# Evaluation of the (modified) John Hopkins Highest Level of Mobility scale in surgical patients: a retrospective cohort study.

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| Date of submission: | 18 June 2020 |
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| Organization: | Amsterdam UMC, Amsterdam, the Netherlands |
| Journal: | Annals of Surgery |
| Number of words: | 3403 |
| Criteria used for transparent reporting: STROBE Checklist for cohort studies | |
| Number of words abstract: | 300 |
| Number of words of Dutch abstract: | 298 |

*Title:* Evaluation of the (modified) John Hopkins Highest Level of Mobility scale in surgical patients: a retrospective cohort study.

**English abstract**

*Background:* The John Hopkins Highest Level of Mobility (JH-HLM) scale is developed to promote early mobility, however, in daily practice a ceiling effect in postoperative care is experienced. This study aimed to investigate whether the experienced ceiling effect of the JH-HLM scale actually exists and to evaluate if a modified version, the AMsterdam UMC Extension of the JOhn HOpkins Highest Level of mObility (AMEXO) scale is more sensitive to detect changes in mobility in hospitalized surgical patients.

*Method:* All patients who underwent gastrointestinal surgery were included and measured with the JH-HLM scale or AMEXO scale in two different periods. Primary outcomes were the percentage of patients with the highest possible mobility score on the first postoperative day and the percentage of patients who showed a change in mobility score between the first three consecutive postoperative days.

*Results*: In total, 373 patients were included (JH-HLM; n=135; AMEXO; n=238). On the first postoperative day, 61 (45.2%) patients scored the highest possible mobility score on the JH-HLM scale compared to 4 (1.7%) patients using the AMEXO scale (p-value < 0.001). During the first three consecutive postoperative days, 88 (65.2%) patients showed a change in mobility score with the JH-HLM scale compared to 225 (94.5%) patients with the AMEXO scale (p-value < 0.001).

*Conclusion and implications of key findings:* Almost half of the patients scored the highest possible mobility score when using the JH-HLM scale which indicates a ceiling effect. The AMEXO scale appeared to be more sensitive to detect changes in mobility in hospitalized surgical patients and is therefore recommended instead of the JH-HLM scale. Future research should focus on how healthcare professionals can use the AMEXO scale to involve surgical patients to improve mobilization during hospital admission.

*Keywords:* early ambulation [MESH], hospitalization [MESH], postoperative period [MESH], retrospective cohort, surgical patients.

*Titel:* Evaluatie van de (aangepaste) John Hopkins Highest Level of Mobility schaal gemeten in chirurgische patiënten: een retrospectieve cohort studie.

**Nederlandse samenvatting**

*Achtergrond:* De John Hopkins Highest Level of Mobility (JH-HLM) schaal is ontwikkeld om vroege mobilisatie te promoten, maar in de praktijk lijkt er een plafondeffect te ontstaan in de postoperatieve zorg. Derhalve onderzocht deze studie of er daadwerkelijk sprake is van een plafondeffect in de JH-HLM schaal en of een aangepaste versie, de AMsterdam UMC Extension of the JOhn HOpkins Highest Level of mObilty (AMEXO) schaal, beter veranderingen in mobiliteit vast kan stellen bij chirurgische patiënten tijdens ziekenhuisopname.

*Methode:* Alle patiënten die een gastro-intestinale operatie ondergingen werden geïncludeerd in twee verschillende perioden en gemeten met de JH-HLM schaal of de AMEXO schaal. Primaire uitkomstmaten waren het percentage patiënten met de hoogste mobiliteitsscore op de eerste postoperatieve dag en het percentage patiënten die een verandering in mobiliteitsscore doormaakte gedurende de eerste drie opeenvolgende postoperatieve dagen.

*Resultaten:* In totaal werden 373 patiënten geïncludeerd (JH-HLM; n=135; AMEXO; n=238). Op de eerste postoperatieve dag scoorden 61 (45.2%) patiënten de hoogste mobiliteitsscore met de JH-HLM schaal in vergelijking met 4 (1.7%) patiënten met de AMEXO schaal (p-waarde < 0.001). In de eerste drie opeenvolgende postoperatieve dagen lieten 88 (65.2%) patiënten een verandering in mobiliteitsscore zien met de JH-HLM schaal en 225 (95.5%) patiënten met de AMEXO schaal (p-waarde < 0.001).

*Conclusie en implicaties van de belangrijkste bevindingen:* Bijna de helft van de patiënten scoorden de hoogste mobiliteitsscore met de JH-HLM schaal wat wijst op een plafondeffect. De AMEXO schaal lijkt beter veranderingen in mobiliteit vast te kunnen stellen bij chirurgische ziekenhuispatiënten en is daarom aan te bevelen in plaats van de JH-HLM schaal. Toekomstig onderzoek zou zich kunnen richten op hoe zorgverleners de AMEXO schaal kunnen inzetten om chirurgische patiënten te betrekken bij het verbeteren van het mobiliteitsniveau gedurende een ziekenhuisopname.

*Trefwoorden:* vroege mobilisatie, ziekenhuisopname, postoperatieve periode, retrospectieve cohort, chirurgische patiënten.

## Introduction

Yearly, more than 1.2 million patients underwent surgical procedures in the Netherlands.[1,2] Almost half of these patients were admitted to the hospital for more than one day, whereas the rest received daycare surgery.[1] Most of these surgical hospital admissions, regardless duration, are characterized by periods of bed rest and/or reduced mobility[3,4] which could lead to functional decline and an increased risk of complications.[5] Notably, it has been shown that oncological patients who underwent abdominal surgery stay in bed with a median of 19 hours a day during the first three postoperative days and walk only six minutes a day.[6]

In order to facilitate recovery in the post-operative period, the enhanced recovery after surgery (ERAS) programmes were developed in which a key component is early mobility.[7] The implementation of these ERAS programmes has been associated with a significant increase of (early) mobility and with significantly decreased hospital length of stay and postoperative complications.[8] In addition, previous research confirmed that multifaceted interventions aimed at creating a culture of safe and early mobilization resulted in significant and sustained improvement of patient mobility.[9] These studies have shown that postoperative mobility is a modifiable factor which might have considerable potential for further reduction of length of stay and complications.

With the intention to sustain a culture of safe and early mobility, the neuroscience department of the John Hopkins Institute, Baltimore, United States developed the John Hopkins Highest Level of Mobility (JH-HLM) scale.[10] The JH-HLM scale is useful to document actual mobility levels, set mobility goals and can be used as a common ground for inter-professional assessment of patient mobility and functional limitation in the hospital setting.[11] To further improve mobility levels in Dutch surgical patients, this scale was implemented at two surgical wards in a tertiary university hospital in the Netherlands.

After the implementation of the JH-HLM scale at these two surgical wards healthcare professionals experienced in daily practice a ceiling effect with hospitalized surgical patients. Consequently, the JH-HLM scale has been modified to the AMsterdam UMC Extension of the JOhn HOpkins Highest Level of mObility (AMEXO) scale, which includes four additional response categories based on local expert knowledge. Due to additional response categories, it is hypothesized that the usability of the AMEXO scale as a tool to set patient-centered goals might improve and will consequently result in a better measurement of the actual mobility levels. As both scales are not yet formally evaluated within the surgical population, this study aims to investigate whether the experienced ceiling effect of the JH-HLM scale actually exists and to evaluate if the modified JH-HLM scale (AMEXO scale) is more sensitive to detect changes in mobility scores in hospitalized surgical patients compared to the original scale.

## Method

This study was conducted according to the principles of the Declaration of Helsinki (64th version, October 2013). Patients were not subject to the Medical Research Involving Human Subjects Act (WMO) which was confirmed by the Medical Ethical Review Committee (METC) of the Amsterdam UMC, with reference number W19_034 # 19.053. In addition, only patients who did not object to reuse care data were included. The datasets that are used were classified as anonymous. The study is reported following the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.[12]

*Design and setting*

This single-center study followed a retrospective cohort design and was conducted at a tertiary university hospital in the Netherlands at two surgical wards with together a total capacity of 50 beds. This retrospective data was delivered in January 2019 and January 2020 by the clinical research unit of the hospital.

*Participants*

All adult patients who were admitted to two surgical wards between July and December 2018 (period 1) and between July and December 2019 (period 2) were eligible for inclusion if they had at least a mobility score on the first postoperative day and underwent gastrointestinal surgery. Patients were only included once and all subsequent hospital admissions within the inclusion periods were excluded from the analysis.

*Primary and secondary outcomes*

The primary outcomes are defined as the percentage of patients with the highest possible mobility score on the first postoperative day and the percentage of patients who showed a change in mobility score between the first three consecutive postoperative days using the JH-HLM scale and AMEXO scale. In order to be more specific, the highest possible mobility score on the JH-HLM scale is a mobility score of 8 and a mobility score of 12 is the maximum on the AMEXO scale. Moreover, a change is defined as a difference in mobility score of at least one point on one of the first three consecutive postoperative days.

Furthermore, several secondary outcomes were defined: the percentage of patients having the highest possible mobility score between the first three consecutive postoperative days measured with the JH-HLM scale and AMEXO scale. The distribution of mobility scores using the JH-HLM scale and AMEXO scale on the first postoperative day and between the first three consecutive postoperative days. Finally, the percentage of patients who showed a change in mobility score using the AMEXO scale and scoring 9-12 between the first three consecutive postoperative days.

*Data sources/measurement*

The JH-HLM is a 1-item scale with eight ordinal response categories and is used by healthcare professionals to quantify a patient's observed activity.[11] Each category is numbered consecutively where 1=only lying and 8=walking approximately 75 meters or more.[11] The AMEXO scale is a modified version of the JH-HLM scale and the following additional response categories have been added: 9=walking approximately 225 meters or more, 10=walking approximately 450 meters or more, 11=750 meters or more and 12=walking approximately 1125 meters or more. In total, the AMEXO scale consists of 12 ordinal response categories with 1=only lying and 12=walking approximately 1125 meters or more (see Appendix 1).

Data registration procedures of the JH-HLM scale and the AMEXO scale were the same. All mobility scores were based on a patient's observed activity, over a fixed observation period (e.g. nurse shifts or physical therapist session).[11] The mobility scores should be reported twice a day (day and evening shift) and registered in the patient's electronic medical record. In both time periods all patients who were admitted to one of the surgical wards received a leaflet, with information about the JH-HLM scale or the AMEXO scale.

In addition, the following patient characteristics were collected: age, gender, organ involved in surgical procedure, acute admission and hospital length of stay. Furthermore, the Katz Activities of Daily Living (Katz) score[13] and the John Hopkins Fall Risk Assessment Tool (JHFRAT)[14] were collected. The Katz score has a range of 0 to 6, with higher scores indicating greater independence in physical functioning on the following activities of daily living: bathing, dressing, toileting, transferring, continence and feeding.[13] The JHFRAT includes seven areas of evaluation: patient age, prior fall history, elimination, medication, use of patient care equipment, mobility and cognition. Total scores range from 0 to 35 and can categorize patients into three risk groups: low risk (0 – 6), moderate risk (7-13) and high risk (14 – 35).[14]

*Sample size calculation*

Guidelines concerning ceiling effect studies describe that a ceiling effect can be concluded if (no) ceiling effect is present in a sample of at least 50 patients.[15] In addition, this study resembles a responsiveness study where the guidelines for sample sizes recommend a minimum sample size of 50 patients, but larger samples (e.g. over 100 patients) are preferred.[16] This sample size could be achieved since it was expected that approximately 300 patients were eligible for inclusion based on expected admissions during both study periods and taking into account missing data.

*Data analysis*

As it is common for patients to have more than one mobility score on a single day, only the highest mobility score on that day was used for analysis as has been done previously.[17] Q-Q plots were used to determine whether continuous and ordinal variables had a normal distribution. Normally distributed data were presented using mean and standard deviation, whereas non-normally distributed data were presented using medians and interquartile range. Categorical data were presented in absolute numbers and percentages. Additionally, patient characteristics were used to assess whether patients within different time periods were comparable.

In general, missing data can introduce potential bias[18] and with regard to responsiveness studies if more than 15% of data is missing this might cause problems with regard to the generalizability.[16] Initially data analysis was based on complete case analysis, which subsequently safely could be done concerning all outcomes on the first postoperative day. Due to the fact that > 15% of the mobility scores on the second and third postoperative days were missing a multiple-imputation model with 10 iterations was applied and pooled by Rubin's rules.[19] Because of the non-normal distribution of missing data predictive mean matching was used.[19] Missing data in this study were assumed to be missing at random, which is an assumption in order to use multiple imputation.[18,19] Missing data were imputed using all patient characteristics, as well as the mobility score of the first postoperative day, and if available, mobility scores of the second and third postoperative day. Analysis was performed on both imputed as well as not imputed data and were presented separately.

The percentage of patients who scored the highest possible mobility score on the first postoperative day and the percentage of patients who showed a change in mobility score between the first three consecutive postoperative days were both analyzed descriptively for the JH-HLM scale and AMEXO scale separately and presented in a table with absolute numbers and percentages. The chi-square test was used to compare the percentages of patients, using the JH-HLM scale or the AMEXO scale, who scored the highest possible mobility score on the first postoperative day and the patients who did not. Furthermore, the percentages of patients who showed a change in mobility score between the first three consecutive postoperative days and the patients who did not were also compared using the chi-square test. The chi-square test could safely be used to compare these percentages since all expected counts in a 2 x 2 table had values equal to 5.0 or greater.[20] Based on previous research, a ceiling effect was considered to be present if more than 15% of patients achieved the highest possible score.[16]

The percentage of patients having the highest possible mobility score between the first three consecutive postoperative days measured with the JH-HLM scale or the AMEXO scale were analyzed descriptively and presented in a table with absolute numbers and percentages. The distribution (percentages) of mobility scores using the JH-HLM scale and AMEXO scale on the first postoperative day were presented in a histogram. The distribution (percentages) of mobility scores between the first three consecutive postoperative days were presented in a table with absolute numbers and percentages, whereas a distinction was made between mobility scores measured with the JH-HLM scale and the AMEXO scale. Finally, the percentage of patients who showed a change in mobility score using the AMEXO scale and scoring 9 – 12 between the first three consecutive postoperative days were also analyzed descriptively and presented in a table with absolute numbers and percentages. All analysis were conducted using IBM-SPSS Statistics version 26 (IBM Corp, Armonk, New York) and R (R core team, Vienna, Austria). A two-tailed p-value of 0.05 was considered statistically significant.[18]

## Results

*Participants*

A total of 933 surgical patients were examined for eligibility (JH-HLM n=402; AMEXO n=531), of whom 560 were excluded (60%). Main reasons for exclusion were no gastrointestinal surgery (JH-HLM n=99; AMEXO n=134) or no mobility score on the first postoperative day (JH-HLM n=168; AMEXO n=159). Therefore, a total of 373 patients (JH-HLM n=135; AMEXO n=238) were included for analysis (see figure 1).

*- Figure 1 approximately here -*

*Patient characteristics*

Patients whose mobility was measured using the JH-HLM scale had a median age of 63 years (IQR: 50–71) and 72 were male (53.3%). Most of these patients underwent pancreatic (n=28; 20.7%) or colon surgery (n=28; 20.7%) and 129 (95.6%) patients were electively admitted for surgery (n=129; 95.6%). Median length of stay was 7 days (IQR: 5–11), patients had a median KATZ-score of 0 (IQR: 0–0) and 46 (34.1%) patients had a low fall risk measured with the JHFRAT.

Patients whose mobility was measured using the AMEXO scale had a median age of 64 years (IQR: 51–72) and 149 were male (62.6%). These patients underwent various types of gastrointestinal surgery, of which most frequently pancreatic surgery (n=41; 17.2%), and 211 (88.7%) patients were electively admitted for surgery (n=211; 88.7%). Median length of stay was 7 days (IQR: 5–12), patients had a median KATZ-score of 0 (IQR: 0–0) and 81 (34,0%) patients had a low fall risk measured with the JHFRAT (see table 1).

*- Table 1 approximately here -*

*Missing data*

In total, 65 (48%) patients whose mobility was measured with the JH-HLM scale had mobility scores between the first three consecutive postoperative days compared to 73 (30.7%) patients whose mobility was measured with the AMEXO scale. More specifically, mobility scores measured with the JH-HLM scale were missing for 35 (25.9%) patients on the second postoperative day, and 60 (44.4%) on the third postoperative day. AMEXO scale mobility scores were missing for 99 (41.6%) patients on the second postoperative day and 134 (56.3%) patients on the third postoperative day.

*Primary outcomes*

On the first postoperative day, 61 (45.2%) patients scored the highest possible mobility score (i.e. 8) on the JH-HLM scale compared to 4 (1.7%) patients measured using the AMEXO scale (i.e. 12) (p-value < 0.001) (see table 2). During the first three consecutive postoperative days, 88 (65.2%) patients showed a change in mobility score if assessed using the JH-HLM scale compared to 225 (94.5%) patients using the AMEXO scale (p-value < 0.001) (see table 2).

Analysis of the original data (i.e. not imputed data) showed that 44 (32.6%) patients showed a change in mobility score between the first three consecutive postoperative days using the JH-HLM scale compared to 67 (28.2%) patients using the AMEXO scale (p-value < 0.001) (see Appendix 2).

*- Table 2 approximately here -*

*Secondary outcomes*

Between the first three consecutive postoperative days 118 (87.4%) patients scored the highest possible mobility score (i.e. 8) using the JH-HLM scale compared to 40 (16.8%) patients using the AMEXO scale (i.e. 12) (see table 2).

Analysis of the original data showed that 55 (40.7%) patients scored the highest possible mobility score using the JH-HLM scale between the first three consecutive postoperative days compared to 7 (2.9%) patients using the AMEXO scale (see Appendix 2). The distribution of mobility scores on the first postoperative days are shown in figure 2. The distribution of mobility scores measured with the JH-HLM scale and the AMEXO scale between the first three consecutive postoperative days are shown in table 3 and results from not imputed data in Appendix 3. Furthermore, 165 (69.2%) patients showed a change in mobility score and using the scores 9–12 between the first three consecutive postoperative days (see table 2) and 46 (19.3%) patients in not imputed data (Appendix 2).

*- Figure 2 and table 3 approximately here -*

**Discussion**

This study demonstrated a ceiling effect of the JH-HLM scale in a surgical population as almost half of the patients achieved the highest possible mobility score on the first postoperative day. In contrast, the percentage of patients who scored the highest possible mobility score using the AMEXO scale was significantly lower indicating that adding four additional response categories results in a reduction of the ceiling effect. Furthermore, the percentage of patients who showed a change in mobility score using the AMEXO scale was significantly higher compared to the percentage of patients measured with the JH-HLM scale. Moreover, this change in mobility score might indicate that the AMEXO scale is more sensitive to detect change in mobility compared to the JH-HLM scale. Finally, the additional response categories of the AMEXO scale were used in the majority of surgical patients during the first three consecutive postoperative days.

Contrary to our study, previous studies did not report a ceiling effect when the JH-HLM scale was used to measure mobility in general medicine, neuroscience and surgical hospitalized patients.[10,11,17,21-23] The ceiling effect found in our study might be explained by the fact that ceiling effects are often encountered when an existing scale is applied to a new target population.[16] So far, the JH-HLM scale has solely been investigated in the American population whereas our study was the first study to use the JH-HLM scale in a Dutch population. Furthermore, in previous research the JH-HLM scale was used within a diverse population in which most of these patients were acutely admitted and therefore at an increased risk of immobility.[17] Contrary, in our study almost all admissions were planned. Moreover, research showed that a previously validated instrument, like the JH-HLM scale, might not be valid in another time, culture or context.[16,24]

In line with previous studies, the majority of patients showed a change in mobility score when mobility was measured with the JH-HLM scale[10,17,21,23] and this change was even more prominent with the AMEXO scale. Previous studies showed that extending a measurement instrument might not only reduce the observed ceiling effect but might also affect the responsiveness.[16,25] This was also shown in our study, in which both, the observed ceiling effect experienced with the JH-HLM scale was reduced and more patients showed a change in mobility with the AMEXO scale. Consequently, by reducing the ceiling effect the AMEXO scale is a more sensitive measurement instrument to measure change in mobility in surgical patients. This makes the AMEXO scale more useful as a tool to set mobility goals and could lead to a better measurement of actual mobility levels compared to the JH-HLM scale.

This study has some strengths and limitations that need to be considered. A strength of this study is that all hospitalized surgical patients who were admitted to two medical wards in a tertiary university hospital were included. Although the population in secondary hospitals may differ, in almost all hospitals ERAS programmes are implemented and mobilization is a key component to facilitate recovery in the post-operative period.[7] Therefore, the results of this study seem to be generalizable to other similar surgical settings. Secondly, patient characteristics in both groups (i.e. JH-HLM and AMEXO) were comparable, so the differences found cannot be attributed to differences in patient characteristics. Thirdly, although expected in routine collected data[26], missing data could lead to less validity and precision in the outcome.[18] In our study a high number of missing data was found, yet, the missing data was imputed using multiple imputation models and the result from these imputation did not differ substantially from the results of the non-imputed dataset. Therefore, negative consequences due to missing data were reduced.

The first limitation is that patients were excluded if they had no mobility score on the first postoperative day, which might have caused selection bias. Selection bias comes from any error in selecting the study participant and/or from factors affecting the study participation and could affect the internal validity of the study.[27] Secondly, the responsiveness of the AMEXO scale could not be tested with a criterion approach due to the lack of a 'golden standard' or a 'global rating scale'. In addition, a construct approach, where hypotheses are formulated or comparable measurement instruments are used[16], was also not possible. Therefore, the outcomes were a priori based on expert consensus with all involved healthcare professionals and researchers.

Since organizational changes in surgical care requires patients to become more responsible for their own care[28], future research should focus on how healthcare professionals can involve patients to improve their mobility levels during hospital admission. Previous research showed that involving patients may increase confidence level and motivation in mobility.[29] Moreover, behaviour change techniques such as goal-setting, self-monitoring, instant feedback and reward, have shown to be promising in involving patients to increase mobilization and could decrease the risk of complications after abdominal surgery.[6] The AMEXO scale could be used to support these behavior change techniques.

Based on the results of this study it seems that a ceiling effect of the JH-HLM scale exists and the AMEXO scale appeared to be more sensitive to detect changes in mobility in hospitalized surgical patients. Therefore, applying the AMEXO scale instead of the JH-HLM scale in hospitalized surgical patients should be recommended to document observed patient mobility and to set mobility goals. Future research should focus on how healthcare professionals can use the AMEXO scale to involve surgical patients in the improvement of their mobility levels during hospital admission.

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## Figures & Tables

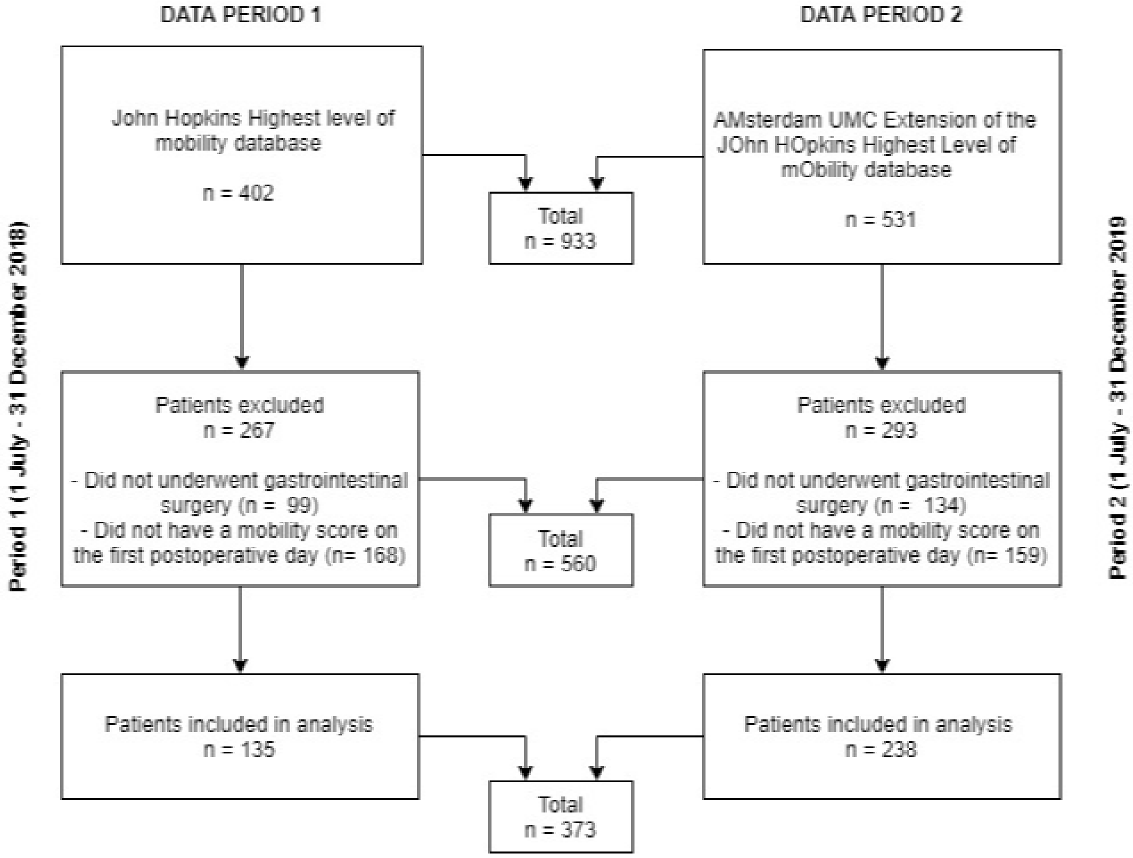


*Figure 1 Flow diagram inclusion of patients*

*Abbreviation: n = number.*

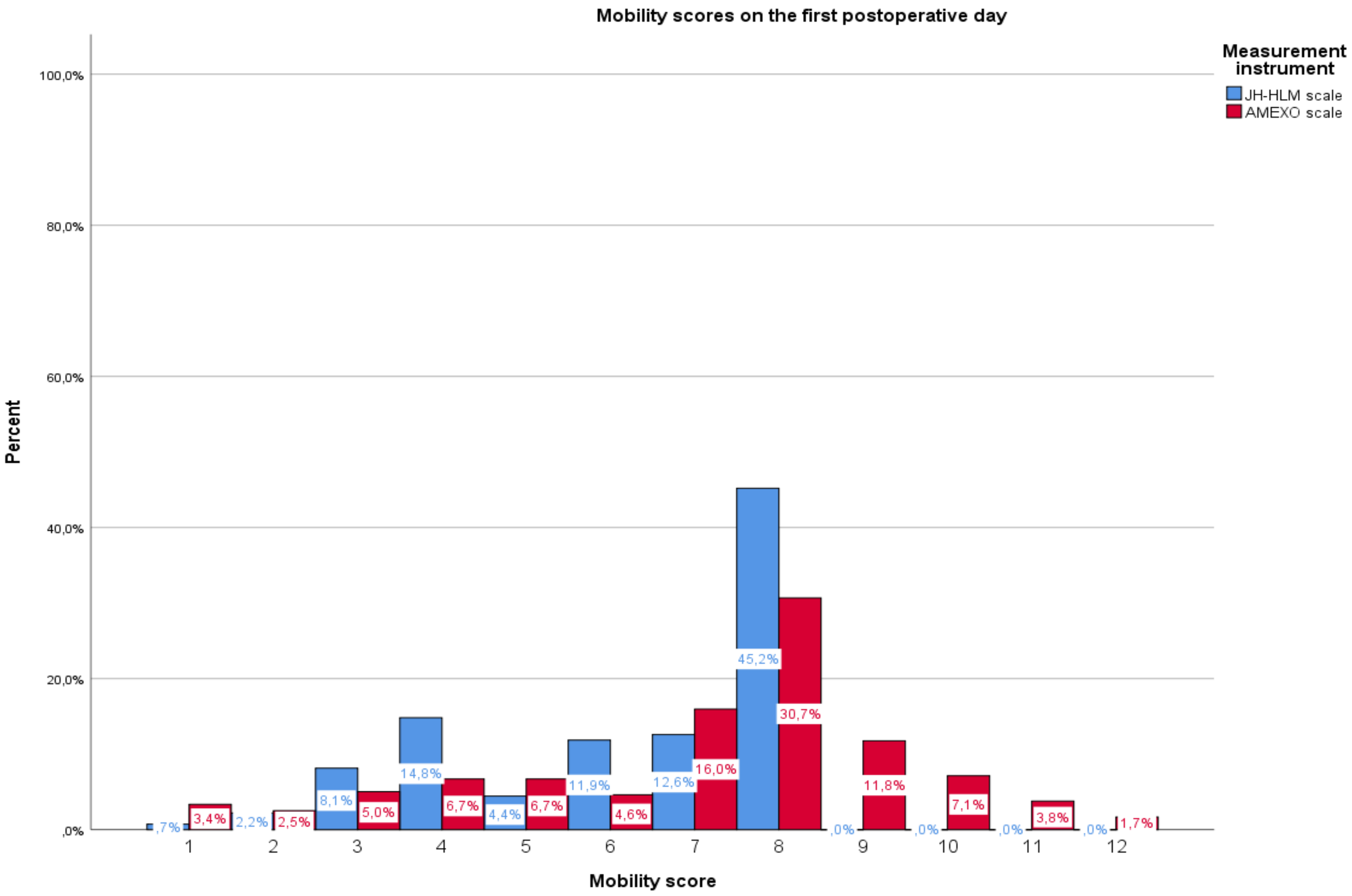


*Figure 2 - Histogram using the JH-HLM scale (n = 135) and the AMEXO scale (n = 238) on the first postoperative day*

*Abbreviations: JH-HLM = John Hopkins Highest Level of Mobility; AMEXO = AMsterdam UMC Extension of the John Hopkins Highest Level of mObility.*

*Table 1 Patient characteristics of the two databases*

| **Characteristics** | **JH-HLM ( n = 135)** | **AMEXO (n = 238)** |
|---|---|---|
| Age (years) - Median, (IQR) | 63 (50 – 71) | 64 (51 – 72) |
| Gender (male) - (n, %) | 72 (53.3) | 149 (62.6) |
| Organ involved in surgical procedure - (n, %) | | |
| - *Anus* | 4 (3.0) | 5 (2.1) |
| - *Abdomen* | 7 (5.2) | 19 (8.0) |
| - *Intestine* | 1 (0.7) | 2 (0.8) |
| - *Colon* | 28 (20.7) | 37 (15.5) |
| - *Small intestine* | 7 (5.2) | 8 (3.4) |
| - *Duodenum* | 1 (0.7) | 8 (3.4) |
| - *Gallbladder* | 2 (1.5) | 8 (3.4) |
| - *Biliary tract* | 4 (3.0) | 7 (2.9) |
| - *Ileum* | 5 (3.7) | 12 (5.0) |
| - *Jejunum* | 0 (0) | 1 (0.4) |
| - *Liver* | 12 (8.9) | 28 (11.8) |
| - *Stomach* | 7 (5.2) | 22 (9.2) |
| - *Esophagus* | 21 (15.6) | 26 (10.9) |
| - *Pancreas* | 28 (20.7) | 41 (17.2) |
| - *Rectum* | 8 (5.9) | 14 (5.9) |
| Acute admission (no) - (n, %) | 129 (95.6) | 211 (88.7) |
| Hospital length of stay (days) (Median (IQR) | 7 (5 – 11) | 7 (5 – 12) |
| Missing data (n,%)* | 0 (0.0) | 1 (0.4) |
| Katz Activities of Daily Living score (0 – 6) | | |
| (Median – IQR) | 0 (0 – 0) | 0 (0 - 0) |
| Missing data (n,%)* | 89 (65.9) | 157 (66.0) |
| John Hopkins Fall Risk Assessment Tool | | |
| Low risk (n, %) | 46 (34.1) | 81 (34.0) |
| Moderate risk (n,%) | 0 (0.0) | 0 (0.0) |
| High risk (n, %) | 0 (0.0) | 0 (0.0) |
| Missing (n,%)* | 89 (65.9) | 157 (66.0) |

**Missing data only reported if present.*

*Abbreviations: JH-HLM = John Hopkins Highest Level of Mobility; AMEXO = AMsterdam UMC Extension of the John Hopkins Highest Level of mObility; IQR = Interquartile range; n = number.*

*Table 2 Outcomes: comparison of the JH-HLM and the AMEXO scale*

| | **JH-HLM scale (n = 135)** | **AMEXO scale ( n = 238)** | **$X^2$ (DF)** | **p-value** |
|---|---|---|---|---|
| Patients achieved the highest possible mobility score on the first postoperative day* – (n,%) | 61 (45.2) | 4 (1.7) | 113.3 (1) | < 0.001 |
| Patients showed a change in mobility score (n,%) | 88 (65.2) | 225 (94.5) | 42.29 (1) | < 0.001 |
| Patients achieved the highest possible mobility score between the first three consecutive postoperative days* (n,%) | 118 (87.4) | 40 (16.8) | N/A | N/A |
| Patients who showed a change in mobility score and scored 9 – 12 (n,%). | N/A | 165 (69.2) | N/A | N/A |

** i.e. JH-HLM scale maximum score of 8; AMEXO scale maximum score of 12.*

*Abbreviations: JH-HLM = John Hopkins Highest Level of Mobility; AMEXO = AMsterdam UMC Extension of the John Hopkins Highest Level of mObility; n = number; X2 = Chi-square; DF = Degrees of Freedom; N/A = not applicable.*

*Table 3 Distribution of mobility scores using the JH-HLM scale and the AMEXO scale between the first three consecutive postoperative days*

| **Measurement instrument** | | **JH-HLM scale (n = 135)** | | | **AMEXO scale (n = 238)** | | |
|---|---|---|---|---|---|---|---|
| Postoperative Day<br><br>Mobility score (n,%) | | Day 1 | Day 2 | Day 3 | Day 1 | Day 2 | Day 3 |
| Score 1 | Only lying | 1 (0.7) | 0 (0.0) | 0 (0.0) | 8 (3.4) | 0 (0.0) | 0 (0.0) |
| Score 2 | Bed activities | 3 (2.2) | 1 (0.7) | 0 (0.0) | 6 (2.5) | 4 (1.7) | 3 (1.3) |
| Score 3 | Sitting at edge of bed | 11 (8.2) | 4 (3.0) | 1 (0.7) | 12 (5.0) | 3 (1.3) | 3 (1.3) |
| Score 4 | Transferring to chair | 20 (14.8) | 8 (5.9) | 3 (2.2) | 16 (6.7) | 5 (2.1) | 5 (2.1) |
| Score 5 | Standing for greater than or equal to 1 minute | 6 (4.4) | 3 (2.2) | 7 (5.2) | 16 (6.7) | 6 (2.5) | 7 (2.9) |
| Score 6 | Walking 10 or more steps | 16 (11.9) | 9 (6.7) | 9 (6.7) | 11 (4.6) | 8 (3.4) | 4 (1.7) |
| Score 7 | Walking approximately 7.5 meter or more | 17 (12.6) | 12 (8.9) | 21 (15.6) | 38 (16.0) | 32 (13.4) | 27 (11.3) |
| Score 8 | Walking approximately 75 meters or more | 61 (45.2) | 98 (72.6) | 94 (69.6) | 73 (30.7) | 71 (29.8) | 57 (24.0) |
| Score 9 | Walking approximately 225 meters or more | N/A | N/A | N/A | 28 (11.8) | 64 (26.9) | 53 (22.3) |
| Score 10 | Walking approximately 450 meters or more | N/A | N/A | N/A | 17 (7.1) | 20 (8.4) | 28 (11.8) |
| Score 11 | Walking approximately 750 meters or more | N/A | N/A | N/A | 9 (3.8) | 7 (2.9) | 25 (10.5) |
| Score 12 | Walking approximately 1125 meters or more | N/A | N/A | N/A | 4 (1.7) | 18 (7.6) | 26 (10.9) |

*Abbreviations: JH-HL = John Hopkins Highest Level of Mobility; AMEXO = AMsterdam UMC Extension of the John Hopkins Highest Level of mObility; n = number; N/A = not applicable.*

***APPENDIX 1 – Content JH-HLM scale and AMEXO scale***

| Mobility score | JH-HLM scale or AMEXO scale | Mobility Level |
|---|---|---|
| **12** | AMEXO | Walking approximately 1125 m or more (3750 ft. or more) |
| **11** | AMEXO | Walking approximately 750 m or more (2500 ft. or more) |
| **10** | AMEXO | Walking approximately 450 m or more (1500 ft. or more) |
| **9** | AMEXO | Walking approximately 225 m or more (750 ft. or more) |
| **8** | JH-HLM | Walking approximately 75 m or more (250 ft. or more) |
| **7** | JH-HLM | Walking approximately 7.5 m or more (25 ft or more) |
| **6** | JH-HLM | Walking 10 or more steps |
| **5** | JH-HLM | Standing for greater than or equal to 1 minute |
| **4** | JH-HLM | Transferring to chair |
| **3** | JH-HLM | Sitting at edge of bed |
| **2** | JH-HLM | Bed activities |
| **1** | JH-HLM | Only lying |

*Abbreviations: AMEXO = AMsterdam UMC EXtension of the JOhn HOpkins Highest Level of mObility scale; JH-HLM = John Hopkins Highest Level of Mobility scale; m = meter; ft = feet*

***APPENDIX 2 – Comparison of the JH-HLM and the AMEXO scale (not imputed data)***

| | **JH-HLM scale (n = 135)** | **AMEXO scale (n = 238)** | **$X^2$ (DF)** | **p-value** |
|---|---|---|---|---|
| Patients showed a change in mobility score (n,%) | 44 (32.6) | 67 (28.2) | 42.29 (1) | < 0.001 |
| *Missing data (n,%)* | 70 (51.9) | 165 (69.3) | | |
| Patients achieved the highest possible mobility score between the first three consecutive postoperative days* (n,%) | 55 (40.7) | 7 (2.9) | N/A | N/A |
| *Missing data (n,%)* | 70 (51.9) | 165 (69.3) | | |
| Patients who showed a change in mobility score and scored 9 – 12 (n,%) | N/A | 46 (19.3) | N/A | N/A |
| *Missing data (n,%)* | | 165 (69.3) | | |

** i.e. JH-HLM scale maximum score of 8; AMEXO scale maximum score of 12.*

*Abbreviations: JH-HLM = John Hopkins Highest Level of Mobility; AMEXO = AMsterdam UMC Extension of the John Hopkins Highest Level of mObility; n = number; X2 = Chi-square; DF = Degrees of Freedom; N/A = not applicable.*

**APPENDIX 3 – Distribution of mobility scores using the JH-HLM and AMEXO scale between the first three consecutive postoperative days (not imputed data)**

| Measurement instrument | | JH-HLM scale (n = 135) | | | AMEXO scale (n = 238) | | |
|---|---|---|---|---|---|---|---|
| Postoperative Day<br>Missing Data (n)<br><br>Mobility score (n,%) | | Day 1 | Day 2<br>(n = 35) | Day 3<br>(n = 60) | Day 1 | Day 2<br>(n = 99) | Day 3<br>(n = 134) |
| Score 1 | Only lying | 1 (0.7) | 0 (0.0) | 0 (0.0) | 8 (3.4) | 0 (0.0) | 0 (0.0) |
| Score 2 | Bed activities | 3 (2.2) | 1 (0.7) | 0 (0.0) | 6 (2.5) | 2 (0.8) | 1 (0.4) |
| Score 3 | Sitting at edge of bed | 11 (8.2) | 3 (2.2) | 1 (0.7) | 12 (5.0) | 2 (0.8) | 2 (0.8) |
| Score 4 | Transferring to chair | 20 (14.8) | 6 (4.4) | 2 (1.5) | 16 (6.7) | 4 (1.7) | 2 (0.8) |
| Score 5 | Standing for greater than or equal to 1 minute | 6 (4.4) | 2 (1.5) | 3 (2.2) | 16 (6.7) | 4 (1.7) | 4 (1.7) |
| Score 6 | Walking 10 or more steps | 16 (11.9) | 7 (5.2) | 5 (3.7) | 11 (4.6) | 5 (2.1) | 2 (0.8) |
| Score 7 | Walking approximately 7.5 meter or more | 17 (12.6) | 9 (6.7) | 12 (8.9) | 38 (16.0) | 20 (8.4) | 12 (5.0) |
| Score 8 | Walking approximately 75 meters or more | 61 (45.2) | 72 (53.3) | 52 (38.5) | 73 (30.7) | 41 (17.2) | 26 (10.9) |
| Score 9 | Walking approximately 225 meters or more | N/A | N/A | N/A | 28 (11.8) | 37 (15.5) | 24 (10.1) |
| Score 10 | Walking approximately 450 meters or more | N/A | N/A | N/A | 17 (7.1) | 12 (5.0) | 12 (5.0) |
| Score 11 | Walking approximately 750 meters or more | N/A | N/A | N/A | 9 (3.8) | 3 (1.3) | 9 (3.8) |
| Score 12 | Walking approximately 1125 meters or more | N/A | N/A | N/A | 4 (1.7) | 9 (3.8) | 10 (4.2) |

*Abbreviations: JH-HLM = John Hopkins Highest Level of Mobility; AMEXO = AMsterdam UMC Extension of the John Hopkins Highest Level of mObility; n = number; N/A = not applicable.*