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Running title: Risk for malnutrition in hospitalised children

Malnutrition risk in hospitalised children: use of three screening tools in a large European population°

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Abbreviations:

BMI: body mass index; **ESPEN**: European Society for Clinical Nutrition and Metabolism; **HFA**, height for age; **IQR**: interquartile ranges; **LOS**: length of hospital stay; **MUAC**: mid upper arm circumference; **PYMS**: Pediatric Yorkhill Malnutrition Score; **STAMP**: Screening Tool for the Assessment of Malnutrition in Pediatrics; **STRONG$_{KIDS}$**: Screening Tool for Risk Of Impaired Nutritional Status and Growth; **TSFT**: triceps skin fold thickness.

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Abstract

Background: Several malnutrition screening tools have been advocated for use in pediatric inpatients.

Objective: This study evaluated how three popular pediatric nutrition screening tools (Pediatric Yorkhill Malnutrition Score-PYMS, Screening Tool for the Assessment of Malnutrition in Pediatrics-STAMP and Screening Tool for Risk of Impaired Nutritional Status and Growth-STRONG$_{KIDS}$) compare and relate to anthropometry, body composition and clinical parameters in patients admitted to tertiary hospitals across Europe.

Design: The three screening tools were applied in 2567 inpatients in 14 hospitals in 12 European countries. Classification of patients into different nutritional risk groups was compared between tools and related to anthropometry and clinical parameters (e.g. length of stay, LOS; infection rates).

Results: A similar rate of completion of the screening tools for each tool was achieved (PYMS 86%, STAMP 84%, STRONG$_{KIDS}$ 81%). Risk classification differed markedly among tools, with an overall agreement of 41% between the tools. Children categorized at high risk (PYMS 25%, STAMP 23% and STRONG$_{KIDS}$ 10%) had a longer LOS compared to children at low risk (1.4, 1.4 and 1.8 days longer, respectively, $p<0.001$). Among high-risk patients identified with PYMS, 22% had a low (<-2 SD) body mass index (BMI) and 8% a low height-for-age (HFA). For STAMP the respective percentages were 19% and 14% and for STRONG$_{KIDS}$ 23% and 19%.

Conclusion: Identification and classification of malnutrition risk varies among the pediatric tools used. A considerable portion of children with subnormal anthropometry was not identified with all tools. The data obtained do not allow recommending using any of these screening tools for clinical practice.

Key words

Nutritional screening, malnutrition, hospitalized children, PYMS, STAMP, $STRONG_{KIDS}$

Introduction

Malnutrition screening has been advocated as part of patients' standard care (1-3). This is because malnutrition upon admission or deterioration of the nutritional status during hospitalisation has been associated with prolonged hospital stay and adverse outcomes (e.g. increased rates of complications such as infections) although causality in these associations remains to be explored (4-7). Early identification of nutritional risk followed by an appropriate nutritional management was proposed as part of routine clinical practice (8). The "*Guidelines for nutrition screening*" by the European Society for Clinical Nutrition and Metabolism (ESPEN) provide recommendations for adult patients but do not address pediatric patients (9). Screening tools for assessing malnutrition risk for adults have been available for many years (9-11). However similar pediatric tools have only recently been developed and were only tested in small cohorts of hospitalized children (5, 7, 12-14). These tools consist of questions related to the patient's history and measurements or clinical estimation of body size to assess the risk of poor nutritional status (15). They aim to screen all inpatients and identify those missed during routine admission and whose disease outcome would improve or would not deteriorate from tailored nutritional intervention. However, there is a lack of sufficient data on the predictive value of such pediatric screening tools on outcome and objective indices of malnutrition in large multicentre studies, and of comparative evaluation of the various tools. Addressing these aspects may direct health professionals on their decision to select the most suitable nutritional screening tool.

We compared the risk scoring of three previously proposed pediatric nutrition screening tools, i.e. the Pediatric Yorkhill Malnutrition Score (PYMS) (16, 17), the Screening Tool for the Assessment of Malnutrition in Pediatrics (STAMP) (13) and the Screening Tool for Risk Of Impaired Nutritional Status and Growth ($STRONG_{KIDS}$) (5) in a large multi-centre study in children admitted to hospitals across Europe. In addition we explored the agreement among

the tools (concurrent validity) and the relation of risk scores to anthropometry and body composition measurements as well as clinical parameters, such as hospital length of stay (LOS).

It is arguable which could be the best outcome measure for the assessment of the effect of using a screening tool as it is somewhat controversial as to whether such screening tools should predict anthropometry or clinical outcome. Therefore, in this study we aimed to explore the association of the scores provided by the tools with both subnormal BMI and with length of hospital stay (LOS).

Subjects and methods

Study design and subjects

This prospective European multi-centre cohort study enrolled patients from February 2010 to July 2011 in 14 centres in 12 countries (Zagreb, Croatia; Copenhagen; Denmark, Lille, France; Munich, Germany; Thessaloniki, Greece, Petah Tikvah, Israel; Milan, Italy; Rotterdam and Groningen, the Netherlands; Warsaw, Poland; Cluj-Napoca, Romania; Oxford, England and Glasgow, Scotland). Patients (1 month to 18 years old) admitted to pediatric and pediatric surgery wards with an anticipated length of stay >24 hours were eligible to participate. They were consecutively invited to participate whenever data collection was possible within the first 24 hours after admission. Patients attending the accident and emergency department of the day care unit were excluded.

We excluded children admitted to intensive care because of the limited feasibility to perform detailed anthropometry on the day of admission in critically ill children. To identify children at risk of malnutrition in this group of patients is redundant, since all of these children are -by the nature of their critical illness (e.g. unconscious hence unable to eat)- at

high risk of malnutrition and therefore should receive respective attention of the medical and dietetic staff. The principle of screening is to identify those at risk who might go missed, and to refer to the clinical team. We also excluded children admitted to day hospital care because their expected LOS was shorter than 24 hours. Patients with cerebral palsy or genetic syndromes were not excluded per protocol. Details about the recruitment and the protocol have been previously published by Hecht el al (18).

Methods

Patients were assessed by a set of questions considering nutritional risk, and measurements of anthropometry and body composition were all performed within the first 24 hours after admission. The assessors were a multidisciplinary team including research nurses, dietitians, medical students and nutritionists. A training workshop to harmonise recruitment and standardise anthropometry and data collection among the different centres was held in March 2010 at Munich, Germany.

Demographic and medical data together with a questionnaire for nutritional status were collected during a structured interview with patients and (when required) their caregivers. The questionnaire integrated the 4 items of the PYMS tool (16, 17), the 3 items of the STAMP tool (13) and the 4 items of the $STRONG_{KIDS}$ screening tool (5) and sorted them by item content. For each patient, the steps of each tool were completed by the same investigator in the same order. The total score for each screening tool was computed during the analysis of the data. The 28 assessors were encouraged not to add the scores for each tool during data collection to avoid bias by the knowledge on categorization in a screening tool. Only the treating physicians and dietitians, and not the assessors, decided on whether or not to start

nutritional support during hospitalisation. This decision was taken according to normal routine procedures and was not by any means influenced by the study data.

Important characteristics of PYMS (1, 16, 17), STAMP (13, 19), and $STRONG_{KIDS}$ (5, 19) are reported in **Supplemental Table 1.** PYMS and STAMP include anthropometry (BMI vs. weight and height, respectively); $STRONG_{KIDS}$ includes a subjective clinical assessment of nutritional status. Total scores for each tool were computed for those age groups for which the tools were validated: PYMS was completed for patients aged 1 to 16 years, STAMP for patients aged 2 to 16 years and $STRONG_{KIDS}$ for patients aged 1 month to 18 years. For the comparison of the three tools, only children aged 2-16 years were considered, since patients within this age range account as eligible for screening by all three tools.

Data on height, weight, mid upper arm circumference (MUAC) and triceps skin fold thickness (TSFT) were collected. Methods have been described previously by Hecht el al (18). Clinical parameters, including LOS as primary outcome and frequency of infectious complications (number of days with temperature >38.5° C and number of days with antibiotic use) were derived from hospital records after discharge.

The total score and classification of malnutrition risk (low, medium or high) was determined for each study participant and screening tool. The scores obtained by the three screening tools were then related to anthropometry, body composition and outcome data. For the cross-tabulation of risk classification between the tools we decided to group the classification of malnutrition risk into two rather than three categories (i.e. “high”: vs. “medium+low”) as children allocated in the high group category are the ones that need to be further referred for assessment to the dietetic and clinical team.

The study protocol was accepted by the local research/medical ethic committees of each participating centre. Prior to participation informed written consent was obtained by parents and their caregivers (whenever required).

Statistical analysis

Risk scores were cross-tabulated within the three screening tools, and agreement rates were computed (concurrent validity). The Cohen's kappa statistic test was applied to describe the level of agreement between the two tools (20) taking into account the agreement occurring by chance. Baseline characteristics between groups were compared using Fisher's exact test or Pearson's chi^2-test for categorical data. Linear regression analysis was applied separately for gender to adjust the association of risk for malnutrition with TSFT and MUAC for age, chronic disease and centre. Residuals were checked for normal distribution. In clinical practice a substantial intervention (e.g. referral to a dietitian) will only occur in children with a high-risk score. Therefore in all data analysis except for the random coefficient model, low and medium risk patients for each screening tool were combined and presented as one group versus the high-risk patients.

Age- and gender-specific BMI and WFH SD-scores were calculated using the WHO reference data: WHO growth reference study data were used for children aged 1 month to ≤5 years (http://www.who.int/childgrowth/software/en/) and further age-adequate WHO reference data were used for patients aged >5-18 years (http://www.who.int/growthref/en/). MUAC and TSFT SD-scores based on WHO reference data were limited to patients aged 3 months to 5 years.

Multilevel mixed-effects Poisson regression was used to accommodate the general dependence of LOS on the centre of the patient and the existing differences in severity and

type of chronic diseases between centres. Thus, centre was included as a random effect while additionally allowing varying effects by chronic disease status. The association of each nutritional risk classification by PYMS, STAMP and $STRONG_{KIDS}$ with LOS was tested including age, sex and chronic disease status as confounders. An interaction between chronic disease status and nutritional risk classification was also tested.

Furthermore, the percentages of children with suboptimal skinfolds or MUAC and suboptimal BMI who were correctly identified or misclassified at high risk of malnutrition by each tool were calculated and compared to each other. Also the percentage of children classified at high risk despite a normal MUAC, TSFT or BMI was compared among the three tools. In order to have the same children included for each tool, only children aged 2-5 years were included for the analysis of SD-scores for MUAC and TSFT.

Data management and statistical analyses were carried out with R 2.13.2 (*The R Foundation for Statistical Computing; Vienna, Austria*) and Stata 12.1 (StataCorp LP, College Station, TX).

Results

Patient characteristics

A total of 2567 patients (median age 4.7 years; IQR: 1.4, 11.1 years) were enrolled into the study (80% general and 20% pediatric/surgical patients). Nearly half of the study population were females (44.9%), 44.8% had an underlying chronic disease and were electively admitted (18). Most study participants were of Caucasian origin (91%) and were at home prior to admission (91%). Nutritional support prior to admission was administered to 11.8% of the study population. During the hospital stay nutritional support was given to 12.3% of the participants (6.2% oral supplements, 6.1% tube feeding and 0.8% parenteral

nutrition, with few overlaps), of whom 76% were already receiving it prior to their admission. Some 20% of children who received nutritional support prior to admission were not allocated to a nutritional support regime after admission, according to hospital data.

Median length of hospital stay was 4 days (IQR: 3, 7 days). A BMI <-2 SDS was present in 7.0% of the study population at hospital admission, whereas for HFA<-2 SDS this was the case for 7.9% of the participants.

Completion of the screening tools

As each of the three screening tools were developed for different age ranges, the number of eligible children these could be applied to varied among them. Some 933 patients were either <2 or ≥16 years and therefore STAMP could not be completed. Similarly, for 621 participants aged either <1 or ≥16 years PYMS could not be applied. In total, PYMS was completed for 1664 (86% of the children in the targeted aged group: *1–16 years*), STAMP was completed for 1374 study participants (84% of children in the targeted aged group: *2–16 years*), and $STRONG_{KIDS}$ was completed for 2089 (81% of the children in the targeted aged group: *1 month –18 years*). For almost half of the study group (1258 children, 49%) all three tools have been completed. The completion rates of each individual component of the three tools are listed in **Table 1.** As the researchers occasionally found it challenging to respond to some of the steps of the individual tools, a numbers of screens were left incomplete.

Malnutrition risk classification

The classification of malnutrition risk of the assessed children by the three screening tools shows a substantial variation among the different tools (**Figure 1**). The risk classification

distribution varied markedly also within and between countries (**Figure 2)**. Overall the proportion of high risk patients ranged between 5-51% (PYMS: 15-51%, STAMP: 9-51% and $STRONG_{KIDS:}$ 5-30%). The greatest difference between the proportions of high-risk patients based on the 3 screening tools within one centre was 32% (Greece).

For the 1258 patients in whom all three tools were completed, the distribution of risk classification according to the three screening tools is shown in **Supplemental Figure 1.** In more detail, in this subgroup of 1258 patients the different tools categorized 10% ($STRONG_{KIDS}$) to 22% (STAMP and PYMS) of children in the high-risk group. In total only 87 participants (7% of all patients with three completed tools) were jointly rated as at high risk for malnutrition from all three tools. Less than half of the patients (41%) were classified at the same risk level for malnutrition with the use of the three different tools. This percentage increased to 74% when children with low and medium risk were group together and compared to the high risk group. The agreement between the tools, accounting for statistical chance, was fair to moderate. (20)

Pairwise comparison resulted in 55% agreement for PYMS with STAMP (κ=0.31, CI: 0.28, 0.35) and 58% PYMS with $STRONG_{KIDS}$ (κ=0.33, CI: 0.29, 0.37). The greatest degree of agreement was found between STAMP and $STRONG_{KIDS}$ (60%, κ=0.37, CI: 0.33, 0.40). This agreement increased to 74% when a combined classification "*low+medium*" versus the "*high*" risk group was used. Pairwise comparison between tool pairs resulted in approx. 80% agreement and is shown in **Table 2 (**PYMS vs. STAMP: *moderate agreement*, PYMS vs. $STRONG_{KIDS}$: *fair agreement*, and STAMP vs. $STRONG_{KIDS}$: *fair agreement*) (21).

Clinical characteristics of patients in the three risk groups for each tool

Characteristics of children within the risk groups of each screening tool are described in **Table 3**. The proportion of patients with an underlying chronic disease was higher for patients identified with high risk vs. medium or low risk for STAMP (75% vs. 53% or 36%) and $STRONG_{KIDS}$ (89% vs. 48% or 30%). With the use of PYMS patients with a chronic disease were equally classified into the three risk categories (48% vs. 49% or 48%). The administration of nutritional support both prior to admission or during the hospital stay was higher for patients identified with high risk vs. medium or low risk for all three tools. Additionally, high-risk patients identified with all three tools experienced fever more frequently and were prescribed more antibiotics than medium-risk-patients and low-risk-patients.

LOS increased from low to high-risk patients as identified by all three tools (**Table 3)**. This was also supported by the effect estimates of the multivariate regression analysis taking age, sex, chronic disease and centre into account (**Table 4**).

Risk categorization and anthropometry

Mean SD-scores for either BMI or HFA were significantly different between the 3 risk groups within each tool. (**Table 3** and in more details in **Supplemental Table 2**). Additionally, a considerable number of children with low BMI (<-2SD) were not picked up as high-risk (and were categorized either in the low or in the medium risk category) by the three tools. **Table 5** displays relevant differences among the 3 tools for the group of children (n=1253) who completed all three tools and had BMI data available.

MUAC and TSFT were measured in 2263 (88%) and 2094 (82%) study participants respectively. Linear regression results for all three screening tools showed a significant relationship between malnutrition risk and MUAC for both sexes after adjustment for age,

296 chronic disease and centre. SD-scores for MUAC and TSFT for patients ≥ 2 years and ≤ 5
297 years of age in relation to the risk groups of each screening tool can be found in **Table 6**.

298

299 **Discussion**

300 The aim of all three screening tools is to identify children at risk of malnutrition on
301 admission to select patients for further evaluation and potential intervention. However, there
302 are differences concerning the use of these tools, as they were designed for application by
303 different users (pediatricians, nurses etc.) and in different age groups (5, 13, 17). Additionally,
304 PYMS and STAMP include anthropometry, while $STRONG_{KIDS}$ focuses on identifying
305 children at nutritional risk on admission by visual inspection of body habitus alone.

306 This study found marked differences in the number of patients who could be screened by
307 the three tools. Also the scores and classification of malnutrition risk among children varied
308 substantially according to the tool used. Few smaller studies conducted previously have
309 looked into the agreement in nutritional risk classification using PYMS, STAMP and
310 $STRONG_{KIDS}$, and also found this to be modest (19, 22-24). Lack of agreement may be
311 explained by the fact that the tools are different, albeit containing similar steps. While several
312 components within the tools are similar, there are discrepancies in scoring, duration of recall
313 history and approaches to assess body size.

314 By definition (item 1) PYMS was expected to categorize all children with a BMI <-2SD
315 into the high risk category. However, this was not the case for a low number of children (7
316 out of 96) with suboptimal BMI not identified correctly by PYMS. This is likely to be
317 explained by discrepancies in the values of low BMI threshold ($<2^{nd}$ centile), between the
318 WHO growth charts, we used to analyse the data, and the UK-WHO adapted version cited on
319 the original PYMS form.

In this study, we assessed the discriminant validity of the screening outcomes of each tool against body composition and explored their ability to predict adverse clinical outcomes. For each tool we found a reverse association between malnutrition risk with body composition and a positive one with LOS. In particular, children scored at high risk for malnutrition, for each tool, stayed longer in the hospital and had lower mean MUAC and TSFT values than the patients with low or medium risk. It should be emphasized that sensitivity and cut off points of MUAC are still debatable, and MUAC might be a more valuable tool in assessing markedly malnourished children. However, it is often considered useful in the clinical assessment and follow-up of patients.

The association between the risk score classification and LOS was strongest with $STRONG_{KIDS.}$ It is, however, unclear how much of this association is explained by disease severity and how much is attributed to the effect of malnutrition.

It is arguable which would be the best benchmark assessing the value of a screening tool. Amaral et al (3) and Kyle et al (25) found a significant association between the screening score of nutrition risk screening tools and LOS in adults, but they stated that LOS is also influenced by many non-nutritional factors. However, adverse effects of malnutrition and the influence of the underlying disease interact and both affect LOS, which should be considered when assessing associations of risk scores and secondary outcomes such as fever or use of antibiotics.

We think that it is important that the tools would agree in the detection of the high risk patients including those with a subnormal BMI, HFA and skinfold thickness measurements, which was not the case in this study. We consider as high-risk patients those who need to be referred to a more detailed assessment and are more likely to need nutritional intervention. Moreover, screening tools are also aiming to identify children at risk of deterioration of malnutrition risk due to an acute medical insult despite normal anthropometry at hospital

admission. This encompasses a large proportion of children admitted in acute settings in developed countries and intervention and prevention of weight loss is probably as important as correction of weight loss and growth catch up in those children who are already malnourished (26).

Strengths of our study are its multicentre setting and the large number of participants from different countries. To our best knowledge this is the first study that compares three different screening tools in a large pediatric population. We used one growth reference (the WHO growth standard) for all children and thereby excluded the variation between different country specific growth charts. However, we did not use disease specific growth charts, as available, for example, for cerebral palsy patients, because these are only available for a few selected diagnoses and have generally not been based on pan-European patient populations.. We also acknowledge that our study may have suffered from a sample selection bias as some children who were severely sick may have not joined the study. Additionally a substantial number of children were on nutritional support at study entry which most likely reflects the profile of patients who regularly attend the highly specialised hospitals which participated in this study. A further potential limitation of this study is the fact that we did not perform full nutritional assessment as a reference for the comparison of the screening scores (1, 17). Moreover, with our data we could not account for the effect of disease groups or severity on the association between malnutrition risk and clinical outcome. The power to detect nutrition-associated infections is limited by the generally short LOS of the patients included in the study, which reflects current clinical practice. Large differences were found between countries, which may reflect differences in population characteristics or clinical practice. Furthermore, our study evaluated the screening tools in the specific study population enrolled, and extrapolation of results to other populations may be done cautiously.

While for all three tools significant associations were observed between high risk of malnutrition with increased LOS and suboptimal anthropometry, the agreement among tools to classify the same patients at the same risk of malnutrition was modest. While screening tools have potential in enhancing clinicians' awareness on the importance of nutritional status of pediatric patients (1, 23), raising awareness amongst health care professionals alone is not a sufficient justification for establishing an additional investigation in patients. Rather, a reasonable prediction of the risk of malnutrition or of outcome with a good sensitivity and specificity is expected, as a prerequisite for clinical routine use of a screening tool.

While $STRONG_{KIDS}$ is not based on anthropometric measurements, the authors describing $STRONG_{KIDS}$ also advocate measuring weight and height as part of assessing nutritional status on admission after the initial risk screening. PYMS or STAMP are based on anthropometry and thus detect the large majority of children with abnormal anthropometric measures (26, 27). However, the use of these tools may be at the expense of too many children being categorized as high risk. Other aspects need to be considered too, such as the clinical performance and impact of any selected tool on current health care resources (e.g. staff workload, practicality).

Identification and classification of risk of malnutrition varied among tools and countries. The agreement between s tools was modest, a finding which partially might be attributed to the absence of and a consensus definition and agreed measurements of malnutrition. Based on these findings, no firm conclusions can be drawn about the superiority of one tool over the other tool. Beyond diagnostic validity, we recommend that the selection of the most appropriate tool, for routine use on hospital admission, will further depend on its clinical performance, the availability of and impact on health care resources.

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Statement of authorship

MC wrote the manuscript, coordinated intragroup reviews and communication, helped with the statistical analyses and drafted the manuscript. CH contributed to writing the study protocol and first draft of the manuscript, coordinated the study, participated in its conduction, and performed the data entry, management and analyses. KG, participated in the initial part of study design, contributed in the sample collection and coordinated intragroup reviews and communication. KJ, TKL, HK, JK, CL, RS, HS and JH participated in the initial part of study design, contributed in the sample collection, were responsible for data acquisition, data interpretation and analysis. BK conceived of the study, participated in its design, contributed to writing the study protocol and helped to draft the manuscript. MC, CH, KG, KJ, BK and JH commented on the first and subsequent drafts. All authors read and approved the final manuscript.

CONFLICT OF INTEREST

The authors hereby declare that the article is original, is not under consideration for publication anywhere else and has not been previously published. Authors declare no potential or actual personal, political or financial interest in the material, information or techniques described in the paper. However, Jessie Hulst, Koen Joosten and Konstantinos Gerasimidis and Diana Flynn have been involved in the development of $STRONG_{KIDS}$ and PYMS, respectively.

References

1. Gerasimidis K, Macleod I, Maclean A, Buchanan E, McGrogan P, Swinbank I, McAuley M, Wright CM, Flynn DM. Performance of the novel Pediatric Yorkhill Malnutrition Score (PYMS) in hospital practice. Clinical nutrition 2011;30(4):430-5. doi: 10.1016/j.clnu.2011.01.015.
2. McCarthy H, Dixon M, Crabtree I, Eaton-Evans MJ, McNulty H. The development and evaluation of the Screening Tool for the Assessment of Malnutrition in Pediatrics (STAMP(c)) for use by healthcare staff. Journal of human nutrition and dietetics : the official journal of the British Dietetic Association 2012;25(4):311-8. doi: 10.1111/j.1365-277X.2012.01234.x.
3. Amaral TF, Antunes A, Cabral S, Alves P, Kent-Smith L. An evaluation of three nutritional screening tools in a Portuguese oncology centre. Journal of human nutrition and dietetics : the official journal of the British Dietetic Association 2008;21(6):575-83. doi: 10.1111/j.1365-277X.2008.00917.x.
4. Campanozzi A, Russo M, Catucci A, Rutigliano I, Canestrino G, Giardino I, Romondia A, Pettoello-Mantovani M. Hospital-acquired malnutrition in children with mild clinical conditions. Nutrition 2009;25(5):540-7. doi: 10.1016/j.nut.2008.11.026.
5. Hulst JM, Zwart H, Hop WC, Joosten KF. Dutch national survey to test the STRONGkids nutritional risk screening tool in hospitalized children. Clinical nutrition 2010;29(1):106-11. doi: 10.1016/j.clnu.2009.07.006.
6. Rocha GA, Rocha EJ, Martins CV. The effects of hospitalization on the nutritional status of children. Jornal de pediatria 2006;82(1):70-4. doi: 10.2223/JPED.1440.
7. Sermet-Gaudelus I, Poisson-Salomon AS, Colomb V, Brusset MC, Mosser F, Berrier F, Ricour C. Simple pediatric nutritional risk score to identify children at risk of malnutrition. The American journal of clinical nutrition 2000;72(1):64-70.
8. Agostoni C, Axelson I, Colomb V, Goulet O, Koletzko B, Michaelsen KF, Puntis JW, Rigo J, Shamir R, Szajewska H, et al. The need for nutrition support teams in pediatric units: a commentary by the ESPGHAN committee on nutrition. Journal of pediatric gastroenterology and nutrition 2005;41(1):8-11. doi: 00005176-200507000-00002 [pii].
9. Kondrup J, Allison SP, Elia M, Vellas B, Plauth M, Educational, Clinical Practice Committee ESoP, Enteral N. ESPEN guidelines for nutrition screening 2002. Clinical nutrition 2003;22(4):415-21. doi: S0261561403000980 [pii].

10. Stratton RJ, King CL, Stroud MA, Jackson AA, Elia M. 'Malnutrition Universal Screening Tool' predicts mortality and length of hospital stay in acutely ill elderly. The British journal of nutrition 2006;95(2):325-30. doi: S0007114506000432 [pii].
11. Kruizenga HM, Seidell JC, de Vet HC, Wierdsma NJ, van Bokhorst-de van der Schueren MA. Development and validation of a hospital screening tool for malnutrition: the short nutritional assessment questionnaire (SNAQ). Clinical nutrition 2005;24(1):75-82. doi: 10.1016/j.clnu.2004.07.015.
12. Secker DJ, Jeejeebhoy KN. Subjective Global Nutritional Assessment for children. The American journal of clinical nutrition 2007;85(4):1083-9. doi: 85/4/1083 [pii].
13. McCarthy H, McNulty H, Dixon M, Eaton-Evans M. Screening for nutrition risk in children: the validation of a new tool. Journal of human nutrition and dietetics : the official journal of the British Dietetic Association 2008;21:395-96.
14. McDonald CM. Validation of a nutrition risk screening tool for children and adolescents with cystic fibrosis ages 2-20 years. Journal of pediatric gastroenterology and nutrition 2008;46(4):438-46. doi: 10.1097/MPG.0b013e318156c2db.
15. Joosten KF, Hulst JM. Nutritional screening tools for hospitalized children: methodological considerations. Clinical nutrition 2014;33(1):1-5. doi: 10.1016/j.clnu.2013.08.002.
16. Gerasimidis K, Macleod I, Finlayson L, McGuckin C, Wright C, Flynn D, McGrogan P, Maclean A, Love E, Swinbank I, et al. Introduction of Pediatric Yorkhill Malnutrition Score--challenges and impact on nursing practice. J Clin Nurs 2012;21(23-24):3583-6. doi: 10.1111/j.1365-2702.2012.04164.x.
17. Gerasimidis K, Keane O, Macleod I, Flynn DM, Wright CM. A four-stage evaluation of the Pediatric Yorkhill Malnutrition Score in a tertiary pediatric hospital and a district general hospital. The British journal of nutrition 2010;104(5):751-6. doi: 10.1017/S0007114510001121.
18. Hecht C, Weber M, Grote V, Daskalou E, Dell'Era L, Flynn D, Gerasimidis K, Gottrand F, Hartman C, Hulst J, et al. Disease associated malnutrition correlates with length of hospital stay in children. Clinical nutrition 2015;34(1):53-9. doi: 10.1016/j.clnu.2014.01.003.
19. Ling RE, Hedges V, Sullivan PB. Nutritional risk in hospitalised children: An assessment of two instruments. European e-journal of clinical nutrition and metabolism 2011;6(3):e153-e7.

20. Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics 1977;33(1):159-74.
21. Viera AJ, Garrett JM. Understanding interobserver agreement: the kappa statistic. Family medicine 2005;37(5):360-3.
22. Wiskin AE, Owens DR, Cornelius VR, Wootton SA, Beattie RM. Pediatric nutrition risk scores in clinical practice: children with inflammatory bowel disease. Journal of human nutrition and dietetics : the official journal of the British Dietetic Association 2012;25(4):319-22. doi: 10.1111/j.1365-277X.2012.01254.x.
23. Moeeni V, Walls T, Day AS. Assessment of nutritional status and nutritional risk in hospitalized Iranian children. Acta pediatrica 2012;101(10):e446-51. doi: 10.1111/j.1651-2227.2012.02789.x.
24. Moeeni V, Walls T, Day AS. Nutritional status and nutrition risk screening in hospitalized children in New Zealand. Acta pediatrica 2013;102(9):e419-23. doi: 10.1111/apa.12299.
25. Kyle UG, Genton L, Pichard C. Hospital length of stay and nutritional status. Current opinion in clinical nutrition and metabolic care 2005;8(4):397-402. doi: 00075197-200507000-00010 [pii].
26. Milani S, Wright C, Purcell O, Macleod I, Gerasimidis K. Acquisition and utilisation of anthropometric measurements on admission in a pediatric hospital before and after the introduction of a malnutrition screening tool. Journal of human nutrition and dietetics : the official journal of the British Dietetic Association 2013;26(3):294-7. doi: 10.1111/jhn.12083.
27. Grek J, Puntis J. Nutritional assessment of acute medical admissions is still done badly despite 'nutrition screening'. Archives of disease in childhood 2013;98(11):922-3. doi: 10.1136/archdischild-2013-304883.

Table 1: Scoring of screening tool items for the group of children aged 2-16 years (N=1724) who completed all tools (N = 1258) expressed as N (%)

	Scores of children completing ALL tools n = 1258 *(%)*				**Children aged 2-16 years n = 1724 *(%)***	
ITEMS[1]	**0**	**1**	**2**	**3**	**Total Assessed**	**Not assessed according to original tool questions**
Item 1: Current nutritional condition[2]						
PYMS (0-2)	1152 (*92*)		106 (*8*)		1538 (*89*)	186 (*11*)
STAMP (0-1-3)	967 (*77*)	169 (*13*)		122 (*10*)	1474 (*85*)	250 (*15*)
$STRONG_{KIDS}$ (0-1)	1031 (*82*)	227 (*18*)			1607 (*93*)	117 (*7*)
Item 2: Weight loss[3]						
PYMS (0-1)	1036 (*82*)	222 (*18*)			1568 (*91*)	156 (*9*)
STAMP (NA)						
$STRONG_{KIDS}$ (0-1)	1027 (*82*)	231 (*18*)			1633 (*95*)	91 (*5*)

Item 3: Reduced intake[4]						
PYMS (0-1-2)	1004 (*80*)	228 (*18*)	26 (*2*)		1633 (*95*)	91 (*5*)
STAMP (0-2-3)	913 (*73*)		317 (*25*)	28 (*2*)	1633 (*95*)	91 (*5*)
$STRONG_{KIDS}$ (0-1)	861 (*68*)	397 (*32*)			1633 (*95*)	91 (*5*)
Item 4: Underlying disease[5]						
PYMS (0-1-2)	994 (*79*)	255 (*20*)	9 (*1*)		1509 (*88*)	215 (*12*)
STAMP (0-2-3)	670 (*53*)		324 (*26*)	264 (*21*)	1529 (*89*)	195 (*11*)
$STRONG_{KIDS}$ (0-2)	893 (*71*)		365 (29)		1515 (*88*)	209 (*12*)

[1] Possible scores are put in parentheses and for each item differ for each tool

Risk classification according to total scores differs between the tools:

low risk: PYMS: 0 points, STAMP: 0-1 points, $STRONG_{KIDS}$: 0 points

medium risk: PYMS: 1 point, STAMP: 2-3 points, $STRONG_{KIDS}$: 1-3 points

high risk: PYMS: 2-7 points, STAMP: 4-9 points, $STRONG_{KIDS}$: 4-5 points

[2]Item 1:

PYMS: Is the BMI below the cut-off value shown in the BMI Scoring Guide?

STAMP: Use a growth chart or the centile quick reference tables to determine the child's weight and height measurements.

$STRONG_{KIDS}$: Is the patient in a poor nutritional status judged by subjective clinical assessment?

[3]Item 2:

PYMS: Has the child lost weight recently?

$STRONG_{KIDS}$: Is there weight loss or poor weight gain (infants <1 year) during the last few weeks/months?

[4]Item 3:

PYMS: Has the child had a reduced intake (including feeds) for at least the past week?

STAMP: What is the child's nutritional intake?

$STRONG_{KIDS}$: Is one of the following items present: excessive diarrhoea (≥5/day) and/ or vomiting (>3/day), reduced food intake during the last few days, pre-existing nutritional intervention or inadequate nutritional intake due to pain?

[5]Item 4:

PYMS: Will the child's nutrition be affected by the recent admission/condition for at least the next week?

STAMP: Does the child have a diagnosis that has any nutritional implication?

$STRONG_{KIDS}$: Is there an underling illness with risk for malnutrition or expected major surgery?

PYMS: Pediatric Yorkhill Malnutrition Score; **STAMP**: Screening Tool for the Assessment of Malnutrition in Pediatrics; **$STRONG_{KIDS}$**: Screening Tool for Risk Of Impaired Nutritional Status and Growth.

Table 2: Cross-tabulation of risk classification between PYMS, STAMP and STRONGKIDS

		Risk for malnutrition		
		low + medium	high	
agreement 82% (n=1308)		**STAMP**		
PYMS	low + medium	897	121	κ= 0.47 (CI: 0.42, 0.53)
	high	118	172	
agreement 83% (n = 1318)		**$STRONG_{KIDS}$**		
STAMP	low + medium	990	32	κ= 0.39 (CI: 0.33, 0.45)
	high	187	109	
agreement 81% (n = 1490)		**PYMS**		
$STRONG_{KIDS}$	low + medium	1088	249	κ= 0.35 (CI: 0.28, 0.42)
	high	39	114	

PYMS: Pediatric Yorkhill Malnutrition Score; **STAMP**: Screening Tool for the Assessment of Malnutrition in Pediatrics; **$STRONG_{KIDS}$**: Screening Tool for Risk Of Impaired Nutritional Status and Growth.

Table 3: Characteristics of children within the risk groups of each screening tool

	PYMS (1–16y) **N=1664**			**STAMP** (2–16y) **N=1374**			**STRONG$_{KIDS}$** (1m–18y) **N=2089**		
	Low N=943	**Medium N=305**	**High N=416**	**Low N=512**	**Medium N=547**	**High N=315**	**Low N=915**	**Medium N=968**	**High N=206**
Median age (y) (95% IQR)	7.4 (3.6, 11.3)	5.8 (3.0, 11.3)	4.4 (2.0, 9.9)	8.3 (4.7, 12.0)	7.8 (4.1, 12.0)	7.6 (3.8, 12.3)	5.1 (1.3, 11.2)	4.4 (1.4, 10.6)	6.3 (1.9, 12.6)
Age groups (%)									
31 days – 0.9 y	0	0	0	0	0	0	21	18	15
1 – 1.9 y	12	13	24	0	0	0	10	14	10
2 – 5.9 y	30	37	34	34	39	41	23	26	24
6 – 12.9 y	40	32	29	49	41	38	29	26	27
13 – 17.9 y	18	18	13	17	20	21	17	17	24
Female (%)	44	50	43	46	45	43	44	45	44
Caucasian (%)	92	93	90	94	91	92	92	91	88
Acute admission (%)	45	54	65	52	48	53	48	62	58

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Chronic disease (%)	48	49	48	36	53	75	30	48	89
Surgical (%)	20	21	17	16	21	19	25	15	20
BMI- SDS (mean, SD)	0.52 (1.23)	0.28 (1.14)	-0.77 (1.58)	0.46 (1.17)	0.15 (1.23)	-0.30 (1.85)	0.42 (1.25)	-0.04 (1.37)	-1.19 (1.61)
HFA-SDS (mean, SD)	0.15 (1.37)	0.19 (1.43)	-0.19 (1.54)	0.38 (1.25)	0.02 (1.29)	-0.34 (1.62)	0.37 (1.31)	0.04 (1.38)	-0.86 (1.97)
Nutritional support (%) Prior admission	6	11	24	1	9	26	1	11	54
Nutritional support (%) During hospitalization	5	12	25	1	9	27	2	11	56
LOS (median (IQR), days)	4 (3, 6)	5 (3, 8)	5 (3, 9)	4 (3, 7)	4 (3, 7)	5 (3, 8)	4 (3, 7)	4 (3, 7)	6 (3, 10)
Secondary outcomes (%)									
Fever (%)[1]	10	21	29	10	17	19	13	23	23
Use of antibiotics (%)[2]	28	44	44	28	33	41	28	43	44

[1] At least one event-day of fever

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[2] At least one event-day of antibiotics

PYMS: Pediatric Yorkhill Malnutrition Score; **STAMP**: Screening Tool for the Assessment of Malnutrition in Pediatrics; **STRONG$_{KIDS}$**: Screening Tool for Risk Of Impaired Nutritional Status and Growth. **BMI**: body mass index; **SDS**: standard deviation score; **HFA**: height for age; **LOS**: length of stay.

Percentages and median (IQR) are reported for the total number of children in the risk groups of each screening tool.

Table 4: Relationship between LOS and nutritional risk classification using a random coefficient model[1] (95% CI), P-value

	PYMS *(N=1669)*	**STAMP** *(N=1379)*	**STRONG$_{KIDS}$** *(N=2089)*
Low risk	-	-	-
Medium risk	1.11[2] *< 0.001* (1.05, 1.18)	1.08 *0.005* (1.02, 1.14)	1.19 *< 0.001* (1.14, 1.24)
High risk	1.38 *< 0.001* (1.32, 1.45)	1.37 *< 0.001* (1.29, 1.46)	1.82 *< 0.001* (1.72, 1.93)

[1] Adjusted for Age, sex and chronic disease status and taking the dependence within centres into account while

[2] Comparison to low risk category, i.e. medium risk patients stayed 1.11 days longer in the hospital than the low risk patients scored by PYMS.

PYMS: Pediatric Yorkhill Malnutrition Score; **STAMP**: Screening Tool for the Assessment of Malnutrition in Pediatrics; **STRONG$_{KIDS}$**: Screening Tool for Risk Of Impaired Nutritional Status and Growth; **LOS**: length of stay.

Table 5: BMI SD-scores within the risk groups of three malnutrition risk screening tools (for the 1253 out of 1258 completing all tools)

BMI	**PYMS** (2–16y) **N=1253**[1]			**STAMP** (2–16y) **N=1253**[1]			**STRONG$_{KIDS}$** (2-16y) **N=1253**[1]		
	Low N= 757	**Medium N=222**	**High N= 274**	**Low N= 485**	**Medium N= 494**	**High N= 274**	**Low N=575**	**Medium N=550**	**High N=128**
Mean *(SD)*	0.50 (1.25)	0.23 (1.16)	-0.78 (1.55)	0.45 (1.18)	0.14 (1.23)	-0.27 (1.88)	0.53 (1.26)	0.05 (1.39)	-0.88 (1.50)
≥ -1SDS	**687**	190	147	**437**	410	177	**518**	434	72
<-1 to ≥-2 SDS	66	**30**	67	42	**75**	46	49	**88**	26
< -2 SDS	4	2	**60**	6	9	**51**	8	28	**30**
% of BMI <-2SD **NOT** categorized in the high-risk group	9.1% *(6/66)*			22.7% *(15/66)*			54.6% *(36/66)*		

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[1] All children with completion of the tool and BMI.For 5 children no BMI could be calculated due to length value missing.

PYMS: Pediatric Yorkhill Malnutrition Score; **STAMP**: Screening Tool for the Assessment of Malnutrition in Pediatrics; **STRONG$_{KIDS}$**: Screening Tool for Risk Of Impaired Nutritional Status and Growth; **SD**: standard deviation; **BMI**: body mass index.

Table 6: MUAC and TSFT SD-scores for children ≥2 and ≤5 years old within the risk groups of three malnutrition risk screening tools

	PYMS			**STAMP**			**STRONG$_{KIDS}$**		
MUAC	N=407[1]			N=389[1]			N=401[1]		
	low	medium	high	low	medium	high	low	medium	high
Mean *(SD)*	0.52 *(1.17)*	0.24 *(1.18)*	-0.27 *(1.13)*	0.44 *(1.15)*	0.31 *(1.11)*	-0.21 *(1.33)*	0.67 *(1.13)*	0.17 *(1.29)*	-0.81 *(1.16)*
≥ -1SDS	197	75	82	119	149	69	156	173	19
<-1 to ≥-2 SDS	13	12	16	10	18	13	5	27	9
< -2 SDS	4	0	8	1	1	9	0	7	5
TSFT	N=382[2]			N=361[2]			N=365[2]		
	low	medium	high	low	medium	high	low	medium	high
Mean *(SD)*	1.13 *(1.22)*	0.85 *(1.12)*	0.42 *(1.33)*	0.96 *(1.23)*	0.88 *(1.15)*	0.75 *(1.50)*	1.09 *(1.23)*	0.87 *(1.30)*	0.34 *(1.32)*
≥ -1SDS	192	81	84	117	150	70	140	178	23
< 1 to ≥2 SDS	8	2	10	7	4	8	7	9	3
< -2 SDS	0	1	4	1	2	2	0	4	1

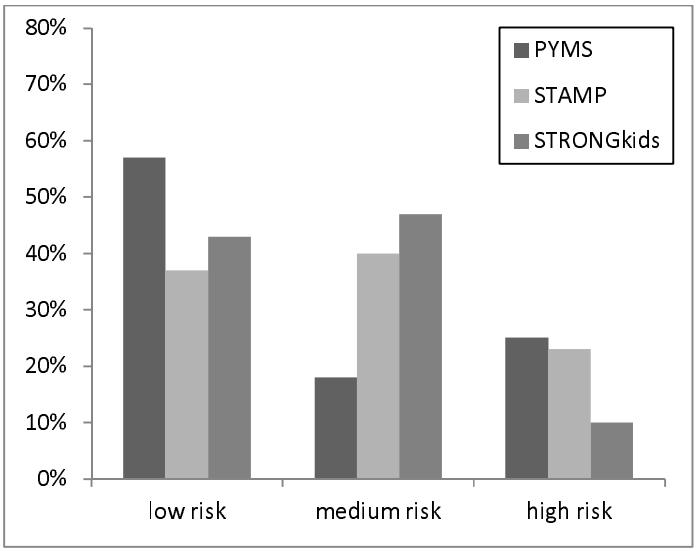
[1] All children with completion of the tool and MUAC (e.g. PYMS and MUAC)

[2] All children with completion of the tool and TSFT (e.g. PYMS and TSFT).

PYMS: Pediatric Yorkhill Malnutrition Score; **STAMP**: Screening Tool for the Assessment of Malnutrition in Pediatrics; **STRONG$_{KIDS}$**: Screening Tool for Risk Of Impaired Nutritional Status and Growth; **SD**: standard deviation; **MUAC**: mid upper arm circumference; **TSFT**: triceps skin fold thickness

Figure 1: Malnutrition risk classification based on the 3 screening tools expressed as percentages of the total number of assessed children for each tool.

Figure 2: Prevalence of malnutrition risk in different countries using the different screening tools.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PYMS
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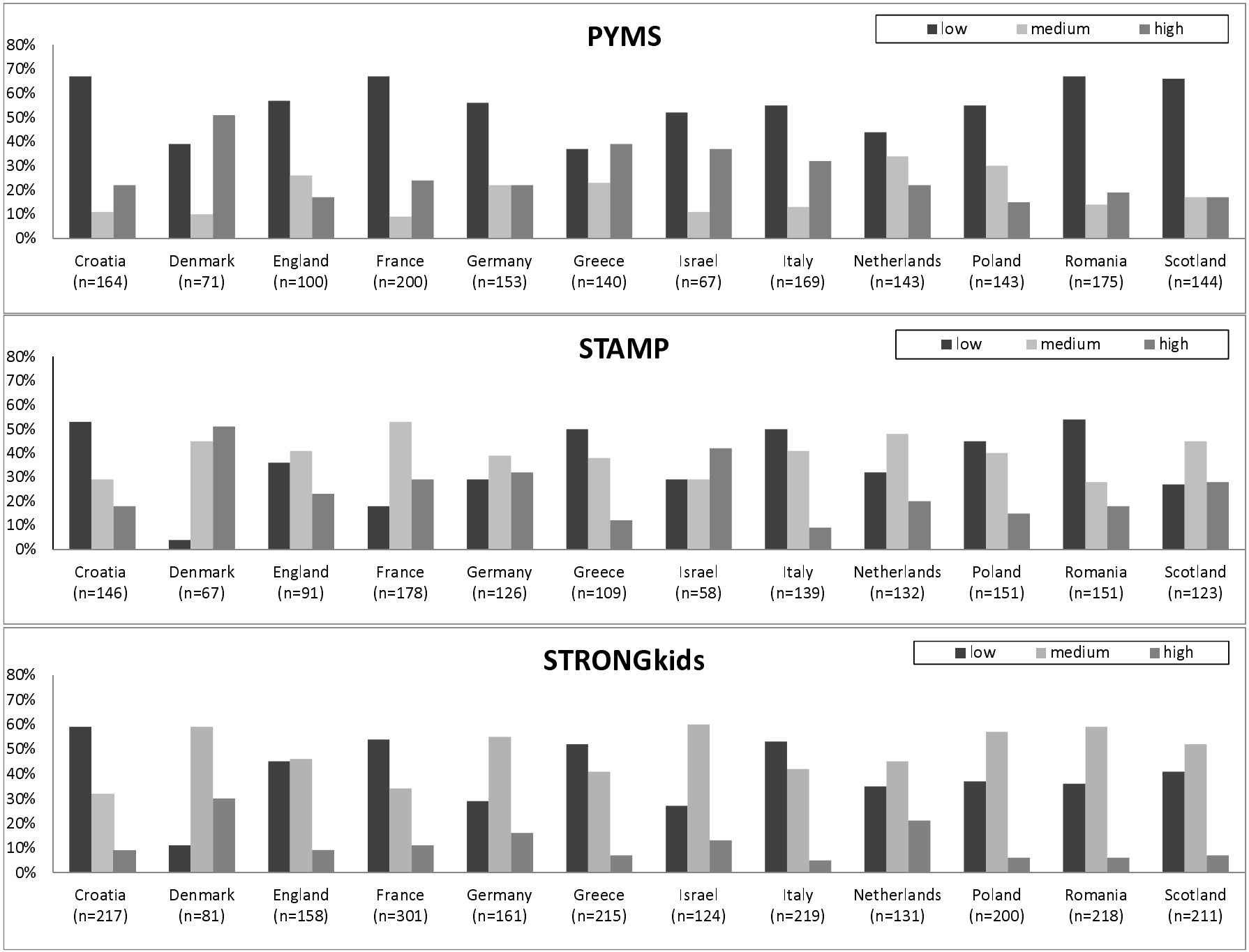

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