

A Systematic Review of Studies on Blood Pressure in Iranian Pediatric Population: First Report From the Middle East and North Africa

Zahra Fallah,^{1,2} Shirin Djalalinia,^{3,4,5} Mostafa Qorbani,⁶ Farshad Farzadfar,^{3,4} and Roya Kelishadi^{1*}

¹Department of Pediatrics, Child Growth and Development Research Center, Research Institute for Primordial Prevention of Non-Communicable Disease, Isfahan University of Medical Sciences, Isfahan, IR Iran

²Student Research Center, Isfahan University of Medical Sciences, Isfahan, IR Iran

³Non Communicable Diseases Research Center, Endocrinology and Metabolism Population Sciences Institute, Tehran University of Medical Sciences, Tehran, IR Iran

⁴Endocrinology and Metabolism Research Center, Endocrinology and Metabolism Research Institute, Tehran University of Medical Sciences, Tehran, IR Iran

⁵Developmental Research and Technology Center, Deputy of Research and Technology, Ministry of Health and Medical Education, Tehran, IR Iran

⁶Department of Community Medicine, School of Medicine, Alborz University of Medical Sciences, Karaj, IR Iran

*Corresponding author: Roya Kelishadi, Department of Pediatrics, Child Growth and Development Research Center, Research Institute for Primordial Prevention of Non-Communicable Disease, Isfahan University of Medical Sciences, P. O. Box: 81676-36954, Isfahan, IR Iran. Tel: +98-3136691216, Fax: +98-3136687898, E-mail: kelishadi@med.mui.ac.ir

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Abstract

Context: Blood pressure (BP) tracks from childhood to adulthood, and has ethnic variations. Therefore, it is important to assess the situation of pediatric BP in different populations. This study aims to systematically review the studies conducted on BP in Iranian children and adolescents.

Evidence Acquisition: We conducted a systematic review on published and national data about pediatric BP in Iran, our search was conducted in Pub Med, Medline, ISI, and Scopus, as well as in national databases including Scientific Information database (SID), IranMedex and Irandoc from 1990 to 2014.

Results: We found 1373 records in the primary search including 840 from international and 533 from national databases. After selection and quality assessment phases, data were extracted from 36 papers and four national data sources. Mean systolic BP (SBP) varied from 90.1 ± 14 mmHg (95% CI 89.25, 90.94) to 120.2 ± 12.3 (118.98, 121.41) mmHg, and for diastolic BP (DBP) from 50.7 ± 11.4 (50.01, 51.38) to 79.2 ± 12.3 (77.95, 80.44) mmHg. The frequency of elevated BP had large variation in sub-national studies with rates as low as 0.4% (0.009, 1.98) for high SBP and as high as 24.1% (20.8, 27.67) for high DBP. At national level, three surveys reported slightly raised rates of elevated BP from 2009 to 2012.

Conclusions: The findings provide practical information on BP levels in Iranian pediatric population. Although differences exist on the findings of various studies, this review underscores the necessity of tracking BP from childhood, and implementing interventions for primordial prevention of hypertension.

Keywords: Non-Communicable Disease, Blood Pressure, Child, Adolescent, Iran, Burden

1. Context

In the last decades and almost all around the world, the disease burden profile has changed from communicable diseases in childhood to non-communicable diseases (NCDs) in adulthood (1, 2). Meanwhile, the worldwide healthy adjusted life expectancy (HALE) has grown slower than life expectancy (0.8 years for each 1 year) and in a few countries HALE even has been reduced (3, 4). In addition, non-fatal health outcomes have resulted in increasing years lived with disability (YLD), worldwide (5). The Global Burden of Diseases (GBD) study on 2010 identified high blood pressure (BP) as the top global burden risk factor. In most parts of Asia, Middle East, North Africa, and Central Europe, high BP was the leading factor. It had worldwide attributable deaths of about 9.4 million and

disability adjusted life years (DALYs) of about 173.6 million and comprised 53 percent of ischemic heart disease (IHD) DALYs (1). Moreover, this study defined IHD, lower respiratory infections, and stroke as the three major causes for years of life lost (YLL) due to premature death (6), with high BP as one of the most important risk factors for all of them.

In 2001, high BP resulted in 7.6 million premature deaths and 92 million DALYs; it also caused 54% of strokes and 47% of IHDs worldwide (7). In 2002, IHD and stroke were the two principal causes of global death (8). The world health organization (WHO) ranked high BP (13% of global death) (9) and, cardiovascular diseases (CVDs) (45% of global deaths) (10) as the leading risk factors for global

death in 2009 and 2011, respectively.

It is well documented that elevated BP during adulthood roots in childhood (11-13). Given the importance of tracking BP from childhood, the Fourth report on the diagnosis, evaluation, and treatment of high BP in children and adolescents highlighted that all children aged above 3 years, who are seen in a medical setting, should have their BP measured (14). The growing pattern of NCDs and the pattern of the GBD are of special concern in low- and middle-income countries (1). As a low-middle income country located in the Middle East and North Africa (MENA) region, Iran is facing rapid epidemiological transition and change in the disease pattern (15). Therefore, increasing our knowledge on the risk factors of NCDs, would be helpful for designing and implementing timely preventive health programs. There are scattered and independent studies in this regard in Iran. Their results mostly are from limited populations or confined areas. It seems necessary to cumulate their findings and estimate the overall burden of elevated BP for the country. Furthermore, comparing data at the local and sub-national levels might yield useful results, which could be used by health policy makers and health workers. None of the published articles has considered this issue. Even the GBD study has drawn an overview of the situation at global level and does not provide each country's specific situation. Therefore in the current review, first we looked for the studies conducted on BP among Iranian pediatric population. Thereafter, we tried to deliberate the relevant trends and burdens in the country. Due to the scarcity of accessible information in many areas of the country, we need to use advanced statistical modeling methods in order to impute the missed data (16, 17).

2. Evidence Acquisition

The present systematic review is a sub-component of cardio-metabolic risk factors burden study in Iranian children and adolescents which itself is a part of the National and Sub-national burden of diseases, injuries and risk factors (NASBOD) study in Iran. We have described detailed designs and protocols elsewhere (18, 19), and here we explain it in brief.

2.1. Outcome Definition

The major outcome in the current review was elevated BP. According to the US national heart, lung, and blood institute (NHLBI), BP is considered normal when the systolic and diastolic values are less than the 90th percentile for the child's age, sex, and height. Prehypertension, is diagnosed when a child's average BP is above the 90th percentile but below the 95th. Every adolescent with a BP greater than 120.80 mmHg is also diagnosed to have prehypertension, even if the BP would be below the 90th percentile. Stage I hypertension is diagnosed if a child's BP is greater than the 95th percentile but less than or equal to

the 99th percentile plus 5 mmHg. Stage II hypertension is diagnosed if a child's BP is greater than the 99th percentile plus 5 mmHg (14). In the current review, the majority of the retrieved articles had used these cut points or earlier definitions proposed by NHLBI (20, 21). Other definitions have been used in some of them (22, 23).

2.2. Measures Definition

Measures consisted of the values/mean (Standard Deviation, SD) values of SBP and/or DBP, or the frequency rates of high BP. In all studies selected for this review, BP value was measured by sphygmomanometer through brachial artery with appropriate cuff size and was reported in mmHg or cmHg. In most of them, BP was measured two to three times in a single session and the mean value was recorded. In some others, two to three measurements were made on separate occasions and the last one was included in their analysis.

2.3. Search Strategy

We searched international databases including PubMed/Medline, ISI web of Science, and Scopus, as well as the Iranian scientific databases (IranMedex, Scientific Information Database (SID), Irandoc) from January 1990 to January 2014.

The search terms were as follows: hypertension, blood pressure, high blood pressure, systolic pressure, diastolic pressure, arterial pressure in any possible combination with school OR student OR girl OR boy OR child* OR adolescen* OR pediater* OR paediatr* AND Iran for searching in the International databases; the Farsi equivalent of these terms were used for searching the national databases. A definite search strategy for each database was also designed and used (Appendix 1). Both search methods results were considered. We also looked at the reference list of relevant retrieved articles to find more publications.

2.3.1. National Data

To the best of our knowledge the only nationwide study on cardio-metabolic risk factors in Iranian pediatric population with the age specific definitions are the surveys of a national surveillance program entitled: Childhood and adolescence surveillance and prevention of adult non-communicable diseases (CASPIAN) study (24, 25). It has been conducted in four different surveys from 2003 to 2012 (25-29). We used the source data of these surveys.

2.4. Inclusion and Exclusion Criteria

We included all cross sectional studies on BP values and prevalence of high BP in 6 - 18 year-old Iranian population. We also included cohort and case-control studies if they had reported their baseline data. We limited the

search to human studies conducted from January 1990 to January 2014 in Iran (Iran, I.R.Iran, Islamic Republic of Iran) or with Iran in the affiliation of the authors with no restriction in the language. Non-human studies and redundant publications were excluded. All document types were included at the first stage. We excluded the studies that reported population normal values or percentiles exclusively or reported findings in more extended age groups than our study age range, or did not use pediatric specific definitions for BP classification. In the case of finding multiple publications from one study, we selected the more comprehensive one.

2.5. Data Management

All retrieved publications underwent selection and qualification processes. The search was repeated throughout the study period to add any newly published articles. The selected documents were saved in computer files with back-ups.

2.6. Selection Process

In the first stage, the retrieved titles were screened to find relevant articles, at the second stage the abstracts were screened, and at the third stage full texts of relevant papers were screened (Appendix 2).

2.7. Quality Assessment

For quality assessment, we considered our study eligibility criteria, study design, sample size, sampling method, response rates, measurement tools and their calibration, as well as measurement methods and estimates. Two independent reviewers (ZF and RK) qualified the articles and the poor rated ones were excluded.

2.8. Data Extraction

The data extraction process is explained in detail elsewhere (19). For most papers, confidence intervals (CI) were calculated. For six papers for which complementary data were needed, we tried to make contact with main authors but unfortunately the response rate was not favorable.

3. Results

The search algorithm including the number of initial search results and included studies are shown in Appendix 2. At first step, we found 840 articles in international and 533 articles in domestic databases. After three steps of selection and then qualifying processes, we included 36 articles (30-68) (Tables 1 and 2) in our systematic review.

Altogether, this review included 1,096,263 total population (515,098 girls, 47%) and 277 data-points. They were from four national, one provincial, 29 district and two community study levels.

Mean BP value had variation in different studies. The least value of mean SBP (90.10 ± 4.00 mmHg (95% CI 89.25, 90.94)) and mean DBP (50.7 ± 11.40 (50.01, 51.38) mmHg) are both reported from Tehran city in the same study (54). The highest mean values reported are 120.2 ± 12.30 (118.98, 121.41) mmHg for mean SBP from Kerman city (59) and 79.20 ± 12.30 (77.95, 80.44) mmHg for mean DBP from Isfahan city (53). The study of Kerman city also had the second rank of highest DBP, i.e. 76 ± 11.4 (4.87, 77.12) mmHg (59).

As presented in Tables 1 and 2, almost all articles reported mean BP values. From 36 published articles, fifteen reported prevalence rates of isolated high SBP and high DBP (Table 1). Fifteen articles reported the prevalence of high SBP and/or high DBP (Table 2).

Table 1 also presents the national data of CASPIAN studies (66-68). The reported mean BP values do not show large variations in these three surveys. The CASPIAN-I study was a nationwide survey conducted in 2003-2004 in 23 provinces, and included 21,111 students, aged 6-18 years. Elevated BP was defined as values equal or greater than 95th percentile, and the prevalence of high SBP, DBP as well as SBP and/or DBP in total population was 4.2% (3.96, 4.51), 5.4% (5.05, 5.67) and 7.7% (7.38, 8.11), respectively (66). The CASPIAN-III study was conducted in 2009-2010 among 5,738 students aged 10-18 years living in 27 provinces. It reported prevalence rates for high BP (values equal or greater than 90th percentile) as follows: 3.8% (3.31, 4.32), 3.3% (2.86, 3.8), and 6% (5.41, 6.65) (66). The corresponding figures reported by CASPIAN-IV study, conducted in 2011-2012 on 13,486 students from 30 provinces, were 4.17% (3.84, 4.52), 4.33% (3.99, 4.68) and 6.88% (6.45, 7.32), respectively (68). These rates were slightly higher than those reported from CASPIAN-III study.

As it is obvious from these two tables, the reported range of high BP in Iranian pediatric population in sub-national studies in the two past decades varies widely, with rates as low as 0.40% (95% CI 0.009, 1.98) for high SBP in Tehran province for 15-19-year-old boys (39-41) and as high as 24.10% (20.80, 27.67) for high DBP in Khorasan-Razavi province (46). Moreover, in national screening of 6-year-old children at school entry, the prevalence of high BP was 0.10% (0.09, 0.109) (31).

Based on the use of ≥ 95 th percentile to define hypertension, the prevalence of hypertension would be expected to be around 5% and in fact 1-3% (69). Our findings showed that the number of sub-national studies in Iranian pediatric population that reported high BP rates above 5% (30, 45, 46, 55, 58, 61, 62, 65) was equal to studies that reported rates below 5% (31, 34, 36, 42, 44, 48, 49, 64). In eight papers, the rates from both ranges (below and above 5%) for different age or sex categories are reported (37-41, 43, 50, 57, 63). Seven studies reported at least one prevalence rate of elevated BP of more than 10 percent (30, 37-39, 41, 43, 50, 62, 63).

Table 1. The Mean Blood Pressure and the Prevalence of High Systolic and Diastolic Blood Pressure in Population-Based Studies in Iranian Children and Adolescents

Number	Reference	Location and Level of Study	Study Year	Publication Year	Age-group, y	Mean Age ^a	Gender	Urban/Rural	HTN Definition ^b	Sample Size, n	Mean Systolic BP mmHg ^a	CI	Mean Diastolic BP mmHg ^a	CI	Prevalence of Systolic HTN ^c	CI	Prevalence of Diastolic HTN ^c	CI
1	Basiratnia et al. (30)	Shiraz, district	2010-2011	2013	11-17	13.85 (1.69)	Both	Urban	2 and 3	T:2000, B:953, G:1047, U:2000, R:0	NA	NA	NA	T:10.7, (preHTN 4.5), B:8.2, G:12.7, 10.74±4.87	T:9.37±2.13 (preHTN 3.63-5.50), B:6.6±10.22, G:6.2, 10.74±4.87	T:6.8, (preHTN 6.29-8.63), B:7.4, B:7.3, G:6.6±10.22, G:4.82-7.84	T:5.73-7.99, (preHTN 6.29-8.63), B:6.6±10.22, G:4.82-7.84	
2	Amiri et al. (31)	Iran, National screening	2009	2012	6	6	Both	Both	1	Total:947967, Boys:484891, Girls:463076, Urban:724103, Rural:226564	NA	NA	NA	Total population:0.1	T:0.09-0.106	Total population:0.1	T:0.09-0.106	
3	Seyedzadeh et al. (32)	Kermanshah, district	2010	2012	6-12	9.5	Both	Urban	NA	T:160, B:80, G:80, U:160, R:0	Cases: (T:107.16, -111.59, G:106.15, -112.36, B:106.04 (7.3), R:65.18(7.5)), Controls: (T:103.47-107.46, (7.0), G:61.51 (105.06 (10), B:105.88 (9.2))	NA	NA	NA	NA	NA	NA	NA
4	Keishadi et al. (33)	Isfahan, provincial	2011-2012	2012	3-10	NA	NA	Both	NA	T:241, B:116, G:125, U:121, R:120	T:102.05(5.89), G:101.32(5.73), B:102.85 (16.9)	T:100.03-104.06, G:98.53-104.10, B:99.74-105.95, (6.61)	T:64.3 (14.23), G:64.54 (13.43), B:64.4 (15.11)	T:62.49 -66.10, G:72.16-76.91, B:61.62-67.7	NA	NA	NA	NA
5	Shajari et al. (34)	Yazd, district	September 2009-March 2010	2011	7 and 7	7 and 17	Both	Urban	2	T:4800, B(7y):1200, B(17y):1200, G(7y):1200, G(17y):1200, R:0	NA	NA	NA	T:7 years 2, 17 years 2, 2.5; Girls: 7 years old 1.50, 17 years 2	T:7 years 2, 17 years 2, 2.5; Girls: 7 years old 1.50, 17 years 2	T:7 years 2, 17 years 2, 2.5; Girls: 7 years old 1.50, 17 years 2	T:7 years 2, 17 years 2, 2.5; Girls: 7 years old 1.50, 17 years 2	
6	Mohkam et al. (35)	Tehran, district	2008-2009	2011	7-11	8.9 (1.34)	Both	Urban	2 and 3	T:425, B:196, G:229, U:425, R:0	T:102 (12.4), 101.95-102.58	T:68.4 (9.8), 68.36-68.44	NA	NA	NA	NA	NA	NA

7	Moradmand et al. (36)	Tehran, district	2006-2009	2011	6-19	14.11 (3.47)	Both	Urban	7	T:2043, B:925, G:118, U:2043, R:0	T:109.37(14.4)	108.74-109.99	T:68.73(16.63)	68-69.45	NA	NA	NA
8	Mehrkaash et al. (37, 38)	Gorgan, district	2009	2011	15-17	16(0.72)	Both	Urban	9	T:450, B:225, G:225, U:450, R:0	T:19.06(12.37), G:108(11.3)	T:11.43-120.68, G:106.51-0.48	T:69.42(9.16), G:70.02(7.29)	-T:68.21, -70.62, G:69.06-70.97	T:5.66-10.90, B:8.80-17.98, G:1.25-6.30	T:4.9, B:6.70, G:3.10	T:4.93,08-7.30, B:3.77-10.75, G:1.25-6.30,
9	Hosseini-Esfahani et al. (39)	Tehran, community (ILGS: Tehran Lipid and Glucose Study)	Survey1 1999-2001	2011	10-14	12.4(1)	Male	Urban	8	B:688	102.17-103.82	69.5(9)	68.72-70.17	4.3	2.96-6.16	11.3	9.06-13.94
9	Hosseini-Esfahani et al. (40)	Tehran, community (ILGS: Tehran Lipid and Glucose Study)	Survey1 1999-2001	2011	15-19	16.8(1)	Male	Urban	8	B:734	109.13-110.86	72.3(9)	71.64-72.95	2.5	1.56-4.01	4.6	3.22-6.41
9	Hosseini-Esfahani et al. (39)	Tehran, community (ILGS: Tehran Lipid and Glucose Study)	Survey 2-2002-2005	2011	10-14	12.2(1)	Male	Urban	8	B:190	99.42-102.57	65.6(10)	64.16-67.03	1.1	0.12-3.75	7.4	4.08-12.05
9	Hosseini-Esfahani et al. (39)	Tehran, community (ILGS: Tehran Lipid and Glucose Study)	Survey 2-2002-2005	2011	15-19	17.1(1)	Male	Urban	8	B:346	106.83-109.16	69.6(10)	68.54-70.65	0.9	0.17-2.51	1.8	0.63-3.73

Hosseini-Esfahani et al. (39)	Tehran, community (ILGS: 3-2006-2008)	Survey	2011	10-14	12.2(1)	Male	Urban	8	B:230	98(12)	96.44-99.55	63.8(10)	62.5-65.09	2.7	1.23-6.16	5.4	3.04-9.47
Ghanbarian et al. (40)	Tehran Lipid and Glucose Study)																
Mousavi-nasl-Khamesh et al. (41)																	
Hosseini-Esfahani et al. (39)	Tehran, community (ILGS: Survey3-2006-2008)	Sur-	2011	15-19	17.2(1)	Male	Urban	8	B:278	108(11)	106.70-109.29	69(10)	67.81-70.18	0.4	0.009-1.98	3.3	1.73-6.51
Ghanbarian et al. (40)	Tehran Lipid and Glucose Study)																
Mousavi-nasl-Khamesh et al. (41)																	
Hosseini-Esfahani et al. (39)	Tehran, community (ILGS: Survey1 Tehran Lipid and Glucose Study)	Survey1	2011	10-14	12.3(1)	FeMale	Urban	8	G: 675	102(11)	101.16-102.83	70(10)	69.24-70.75	3.9	2.65-5.76	12.3	10.04-15.17
Ghanbarian et al. (40)	Tehran Lipid and Glucose Study)																
Mousavi-nasl-Khamesh et al. (41)																	
Hosseini-Esfahani et al. (39)	Tehran, community (ILGS: Survey1 Tehran Lipid and Glucose Study)	Survey1	2011	15-19	17(1)	Female	Urban	8	G:913	106(11)	105.28-106.71	72.9(9)	72.31-73.48	1.3	0.68-2.28	4.8	3.52-6.41
Ghanbarian et al. (40)	Tehran Lipid and Glucose Study)																
Mousavi-nasl-Khamesh et al. (41)																	
Hosseini-Esfahani et al. (39)	Tehran, community (ILGS: Tehran Lipid and Glucose Study)	Survey	2-2002-2005	10-14	12.3(1)	Female	Urban	8	G: 214	97(11)	95.51-98.48	66(10)	64.65-67.34	1.6	0.51-4.71	0.7	0.11-3.33
Ghanbarian et al. (40)	Tehran Lipid and Glucose Study)																
Mousavi-nasl-Khamesh et al. (41)																	

9	Hosseini-Esfahani et al. (39) Ghanbarian et al. (40) Mousavi-nasl-Khamehneh et al. (41)	Tehran, community Survey	2-2002-2005	2011	15-19	173 (1)	Female	Urban	8	G:357	106 (10)	104.95-107.04	69.2 (8)	67.65-70.74	0.6	0.06-2	2.1	0.97-4.36	
9	Hosseini-Esfahani et al. (39) Ghanbarian et al. (40) Mousavi-nasl-Khamehneh et al. (41)	Tehran, community Survey	3-2006-2008	2011	10-14	123 (1)	Female	Urban	8	G: 231	91 (12)	89.44-92.55	62.3 (10)	61-63.59	23	0.95-5.56	3.9	1.76-7.26	
9	Hosseini-Esfahani et al. (39) Ghanbarian et al. (40) Mousavi-nasl-Khamehneh et al. (41)	Tehran, community Survey	3-2006-2008	2011	15-19	172 (1)	Female	Urban	8	G:351	99 (11)	97.84-100.15	65.6 (9)	64.65-66.54	0.6	0.06-2.04	0.9	0.17-2.47	
10	Salem et al. (42)	Rafsanjan, district	2008-9	2010	7-11	NA	Both	Urban	8	T:2275;B:500;G:775;U:1275;R:0	NA	NA	NA	NA	12.9, 12.9, -13.19;G:10.62 -15.46	10.04- 13.66;B:7.68 43	6.8;HTN:T: 3.6;B:2.4;G: 43	Pre HTN:T: 13.28-17.30;B: 15.2;B: 13.44- 16.6;G: 20.15;G:11.93 6.8;HTN:T: -16.98;HTN:T: 14.3;HTN:T: 11.8;B: 10.2;G: 12.9, -13.19;G:10.62 -15.46	Pre HTN:T: 4.79-7.49;B: 3.09-7.05;G: 5.16- 8.85;HTN:T: 2.65-4.78;B: 1.24-4.15;G: 3.05-6.07
11	Salem (43)	Rafsanjan, district	2007-8	2009	Only saidmiddle and highschool adolescent	NA	Female	Both	8	T:2221;B:0;G:1221;U:;R:-	NA	NA	NA	NA	1.3.8, HTN grade 2: 1.2	2.84 -5.08;HTN grade 2: 0.68	HTN grade 1: 1.4;HTN grade 2: 2.8	T (= F);Pre HTN: 6.26 -9.33; HTN grade 1: 0.81 -2.21; HTN grade 2: 2.193 -3.86	
12	Koohestani et al. (44)	Arak, district	2007	2009	3-18	13.31 (4.15)	Both	Urban	2	T:209;B:103;G:106;U: 209;R: 0,	T:110.22 (5.02);G:111(01 (12.94));R:109.43 (5-43)	T:108.17-112.26;G: 73.58;G: " 70.01 (10.63);B: 67.96-72.05;B: 71.59-75.90	T:74.84 (12.76);G: 73.58;G: " 70.01 (10.63);B: 67.96-72.05;B: 71.59-75.90	NA	NA	NA	NA		
13	Mahyar et al. (45)	Eghbali, district	2005	2009	7-12	NA	Both	Urban	2 and 6	T:789;B:306;G:483;U:789;R:0,	NA	NA	NA	NA	T:6.5;B: 8.55;B: 3.01 5.2;G: 7.9, -8.35;G: 5.80 -10.87	T: 4.96- T: 12.8;B: 18.1;G: 7.6, -23.09;G: 5.45 -10.4	T:10.54 - 15.338;B:14.13 -23.09;G: 5.45 -10.4		

14	Mirhosseini et al.(46)	Mashhad, district	Not declared	2009	15-17	16.4 (0.9)	Female	Urban	9	T:622;O:G; 622;U: 622,R: 0, T:1107;B:486;G; 621;U:1107;R:0,	T:95(12.9)	93.98-96.01	T:59(9.3)	58.26-59.73	T:7.2	T:5.32-9.56	T:24.1	T:20.80-27.67	
15	Keishadi et al.(47)	Isfahan, district	2006-2007	2009	6-18	12.57(3.3)	Both	Urban	-	T:103.39(14.9)	T:63.85(10.3)	63.24-64.45	NA	NA	NA	NA	NA	NA	
16	Zand et al.(48)	Arak, district	2007(?)	2008	3-18	12.9(4.38)	Both	Urban	2	T:418;B:209;G:209;U: 418,R:0	T:991(13.2),	97.29-100.9	T:60.6(11.7),	59.62-19	NA	NA	NA	NA	
17	Ataei et al.(49)	Tehran, district	Feb 2004- sep 2005	2007	13-18	NA	Both	Urban	2	T:6038;B:2758;G: 3280;U:6038,R:0,	NA	NA	NA	NA	T:2.8	T:2.41-3.26	T:3.4	T:2.96-3.9	
18	Ashrafi et al.(50)	Tehran, district	1998-1999 and 1999-2000 school years	2005	6-13	NA	Both	Urban	4	T:10288;B:4871;G: 5417;U:10288,R:0,	NA	NA	NA	NA	T:significant HTN 4.5.severe HTN1.5;B: 4.9 ,2.G: 3.5,0.9	T sig: 4.10 -4.91;T sev: 1.28-1.76;B sig: 4.31-5.55;B sev: 1.63-2.44;G sig:3.03-4.03;G sev: 0.66-1.19	T sig: 6.03	T:significant HTN 6.5, severe HTN 9.26-10.98;M 1.4;B:10.1, sev:1.89 -2.3;G:3.35 ,0.5 -3.87;F sev: 0.32-0.72	
19	Khajji et al.(51)	Tehran, community,	2003-4 school year	2005	Median age 11	11.5 (0.59)	Both	Urban	2	T:2766;B:1159;G: 1607;U:2766;R:0,	G:100.8(12.7),B: 98.1(3.8)	G:100.17-101.42;B: 97.30-98.89	G:64.9(9.8);B: 64.3(10.9)	NA	NA	NA	NA	NA	
20	Ayatollahi et al.(52)	Shiraz, district	2003-5 school year	2005	6-12	NA	Both	Urban	NA	T:1244;B:663;G: 581;U:1244;R:0,	T:93(10.9);G:93.4(11.4);B:92.6(10.5)	T:92.39-93.60;G: 92.47-94.32;B: 91.79-93.40	T:59.3(8.8);G: ,60.3(8.8);B:58.5(8.8)	59.78;G:59.58 -61.0;B:57.82 -59.17	NA	NA	NA	NA	
21	Keishadi et al.(53)	Isfahan, district	not mentioned probably 2001	2004	6- under 12	-	Both	Urban	2	T cases:369;U cases:369;T controls:113;U controls:113	T cases: 107.4(5.1);T controls:100.2(2.3)	T cases:106.36 -108.43;T controls:99.47-100.92	T cases: 69.7;T controls: 61.1(10.1)	60.5-61.69	NA	NA	NA	NA	
21	Keishadi et al.(53)	Isfahan, district	not mentioned probably 2001	2004	12-18	-	Both	Urban	2	T cases:377;U cases:377;T controls:1125;U controls:1125	T cases:110.7(14.5);T controls:109.4(14.1)	T cases:109.23 -112.16;T controls:108.57-110.22	T cases:79.2(12.3);T controls:70.4(11)	80.44;T controls: 69.75;71.04	NA	NA	NA	NA	
22	Fallah et al.(54)	Tehran, district	2002-3	2003	7-11	-	Both	Urban	-	T:1061;B:542;G:515;U: 1061;R:0	T:90.1(14)	89.25-90.94	T:50.7(11.4),	50.01-51.38	NA	NA	NA	NA	
23	Fesharaki-mia et al.(55)	Birjand, district	2002 spring	2002	7-11	-	Both	Urban	2	T:1928;B:1010;G: 918;U:1928;R:0,	G:101.2(9);B:100.9(9.5)	G:100.61-101.78;M: 100.31-101.48	G:67(9),B:70(9.5)	G:66.41-67.58;B:69.41-70.58	NA	NA	NA	NA	
24	Keishadi et al.(56)	Isfahan, district	Not declared	2002	2-18	11.7 (0.4)	Both	Urban	-	T:200;B:100;G: 100;U:200;R:0	Cases:(T:101.44-103.35;G:100.62 -103.57;B:102.84 -105.35);Controls:(T:103.6(4.5),G:103.6(4.8),B: 104.8(5.4)),	Cases:(T:51.07-53.72;G: 49.43 -52.96;B:51.38 -55.4)(71),Controls:(T:50.81(6.7),G:50.81(6.7),B:50.81(6.7), -52.13;G:48.9 -52.71;B:48.9 -52.71)	51.07-53.72;G: 49.43 -52.96;B:51.38 -55.4)(71),Controls:(T:50.81(6.7),G:50.81(6.7),B:50.81(6.7), -52.13;G:48.9 -52.71;B:48.9 -52.71)	NA	NA	NA	NA	NA	NA

25	Kelishadi et al.(57)	Isfahan,district	1993 & 1999	2001	2-18	NA	Both	Urban	2	T: 4500 (3825), T: 5917, B: 3046, G: 2871, U: 5917, R: 0,	NA	NA	NA	1993, G: 6,10, B: 5,2,1999, G: 6,4, B: 5,5	NA
26	Motiee -Langroodi et al.(58)	Qazvin,district	1995-96	2000	7-12	NA	Both	Urban	2	T: 5917, B: 3046, G: 2871, U: 5917, R: 0,	NA	NA	NA	NA	NA
27	Mirzaee Poor et al.(59)	Kerman,district	1996-7	1998	14-17	NA	Both	Urban	10	T: 870, B: 409, G: 394, U: 870, R: 0,	G: 118,22-120,57, B: 118,98-121,41	G: 70,30-73,89, B: 74,87-77,12	NA	NA	NA
28	Torghhi (60)	Guilan,district	not mentioned	1998	7-12	NA	Both	Urban	NA	T: 444, B: 230, G: 214, U: 444, R: 0	Cases: (G: 62,8 (-), B: 66,6 (-)), Controls: (G: 61 (-), B: 62,1 (-))	NA	NA	NA	NA
29	CASPIAN 1 (61)	national	2003-2004	2006	6-18	12,2 (3,3)	Both	Both	11	Total: 2111, Boys: 1025, Girls: 1085, U: 166, R: 3048	T: 102,28-102,63, B: 103,02-103,51, G: 101,33-101,82, U: 102,39-102,78, R: 101,49-102,4	T: 64,70 (10,65), B: 64,84, B: 64,76	T: 3,93-4,48, B: 4,27-5,07, G: 3,41-4,17, U: 4,19-4,88, R: 2,29-3,50	T: 5,09-5,71, B: 5,52-6,43, G: 4,30-5,14, U: 5,6, R: 5,1	T: 5,4, B: 6, G: 4,7, U: 5,6, R: 5,1
30	CASPIAN 3 (62)	national	2009-2010	2013	10-18	14,7 (2,4)	Both	Both	12	T: 5738, B: 2863, G: 2875, U: 3585, R: 1529	T: 102,084-103,55, M: 101,01	T: 65,58-66,15, B: 64,43	T: 3,31-4,32, B: 2,15-3,38, G: 2,7, G: 4,14-5,75, U: 3,21-4,5, R: 2,66-4,58	T: 2,86-3,8, B: 1,78-2,92, G: 2,3, G: 4,4, U: 3,9, R: 2,1	T: 2,86-3,8, B: 1,78-2,92, G: 2,3, G: 4,4, U: 3,9, R: 2,1
31	CASPIAN 4 (63)	national	2011-2013	2014	6-19	11,47 (3,36)	Both	Both	13	T: 13486, B: 6846, G: 6640, U: 10191, R: 3295	T: 101,29-101,74, B: 102,1-103,5, G: 99,6-100,8, U: 102,1-102,6, R: 98,1	T: 64,68-65,07, B: 65,66,2, G: 63,6-64,7, U: 65-66, R: 62-63,9	T: 0,73-1,16 HTN, 3,25 HTN, 2,79-3,8 preHTN, 4,17 HBP, 3,84-4,52 HBP, R: 1,3 HTN, G: 0,6 HTN, U: 1,1 HTN, R: 0,4 HTN, 0,7-1,2 HTN	T: 3,08 HTN, 1,25 HTN, 0,98-1,6 preHTN, 4,3 HBP, B: 3,6-4,68 HBP, B: 2,5 HTN, G: 1,8 HTN, U: 3,1 HTN, R: 3-3,8, R: 1,9-4,6 HTN	T: 2,58-3,67 HTN, 0,98-1,6 preHTN, 3,99 HBP, B: 3,6-4,68 HBP, B: 2,5 HTN, G: 1,8 HTN, U: 3,1 HTN, R: 3-3,8, R: 1,9-4,6 HTN

^aValues are presented as mean (SD).

^b1. High BP (systolic: 120+, and diastolic: 100+). 2. SBP more than 95th percentile, defined as hypertension, DBP more than 95th percentile for age and sex: normal, Between 90th to 95th: high normal, Above 95th: High blood pressure. 3. Prehypertension was defined as an average systolic or diastolic blood pressure between the 90th and 95th percentiles for gender, age, and height. 4. For children aged 6-9 years, significant hypertension and severe hypertension were defined as systolic blood pressure greater than 122 mmHg and diastolic blood pressure greater than 78 mmHg and 86 mmHg respectively. Significant and severe hypertension in children aged 10-12 years was defined as systolic blood pressure greater than 126 mmHg and diastolic blood pressure greater than 82 mmHg and 90 mmHg respectively (Second Task Force) (20-21). 5. According to Task Force. Report of the Second Task Force on Blood Pressure Control in Children-1987. Task Force on Blood Pressure Control in Children. National Heart, Lung, and Blood Institute, Bethesda, Maryland, Pediatrics. 1987;79:1-25 (20), 6. According to the Nelson textbook of pediatrics (22). 7. According to the harriet lane Handbook: A Manual for Pediatric House Officers (23). 8. According to the fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents (between 90 and 95 percentile: preHTN, between 95th percentile and 99th percentile: 5 mmHg: stage 1 HTN and over 99th percentile: 5 mmHg: stage 2 HTN (14). 9. Equal or greater than age- and gender-specific 90th percentile. 10. According to the Update on the 1987 Task Force Report on High Blood Pressure in Children and Adolescents: a working group report from the National High Blood Pressure Education Program (between 90th and 95th percentiles: significant HTN and over 99th percentile severe HTN) (21). 11. BP above the 95th percentile for that age and sex after adjusting for weight and height=HTN (19-21). 12. BP in the 90th percentile for their age, sex, and height=HTN (19-21). 13. Pre HTN = BP equal or greater than the age- and gender-specific 90th percentile after adjusting for weight and height or BP equal or more than 120/80 mm Hg. When BP was equal or over the age- and gender-specific 95th percentile value, it was considered as HTN (14).

Table 2. The Mean Blood Pressure and Prevalence of High Systolic and/or Diastolic Blood Pressure in Population-Based Studies on Iranian Children and Adolescents

Number	Reference	Location and Level of Study	Study Year	Publication Year	Age-Group ^a	Mean Age ^a	Gender	Urban/Rural	HTN Definition ^b	Sample Size, n	Mean Systolic BP mmHg ^a	CI	Mean Diastolic BP mmHg ^a	CI	Prevalence of Sys. and/or Dias. HTN ^c	CI
1	Basiratnia et al. (30)	Shiraz, district	2010-2011	2013	11-17	13.85(1.69)	Both	Urban	2and3	T:2000, B:953, G:1047, U:2000, R:0	NA	NA	NA	T:11.8, B:10.40, G:13.15, G:11.01-15.17	T:10.41-13.29, B:8.52-12.5, G:11.01-15.17	
2	Amiri et al. (31)	Iran, National screening	2009	2012	6	6	Both	Both	1	Total:947967, Boys:484891, Girls:463076, Urban:721403, Rural:226564	NA	NA	NA	Under 0.1% (both systolic and diastolic)	NA	
3	Moradmand et al. (36)	Tehran, district	2006-2009	2011	6-19	14.11(3.47)	Both	Urban	7	T:2043, B:925, G:118, U:2043, R:0	T:109.37(14.4)	108.74-109.99	T:68.73(16.63)	68-69.45	T:3.4, B:3.5, G:4.8	T:2.68-4.3, B:2.46-4.97, G:3.64-6.25
4	MehrAlizadeh et al. (64)	Semnan, district	2006-7	2010	9-17	NA	Both	Urban	8	T:2127, B:1058, G:1067, U:2127, R:0	NA	NA	NA	T:6.7, B:6.10, G:7.30	T:5.69-7.87, B:4.77-7.76, G:5.82-9.03	
5	Rafraf et al. (65)	Tabriz, district	NA	2010	High school	NA	Female	Both	8	T:985, B:0, G:985, U:1, R:0	NA	NA	NA	T(=f):preHTN, 13.9, HTN, 19.4	T(=f):preHTN, 11.80-16.22, HTN, 16.96-22	
6	Koohestani et al. (44)	Arak, district	2007	2009	3-18	13.31(4.15)	Both	Urban	2	T:209, B:103, G:106, U:209, R:0	T:110.22(15.02), -112.26, G:111/01(12.94), -113.49, B:109.43(15.43)	T:108.17(12.76), -112.26, G:108.5(10.63), -113.49, B:106.41-112.44	T:70.09(12.76), -73.58, G:67.96(10.63), -72.05, B:71.59-75.90	T:70.09(12.76), -73.58, G:67.96(10.63), -72.05, B:71.59-75.90	T:4.31	T:1.98-8.01
7	Mirhosseini et al. (46)	Mashad, district	Not declared	2009	15-17	16.4(0.9)	Female	Urban	9	T:622, B:0, G:622, U:622, R:0	T:95(12.9)	93.98-96.01	T:59(9.3)	58.26-59.73	T:6.1	T:4.35-8.28
8	Zand et al. (48)	Arak, district	2007	2008	3-18	12.9(4.38)	Both	Urban	2	T:418, B:209, G:209, U:418, R:0	T:99.1(13.2)	97.29-100.9	T:60.6(11.7)	59-62.19	T:1.9	T:0.82-3.73
9	Ataei et al. (49)	Tehran, district	Feb 2004-Sep 2005	2007	13-18	NA	Both	Urban	2	T:6038, B:2758, G:3280, U:6038, R:0	NA	NA	NA	NA	T:4.7	T:4.18-5.26

10	Kelishadi et al. (66)	Isfahan, Najafabad, Arak, 3 districts	2001	2005	11-18	14.3(1.2)	Both	Both	2	T:2000, B:1000, G:1000, U:1300, R:700	NA	NA	NA	T:5.7, B:7.4, G:4.1, S-fahan 6.7, Najafabad 17.10, Arak 1.5	T:4.72-6.80, B:5.85-9.20, G:2.87-5.40
11	Derakhshan et al. (67)	Hamedan, district	1996	2002	11-17	NA	Both	Urban	5 and 6	T:1495, B:732, G:763, U:1495, R:0	NA	NA	NA	T:0.8, B:0.45-2, G:1	T:0.30-1.77, G:0.45-2
12	Fesharaki- nia et al. (68)	Birjand, district	2001-2 school year	2002	7-11	NA	Both	Urban	2	T:1760, B:925, G:835, U:1760, R:0	NA	NA	NA	T:8.1	T:6.89-9.5
13	Fesharaki- nia et al. (55)	Birjand, district	2002 spring	2002	7-11	NA	Both	Urban	2	T:1928, B:1010, G:918, U:1928, R:0	G:101.2 (9), B:100.9 (9.5)	G:100.61-101.78, M:100.31-101.48	G:66.41, B:-67.58, B:69.41-70.58	T:6.76-9.23, B:5.61-8.89, G:6.97-10.72	
14	Motiee- Langroodi et al. (58)	Qazvin, district	1995-96	2000	7-12	NA	Both	Urban	2	T:5917, B:3046, G:2871, U:5917, R:0	G:110 (-), B:108.4 (-)	NA	NA	T:6.27-7.58, B:6.32-8.2, G:5.73-7.58	
15	Mirzaee Poor et al. (59)	Kerman, district	1996-7	1998	14-17	NA	Both	Urban	10	T:870, B:409, G:394, U:870, R:0	G:119.4 (12.1), B:120.2 (12.3)	G:118.22-120.57, B:118.98-121.41	G:70.30, B:-73.89, B:74.87-77.12	T:4.39-9.45, B:5.4-10.98, B:7.8, Severe, B:0.69-3.49, G:0.41-2.93	

^aValues are presented as mean (SD).

^{b1} Hypertension (systolic: 120+, and diastolic: 100+). 2. SBP more than 95th percentile, defined as hypertension, DBP more than 95th percentile, defined as hypertension or BP under 90th percentile for age and sex: normal, Between 90th to 95th: high normal, Above 95th: High blood pressure. 3. Prehypertension was defined as an average systolic or diastolic blood pressure between the 90th and 95th percentiles for gender, age, and height. 4. For children aged 6-9 years, significant hypertension and severe hypertension were defined as systolic blood pressure greater than 122 mmHg and 130 mmHg and diastolic blood pressure greater than 78 mmHg and 86 mmHg respectively. Significant and severe hypertension in children aged 10-12 years was defined as systolic blood pressure greater than 126 mmHg and 134 mmHg and diastolic blood pressure greater than 82 mmHg and 90 mmHg respectively (Second Task Force) (20-21). 5. According to the Task Force Report of the Second Task Force on Blood Pressure Control in Children - 1987. Task Force on Blood Pressure Control in Children. National Heart, Lung, and Blood Institute, Bethesda, Maryland. Pediatrics. 1987;79:125 (20). 6. According to the Nelson textbook of pediatrics (22). 7. According to the harriet Lane Handbook: A Manual for Pediatric House Officers (23). 8. According to the fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents (between 90 and 95 percentile: preHTN, between 95th percentile and 99th percentile+5 mmHg: stage 1 HTN and over 99th percentile+5 mmHg: stage 2 HTN) (14). 9. equal or greater than 90th percentile. 10. according to the Update on the 1987 Task Force Report on High Blood Pressure in Children and Adolescents: a working group report from the National High Blood Pressure Education Program (between 90th and 95th percentiles: significant HTN and over 99th percentile severe HTN) (21).

^cValues unit is %.

4. Conclusions

To the best of our knowledge, this study is the first systematic review on studies related to BP in the pediatric population, not only in Iran, but also, in the MENA region. As expected, we found that the prevalence of elevated BP was not negligible in healthy children and adolescents in Iran, and varied in different regions. It should be considered that in addition to detecting prehypertension and hypertension at early stages, BP screening programs would help in monitoring the mean SBP and DBP over time.

Though a decrease from 41% in 1990 to 25% in 2010 has occurred in the contribution of pediatric mortality and morbidity to global DALYs (3), considering that many adult NCDs actually start from earlier stages of life, the importance of this side of pediatric health and its significant sequels in the adult life should not be neglected. Even because of the high susceptibility of fetal life to environmental and nutritional disorders, preventive measures should focus on this stage of life (70). The childhood obesity epidemic has resulted in left ventricular hypertrophy and evidence for premature development of atherosclerosis, therefore it makes the issue of tracking BP and screening for elevated BP of special concern in the pediatric age group (71).

Children and adolescents with pre-hypertension and hypertension tend to maintain this situation over time (1, 72-76). Many risky behaviors as smoking, alcohol use, physical inactivity, and unhealthy dietary habits are developed during adolescence period. Changing such lifestyle habits would be difficult after establishment, and would have lifelong consequences including NCDs and their risk factors as high BP (77). A longitudinal study with 17 years of follow up of a pediatric population showed a 6.88 fold increase in the prevalence of hypertension in those who had high BP at baseline (78).

National studies in American children and adolescents found that that the mean BP levels (79), as well as the prevalence of high BP (80) are gradually rising over time. The situation in Iran seems similar. The mean age of Iranian population is estimated to be increasing by 6.5 years in the two coming decades. Presuming the persistent prevalence of risk and protective factors and only because of that increase in the age, the country's YLL from CVDs will be duplicated in 2025 compared to 2005, without difference in terms of gender (81). A Study in 2003 showed that in Iran 58 percent of DALYs resulted from NCDs and the country health burden is changing from communicable diseases to NCDs and road accidents (82). WHO has reported an age-standardized mortality rate of 420.8 (males) and 348.0 (females) per 100000 for CVD and diabetes in Iran for 2008, and estimated a prevalence rate of around 33.7% for hypertension (7). A national survey (SuRFNCD) in 2007 showed a remarkable prevalence of NCDs and their risk factors among Iranians aged 15 - 65 (83). Another national study showed that high SBP is responsible for most deaths in all regions of Iran. It is expected that by optimizing SBP, the

years of life expectancy would increase by 3.2 (2.6, 3.9 95% uncertainty interval) years in men and by 4.1 (3.2, 4.9 UI) years in women, therefore it is concluded that prevention and control of high BP should be considered as a health priority for Iran (84). Many studies documented high rates of cardio-metabolic predisposing factors in Iranian pediatric population (25-29, 85-90). The CASPIAN-I study (25, 26), showed that the percentiles of SBP and DBP of Iranian children and adolescents were in close agreement with reference values (14). As mentioned earlier, the study has continued to the 4th survey till now and different rates of elevated BP are reported. Overall, these surveys showed that in recent years, the prevalence of elevated BP has increased slightly. The variation between surveys could be attributed to differences between definitions of elevated BP (the first phase was conducted before the introduction of pediatric pre-HTN) and differences in study populations, i.e. different proportion of age and gender subgroups, different provinces, different total populations and changes in the prevalence of associated conditions as obesity, unhealthy dietary habits, inactivity, air and noise pollution, urbanization, etc. (69, 91).

Given the association of BP level with excess weight as well as with environmental factors as air pollution, noise pollution, and passive smoking (91), and the high sodium intake of Iranian children (33), it is proposed that in the near future, the mean BP and the prevalence of high BP will be escalating in Iranian children and adolescents.

The high prevalence of NCD risk factors in various age groups of Iranians, underscores the necessity of conducting comprehensive research and preventive programs to achieve a multidisciplinary intervention plan involving the whole health system of Iran (92). Both in the 53rd session of Eastern Mediterranean Region (EMRO) (93) and September 2011 session of the United Nations (UN) in New York, all members committed to develop national strategies as well as preventive and controlling action plans, to involve all stakeholders and to organize financial resources targeting NCDs. It seems that still no effective public and community interventions have been done in this regard. The GBD study 2010 revealed that some parts of underachievement of the WHO 4th millennium goal is because of the lack of relevant information from the pediatric age group (94). Presenting the information regarding pediatric studies to policymakers in a systematic and concluding manner would be of help for planning action-oriented programs. Moreover, there is increasing need to know where and how the complementary research and action plans must be implemented.

The current study summarized the information on the mean BP and the prevalence of high BP in the Iranian pediatric population. The wide heterogeneity of the retrieved papers and their point estimates led the researchers not to consider a meta-analysis. It is planned to draw the trend of BP changes across these years. As mentioned

before, we will use advanced statistical modeling for missed data handling and estimations. After that, YLDs, YLLs, DALYs and burden of the HBP in pediatric population of Iran will be estimated.

The importance of BP tracking and the pediatric hypertension per se and as a CVD risk factor becomes more obvious, making it important for including BP measurement in screening programs and conducting further comprehensive and cumulative studies on its time trends, primary prevention and early diagnosis.

Health policies on prevention and early control of high BP can be effective in reducing the prevalence and the adverse consequences of high BP in adulthood. Therefore, the findings of the current systematic review and succeeding works on BP of Iranian children and adolescents would be useful for future health policies and research activities aimed to reduce the burden of high BP at individual and public health levels. Follow up surveillance programs and comparison of BP trends of children and adolescents over time are recommended.

Footnote

Authors' Contribution: Zahra Fallah: acquisition of data, data interpretation, drafting of the manuscript, critical revision of the manuscript and approval of the article. Shirin Djalalinia: critical revision of the manuscript and approval of the article. Mostafa Qorbani: include contributions to concept/design, data analysis/interpretation, critical revision of the manuscript and approval of the article. Farshad Farzadfar: include contributions to concept/design, data analysis/interpretation, critical revision of the manuscript and approval of the article. Roya Kelishadi: include contributions to concept/design, data interpretation, drafting of the manuscript, critical revision of the manuscript and approval of the article.

Appendices

Please visit article's online version for appendices.

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