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Validation of the acutely presenting older patients tool in a real world setting: results from a large clinical hospital in the Netherlands

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ABSTRACT

Introduction: The number of older patients visiting the emergency department (ED) is increasing. The Acutely Presenting Older Patients (APOP) screener has been developed to identify older patients at highest risk of mortality or functional decline after the hospital visit. In this study we aim to assess association between the APOP score and mortality for older patients presenting in the ED at the Maasstad hospital using real world data.

Methods: Within this retrospective cohort study, all patients aged 70 years and older, who visited the ED of the Maasstad Hospital in 2021 were included. The use of the APOP screener is standard practice at the ED of the Maasstad Hospital. Patients who were triaged red with the Manchester Triage System were excluded from the analyses.

Results: 6136 patients of 70 years and older were included at the ED of the Maasstad Hospital. 70.9 % of these patients had a filled APOP screener. Of those patients, 663 died (15.2 %). Mortality rate was lower in patients with a negative APOP screener than in patients with a positive APOP screener (9.7 % vs 25.6 %), with an odds ratio of 2.08 (CI95% 1.88–2.30).

Conclusion: This study shows that the APOP screener, when used in the real word, has a fairly high association with three month mortality, even when adjusting for other variables that could indicate frailty. Furthermore the fill-in rate, in the real world, is high which shows that its implementation in a large teaching hospital is feasible.

1. Introduction

The number of older patients visiting the emergency department (ED) is increasing (Kahn et al., 2016). These older patients have a higher chance of functional decline and an increased risk of mortality (Ukkonen et al., 2019; Wittenberg et al., n.d.; Tanderup et al., 2018). Approximately 30 % of patients aged over 70 years of age, who visit the ED, experience a permanent functional decline (de Gelder et al., 2018). Such functional decline decreases quality of life and may lead to institutionalization.

Dutch guidelines state that every patient above 70 years of age, visiting the ED, has to be screened for their risk of functional and/or cognitive decline (NVKG, 2021). In the ED of the Maasstad Hospital the Acutely Presenting Older Patients (APOP) screener is used. The APOP screening tool has been developed and validated to identify older patients at highest risk of undesirable outcomes such as mortality or

functional decline after the hospital visit (de Gelder et al., 2016). The APOP screening tool provides two separate risk quantifications. One for the risk of functional decline or three month mortality and one for the risk of cognitive decline.

The APOP screener has been proven to be positive, in either domain, in approximately 35 % of patients above 70 years of age that are screened (Blomaard et al., 2021). When hospitalized, approximately 20 % of those with a positive APOP score died within three months after their hospitalization (de Gelder et al., 2018). After a positive screening, the second step should be to provide targeted interventions during the ED visit (Blomaard et al., 2021). Current guidelines recommend that a positive screener is followed by a (comprehensive) geriatric assessment ((C)GA). A CGA is used to fully explore all risk factors for functional decline and provide information on domains that are important for improving quality of life e.g. nutrition, functionality or cognition (NVKG, 2021).

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After the validation process the APOP program was implemented in several hospitals in the Netherlands (de Gelder et al., 2018; Blomaard et al., 2021). To our knowledge, no additional studies have been published to further study the association of a positive APOP screener and three month mortality when adjusting for possible confounders, such as variables that are present in a CGA but are not added in the APOP screener. Our study adds to the existing studies by presenting real world data, which gives insights to the functionality of the APOP screener in an uncontrolled setting. Furthermore, it gives insights in the added benefits of other variables that indicate frailty.

Therefore, in this study we aim to assess association between the APOP score and mortality for older patients presenting in the ED at the Maastricht hospital using real world data. Furthermore, we aim to assess if separate covariates that all are part of a CGA, which is currently used to predict risk of functional decline and mortality in frail older patients, have an added value to the APOP screener.

2. Methods

2.1. Study design & participants

Within this retrospective cohort study, all patients aged 70 years and older, who visited the ED of the Maastricht Hospital in 2021 were included. The use of the APOP screener is standard practice at the ED of the Maastricht Hospital. All patients, who visited the ED in 2021 were included in the analysis. Patients who were triaged red according to the Manchester Triage System, i.e. deemed acutely ill, at presentation could not be included in our sample, because APOP screener is not used in these patients to minimize time delays. The study protocol was approved by the institutional review board of the Maastricht Hospital. As data collection followed the routine practice, the board waived the necessity for informed consent of the individual patients.

2.2. Data collection

2.2.1. The APOP screening tool

The APOP screening tool is developed in the Netherlands for acutely presenting older people in the ED, which is used to predicted mortality and functional decline in the next three months. It is comprised of nine questions that are related to daily function and cognition. Besides age and sex/gender, the first questions are related to the level of function of the patient: if they arrived at the ED by ambulance, if the patient needed external help regularly before the ED visit, if the patient needed help with bathing or showering before the ED visit and if the patient has been admitted to the hospital in the past six months. The last three questions are related to the cognition of the patient: the first question is if the patient has a diagnosis of dementia. If the answer to this is negative the patient is asked to tell what year it is and if they can recount the months of the year backwards (de Gelder et al., 2016).

2.2.2. Covariates

Study parameters collected at the ED are: age at time of presentation in years, sex and polypharmacy as registered according to the pharmacy assistant. Triage color as determined by a ED nurse according to the Manchester Triage System (MTS). Other parameters are collected during hospital admission, which include: BMI (in kg/m²) as filed during hospital stay, risk of malnutrition based on the short nutritional assessment questionnaire (SNAQ) score during hospital stay, risk of falling based on the John Hopkins fall assessment during hospital stay, risk of delirium based on the 'delirrisico' (delirium risk) assessment tool and functional status according to the Katz activities of daily living (ADL) questionnaire.

Interviews with the patient and his/her relatives were conducted at the ED or during hospital stay to obtain the following parameters: marital status, smoking, use of alcohol, restrictions in visual or hearing capacity and presence of urine incontinence.

2.3. Outcomes

The primary objective of this study is to validate the predictive value for mortality of the APOP screening tool in patients with a positive versus patients with a negative outcome.

Secondly, in a subpopulation of the patients that was admitted to the hospital, to determine the predictive power of the APOP, analyses were performed when adjusting for factors that are a part of a CGA and are not included in the APOP screener. These factors were: malnutrition, risk of delirium, fall risk, incontinence, visual impairment, hearing impairment (NVKG, 2021). The secondary analysis was done, as part of the current guidelines that present a CGA as a golden standard to determine frailty in older patients (NVKG, 2021).

2.4. Statistics

Data was analysed using descriptive statistics, as well as a multivariate logistic regression using mortality as outcome and patients with a negative outcome on the APOP screener as reference group, while adjusting for other study parameters of interest. Furthermore, AUC's were calculated to determine the discrimination of the model for the different outcomes. For analysis IBM SPSS Statistics v26 and Stata were used. *P*-values were considered statistically significant when <0.05.

3. Results

3.1. Study population and baseline characteristics

In 2021, a total of 6136 patients of 70 years and older presented at the ED of the Maastricht Hospital in Rotterdam. Of these patients, 102 patients (1.6 %) were triaged red and excluded from analysis. The baseline characteristics can be found in Table 1. The mean age at presentation was 79.7 years (SD 6.8 years). Of all patients 14.7 % (*n* = 905) died within three months after presentation at the ED. Absence of the data of a completed APOP screener was not associated with mortality (OR of 1.14 (CI95% 0.98–1.34). Sensitivity analysis showed comparable groups, whereby data was assumed missing at random (Table 1). (See Fig. 1.)

A completed APOP screener was present at 70.9 % of cases (*n* = 4352), a summary can be found in Table 2. Patients with a completed APOP screener, did not differ significantly from patients without a

Table 1
Characteristics of study population.

	All (<i>n</i> = 6136)	APOP completed (<i>n</i> = 4352)	APOP not completed (<i>n</i> = 1784)	<i>P</i> -value
Male sex, no. (%)	2835 (46.2)	2034 (46.7)	801 (44.9)	0.190
Age (years), mean (SD)	79.7 (6.8)	79.9 (6.8)	79.5 (6.7)	0.054
Number of medications, mean (SD)	5.8 (5.2)	5.8 (5.2)	5.6 (5.2)	0.141
Duration of hospital stay (hours), mean (SD)	108.5 (138.0)	110.3 (136.8)	103.2 (141.4)	0.135
Color of triage, no. (%)				<0.001
Blue	36 (0.6)	15 (0.3)	21 (1.2)	
Green	1342 (21.9)	872 (20.0)	470 (26.3)	
Yellow	3249 (52.9)	2446 (56.2)	803 (45.0)	
Orange	1418 (23.1)	1014 (23.3)	404 (22.6)	
Unknown	91 (1.5)	5 (0.1)	86 (4.8)	
3-month mortality, no. (%)	905 (14.7)	663 (15.2)	242 (13.6)	0.094

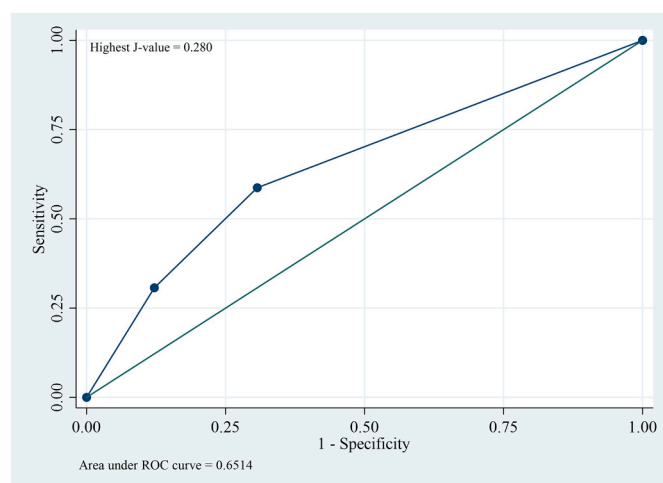


Fig. 1. Area under the receiver operator curve of the APOP screener. The AUC shows an outcome of 0.65 (CI95% 0.63–0.67, SE 0.012).

Table 2

Descriptives of the outcome of the APOP screening tool.

APOP Score	Patients (n = 6136)
No impairment	2830 (46.1)
Functional or cognitive impairment	870 (14.2)
Functional and cognitive impairment	652 (10.6)
Missing	1784 (29.1)

completed screener as regards to the baseline characteristics and the primary outcome, mortality at three months. The only parameter that was significantly different was the triage color. Of patients with a completed APOP screener 35.0 % ($n = 1522$) had a positive APOP and therefore, a high risk of functional and/or cognitive decline and mortality within three months.

3.2. Mortality

Of the 4352 patients with a completed APOP screener, 663 patients died (15.2 %). Mortality rate was significantly lower in patients with a negative APOP screener than in patients with a positive APOP screener (9.7 % vs 25.6 %, $p < 0.001$) as presented in [table 3](#). If the APOP screener indicated a high risk of decline in either functional or cognitive domain, mortality rate was 21.5 % while mortality rate rose to 31.0 % when screening was positive both functional domain and cognitive domain.

As shown in [Table 4](#) a positive APOP score (either functionality or cognition) was associated with a doubled risk of mortality, with an odds ratio of 2.08 (CI95% 1.88–2.30). This association remained statistically significant (OR 2.07, CI95% 1.87–2.29) when adjusting for triage color at ED presentation ([Table 4](#)). No effect modification was found for triage color ($p = 0.74$). A positive APOP score on both the functional and the cognitive domain was associated with mortality with an odds ratio of 4.19 (CI95% 3.40–5.15) ([Table 4](#)).

After adjusting for the different variables that are part of a CGA but not of the APOP, the APOP score remained statistically significant. As

Table 3

Mortality and APOP score.

We used a unpaired t -test to compare the number of patients that died within the group with a positive and the group with a negative APOP screener.

	Positive APOP (n = 1522)	Negative APOP (n = 2830)	p-value
Mortality (%)	389 (25.6 %)	274 (9.7 %)	<0.001

can be seen in [Table 5](#) a positive APOP score at either the functional or cognitive domain was associated with a 1.52 to 1.92 (CI95% 1.31–2.22) heightened risk of mortality when adjusting for individual variables.

The area under the receiver curve (AUC) was 0.65 (CI95% 0.63–0.67; Youden index = 0.280) for mortality at three months after hospital admission. Which shows a fair accuracy of the APOP model in our cohort.

4. Discussion

In this study we assessed the association of a positive APOP screener and mortality, while adjusting for other relevant variables, in a large cohort of patients of 70 years and older presenting at the ED of a large top clinical teaching hospital in the Netherlands.

4.1. Mortality

Our study showed that the APOP screening tool has a high association with three month mortality in patients of 70 years and older. We confirm that mortality is more than doubled when patients have a positive APOP screener. When both functional and cognitive scores are positive mortality risk is even quadrupled. These findings are similar to those in earlier studies, where a high change of functional decline leads to a doubling of mortality at 90 days ([de Gelder et al., 2018](#); [Blomaard et al., 2020a](#)). Our study adds to the existing literature that when there is a high chance of cognitive decline your chance at 90-day mortality is also severely heightened.

4.2. AUC

The AUC calculated in our study is comparable to the AUC for mortality found within the optimization study of the APOP screener, which showed an AUC of 0.74 (95%CI 0.71–0.77) ([de Gelder et al., 2018](#)). This outcome shows that in the overall Dutch population this model is a fair predictor of the mortality. However, since the Youden index is only 0.28, caution has to be made to use the APOP to make treatment decisions, and other more comprehensive assessments should be used after a first identification of frail patients with the APOP tool.

4.3. Confounders

Other confounders than triage color, which was included in the final logistic regression model, were tested. Age, sex, function and cognition at the time of admission are a part of the APOP screener and were therefore not separately put in the final model. Triage color was not an effect modifier but was considered a confounder, because it has been shown to be a predictor of risk of short-term death ([Martins et al., 2009](#)). We examined the variables that were part of a CGA but not of the APOP, since the current recommendation is to screen patients with a complete CGA if they are potentially deemed fragile and to see if the variables in the CGA will add more precise knowledge concerning the risk of mortality in our population. Previous studies of the APOP screener, have shown that adding variables has no effect on the predictive value of the APOP ([de Gelder et al., 2018](#); [de Gelder et al., 2016](#)), which is confirmed in our population. The APOP score stayed significant on the risk of mortality, when adjusting for these variables. Most of the variables did have an effect on the risk of mortality, which means that a CGA during admission can help to further address specific domains to prevent functional decline. However, the results of this analysis show that the APOP screener is a valuable tool, including a minimal amount of necessary questions, consuming the least possible amount of time in the ED, to make the best possible prediction for risk of mortality for each patient.

Table 4

Risk of mortality per APOP score (unadjusted and adjusted for triage color).

	OR	CI 95 %	p-value	OR	CI 95 %	p-value
	Unadjusted			Adjusted for triage color		
APOP function and cognition both positive	4.187	3.403–5.153	<0.001	4.147	3.368–5.105	<0.001
APOP function and/or cognition positive	2.082	1.882–2.304	<0.001	2.071	1.872–2.292	<0.001
APOP function positive	3.278	2.753–3.904	<0.001	3.264	2.740–3.888	<0.001
APOP cognition positive	2.724	2.296–3.231	<0.001	2.691	2.268–3.193	<0.001

Table 5

Logistic regression CGA.

	OR	CI 95 %	p-value	OR	CI 95 %	p-value	OR	CI 95 %	p-value	OR	CI 95 %	p-value
	Unadjusted			Adjusted for SNAQ			Adjusted for fall-risk			Adjusted for delirium risk		
APOP function and cognition both positive	4.187	3.403–5.153	<0.001	2.801	2.154–3.642	<0.001	2.794	2.073–3.765	<0.001	2.016	1.472–2.761	<0.001
APOP function and/or cognition positive	2.082	1.882–2.304	<0.001	1.694	1.492–1.924	<0.001	1.735	1.507–1.998	<0.001	1.515	1.305–1.758	<0.001
APOP function positive	3.286	2.762–3.910	<0.001	2.364	1.903–2.938	<0.001	2.351	1.848–2.990	<0.001	1.982	1.558–2.521	<0.001
APOP cognition positive	2.749	2.320–3.258	<0.001	1.936	1.567–2.392	<0.001	2.084	1.651–2.631	<0.001	1.520	1.193–1.937	<0.001

	OR	CI 95 %	p-value	OR	CI 95 %	p-value	OR	CI 95 %	p-value	OR	CI 95 %	p-value
	Adjusted for visual impairment			Adjusted for hearing impairment			Adjusted for incontinence			Adjusted for number of medication		
APOP function and cognition both positive	3.561	2.639–4.807	<0.001	3.044	2.100–4.411	<0.001	2.694	2.094–3.466	<0.001	4.173	3.389–5.137	<0.001
APOP function and/or cognition positive	1.921	1.660–2.222	<0.001	1.750	1.457–2.103	<0.001	1.649	1.457–1.866	<0.001	2.076	1.876–2.297	<0.001
APOP function positive	2.559	2.001–3.272	<0.001	2.267	1.669–3.078	<0.001	2.158	1.746–2.667	<0.001	3.232	2.713–3.850	<0.001
APOP cognition positive	2.511	1.973–3.195	<0.001	2.121	1.573–2.860	<0.001	1.935	1.579–2.371	<0.001	2.725	2.296–3.233	<0.001

4.4. Strengths and limitations

One of the strengths of our research is that the results are based on a heterogeneous population. We have included all patients of 70 years and older and our only exclusion criteria were patients that were triaged red in the ED, because the APOP was not tested and evaluated for that patient population (de Gelder et al., 2016). The APOP screener is not validated in the most critically ill and time restraint in this cases might prevent the use of any screening tool. Furthermore, the percentage of completed APOP was high with a complete APOP in 71 % of patients. This shows that the APOP screening tool is easily administered and part of routine care in our ED (Blomaard et al., 2020b). The missing data of 29 % of patients may have introduced selection bias. However, we expect that this bias likely led to an underestimation of the APOP screener's effect. This is because patients at the highest risk of mortality, who are also the most difficult to screen due to cognitive or functional impairments at admission, were less likely to have been assessed.

Our study also has some limitations. Firstly, due to the retrospective design of our study, we only assessed risk of mortality at three months, as functional outcomes of patients at three months was not available for our analyses. This lack of data could give an underestimation of the effectiveness of the APOP screener, as functional decline is one of the endpoints that the APOP is validated on. Furthermore, the retrospective design could lead to unmeasured confounding, which could give an overestimation of the effect of the APOP screener as the results could be partly explained by another non measured confounder. However, on theoretical basis we hypothesize that we have included the most important confounders. Another limitation is that we could not compare the APOP screener to other existing risk stratification tools in the ED as in the Maasstad hospital, the APOP was already implemented and no other tools were used at the time of this study. Furthermore, we do not have data about comorbidities of the patients, which can also have an

effect on chance of mortality (Tanderup et al., 2018). However, we did have information about the number of medications that each person was taking and how this influenced mortality rate. Literature shows that this is a parameter that is relatively easy to attain and can be used as a proxy for the number of comorbidities (Vitry et al., 2009). Additionally, since the study was a single center study conducted in one hospital in the Netherlands, the findings may not be generalizable to other healthcare systems, particularly those with different ED workflows, or other patient demographics. Last, although we had information on separate variables that are part of the CGA, we did not have a full CGA for all patients which is considered the gold standard in this population. In our opinion, this could give an underestimation of the effect/knowledge of a complete CGA on the risk of mortality, because a good estimation of the risk of mortality is based on the outcome of the whole CGA and not based on individual factors. However, this result does show that the added effect of individual factors on the risk of mortality is small and the APOP screener gives a good estimate of the risk of mortality especially given the amount of time consumed filling the APOP screener.

4.5. Conclusion

In conclusion, in our study, 26 % of patients aged 70 years and over, with a positive APOP score died within three months after presentation at the ED. A positive APOP score is associated with a doubling of mortality risk of these patients. The APOP tool shows a fair accuracy in our real world cohort. This study shows that the APOP screener, when used in the real world, has a fairly high association with three month mortality, even when adjusting for other variables that could indicate frailty. The APOP tool should be implemented in clinical practice to signal frailty of patients which could identify those who need extra attention to their frailty and could benefit from a complete CGA.

CRediT authorship contribution statement

J.C. van Groen: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **A.M. van Alphen:** Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Methodology, Investigation, Formal analysis, Conceptualization. **S.P. Mooijaart:** Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Investigation, Formal analysis. **C. van Noord:** Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Methodology, Investigation, Formal analysis. **R. Ruiter:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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