Prediction of adverse health outcomes in older patients visiting the Emergency Department: the APOP study

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CHAPTER 5

Refinement of the APOP screener

Optimization of the APOP screener to predict functional decline or mortality in older emergency department patients: cross-validation in four prospective cohorts

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Abstract

INTRODUCTION: Many screening instruments to predict adverse health outcomes in older patients visiting the emergency department (ED) have been developed, but successful implementation has been hampered because they are insufficiently validated or not tailored for the intended use of everyday clinical practice. The present study aims to refine and validate an existing screening instrument (the APOP screener) to predict 90-day functional decline or mortality in older ED patients.

METHODS: Consecutive older patients (>/=70years) visiting the EDs of four hospitals were included and prospectively followed. First, an expert panel used predefined criteria to decide which independent predictors (including demographics, illness severity and geriatric parameters) were suitable for refinement of the model predicting functional decline or mortality after 90days. Second, the model was cross-validated in all four hospitals and predictive performance was assessed. Additionally, a pilot study among triage nurses experiences and clinical usability of the APOP screener was conducted.

RESULTS: In total 2629 older patients were included, with a median age of 79years (IQR 74-84). After 90days 805 patients (30.6%) experienced functional decline or mortality. The refined prediction model included age, gender, way of arrival, need of regular help, need help in bathing/showering, hospitalization the prior six months and impaired cognition. Calibration was good and cross-validation was successful with a pooled area under the curve of 0.71 (0.69-0.73). In the top 20% patients predicted to be at highest risk in total 58% (95%CI 54%-62%) experienced functional decline or mortality. Triage nurses found the screener well suited for clinical use, with room for improvement.

CONCLUSION: In conclusion, optimization of the APOP screener resulted in a short and more simplified screener, which adequately identifies older ED patients at highest risk for functional decline or mortality. The findings of the pilot study were promising for clinical use.

Introduction

Up to 45% of all older patients experience functional decline or mortality within three months after an emergency department (ED) visit.[1] Multiple screening instruments have been developed to identify older patients at high risk for adverse functional outcomes.[2, 3, 69, 70] Although guidelines include the policy to screen all older patients who visit the ED,[71] these instruments have been rarely implemented as part of routine care. The frequent rejection of developed screening instruments is likely due to poor external validation or the impossibility to integrate the instrument in daily routine care.[72]

The Stiell criteria lists six major methodologic stages to disseminate and implement a developed screener in daily practice.[73] Previously, we have developed and validated the APOP screener to identify patients at risk of mortality or functional decline.[62] The APOP screener is characterised with a high specificity and high positive predictive value, to rule-in patients at highest risk, compared to the well-known Identification of Seniors at Risk (ISAR)[62] and other screening instruments.[4] To improve the chance of successful implementation in clinical practice, a refinement process of the screener is advised.[73] In this process accuracy can be improved, the screener can be simplified and acceptance among the people who have to use the screener in daily practice can be evaluated.

In the present study we aimed to optimize the APOP screener for predicting 90-day functional decline or mortality in older ED patients by selecting predictors based on pre-defined criteria, cross-validation in patients of four hospitals. Additionally, facilitators and barriers of adoption by triage nurses were evaluated in a pilot study.

Methods

Study design and setting

We conducted a multicentre cohort study among consecutive older patients visiting emergency departments (EDs) of four hospitals in the Netherlands: the APOP study[62]. In short, patients were included from September 2014 – November 2014 in the Leiden University Medical Center (LUMC, , Leiden), from March 2015 – June 2015 in Alrijne hospital (Alrijne, Leiderdorp), from May 2016 – July 2016 in Haaglanden Medical Center, location Bronovo (Bronovo, The Hague) and from July 2016 – January 2017 in Erasmus University Medical Center (Erasmus MC, Rotterdam). Training sessions were organized to guarantee that in all hospitals inclusion procedures were equal. During twelve weeks patients were included in the LUMC (7 days a week, 24 hours a day) and in Alrijne hospital (7 days a week, from 10AM-10PM). In Bronovo and Erasmuc MC we aimed to include 500 patients. In Bronovo inclusion was performed 6 days a week, from 10 AM-10 PM and in Erasmus MC 4 days a week (including weekend days) from 10 AM- 10 PM. All patients aged 70 years and over were eligible for inclusion. Exclusion criteria were: red triage category (highest acuity) according to the Manchester Triage System (MTS),[44] an unstable medical condition, no permission of nurse or physician to approach the patient, a language barrier and impossibility to obtain informed consent. The medical ethics committees waived the necessity for formal approval of the study protocol, as the study closely followed routine care. Written informed consent was obtained of all patients or relatives before inclusion.

Baseline

At baseline, data on three domains were assessed. First, demographics including age, sex, living arrangement and level of education. Living arrangement was defined as patients living independent with others, independent alone or in a residential care centre or nursing home. High education includes patients with vocational training or university. Second, severity of disease indicators, included arrival by ambulance, fall related ED visits, triage urgency and chief complains as obtained with the Manchester Triage System (MTS), was scored.[44] The 52 possible chief complaints were classified into seven main groups (supplementary table 1). Third, the geriatric parameters included the presence of polypharmacy, use of walking device, Katz ADL (activities of daily living) score[46] and cognition measured by the six item Cognitive Impairment Test (6-CIT).[45] Polypharmacy was defined as the use of five or more different medications at home, self-reported by the patient. The Katz ADL evaluates the ADL situation two weeks prior to the ED visit with six yes/no questions on basic activities of daily living (zero to six point scale). Higher scores indicate more dependency. The 6-CIT is a short cognition test with scores ranging from 0-28, with a score of 11 or higher indicating moderate to severe cognitive impairment, comparable to an MMSE of 24 or lower.[48] To reduce the number of questions needed to be asked to test cognition, all possible single 6-CIT questions were combined. The

combination with the highest Phi correlation coefficient was selected (supplementary table 2). Patients were considered cognitively impaired if they incorrectly answered the question 'what year is it now?' and/or 'say the months in reverse order' (incorrect if two or more errors in months). If the patient is diagnosed with dementia or if it is impossible to obtain answers for the two questions for any reason (e.g. due to mental status), cognition was also considered to be impaired.

Outcome

The primary adverse health outcome was the composite outcome of functional decline or mortality at 90 days follow-up, equal to the development study and to ensure that screening can be implemented for all geriatric ED patients.[62, 74] Mortality was incorporated into the composite outcome, as it can be seen as ultimate decline. Functional decline was defined as at least one point increase in Katz ADL score or new institutionalization (e.g. nursing home admission) at 90 days after ED visit. To obtain follow-up data, patients were contacted by telephone 90 days after the ED index visit. In case of no response after three attempts the general practitioner was contacted to verify phone number and living arrangement (new institutionalization). Finally, to patients who could not be contacted, a letter was sent with a request for a written response. Data on mortality were obtained from the municipal records.

1. Refinement of predictors in the model

The original APOP screener, which predicts 90-day functional decline or mortality and solely 90-day mortality, was developed with data of LUMC patients and validated with Alrijne patients.[62]. For refining of the model, instead of redeveloping the APOP screener with regression techniques, selection criteria were formulated to select predictors[Box 1].[38] The five most important criteria for a strong and user friendly prediction model were extracted and reformatted with permission. Consensus to meet all five criteria of predictors was obtained in a multidisciplinary meeting consisting of physicians (emergency medicine, internal medicine and geriatrics), nurses (emergency medicine, internal medicine and geriatrics) and a statistician.

Box 1: Selection criteria for predictors

Selection criteria	Explanation
Applicable	The collection and definition of predictors should follow routine clinical care as good as possible and require as little extra work as possible
Reliably measured	Objective and robust predictor to reduce inter-observer variability or variability between different hospitals.
Easily measured	Predictor should be fast and easy to obtain, to ensure screening can be finished in short time.
Early available	Predictor should be available at the moment of triage of the patient
Strong predictors	Based on the strength of association with outcome Based on the prevalence of predictor. A wide distribution is preferred over a narrow distribution.

2. Cross-validation of the screener

The final selection of predictors represent the APOP screener and were cross-validated in four hospitals. The LUMC is an academic hospital in with a level 1 trauma centre and Alrijne hospital is a community hospital with a level 2 trauma centre. Both hospitals are located in a small city. The Bronovo hospital is an community hospital with a level 2 trauma centre. The Bronovo hospital is located in a district with relatively many wealthy older people. In the region patients with a suspicion of hip fracture will be sent to the Bronovo. The Erasmus MC is an academic hospital with a level 1 trauma centre and located in the centre of a big city.

3. Pilot study for usability and acceptance of the screener

Eight triage nurses were instructed to use the refined APOP screener for one week in patients aged 70 and over to track the time needed to complete the screening and evaluate usability. Afterwards, an evaluation form was sent to the nurses to get an first impression of possible barriers and clinical application of the APOP screener. A five-level Likert scale was used to score results with the possibility to score strongly disagree (1), disagree (2), neither agree nor disagree (3), agree (4) and strongly agree (5). It was possible to write down additional feedback in free text.

Statistical analysis

Baseline descriptive characteristics are presented as numbers with percentages (%) and median with inter quartile ranges (IQR). Multivariable binary logistic regression was used to estimate the regression coefficients of the prediction model for 90-day functional decline or mortality. Calibration of the prediction model was graphically displayed with calibration plots.[75] A minimum number of 10 events per candidate predictor was used to obtain good predictions with adequate statistical power.[38] Validity of the model was assessed with an internal-external validation design.[76] The robustness of the model was evaluated by a leave-one-hospital-out cross-validation procedure, with patients of each single hospital representing the validation cohort for a model based on the patients of the other three hospitals.[77] External validity was assessed by pooling the cross-validated area under the receiver operating characteristic curves (AUCs) of the four single hospitals using a random-effect meta-analysis.[77] Predictive performance of the model was evaluated for the patients with the highest 30%, 20% and 10% predicted risk, with sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), positive likelihood ratio (LR+) and negative likelihood ratio (LR-). Additionally, the prediction model, calibration plot and predictive performance for solely 90-day mortality was assessed. Mean Likert scale scores with standard deviation (SD) were used to analyse usability of the screener. Analysis was performed with IBM SPSS statistics version 23 and R software (version 3.1.1.)

Results

A total of 3,544 individual patients aged 70 years and older visited the emergency departments (EDs) of the four hospitals combined during the inclusion of the study period. Of those, 3,147 were eligible for inclusion in the APOP study. In total 2,629 patients were included (84% of the eligible patients (figure 1)).

Table 1 shows the baseline characteristics of the APOP study population and stratified per study centre. The median age was 79 years (IQR 74-84) for the combined group, ranging from a median of 76 years in the Erasmus MC to median 82 years in Bronovo. In total 1,236 patients (47.0%) were male, 1,339 patients (50.9%) arrived by ambulance and 659 patients (25.1%) experienced a fall prior to the ED visit. Polypharmacy was found in 1,552 patients (57.9%). Impaired cognition was present in 492 patients (20.5%).

Table 1: Baseline characteristics of older patients visiting the emergency department

	All (N = 2629)	LUMC (N = 751)	Alrijne (N = 881)	Bronovo (N = 498)	Erasmus MC (N = 499)
Demographics					
Age (years), median (IQR)	79 (74-84)	78 (74-83)	80 (75-84)	82 (75-87)	76 (73-80)
Male, n(%)	1236 (47.0%)	362 (48.2%)	427 (48.5%)	164 (32.9%)	283 (56.7%)
Living arrangement, n (%)					
Independent with others	1421 (54.1%)	414 (55.1%)	498 (56.5%)	208 (41.8%)	301 (60.4%)
Independent alone	991 (37.7%)	274 (36.5%)	314 (35.6%)	231 (46.4%)	172 (34.5%)
Residential care or nursing home	216 (8.2%)	63 (8.4%)	69 (7.8%)	59 (11.8%)	25 (5.0%)
High educated, n (%)	586(22.4%)	155 (20.6%)	164 (18.6%)	147 (29.6%)	120 (24.3%)
Severity of disease indicators					
Arrival by ambulance, n (%)	1339 (50.9%)	405 (53.9%)	432 (49.0%)	256 (51.4%)	246 (49.3%)
Triage urgency, n (%)					
> 1 hour (green)	717 (27.3%)	159 (21.2%)	353 (40.1%)	104 (20.9%)	101 (20.2%)
< 1 hour (yellow)	1534 (58.3%)	391 (52.1%)	470 (53.3%)	347 (69.7%)	326 (65.3%)
< 10 min (orange)	378 (14.4%)	201 (26.8%)	58 (6.6%)	47 (9.4%)	72 (14.4%)
Chief complaint, n (%)					
Minor trauma	815 (31.0%)	218 (29.0%)	232 (26.3%)	232 (46.6%)	133 (26.7%)
Malaise	465 (17.7%)	137 (18.2%)	176 (20.0%)	85 (17.1%)	67 (13.4%)
Chest pain	393 (14.9%)	111 (14.8%)	167 (19.0%)	57 (11.4%)	58 (11.6%)
Dyspnea	320 (12.2%)	76 (10.1%)	131 (14.9%)	43 (8.6%)	70 (14.0%)
Abdominal pain	282 (10.7%)	84 (11.2%)	96 (10.9%)	35 (7.0%)	67 (13.4%)
Loss of consciousness	146 (5.6%)	49 (6.5%)	38 (4.3%)	14 (2.8%)	45 (9.0%)
Others	208 (7.9%)	76 (10.1%)	41 (4.7%)	32 (6.4%)	59 (11.8%)
Fall prior to ED visit, n (%)	659 (25.1%)	211 (28.1%)	192 (21.8%)	179 (35.9%)	77 (15.4%)
Geriatric measurements					
Polypharmacy, n (%)	1552 (57.9%)	441 (58.7%)	509 (57.8%)	241 (48.4%)	331 (66.3%)
Use of walking device, n (%)	1114 (42.5%)	302 (40.2%)	378 (42.9%)	243 (48.9%)	191 (38.4%)
Katz ADL score, median (IQR)	0 (0-1)	0 (0-1)	0 (0-1)	0 (0-2)	0 (0-1)
Impaired cognition, n (%)	492 (20.5%)	140 (19.9%)	174 (21.6%)	111 (23.9%)	67 (15.9%)

N = number, IQR= Interquartile range, ADL = activities of daily living, ED = emergency department
Missings
LUMC: 5 level of education, 4 walking device, 6 Katz ADL score, 47 impaired cognition
Alrijne: 3 level of education, 3 walking device, 22 Katz ADL score, 75 impaired cognition
Bronovo: 2 level of education, 1 walking device, 3 Katz ADL score, 33 impaired cognition
Erasmus: 1 living arrangement, 6 level of education, 2 walking device, 9 Katz ADL score, 77 impaired cognition

1. Refinement of predictors in the model

Table 2 shows the results of the selection of the predictors based on the predefined criteria. The APOP screener consists of seven predictors which meet all criteria: age, gender, arrival by ambulance, need of regular help (IADL), need for help with bathing or showering, hospitalization in the prior 6 months and impaired cognition. Arguments of ineligibility of the other predictors can be found in supplementary table 3.

Table 2: Selection of predictors for refinement of the APOP screener

	Applicable	Reliably measured	Easily measured	Readily available	Strong predictor
Age	+	+	+	+	+
Gender	+	+	+	+	+
Living arrangement	-	+	+	+	+
Level of education	+	+	+	+	-
Arrival by ambulance	+	+	+	+	+
Triage category	+	-	+	+	-
Chief complaint	+	-	+	+	+
Fall prior to ED visit	+	-	-	+	+
Vital measurements	+	+	+	-	-
Laboratory results	+	+	+	-	+
Polypharmacy	+	-	-	+	+
Use of walking device	+	+	+	+	-
Need regular help (IADL)	+	+	+	+	+
Need help bathing showering	+	+	+	+	+
Need help dressing	+	+	+	+	-
Hospitalized past 6 months	+	+	+	+	+
Impaired cognition	+	+	+	+	+

In bold: eligible predictors

ED: Emergency department, IADL: Instrumental activities of daily living

Table 3: Prediction model for 90-day functional decline or mortality in older patients visiting the emergency department

	OR (95% CI)
Age (per 5 years increase)	1.30 (1.21-1.40)
Male	0.93 (0.78-1.12)
Arrival by ambulance	1.58 (1.32-1.91)
Need help prior to ED visit (IADL)	1.71 (1.39-2.10)
Need help bathing or showering	1.76 (1.40-2.21)
Hospitalized past six months	1.54 (1.27-1.87)
Impaired cognition	1.29 (1.06-1.57)

OR = odds ratio, ED = emergency department, IADL = instrumental activities of daily living
Equation:
1/(1+exp(-(-5.848 + 0.262 x 'age/5)' + -0.072 x 'male' + 0.460 x 'arrival by ambulance' + 0.534 x 'need help prior to ED visit' + 0.567 x 'need help bathing or showering' + 0.432 x 'hospitalized past six months' + 0.255 x 'impaired cognition')))
Application: http://screener.apop.eu

2. Cross-validation of the screener

A total of 139 out of 2,629 patients (5.3%) were lost to follow-up for data on physical functioning, but from municipal records we verified that they were alive. The incidence of 90-day composite outcome in the study population was 30.6% (805 out of 2,629 patients) (supplementary figure 1). Table 3 shows the result of the multivariable logistic regression of the refined screener. All selected predictors, except gender, were statistically significant associated with the outcome. The individual predicted risk of a patient to experience the outcome can be calculated by using the equation in the legend of the table or by using a free web-based calculator: http://screener.apop.eu/. Cross-validation of the screener was successful, with comparable AUC's between the four individual hospitals (figure 2). External validity of the screener was good, with a pooled AUC of 0.71 (95%CI 0.69-0.73). The predicted probabilities were in line with the observed, as can be seen in the calibration plot (supplementary figure 2). Predictive performance for 90-day functional decline or mortality is shown for the 30%, 20% and 10% patients at highest risk (table 4). Stricter thresholds for high risk increased specificity, positive predictive value (PPV) and positive likelihood ratio (LR+). The PPV for 90-day functional decline or mortality was 0.53 (95%CI 0.49-0.56) in the 30% patients at highest risk, 0.58 (95%CI 0.54-0.62) in the 20% patients at highest risk and 0.60 (95%CI 0.54-0.66) in the 10% patients at highest risk.

An additional analysis was performed to predict 90-day mortality as a separate end point (supplementary material). In total 9.9% of the patients (259 out of 2,629) deceased within 90 days after visiting the emergency department (supplementary figure 1). Accuracy of the refined screener was good with an AUC of 0.74 (95%CI 0.71-0.77) (supplementary table 3), calibration was successful (supplementary figure 2) and the PPV ranged from 0.20 (95%CI

0.17-0.23) for the 30% patients at highest risk to 0.28 (95%CI 0.23-0.34) for the 10% patients at highest risk (supplementary table 4).

3. Usability and acceptance of the screener in the pilot study

A total of 60 patients was screened by eight triage nurses. The mean time to complete the screener was 93 seconds (SD 29). The overall rating of clinical usability was positive, with a mean Likert score of 3.79 (SD 0.63) (supplementary table 5). The screener was easy to administer, the triage nurses found it important to screen and experienced no big burden for the patient. In current form some nurses experienced an increase in workload. These nurses advised that workload can be reduced by incorporating the APOP-screener in the electronic patient files instead of using the web-based application.

Table 4: Predictive performance of final prediction model for 90-day functional decline or mortality (N=2608)

	Number of patients at risk	Sens (95% CI)	Spec (95% CI)	PPV (95% CI)	NPV (95% CI)	LR+ (95% CI)	LR- (95% CI)
30% at highest risk	780	0.52 (0.48-0.55)	0.80 (0.78-0.81)	0.53 (0.79-0.56)	0.79 (0.77-0.81)	2.51 (2.24-2.81)	0.61 (0.57-0.66)
20% at highest risk	521	0.38 (0.35-0.41)	0.88 (0.86-0.89)	0.58 (0.54-0.62)	0.76 (0.74-0.78)	3.15 (2.71-3.67)	0.71 (0.67-0.74)
10% at highest risk	260	0.20 (0.17-0.23)	0.94 (0.93-0.95)	0.60 (0.54-0.66)	0.73 (0.71-0.74)	3.40 (2.69-4.30)	0.85 (0.82-0.88)

Sens = sensitivity, Spec = specificity, PPV = positive predictive value, NPV = negative predictive value, LR+ = positive likelihood ratio, LR- = negative likelihood ratio, CI = confidence interval

Discussion

The screener was refined by selecting predictors based on predefined criteria for predicting 90-day functional decline or mortality in older emergency department patients. The refined model was cross-validated in four hospitals and showed satisfactory discrimination and calibration. Predictive performance was good, with high positive predictive values. A pilot performed by triage nurses showed adequate usability of the screener in clinical practice, with room for improvement.

In the present study the screener was refined in order to increase its usefulness in clinical practice. In a multidisciplinary meeting predictors were chosen with predefined generally accepted criteria,[38] which took into account both the association with the outcome and possible barriers for implementation. Compared to the original model, gender and cognition were added and number of medications was removed. Gender is readily information upon attendance and associated with the outcome.[62, 78] Impaired

cognition is highly prevalent in the ED,[18, 20] and frequently underdiagnosed[79] and is associated with functional decline.[80, 81] Although number of medications is known to be associated with functional decline and mortality,[62] the predictor was not selected for other reasons. Inter observer variability can easily be introduced due to the combined medications of different pharmacological sub classifications or prescribed 'as-needed' and patients tend to hand over pill boxes, which takes too much time at the moment of triage. At the end, the refinement process resulted in a more simplified screener, based on a large heterogenetic group of older patients.

The refined APOP screener was successful cross-validated in four different hospitals, with universal predictors . The study population was representative, with a high proportion of included patients. We therefore assume that the screener is generalizable for EDs in Western countries, but needs to be external validated for confirmation first. Predictive performance of the APOP screener differs compared to the Identification of Seniors at Risk (ISAR) tool[2] and Triage Risk Screening Tool (TRST)[3]. Sensitivity of the ISAR and TRST are higher (pooled estimate 0.79 and 0.66) and both the specificity (pooled estimate 0.37 and 0.47) and positive likelihood ratio (pooled estimate 1.25 and 1.23) are lower.[4] Although a higher sensitivity will including more patients who will decline, the increased risk to experience the composite outcome for the 'high risk' group by using the screener is minimal. According to these estimates, given the baseline risk of 30% for experiencing the composite outcome, patients with a positive ISAR or TRST screening have a risk of 35% to experience the outcome. We suggest to effectively select patients at highest risk, enabling clinicians to take measures in a smaller group of patients with a higher risk of a potential adverse outcome. The cut-off was therefore set for the 20% patients at highest risk.[56] The risk of experiencing functional decline or mortality in this high risk group increases from 30% (incidence) to 58% (PPV).

Usability of the screener was evaluated among triage nurses in a pilot. With a mean time of 93 seconds to complete screening, the APOP screener is now shorter compared to the original screener. Although the screener was easy to administer and no burden for the patient, suggestions for improvement were given. Some triage nurses experienced difficulties in obtaining the screening result via the web-based application. To make the screener more applicable for routine care, the screener needs to be integrated in the electronic patient files. Second, no follow-up interventions were conducted after screening yet, which ensures that some nurses experienced that workload rather increased than decreased. As an example, in order to reduce the ED length of stay, a fast-track admission trajectory can be developed in high risk patients who need to be hospitalized. We are currently developing a concomitant educational program to train medical personal and will take the feedback into account.

The APOP screener has been prospectively validated[62] and in the present study the screener is successfully refined to increase its usefulness in clinical practice while preserving predictive performance. The next step is to implement the APOP screener in clinical practice. In addition, an implementation study will be conducted to translate the research into clinical practice and to achieve acceptance of the screener of involved stakeholders. At the same moment the educational program will be disseminated to increase awareness of all health care professionals, of which low-risk patients also will benefit. In patients at high risk for functional decline or mortality and in patients with impaired cognition, follow-up actions and interventions will be conducted[Box 2]. Effect of the interventions on outcomes, including quality of life, will be evaluated.[82] After patient and physicians acceptance is evaluated, the balance between 'costs' and 'benefits'[41] will be investigated and a strategy for wide-spread dissemination and implementation will be developed.

Box 2: Overview of possible actions and interventions after screening result

	High risk functional decline or mortality	**Impaired cognition**
Emergency Department		
(triage) Nurse	Informs involved health care professionals If patient is alone, ask family member or care giver to come to the ED. Nurses patient on a comfortable bed	Informs involved health care professionals If patient is alone, ask family member or care giver to come to the ED. Nurses patient on a comfortable bed Starts multicomponent delirium prevention measures
(ED) Physician	Takes the screening result into account in the diagnostic process (e.g. screen for delirium) and decision making.	
Patients discharged home		
(triage) Nurse	Put patient on the list to call back the next day to verify status and to answer questions	Put patient on the list to call back the next day to verify status and to answer questions
(ED) Physician	Informs general practitioner (by telephone or email)	Hands over paper discharge instructions Informs general practitioner (by telephone or email)
Patients admitted to the hospital		
(triage) Nurse	Informs colleague Invites family member or care giver to stay with the patient during transfer	Informs colleague Invites family member or care giver to stay with the patient during transfer
(ED) Physician	Informs colleague Ask geriatric liaison service in consultation	Informs colleague Ask geriatric liaison service in consultation

Some limitations have to be addressed. First, we were not able to investigate all potentially important determinants of the composite outcome (e.g. malnutrition or the presence of care givers). Second, the screener needs further validation to obtain performance in other countries. Third, the pilot study has insufficient power to draw firm conclusions and did not test the effect of applying measures in high-risk patients. Currently we are conducting a large implementation study of the refined APOP screener. Our study has several strengths. First, a large unselected group of older patients visiting the ED of four hospitals was included (84%) with a high follow-up rate (95%). Second, the prospective design of the study enabled to take important geriatric parameters, such as cognition, into account. Third, the differences between baseline characteristics in study centers and the internal-external validation design enabled to use as much possible data to increase generalisability of the screener.

In conclusion, optimization of the APOP screener resulted in a short and more simplified screener, which adequately identifies older ED patients at highest risk for functional decline or mortality. The findings of the pilot study were promising for clinical use.

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