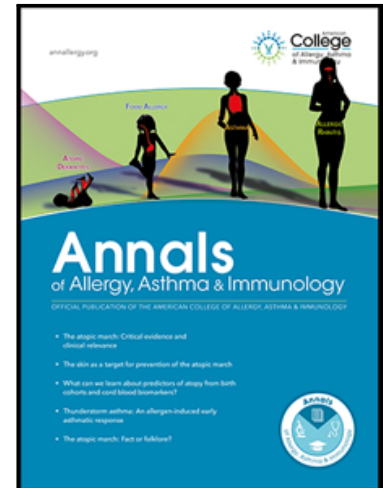


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Amelia Licari MD , Riccardo Castagnoli MD ,
Riccardo Ciprandi PsyD , Gian Luigi Marseglia MD ,
Giorgio Ciprandi MD

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Inadequate literacy is associated with uncontrolled asthma in adolescents.

Amelia Licari¹, MD, Riccardo Castagnoli¹, MD, Riccardo Ciprandi², PsyD, Gian Luigi Marseglia¹, MD, Giorgio Ciprandi³, MD.

¹ Department of Paediatrics, Fondazione IRCCS Policlinico San Matteo, University of Pavia, Pavia, Italy;

² Cystic Fibrosis Unit, Istituto G. Gaslini, Genoa, Italy

³ Allergy Clinic, Casa di Cura Villa Montallegro, Genoa, Italy

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Correspondence:

Giorgio Ciprandi

gio.cip@libero.it

Health literacy is a key requisite for reaching and maintaining optimal response to treatments, especially for chronic diseases. The concept of health literacy was introduced by Simonds in the 1970s (1), and since then, has become part of the larger concept of medical education. Health literacy is linked to many factors, such as educational level, socioeconomic status, and personal experience.

Asthma is the most common chronic disease in adolescence (2), and health literacy plays a pivotal role in its successful management. As recently reported by Tosca et al., in Italy, asthma affects an estimated 10% of adolescents (3). . Another recent study by Tosca et al. found that despite the widespread dissemination of asthma guidelines, the percentage of adolescents with well-controlled asthma remains unsatisfactory. The study described a nationwide survey of 480 asthmatic children and adolescents, in which only 55% had well-controlled asthma (4).

Many factors may lead to poor asthma control, including asthma severity, inappropriate work-up and treatment, co-morbidities, low adherence, incorrect inhaler technique, and emotional disorders. Among adolescents, health literacy could be a relevant factor associated with disease severity, inappropriate work-up and treatment, and co-morbidities.. Because adolescence is a critical period of life characterized by personal insecurity tied to confronting many life changes, some in this age

group tend to deny the disease, and consequently, disregard treatment (5). As a result, asthma management in adolescents requires thorough attention to psychological issues, including awareness of one's illness.

The relevance of health literacy in adolescents with asthma has not been extensively investigated, but there are some studies. Work by Valerio et al. showed that inadequate health literacy was associated with suboptimal asthma management in African-American adolescents with undiagnosed asthma (6). That study evaluated asthma control according to the Guidelines for the Diagnosis and Management of Asthma: Expert Panel Report 2 (EPR-2), put forth by the National Asthma Education and Prevention Program (NAEPP). The same study group extended the research to include Hispanic American adolescents, confirming the previous outcomes (7). These studies showed a relevant correlation between health literacy and measures of uncontrolled asthma. More recently, Jordan and colleagues demonstrated an association between educational level and traditional literacy, suggesting a role for health literacy in adolescents with asthma (8). However, to the best of our knowledge, no study has compared the asthma control scores with adequate health literacy. To address this gap, our current study investigated a group of adolescents with asthma by assessing asthma control and health literacy.

This cross-sectional study consecutively enrolled 87 adolescents (60 males, 27 females, median age 14.2 years) who were newly diagnosed with asthma at the third-level pediatric clinic of the Policlinico San Matteo of Pavia (Italy). Inclusion criteria were: between 12 and 18 years of age, both genders, and asthma diagnosis. Exclusion criteria were: current respiratory infections; severe chronic disorders (e.g., metabolic disorders, autoimmunity, neuropsychiatric diseases, cancer); and medications, including immune-suppressants, psychiatric drugs, chemotherapy, as they could interfere with interpretation of the results.

The internal Ethics Review Committee obtained approval for the study (code number: 22253/2017; in the Italian Project "Control'Asma" promoted by the Italian Society of Pediatric Allergy and Immunology). Either both parents or guardians signed the informed consent.

Based on the Global Initiative for Asthma (GINA) Guidelines, asthma diagnosis and asthma control were documented (2). As defined by those guidelines, patients were stratified into three groups according to asthma control: well-controlled, partly-controlled, and uncontrolled. Asthma diagnosis was confirmed by the consistency between typical symptoms history and reversibility to bronchodilators and/or bronchial hyper-responsiveness to methacholine (MCH). Investigators assessed asthma symptom perception by a visual analog scale (VAS), measured lung function by spirometry, and administered the Asthma Control Test (ACT).

Symptom intensity was measured on a horizontal 10-cm VAS scale labeled: no symptom (0) as the left anchor, and the worst possible symptom (10) as the right anchor. The patient drew a vertical mark on the line to indicate his/her symptom perception. The ACT consists of five questions with five possible responses to explore the patient's perception of his/her asthma control. The result ranges between 0 and 25, with 25 as the optimal asthma control, and <20 indicating uncontrolled asthma.

Health literacy screening was determined by the Rapid Estimate of Adolescent Literacy in Medicine (REALM-Teen) test (9). REALM-Teen measures an individual's ability to pronounce words in ascending order of difficulty. REALM-Teen scores range from 0 (no word pronounced correctly) to 66 (all words pronounced correctly). The obtained raw score was translated into a high school grade equivalent and expressed as adequate or inadequate literacy.

Descriptive statistics of the study patients were first calculated, and qualitative data were reported in terms of absolute frequencies and percentages, while quantitative data were reported in terms of

medians, first and third quartiles (1st – 3rd q). The normality of distributions was evaluated using the Shapiro-Wilk test. A comparison of frequencies was performed by the Chi-square test or Fisher's Exact test (in case of expected frequencies < 5). Quantitative data of three groups were analyzed using the non-parametric Analysis of Variance (Kruskal-Wallis test). We used the GraphPad Prism (version 8.4.0 for Mac OS X GraphPad Software, San Diego, California, US).

Table 1 shows the outcomes of the study after stratifying for the asthma control level. There were significant differences among groups concerning symptom perception, bronchial obstruction, ACT score, and adequate literacy. Adolescents with uncontrolled asthma had the lowest VAS score ($p=0.002$), such as perception of the worst asthma symptoms, and more frequently had bronchial obstruction (44% versus 3.3% in partly-controlled, and 6.2% in well-controlled, $p=0.0005$). Adolescents with uncontrolled asthma also had the lowest FEF_{25-75} values ($p=0.034$), a marker of early bronchial impairment, mostly when FEV_1 is still normal (10), and the lowest ACT scores ($p<0.0001$).

As expected, the current study demonstrated that adolescents with uncontrolled asthma had more severe symptoms and impaired lung function than adolescents with well-controlled or partly-controlled asthma. In addition, the ACT score confirmed the GINA grading. Moreover, adolescents with uncontrolled asthma consistently illustrated adequate health literacy less frequently (56% in uncontrolled versus 94% in well-controlled, and 86% in partly-controlled patients, $p=0.044$). This outcome underlined the clinical relevance of adequate health literacy in asthma control. Interestingly, all adolescents were students, and the school grade did not have an impact, as there was no age difference among groups.

The strengths of this study were that the clinical measures (e.g., lung function, asthma control, and VAS of symptoms) were consistent with variations in asthma control. The REALM-Teen test, while

not the most rigorous assessment, has been validated and is frequently used. There were, however, limitations to our study, notably the cross-sectional design; small sample size; recruitment from a single clinic; the basic approach to evaluate health literacy (the REALM-Teen assesses health-related word recognition and pronunciation, and not functional health literacy); the use of VAS, which requires complex abstract thinking, so it may not accurately reflect symptoms among those with low literacy; and the lack of an in-depth socioeconomic evaluation. Low health literacy could be related to low socioeconomic status and poverty, which could align more closely with challenges with asthma management and severity. Moreover, the subjects were newly diagnosed youth, so it was difficult to disentangle inherent severity and asthma control.

From this analysis, it cannot be assumed that level of health literacy is the reason for poorly controlled asthma due to the very small number of adolescents with uncontrolled asthma. Furthermore, the current study had other drawbacks, including the lack of some variables, such as co-morbidities, obesity, environmental tobacco smoke, teen smoking, adherence to medication, family history, and socioeconomic status (11-13). As a result, further studies should address these unmet needs, mainly concerning tobacco smoking and family history that represent important risk factors for asthma severity. In particular, environmental tobacco smoke is a variable frequently associated with lower levels of education and low income, which in turn, are related to asthma control and health literacy.

In conclusion, poor health literacy does seem to be associated with uncontrolled asthma in adolescents, and therefore, should be considered part of the global approach to treatment of adolescents with asthma. Further research is needed to confirm this conclusion.

Table 1. Comparison among the 3 groups of adolescents with asthma, stratified as: well-controlled, partially-controlled, and uncontrolled, according to GINA guidelines

	Well-controlled [N = 48]	Asthma control (GINA) Partly-controlled [N = 30]
Gender: Male, n/N (%)	33/48 (68.7%)	22/30 (73.3%)
Age (years)	14.8 [13 - 17]	14.5 [13.5 - 17.3]
VAS for asthma symptoms	9 [8 - 10]	8 [8 - 8]
FVC (% pred.)	101.5 [93.7 - 109.5]	101.5 [91.2 - 108.7]
FEV ₁ (% pred.)	97.5 [91.7 - 107.2]	101.5 [93.5 - 111.7]
Bronchial obstruction (FEV ₁ < 80% pred.), n/N (%)	3/48 (6.2%)	1/30 (3.3%)
FEV ₁ /FVC	83.4 [79.9 - 87.8]	87.6 [84.1 - 90.9]
FEF ₂₅₋₇₅ (% pred.)	89 [75.2 - 99.2]	99 [84.4 - 113.7]
Asthma Control Test (ACT) score	24 [23 - 25]	22 [21 - 22]
Health Literacy Questionnaire, adequate health literacy	45/48 (94%)	26/30 (86%)

Figures represent median values (unless otherwise specified) and figures in brackets represent 1st and 3rd quartiles; figures in parentheses represent column percentages; # P: Chi-square test; p values in bold when significant.

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