons with poor health status, even in the absence of known cognitive decline. Finally, the DSC classification was shown to be strongly associated with the time spent in the ED and the proportion of hospitalizations or deaths in the ED; thus, besides long-term survival, short-term outcomes also can be predicted by the tool, a finding further supporting its value.

Study limitations must be acknowledged. We had a relatively high proportion of nonparticipation: nearly a quarter of those potentially eligible for the study did not consent to the interview or gave incomplete answers. This was mostly due to difficulties in performing a face-to-face interview with older patients in an unstable or critical status: red and yellow triage color codes, indeed, prevailed among patients not included in the study. In a way, this finding corroborates the value of the DSC score, which may provide valuable information even in patients unable to collaborate. Furthermore, as discussed above, evaluation of previous cognitive status was fairly imprecise, yet it reflected the approach usually applicable in the ED, where in-depth cognitive evaluation is commonly precluded. We did not compare the DSC with the Clinical Frailty Scale, which has been recently validated also for application in the ED,[26] neither with laboratory markers of frailty, such as hemoglobin and albumin. However, it should be pointed out that the Clinical Frailty Scale provides a summary evaluation of frailty status and does not consent to analytically recognize and score individual physical and cognitive components of frailty, as indeed we aimed doing. Moreover, laboratory markers are less appropriate to identifying frail individuals in the setting of the ED, because they may be commonly altered as an effect of the acute disease leading to ED access.

Conclusions and Implications

This study shows that the DSC reflects well-known components of frailty, and functional impairment in particular, a finding that may justify the good prognostic ability of the tool. We believe that the evidence provided increases the confidence in the DSC and supports its potential for clinical utilization.

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