BMC Oral Health

RESEARCH

Open Access

Prevalence and trend of periodontal diseases in Iran from 1990 to 2017: a national study

Shervan Shoaee[2,3,1], Mohammad-Hossein Heydari[2,4,5*], Sahar Saeedi Moghaddam[1,6], Masoud Masinaei[1], Negar Khorasani[4], Kiarash Parchami[1,2], Hossein Hessari[7], Mohammad-Hossein Khoshnevisan[4,5] and Shayan Sobhaninejad[1,2*]

Abstract

Introduction and aims Periodontal diseases are significant public health challenges, affecting millions globally. This study aimed to analyze the national and subnational trends of periodontal diseases in Iran from 1990 to 2017.

Methods A comprehensive analysis was conducted using data from national health surveys, the Behvarz Health Study, and published literature from 1990 to 2017. The Age-Spatial–Temporal (AST) Bayesian hierarchical model was employed to estimate the prevalence of bleeding on probing (BOP), shallow pocket (SP), and deep pocket (DP), adjusting for covariates such as age, sex, education, and socioeconomic factors.

Results From 1990 to 2017, the age-standardized prevalence of BOP increased significantly by 73.77%, from 27.11% (95% UI: 22.86%-31.36%) to 47.11% (95% UI: 40.11%-54.12%). Similarly, SP prevalence rose by 70.01%, from 14.34% to 24.38%. Conversely, DP prevalence declined by 69.27%, from 8.98% to 2.76%. Geographic disparities were observed, with provinces such as Tehran and Sistan and Baluchistan experiencing contrasting burdens. Trends highlighted increasing BOP and SP prevalence among younger populations.

Conclusion The study underscores the growing burden of BOP and SP in Iran, reflecting inadequate preventive measures and healthcare disparities. The findings highlight an urgent need for policy reforms prioritizing preventive care, equal access to dental services, and targeted interventions addressing socioeconomic and geographic inequalities. More focus should be put on training mid-level or intermediary oral health providers.

Keywords Periodontitis, Gingivitis, Bleeding on probing, Shallow pocket, Deep pocket, Iran, Trend

*Correspondence:
Mohammad-Hossein Heydari
mohmmadhossein.heydari@gmail.com
Shayan Sobhaninejad
dr.sobhaninejad.sh@gmail.com
[1]Non-Communicable Diseases Research Center, Endocrinology and Metabolism Population Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran
[2]Elderly Health Research Center, Endocrinology and Metabolism Population Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran
[3]Kerman Oral and Dental Diseases Research Center, Kerman University of Medical Sciences, Kerman, Iran
[4]Dental Research Center, Research Institute of Dental Sciences, Shahid Beheshti University of Medical Sciences, School of Dentistry, Tehran, Iran
[5]Community Oral Health Department, School of Dentistry, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[6]Kiel Institute for the World Economy, Kiel, Germany
[7]Research Center for Caries Prevention, Dentistry Research Institute, Tehran University of Medical Sciences, Tehran, Iran

Introduction

Periodontal diseases represent a significant public health concern globally, affecting millions of individuals and leading to severe health complications. Approximately 1 in 5 adults globally, or over 1 billion people, suffer from severe forms of gum disease. The World Health Organization (WHO) reported that about 19% of the adult population is affected by severe periodontal disease, with an estimated global prevalence of nearly 60% for all stages of periodontitis. The burden of periodontal disease is particularly high among older adults, with studies indicating that about 79.3% of individuals aged 65 and older are affected [1–3]. Additionally, the prevalence of periodontal disease varies across age groups, with approximately 42% of adults aged 30 years or older suffering from some form of periodontal disease [4–6].

Implementing effective policies to lower the ever-rising burden of periodontal diseases requires data-driven decision-making based on the WHO's global oral health improvement strategy [7]. Thus, elucidating the pattern and trend of global or national health concerns are among the primary and crucial steps in this process. In Iran, the existing literature predominantly focuses on specific age groups or regions, often lacking a nationwide perspective that encompasses diverse demographics. This data gap is concerning, particularly as oral diseases can contribute to the exacerbation of other health issues and complications of the treatment for chronic conditions [8–10]. The Iranian healthcare system faces challenges in addressing these diseases, especially in underserved regions where access to dental care is limited and public awareness of personal oral health care is low. This is also a global challenge due to the scarcity of original studies focusing on trends of periodontal diseases. A majority of the studies used the data from the Global Burden of Disease (GBD), which has its own limitations [11].

This study aimed to fill the existing knowledge gap by providing a comprehensive analysis of the national and subnational prevalence and trends of periodontal diseases in Iran from 1990 to 2017, utilizing the Age-Spatial–Temporal (AST) Bayesian hierarchical model [12, 13].

Methods and materials

Study design

The burden of oral diseases (BOD) project was part of a national project called the National and Subnational Burden of Diseases (NASBOD) in Iran. NASBOD aimed at estimating the burden and trend of non-communicable diseases using the AST model in national and provincial levels, among both genders, and 14 age groups. Further information regarding the methodology of our study and the NASBOD project is available [14, 15].

The main aim of the BOD was to estimate the trend of dental caries, periodontal diseases, and tooth loss in Iran from 1990 to 2017. The results of the trend of dental caries for deciduous and permanent teeth were published previously [16, 17]. This study focuses on the national and subnational trends of periodontal diseases in Iran from 1990 to 2017 (Tables 1 and 2).

Definition of periodontal disorders

Periodontal disorders were defined based on the 10th version of the international statistical classification of diseases and health problems (ICD-10, Code: K05.0-K05.6). Gingivitis was defined as the presence of gingival inflammation and bleeding on probing based on clinical examination. Shallow and deep pockets were defined as having a periodontal pocket between 3 to 5 mm and 6 mm or higher, respectively, based on clinical examination [18].

Data sources

We used several data sources to feed our AST model. These data sources included: (1) National oral health surveys (1998, 2002, 2004, 2013, and 2016), (2) National health surveys (1990 and 1999), (3) Behvarz Health Study (2013–2017), and (4) Published literature (1990 to 2017). The first three data sources have been extensively explained in the study protocol [15–17].

Literature published in English and Persian was searched in the following databases (Appendix 1): PubMed, Web of Science, Scopus, and Iranian Databases (IranMedex and SID [Scientific Information Database], and IranDoc). In the next phase, a comprehensive quality assessment form was used to assess the quality of studies with different sampling and measuring methods (Appendix 2). Data extraction was performed after quality assessment using the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement [19]. A data extraction sheet was used to prepare a summary of findings based on sex, age, sample size, prevalence, and confidence intervals (Appendix 3). After quality assessment, 16 articles and 5 national oral health surveys were included for data extraction.

This study complies with the Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER) [16, 17, 20, 21]. The full GATHER checklist is available in Appendix 4.

Statistical analysis

Converting CPI max to BOP, SP, and DP

Among the included data sources, some reported the maximum value of Community Periodontal Index (CPI) and did not report BOP, SP, and DP separately. Hence, as the reported outcome was different from what we defined for our outcome measures, we either had to exclude these surveys or come up with a new method to convert CPI

Table 1 National prevalence of bleeding on probing, shallow pocket, and deep pocket

Age Groups	Year	BOP			SP			DP		
		Male	*Female*	*Both*	*Male*	*Female*	*Both*	*Male*	*Female*	*Both*
		Mean (95% UI)			*Mean (95% UI)*			*Mean (95% UI)*		
5–9	***1990***	4.51 (0.49—8.57)	6.81 (2.61—11.01)	5.64 (1.53—9.76)	0.92 (0.24—2.43)	0.40 (0.07—1.31)	0.67 (0.16—1.88)	0.00 (0.00—0.00)	0.00 (0.00–0.00)	0.00 (0.00–0.00)
	2000	7.98 (4.08—11.89)	10.38 (6.48—14.29)	9.16 (5.25—13.06)	1.04 (0.31—2.56)	0.48 (0.11—1.37)	0.77 (0.21—1.98)	0.00 (0.00—0.00)	0.00 (0.00–0.00)	0.00 (0.00–0.00)
	2010	12.02 (6.59—17.50)	14.47 (9.09—19.87)	13.22 (7.81—18.66)	1.26 (0.35—3.24)	0.62 (0.15—1.82)	0.95 (0.25—2.55)	0.00 (0.00—0.00)	0.00 (0.00–0.00)	0.00 (0.00–0.00)
	2017	15.20 (8.28—22.26)	17.68 (10.74—24.64)	16.41 (9.48—23.42)	1.47 (0.36—4.08)	0.76 (0.16—2.38)	1.13 (0.26—3.25)	0.00 (0.00—0.00)	0.00 (0.00–0.00)	0.00 (0.00–0.00)
10–14	***1990***	18.17 (14.28—22.07)	19.58 (15.43—23.73)	18.85 (14.84—22.87)	4.48 (2.30—7.85)	2.56 (1.11—5.03)	3.55 (1.72—6.49)	0.90 (0.25—2.24)	0.76 (0.18—2.02)	0.83 (0.22—2.14)
	2000	22.87 (19.30—26.45)	25.01 (21.25—28.78)	23.92 (20.25—27.59)	5.17 (3.01—8.25)	3.19 (1.68—5.46)	4.20 (2.36—6.88)	0.25 (0.05—0.82)	0.21 (0.03—0.72)	0.23 (0.04—0.77)
	2010	27.27 (22.10—32.45)	29.83 (24.63—35.05)	28.52 (23.34—33.72)	5.83 (3.19—9.68)	3.79 (1.94—6.61)	4.83 (2.58—8.17)	0.04 (0.00—0.31)	0.03 (0.00—0.26)	0.04 (0.00—0.29)
	2017	30.27 (23.50—37.07)	33.04 (26.25—39.84)	31.62 (24.84—38.42)	6.32 (3.10—11.33)	4.26 (1.96—8.00)	5.32 (2.54—9.70)	0.01 (0.00—0.26)	0.01 (0.00—0.23)	0.01 (0.00—0.25)
15–19	***1990***	27.30 (23.29—31.30)	26.12 (22.02—30.23)	26.73 (22.68—30.78)	10.42 (6.37—16.04)	5.99 (3.25—10.07)	8.28 (4.86—13.15)	2.57 (1.09—5.03)	2.01 (0.76—4.21)	2.30 (0.93—4.63)
	2000	33.77 (30.05—37.51)	35.43 (31.51—39.36)	34.60 (30.77—38.42)	12.55 (8.67—17.54)	8.60 (5.54—12.68)	10.60 (7.13—15.13)	1.20 (0.48—2.47)	1.05 (0.37—2.29)	1.12 (0.43—2.38)
	2010	40.58 (35.33—45.84)	43.37 (37.96—48.80)	41.95 (36.62—47.30)	15.28 (10.47—21.39)	11.27 (7.34—16.41)	13.30 (8.93—18.94)	0.49 (0.11—1.40)	0.44 (0.09—1.34)	0.46 (0.10—1.37)
	2017	45.39 (38.54—52.25)	48.50 (41.54—55.47)	46.91 (40.01—53.83)	17.59 (11.35—25.81)	13.39 (8.27—20.31)	15.53 (9.85—23.12)	0.23 (0.02—1.03)	0.21 (0.02—0.98)	0.22 (0.02—1.01)
20–24	***1990***	29.39 (25.26—33.52)	26.02 (22.07—29.97)	27.73 (23.69—31.77)	15.02 (9.68—22.24)	8.24 (4.84—13.10)	11.69 (7.30—17.74)	4.24 (2.04—7.66)	3.11 (1.39—5.88)	3.68 (1.72—6.79)
	2000	37.77 (33.91—41.64)	38.13 (34.32—41.94)	37.95 (34.12—41.79)	19.23 (13.92—25.86)	13.03 (8.97—18.23)	16.10 (11.42—22.01)	2.50 (1.21—4.50)	2.07 (0.94—3.91)	2.28 (1.08—4.20)
	2010	45.67 (40.31—51.04)	48.91 (43.46—54.36)	47.29 (41.89—52.70)	23.36 (16.91—31.30)	18.36 (12.85—25.29)	20.86 (14.87—28.29)	1.27 (0.43—2.87)	1.22 (0.39—2.83)	1.25 (0.41—2.85)
	2017	51.20 (44.10—58.31)	55.64 (48.56—62.74)	53.39 (46.30—60.49)	27.63 (18.87—38.75)	22.66 (15.16—32.34)	25.19 (17.04—35.60)	0.80 (0.15—2.46)	0.79 (0.15—2.46)	0.80 (0.15—2.46)

Table 1 (continued)

Age Groups	Year	BOP			SP			DP		
		Male	*Female*	*Both*	*Male*	*Female*	*Both*	*Male*	*Female*	*Both*
		Mean (95% UI)			*Mean (95% UI)*			*Mean (95% UI)*		
25–29	***1990***	30.95 (26.67—35.24)	25.85 (21.94—29.76)	28.41 (24.31—32.51)	19.89 (13.21—28.74)	10.32 (6.34—15.89)	15.14 (9.79—22.35)	6.30 (3.28—10.79)	4.42 (2.19—7.83)	5.37 (2.74—9.32)
	2000	39.07 (35.09—43.05)	36.62 (32.97—40.27)	37.85 (34.04—41.67)	24.28 (17.89—32.16)	14.80 (10.49—20.26)	19.58 (14.22—26.26)	3.87 (2.05—6.57)	2.89 (1.48—5.03)	3.39 (1.77—5.81)
	2010	47.55 (42.11—53.00)	49.29 (43.97—54.62)	48.41 (43.04—53.81)	29.67 (21.98—39.00)	21.90 (15.79—29.43)	25.81 (18.90—34.25)	2.24 (0.92—4.49)	1.96 (0.78—4.03)	2.10 (0.85—4.26)
	2017	53.51 (46.42—60.63)	58.48 (51.43—65.54)	55.97 (48.90—63.05)	34.67 (24.47—47.35)	28.88 (20.02—40.04)	31.81 (22.27—43.73)	1.53 (0.42—3.89)	1.54 (0.42—3.94)	1.53 (0.42—3.92)
30–34	***1990***	32.62 (28.61—36.63)	26.37 (22.47—30.26)	29.54 (25.59—33.49)	19.62 (13.10—28.22)	11.65 (7.28—17.67)	15.69 (10.24—23.03)	7.78 (4.31—12.76)	5.85 (3.10—9.92)	6.83 (3.71—11.36)
	2000	39.72 (36.00—43.44)	35.43 (31.86—39.01)	37.61 (33.96—41.25)	23.19 (17.18—30.58)	15.64 (11.23—21.20)	19.47 (14.25—25.96)	4.80 (2.73—7.75)	3.77 (2.08—6.22)	4.29 (2.41—7.00)
	2010	47.42 (42.19—52.66)	46.64 (41.47—51.83)	47.03 (41.83—52.25)	27.86 (20.74—36.48)	21.66 (15.75—28.91)	24.80 (18.28—32.74)	2.79 (1.26—5.25)	2.45 (1.08—4.72)	2.62 (1.17—4.99)
	2017	53.30 (46.49—60.14)	55.70 (48.87—62.56)	54.49 (47.67—61.34)	32.34 (23.08—43.81)	28.22 (19.80—38.74)	30.30 (21.46—41.30)	1.88 (0.60—4.42)	1.92 (0.61—4.51)	1.90 (0.61—4.46)
35–39	***1990***	33.16 (29.19—37.13)	26.82 (22.83—30.82)	30.03 (26.05—34.02)	19.97 (13.39—28.64)	14.34 (9.24—21.25)	17.19 (11.34—24.99)	9.47 (5.47—15.09)	7.91 (4.45—12.85)	8.70 (4.97—13.99)
	2000	40.47 (36.84—44.11)	35.03 (31.36—38.70)	37.80 (34.15—41.46)	24.05 (17.95—31.54)	18.36 (13.40—24.54)	21.26 (15.72—28.11)	6.12 (3.67—9.52)	5.16 (3.03—8.16)	5.65 (3.35—8.85)
	2010	47.67 (42.52—52.84)	43.84 (38.70—48.99)	45.80 (40.65—50.96)	28.32 (21.20—36.89)	22.91 (16.87—30.27)	25.67 (19.09—33.65)	3.66 (1.81—6.52)	3.17 (1.54—5.75)	3.42 (1.68—6.14)
	2017	53.02 (46.28—59.78)	50.60 (43.83—57.39)	51.83 (45.07—58.60)	32.14 (23.03—43.40)	27.41 (19.27—37.58)	29.81 (21.17—40.53)	2.50 (0.91—5.43)	2.27 (0.80—5.05)	2.39 (0.85—5.24)
40–44	***1990***	34.01 (29.97—38.05)	26.50 (22.39—30.61)	30.28 (26.21—34.36)	19.79 (13.22—28.46)	16.07 (10.50—23.56)	17.95 (11.87—26.03)	11.31 (6.73—17.63)	9.92 (5.80—15.66)	10.62 (6.27—16.65)
	2000	41.55 (37.90—45.21)	34.70 (30.91—38.50)	38.19 (34.47—41.92)	24.65 (18.44—32.25)	20.67 (15.22—27.41)	22.69 (16.86—29.87)	7.67 (4.78—11.57)	6.74 (4.12—10.32)	7.21 (4.46—10.96)
	2010	48.56 (43.41—53.71)	43.38 (38.17—48.60)	46.00 (40.83—51.20)	28.33 (21.28—36.81)	25.25 (18.76—33.12)	26.81 (20.04—34.99)	4.69 (2.48—7.99)	4.29 (2.23—7.40)	4.50 (2.35—7.70)
	2017	53.50 (46.63—60.39)	49.71 (42.89—56.54)	51.65 (44.80—58.51)	32.00 (22.65—43.60)	29.43 (20.81—40.15)	30.74 (21.75—41.91)	3.30 (1.29—6.85)	3.13 (1.24—6.48)	3.22 (1.26—6.67)

Table 1 (continued)

Age Groups	Year	BOP			SP			DP		
		Male	*Female*	*Both*	*Male*	*Female*	*Both*	*Male*	*Female*	*Both*
		Mean (95% UI)			*Mean (95% UI)*			*Mean (95% UI)*		
45–49	***1990***	33.78 (29.55—38.01)	27.33 (23.09—31.57)	30.61 (26.37—34.84)	19.17 (12.69—27.77)	18.42 (12.17—26.74)	18.80 (12.43—27.27)	13.15 (7.97—20.21)	12.61 (7.63—19.42)	12.88 (7.80—19.82)
	2000	41.61 (37.86—45.36)	34.27 (30.33—38.21)	37.93 (34.09—41.78)	24.74 (18.49—32.39)	22.20 (16.39—29.39)	23.47 (17.44—30.89)	9.25 (5.92—13.67)	8.41 (5.29—12.61)	8.83 (5.61—13.14)
	2010	49.69 (44.47—54.92)	42.39 (37.13—47.67)	46.07 (40.83—51.32)	29.01 (21.83—37.63)	26.28 (19.60—34.36)	27.66 (20.72—36.01)	6.01 (3.34—9.86)	5.41 (2.95—9.00)	5.71 (3.15—9.43)
	2017	55.38 (48.46—62.30)	48.06 (41.18—54.95)	51.78 (44.89—58.69)	32.75 (23.32—44.40)	29.77 (21.04—40.65)	31.28 (22.20—42.56)	4.38 (1.88—8.55)	3.91 (1.65—7.77)	4.15 (1.77—8.17)
50–54	***1990***	33.60 (29.14—38.07)	28.29 (23.97—32.61)	31.08 (26.69—35.48)	17.98 (11.73—26.35)	19.92 (13.22—28.80)	18.90 (12.44—27.51)	15.01 (9.24—22.80)	15.40 (9.56—23.25)	15.19 (9.39—23.01)
	2000	41.71 (37.75—45.68)	34.49 (30.44—38.53)	38.12 (34.12—42.12)	24.41 (18.12—32.14)	23.60 (17.45—31.18)	24.00 (17.79—31.66)	10.96 (7.13—15.98)	10.40 (6.71—15.27)	10.68 (6.92—15.63)
	2010	49.66 (44.28—55.05)	41.62 (36.28—46.98)	45.65 (40.29—51.02)	28.16 (21.05—36.73)	26.50 (19.73—34.71)	27.33 (20.39—35.72)	7.19 (4.12—11.54)	6.60 (3.74—10.70)	6.90 (3.93—11.12)
	2017	55.35 (48.28—62.43)	46.88 (39.97—53.80)	51.15 (44.16—58.15)	31.32 (22.08—42.80)	29.29 (20.67—40.06)	30.31 (21.38—41.44)	5.34 (2.41—10.11)	4.79 (2.14—9.16)	5.07 (2.28—9.64)
55–59	***1990***	33.04 (28.32—37.76)	29.68 (25.23—34.13)	31.51 (26.92—36.11)	17.67 (11.41—26.09)	23.06 (15.50—32.99)	20.12 (13.27—29.22)	17.23 (10.75—25.92)	19.24 (12.26—28.49)	18.15 (11.43—27.08)
	2000	40.89 (36.71—45.08)	34.88 (30.68—39.09)	37.95 (33.75—42.15)	23.85 (17.58—31.58)	26.11 (19.40—34.37)	24.96 (18.47—32.95)	12.72 (8.39—18.36)	12.99 (8.59—18.72)	12.85 (8.49—18.54)
	2010	49.23 (43.68—54.81)	41.34 (35.84—46.86)	45.24 (39.71—50.78)	27.88 (20.72—36.54)	28.12 (20.90—36.87)	28.00 (20.81—36.71)	8.57 (5.03—13.52)	8.23 (4.79—13.06)	8.40 (4.91—13.28)
	2017	55.35 (48.11—62.62)	46.09 (39.12—53.08)	50.72 (43.61—57.84)	30.29 (21.18—41.64)	29.62 (20.92—40.48)	29.95 (21.05—41.06)	6.36 (2.99—11.71)	5.83 (2.74—10.77)	6.09 (2.86—11.24)
+60	***1990***	36.73 (30.73—42.73)	34.12 (29.31—38.93)	35.57 (30.10—41.04)	17.53 (10.72—26.94)	33.15 (22.81—46.48)	24.49 (16.11—35.65)	23.80 (14.74—35.98)	30.42 (20.16—43.68)	26.75 (17.16—39.41)
	2000	41.47 (36.05—46.90)	38.01 (33.28—42.74)	39.84 (34.74—44.94)	21.18 (14.78—29.33)	36.62 (27.42—47.83)	28.47 (20.75—38.06)	17.46 (11.38—25.44)	22.16 (15.23—30.96)	19.68 (13.19—28.05)
	2010	46.70 (40.21—53.21)	42.43 (36.38—48.48)	44.55 (38.28—50.83)	23.47 (16.52—32.18)	38.06 (28.51—49.56)	30.82 (22.56—40.93)	12.12 (7.16—19.01)	15.17 (9.52—22.73)	13.66 (8.35—20.89)
	2017	49.64 (41.68—57.61)	45.13 (37.74—52.53)	47.36 (39.68—55.05)	21.69 (14.08—31.63)	36.13 (25.69—49.06)	28.99 (19.95—40.44)	7.86 (3.69—14.44)	10.27 (5.40—17.52)	9.08 (4.55—16.00)

Table 1 (continued)

Age Groups	Year	BOP			SP			DP		
		Male	*Female*	*Both*	*Male*	*Female*	*Both*	*Male*	*Female*	*Both*
		Mean (95% UI)			*Mean (95% UI)*			*Mean (95% UI)*		
All Ages	***1990***	24.41 (20.19—28.63)	22.16 (18.02—26.29)	23.31 (19.14—27.50)	11.88 (7.54—17.88)	9.39 (5.90—14.32)	10.67 (6.74—16.15)	6.22 (3.55—10.06)	5.76 (3.36—9.24)	6.00 (3.46—9.67)
	2000	32.76 (28.85—36.67)	31.32 (27.45—35.20)	32.05 (28.16—35.95)	16.22 (11.67—22.02)	13.54 (9.64—18.54)	14.90 (10.67—20.31)	4.60 (2.78—7.18)	4.44 (2.73—6.87)	4.52 (2.76—7.02)
	2010	42.11 (36.72—47.53)	41.34 (35.97—46.73)	41.73 (36.35—47.13)	21.84 (15.90—29.22)	19.51 (14.11—26.24)	20.68 (15.01—27.74)	3.43 (1.81—5.93)	3.52 (1.91—6.00)	3.48 (1.86—5.97)
	2017	47.33 (40.29—54.38)	46.88 (39.92—53.86)	47.11 (40.11—54.12)	25.09 (17.36—34.97)	23.65 (16.39—32.91)	24.38 (16.88—33.95)	2.67 (1.10—5.48)	2.85 (1.24—5.68)	2.76 (1.17—5.58)
Age-standardized	***1990***	28.87 (24.55—33.19)	25.25 (21.09—29.41)	27.11 (22.86—31.36)	15.38 (9.96—22.71)	13.51 (8.74—20.01)	14.34 (9.27—21.23)	8.99 (5.26—14.24)	9.06 (5.46—14.09)	8.98 (5.32—14.11)
	2000	35.58 (31.62—39.55)	32.82 (28.92—36.72)	34.23 (30.30—38.17)	19.02 (13.85—25.52)	16.84 (12.19—22.70)	17.88 (12.98—24.05)	6.11 (3.77—9.36)	6.19 (3.90—9.34)	6.13 (3.82—9.33)
	2010	42.44 (37.03—47.87)	40.99 (35.62—46.38)	41.73 (36.33—47.14)	22.41 (16.37—29.89)	20.51 (14.93—27.45)	21.46 (15.65—28.67)	3.89 (2.08—6.62)	4.03 (2.23—6.75)	3.96 (2.15—6.68)
	2017	47.33 (40.29—54.38)	46.88 (39.92—53.86)	47.11 (40.11—54.12)	25.09 (17.36—34.97)	23.65 (16.39—32.91)	24.38 (16.88—33.95)	2.67 (1.10—5.48)	2.85 (1.24—5.68)	2.76 (1.17—5.58)

BOP Bleeding on Probing, *SP* Shallow Pocket, *DP* Deep Pocket, *UI* Uncertainty Interval

max index to the three indices. Crosswalk is a method of mapping equivalent, identical or similar information in two or more datasets. Suppose you have a definition for a certain type of disease that has changed overtime. Crosswalk maps your data that was based on the previous definition to the new definition [22–26].

We used crosswalk to convert CPI-max to BOP, SP, and DP. The 2012 survey and Behvarz health study did not report the CPI index, rather reported the three indices separately. Therefore, we aggregated the results of these studies in two formats, once with our indices and then with CPI-max. The main objective was to find a formula to convert CPI max into our three indices (BOP, SP, and DP). Finally, a logistic regression model was fitted including the data from 2012 national survey, Behvarz study, and the following covariates (wealth index, years of schooling, area of residence, urbanization, age, and sex) to calculate BOP, SP, and DP from CPI-max based on the following calculation (U stands for urbanization):

$$\text{logit}\left(BOP_{cpimax}\right) = \beta_0 + \beta_1 BOP_{cpimax} + \beta_2 YOS + \beta_3 WI + \beta_4 U + \beta_5 midage$$

$$n\text{logit}\left(SP_{cpimax}\right) = \beta_0 + \beta_1 SP_{cpimax} + \beta_2 YOS + \beta_3 WI + \beta_4 U + \beta_5 midage$$

$$\text{logit}\left(DP_{cpimax}\right) = \beta_0 + \beta_1 DP_{cpimax} + \beta_2 YOS + \beta_3 WI + \beta_4 U + \beta_5 midage$$

AST model

The methods we used in this study have been used for estimation of the burden of diseases in Iran previously [27, 28]. For analyzing the categorized and cleaned data, first, a random intercept mixed-effects model [29] was designed for BOP, SP, and DP using these independent variables: mean years of schooling (derived from Iran's household expenditure and income survey), wealth index (derived from Iran's household expenditure and income survey), and mean weight of each age within each age group (derived from Iran's regular national census). Secondly, the correlation between age, space (in our study: provinces), and time was estimated using the AST model. The weight of these three components was estimated based on the following calculations:

- Spatial component $\left(W_{L_{ij}}\right)$: if two provinces were adjacent, the weight was considered to be 1; otherwise, 0 was considered as the spatial weight;
- Temporal component $\left(W_{T_{ij}}\right)$: Similar to the LOESS (locally estimated scatterplot

Table 2 Annual percentage change and growth rate of bleeding on probing, shallow pocket, and deep pocket from 1990 to 2017 based on different age groups

Age	Metric	Bleeding on Probing			Shallow Pocket			Deep Pocket		
		Male	*Female*	*Both*	*Male*	*Female*	*Both*	*Male*	*Female*	*Both*
5–9	*TAPC*	237.03%	159.62%	190.96%	59.78%	90.00%	68.66%	-	-	-
	CAGR	4.43%	3.47%	3.89%	1.69%	2.32%	1.88%	-	-	-
10–14	*TAPC*	66.59%	68.74%	67.75%	41.07%	66.41%	49.86%	−98.89%	−98.68%	−98.80%
	CAGR	1.84%	1.89%	1.86%	1.24%	1.84%	1.46%	−14.85%	−14.33%	−14.60%
15–19	*TAPC*	66.26%	85.68%	75.50%	68.81%	123.54%	87.56%	−91.05%	−89.55%	−90.43%
	CAGR	1.83%	2.23%	2.03%	1.89%	2.91%	2.27%	−8.26%	−7.75%	−8.04%
20–24	*TAPC*	74.21%	113.84%	92.54%	83.95%	175.00%	115.48%	−81.13%	−74.60%	−78.26%
	CAGR	2.00%	2.75%	2.37%	2.20%	3.68%	2.78%	−5.78%	−4.78%	−5.30%
25–29	*TAPC*	72.89%	126.23%	97.01%	74.31%	179.84%	110.11%	−75.71%	−65.16%	−71.51%
	CAGR	1.97%	2.96%	2.45%	2.00%	3.74%	2.69%	−4.93%	−3.70%	−4.39%
30–34	*TAPC*	63.40%	111.22%	84.46%	64.83%	142.23%	93.12%	−75.84%	−67.18%	−72.18%
	CAGR	1.77%	2.71%	2.21%	1.80%	3.21%	2.38%	−4.95%	−3.90%	−4.47%
35–39	*TAPC*	59.89%	88.67%	72.59%	60.94%	91.14%	73.41%	−73.60%	−71.30%	−72.53%
	CAGR	1.69%	2.29%	1.97%	1.71%	2.34%	1.99%	−4.65%	−4.36%	−4.51%
40–44	*TAPC*	57.31%	87.58%	70.57%	61.70%	83.14%	71.25%	−70.82%	−68.45%	−69.68%
	CAGR	1.63%	2.27%	1.93%	1.73%	2.18%	1.94%	−4.30%	−4.04%	−4.17%
45–49	*TAPC*	63.94%	75.85%	69.16%	70.84%	61.62%	66.38%	−66.69%	−68.99%	−67.78%
	CAGR	1.78%	2.04%	1.90%	1.93%	1.73%	1.83%	−3.85%	−4.10%	−3.96%
50–54	*TAPC*	64.73%	65.71%	64.58%	74.19%	47.04%	60.37%	−64.42%	−68.90%	−66.62%
	CAGR	1.80%	1.82%	1.80%	2.00%	1.39%	1.70%	−3.62%	−4.09%	−3.84%
55–59	*TAPC*	67.52%	55.29%	60.96%	71.42%	28.45%	48.86%	−63.09%	−69.70%	−66.45%
	CAGR	1.86%	1.58%	1.71%	1.94%	0.90%	1.43%	−3.50%	−4.17%	−3.83%
60+	*TAPC*	35.15%	32.27%	33.15%	23.73%	8.99%	18.37%	−66.97%	−66.24%	−66.06%
	CAGR	1.08%	1.00%	1.03%	0.76%	0.31%	0.60%	−3.88%	−3.80%	−3.79%
All Age	*TAPC*	93.90%	111.55%	102.10%	111.20%	151.86%	128.49%	−57.07%	−50.52%	−54.00%
	CAGR	2.39%	2.71%	2.54%	2.71%	3.35%	3.00%	−2.98%	−2.48%	−2.74%
Age-std	*TAPC*	63.94%	85.66%	73.77%	63.13%	75.06%	70.01%	−70.30%	−68.54%	−69.27%
	CAGR	1.78	2.23%	1.99%	1.76%	2.02%	1.91%	−4.24%	−4.05%	−4.13%

TAP C Total Annual Percentage Change, *CAGR* Compound Annual Growth Rate, *Age–std* Age–standardized

smoothing) regression, we used the cubic power: $W_{T_{ij}} = (1 - (\frac{|i-j|}{ArgMax(|i-j|+1)})^{\lambda})^3$.

- o λ is a smoothing parameter. Based on the previous studies, this parameter was considered to be 2.

- Age component $\left(W_{A_{ij}}\right)$: assuming that increased difference between two age groups is associated with a reduction in their weight, defined as $W_{A_{ij}} = \frac{1}{e^{\varpi|i-j|}}$ in the matrix.

  - o ϖ is a smoothing parameter that with lower values of it, smoothing will be higher. Based on the previous studies, this parameter was considered to be 1.

To predict the uncertainty interval (UI), we used a bootstrap method for multilevel models [30, 31]. Using this method, first, we pooled the covariates we had -such as sex, mean years of schooling, wealth index, and mean weighting of the age group- using a fixed effects model and province and year based on a random effects model. Then, we evaluated the distribution of these pooled covariates and fitted the bootstrap model based on their distribution to estimate the UI. The advantage of using this method over other bootstrapping methods is that it considers all the uncertainties [32, 33].

We calculated the age-standardized BOP, SP, and DP at the provincial level for each age group, based on the report of the population and housing census conducted by Iran's Statistical Center in 2016 [34]. We reported estimations of BOP, SP, and DP from 1990 to 2017 with 95% UI. Total Annual Percentage Change (TAPC) and Compound Annual Growth Rate (CAGR) were calculated based on the following formula (t is the number of years, which is 28 in our study):

$$TAPC = \frac{Prevalence_{endyear} - Prevalence_{startingyear}}{Prevalence_{startingyear}} \times 100$$

$$CAGR = ((\frac{Prevalence_{endyear}}{Prevalence_{startingyear}})^{\frac{1}{t}} - 1) \times 100$$

The statistical analyses and creating the figures were performed using STATA V.14.0.0., V.17.0.0. and R V.3.5.2 (R Core Team, R Foundation for Statistical Computing, Vienna, Austria; http://www.R-project.com) with the Age-Spatial–Temporal Model V.0.1.0 (*AST*) package (https://cran.r-project.org/web/packages/AST/index.html).

Results

National trend of BOP, SP, and DP

Age-standardized prevalence of BOP increased from 27.11% (95%UI: 22.86%–31.36%) in 1990 to 47.11% (95%UI: 40.11%- 54.12%) in 2017, indicating a 73.77% increase. Prevalence of BOP was slightly higher among males than females both in 1990 (24.41% vs. 22.16%) and 2017 (47.33% vs 46.86%), however, this gap decreased in 2017. The age-standardized prevalence of SP in Iran increased significantly from 14.34% (95%UI: 9.27–21.23) in 1990 to 24.38% (95%UI: 16.88–33.95) in 2017, marking a rise of 70.01%. In contrast, the age-standardized prevalence of deep pocket decreased by 69.27%, from 8.98% (95%UI: 5.32–14.11) in 1990 to 2.76% (95%UI: 2.76–5.58) in 2017. Initially, males had a higher prevalence than females, but by 2017, females showed a slightly higher prevalence than males (Figs. 1, 2, 3 and 4).

Children and adolescents (5 – 9, 10 – 14, and 15 – 19 years)

The prevalence of BOP increased from 5.64% (95%UI: 1.53–9.76%) in 1990 to 16.41% (95%UI: 9.48–23.42%) in 2017 among children aged 5 – 9 years. The trend indicated a notable increase in BOP (18.85% vs 31.62%) and shallow pocket (3.55% vs 5.32%), among the 10–14 years old children. Almost similar pattern was observed among the 15–19 years old adolescents, with BOP and SP increasing from 26.73% (95%UI: 22.68–30.78%) and 8.28% (95%UI: 4.86—13.15) in 1990 to 46.91% (95%UI: 40.01–53.83%) and 15.53% (95%UI: 9.85%—23.12%) in 2017, respectively. No cases of deep pockets were recorded among the 5–9-year-olds and showed similar decreasing pattern among the other age groups.

Young adults (20 – 24, 25 – 29, and 30 – 34 years)

Among the young adults, BOP and SP showed a consistent 80% increase in all age groups, with the highest increase being for the 25–29-year-olds in prevalence of BOP (96.96%, 28.41% vs 55.97%) and 20–24-year-olds in prevalence of SP (115.47%, 11.69%–25.19%). Deep pocket showed an approximate 70% steady decrease across all age groups. The highest prevalence in 2017 was for the 30–34-year-olds with 1.90% (95%UI: 0.61%—4.46%).

Middle aged Adults (35 – 39, 40 – 44, and 45 – 49 years)

The increase in the prevalence of BOP ranged from 60 to 88% with females showing more pronounced rise in the prevalence across all age groups. More importantly, the prevalence of BOP and SP among the middle-aged adults was the highest across all age groups (from 5 to 60 +) with the prevalence of BOP and SP being 51.78% (95%UI: 44.89%—58.69%) and 31.28% (95%UI: 22.20%—42.56%) in 2017, respectively. Across all age groups, males experienced higher prevalence, although the data shows

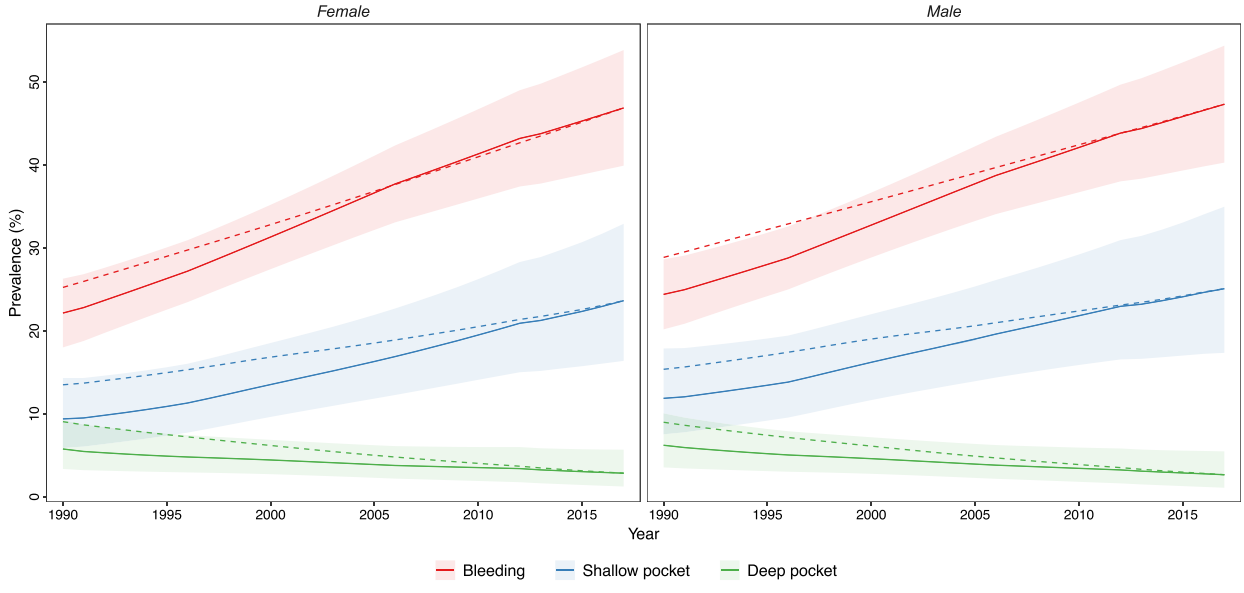

Fig. 1 National trend of bleeding on probing, shallow pocket, and deep pocket from 1990 to 2017 among all ages

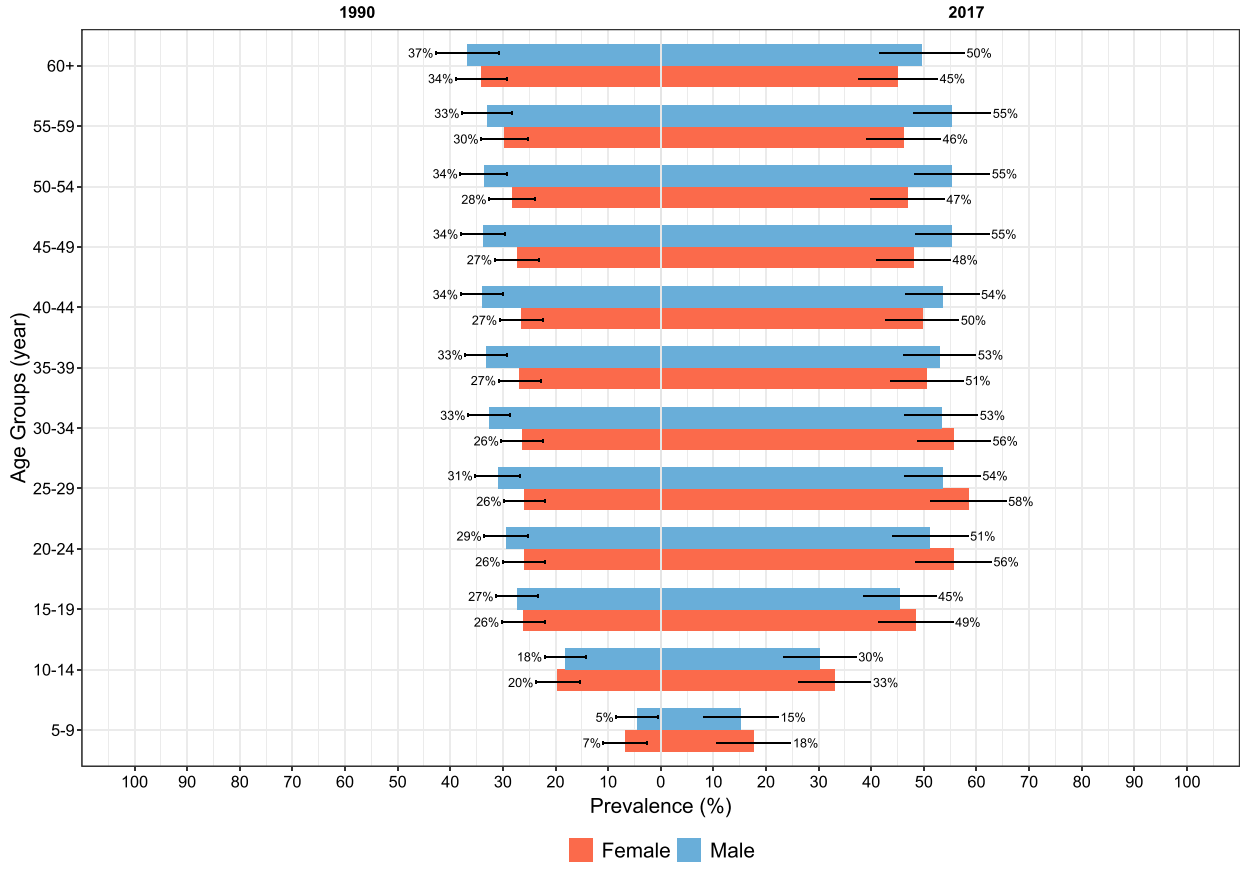

Fig. 2 Pyramid plot of the prevalence of bleeding on probing among age groups in 1990 and 2017

higher increase among females. The trend of BOP and SP reaches its peak in this age category and from here on shows a downward trend in older age groups. There was a significant reduction in the prevalence of DP. For instance, the 35–39 age group showed a decrease from 8.70% (95%UI: 4.97%—13.99%) to 2.39% (95%UI: 0.85%—5.24%). The downward trend was similar in the 40–44 and 45–49 age groups. However, a rising trend was evident from younger to older age groups with the 45–59 age group demonstrating the highest prevalence 4.15% (95%UI: 1.77%—8.17%).

Older adults (50 – 54 and 55 – 59 years)

BOP prevalence increased from approximately 31.08% to 51.15% in the 50–54 age group and from 31.51% to 50.72% in the 55–59 age group. Regarding SP, the prevalence increased from 18.90% to 30.31% for those aged 50–54, and from 20.12% to 29.95% for the 55–59 age group. The prevalence of DP declined similarly to the middle-aged groups, with the 50–54 age group decreasing from 15.19% (95%UI: 9.39%—23.01%) to 5.07% (95%UI: 2.28%—9.64%), and the 55–59 group declined from 18.15% to 6.09%.

Elderly adults (>60 years)

The BOP prevalence increased by 33.14% from 35.57% (95%UI: 30.09%–41.04%) in 1990 to 47.36% (95%UI: 39.68%–55.04%) in 2017. The lowest increase of SP was observed in this age group with a 18% increase from 24.49% (95%UI: 16.10%–35.65%) in 1990 to 28.98% (95%UI: 19.95%–40.44%) in 2017. This age group had also the highest prevalence of DP among all age groups in both 1990 (26.75% [95%UI: 17.16%–39.41%]), and 2017 (9.08% [95%UI: 4.55%–16.00%]). The prevalence of DP was higher among females than males in both 1990 (30.42% vs 23.80%) and 2017 (10.27% vs. 7.86%).

Provinces

In 1990, for BOP, the provinces with the lowest values were South Khorasan (22%, 95%UI: 17%, 26%), Kurdistan (22%, 95%UI: 18%, 27%), and Hormozgan (24%, 95%UI: 20%, 28%). Regarding SP, Ardabil had the lowest value at 10% (95%UI: 6%, 15%), followed by Hormozgan (15%, 95%UI: 10%, 23%) and Alborz (14%, 95%UI: 9%, 21%). For DP, the lowest values were found in East Azerbaijan (7%, 95%UI: 4%, 11%), Kurdistan (8%, 95%UI: 4%, 12%), and Alborz (10%, 95%UI: 6%, 15%). The provinces with the highest BOP prevalence were Tehran (32%, 95%UI: 28%, 37%),

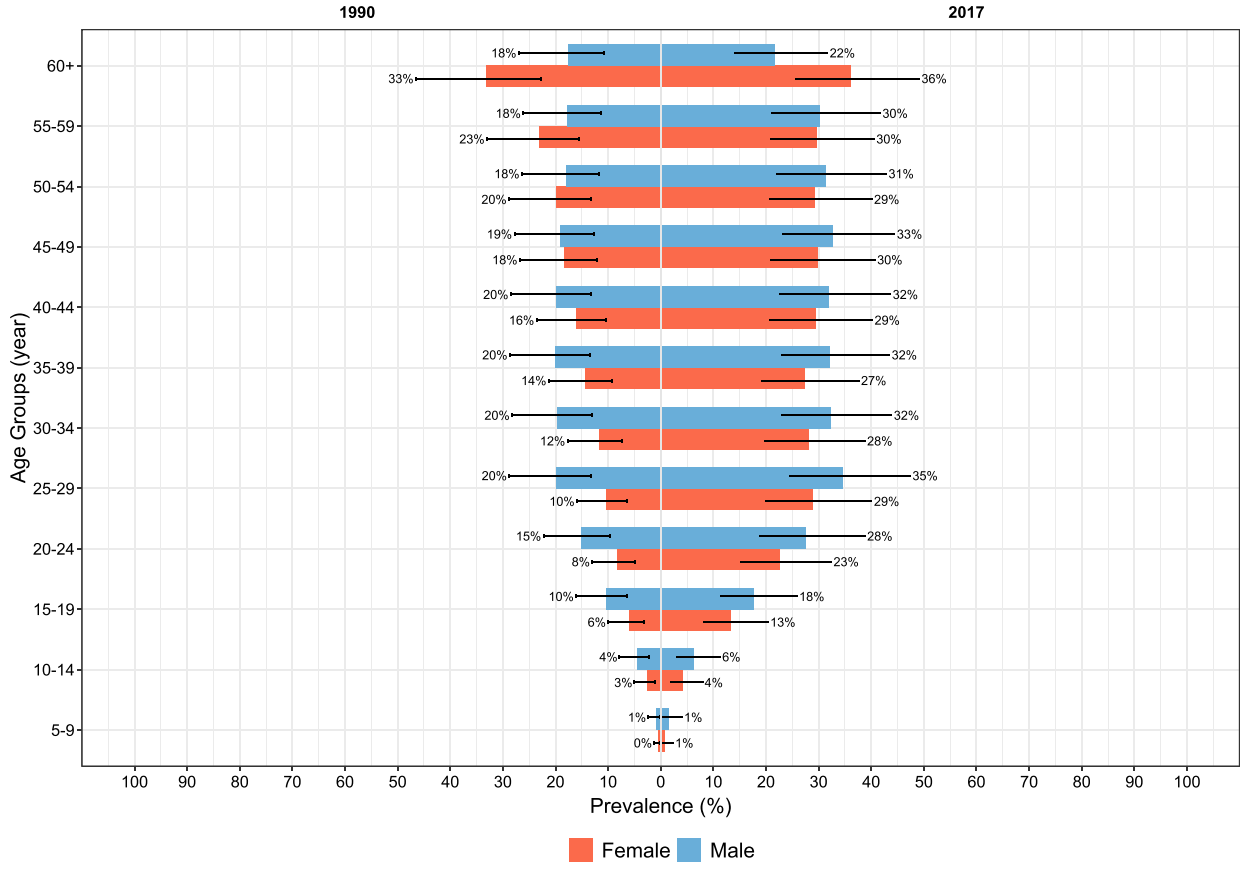

Fig. 3 Pyramid plot of the prevalence of shallow pocket among age groups in 1990 and 2017

Qom (29%, 95%UI: 25%, 34%), and Isfahan (28%, 95%UI: 24%, 33%). In terms of SP, Sistan and Baluchistan had the highest value at 24% (95%UI: 15%, 37%), followed by Tehran (21%, 95%UI: 14%, 29%), and Kerman (18%, 95%UI: 12%, 26%). For DP, Sistan and Baluchistan had the highest value of 11% (95%UI: 6%, 18%), followed by Tehran (11%, 95%UI: 7%, 17%) and Markazi (11%, 95%UI: 7%, 18%).

In 2017, the provinces with the lowest BOP prevalence were Kurdistan (37%, 95%UI: 31%, 43%), East Azerbaijan (37%, 95%UI: 29%, 45%), and South Khorasan (41%, 95%UI: 33%, 49%). For SP (Figs. 5 and 6), the lowest values were recorded in Khorasan North (17%, 95%UI: 11%, 26%), Gilan (21%, 95%UI: 13%, 30%), and Khorasan Razavi (23%, 95%UI: 17%, 30%). For DP, the lowest values were found in Kerman (3%, 95%UI: 1%, 6%), Tehran (4%, 95%UI: 2%, 7%), and Kurdistan (2%, 95%UI: 1%, 3%). The provinces with the highest BOP prevaalence were Kohkiluyeh and Boyer-Ahmad (54%, 95%UI: 46%, 62%), Fars (54%, 95%UI: 46%, 62%), and Isfahan (53%, 95%UI: 46%, 61%). Sistan and Baluchistan had the highest value for SP at 41% (95%UI: 28%, 58%), followed by Tehran (33%, 95%UI: 25%, 44%), and Hormozgan (26%, 95%UI: 17%, 37%). For DP, the worst provinces were Sistan and Baluchistan (4%, 95%UI: 2%, 8%), Tehran (4%, 95%UI: 2%, 7%), and Kohkiluyeh and Boyer-Ahmad (1%, 95%UI: 0%, 3%). Further information regarding the provincial prevalence of the three indices is available in Appendix 5 to 11.

Discussion

Our study aimed at evaluating the prevalence and trend of BOP, shallow pocket and deep pocket across all age groups from 1990 to 2017. Based on our results, the prevalence of BOP and SP showed a consistent increase from 1990 to 2017 while DP showed a decreasing pattern. There were gender disparities across different age groups, however, from 1990 to 2017 the prevalence of BOP and SP not only increased among females but also surpassed malesin some age groups. Conversely, the age-standardized prevalence of DP decreased by 69.49% and the highest prevalence for both years remained among the + 60-age group. These trends underscore shifts in age and gender patterns over time, highlighting a growing burden of periodontal diseases in younger populations.

As shown in Fig. 2, 3 and 4 and the above summary, the results suggest that prevalence of BOP and SP increased while the prevalence of DP decreased. Approximately half of the Iranian population are suffering from gingival inflammation. The starting point is around the age of 10

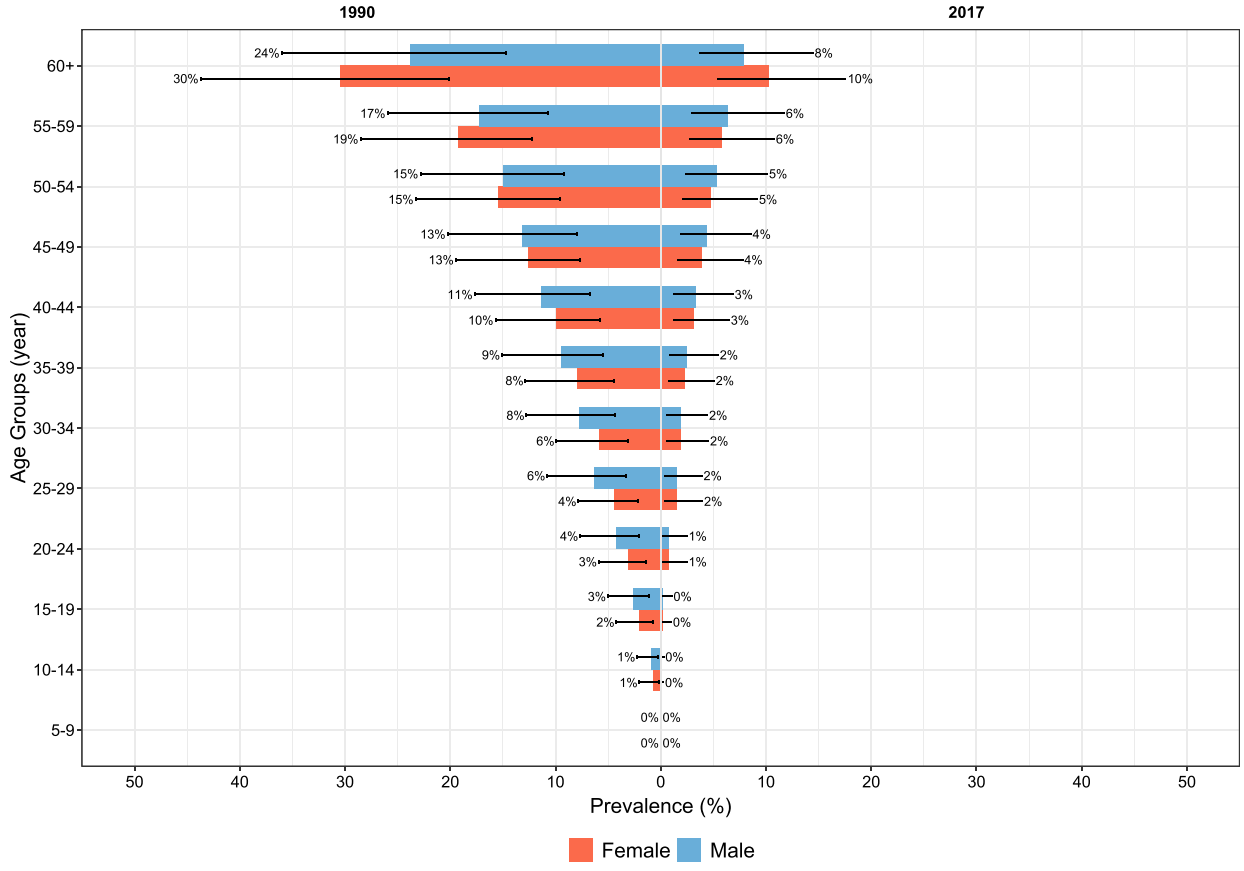

Fig. 4 Pyramid plot of the prevalence of deep pocket among age groups in 1990 and 2017

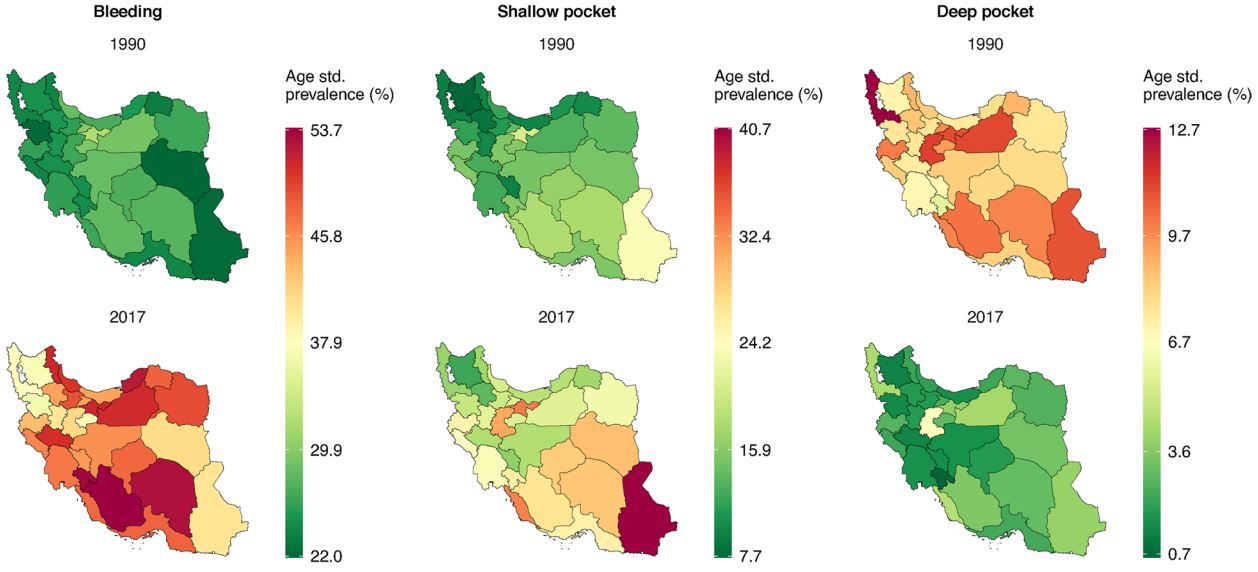

Fig. 5 Provincial prevalence of bleeding on probing, shallow pocket, and deep pocket in 1990 and 2017

to 14 and reaches its peak around 40 to 45 years-of-age. The decreasing pattern can be attributed to two factors. First, increased utilization of dental care and improved oral health or secondly and more probably, to higher extraction rates, thus, increasing the prevalence of tooth loss rather than increasing the prevalence of deep pocket itself. This is more reasonable when we take into account the fact that the peak of SP prevalence changed from

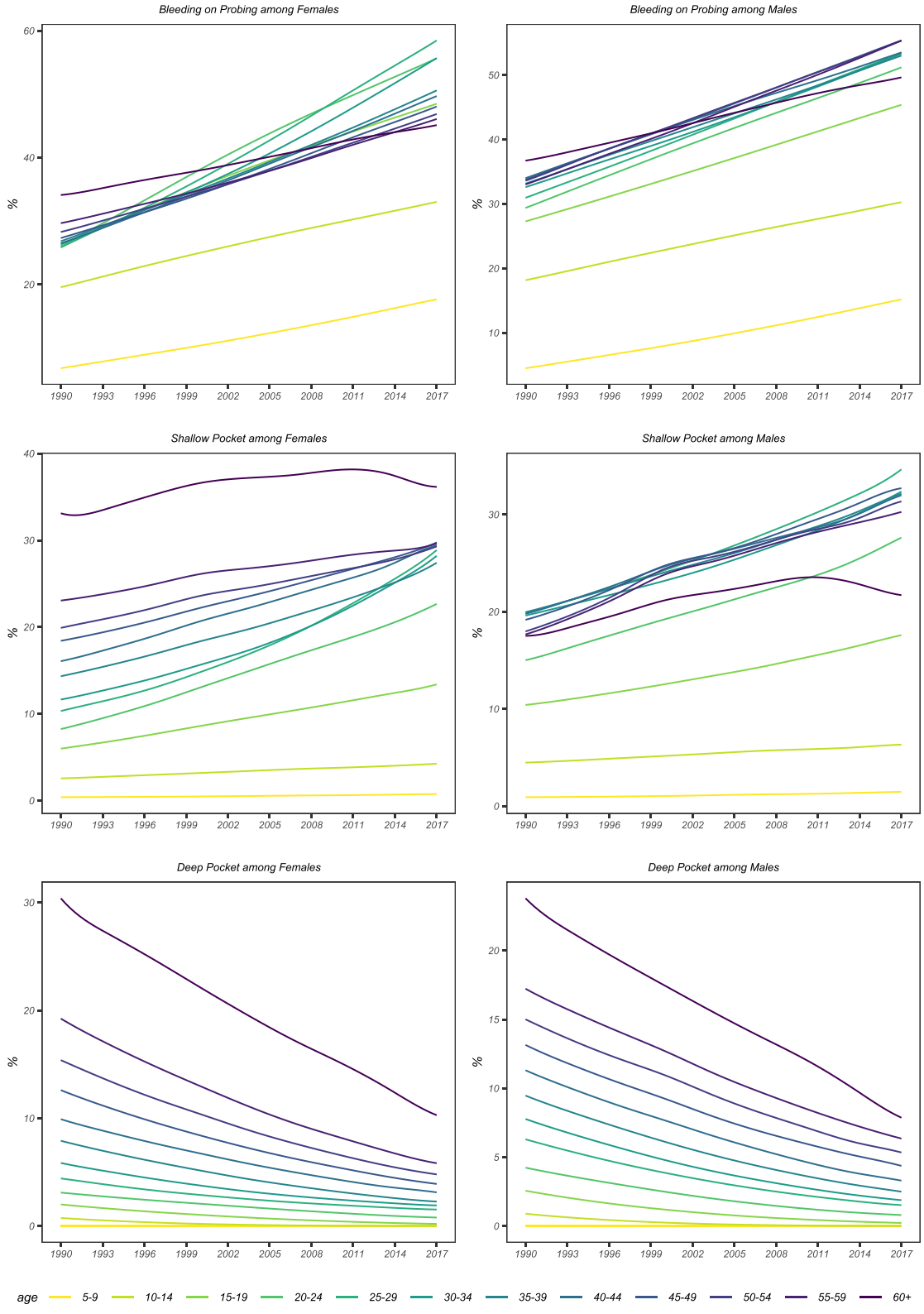

Fig. 6 Trend of BOP, SP, and DP from 1990 to 2017 among different age groups of males and females

60 + age group to 45–49 age group. Overall, this could be interpreted as this: the onset of gingival inflammation in the form of BOP has decreased and younger people are experiencing gingivitis and this inflammation tends to persist and transform into mild to moderate periodontitis. When the condition gets more severe and causes severe periodontitis, patients often seek extraction, thus justifying the lower prevalence of DP among the 60 + age group. This explanation is supported by previous evidence. Based on a previous study regarding the national DMFT among Iranians, it was found that the mean of Missing Teeth (the M component of the DMFT index) was 10 among 45–49 years old adults and increased to 21.5 among those older than 60 years [17]. The significant lower rates of Decayed Teeth across the adult population in this study compared to the Missing teeth, also points towards an underlying condition (severe forms of periodontitis) other than tooth decay for extraction of teeth. Two other studies also reported relatively similar results. A recent meta-analysis study reported that the mean M was 24 among the elderly population in Iran [35]. Another study in Iran reported the mean DMFT of 26 and M of 22 to 24 among the elderly population [8].

If we delve deeper into the underlying causes for the results of our study, we should mention the basic oral health care package in Iran. The ministry of health, as the guardian of oral healthcare in Iran, provides a basic oral healthcare package. This package is comprised of two main categories: (1) oral health education and primary care interventions including only fluoride therapy and pits and fissures sealant therapy (only for permanent first molars), and (2) dental treatments including restoration, scaling and root planing, extraction, and pulpotomy. In the first glance, this appears to be a valid basic package for improvement and maintenance of oral health. However, the target population for this package are: (1) children up to 6 years of age, (2) children from 7 to 14 years of age, and (3) pregnant women up to 1 year after their labor. Thus, it is evident that a majority of the Iranian population and more importantly vulnerable elderly populations, cannot benefit from basic interventions such as scaling and root planing that can significantly improve their oral and periodontal health care and postpone or prevent gingival inflammation, periodontitis, and tooth loss [36–39]. This should be mentioned that the first initiative for national provision of this package started in 2013 -due to the national oral health reform plan- and was finally implemented in 2015. Currently, no valid report is available regarding its coverage and cost-effectiveness.

Another contributing factor is insufficient mid-level or intermediary oral health providers in Iran. Currently, valid reports regarding the number of intermediary oral health workers are scarce. Bayat et al. performed a concise analysis on the number oral health workers encompassing both dentists and auxiliary personnel from 1962 to 2014 [40]. The number of active dentists were 26,958 with a dentist to population ratio of 1:2908 and an annual growth rate of 8 to 10%, while the number of active intermediary personnel was only 789. The dentist to dental auxiliary personnel ratio was 1:33. This number ranges between 1:1 to 1:4.5 among developed countries such as Japan and United Kingdom with preventive national oral health policies [40]. Although a study by Khoshnevisan et al. [41] has emphasized the fact that for a preventively-oriented oral health plan, intermediary oral health personnel are necessary, no evidence is available regarding the training of these work forces [42, 43]. Studies have highlighted that Iran's health system has struggled with integrating preventive measures into broader health policies, with a greater emphasis placed on treatment rather than prevention [44, 45]. Further studies should focus on this issue for more precise and updated statistics.

The rise in BOP and SP corresponds to national studies which showed that oral health conditions, including periodontal diseases, have worsened over time. For instance, from 1990 to 2010, the Global Burden of Disease study reported a significant increase in Disability-Adjusted Life Years (DALYs) due to periodontal diseases in Iran, reflecting an increase in both prevalence and the burden associated with these conditions. This increase was largely driven by risk factors such as poor oral hygiene practices, lack of access to dental care, and lifestyle factors including unhealthy diet and smoking, which have been documented across most Iranian provinces [46, 47]. Moreover, the national and subnational trends of oral health studies also show the impact of socioeconomic factors on the worsening of oral health conditions. Research that assessed dental caries trends from 1990 to 2017 in Iran identified a 58% increase in the DMFT index with poor oral hygiene and limited access to preventive care as contributing factors. Such findings parallel with the increasing BOP and SP in our study, where younger age groups consistently exhibited higher prevalence rates than before [17].

Currently there are no other studies available to report the national and subnational trend of periodontal diseases in Iran based on original studies. However, based on the publicly available GBD dataset, the prevalence of periodontal disorders was estimated to be 7.82% (95%UI: 5.78%—9.86%) in 1990 for both sexes in national level and experienced a steady increase to 13.53% (95%UI: 10.59%—16.5%) in 2017. This result should not be compared to ours, as we did not aggregate the prevalence of BOP, SP, and DP. However, if we calculate the percent change for the GBD dataset, which is 73.01%, and compare it to our percent change for BOP (73.77%) and SP

(70.01%), we see that they are almost equal. But as mentioned earlier, this comparison may be erroneous in essence and should be read with caution [48].

The inequalities in oral health between provinces in Iran, align with broader socioeconomic disparities observed in access and utilization of dental care across the country. Studies revealed that dental care utilization is highly concentrated among wealthier households. For instance, a recent study in 2017 showed that only 4.67% of Iranian households used dental care services in a given month, while the utilization rates were significantly higher in urban areas compared to rural areas, indicating a strong urban–rural divide. Wealthier provinces such as East Azarbaijan and Isfahan had much higher utilization rates, while provinces like Sistan and Baluchestan had utilization rates below 1% [49]. Another major contributing factor to these disparities is the improper distribution of dentists across Iran. Wealthier provinces tend to have a higher density of dental professionals, while less affluent and rural areas struggle with limited dental care availability [50]. In comparison to other countries in the region, similar trends are observed. For example, studies from Turkey and Saudi Arabia also highlight that access to dental care is closely tied to socioeconomic status, with wealthier urban populations experiencing better periodontal health outcomes [49, 51]. The Gini coefficient, which measures income inequality, revealed that dental care expenditures were distributed more unequally compared to general healthcare spending. Such disparity is particularly pronounced in restorative dental care like filling and root canal treatments [52]. Policymaking challenges have further exacerbated these issues. Evidence shows that dental health has not yet been a priority in Iran's public health policy, and limited insurance coverage for dental services have all contributed to the limited accessibility to dental care in Iran [45]. Although stating that increasing insurance coverage is widely accepted as one of the key answers for the question "How can we improve oral health?", however, current evidence regarding this matter shows mixed results. Extensive studies have shown that increasing insurance coverage is associated with increased utilization of dental or periodontal care in middle-aged and elderly individuals, however [53, 54], direct and reliable association between insurance coverage and improved oral health is less clear [55]. This matter should be investigated in future studies.

Strengths and limitations

This study has several strengths, including its comprehensive national and subnational coverage of Iran over a 28-year period across different demographics. Another major strength is the application of the Age-Spatial–Temporal Bayesian hierarchical model to estimate the missing point data which is one of the most prevalent problems in epidemiological studies. However, the study has encountered some limitations. As demonstrated in Fig. 5, a worsening pattern is evident for BOP and SP. Although our estimation of the prevalence of these indices is the best we could get based on the available data, however, the better status of earlier years should be interpreted cautiously due to the fact that published literature and national surveys were scarce for those years and this may have affected our results towards a general underestimation. Although the AST model the best method we could use to estimate and fill missing data point, we did not compare the accuracy and performance of AST versus other methods such as joinpoint regression or linear time trend models.

Policy implications

- Shifting the national oral health plan towards a preventively oriented policy
- Making the role of intermediary oral health providers clearer in the national health plan
- Incentivizing and training more people to study such fields
- Expanding insurance coverage for preventive and basic oral health treatments for all age groups with a focus on more vulnerable populations such as the elderly population
- A national governance on the quality of provided oral health care

Conclusions

Based on the results of this study, there has been a significant increase in the prevalence of BOP and SP in Iran from 1990 to 2017, while the prevalence of DP was decreasing. The rise in BOP and the geographic disparities in periodontal disease highlight the growing burden of oral health issues, especially in provinces with lower access to dental care. These findings emphasize the need for targeted public health policies focusing on preventive strategies, improving dental service accessibility, and addressing socioeconomic and regional disparities to mitigate the long-term impact of periodontal diseases.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12903-025-06842-1.

Supplementary Material 1.

Acknowledgements

The authors would like to thank Dr. Farshad Farzadfar, Dr. Bagher Larijani, and Dr. Farshad Sharifi for their invaluable help in our project.

Authors' contributions

Shervan Shoaee: designing the study, data gathering, writing the first draft of the manuscript, revising the manuscript, supervision; Mohammad-Hossein

Heydari: data gathering, data cleaning, data visualization, writing the first draft of the manuscript, revising the manuscript; Sahar Saeidi Moghaddam: data gathering, data cleaning, data analysis, revising the manuscript, supervision; Masoud Masinaie: data cleaning, data analysis, data visualization, revising the manuscript; Shayan Sobhaninejad: writing the first draft of the manuscript, revising the manuscript; Negar Khorasani: writing the first draft of the manuscript, revising the manuscript; Kiarash Parchami: writing the first draft of the manuscript, revising the manuscript; Hossein Hessari: writing the original draft, revising the manuscript, supervision; Mohammad-Hossein Khoshnevisan: writing the first draft of the manuscript, revising the manuscript, supervision; Shayan Sobhaninejad: writing the first draft of the manuscript, revising the manuscript, supervision.

Funding
This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data availability
Data is available in the supplementary materials section.

Declarations

Ethics approval and consent to participate
This research was conducted in compliance with the Helsinki Declaration. We used only secondary data in our study and no first-hand data was gathered. This study was approved by the Ethics Committee of Tehran University of Medical Sciences (ethics code: IR.TUMS.EMRI.REC.1397.022.).

Competing interests
The authors declare no competing interests.

Received: 21 December 2024 / Accepted: 22 August 2025
Published online: 29 September 2025

References

1. Chen MX, Zhong YJ, Dong QQ, Wong HM, Wen YF. Global, regional, and national burden of severe periodontitis, 1990–2019: an analysis of the Global Burden of Disease Study 2019. J Clin Periodontol. 2021;48(9):1165–88.
2. Nazir M, Al-Ansari A, Al-Khalifa K, Alhareky M, Gaffar B, Almas K. Global prevalence of periodontal disease and lack of its surveillance. Sci World J. 2020;2020(1):2146160.
3. Petersen PE, Baehni PC. Periodontal health and global public health. Periodontol 2000. 2012;60(1):7–14.
4. Dye BA. Global periodontal disease epidemiology. Periodontol 2000. 2012;58(1):10–25.
5. Zhang X, Wang X, Wu J, Wang M, Hu B, Qu H, et al. The global burden of periodontal diseases in 204 countries and territories from 1990 to 2019. Oral Dis. 2024;30(2):754–68.
6. Petersen PE, Ogawa H. The global burden of periodontal disease: towards integration with chronic disease prevention and control. Periodontol 2000. 2012;60(1):15–39.
7. Petersen PE. World Health Organization global policy for improvement of oral health - World Health Assembly 2007. Int Dent J. 2008;58(3):115–21.
8. Heydari MH, Sharifi F, Sobhaninejad S, Sharifi A, Alizadeh L, Darmiani S, et al. The association between dental caries, periodontal diseases, and tooth loss with diabetes mellitus among the elderly population. J Diabetes Metab Disord. 2024:1-10.
9. Rabiei M, Masoudi Rad H, Homaie Rad E, Ashourizadeh S. Dental status of the Iranian elderly: a systematic review and meta-analysis. J Investig Clin Dent. 2019;10(4):e12459.
10. Bazyar H, Adibmanesh A, Javid AZ, Maghsoumi-Norouzabad L, Gravand E, Alipour M, et al. The relationship between metabolic factors and anthropometric indices with periodontal status in type 2 diabetes mellitus patients with chronic periodontitis. Obesity Medicine. 2019;16:100138.
11. Shoaee S, Ghasemian A, Mehrabani K, Naderimagham S, Hessari H. Burden of oral diseases in Iran, 1990–2010: findings from the global burden of disease study 2010. Archives of Iranian Medicine. 2015;18(8):0-.
12. Jay M, Oleson J, Charlton M, Arab A. A bayesian approach for estimating age-adjusted rates for low-prevalence diseases over space and time. Stat Med. 2021;40(12):2922–38.
13. Yin X, Aiken JM, Harris R, Bamber JL. A bayesian spatio-temporal model of COVID-19 spread in England. Sci Rep. 2024;14(1):10335.
14. Farzadfar F, Delavari A, Malekzadeh R, Mesdaghinia A, Jamshidi H, Sayyari A, et al. NASBOD 2013: design, definitions, and metrics. Arch Iran Med. 2014;17:7–15.
15. Shoaee S, Ghasemian A, Najafi B, Kasaeian A, Farzadfar F, Hessari H. National and sub-national burden of oral diseases in Iran: 1990–2013, study protocol. Arch Iran Med. 2014;17(3):159–68.
16. Shoaee S, Saeedi Moghaddam S, Masinaei M, Sofi-Mahmudi A, Hessari H, Heydari M-H, et al. Trends in dental caries of deciduous teeth in Iran: a systematic analysis of the national and sub-national data from 1990 to 2017. BMC Oral Health. 2022;22(1):634.
17. Shoaee S, Masinaei M, Moghaddam SS, Sofi-Mahmudi A, Hessari H, Shamsoddin E, et al. National and Subnational Trend of Dental Caries of Permanent Teeth in Iran, 1990–2017. Int Dent J. 2023.
18. World Health O. ICD-10: international statistical classification of diseases and related health problems : tenth revision. 2nd ed. Geneva: World Health Organization; 2004.
19. Cuschieri S. The STROBE guidelines. Saudi J Anaesth. 2019;13(Suppl 1):S31–4.
20. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. Strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. BMJ. 2007;335(7624):806–8.
21. Stevens GA, Alkema L, Black RE, Boerma JT, Collins GS, Ezzati M, et al. Guidelines for accurate and transparent health estimates reporting: the GATHER statement. Lancet. 2016;388(10062):e19–23.
22. Amos K, Levy NA, Bialek R, Arana M, Murrman M. Developing complex, cross-cutting skills in the public health workforce: using a crosswalk analysis to map public health competencies to strategic skills for the governmental public health workforce. J Public Health Manag Pract. 2022. https://doi.org/10.1097/PHH.0000000000001532.
23. Bönisch C, Kesztyüs D, Kesztyüs T. Harvesting metadata in clinical care: a crosswalk between FHIR, OMOP, CDISC and openEHR metadata. Sci Data. 2022;9(1):659.
24. Finucane MM, Stevens GA, Cowan MJ, Danaei G, Lin JK, Paciorek CJ, et al. National, regional, and global trends in body-mass index since 1980: systematic analysis of health examination surveys and epidemiological studies with 960 country-years and 9·1 million participants. Lancet. 2011;377(9765):557–67.
25. Johnson JL, Boulton AJ, Spindler KP, Huston LJ, Spalding T, Asplin L, et al. Creating crosswalks for knee outcomes after ACL reconstruction between the KOOS and the IKDC-SKF. J Bone Joint Surg Am. 2022;104(8):723–31.
26. ten Klooster PM, Oude Voshaar MA, Gandek B, Rose M, Bjorner JB, Taal E, et al. Development and evaluation of a crosswalk between the SF-36 physical functioning scale and health assessment questionnaire disability index in rheumatoid arthritis. Health Qual Life Outcomes. 2013;11:199.
27. Parsaeian M, Farzadfar F, Zeraati H, Mahmoudi M, Rahimighazikalayeh G, Navidi I, et al. Application of spatio-temporal model to estimate burden of diseases, injuries and risk factors in Iran 1990–2013. Arch Iran Med. 2014;17(1):28–33.
28. Farzadfar F, Delavari A, Malekzadeh R, Mesdaghinia A, Jamshidi HR, Sayyari A, et al. NASBOD 2013: design, definitions, and metrics. Arch Iran Med. 2014;17(1):7–15.
29. Bates D, Mächler M, Bolker B, Walker S. Fitting linear mixed-effects models using lme4. arXiv preprint arXiv:14065823. 2014.
30. Knowles JE, Frederick C. merTools: tools for analyzing mixed effect regression models. R package version 03 0. 2016.
31. Efron B. Bootstrap confidence intervals for a class of parametric problems. Biometrika. 1985;72(1):45–58.
32. Green P, Silverman B. Nonparametric regression and generalized linear models: a roughness penalty approach. United Kingdom: Chapman and Hall; 1994.
33. Hastie TJ, Tibshirani RJ. Generalized Additive Models: Taylor & Francis; 1990.
34. Statistical Center of Iran. Population and Housing Censuses [Available from: https://www.amar.org.ir/english/Population-and-Housing-Censuses.
35. Shoaee S, Sharifi F, Ghavidel Parsa P, Sobhaninejad S, Heydari MH, Sofi-Mahmudi A. Dental caries among the elderly in Iran: a meta-analysis. Med J Islam Repub Iran. 2024;38:11.

36. Bayat F, Murtomaa H, Vehkalahti MM, Tala H, Mautsch W. Does dental insurance make a difference in type of service received by Iranian dentate adults? Eur J Dent. 2011;5(01):068–76.
37. Bayat F. Impact of dental insurance on adults' oral health care in Tehran, Iran. 2010.
38. Bayat F, Vehkalahti MM, Tala H, Zafarmand AH. Dental attendance by insurance status among adults in Tehran, Iran. Int Dent J. 2006;56(6):338–44.
39. Bayat F, Akbarzadeh A, Monajemi F. Assessment of demand for and utilization of dental services by insurance coverage in a developing oral health care system. J Dent Sch. 2017;35(2):36–42.
40. Bayat F, Vehkalahti MM, Akbarzadeh A, Monajemi F. Varying manpower alters dental health in a developing health care system. Int Dent J. 2022;72(3):360–5.
41. Khoshnevisan MH, Ghasemianpour M, Samadzadeh H, Baez RJ. Oral Health Status and Healthcare System in I.R. Iran. Journal of Contemporary Medical Sciences. 2018;4(3).
42. Tahani B, Yazdani S, Khoshnevisan M, Dugdale P, Siddiqi S, Ebn Ahmady A. Framework for assessing stewardship of the oral health system in Islamic Republic of Iran. EMHJ-Eastern Mediterranean Health J. 2014;20(2):73-81. 2014.
43. Hajizamani A, MalekMohammadi T, Hajmohammadi E, Shafiee S. Integrating oral health care into primary health care system. Int Sch Res Notices. 2012;2012(1):657068.
44. Bastani P, Mohammadpour M, Mehraliain G, Delavari S, Edirippulige S. What makes inequality in the area of dental and oral health in developing countries? A scoping review. Cost Eff Resour Alloc. 2021;19(1):54.
45. Mohammadpour M, Bastani P, Brennan D, Ghanbarzadegan A, Bahmaei J. Oral health policymaking challenges in Iran: a qualitative approach. BMC Oral Health. 2020;20(1):158.
46. Tahani B, Baghban AA, Kazemian A. Determinants of oral health status: an ecological study in Iran. BMC Oral Health. 2023;23(1):910.
47. Shoaee S, Ghasemian A, Mehrabani K, Naderimagham S, Hessari H. Burden of Oral Diseases in Iran, 1990–2010: Findings from the Global Burden of Disease Study 2010. Arch Iran Med. 2015;18(8):0-.
48. (IHME) IfHMaE. Prevalence of Peridontal Diseases in Iran from 1990 to 2017 2025 [Available from: https://vizhub.healthdata.org/gbd-compare/.
49. Rezaei S, Hajizadeh M, Irandoost SF, Salimi Y. Socioeconomic inequality in dental care utilization in Iran: a decomposition approach. Int J Equity Health. 2019;18(1):161.
50. Kiadaliri AA, Hosseinpour R, Haghparast-Bidgoli H, Gerdtham U-G. Pure and social disparities in distribution of dentists: a cross-sectional province-based study in Iran. Int J Environ Res Public Health. 2013;10(5):1882–94.
51. Singh A, Antunes JLF, Peres MA. Socio-Economic Inequalities in Oral Health. In: Peres MA, Antunes JLF, Watt RG, editors. Oral Epidemiology: A Textbook on Oral Health Conditions, Research Topics and Methods. Cham: Springer International Publishing; 2021. p. 279–94.
52. Najafi E, Amini-Rarani M, Moeeni M. Inequality in dental care expenditure in Iranian households: analysis of income quintiles and educational levels. BMC Oral Health. 2021;21(1):550.
53. Jang YE, Kim CB, Kim NH. Utilization of preventive dental services before and after health insurance covered dental scaling in Korea. Asia Pac J Public Health. 2017;29(1):70–80.
54. Jang YE, Kim CB, Kim NH. Influence of dental insurance coverage on access to preventive periodontal care in middle-aged and elderly populations: analysis of representative Korean Community Health Survey Data (2011–2015). Int Dent J. 2019;69(6):445–53.
55. Gnanamanickam ES, Teusner DN, Arrow PG, Brennan DS. Dental insurance, service use and health outcomes in Australia: a systematic review. Aust Dent J. 2018;63(1):4–13.

Publisher's Note