Table 4. *Cont.*

Variables	Intervention (n = 188)			Control (n = 183)		
	Improved	Worsened	p-Value [7]	Improved	Worsened	p-Value [7]
Categorical variables						
CPI [3]	33 (17.6) [5]	25 (13.3)	0.358	32 (17.5)	26 (14.2)	0.512
Have you had any problems with work performance because of oral diseases?						
	9 (4.8)	7 (3.7)	0.804	10 (5.5)	5 (2.7)	0.302
Do you have a family dental doctor?						
	13 (6.9)	5 (2.7)	0.096	18 (9.8)	12 (6.6)	0.362
Does your work disturb you going to dental clinic?						
	26 (13.8)	18 (9.6)	0.291	25 (13.7)	20 (10.9)	0.551
Do you brush your teeth in your workplace?						
	30 (16.0)	16 (8.5)	0.003	22 (12.1)	19 (10.4)	0.256
Do you eat snack food between meals?						
	27 (14.4)	26 (13.8)	0.997	18 (9.8)	28 (15.3)	0.403
Do you smoke tobacco?						
	4 (2.1)	7 (3.7)	0.392	8 (4.3)	7 (3.8)	0.978
Do you brush your teeth before going to bed?						
	13 (6.9)	4 (2.1)	0.132	13 (7.1)	10 (5.4)	0.733
Do you use fluoride toothpaste?						
	53 (28.2)	7 (8.0)	<0.001	35 (19.1)	22 (12.0)	0.076
Do you use interdental brushes/dental floss?						
	50 (26.6)	7 (3.7)	<0.001	26 (14.2)	15 (8.2)	0.049
Have you received tooth brushing instruction at a dental clinic?						
	24 (12.8)	7 (3.7)	0.003	16 (8.7)	10 (5.5)	0.327
Have you received an oral examination in the past year at a dental clinic?						
	28 (14.9)	11 (5.9)	0.009	32 (17.5)	10 (5.5)	0.001

[1] Debris index-simplified; [2] Percentage of bleeding on probing; [3] Community periodontal index; [4] Mean ± standard deviation; [5] n (%); [6] Paired t-test; [7] McNemar test or McNemar-Bowker test.

Oral health behavioral interventions are not invasive. Therefore, there were no study-related serious adverse events in this study. Furthermore, outcomes did not change after the trial commenced.

4. Discussion

To the best of our knowledge, this was the first study to assess changes in work performance after oral health-related behavioral modification intervention. The study design was reliable as examinations were performed blinded, participants were quasi-randomly (alternate allocation) separated into either an intervention group or a control group, and the sample size was sufficiently large. Unfortunately, this intervention did not improve work performance, and there are several reasons for this. In a previous study [21], it was reported that work performance is mainly influenced by pain from oral diseases. In this study, there was a significant association between work performance and oral pain (baseline, $p = 0.002$; follow-up, $p = 0.019$; chi-squared tests; data not shown). However, there was no significant difference in the decrease in oral pain between the intervention and control groups ($p \geq 0.05$). A previous study showed that a combination of professional oral hygiene treatment and oral hygiene instructions contributed to a decrease in gingival-related pain [22]. Thus, in the future, we should investigate whether a combination of professional oral hygiene treatment and oral health instruction improves work performance.

Oral health-related behavioral modification intervention improved oral health behavior but not oral health status. A systematic review showed that oral hygiene instruction had short-term and long-term effects [10]. The short-term effects were improving knowledge, attitudes, self-efficacy, oral health behavior, and theory constructs. The long-term effects included improving the number of decayed teeth, plaque score, BOP, and gingival condition [10]. The results of this study may be included in the short-term effects. Menegaz et al. suggested that a follow-up time of less than one year led to a lack of efficacy for educational intervention [23]. In addition, Oshikohji et al. reported that workers who had more participation time for oral examination and oral health instruction had better periodontal condition than those with less time [24]. If the duration of this study and/or the frequency of instruction was increased, oral health status might improve.

The intervention in this study was advantageous as it included some of the known factors that lead to behavioral modification. We explained why the workers should change their behavior (prompt intention formation), let the workers set goals independently (prompt specific goal setting), and checked their improvement and prompted them to reconsider their goals (prompt self-monitoring of behavior and prompt review of behavioral goals) [12,13]. Goals to improve oral status were also set based on individual situations in this study. These concepts were supported by a previous study [25]. Finally, the intervention time was short (5 min), a factor which may be effective in workplaces to improve oral health behavior.

There were 17 participants who had problems with work because of tooth or gum disease (4.6% of participants) at baseline. These conditions agree with the prevalence of poor work performance caused by oral pain in previous studies, which ranged between 1.0–7.6% [25–28]. The percentage in this study was within this range. However, the job sector of participants in this study was skewed. The percentage of workers who belonged to the tertiary industry sector was high (83%), and there were no workers from the primary industry sector. Therefore, we should exercise caution when applying our results more generally.

There were some limitations with regard to the interpretation of these results. First, although most of the participants visited a dental clinic during the study period, the type of dental health instruction they received was not confirmed. The intensity of instruction may have affected the results. Second, the follow up rate was not high (approximately 60.7%). As >20% loss would pose a serious threat [29], the high percentage of loss to follow-up may have affected our results. In the intervention group, the ratios of work performance, oral status, and oral health behavior were not significantly different between the analyzed and non-analyzed workers (188 vs. 85 workers, chi-squared test and non-paired t-test, $p > 0.05$). However, in the control group, the percentage of those using interdental brushes/dental floss was significantly different (183 vs. 90 workers, chi-squared test, $p = 0.034$). In the control group, use of interdental brushes or dental floss might have been improved because more workers who did not use these were not analyzed. Other limitations include the short-term scale of the study period and the fact that this was not a randomized trial.

5. Conclusions

In conclusion, oral health-related behavioral modification intervention improved oral health behavior, but not work performance in Japanese workers.

Author Contributions: Conceptualization, A.T.-T., S.M., D.E. and M.M.; investigation, A.T.-T., N.S., Y.S., D.F., Y.U., H.M. and A.Y.; data curation, A.T.-T. and N.T.; writing—original draft preparation, N.T.; writing—review and editing, all authors; project administration, M.M.; funding acquisition, M.M.

Funding: The research was funded by the "Research Fund of Clinical Study for Industrial Accident and Disease" (14020101–01) from the Japanese Ministry of Health, Labour and Welfare.

Acknowledgments: The authors are grateful to Junko Emi (Animal Development and Reproductive Biotechnology, Okayama University Graduate School of Environmental and Life Science Okayama, Japan) for data entry and collection, Hirofumi Mizuno (Sasaki dental clinic, Aichi, Japan) for oral examination, and Yuko Kimura (International Dental Hygienist College, Okayama, Japan) for collaboration with regard to oral health behavioral modification intervention.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Pronk, N.P.; Martinson, B.; Kessler, R.C.; Beck, A.L.; Simon, G.E.; Wang, P. The Association Between Work Performance and Physical Activity, Cardiorespiratory Fitness, and Obesity. *J. Occup. Environ. Med.* **2004**, *46*, 19–25. [CrossRef] [PubMed]
2. Suvinen, T.I.; Ahlberg, J.; Rantala, M.; Nissinen, M.; Lindholm, H.; Könönen, M.; Savolainen, A. Perceived stress, pain and work performance among non-patient working personnel with clinical signs of temporomandibular or neck pain. *J. Oral Rehabil.* **2004**, *31*, 733–737. [CrossRef] [PubMed]
3. Khubchandani, J.; Price, J.H. Association of Job Insecurity with Health Risk Factors and Poorer Health in American Workers. *J. Community Health* **2017**, *42*, 242–251. [CrossRef] [PubMed]
4. Sigurdardottir, V.; Drivelegka, P.; Svärd, A.; Jacobsson, L.T.H.; Dehlin, M. Work disability in gout: A population-based case—Control study. *Ann. Rheum. Dis.* **2018**, *77*, 399–404. [CrossRef] [PubMed]
5. Protecting Workers' Health. Available online: http://www.who.int/news-room/fact-sheets/detail/protecting-workers\T1\textquoteright-health (accessed on 26 October 2018).
6. Fouad, A.M.; Waheed, A.; Gamal, A.; Amer, S.A.; Abdellah, R.F.; Shebl, F.M. Effect of Chronic Diseases on Work Productivity: A Propensity Score Analysis. *J. Occup. Environ. Med.* **2017**, *59*, 480–485. [CrossRef] [PubMed]
7. Ichihashi, T.; Mutou, T.; Shibuya, K. Influence of Dental Diseaseon Workers in Terms of Hours Lost from Work or Daily Life Activities. *Jpn. Soc. Dent. Health* **2002**, *52*, 141–149. [CrossRef]
8. Listl, S.; Galloway, J.; Mossey, P.A.; Marcenes, W. Global Economic Impact of Dental Diseases. *J. Dent. Res.* **2015**, *94*, 1355–1361. [CrossRef] [PubMed]
9. Kay, E.; Vascott, D.; Hocking, A.; Nield, H.; Dorr, C.; Barrett, H. A review of approaches for dental practice teams for promoting oral health. *Community Dent. Oral Epidemiol.* **2016**, *44*, 313–330. [CrossRef] [PubMed]
10. Ghaffari, M.; Rakhshanderou, S.; Ramezankhani, A.; Buunk-Werkhoven, Y.; Noroozi, M.; Armoon, B. Are educating and promoting interventions effective in oral health?: A systematic review. *Int. J. Dent. Hyg.* **2018**, *16*, 48–58. [CrossRef] [PubMed]
11. Haresaku, S.; Tsutsui, A.; Sakai, K.; Ryu, C.; Kanesaki, N.; Hanioka, T.; Kashiwagi, S.; Mishima, K.; Chinju, N.; Ogawa, K. Relationships of Dental Factors for Behavior Change with the Effects of an Intervention Program in the Workplace and Consciousness of the Oral Health of Workers. *Jpn. Soc. Dent. Health* **2004**, *54*, 122–131. [CrossRef]
12. Michie, S.; Abraham, C.; Whittington, C.; McAteer, J.; Gupta, S. Effective techniques in healthy eating and physical activity interventions: A meta-regression. *Health Psychol.* **2009**, *28*, 690–701. [CrossRef] [PubMed]
13. Ishikawa, Y. Recent Global Trends in Standardized Reporting of Behavior Change Technique. *Jpn. J. Behav. Med.* **2014**, *20*, 41–46. [CrossRef]
14. Cohen, J. A power primer. *Psychol. Bull.* **1992**, *112*, 155–159. [CrossRef] [PubMed]
15. Davis, K.D.; Lawson, K.M.; Almeida, D.M.; Kelly, E.L.; King, R.B.; Hammer, L.; Casper, L.M.; Okechukwu, C.A.; Hanson, G.; McHale, S.M. Parents' Daily Time With Their Children: A Workplace Intervention. *Pediatrics* **2015**, *135*, 875–882. [CrossRef] [PubMed]
16. Yoshihara, A.; Yagi, M.; Sawamura, E.; Kanako, N.; Miyazaki, H. Evaluation of Personalized Oral Health Program with Mailing Pamphlets for Women. *Jpn. Soc. Dent. Health* **1999**, *49*, 809–815. [CrossRef]
17. World Health Organization. *Oral Health Surveys: Basic Methods*; World Health Organization: Geneva, Switzerland, 1997.
18. Greene, J.G.; Vermillion, J.R. The Simplified Oral Hygiene Index. *J. Am. Dent. Assoc.* **1964**, *68*, 7–13. [CrossRef] [PubMed]
19. Ministry of Internal Affairs and Communications. Japan Standard Industrial Classification 2013. Available online: http://www.soumu.go.jp/english/dgpp_ss/seido/sangyo/san13-3.htm (accessed on 23 November 2018).
20. Japan Dental Association. Lifelong Teeth Support Program. Available online: http://www.jda.or.jp/dentist/program/ (accessed on 23 November 2018).
21. Lawal, F.B.; Taiwo, J.O.; Oke, G.A. Impact of Oral Health on The Quality of Life of Elementary School Teachers. *Ethiop. J. Health Sci.* **2015**, *25*, 217–224. [CrossRef] [PubMed]

22. Arduino, P.G.; Lopetuso, E.; Carcieri, P.; Giacometti, S.; Carbone, M.; Tanteri, C.; Broccoletti, R. Professional oral hygiene treatment and detailed oral hygiene instructions in patients affected by mucous membrane pemphigoid with specific gingival localization: a pilot study in 12 patients. *Int. J. Dent. Hyg.* **2012**, *10*, 138–141. [CrossRef] [PubMed]
23. Menegaz, A.M.; Silva, A.E.R.; Cascaes, A.M. Educational interventions in health services and oral health: Systematic review. *Rev. Saúde Pública* **2018**, *52*. [CrossRef] [PubMed]
24. Oshikohji, T.; Shimazaki, Y.; Shinagawa, T.; Fukui, N.; Akifusa, S.; Yamashita, Y. Relationship between Receiving a Workplace Oral Health Examination Including Oral Health Instruction and Oral Health Status in the Japanese Adult Population. *J. Occup. Health* **2011**, *53*, 222–229. [CrossRef] [PubMed]
25. Abegg, C.; Fontanive, V.N.; Tsakos, G.; Davoglio, R.S.; de Oliveira, M.M.C. Adapting and testing the oral impacts on daily performances among adults and elderly in Brazil. *Gerodontology* **2015**, *32*, 46–52. [CrossRef] [PubMed]
26. Nagarajappa, R.; Batra, M.; Sanadhya, S.; Daryani, H.; Ramesh, G. Oral impacts on daily performance: Validity, reliability and prevalence estimates among Indian adolescents. *Int. J. Dent. Hyg.* **2018**, *16*, 279–285. [CrossRef] [PubMed]
27. Gülcan, F.; Nasir, E.; Ekbäck, G.; Ordell, S.; Åstrøm, A.N. Change in Oral Impacts on Daily Performances (OIDP) with increasing age: testing the evaluative properties of the OIDP frequency inventory using prospective data from Norway and Sweden. *BMC Oral Health* **2014**, *14*, 59. [CrossRef] [PubMed]
28. Peker, I.; Alkurt, M.T. Oral impacts on daily performance in Turkish adults attending a dental school. *J. Contemp. Dent. Pract.* **2014**, *15*, 92–98. [CrossRef] [PubMed]
29. Dettori, J.R. Loss to follow-up. *Evid.-Based Spine-Care J.* **2011**, *2*, 7–10. [CrossRef] [PubMed]

資料３

口腔衛生会誌　J Dent Hlth 69: 27-33, 2019

原　著

職域における歯科健診と個別保健指導による行動変容

金子　昇[1)]　蔑原　明弘[2)]　濃野　要[1)]　山賀　孝之[1)]
財津　崇[3)]　川口　陽子[3)]　宮﨑　秀夫[1,4)]

概要：職域における歯科保健事業として，疾病の早期発見を目的とした歯科健診が主に行われてきた．こうした従来型の歯科健診から，行動・環境リスク発見型・行動変容支援型歯科健診への転換を目的として，日本歯科医師会で「標準的な成人健診プログラム・保健指導マニュアル」（生活歯援プログラム）が策定された．本調査ではこのプログラムに基づいた歯科健診と保健指導が，歯科健診単独に比べてどの程度優れているのか検討を行った．新潟市内の３企業の従業員129名（44.6±11.5歳）を対象としてランダムに２群に分け，介入群には生活歯援プログラムに準じた歯科健診と保健指導を，対照群には歯科健診のみを行った．保健行動を把握するための質問紙調査をベースライン時，３カ月後，６カ月後および１年後に行い，この間の行動変容を調べた．その結果，介入群と対照群のいずれにおいても「職場や外出先での歯磨き」や「フッ素入りの歯磨剤の使用」，「歯間ブラシ・フロスの使用」が有意に改善していた．ただ，介入群では１年後まですべての時点でベースライン時に比べ有意に改善していたのに対し，対照群では一部の時点で有意な改善がみられたのみであった．したがって，従来型の歯科健診でも保健行動の変容がある程度期待できるが，その期間は限定的であること，歯科健診に加え生活歯援プログラムに準じた保健指導を行うことで行動変容はより確実となり，効果が少なくとも１年間持続することが明らかとなった．

索引用語：成人歯科保健，保健指導，行動変容

口腔衛生会誌 69：27-33, 2019
（受付：平成 30 年 6 月 12 日／受理：平成 30 年 10 月 2 日）

緒　言

職域において，歯科疾患は欠勤や仕事の能率低下を引き起こす原因となり，労働損失をもたらす大きな問題である[1)]．さらに，歯周病は糖尿病[2)]や心疾患[3,4)]，腎臓疾患[5,6)]などの全身疾患との関連性が指摘されており，フロスや歯間ブラシの不使用は，心血管系イベントのリスク上昇[7)]やメタボリックシンドローム[8)]と関連していることが報告されるなど，成人における歯科保健活動の重要性は増加している．

こうした中，日本歯科医師会は平成21年に「標準的な成人歯科健診プログラム・保健指導マニュアル」（生活歯援プログラム）を策定した[*1]．これは歯科健診を，単に疾患を発見する場としてではなく，受診者の口腔内状態の改善と行動変容に繋がるような指導・支援の場と位置づけることで，従来型の歯科健診から行動・環境リスク発見型・行動変容支援型歯科健診への転換を目指したものである．このプログラムでは，まず質問紙により受診者の環境・行動診断を行う．この結果に基づいて受診者を類型化し，受診者に必要と考えられる情報提供・保健指導を行うというプロセスを取る．従来型の歯科健診がスクリーニングを主な目的としているのに対し，生活歯援プログラムは受診者の行動変容を主な目的としているといえる．

これまでに生活歯援プログラムに準拠した歯科健診と保健指導を行った調査がいくつか実施されている．佐々木らは北海道内の29の事業所においてこのプログラムに準拠した成人歯科健診を行い，10項目の保健行動のうち６項目で望ましい方向への変化がみられたことを報告している[9-11)]．また，岩本らは４都県の事業所・団体でこのプログラムに基づいた成人歯科健診を行い，同様に８項目の保健行動のうち６項目で有意な改善がみられ

[1)] 新潟大学大学院医歯学総合研究科予防歯科学分野
[2)] 新潟大学大学院医歯学総合研究科口腔保健学分野
[3)] 東京医科歯科大学大学院医歯学総合研究科健康推進歯学分野
[4)] 明倫短期大学歯科衛生士学科

[*1] 日本歯科医師会：標準的な成人歯科健診プログラム・保健指導マニュアル，https://www.jda.or.jp/program/main.pdf（2018年５月29日アクセス）．

たことを報告している[12]．しかしこれまでのところ，対照群として従来型の歯科健診のみを行った群を設定した調査は行われておらず，生活歯援プログラムに準拠した歯科健診が従来型の歯科健診に比べてどの程度優れているのかは明らかでない．また，保健指導を行った後，行動変容がどの程度持続するかは不明であった．

そこで本研究では，従来型の歯科健診単独の場合に比べて生活歯援プログラムがどの程度優れているのか，またそれによる行動変容がどの程度持続するのか調査することを目的とした．

対象および方法

1.　対象者

新潟市内の製造業，飲食業，建設業から各1企業を任意に選出し，その従業員を対象とした．各企業における対象人数は，製造業59名（参加率100%），飲食業32名（参加率100%），建設業38名（参加率90.5%）の合計129名（男性100名，女性29名）であった．各企業の従業員を介入群65名と対照群64名に振り分けた．その際，年齢が偏らないようにするため，各企業の従業員を年齢順にソートした後，ランダムに2群に振り分けた．介入群に対しては口腔内診査と質問紙調査の後に保健指導を，対照群に対しては口腔内診査と質問紙調査のみを行った．なお，口腔内診査で治療が必要とされた者には，介入群と対照群とも歯科医師による治療勧告が行われた．本研究は新潟大学歯学部倫理委員会の承認を受けて行われ（承認番号：27-R17-9-14），対象者には事前に十分な説明を行ったうえで同意の書面を得た．また，本研究には利益相反は存在しない．

2.　質問紙調査

日本歯科医師会が作成した生活歯援プログラム質問紙[*1]を用いて，口腔清掃習慣やかかりつけ歯科医院の有無など，対象者の保健行動に関する情報を得た．また3カ月後，6カ月後，1年後にも同じ質問紙を用いて保健行動の変化を把握した．

3.　保健指導

介入群に対しては，口腔内診査と質問紙調査を行った後，事前に研修を受けた歯科衛生士が「標準的な成人歯科健診プログラム・保健指導マニュアル」[*1]に準拠して保健指導を行った．すなわち，まず質問紙の回答内容から受診者を類型化し，「知識提供・気づき支援型」指導，「相談・カウンセリング型」指導，「環境・受け皿整備型」指導，「実技指導型」指導のうち受診者に必要と考えられる保健指導を行った．まず「知識提供・気づき支援型」指導として，う蝕や歯周病に関する基本的な知識とセルフケアの方法，喫煙および食生活等についての情報提供を質問紙の情報を基に行い，もし「QOL，口腔内の状態・機能」についての質問Q1～6のうち2項目以上該当したらさらに「相談・カウンセリング型」の指導としてセルフケアの改善に必要な実践的な指導を，また「支援的環境」についての質問Q7～12のうち3項目以上該当したら，さらに「環境・受け皿整備型」の指導として歯科医院への受診を勧め，職場での環境整備のためのアドバイスを行った．Q13～20の「保健行動」のうち3項目以上該当する者はさらに保健指導の必要性が高いことから，これらすべての指導に加えて「実技指導型」の指導も行った．

また，保健指導の最後に対象者自身によって実現可能と考えられる行動目標を設定させ，紙に記入してもらった．3カ月後，6カ月後および1年後に質問紙調査票を郵送する際，保健指導のパンフレットに加えてこの自筆の行動目標のコピーも同封して，目標の再認識を促した．

4.　統計

ベースライン時における介入群と対照群の対象者特性を，質的変数に対してはχ^2検定，量的変数に対してはt検定を用いて比較した．また，介入群と対照群のそれぞれで，ベースライン時と追跡調査時（3カ月後，6カ月後，1年後）の比較を行う際，2×2表データの比較にはMcNemer検定を，それ以外の比較にはWilcoxonの符号付き順位検定を用い，それぞれBonferroni補正を行った．すべての統計的分析にはSTATA SE 14（USA STATA Corporation）を用い，$p<0.05$を有意とした．

結　　果

1.　対象者の特性

3カ月後，6カ月後，1年後の質問紙調査および1年後の歯科健診にすべて参加した者は111名（86%，介入群52名，対照群59名）であり，以降，この111名について解析を行った．

表1に対象者の特性を示す．介入群と対照群における男性の割合はそれぞれ78.8%と79.7%，年齢は45.6±10.8歳と44.3±12.0歳であり，2群間で有意差は認められなかった．また，各群の所属企業構成についても有意差はなかった．ベースライン時の質問紙調査の項目中，保健行動に関する質問項目Q12～20のいずれの項目においても，介入群と対照群とで有意差は認められなかった（表2）．

2.　保健行動の変容

次に介入群と対照群のそれぞれで，質問紙の回答がどのように変化したかを表3に示す．介入群ではQ12「職

場や外出先での歯磨き」が，ベースライン時（毎回 9.6%，時々 34.6%）と比較して，3 カ月後（毎回 21.6%，時々 33.3%；p=0.007），6 カ月後（毎回 19.2%，時々 40.4%；p=0.004），1 年後（毎回 19.2%，時々 40.4%；p=0.014）と，いずれの時点でも有意に改善していた．対照群ではベースライン時（毎回 18.6%，時々 16.9%）と比較して，3 カ月後（毎回 22.0%，時々 16.9%；p=0.309），6 カ月後（毎回 16.9%，時々 27.1%；p=0.309）では有意な改善を認めなかったが，徐々に「いいえ」の回答が減少し，1 年後（毎回 22.0%，時々 27.1%；p=0.030）には有意な改善を示した．

また Q16「フッ素入り歯磨剤の使用」についても，介入群はベースライン時（30.8%）と比較して，3 カ月後（63.5%；p=0.005），6 カ月後（75.0%；p<0.001），1 年後（69.2%；p<0.001）のいずれの時点でも「はい」の割合が有意に増加していた．対照群ではベースライン時（25.4%）と比較して，3 カ月後（40.7%；p=0.087）と 1 年後（32.2%；p=1.000）の時点では有意な変化を認めなかったが，6 カ月後（44.1%；p=0.024）の時点では「はい」の割合が有意に増加していた．

Q17「歯間ブラシ・フロスの使用」についても，介入群ではベースライン時（毎日 17.3%，時々 28.8%）と比べて 3 カ月後（毎日 25.0%，時々 34.6%；p=0.022），6 カ月後（毎日 17.3%，時々 51.9%；p=0.027），1 年後（毎日 19.2%，時々 48.1%；p=0.010）のいずれの時点でも使用習慣が有意に改善していた．対照群ではベースライン時（毎日 6.8%，時々 40.7%）に比べて 3 カ月後（毎日 8.5%，時々 44.1%；p=0.745）は有意な変化は認めなかったが，

表 1　対象者の特性

		介入群 (N=52)	対照群 (N=59)	p 値
性別　N（%）†	男	41（78.8）	47（79.7）	0.916
	女	11（21.2）	12（20.3）	
年齢　平均±S.D.‡		45.6±10.8	44.3±12.0	0.546
N（%）†	～ 29 歳	4（7.7）	7（12.1）	0.841
	30～39 歳	10（19.2）	13（22.4）	
	40～49 歳	17（32.7）	14（24.1）	
	50～59 歳	17（32.7）	20（34.5）	
	60 歳～	4（7.7）	4（6.9）	
企業　N（%）†	製造業	26（50.0）	29（49.2）	0.930
	飲食業	10（19.2）	13（22.0）	
	建設業	16（30.8）	17（28.8）	

†：χ^2 検定，‡：t 検定

表 2　ベースライン時における口腔保健行動に関する質問紙調査結果

質問項目	回答	介入群 (N=52)	対照群 (N=59)	p 値
Q12.　普段，職場や外出先でも歯を磨きますか　N（%）	毎回	5（9.6）	11（18.6）	0.070
	時々	18（34.6）	10（16.9）	
	いいえ	29（55.8）	38（64.4）	
Q13.　間食（甘い食べ物や飲み物）をしますか　N（%）	毎日	9（17.3）	13（22.0）	0.657
	時々	30（57.7）	35（59.3）	
	いいえ	13（25.0）	11（18.6）	
Q14.　たばこを吸っていますか　N（%）	はい	22（42.3）	18（30.5）	0.433
	やめた	6（11.5）	8（13.6）	
	いいえ	24（46.2）	33（55.9）	
Q15.　夜，寝る前に歯をみがきますか　N（%）	毎日	33（63.5）	35（59.3）	0.480
	時々	7（13.5）	13（22.0）	
	いいえ	12（23.1）	11（18.6）	
Q16.　フッ素入り歯磨剤（ハミガキ）を使っていますか　N（%）	はい	22（42.3）	22（37.3）	0.503
	いいえ	14（26.9）	22（37.3）	
	わからない	16（30.8）	15（25.4）	
Q17.　歯間ブラシまたはフロスを使っていますか　N（%）	毎日	9（17.3）	4（6.8）	0.155
	時々	15（28.8）	24（40.7）	
	いいえ	28（53.8）	31（52.5）	
Q18.　ゆっくりよく噛んで食事をしますか　N（%）	毎日	10（19.2）	9（15.3）	0.741
	時々	20（38.5）	21（35.6）	
	いいえ	22（42.3）	29（49.2）	
Q19.　歯科医院等で歯みがき指導を受けたことはありますか　N（%）	はい	33（63.5）	41（69.5）	0.501
	いいえ	19（36.5）	18（30.5）	
Q20.　年に 1 回以上は歯科医院で定期健診を受けていますか　N（%）	はい	11（21.2）	14（23.7）	0.746
	いいえ	41（78.8）	45（76.3）	

χ^2 検定

表 3　介入群・対照群における口腔保健行動の変化

質問項目	回答	介入群				対照群			
		ベースライン	3M 後	6M 後	1Y 後	ベースライン	3M 後	6M 後	1Y 後
Q12. 普段，職場や外出先でも歯を磨きますか　N (%)	毎回	5 (9.6)	11 (21.6)**	10 (19.2)**	10 (19.2)*	11 (18.6)	13 (22.0)	10 (16.9)	13 (22.0)*
	時々	18 (34.6)	17 (33.3)	21 (40.4)	21 (40.4)	10 (16.9)	10 (16.9)	16 (27.1)	16 (27.1)
	いいえ	29 (55.8)	23 (45.1)	21 (40.4)	21 (40.4)	38 (64.4)	36 (61.0)	33 (55.9)	30 (50.8)
Q13. 間食（甘い食べ物や飲み物）をしますか　N (%)	毎日	9 (17.3)	11 (22.0)	6 (11.5)	9 (17.3)	13 (22.0)	8 (13.6)	12 (20.7)	13 (22.0)
	時々	30 (57.7)	27 (54.0)	37 (71.2)	32 (61.5)	35 (59.3)	45 (76.3)	33 (56.9)	36 (61.0)
	いいえ	13 (25.0)	12 (24.0)	9 (17.3)	11 (21.2)	11 (18.6)	6 (10.2)	13 (22.4)	10 (16.9)
Q14. たばこを吸っていますか N (%)	はい	22 (42.3)	20 (40.0)	21 (40.4)	21 (40.4)	18 (30.5)	16 (27.6)	17 (28.8)	16 (27.1)
	やめた	6 (11.5)	6 (12.0)	8 (15.4)	4 (7.7)	8 (13.6)	11 (19.0)	9 (15.3)	11 (18.6)
	いいえ	24 (46.2)	24 (48.0)	23 (44.2)	27 (51.9)	33 (55.9)	31 (53.4)	33 (55.9)	32 (54.2)
Q15. 夜，寝る前に歯をみがきますか　N (%)	毎日	33 (63.5)	32 (62.7)	31 (59.6)	34 (65.4)	35 (59.3)	40 (67.8)	36 (62.1)	33 (55.9)
	時々	7 (13.5)	13 (25.5)	13 (25.0)	10 (19.2)	13 (22.0)	9 (15.3)	11 (19.0)	16 (27.1)
	いいえ	12 (23.1)	6 (11.8)	8 (15.4)	8 (15.4)	11 (18.6)	10 (16.9)	11 (19.0)	10 (16.9)
Q16. フッ素入り歯磨剤（ハミガキ）を使っていますか　N (%)	はい	16 (30.8)	33 (63.5)**	39 (75.0)***	36 (69.2)***	15 (25.4)	24 (40.7)	26 (44.1)*	19 (32.2)
	いいえ	14 (26.9)	7 (13.5)	7 (13.5)	4 (7.7)	22 (37.3)	18 (30.5)	18 (30.5)	19 (32.2)
	わからない	22 (42.3)	12 (23.1)	6 (11.5)	12 (23.1)	22 (37.3)	17 (28.8)	15 (25.4)	21 (35.6)
Q17. 歯間ブラシまたはフロスを使っていますか　N (%)	毎日	9 (17.3)	13 (25.0)*	9 (17.3)*	10 (19.2)*	4 (6.8)	5 (8.5)	6 (10.2)*	8 (13.6)*
	時々	15 (28.8)	18 (34.6)	27 (51.9)	25 (48.1)	24 (40.7)	26 (44.1)	30 (50.8)	28 (47.5)
	いいえ	28 (53.8)	21 (40.4)	16 (30.8)	17 (32.7)	31 (52.5)	28 (47.5)	23 (39.0)	23 (39.0)
Q18. ゆっくりよく噛んで食事をしますか　N (%)	毎日	10 (19.2)	12 (23.1)	10 (19.2)	12 (23.1)	9 (15.3)	9 (15.3)	10 (16.9)	9 (15.3)
	時々	20 (38.5)	22 (42.3)	27 (51.9)	24 (46.2)	21 (35.6)	22 (37.3)	21 (35.6)	21 (35.6)
	いいえ	22 (42.3)	18 (34.6)	15 (28.8)	16 (30.8)	29 (49.2)	28 (47.5)	28 (47.5)	29 (49.2)
Q19. 歯科医院等で歯みがき指導を受けたことはありますか　N (%)	はい	33 (63.5)	39 (75.0)	36 (69.2)	36 (69.2)	41 (69.5)	40 (67.8)	39 (66.1)	40 (67.8)
	いいえ	19 (36.5)	13 (25.0)	16 (30.8)	16 (30.8)	18 (30.5)	19 (32.2)	20 (33.9)	19 (32.2)
Q20. 年に 1 回以上は歯科医院で定期健診を受けていますか　N (%)	はい	11 (21.2)	17 (33.3)	17 (32.7)	14 (26.9)	14 (23.7)	21 (36.2)	20 (34.5)	22 (37.3)
	いいえ	41 (78.8)	34 (66.7)	35 (67.3)	38 (73.1)	45 (76.3)	37 (63.8)	38 (65.5)	37 (62.7)

*：p<0.05, **：p<0.01, ***：p<0.001（Q19, Q20 は McNemar 検定，それ以外は Wilcoxon の符号付き順位検定（いずれも Bonferroni 補正））

徐々に改善する傾向がみられ，6 カ月後（毎日 10.2%，時々 50.8%；p=0.037），1 年後（毎日 13.6%，時々 47.5%；p=0.033）に使用習慣が有意に改善していた．

その他 Q13「間食習慣」や Q14「喫煙習慣」，Q15「就寝前の歯磨き」，Q18「ゆっくりよく噛む」，Q19「歯磨き指導の経験」，Q20「年 1 回以上の歯科医院での定期健診」については，介入群と対照群共にいずれの時点でもベースライン時と比べて有意差は認められなかった．

考　察

本研究では，生活歯援プログラムに準拠した歯科健診を行った場合と従来型の歯科健診を行った場合のそれぞれで行動変容が生じるかどうか，またそれぞれの歯科健診で行動変容の持続期間に差がみられるかどうか検討を行った．まず，ベースライン時とその後の質問紙の回答結果に注目したところ，介入群と対照群のそれぞれで「職場や外出先での歯磨き」や「フッ素入り歯磨剤の使用」，「歯間ブラシ・フロスの使用」の項目で保健行動の改善が認められた．ただ，介入群では 3 カ月後，6 カ月後および 1 年後のいずれの時点においてもベースライン時と比べて改善が認められたのに対し，対照群ではベースライン時と比べて有意な改善が認められた時期は限定的であった．したがって従来型の口腔内診査主体の歯科健診であっても，一部の項目で行動変容が期待できること，また口腔内診査に加えて「標準的な成人歯科健診プログラム」に準じた保健指導を行うことで，1 年以上の長期間にわたっての行動変容が期待できることが示唆された．

これまでに生活歯援プログラムに準拠した成人歯科検診による行動変容について調べた調査はいくつかある．佐々木らは北海道内の 29 の事業所においてこのプログラムに準拠した成人歯科健診を行ったところ，受診者の「1 日の歯磨き回数」，「歯間ブラシ・フロスの使用頻度」，「職場や外出先での歯磨き」，「フッ素入り歯磨剤の使用」，「ゆっくり良く噛んで食事する」，「歯科医院等で歯磨き指導を受けたことがある」の項目が有意に改善したことを報告している[9–11]．また，岩本らは 4 都県の事業所・団体でこのプログラムに基づいた成人歯科健診を行ったところ，「間食を毎日する」，「フッ素入り歯磨剤の使用」，「歯間ブラシ・フロスの毎日の使用」，「ゆっくり良く噛んで食事する」，「歯科医院で歯磨き指導を受けたことがある」，「年 1 回以上の歯科医院での定期健

診」の項目が望ましい方向に有意に改善したことを報告している[12]．これらの調査では口腔内診査は行わずに質問紙のみで受診者の行動把握を行っていた．また佐々木らの調査では，保健指導を初回は歯科衛生士が直接行ったが，2回目は95%が通信（レターまたは電子メール）により行われていた．岩本らの調査では初回の保健指導はスタッフが直接行ったが，その後は月に1, 2回の頻度で2カ月程度，直接指導・電話での指導・メールでの指導のいずれかが行われた．本研究においては，質問紙に加えて口腔内診査結果からも受診者の状態把握を行い，保健指導を初回は歯科衛生士が直接行ったが，その後は3カ月後，6カ月後，1年後に保健指導のパンフレットと共に対象者自身が設定した自筆の行動目標のコピーを郵送することで行った．その結果，本研究においてもこれら先行研究と共通する項目で有意な改善が認められた．このことから，口腔内診査の有無に関わらず，受診者の状態を把握したうえでそれに応じた個別指導とその後の行動変容を維持するための指導を繰り返すスタイルの生活歯援プログラムは，多くの保健行動を良い方向に改善する効果があることが確認された．

行動変容の持続期間についてみると，生活歯援プログラムに準拠した保健指導を行った介入群において，1年間にわたり行動変容が持続していた．過去の調査では，歯科衛生士が個別に保健指導を行った後，1年後にフロス使用者の割合が有意に増加していたという葭原らの報告[13]や1カ月後は歯間部清掃器具を使用している者が有意に増加したが，1年後にはその差が有意でなくなっていたという晴佐久らの報告[14]等，行動変容の持続期間にはばらつきがみられる[15,16]．葭原らの調査では口腔内診査を行わず，ペリオスクリーンと咀嚼能力試験の結果を受診者の状態把握に利用して歯科衛生士が個別に保健指導を行い，またモチベーションの維持を目的として3カ月後に保健指導のパンフレットを郵送していた．一方，晴佐久らの調査では，口腔内診査と質問紙により受診者の状態を把握したうえで保健指導を行っていたが，受診者3人を1グループとして歯科衛生士が保健指導を行っていることから個別指導とまではいえず，また，保健指導は1回のみであった．晴佐久らは2014年，歯科衛生士が個別保健指導を複数回行った調査についても報告している[17]．これはブラッシング行動自己管理スキル尺度[18]により受診者の状態を把握したうえで，歯科衛生士による個別保健指導を3カ月おきに3回行った調査であり，最初の保健指導から1年後の時点で歯間部清掃用器具を使用する者の割合が有意に増加していた．個別指導・集団指導の違いや，モチベーションを維持するためのその後の保健指導の有無が，行動変容の持続時間に大きく影響を与えていると考えられる．

トランスセオレティカル・モデル（行動変容ステージモデル）によると，行動変容に至るまでの過程には無関心期，関心期，準備期，実行期，維持期があり，これら細かく分かれたステージに応じた働きかけを行うことで，次のステージへと進んでいく[19]．各ステージで受診者の行動や心理等が異なるため，ステージに応じてアプローチを変える必要がある．集団指導では，さまざまなステージにある受診者に対して画一的な指導を行うことになるため，保健に関する知識の習得には有効であるが[20]，行動変容はそれほど期待できない[13]．明確なメッセージ性のある個別指導を行うことにより，必ずしも口腔内診査を行わなくても行動変容を引き起こすことも可能である[21]．生活歯援プログラムでは，質問紙により受診者の環境・行動診断を行って受診者を類型化し，受診者の行動ステージに合わせた情報提供・保健指導を行っており，このことが長期間に渡って行動変容をもたらしていると考えられた．

一方で今回の調査では，保健指導を伴わない従来型の歯科健診のみでも，一時的ではあるが保健行動の変容が認められ，3カ月後，6カ月後，1年後と歯科健診から時間が経つにつれて「職場や外出先での歯磨き」，「歯間ブラシ・フロスの使用」が徐々に改善する傾向が認められた．この理由としては，今回の調査では各企業それぞれで従業員を介入群と対照群に分けたことで同じ職場に介入群と対照群が働いており，介入群の保健行動が，対照群の保健行動に影響を及ぼしたためではないかと考えられた[17]．「職場や外出先での歯磨き」は，保健行動についての質問項目であるとともに職場環境についての質問項目でもある．職場で口腔清掃を行う者が増えれば，それまで他の人の目を気にして口腔清掃を行っていなかった者が口腔清掃を行いやすくなったり，職場の中で口腔清掃を行う場所や時間が整備されたりという環境要因の改善が期待できる．「歯間ブラシ・フロスの使用」についても同様の傾向が認められたが，同様のことがいえるかもしれない．また本研究においては，対照群に対しても口腔内診査とその結果に基づいた治療勧告が行われた．治療勧告によって受診した歯科医院で保健指導を受けた可能性や，3カ月後，6カ月後，1年後に保健行動に関する質問紙が郵送されたこと等も，対照群における保健行動の変容に影響していた可能性が考えられる．

「間食（甘い食べ物や飲み物）」，「喫煙」のような嗜好に関わる項目や「就寝前の歯磨き」については，介入群と対照群のいずれにおいてもベースライン時と比べて有

意な変化は認められなかった．間食や喫煙のような嗜好に関わる生活習慣については，保健指導を行っても行動変容が得られなかったことが過去の研究でも報告されている[9,12]．本研究においても先行研究と同様の傾向が認められ，これらの項目について行動変容を生じさせるような保健指導方法を今後考えていく必要がある．また，就寝前の歯磨きは介入群においてベースライン時に76.9%だったのが3カ月後に88.2%と若干の改善は認められたが統計学的には有意ではなかった．これは，元々行っている者が多いために効果がみえにくくなる「天井効果」の影響と考えられた[12]．

最後に本研究の限界について述べる．本研究では，新潟県内の一部業種の従業員を対象としており，それ以外の業種の従業員についての検討が不十分であった．職種によって保健行動が異なることから[22,23]，保健指導に対する反応が業種や職種によって異なる傾向を示す可能性があり，今後，他業種や職種別の調査を行う必要があると考えられる．また，本研究では，対象者自身により設定された保健行動目標の内容，およびそれが達成されたかどうか検討を行わなかった．これは保健行動目標が対象者によって千差万別であり，集計と解析が困難であったためである．とはいえ，そこには対象者自身が実行可能で優先度が高いと考えている内容が含まれており，今後検討を行っていく必要があると考えられる．

謝　辞

本研究の一部は厚生労働省労災疾病臨床研究事業費補助金（14020101-01および170501-01）の助成を受けて行われた．

文　献

1）市橋　透，武藤孝司，渋谷耕司：勤労者における仕事及び日常生活への歯科疾患による影響の実態．口腔衛生会誌 52：141-149，2002.
2）Teeuw WJ, Kosho MX, Poland DC et al.: Periodontitis as a possible early sign of diabetes mellitus. BMJ Open Diabetes Res Care 5: e000326, 2017.
3）Humphrey LL, Fu R, Buckley DI et al.: Periodontal disease and coronary heart disease incidence: A systematic review and meta-analysis. J Gen Intern Med 23: 2079-2086, 2008.
4）Beck J, Garcia R, Heiss G et al.: Periodontal disease and cardiovascular disease. J Periodontol 67: 1123-1137, 1996.
5）Iwasaki M, Taylor GW, Manz MC et al.: Serum antibody to *Porphyromonas gingivalis* in chronic kidney disease. J Dent Res 91: 828-833, 2012.
6）Iwasaki M, Taylor GW, Nesse W et al.: Periodontal disease and decreased kidney function in Japanese elderly. Am J Kidney Dis 59: 202-209, 2012.
7）Reichert S, Schlitt A, Beschow V et al.: Use of floss/interdental brushes is associated with lower risk for new cardiovascular events among patients with coronary heart disease. J Periodontal Res 50: 180-188, 2015.
8）Kim YH, Kim DH, Lim KS et al.: Oral health behaviors and metabolic syndrome: the 2008-2010 Korean National Health and Nutrition Examination Survey. Clin Oral Investig 18: 1517-1524, 2014.
9）佐々木　健：対象者の主体性を引き出す歯科保健プログラムの効果 「標準的な成人歯科健診プログラム・保健指導マニュアル」を適用した成人歯科保健事業の展開例．ヘルスサイエンス・ヘルスケア 10：63-69，2010.
10）佐々木　健，高橋　収，三上和恵ほか：職域における新しい成人歯科健診プログラムの効果．ヘルスサイエンス・ヘルスケア 11：64-71，2011.
11）佐々木　健：新しい成人歯科健診プログラムの活用事例と歯科保健指導の課題．日健教会誌 21：77-83，2013.
12）岩本　彩，石川裕子，八木　稔ほか：リスク発見・保健指導重視型の成人歯科健診プログラムにおける口腔保健行動の変化．口腔衛生会誌 62：33-40，2012.
13）葭原明弘，八木　稔，澤村恵美子ほか：個別保健指導及びパンフレット郵送の成人歯科保健に対する有効性　成人女性を対象として．口腔衛生会誌 49：809-815，1999.
14）晴佐久　悟，筒井昭仁，境　憲治ほか：職域における口腔健康教育の効果及び歯科保健意識と行動変容因子との関連性の検討．口腔衛生会誌 54：122-131，2004.
15）森　智恵子：職域における定期歯科健診と事後措置に関する評価．口病誌 69：162-170，2002.
16）尾崎哲則，小山圭子，三澤麻衣子ほか：成人集団における定期的歯科保健指導と口腔保健状況　3年間の口腔保健行動の変容と口腔保健状況の差異．日歯医療管理誌 49：145-148，2014.
17）晴佐久　悟，山本未陶，三島公彦ほか：歯周病予防のための健康教育は生活習慣病の予防能力に影響するか？口腔衛生会誌 64：382-391，2014.
18）山本未陶，今里憲弘，筒井昭仁ほか：自己管理スキルを応用したブラッシング行動スキル尺度の開発．口腔衛生会誌 59：51-57，2009.
19）Prochaska JO, Velicer WF: The transtheoretical model of health behavior change. Am J Health Promot 12: 38-48, 1997.
20）影山　淳，小田切圭一，鈴木直子ほか：職域における集団健康教育の教育効果および行動変容につながる教育方法の検討．産業衛誌 56：141-151，2014.
21）葭原明弘，金子　昇，杉本智子ほか：乳幼児健診に併設し実施する簡易スクリーニング検査および個別指導が行動変容に及ぼす影響．口腔衛生会誌 60：11-16，2010.
22）深井穫博，眞木吉信，吉野浩一ほか：成人の口腔保健行動におよぼす年齢および職域特性．口腔衛生会誌 45：522-523，1995.
23）深井穫博，眞木吉信，高江洲義矩：成人の口腔保健行動と職種との関連．口腔衛生会誌 47：89-97，1997.

著者への連絡先：金子　昇　〒951-8514　新潟市中央区学校町通2-5274　新潟大学大学院医歯学総合研究科予防歯科学分野
TEL：025-227-2858　FAX：025-227-0807
E-mail：nkaneko@dent.niigata-u.ac.jp

Changes in Health-promoting Behavior Due to Dental Examination and Individualized Health Instruction in Workplace

Noboru KANEKO[1)], Akihiro YOSHIHARA[2)], Kaname NOHNO[1)], Takayuki YAMAGA[1)], Takashi ZAITSU[3)], Yoko KAWAGUCHI[3)] and Hideo MIYAZAKI[1,4)]

[1)]Division of Preventive Dentistry, Niigata University Graduate School of Medical and Dental Sciences
[2)]Division of Oral Science for Health Promotion, Niigata University Graduate School of Medical and Dental Sciences
[3)]Department of Oral Health Promotion, Graduate School of Medical and Dental Sciences, Tokyo Medical and Dental University
[4)]Department of Dental Hygiene and Welfare, Meirin College

Abstract: For oral health in the workplace, dental examinations for the early detection of oral diseases have been mainly conducted. In order to shift from conventional dental examination programs to those for investigating environmental risks and promoting behavioral changes, the Japan Dental Association developed a new oral health examination, assessment, and health instruction program for adults.

The aim of this study was to evaluate how dental examination and health instruction based on this program improved health-promoting behavior compared with the traditional dental examination program.

Subjects were recruited from employees of three companies in Niigata City (n=129; 44.6±11.5 years old). They were randomly divided into an intervention group and a control group. For the intervention group, dental examination and health instruction, based on the program newly developed by the Japan Dental Association, were conducted, whereas only a dental examination was conducted for the control group. Questionnaire surveys were performed at the baseline and 3 months, 6 months, and 1 year later to evaluate behavioral changes.

As a result, "tooth brushing at the workplace and outside home", "use of fluoride-containing dentifrice", and "use of interdental brush or dental floss" were significantly improved in both groups. In the intervention group, changes were noted at all time points until 1 year later, but changes were limited and only seen at some time-points in the control group.

This study revealed that the conventional dental examination program only marginally improves health behavior, but the new dental examination and health instruction program more markedly improves such behavior and its effects persist for at least 1 year.

J Dent Hlth 69: 27-33, 2019

Key words: **Oral health in adults, Health instruction, Behavioral change**

Reprint requests *to* N. KANEKO, Division of Preventive Dentistry, Niigata University Graduate School of Medical and Dental Sciences, 2-5274 Gakkocho-Dori, Chuo-Ku, Niigata, 951-8514, Japan
TEL: 025-227-2858/FAX: 025-227-0807/E-mail: nkaneko@dent.niigata-u.ac.jp

Original Article | Int J Clin Prev Dent 2018;14(4):256-263 · https://doi.org/10.15236/ijcpd.2018.14.4.256
ISSN (Print) 1738-8546 · ISSN (Online) 2287-6197

Masticatory Performance Measured with a Chewing Gum Containing Spherical Resinous Microparticles

Toshiya Kanazawa, Takashi Zaitsu, Masayuki Ueno, Yoko Kawaguchi

Department of Oral Health Promotion, Tokyo Medical and Dental University, Tokyo, Japan

Objective: This study aimed to investigate the factors associated with masticatory performance, as measured with a chewing gum containing spherical resinous microparticles, and to evaluate the method by examining the relationship with self-reported masticatory status.
Methods: The participants in this study comprised 903 industrial workers (mean age, 42.2±11.6 years). A questionnaire was administered to assess self-reported masticatory status. The masticatory performance score was calculated by counting the number of particles in the chewing gum. Clinical oral examinations were administered. Multiple linear regression analysis was conducted on the masticatory performance scores to examine the related factors. Analysis of covariance was conducted to investigate the association between the masticatory performance score and the self-reported masticatory status.
Results: Significant predictors of the masticatory performance score were sex ($p < 0.001$), age ($p < 0.001$), decayed teeth ($p=0.009$), total-functional tooth units ($p < 0.001$), periodontitis ($p=0.003$), and malocclusion ($p=0.011$). The relationship between the masticatory performance score and the self-reported masticatory status was attenuated after controlling for confounding factors.
Conclusion: The masticatory performance increased with age and decreased as the oral health status worsened. Using this chewing gum method partly, but not comprehensively, reflects masticatory performance. Therefore, various masticatory performance-related indexes should be employed to measure masticatory performance accurately.

Keywords: masticatory performance, measurement, oral health status, self-reported masticatory status, chewing gum

Introduction

Mastication is the first step in a series of physiological food digestion processes which include cutting the food, mixing it with saliva, and preparing the food bolus for swallowing. This process is complex, and stomatognathic organs and structures, such as teeth, periodontal tissue, tongue, maxillofacial muscle, gnathic bone, and nervous system work in concert.

The main role of mastication is to reduce the particle of ingested food and to support digestion, absorption, and nutrition intake [1]. Furthermore, mastication prevents overeating by stimulating the satiety center of the brain [2]. Previous studies report that the proportion of metabolic syndrome [3] or diabetes [4] or hypertension [5] was higher in individuals with poor mastication than in healthy individuals. Another study demonstrated that good masticatory performance decreased stress [6].

Corresponding author **Takashi Zaitsu**
Department of Oral Health Promotion, Tokyo Medical and Dental University, 1-5-45 Yushima, Bunkyo-ku, Tokyo 113-8549, Japan. Tel: +81-3-5803-5476, Fax: +81-3-5803-0194, E-mail: zaitsu.ohp@tmd.ac.jp
https://orcid.org/0000-0001-5786-4879

Received October 22, 2018, Accepted November 2, 2018

Mastication affects physical health and mental health; therefore, it is important to maintain and to improve masticatory performance for a lifetime.

As a method to subjectively assess masticatory performance, self-reported questionnaires have been employed to inquire about masticable food [7,8] or masticatory status [9]. However, a sieving method that measures the percentage or distribution of masticated particles of peanuts or silicon tablets [10-19] and a mixing test that evaluates color change or the amount of dissolved glucose from a chewing gum or gummy jelly [3,4,6,11,20-25] have been used to estimate masticatory performance objectively. The sieving method and mixing test have been applied to estimate the improvement in mastication after prosthetic treatment [16], periodontitis treatment [17], or malocclusion treatment [10].

However, the aforementioned methods evaluate only a portion of mastication rather than the whole masticatory performance [26,27]. Thus, it is preferable to use a technique or a method that can more comprehensively estimate masticatory performance.

A chewing gum containing spherical resinous microparticles has been developed to measure masticatory performance. By calculating the proportion of broken particles in the chewing gum after mastication, masticatory performance can be measured. Very few studies have examined masticatory performance by using this chewing gum; therefore, the applicability of the gum has not been fully assessed. Therefore, the current study aimed to investigate the factors associated with masticatory performance, as measured with the chewing gum, and to evaluate the method by examining the relationship between masticatory performance and self-reported masticatory status.

Materials and Methods

1. Study participants

The study participants were industrial workers from 10 companies in Japan. Among 948 participants (741 men and 207 women) who participated in the study, 903 (709 men and 194 women) were used in the final analysis, after excluding edentate participants and workers with missing information about study variables. A self-administered questionnaire, masticatory performance measurement, and clinical oral examinations were conducted from 2015 to 2016.

All participants agreed to participate in the study and signed an informed consent form after the research investigators explained the study procedure. This study protocol was approved by the Ethical Review Board of Tokyo Medical and Dental University (N0.D2014-139-01).

2. Questionnaire

A self-administered questionnaire asked the participants about sex, age, and masticatory status. The self-reported masticatory status was assessed by using the question “Can you bite tightly with your back teeth or dentures?”, and the participants responded with one of the following three answers: “I can bite on both sides” (good mastication), “I can bite on only one side” (fair mastication), and “I can’t bite on either side” (poor mastication).

3. Objective masticatory performance

The masticatory performance was evaluated using 1.0 g of chewing gum measuring 20.0×12.0×5.0 mm (Welcome Gum; Examastica Co., Tokyo, Japan). The gum contains 2,159±28 spherical carnauba wax microparticles of 250-300 μm in diameter.

The participants were instructed to freely chew the gum 25 times in 25 seconds. The particles in the chewing gum were crushed into small pieces when pressed under a weight of >50 g. After chewing, the gum was stretched by a specific compressor and the number of remaining particles in an arbitrary area was counted with dedicated software (Examastica Co.). The number of remaining particles in the whole gum was estimated by the proportion of the area counted to the whole area. A masticatory performance score, based on the proportion of broken particles induced by one-time chewing, was calculated by comparing the number of particles before and after chewing 25 times.

The algorithm for the masticatory performance score calculation was as follows. The number of broken particles after one-time chewing is exponential; therefore, the proportion of remaining particles after chewing 25 times, p (%), is presented as $(1-p/100)^{25}$. Assuming K is the mean number of particles in a counted area before chewing, and X is the mean number of remaining particles in the counted area after chewing 25 times, then X/K is $(1-p/100)^{25}$, and p is $[1-(X/K)^{1/25}]\times100$.

4. Oral examination

Clinical oral examinations were conducted by six dentists, who were calibrated regarding the examination criteria before the study. The dentition status, excluding the third molars, was determined using a dental mirror and a World Health Organization-type periodontal probe under an artificial light. Functional tooth units (FTUs) were calculated as an indicator of the posterior occlusal condition.

The FTUs were defined as the number of pairs of opposing premolars and molars. Two opposing premolars were defined

as one FTU and two opposing molars as two FTUs. Therefore, FTUs ranged from 0 to 12.

In this study, three types of FTUs were computed. Natural FTUs (n-FTUs) were calculated only from natural teeth and included sound, restored, and carious teeth with occluding function. FTUs consisting of natural teeth, implanted teeth, and fixed prosthetic pontics were called nif-FTUs. Total-FTUs comprised natural teeth, implanted teeth, fixed prosthetic pontics, and removable prosthetic teeth.

Periodontal status was assessed with the modified Community Periodontal Index (CPI). Six index teeth (17 or 16, 11, 26 or 27, 36 or 37, 31, and 46 or 47) were examined by using the following codes: Code 0, periodontal pocket depth <4 mm; Code 1, periodontal pocket depth of 4-5 mm; and Code 2, periodontal pocket depth ≥6 mm. The highest CPI code among the six index teeth was recorded as the representative value. Individuals with CPI code 0 were classified as having no periodontitis and individuals with CPI code 1 or 2, as having periodontitis.

Malocclusion and temporomandibular disorders (TMDs) were assessed by visual and palpatory examinations. Malocclusion or TMDs was present if the dentist indicated the necessity for a detailed examination or treatment.

5. Statistical analysis

Descriptive statistics of age and clinical oral health status were computed, based on sex and the self-reported masticatory status. The mean difference by age or self-reported masticatory status was analyzed using the independent t-test, and distributional differences were analyzed using the chi-square test. One-way analysis of variance and the Jonkheere-Terpstra trend test were used to analyze the association between the masticatory performance score and the self-reported masticatory status. The relationship of the masticatory performance score with age and with clinical oral health status were analyzed using Pearson's correlation coefficient and the independent t-test.

Multiple linear regression analysis was conducted on the masticatory performance scores to examine the scores' relationship with sex, age, and clinical oral health status. After controlling for confounding variables, an analysis of covariance was employed to investigate the association between the masticatory performance score and self-reported masticatory status.

PASW Statistics ver. 18.0 (IBM Japan, Tokyo, Japan) was used for all statistical analyses. The significance level was set at 5%.

Results

1. Characteristics of the study participants

Table 1 shows participants' age and the clinical oral health status by sex. The mean ages were 42.9±11.7 years in men and 39.8±10.9 years in women. The mean age was significantly higher in men than in women ($p<0.001$).

The mean number of teeth was 26.7±2.7 teeth in men and 27.0±2.1 teeth in women. There was no significant difference

Table 1. Characteristics of the study participants

Characteristic	Total (n=903)	Men (n=709)	Women (n=194)	p-value
Age (yr)	42.2±11.6	42.9±11.7	39.8±10.9	<0.001
No. of teeth	26.7±2.6	26.7±2.7	27.0±2.1	0.065
DT	0.7±1.7	0.8±1.8	0.4±1.3	0.004
n-FTUs	10.5±2.6	10.4±2.6	10.8±2.3	0.033
nif-FTUs	10.9±2.3	10.8±2.4	11.2±1.6	0.003
Total-FTUs	11.0±2.0	10.9±2.1	11.2±1.6	0.030
Periodontitis				
(+)	113 (12.5)	100 (14.1)	13 (6.7)	0.005
(−)	790 (87.5)	609 (85.9)	181 (93.3)	
Malocclusion				
(+)	75 (8.3)	56 (7.9)	19 (9.8)	0.382
(−)	828 (91.7)	653 (92.1)	175 (90.2)	
TMDs				
(+)	18 (2.0)	11 (1.6)	7 (3.6)	0.082
(−)	885 (98.0)	698 (98.4)	187 (96.4)	

Values are presented as mean±standard deviation or number (%). DT: decayed teeth, n-FTUs: natural teeth functional tooth units, nif-FTUs: natural, implanted and fixed prosthetic pontic teeth functional tooth units, Total-FTUs: total teeth functional tooth units, TMDs: temporomandibular disorders.

in the mean number of teeth between men and women. The mean number of decayed teeth (DT) was 0.8±1.8 teeth in men and 0.4±1.3 teeth in women, and significantly higher in men than in women (p=0.004).

The mean number of n-FTUs, nif-FTUs, and total-FTUs was 10.4±2.6, 10.8±2.4, and 10.9±2.1, respectively, in men and 10.8±2.3, 11.2±1.6, and 11.2±1.6, respectively, in women. For each type of FTUs, women had significantly higher numbers than men (n-FTUs, p=0.033; nif-FTUs, p=0.003; and total-FTUs, p=0.030).

The proportion of individuals with periodontitis were 14.1% in men and 6.7% in women; the proportion was significantly higher in men than in women (p=0.005). The overall proportion of participants with malocclusion and TMDs was 8.3% and 2.0%, respectively, and there were no significant distributional differences by sex.

2. Self-reported masticatory status and related factors

Table 2 shows the relationship of the self-reported masticatory status with age and with clinical oral health status by sex. The mean ages of participants with 'good', 'fair', and 'poor' self-reported masticatory status were 41.6±11.5 years, 45.3± 11.5 years, and 46.3±11.7 years, respectively. The mean age of participants with a good self-reported masticatory status was significantly lower than that of participants with a self-reported masticatory status of fair (p=0.010) or poor (p=0.049).

The mean number of teeth in participants with good, fair, and poor self-reported masticatory statuses was 27.0± 2.3 teeth, 25.6±3.1 teeth, and 24.0±4.0 teeth, respectively. The mean number of teeth was significantly higher in participants with a self-reported masticatory status of good than in participants with a self-reported masticatory status of fair (p<0.001) or poor (p<0.001). The mean number of DT in participants with good, fair, and poor self-reported masticatory statuses were 0.6±1.4 teeth, 1.3±2.3 teeth, and 2.2±3.0 teeth, respectively. The mean number of DT was significantly lower in participants with a self-reported masticatory status of good than in participants with a self-reported masticatory status of fair (p<0.001) or poor (p<0.001).

All FTUs showed a similar trend in that the mean number of FTUs was significantly higher in participants with a good self-reported masticatory status (n-FTUs, 10.9±2.2; nif-FTUs, 11.2±1.8; and total-FTUs, 11.3±1.5) than in patients with a fair self-reported masticatory status (n-FTUs, 8.7±3.3; nif-FTUs, 9.2±3.1; and total-FTUs, 9.5±2.9; p<0.001, p<0.001, and p<0.001, respectively) or a poor self-reported masticatory status (n-FTUs, 7.5±3.8; nif-FTUs, 7.8±3.9; and total-FTUs, 7.9±3.9; p<0.001, p<0.001, and p<0.001, respectively).

Table 2. Self-reported masticatory status and related factors

Variable	Total				Men				Women			
	Self-reported masticatory performance			p-value	Self-reported masticatory performance			p-value	Self-reported masticatory performance			p-value
	Good (n=767)	Fair (n=99)	Poor (n=37)		Good (n=595)	Fair (n=86)	Poor (n=28)		Good (n=172)	Fair (n=13)	Poor (n=9)	
Age (yr)	41.6±11.5	45.3±11.5	46.3±11.7	0.001	42.2±11.6	45.5±11.7	49.6±10.0	<0.001	39.7±10.9	43.4±10.3	36.0±11.0	0.286
No. of teeth	27.0±2.3	25.6±3.1	24.0±4.0	<0.001	27.0±2.3	25.5±3.2	23.0±4.0	<0.001	27.0±2.1	26.5±1.6	27.0±1.6	0.635
DT	0.6±1.4	1.3±2.3	2.2±3.0	<0.001	0.6±1.5	1.3±2.5	2.5±3.3	<0.001	0.4±1.3	0.7±1.2	1.2±1.6	0.137
n-FTUs	10.9±2.2	8.7±3.3	7.5±3.8	<0.001	10.9±2.2	8.6±3.3	6.6±3.8	<0.001	10.9±2.3	9.6±2.7	10.4±2.1	0.122
nif-FTUs	11.2±1.8	9.2±3.1	7.8±3.9	<0.001	11.2±1.8	9.0±3.2	7.0±4.0	<0.001	11.3±1.5	10.4±2.1	10.4±2.1	0.046
Total-FTUs	11.3±1.5	9.5±2.9	7.9±3.9	<0.001	11.3±1.5	9.3±3.0	7.0±4.0	<0.001	11.3±1.5	10.6±1.9	10.4±2.1	0.098
Periodontitis (+)	83 (10.8)	20 (20.2)	10 (27.0)	<0.001	73 (12.3)	18 (20.9)	9 (32.1)	0.002	10 (5.8)	2 (15.4)	1 (11.1)	0.356
Malocclusion (+)	62 (8.1)	9 (9.1)	4 (10.8)	0.805	49 (8.2)	6 (7.0)	1 (3.6)	0.633	13 (7.6)	3 (23.1)	3 (33.3)	0.010
TMDs (+)	16 (2.1)	1 (1.0)	1 (2.7)	0.734	10 (1.7)	0 (0)	1 (3.6)	0.338	6 (3.5)	1 (7.7)	0 (0)	0.616

Values are presented as mean±standard deviation or number (%). DT: decayed teeth, n-FTUs: natural teeth functional tooth units, nif-FTUs: natural, implanted and fixed prosthetic pontic teeth functional tooth units, Total-FTUs: total teeth functional tooth units, TMDs: temporomandibular disorder.

The proportion of participants with periodontitis who reported good, fair, and poor masticatory status was 10.8%, 20.2%, and 27.0%, respectively. The proportion of periodontitis was significantly lower in participants reporting a good masticatory status than in participants reporting a poor masticatory status ($p<0.001$). There were no significant distributional differences in malocclusion and TMDs, based on the self-reported masticatory status. Similar results regarding the association of self-reported masticatory status with age and clinical oral health status were also observed in men.

3. Masticatory performance score, based on the self-reported masticatory status

Table 3 presents the mean masticatory performance scores, based on self-reported masticatory status. The overall mean masticatory performance scores in participants reporting good, fair and poor masticatory statuses were 1.38±0.47, 1.30±0.53, and 1.10±0.42, respectively. The masticatory performance scores showed a significant positive linear trend with the self-reported masticatory status ($p=0.002$). A similar significant positive linear trend was also found in men ($p=0.003$).

4. Masticatory performance score and related factors

Table 4 presents the relationship of masticatory performance score with age and clinical oral health status. Overall, the masticatory performance score had a significant positive correlation with age ($r=0.184$, $p<0.001$), number of teeth ($r=0.100$, $p=0.003$), n-FTUs ($r=0.122$, $p<0.001$), nif-FTUs ($r=0.156$, $p<0.001$), and total-FTUs ($r=0.144$, $p<0.001$). There was a significant negative correlation between the masticatory performance score and DT ($r=-0.138$, $p<0.001$).

The masticatory performance score was significantly lower in participants with malocclusion (1.22±0.37) than in participants without malocclusion (1.37±0.49; $p=0.002$). There were no significant relationship of the masticatory performance score with periodontitis or with TMDs. Similar results regarding the association of the masticatory performance score with age and clinical oral health status were also obtained in men.

Table 3. Masticatory performance score, based on the self-reported masticatory status

Variable	Total (n=903)		Men (n=709)		Women (n=194)	
	Mean±SD	p for trend	Mean±SD	p for trend	Mean±SD	p for trend
Good	1.38±0.47	0.002	1.41±0.48	0.003	1.25±0.43	0.312
Fair	1.30±0.53		1.32±0.55		1.17±0.39	
Poor	1.10±0.42		1.12±0.45		1.06±0.33	

SD: standard deviation.

Table 4. Masticatory performance score and related factors

Variable	Total (n=903)	p-value	Men (n=709)	p-value	Women (n=194)	p-value
Age (r)	0.184	<0.001	0.175	<0.001	0.155	0.031
No. of teeth (r)	0.100	0.003	0.119	0.001	0.046	0.525
DT (r)	−0.138	<0.001	−0.159	<0.001	−0.106	0.140
n-FTUs (r)	0.122	<0.001	0.141	<0.001	0.087	0.226
nif-FTUs (r)	0.156	<0.001	0.184	<0.001	0.082	0.255
Total-FTUs (r)	0.144	<0.001	0.169	<0.001	0.074	0.308
Periodontitis (mean±SD)						
(+)	1.28±0.46	0.058	1.28±0.47	0.018	1.23±0.37	0.954
(−)	1.37±0.48		1.41±0.49		1.24±0.43	
Malocclusion (mean±SD)						
(+)	1.22±0.37	0.002	1.21±0.38	<0.001	1.24±0.32	0.945
(−)	1.37±0.49		1.41±0.49		1.24±0.44	
TMDs (mean±SD)						
(+)	1.39±0.45	0.762	1.40±0.50	0.928	1.37±0.40	0.392
(−)	1.36±0.48		1.39±0.49		1.23±0.43	

r: correlation coefficient, DT: decayed teeth, n-FTUs: natural teeth functional tooth units, nif-FTUs: natural, implanted and fixed prosthetic pontic teeth functional tooth units, Total-FTUs: total teeth functional tooth units, SD: standard deviation, TMDs: temporomandibular disorder.

Table 5. Predictors of the masticatory performance score

Variable	B	SE	p-value
Sex	−0.155	0.037	<0.001
Age	0.010	0.001	<0.001
DT	−0.025	0.010	0.009
Total-FTUs	0.045	0.008	<0.001
Periodontitis	−0.140	0.047	0.003
Malocclusion	−0.139	0.055	0.011
TMDs	0.101	0.108	0.350

Multiple R=0.340, adjusted R^2=0.109. SE: standard error of the mean, DT: decayed teeth, Total-FTUs: total teeth functional tooth units, TMDs: temporomandibular disorder.

5. Predictors of the masticatory performance score

There were multicollinearities among the number of teeth, n-FTUs, nif-FTUs, and total-FTUs. Therefore, in a multiple linear regression on the masticatory performance scores, the total-FTUs was chosen as an independent variable, as well as sex, age, DT, periodontitis, malocclusion, and TMDs.

Table 5 presents the results of the analysis, which showed that sex (B=−0.155, p<0.001), age (B=0.010, p<0.001), DT (B=−0.025, p=0.009), total-FTUs (B=0.045, p<0.001), periodontitis (B=−0.140, p=0.003), and malocclusion (B=−0.139, p=0.011) were significant predictors of the masticatory performance score. However, TMDs was not a significant contributor of the masticatory performance score.

6. Adjusted masticatory performance score, based on the self-reported masticatory status

Table 6 shows the relationship between the adjusted mean masticatory performance scores and the self-reported masticatory status. The scores were adjusted for sex, age, DT, total-FTUs, periodontitis, and malocclusion, all of which were significant predictors of the masticatory performance score, based on the multiple linear regression. The adjusted mean masticatory performance scores for the good, fair, and poor self-reported masticatory statuses were 1.37±0.02, 1.35±0.05, and 1.26±0.08, respectively. There was no significant linear relationship between the adjusted masticatory performance scores and the self-reported masticatory status.

Table 6. Adjusted masticatory performance score, based on the self-reported masticatory status

Variable	Mean±SE	p for trend
Good	1.37±0.02	0.182
Fair	1.35±0.05	
Poor	1.26±0.08	

Adjusted for sex, age, decayed teeth, total teeth functional tooth units, periodontitis, malocclusion. SE: standard error of the mean.

Discussion

This study evaluated a chewing gum containing spherical resinous microparticles for measuring masticatory performance among Japanese industrial workers. The masticatory performance was measured by calculating the number of particles in the chewing gum. The diameter of the particles was determined to assume that teeth move approximately 100 mm during mastication.

Since an existing material used in the sieving test is an ordinary food, its quality is not uniform in case of using natural food [27]. It is also possible that a one-time measurement is of low quality; however, acquiring several measurements takes a long time [19]. The mixing test is affected by mastication and by saliva flow [20]. However, the current gum-based material is homogeneous and is not influenced by saliva. Chewing a gum is not a special activity for most people; therefore, they could produce the performance measurement with little consciousness of mastication [24]. Thus, it is possible to use the method to estimate the masticatory performance in a standardized condition and in a state that is close to natural mastication.

The masticatory performance using the current gum was associated with the clinical oral health status such as the number of teeth, DT, FTUs, periodontitis, and malocclusion. Many studies have demonstrated a positive association between masticatory performance and the number of teeth and occlusal units such as FTUs [12,13,21,22]. These results suggest that the number of teeth and the functional occlusal support of teeth are fundamental elements in mastication.

The number of DT negatively affected masticatory performance. A broken occlusal surface due to dental caries and pain-contingent with dental caries may prevent normal mastication. One study using a carrot or gummy jelly as the sieve food also reported that masticatory function decreased if an individual had dental caries [11]. The authors of that study conjectured that the participant may have reflexively avoided the pain that arose from dental caries.

A reason for the relationship between periodontitis and masticatory performance could be tooth mobility caused by advanced periodontitis. It has been reported that the occlusal force and occlusal surface area in patients with periodontitis are smaller than those of healthy individuals [28]. The decrease in occlusal force and surface area may deteriorate masticatory performance.

The masticatory performance of the participants with maloc-

clusion was poorer than that of healthy individuals. Malocclusion could aggravate the occlusal condition and reduce the occlusal surface area. One study using a silicon tablet as the sieve material showed that the masticatory performance of individuals with malocclusion was lower than that of healthy individuals because of the reduction of the occlusal surface area and alteration of jaw movement due to the malocclusion [18].

In the current study, masticatory performance increased with age, which could be related to a unique characteristic of the currently used chewing gum. The diameter of the particles in the chewing gum is very small so that a tooth with a flat occlusal surface is more favorable in crushing the particles, compared with a pointed occlusal surface. The proportion or area of a worn occlusal surface of the teeth increases with age because of the progression of abrasion and attrition [29]. The occlusal contact surface area increases accordingly [30,31]. Therefore, particles in the chewing gum were more likely to be crushed by a flat occlusal surface, and the masticatory performance consequently increased with age.

In this study, the question "Can you bite tightly with your back teeth or dentures?" was used to represent the self-reported masticatory status. The validity of this question has been demonstrated, and the response to the question was strongly associated with Yamamoto's chewing test results and with the clinical oral health conditions. Participants reporting a good masticatory status could chew all 15 test foods and had a higher number of present teeth, molars, and FTUs [7].

The validity of the self-reported masticatory status was reconfirmed in this study. The self-reported masticatory status worsened as the number of teeth or three types of FTUs decreased and as the number of DT increased. A similar trend was also observed for the periodontal condition. As the self-reported masticatory status worsened, the proportion of participants with periodontitis increased.

The relationship between masticatory performance and self-reported masticatory status, as indicated with bivariate analysis, disappeared after adjusting for confounding factors. This finding suggested that, as with other existing methods, the masticatory performance measured with the chewing gum reflected only a portion of the masticatory performance. Other factors had a substantial effect on masticatory performance.

There were several limitations to this study. This study was conducted as a part of a regular health check-up at each company site; thus, the content of the oral examinations was limited. Other mastication-related information such as occlusal contact area, occlusal force, jaw movement, and mastication pattern were therefore not collected. Furthermore, current industrial workers were not necessarily the representative of the general adult. However, the oral health status of the participants, whose mean age was approximately 43 years, was similar to that of 40- to 44-year-old individuals in the national oral health survey in Japan [32].

Conclusion

A gum containing microparticles for measuring masticatory performance was evaluated. The measurements revealed that the masticatory performance increased with age and decreased as the oral health status worsened. The association between masticatory performance and the self-reported masticatory status was attenuated after controlling for confounding factors. These results indicated that, as with other existing methods, the measurement method using this gum can partly, but not comprehensively, reflect masticatory performance. Therefore, to measure the masticatory performance accurately, various mastication-related indexes and chewing gum should be employed simultaneously.

Acknowledgements

This study was partly supported by the "Research Fund of Clinical Study for Industrial Accident and Disease" by Ministry of Health, Labor and Welfare, Japan (14020101-01, 170501-01).

References

1. Hollis JH. The effect of mastication on food intake, satiety and body weight. Physiol Behav 2018;193:242-5.
2. Miquel-Kergoat S, Azais-Braesco V, Burton-Freeman B, Hetherington MM. Effects of chewing on appetite, food intake and gut hormones: a systematic review and meta-analysis. Physiol Behav 2015;151:88-96.
3. Kikui M, Ono T, Kokubo Y, Kida M, Kosaka T, Yamamoto M, et al. Relationship between metabolic syndrome and objective masticatory performance in a Japanese general population: the Suita study. J Dent 2017;56:53-7.
4. Yamazaki T, Yamori M, Asai K, Nakano-Araki I, Yamaguchi A, Takahashi K, et al. Mastication and risk for diabetes in a Japanese population: a cross-sectional study. PLoS One 2013;8:e64113.
5. Heo SY, Lee EH. The correlation among systemic health, hypertension and oral health of Korean adults. Int J Clin Prev Dent 2018;14:112-8.
6. Nishigawa K, Suzuki Y, Matsuka Y. Masticatory performance alters stress relief effect of gum chewing. J Prosthodont Res 2015;59:262-7.
7. Ueno M, Yanagisawa T, Shinada K, Ohara S, Kawaguchi Y. Masticatory ability and functional tooth units in Japanese adults. J Oral Rehabil 2008;35:337-44.
8. Ueno M, Yanagisawa T, Shinada K, Ohara S, Kawaguchi Y. Category of functional tooth units in relation to the number of

teeth and masticatory ability in Japanese adults. Clin Oral Investig 2010;14:113-9.
9. Ueno M, Shimazu T, Sawada N, Tsugane S, Kawaguchi Y. Validity of self-reported tooth counts and masticatory status study of a Japanese adult population. J Oral Rehabil 2018;45: 393-8.
10. Abrahamsson C, Henrikson T, Bondemark L, Ekberg E. Masticatory function in patients with dentofacial deformities before and after orthognathic treatment: a prospective, longitudinal, and controlled study. Eur J Orthod 2015;37:67-72.
11. Decerle N, Nicolas E, Hennequin M. Chewing deficiencies in adults with multiple untreated carious lesions. Caries Res 2013; 47:330-7.
12. Fontijn-Tekamp FA, van der Bilt A, Abbink JH, Bosman F. Swallowing threshold and masticatory performance in dentate adults. Physiol Behav 2004;83:431-6.
13. Hatch JP, Shinkai RS, Sakai S, Rugh JD, Paunovich ED. Determinants of masticatory performance in dentate adults. Arch Oral Biol 2001;46:641-8.
14. Laird MF, Vogel ER, Pontzer H. Chewing efficiency and occlusal functional morphology in modern humans. J Hum Evol 2016;93:1-11.
15. Lepley C, Throckmorton G, Parker S, Buschang PH. Masticatory performance and chewing cycle kinematics-are they related? Angle Orthod 2010;80:295-301.
16. Omo JO, Sede MA, Esan TA. Masticatory efficiency of shortened dental arch subjects with removable partial denture: a comparative study. Niger J Clin Pract 2017;20:459-63.
17. Pereira LJ, Gazolla CM, Magalhães IB, Dominguete MH, Vilela GR, Castelo PM, et al. Influence of periodontal treatment on objective measurement of masticatory performance. J Oral Sci 2012;54:151-7.
18. Rios-Vera V, Sánchez-Ayala A, Senna PM, Watanabe-Kanno G, Cury AA, Garcia RC. Relationship among malocclusion, number of occlusal pairs and mastication. Braz Oral Res 2010;24: 419-24.
19. van der Bilt A, Fontijn-Tekamp FA. Comparison of single and multiple sieve methods for the determination of masticatory performance. Arch Oral Biol 2004;49:193-8.
20. Anastassiadou V, Heath MR. The development of a simple objective test of mastication suitable for older people, using chewing gums. Gerodontology 2001;18:79-86.
21. Ikebe K, Matsuda K, Kagawa R, Enoki K, Okada T, Yoshida M, et al. Masticatory performance in older subjects with varying degrees of tooth loss. J Dent 2012;40:71-6.
22. Ikebe K, Matsuda K, Kagawa R, Enoki K, Yoshida M, Maeda Y, et al. Association of masticatory performance with age, gender, number of teeth, occlusal force and salivary flow in Japanese older adults: is ageing a risk factor for masticatory dysfunction? Arch Oral Biol 2011;56:991-6.
23. Kosaka T, Ono T, Kida M, Kikui M, Yamamoto M, Yasui S, et al. A multifactorial model of masticatory performance: the Suita study. J Oral Rehabil 2016;43:340-7.
24. Schimmel M, Christou P, Miyazaki H, Halazonetis D, Herrmann FR, Müller F. A novel colourimetric technique to assess chewing function using two-coloured specimens: validation and application. J Dent 2015;43:955-64.
25. Uesugi H, Shiga H. Relationship between masticatory performance using a gummy jelly and masticatory movement. J Prosthodont Res 2017;61:419-25.
26. Elgestad Stjernfeldt P, Wårdh I, Trulsson M, Faxén Irving G, Boström AM. Methods for objectively assessing clinical masticatory performance: protocol for a systematic review. Syst Rev 2017;6:20.
27. van der Bilt A. Assessment of mastication with implications for oral rehabilitation: a review. J Oral Rehabil 2011;38:754-80.
28. Alkan A, Keskiner I, Arici S, Sato S. The effect of periodontitis on biting abilities. J Periodontol 2006;77:1442-5.
29. Van't Spijker A, Rodriguez JM, Kreulen CM, Bronkhorst EM, Bartlett DW, Creugers NH. Prevalence of tooth wear in adults. Int J Prosthodont 2009;22:35-42.
30. Bourdiol P, Abou El Karam S, Martin JF, Nicolas E, Mioche L. Age and gender-related differences in premolar and molar functional areas. J Oral Rehabil 2007;34:251-8.
31. Kim SK, Kim KN, Chang IT, Heo SJ. A study of the effects of chewing patterns on occlusal wear. J Oral Rehabil 2001;28: 1048-55.
32. Japan Ministry of Health, Labour and Welfare. Report on the survey of dental diseases 2016 [Internet]. Tokyo: Ministry of Health, Labour and Welfare, Japan [cited 2018 Oct 19]. Available from: https://www.mhlw.go.jp/toukei/list/62-17.html.

ORIGINAL ARTICLE

OPEN

The Impact of Oral Health on Work Performance of Japanese Workers

Takashi Zaitsu, PhD, DDS, Tomoya Saito, DDS, Akiko Oshiro, PhD, DDS, Takeo Fujiwara, PhD, MPH, MD, and Yoko Kawaguchi, PhD, DDS

Objective: The aim of this study was to investigate the association between oral health and work performance measured as absenteeism and presenteeism. **Methods:** Study participants were employees (mean age: 42.7 ± 11.4 years) of 11 companies in Japan. Oral examination and self-administered questionnaires provided information on industrial category, work schedule, work performance (absenteeism and presenteeism), and smoking status. **Results:** The proportion of absenteeism (2.7%) or presenteeism (6.8%) of workers caused by oral health problems was low. Logistic regression analysis showed that the risk of absenteeism due to oral health problems was not significantly related to occupation or oral health status. However, the risk of presenteeism caused by oral health problems was 2.01 (95% confidence interval, 1.03 to 3.92) times higher among participants with periodontitis. **Conclusions:** Periodontal disease is associated with presenteeism of workers. It is considered that the periodontal disease countermeasure in the workplace should be provided.

Keywords: absenteeism, occupational health, oral health, presenteeism, work performance

BACKGROUND

Absenteeism and presenteeism have been used as indicators of poor individual work performance. Absenteeism is defined as absence from work attributed to disease or accident, whereas presenteeism is implied when workers are dysfunctional by health problems, but are physically present in the workplace.[1,2] Absenteeism and presenteeism are crucial measures for work productivity.[3]

There is much research reporting that health condition and stress of employees are associated with work performance.[4–7] Previous papers report that diseases such as rheumatoid arthritis,[8–11] diabetes,[12,13] and depression and anxiety[14,15] were associated with absenteeism and presenteeism among workers.

There are considerable studies which investigated the relationship between oral disease and work-related problems. They reported associations between temporomandibular joint-related pain and declining work performance,[16] and frequent bruxism and working stress.[17] Moreover, perceived poor oral health status was related to high levels of work-related stress.[18]

However, there are few studies which investigated the rates of absenteeism and presenteeism due to oral health problems and workplace performance.[19] Moreover, no studies have explored the relationship between dental caries, periodontal disease, and presence of natural teeth (the three most prevalent oral conditions) and work performance, especially in its manifestation in absenteeism and presenteeism among Japanese workers.

The purpose of this study was to explore the proportion of absenteeism and presenteeism caused by oral health problems of Japanese workers, and to investigate the relationship between oral health conditions such as dental caries, periodontal disease and number of natural teeth present, and work performance using absenteeism and presenteeism.

METHODS

Study Participants

Originally, we invited 2145 workers employed at 11 companies in Japan to take part in this study. Of these subjects, 1179 workers consented to participate in this research with completing a self-administered questionnaire and underwent oral examinations at their place of work. And the final sample used for the analysis consisted of 1167 workers (878 males, 289 females, aged 19 to 70 years, mean age 42.7 ± 11.4 years) who had provided complete data. The Research Ethics Committee of the Faculty of Dentistry, Tokyo Medical and Dental University (No. 1152) approved the study protocol.

Measurement

Each participant completed a self-administered questionnaire containing these items: absenteeism due to general and oral health problems was reported by the participants as (1) the number of days absent from work due to general health problems in the past year, and (2) the number of days absent from work due to oral health problems in the past year (a half day absence was recorded as 0.5 days). Presenteeism caused by oral health problems was addressed by the question, ‘‘have you had trouble working due to an oral health condition in the past year?’’

Participants’ ‘‘industry’’ was trichotomized by the Japan Standard Industrial Classification[20] as (1) education and learning support, (2) manufacturing, and (3) transport. We classified work schedules as (1) daytime work only, (2) nighttime work or mixed daytime and nighttime work, (3) flexible time work, and (4) others. Smoking status was classified as (1) current smoker, (2) past smoker, and (3) nonsmoker.

From the Department of Oral Health Promotion, Graduate School of Medical and Dental Sciences, Tokyo Medical and Dental University, Tokyo, Japan (Dr Zaitsu, Dr Saito, Dr Oshiro, Dr Fujiwara, and Dr Kawaguchi); and Department of Global Health Promotion, Graduate School of Medical and Dental Sciences, Tokyo Medical and Dental University, Tokyo, Japan (Dr Fujiwara).

Authors’ contributions: TZ conceived the study, participated in its design and coordination, collected data, performed statistical analysis, and wrote the manuscript draft. TS and AO participated in the study design and assisted in interpretation of the data. TF coordinated statistical analysis and revised the manuscript. YK contributed to the study protocol and data collection; coordinated the study implementation, statistical analysis, and interpretation of the results; and revised the manuscript. All authors read and approved the final manuscript.

Clinical significance: The proportion of workers’ absenteeism and presenteeism caused by oral health problems was 2.7% and 6.8%. Workers with periodontitis had significantly higher risk of absenteeism caused by oral health problems (OR:2.01) compared with healthy workers.

This study was partly supported by the ‘‘Research Fund of Clinical Study for Industrial Accident and Disease’’ by the Ministry of Health, Labor and Welfare, Japan (170501-01) and the Sciences Research Grant by Ministry of Health, Labor and Welfare, Japan (201315006B).

The authors report no conflicts of interest.

Address correspondence to: Takashi Zaitsu, PhD, DDS, Department of Oral Health Promotion, Graduate School of Medical and Dental Sciences, Tokyo Medical and Dental University, Tokyo, Japan (zaitsu.ohp@tmd.ac.jp).

DOI: 10.1097/JOM.0000000000001798

A World Health Organization (WHO) periodontal probe and a dental mirror were used to conduct the oral examinations with visual and tactile inspection to assess oral health condition (dental, periodontal, and oral hygiene status). Dental status was evaluated by the number of natural teeth present and decayed teeth (DT). Also, periodontal condition was evaluated using the Community Periodontal Index (CPI) periodontal pocket code.[21] The CPI divides the dentition into six sextants, and the individual's score was defined as the highest score of each sextant (code 0: healthy; code 1: 4 to 5 mm deep periodontal pocket depth; and code 2: 6 mm or deeper periodontal pocket depth). And participants with code X (missing index teeth) in all sextants were excluded in this study. Also, we evaluated oral hygiene status with the Simplified Debris Index (DI-S) of the Simplified Oral Hygiene Index (OHI-S).[22–24]

Analysis

We divided the participants into two groups based on the number of teeth present ($\leq$23 or $\geq$24), number of DT (0 or $\geq$1), and severity of periodontal condition (CPI code 0: healthy group or 1 to 2: periodontitis group).

Logistic regression analysis was conducted using absenteeism (0: none, 1: 1 day and more) and presenteeism (0: no, 1: yes) due to oral health problems as dependent variables, and age, sex, industrial category, work schedule, the number of teeth present, the number of DT, the CPI score, and DI-S as independent variables. SPSS 23.0 (IBM, Tokyo, Japan) was used for all statistical analyses, with the significance level set at $P < 0.05$.

RESULTS

Table 1 shows age, occupational parameters, smoking status, and oral health condition by sex. Males were older than females. There were more males in the transport industry than in the manufacturing industry and education/learning support industries. In work schedule differences, more males work at night than females. Also, smoking was more common among males than among females.

Males had significantly more DT than females, and males had poorer CPI scores than females. Moreover, DI-S was significantly worse among males. However, the number of teeth present did not differ significantly between males and females.

Table 2 shows the relationship between sex and work performance. The number of participants absent from work due to general health problems were 41.6%, with no significant difference between males (40.7%) and females (44.3%). The number of participants absent from work due to oral health problems was 2.7%, with no significant difference between males (2.4%) and females (3.5%). Moreover, the percentage of participants who practiced presenteeism due to oral disease was 6.8%, with no significant difference between males (6.7%) and females (6.9%).

Table 3 shows the relationship between work performance due to oral health problems and oral health status. There was no significant association between the number of teeth present, DT, and DI-S and absenteeism or presenteeism due to oral health problems. However, periodontal disease was associated with presenteeism due to oral health problems, though absenteeism was not associated. There were significantly more participants who had presenteeism due to oral health problems among those with periodontitis participants (CPI code 1 to 2) (P=0.022).

Table 4 shows the risk of absenteeism due to oral health problems by logistic regression analysis. No significant differences were found between the risk of absenteeism and any independent variables. We found that the risk of presenteeism due to oral health problems was 2.01 (95% confidence interval, 1.03 to 3.92) times higher in participants with CPI 1 to 2 than those with CPI 0 (Table 5). No significant difference was found for other independent variables.

DISCUSSION

The study revealed that periodontal disease affected workers' attendance more than did dental caries or the number of teeth present. However, no oral disease affected employee absenteeism.

Periodontal disease is described as a silent disease. Reports from previous studies indicate that periodontal disease, at early stage, has fewer subjective symptoms and effects on quality of life than other dental diseases.[25–27] However, several studies have revealed that periodontal disease causes halitosis,[28,29] and is related to psychological stress or depression.[30,31] These symptoms are likely to influence social communications for workers in a company. In addition, when the periodontal disease is exacerbated, the tooth

TABLE 1. Occupational Parameters, Smoking Status, and Oral Health Status by Sex

	Total (N = 1,167)		Male (N = 878)		Female (N = 289)		
	Mean/N	SD/%	Mean/N	SD/%	Mean/N	SD/%	P
Age	42.7	11.4	43.5	11.5	40.4	10.6	<0.001
Industrial category							
Education and learning support	261	22.4%	173	19.7%	88	30.4%	**<0.001**
Manufacturing	659	56.5%	480	54.7%	179	61.9%	
Transport	247	21.2%	225	25.6%	22	7.6%	
Work schedule							
Daytime work	902	77.3%	631	71.9%	271	93.8%	**<0.001**
Nighttime work/Mixed daytime and nighttime work	191	16.4%	185	21.1%	6	2.1%	
Flexible time work	47	4.0%	36	4.1%	11	3.8%	
Others	27	2.3%	26	3.0%	1	0.3%	
Smoking status							
No	776	66.5%	531	60.5%	245	84.8%	**<0.001**
Current	306	26.2%	272	31.0%	34	11.8%	
Past	85	7.3%	75	8.5%	10	3.5%	
No. of present teeth	27.7	3.3	27.6	3.5	27.9	2.6	0.109
No. of decayed teeth (DT)	0.8	1.9	1.0	2.0	0.5	1.3	**<0.001**
CPI periodontal pocket code							
Code 0 (healthy)	1,048	89.8%	770	87.7%	278	96.2%	**<0.001**
Code 1–2 (periodontitis)	119	10.2%	108	12.3%	11	3.8%	
DI-S	0.6	0.5	0.7	0.5	0.4	0.3	**<0.001**

CPI, Community Periodontal Index; DI-S, Simplified Debris Index.

TABLE 2. Work Performance by Sex

	Total ($N = 1,167$)		Male ($N = 878$)		Female ($N = 289$)		
	Mean/*N*	SD/%	Mean/*N*	SD/%	Mean/*N*	SD/%	*P*
Absenteeism							
Absent days							
Due to general health problems	2.2	10.8	2.4	11.6	1.7	3.7	0.321
Due to oral health problems	0.03	0.23	0.03	0.25	0.03	0.15	0.678
Rate of absent person							
Due to general health problems	485	41.6%	357	40.7%	128	44.3%	0.155
Due to oral health problems	31	2.7%	21	2.4%	10	3.5%	0.217
Presenteeism							
Trouble at work due to oral health condition in the past year							
Yes	79	6.8%	59	6.7%	20	6.9%	0.903
No	1,088	93.2%	819	93.3%	269	93.1%	

mobility is caused, and the effect is given to mastication and occlusion, and further lowering of the quality of life is caused. Several cross-sectional studies reported that deterioration of periodontal disease is related to physical weakness.[32–34] It has been reported that periodontal disease could be linked to physical fitness by acting on sensations of fatigue, which arise from a central mechanism or from local factors at the muscle-tissue level,[35] or that periodontal inflammation may break the lining of the oral mucosa, allowing commensal flora to enter the circulatory system and behave as an opportunistic pathogen that may act as an underlying mechanism.[32] Physical fitness is important in the workplace for people doing heavy physical work such as in the manufacturing industry. People with severe periodontal disease might be more dysfunctional due to these reasons. However, in our study, periodontal disease did not lead to workers' absenteeism from their jobs. As the symptoms of periodontal disease were not serious, the worker might not feel it necessary to be absent from work, but have lower capacities to perform their normal duties such as decreased ability of physical fitness or psychological stress.

Although dental caries and tooth loss did not influence presenteeism or absenteeism of workers, caries is often associated with pain,[36,37] aesthetics,[38,39] and quality of life.[36,40] Pain is usually related to work concentration,[41] but appearance is more likely to influence work performance because sociability and aggressiveness are connected with appearance. However, reduced work performance due to dental caries was not observed in this study. The effect on appearance and pain depends on the stage of caries,[37] which was not investigated in this study. It was suggested that there were few participants with severe caries and pain in our study. A detailed investigation of the severity of dental caries is necessary in the future.

Reduced work performance did not occur due to tooth loss. Previous studies report that the number of teeth present affects physical fitness[42] and quality of life.[43] However, participants in previous studies were older and had lost more teeth than those in this study. Only 8.1% of participants were 60 years old and beyond, with only 2.7% of participants have fewer than 20 teeth. It was considered that significant differences may appear in elderly participants with greater tooth loss.

Our study indicated that both absenteeism and presenteeism caused by oral health problems were very low among Japanese workers. Japanese in general have a higher rate of dental treatment compared with other countries[44] because Japan has a universal public health insurance scheme which caters for both medical and dental care. As a result, dental treatment is received willingly in Japan. However, many people are poorly motivated to get periodontal disease treatment compared with restorations and crowns for dental caries and replacement of missing teeth, according to a report on the consultation situation of dental clinics in Japan.[45] Dental caries and tooth loss can be detected and treated early, but periodontal disease, because of its lack of symptoms, may not provide sufficient motivation for a person/worker to seek dental care.[25–27] Also, in this study, female workers had better oral health status than male workers, and the social factors presented significant differences by sex. No sex differences were seen to be related with absenteeism or presenteeism at work. Thus, the effect on

TABLE 3. Relationships Between Work Performance Due to Oral Symptoms and Oral Health Status

	Absenteeism					Presenteeism				
	Yes ($N = 31$)		No ($N = 1,136$)			Yes ($N = 79$)		No ($N = 1,088$)		
	Mean/*N*	SD/%	Mean/*N*	SD/%	*P*	Mean/*N*	SD/%	Mean/*N*	SD/%	*P*
No. of teeth present										
≤23	1	1.3%	78	98.7%	0.426	7	8.9%	72	91.1%	0.444
≥24	30	2.8%	1,058	97.2%		72	6.6%	1,016	93.4%	
No. of decayed teeth (DT)										
0	22	2.8%	763	97.2%	0.656	49	6.2%	736	93.8%	0.304
≥1	9	2.4%	373	97.6%		30	7.9%	352	92.1%	
CPI										
Code 0	27	2.6%	1,021	97.4%	0.614	65	6.2%	983	93.8%	0.022
Code 1–2	4	3.4%	115	96.6%		14	11.8%	105	88.2%	
DI-S	0.6	0.5	0.6	0.5	0.817	0.6	0.4	0.6	0.5	0.644

CPI, Community Periodontal Index; DI-S, Simplified Debris Index.

TABLE 4. Logistic Regression Analysis With Absenteeism as the Dependent Variable

Dependent Variables	Odds Ratio	95% CI		*P*
		Lower	Upper	
Sex				
Female (reference)	1.000			
Male	0.736	0.322	1.685	0.469
Age	0.983	0.948	1.019	0.345
Industrial category				
Education and learning support (reference)	1.000			
Manufacturing	1.218	0.471	3.146	0.684
Transport	1.080	0.193	6.043	0.930
Work schedule				
Daytime work (reference)	1.000			
Nighttime/Mixed daytime and nighttime work	–	–	–	0.995
Flexible time work	2.301	0.626	8.460	0.210
Other	1.285	0.107	15.477	0.843
Smoking				
No (reference)	1.000			
Past	2.153	0.562	8.245	0.263
Current	1.126	0.452	2.804	0.799
No. of present teeth				
≥24 (reference)	1.000			
≤23	0.739	0.089	6.149	0.780
No. of decayed teeth (DT)				
0 (reference)	1.000			
≥1	0.922	0.403	2.111	0.848
CPI				
Code 0 (reference)	1.000			
Code 1–2	1.876	0.578	6.092	0.295
DI-S	1.180	0.515	2.704	0.695

CI, confidence interval; CPI, Community Periodontal Index; DI-S, Simplified Debris Index.

TABLE 5. Logistic Regression Analysis With Presenteeism as the Dependent Variable

Dependent Variables	Odds Ratio	95% CI		*P*
		Lower	Upper	
Sex				
Female (reference)	1.000			
Male	0.826	0.466	1.465	0.514
Age	0.995	0.972	1.018	0.648
Industrial category				
Education and learning support (reference)	1.000			
Manufacturing	1.644	0.795	3.398	0.180
Transport	2.354	0.875	6.333	0.090
Work schedule				
Daytime work (reference)	1.000			
Nighttime/Mixed daytime and nighttime work	0.766	0.338	1.736	0.524
Flexible time work	0.344	0.045	2.609	0.302
Other	0.670	0.133	3.379	0.628
Smoking				
No (reference)	1.000			
Past	1.257	0.527	2.996	0.606
Current	1.371	0.802	2.342	0.249
No. of present teeth				
≥24 (reference)	1.000			
≤23	1.042	0.429	2.533	0.927
No. of decayed teeth (DT)				
0 (reference)	1.000			
≥1	1.226	0.739	2.033	0.429
CPI				
Code 0 (reference)	1.000			
Code 1–2	2.011	1.031	3.923	0.040
DI-S	0.857	0.506	1.119	0.564

CI, confidence interval; CPI, Community Periodontal Index; DI-S, Simplified Debris Index.

presenteeism of periodontal disease was thought to be important because periodontal disease was associated with more dysfunction even when sex, age, and social factors were adjusted.

It is strongly suggested that oral health promotion programs focused on periodontal disease prevention should be implemented in workplaces. Because periodontal disease is an inflammatory reaction of the gums caused by dental plaque, routine oral hygiene is likely to prevent its development. Health education for oral self-care in the workplace may have a major effect to prevent workers' periodontal condition. And this not only results in oral health promotion, but also has prominent effects on the prevention of other physical diseases such as diabetes,[46] arteriosclerosis,[47] cerebral infarction,[48] and myocardial infarction.[49]

There are limitations that need to be addressed in this study. This study is a cross-sectional study, and the causal relationship between dental diseases and presentation and absenteeism has not been investigated. The relationship between periodontal disease and presenteeism, which was found to be related in this study, requires more detailed investigation including the time course. Future research should target on more elderly workers with more tooth loss to investigate the impact of tooth loss on the effects of work performance. Also, a detailed investigation about how oral diseases lead to discomfort and dysfunction at work should be conducted.

CONCLUSIONS

This study revealed that the proportion of absenteeism or presenteeism of workers caused by oral health problems was low (<10%) to compare with general health problems. However, it was proven that the periodontal disease was related to the presenteeism of workers. Therefore, it is important to provide workplace oral health promotion programs for the prevention of periodontal diseases and to support workers to make favorable behavioral changes leading to good oral health.

REFERENCES

1. Smith DJ. Absenteeism and "presenteeism" in industry. *Arch Environ Health*. 1970;21:670–677.
2. Saijo Y, Yoshioka E, Nakagi Y, et al. Social support and its interrelationships with demand-control model factors on presenteeism and absenteeism in Japanese civil servants. *Int Arch Occup Environ Health*. 2017;90:539–553.
3. Stromberg C, Aboagye E, Hagberg J, Bergstrom G, Lohela-Karlsson M. Estimating the effect and economic impact of absenteeism, presenteeism, and work environment-related problems on reductions in productivity from a managerial perspective. *Value Health*. 2017;20:1058–1064.
4. Nigatu YT, Reijneveld SA, Penninx BW, Schoevers RA, Bultmann U. The longitudinal joint effect of obesity and major depression on work performance impairment. *Am J Public Health*. 2015;105:e80–e86.
5. Ivandic I, Kamenov K, Rojas D, et al. Determinants of work performance in workers with depression and anxiety: a cross-sectional study. *Int J Environ Res Public Health*. 2017;14. pii: E466.
6. Brey JK, Wolf TJ. Socioeconomic disparities in work performance following mild stroke. *Disabil Rehabil*. 2015;37:106–112.
7. Baughman BC, Basso MR, Sinclair RR, Combs DR, Roper BL. Staying on the job: the relationship between work performance and cognition in individuals diagnosed with multiple sclerosis. *J Clin Exp Neuropsychol*. 2015;37:630–640.
8. Verstappen SM. Rheumatoid arthritis and work: the impact of rheumatoid arthritis on absenteeism and presenteeism. *Best Pract Res Clin Rheumatol*. 2015;29:495–511.
9. Knies S, Candel MJ, Boonen A, et al. Lost productivity in four European countries among patients with rheumatic disorders: are absenteeism and presenteeism transferable? *Pharmacoeconomics*. 2012;30:795–807.
10. Braakman-Jansen LM, Taal E, Kuper IH, van de Laar MA. Productivity loss due to absenteeism and presenteeism by different instruments in patients with RA and subjects without RA. *Rheumatology (Oxford)*. 2012;51:354–361.
11. Bansback N, Zhang W, Walsh D, et al. Factors associated with absenteeism, presenteeism and activity impairment in patients in the first years of RA. *Rheumatology (Oxford)*. 2012;51:375–384.
12. Zalewska U, Macioch T, Sobol E, et al. Absenteeism and presenteeism in a population of patients with diabetic foot ulcers in Poland. *Value Health*. 2014;17:A351.
13. Burton WN, Chen CY, Li X, Schultz AB, Abrahamsson H. The association of self-reported employee physical activity with metabolic syndrome, health care costs, absenteeism, and presenteeism. *J Occup Environ Med*. 2014;56:919–926.
14. Wada K, Arakida M, Watanabe R, et al. The economic impact of loss of performance due to absenteeism and presenteeism caused by depressive symptoms and comorbid health conditions among Japanese workers. *Ind Health*. 2013;51:482–489.
15. Bailey SK, Haggarty J, Kelly S. Global absenteeism and presenteeism in mental health patients referred through primary care. *Work*. 2015;53:399–408.
16. Suvinen TI, Ahlberg J, Rantala M, et al. Perceived stress, pain and work performance among non-patient working personnel with clinical signs of temporomandibular or neck pain. *J Oral Rehabil*. 2004;31:733–737.
17. Ahlberg J, Rantala M, Savolainen A, et al. Reported bruxism and stress experience. *Community Dent Oral Epidemiol*. 2002;30:405–408.
18. Scalco GP, Abegg C, Celeste RK, Hokerberg YH, Faerstein E. Occupational stress and self-perceived oral health in Brazilian adults: a Pro-Saude study. *Cien Saude Colet*. 2013;18:2069–2074.
19. Miotto MH, Silotti JC, Barcellos LA. [Dental pain as the motive for absenteeism in a sample of workers]. *Cien Saude Colet*. 2012;17:1357–1363.
20. Health expenditure and financing of OECD. Organization for Economic Co-operation and Development (OECD). 2017. Availabe at: http://stats.oecd.org/Index.aspx?DataSetCode=SHA. Accessed July 24, 2019.
21. World Health Organization. Oral health surveys: basic methods: World Health Organization. 2013. Available at: internal-pdf://2974493261/WHO Oral health survey 5th edition.pdf. Accessed July 24, 2019.
22. Moore BJ. Measuring treatment and scale bias effects by linear regression in the analysis of OHI-S scores. *J Dent Res*. 1977;56:460–464.
23. Erickson JD. Statistical tests for the OHI-S and PI: a commentary. *J Dent Res*. 1973;52:36–39.
24. Durovic E, Markovska N, Martinukova B, Mincik J, Sutak J. [Correlation of the Loe-Silness GI and the Green-Vermillion OHI-S]. *Prakt Zubn Lek*. 1986;34:33–37.
25. Zaitsu T, Ueno M, Shinada K, et al. Association of clinical oral health status with self-rated oral health and GOHAI in Japanese adults. *Community Dent Health*. 2011;28:297–300.
26. Buset SL, Walter C, Friedmann A, et al. Are periodontal diseases really silent? A systematic review of their effect on quality of life. *J Clin Periodontol*. 2016;43:333–344.
27. Andersson P, Hakeberg M, Karlberg G, Ostberg AL. Clinical correlates of oral impacts on daily performances. *Int J Dent Hyg*. 2010;8:219–226.
28. Tanaka M, Yamamoto Y, Kuboniwa M, et al. Contribution of periodontal pathogens on tongue dorsa analyzed with real-time PCR to oral malodor. *Microbes Infect*. 2004;6:1078–1083.
29. Bolepalli AC, Munireddy C, Peruka S, et al. Determining the association between oral malodor and periodontal disease: A case control study. *J Int Soc Prev Community Dent*. 2015;5:413–418.
30. Park HJ, Lee HJ, Cho SH. [Influences of oral health behaviors, depression and stress on periodontal disease in pregnant women]. *J Korean Acad Nurs*. 2016;46:653–662.
31. Jaiswal R, Shenoy N, Thomas B. Evaluation of association between psychological stress and serum cortisol levels in patients with chronic periodontitis—estimation of relationship between psychological stress and periodontal status. *J Indian Soc Periodontol*. 2016;20:381–385.
32. Wakai K, Kawamura T, Umemura O, et al. Associations of medical status and physical fitness with periodontal disease. *J Clin Periodontol*. 1999;26:664–672.
33. Oliveira JA, Hoppe CB, Gomes MS, Grecca FS, Haas AN. Periodontal disease as a risk indicator for poor physical fitness: a cross-sectional observational study. *J Periodontol*. 2015;86:44–52.
34. Akhter R, Hassan NM, Moriya S, et al. Relationship between periodontal status and physical fitness in an elderly population of nonsmokers in Bangladesh. *J Am Geriatr Soc*. 2008;56:2368–2370.
35. Ament W, Verkerke GJ. Exercise and fatigue. *Sports Med*. 2009;39:389–422.
36. Brignardello-Petersen R. Active caries, consequences of untreated caries, and tooth pain relate to only a small decrease in older adults' quality of life. *J Am Dent Assoc*. 2017;148:e62.

37. Ardila CM, Agudelo-Suarez AA. Association between dental pain and caries: a multilevel analysis to evaluate the influence of contextual and individual factors in 34 843 adults. *J Investig Clin Dent*. 2016;7:410–416.
38. Solomon D, Katz RV, Bush AC, et al. Psychosocial impact of anterior dental esthetics on periodontal health, dental caries, and oral hygiene practices in young adults. *Gen Dent*. 2016;64:44–50.
39. Anson D. Periodontal esthetics and soft-tissue root coverage for treatment of cervical root caries. *Compend Contin Educ Dent*. 1999;20:1043–1046. 1048–1050, 1052; quiz.
40. Chaffee BW, Rodrigues PH, Kramer PF, Vitolo MR, Feldens CA. Oral health-related quality-of-life scores differ by socioeconomic status and caries experience. *Community Dent Oral Epidemiol*. 2017;45:216–224.
41. Langley P, Muller-Schwefe G, Nicolaou A, et al. The impact of pain on labor force participation, absenteeism and presenteeism in the European Union. *J Med Econ*. 2010;13:662–672.
42. Inui A, Takahashi I, Sawada K, et al. Teeth and physical fitness in a community-dwelling 40 to 79-year-old Japanese population. *Clin Interv Aging*. 2016;11:873–878.
43. Niesten D, van Mourik K, van der Sanden W. The impact of having natural teeth on the QoL of frail dentulous older people. A qualitative study. *BMC Public Health*. 2012;12:839.
44. Ministry of Internal Affairs and Communications, Japan Standard Industrial Classification. 2013. Available at: http://www.soumu.go.jp/toukei_toukatsu/index/seido/sangyo/H25index.htm. Accessed July 24, 2019.
45. Lambruschini OA. [Motivation to the treatment and periodontal control]. *An Esp Odontoestomatol*. 1975;34:385–412.
46. Nelson RG, Shlossman M, Budding LM, et al. Periodontal disease and NIDDM in Pima Indians. *Diabetes Care*. 1990;13:836–840.
47. Beck J, Garcia R, Heiss G, Vokonas PS, Offenbacher S. Periodontal disease and cardiovascular disease. *J Periodontol*. 1996;67:1123–1137.
48. Grau AJ, Becher H, Ziegler CM, et al. Periodontal disease as a risk factor for ischemic stroke. *Stroke*. 2004;35:496–501.
49. Ridker PM, Cushman M, Stampfer MJ, Tracy RP, Hennekens CH. Inflammation, aspirin, and the risk of cardiovascular disease in apparently healthy men. *N Engl J Med*. 1997;336:973–979.

International Journal of
Environmental Research and Public Health

MDPI

Article

Influence of Occupational Stress and Coping Style on Periodontitis among Japanese Workers: A Cross-Sectional Study

Md Monirul Islam, Daisuke Ekuni, Toshiki Yoneda, Aya Yokoi * and Manabu Morita

Department of Preventive Dentistry, Okayama University Graduate School of Medicine, Dentistry and Pharmaceutical Sciences, Okayama 700-8558, Japan; p3a99o50@s.okayama-u.ac.jp (M.M.I.); dekuni7@md.okayama-u.ac.jp (D.E.); de17057@s.okadai.jp (T.Y.); mmorita@md.okayama-u.ac.jp (M.M.)
* Correspondence: yokoi-a1@cc.okayama-u.ac.jp; Tel.: +81-86-235-6712

Received: 22 August 2019; Accepted: 18 September 2019; Published: 22 September 2019

Abstract: The aim of this cross-sectional study was to evaluate the association between the influence of occupational stress and coping style on periodontitis among Japanese workers. The study sample included 738 workers (age range: 19–65 years) at a manufacturing company in Kagawa Prefecture, Japan. To analyze occupational stress and coping style, all participants answered a self-report questionnaire composed of items on their work environment and oral health behavior. Oral examinations were performed by calibrated dentists. Among all workers, 492 (66.7%) workers were diagnosed with periodontitis, and 50 (6.8%) were diagnosed with a high stress-low coping condition. Significant differences ($p < 0.05$) were observed between the periodontitis and non-periodontitis groups in terms of age, gender, body mass index, smoking status, daily alcohol drinking, monthly overtime work, worker type, and stress-coping style. Logistic regression analysis showed that a high stress–low coping condition was associated with an increased risk of periodontitis (odds ratio: 2.79, 95% confidence interval: 1.05–7.43, $p = 0.039$). These findings suggest that a high stress-low coping condition is associated with periodontitis among the 19–65 years of age group of Japanese workers.

Keywords: occupational stress; coping; periodontitis; Japanese workers

1. Introduction

In recent years, occupational stress has become an increasingly serious problem around the world [1]. Remarkable changes in working duration, job engagement, and type of working environment have led to increased levels of occupational stress in workers [2]. The World Health Organization considers occupational stress among workers a global epidemic and is actively seeking to ascertain its severity [3]. Occupational stress is becoming a markedly serious problem among Japanese workers. According to previous studies, more than 60% of Japanese workers have reported experiencing work-related stress, and the number of workers with mental health problems has been rapidly increasing [4,5].

Occupational stress has adverse effects on employment (e.g., absenteeism, lateness, job dissatisfaction, and job turnover) [6–8]. Moreover, it contributes to poor physical and mental health [9]. For instance, research has shown that occupational stress is associated with certain oral health problems, including caries [10], periodontal disease [11], temporomandibular disorder, and halitosis [12]. Stress has long been regarded as an important predisposing factor for periodontal disease among workers, and an association has been reported between periodontal disease and work-related stress and dissatisfaction [13]. Coping is the response of the individual to control, minimize, or avoid the

adverse and unpleasant effects of stress. According to Lazarus et al., an individual's psychological and physical well-being depends on coping strategies more than the frequency and intensity of stress [14,15]. Concurrently, the relationship between stress and individual coping styles has been shown to be associated with periodontal disease. A 24-month prospective study involving chronic periodontitis patients found that patients with an active coping style showed a lesser degree of disease advancement than those with a passive coping style [16]. Furthermore, the effects of stress on periodontal disease can be restrained by adequate coping behaviors [17]. Another study found that coping style had a protective effect against tooth loss [18]. However, to our knowledge, no studies have explained the influence of coping style against stress, especially workplace-induced occupational stress, on periodontal disease.

Therefore, the aim of the present cross-sectional study was to investigate the influence of occupational stress and coping style on periodontitis among Japanese workers, and, thereby, test the hypothesis that the balance between occupational stress and coping style is related to periodontal disease.

2. Materials and Methods

2.1. Study Design and Participants

Anonymous data for this cross-sectional study were obtained from the workers of a Japanese crane manufacturing company located in Kagawa Prefecture, Japan, for the years 2016–2018 (in February each year). All workers received a routine general health checkup, including a voluntary dental checkup. We distributed the questionnaires to the participants prior to health checkups and collected them during the annual health checkups. A total of 1476 workers participated in the general health examinations, among whom, those who received a voluntary dental checkup and completed a questionnaire (n = 855) were enrolled in the study. After excluding those with incomplete questionnaires, we analyzed the data of 738 (86.3%) workers. All participants provided informed consent at the time of their interview.

2.2. Job Category

We followed the job category criteria provided by the Ministry of Health, Labor, and Welfare of Japan. According to these criteria, all participants were classified as office workers (e.g., computer operators, clerks, secretaries) or skilled workers (e.g., factory workers, construction workers).

2.3. Assessment of Stress and Coping Style

In this study, we used the "Co–Labo57 +" questionnaire [19], which is composed of six parts (parts A–F). Questions from parts A–D adopt the Brief Job Stress Questionnaire (BJSQ) to measure occupational stress. The reliability and validity of the BJSQ was confirmed for Japanese workers [12,20,21]. The BJSQ is composed of 57 items used to assess job stressors (Part A, 17 items: e.g., psychological job demands, job control), stress response (Part B, 29 items: e.g., psychological and physical stress reactions), and buffering factors (Parts C and D, 11 items: e.g., social support at work). The BJSQ program manual suggests criteria for categorizing stress levels [22]. High-stress was determined as having the highest level of a stress reaction [criterion (i)] or a moderate level of a stress reaction, along with having the highest job stressors (or lowest social support in the workplace) [criterion (ii)]. In this study, to calculate the stress reaction and job stressor scores, we summed the item scores from a four-point Likert scale (from 1 = low stress to 4 = high stress). The scores ranged from 29 to 116 for stress reactions (Part A) and from 26 to 104 for job stressors (Part B). The cutoff points were 77 for the stress reaction score for criterion (i), 63 for the stress reaction score, and 76 for the job stressor score for criterion (ii) [23]. If the score for criterion (i) or criterion (ii) was higher than the cutoff point, the participant was classified as high stress.

Coping style was assessed using the remaining two parts (E and F). The participant was considered to have a high coping style if the summed score was ≥ 20 for part E or ≥ 68 for part F.

2.4. General Health and Lifestyles Assessment

All participants underwent a mandatory general health examination. Body weight and height were measured to calculate body mass index (BMI), which was categorized as <25 or ≥25 kg/m^2 [24]. In addition, the participants provided answers regarding their age, gender, and other lifestyle-related factors, including job type (office or skilled worker), smoking status (current, never, or former), daily alcohol drinking (yes or no), daily sleep duration (≥6 or <6 h) [25], and amount of overtime work (≥40 or <40 h/month) [26]. The amount of overtime work was assessed by calculating total hours worked minus the standard 8 working hours per day on weekdays, plus the number of hours worked on holidays during the entire month.

Oral health behavior was assessed by asking about the use of dental floss (yes or no) and whether the participant had a regular dental checkup in the past year (yes or no) [27].

2.5. Oral Examinations

The participants' oral conditions (e.g., number of healthy, missing, and decayed teeth, plaque and calculus level, gingival and periodontal health, malocclusion, temporomandibular joint findings) were evaluated by calibrated dentists. Using an objective method [28], the participants were then classified into either a periodontitis or a non-periodontitis group. Briefly, no inflammation in the gingiva or redness and/or swelling of the interdental papilla without gingival recession was classified as non-periodontitis, and any redness and/or swelling in the gingiva with gingival recession and/or tooth mobility was classified as periodontitis. The intra and inter-examiner reliabilities was evaluated by kappa statistics of more than 0.8.

2.6. Ethical Considerations

The study protocol was approved by the Okayama University Graduate School of Medicine, Dentistry, and Pharmaceutical Sciences and Okayama University Hospital Ethics Committee (No. 1905-016).

2.7. Statistical Analysis

The normality of the data was investigated using a histogram, quantile–quantile plot, and the Shapiro-Wilk test [29]. The sample size was estimated using G * Power (ver. 3.1.9.2, Universität Kiel, Kiel, Germany), and the minimum sample sizes were calculated for analysis using a chi-squared test [30]. Considering an effect size of 0.3, alpha of 0.05, and power ($1 - \beta$) of 0.80, the minimum sample size required was 88 [31]. Since the company had more than an adequate number of workers to obtain reasonable results, we enrolled more than 88 workers in our study.

For the descriptive analysis, means and standard deviations were calculated for continuous variables, whereas categorical variables were presented as percentiles. p values were calculated for the continuous and categorical variables using the Mann-Whitney U test and chi-squared test, respectively. The results from the logistic regression analysis were presented as odds ratios (ORs) and 95% confidence intervals (CIs). p values < 0.05 were considered statistically significant. All analyses were performed using the SPSS statistical package (v. 25.0; SPSS Inc., Chicago, IL, USA).

3. Results

Figure 1 shows a flowchart of the enrollment procedure. Following the scoring criteria of the Co-Labo57+ questionnaire, we identified a total of 88 (11.9%) workers as high-stress and 438 (59.3%) as having a high coping style. The characteristics of the workers are shown in Table 1. Among the 738 workers, 646 were men (87.5%) and 92 were women (12.5%). The mean age was 40.7 ± 10.5 years. The prevalence of periodontitis was 66.7% (n = 492). Among the workers, 88.1% (n = 650) were classified to the "low stress," 5.1% (n = 38) to the "high stress–high coping," and 6.8% (n = 50) to the "high stress–low coping" group.

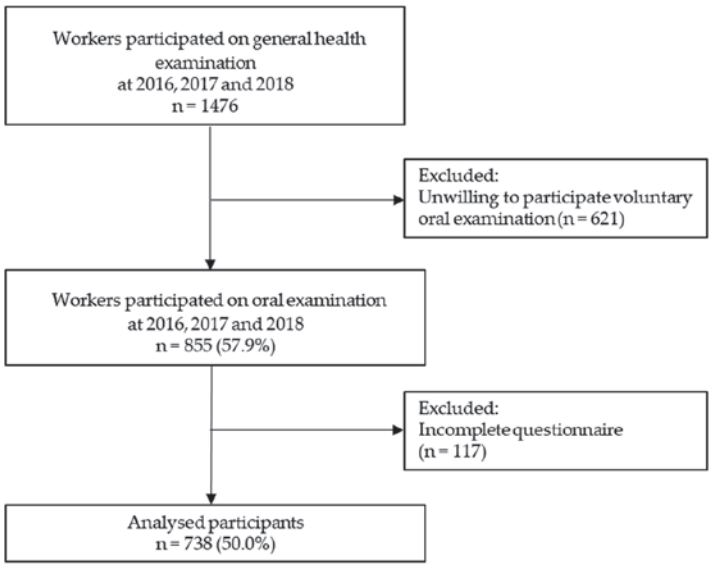

Figure 1. Flowchart of the enrollment procedure.

Table 1. Characteristics of all workers.

Parameters (n = 738)	n (%) Mean ± SD
Age (y)	40.7 ± 10.5
Gender	
Male	646 (87.5)
Female	92 (12.5)
Daily flossing (Yes)	95 (12.9)
Regular dental checkup (Yes)	107 (14.5)
Periodontitis (Yes)	492 (66.7)
BMI (kg/m^2)	
<25	545 (73.8)
≥25	193 (26.2)
Hypertension (Yes)	47 (6.4)
Daily sleeping duration (≥6 h)	631 (85.5)
Current smoker (Yes)	206 (27.9)
Daily alcohol drinking (Yes)	128 (17.3)
Monthly overtime work (≥40 h)	187 (25.3)
Worker type	
Skilled worker	334 (45.3)
Office worker	404 (54.7)
Low stress	650 (88.1)
High stress-High coping	38 (5.1)
High stress-Low coping	50 (6.8)

BMI, body mass index. SD, standard deviation.

Table 2 shows a comparison between the periodontitis and non-periodontitis groups. The mean age in the periodontitis group was significantly higher than that in the non-periodontitis group ($p < 0.001$). Significant differences were also seen between the two groups in gender, BMI, smoking status, daily alcohol drinking, monthly overtime work, worker type, and stress-coping style ($p < 0.05$).

As shown in Table 3, the logistic regression analysis revealed that periodontitis was significantly associated with age, the male gender, BMI ≥ 25 kg/m^2, and smoking status (current smoker) ($p < 0.001$). Moreover, periodontitis was significantly associated with the "high stress-low coping" style ($p = 0.039$).

Table 2. Comparisons of the between periodontitis and non-periodontitis groups.

Parameters (n = 738)	Periodontitis (n = 492)	Non-Periodontitis (n = 246)	*p* Value
	n (%) Mean ± SD	n (%) Mean ± SD	
Age (y)	43 ± 10.1	34.9 ± 8.9	<0.001 [1]
Gender (Male)	462 (93.9)	184 (74.8)	<0.001 [2]
Daily flossing (Yes)	64 (13.0)	31 (12.6)	0.876 [2]
Regular dental checkup (Yes)	70 (14.2)	37 (15.0)	0.767 [2]
BMI (kg/m^2)			
<25	336 (68.3)	209 (85.0)	<0.001 [2]
≥25	156 (31.7)	37 (15.0)	
Sleeping duration (daily)			
≥6 h	418 (85.0)	213 (86.6)	0.554 [2]
<6 h	74 (15.0)	33 (13.4)	
Current smoker (Yes)	161 (32.7)	45 (18.3)	<0.001 [2]
Daily alcohol drinking (Yes)	104 (21.1)	26 (10.6)	<0.001 [2]
Monthly overtime work (≥40 h)	145 (29.5)	42 (17.1)	<0.001 [2]
Worker type			
Skilled worker	245 (49.8)	89 (36.2)	<0.001 [2]
Office worker	247 (50.2)	157 (63.8)	
Low stress	431 (87.6)	219 (89.0)	<0.001 [2]
High stress-High coping	17 (3.5)	21 (8.5)	
High stress-Low coping	44 (8.9)	6 (2.5)	

BMI, body mass index. SD, standard deviation. [1] Mann–Whitney *U* test, and [2] chi-squared test.

Table 3. Adjusted odds ratios (OR) and 95% confidence intervals (95% CI) for periodontitis.

Dependent Variable	Independent Variable		OR	95% CI	*p*-Value [1]
Periodontitis	Age		1.11	1.09–1.14	<0.001
	Gender	Female	Ref		
		Male	5.11	2.81–9.30	<0.001
	Daily flossing	Yes	Ref		
		No	0.99	0.57–1.76	0.990
	Regular dental checkup	Yes	Ref		
		No	1.17	0.69–1.99	0.562
	BMI (kg/m^2)	<25	Ref		
		≥25	2.23	1.42–3.51	< 0.001
	Sleeping duration (daily)	≥6 h	Ref		
		<6 h	0.98	0.58–1.67	0.938
	Current smoker	No	Ref		
		Yes	2.08	1.35–3.22	< 0.001
	Daily alcohol drinking	No	Ref		
		Yes	1.24	0.73–2.11	0.424
	Monthly overtime work	<40 h	Ref		
		≥40 h	1.07	0.68–1.71	0.765
	Worker type	Office worker	Ref		
		Skilled worker	1.31	0.89–1.95	0.175
	Low stress		Ref		
	High stress-High coping		0.30	0.14–0.66	0.003
	High stress-Low coping		2.79	1.05–7.43	0.039

BMI, body mass index. CI, confidence interval. OR, odds ratio. [1] Multiple logistic regression model adjusted for age, gender, daily flossing, regular dental checkups, BMI, sleeping duration (daily), smoking status (current smoker), daily alcohol drinking, monthly overtime work, worker type, and stress-coping style.

4. Discussion

In this cross-sectional study, we focused on the influence of occupational stress and coping style on periodontitis. To the best of our knowledge, this is the first study to investigate whether the balance between occupational stress and coping style is associated with the prevalence of periodontitis among Japanese workers. Our results showed that having a low coping style against high occupational stress was significantly associated with periodontitis (adjusted ORs: 2.79, 95% CI: 1.05–7.43, $p = 0.039$).

The workers with the high stress–high coping style were not found to be at a higher risk for periodontitis in this study, which suggests an association between periodontitis and an effective stress-coping style. This condition can be explained by several possible mechanisms. For example, an inappropriate coping attitude (e.g., increased tobacco smoking, alcohol drinking) and the adoption of unhealthy behaviors (e.g., poor oral hygiene, insufficient nutritional intake) can lead to drastic changes in oral health [32–34]. Concurrently, an inadequate stress-coping style may cause mental alterations and induce immune suppression, which may aggravate chronic inflammatory diseases such as periodontitis [35].

Our results found a higher prevalence of current smokers with periodontitis than in the non-periodontitis group. Previous studies have reported smoking as a coping mechanism against stress among workers [36,37]. On the other hand, an association between smoking and the risk of periodontitis has been established [18,38,39]. Therefore, attempts should be made to prevent smoking among workers.

In the present study, no significant difference in overtime work was found between the periodontitis and non-periodontitis groups. A previous study among Korean workers reported that overtime work was associated with the prevalence of periodontitis [40]. The discrepancy in the findings from the previous study and the present study may depend on race (Korean vs. Japanese) and the percentage of overtime workers (60.3% vs. 25.3%). In addition, no significant difference in job category was found between the periodontitis and non-periodontitis groups, which is in line with previous studies finding no significant association between the job category (skilled and office workers) and periodontitis [41,42].

Additionally, in line with a previous study [43], the overweight factor was found to be a risk factor for periodontitis among workers. Other previous studies have reported finding a positive relation between coping style and BMI [44,45]. Hence, to help find balance between stress and coping, workers should be encouraged to limit their working hours and engage in a healthy lifestyle while maintaining a normal body weight.

The prevalence of periodontitis in this study was 66.7%, which differed from other studies in Japan. A five-year cohort study that defined periodontitis as having one or more sextants with a Community Periodontal Index score > 2 (pockets ≥ 4 mm deep) reported that 55.4% of Japanese workers had periodontitis [41]. Another cross-sectional study that measured periodontitis by probing pocket depth and clinical attachment loss (CAL) at mesio-buccal and mid-buccal sites for all of the teeth in two randomly selected quadrants indicated that only 13% of Japanese workers had periodontitis, which was defined as having at least one tooth with a CAL of ≥7 mm [46]. Possible causes for this discrepancy might be the type of oral examination or the study design. On the other hand, in the present study, 11.9% of workers reported having high occupational stress. This result was in line with a previous Japanese study using the same questionnaire [23].

The present study showed that the risk of periodontitis is influenced by the balance between occupational stress and coping style. Therefore, a comprehensive approach should be taken to minimize the occupational stress and improve the coping ability of the workers. Our results also suggest that, during the management of periodontitis in a clinical setting, the coping style of workers against occupational stress should be taken into consideration.

This study had some limitations. First, all workers were enrolled from a Japanese crane manufacturing company. Therefore, the influence of stress and coping style on periodontitis might differ from other types of workers. Second, no other possible confounders, such as working schedule [40], education level [3], income level [47], and family situation [48], were examined in this study. Third,

periodontitis was diagnosed using an objective method due to time constraints, but no probing or X-ray findings were used. Hence, there is a possibility of presenting a large group of mild periodontitis with little clinical impact. Lastly, a causal association could not be shown because this study was cross-sectional.

5. Conclusions

The findings of the present study suggest that a high stress–low coping style is associated with an increased risk of periodontitis among the 19–65 years of age group of Japanese workers. Therefore, during the management of periodontitis, the balance between occupational stress and coping style should also be considered.

Author Contributions: Conceptualization, M.M., D.E., and M.M.I. Methodology, D.E., T.Y., and A.Y. Validation, D.E. Formal analysis, M.M.I. Investigation, D.E., T.Y., and A.Y. Resources, M.M. Data curation, D.E., T.Y., and A.Y. Writing the original draft preparation, M.M.I. Writing the review and editing, all authors. Project administration, M.M.

Funding: This research received no external funding.

Acknowledgments: The authors are grateful to Ms. Yuriko Akazawa (Tadano Ltd., Takamatsu, Japan) and General Incorporated Association Total Health Promotion Association Kansai (Osaka, Japan) for the data entry.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Anderson, N.; Ones, S.; Sinangil, K.; Viswesvaran, C. *Handbook of Industrial, Work & Organizational Psychology—Volume 2: Organizational Psychology*; SAGE Publications: London, UK, 2001.
2. Papadopoulos, G.; Georgiadou, P.; Papazoglou, C.; Michaliou, K. Occupational and public health and safety in a changing work environment: An integrated approach for risk assessment and prevention. *Saf. Sci.* **2010**, *48*, 943–949. [CrossRef]
3. Li, Y.; Sun, X.; Ge, H.; Liu, J.; Chen, L. The Status of Occupational Stress and Its Influence the Quality of Life of Copper-Nickel Miners in Xinjiang, China. *Int. J. Environ. Res. Public Health* **2019**, *16*, 353. [CrossRef] [PubMed]
4. Annual Health, Labour and Welfare Report 2009–2010 Section 7. Creating an Environment Where People Can Work with Confidence and Satisfaction. *Japan Ministry of Health, Labour and Welfare.* Available online: https://www.mhlw.go.jp/english/wp/wp-hw/index.html (accessed on 12 June 2019).
5. Hara, Y. Mental Disorders among Today's Labor Force and Preventive Measures. *Jpn. Lab. Rev.* **2014**, *11*, 5.
6. Melchior, M. Do psychosocial work factors and social relations exert independent effects on sickness absence? A six year prospective study of the GAZEL cohort. *J. Epidemiol. Community Health* **2003**, *57*, 285–293. [CrossRef] [PubMed]
7. Kammeyer-Mueller, J.D.; Wanberg, C.R. Unwrapping the organizational entry process: Disentangling multiple antecedents and their pathways to adjustment. *J. Appl. Physiol.* **2003**, *88*, 779–794. [CrossRef] [PubMed]
8. Bond, F.W.; Bunce, D. Job control mediates change in a work reorganization intervention for stress reduction. *J. Occup. Health Psychol.* **2001**, *6*, 290–302. [CrossRef]
9. Leka, S.; Cox, T.; Griffiths, A. *Work Organization & Stress: Systematic Problem Approaches for Employers, Managers and Trade Union Representatives*; World Health Organization: Geneva, Switzerland, 2003.
10. Marcenes, W.S.; Sheiham, A. The relationship between work stress and oral health status. *Soc. Sci. Med.* **1992**, *35*, 1511–1520. [CrossRef]
11. Linden, G.J.; Mullally, B.H.; Freeman, R. Stress and the progression of periodontal disease. *J. Clin. Periodontol.* **1996**, *23*, 675–680. [CrossRef]
12. Yoshino, K.; Suzuki, S.; Ishizuka, Y.; Takayanagi, A.; Sugihara, N.; Kamijyo, H. Relationship between job stress and subjective oral health symptoms in male financial workers in Japan. *Ind. Health* **2017**, *55*, 119–126. [CrossRef]
13. Atri, M.; Srivastava, D.; Kharbanda, J.; Bugalia, A.; Yousuf, A.; Anup, N. Occupational Stress, Salivary Cortisol, and Periodontal Disease: A Clinical and Laboratory Study. *J. Int. Oral Health* **2015**, *7*, 65–69.

14. Lazarus, R.S. *Stress and Emotion: A New Synthesis*; Springer: New York, NY, USA, 2006.
15. Lazarus, R.S.; Folkman, S. *Stress, Appraisal, and Coping*; Springer: New York, NY, USA, 1984.
16. Wimmer, G.; Köhldorfer, G.; Mischak, I.; Lorenzoni, M.; Kallus, K.W. Coping with Stress: Its Influence on Periodontal Therapy. *J. Periodontol.* **2005**, *76*, 90–98. [CrossRef] [PubMed]
17. Genco, R.; Ho, A.; Grossi, S.; Dunford, R.; Tedesco, L. Relationship of Stress, Distress, and Inadequate Coping Behaviors to Periodontal Disease. *J. Periodontol.* **1999**, *70*, 711–723. [CrossRef] [PubMed]
18. Sanders, A.; Slade, G.; Turrell, G.; Spencer, A.; Marcenes, W. Does Psychological Stress Mediate Social Deprivation in Tooth Loss? *J. Dent. Res.* **2007**, *86*, 1166–1170. [CrossRef] [PubMed]
19. Sumiko, S. Case studies and Effect of Psychological Counselling Using Co-Labo Scale (Job stress scale-Revised, EAP version) at Workplace. *Job Stress Res.* **2009**, *16*, 93–103. (In Japanese)
20. Endo, M. Recurrent Sickness Absence due to Depression: A Two-year Cohort among Japanese Employees. *Int. J. Epidemiol.* **2015**, *44*, i48. [CrossRef]
21. Fukuda, Y.; Iwasaki, S.; Deguchi, Y.; Ogawa, K.; Nitta, T.; Inoue, K. The effect of long-term sickness absence on coworkers in the same work unit. *Ind. Health* **2018**, *56*, 2–9. [CrossRef] [PubMed]
22. Ministry of Health, Labour and Welfare, Japan. Available online: http://www.mhlw.go.jp/bunya/roudoukijun/anzeneisei12/ (accessed on 10 June 2019).
23. Tsutsumi, A.; Shimazu, A.; Eguchi, H.; Inoue, A.; Kawakami, N. A Japanese Stress Check Program screening tool predicts employee long-term sickness absence: A prospective study. *J. Occup. Health* **2018**, *60*, 55–63. [CrossRef]
24. Yoshino, K.; Suzuki, S.; Ishizuka, Y.; Takayanagi, A.; Sugihara, N.; Kamijyo, H. Relationship between amount of overtime work and untreated decayed teeth in male financial workers in Japan. *J. Occup. Health* **2017**, *59*, 280–285. [CrossRef]
25. Utsugi, M.; Saijo, Y.; Yoshioka, E.; Horikawa, N.; Sato, T.; Gong, Y.; Kishi, R. Relationships of Occupational Stress to Insomnia and Short Sleep in Japanese Workers. *Sleep* **2005**, *28*, 728–735. [CrossRef]
26. Sato, Y.; Miyake, H.; Theriault, G. Overtime work and stress response in a group of Japanese workers. *Occup. Med.* **2009**, *59*, 14–19. [CrossRef]
27. Lang, W.P.; Farghaly, M.M.; Ronis, D.L. The relation of preventive dental behaviors to periodontal health status. *J. Clin. Periodontol.* **1994**, *21*, 194–198. [CrossRef] [PubMed]
28. Yokoi, A.; Ekuni, D.; Yoneda, T.; Morita, M. Relationships among Metabolic Syndrome, Eating Quickly, and Oral Status in the Workplace. *J. Dent. Health* **2018**, *68*, 9–14. (In Japanese)
29. Henderson, A.R. Testing experimental data for univariate normality. *Clin. Chim. Acta* **2006**, *366*, 112–129. [CrossRef] [PubMed]
30. Faul, F.; Erdfelder, E.; Buchner, A.; Lang, A.G. Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behav. Res. Methods* **2009**, *41*, 1149–1160. [CrossRef] [PubMed]
31. Cohen, J. A power primer. *Psychol. Bull.* **1992**, *112*, 155–159. [CrossRef]
32. Wiebe, D.J.; Mccallum, D.M. Health practices and hardiness as mediators in the stress-illness relationship. *Health Psychol.* **1986**, *5*, 425–438. [CrossRef] [PubMed]
33. Shankardass, K. Place-based stress and chronic disease: A systems view of environmental determinants. In *Rethinking Social Epidemiology: Towards a Science of Change*; Springer: Dordrecht, The Netherlands, 2012; ISBN 9789400721388.
34. Stabholz, A.; Soskolne, W.A.; Shapira, L. Genetic and environmental risk factors for chronic periodontitis and aggressive periodontitis. *Periodontology 2000* **2010**, *53*, 138–153. [CrossRef] [PubMed]
35. Wimmer, G.; Janda, M.; Wieselmann-Penkner, K.; Jakse, N.; Polansky, R.; Pertl, C. Coping with Stress: Its Influence on Periodontal Disease. *J. Periodontol.* **2002**, *73*, 1343–1351. [CrossRef]
36. Keller-Hamilton, B.; Moe, A.M.; Breitborde, N.J.K.; Lee, A.; Ferketich, A.K. Reasons for smoking and barriers to cessation among adults with serious mental illness: A qualitative study. *J. Community Psychol.* **2019**, *47*, 1462–1475. [CrossRef]
37. Tran, B.X.; Vu, G.T.; Pham, K.T.H.; Vuong, Q.-H.; Ho, M.-T.; Vuong, T.-T.; Nguyen, H.-K.T.; Nguyen, C.T.; Latkin, C.A.; Ho, C.S.; et al. Depressive Symptoms among Industrial Workers in Vietnam and Correlated Factors: A Multi-Site Survey. *Int. J. Environ. Res. Public Health* **2019**, *16*, 1642. [CrossRef]
38. Yamamoto, Y.; Nishida, N.; Tanaka, M.; Hayashi, N.; Matsuse, R.; Nakayama, K.; Morimoto, K.; Shizukuishi, S. Association between passive and active smoking evaluated by salivary cotinine and periodontitis. *J. Clin. Periodontol.* **2005**, *32*, 1041–1046. [CrossRef] [PubMed]

39. Ojima, M.; Hanioka, T.; Tanaka, K.; Inoshita, E.; Aoyama, H. Relationship between smoking status and periodontal conditions: Findings from national databases in Japan. *J. Periodontal Res.* **2006**, *41*, 573–579. [CrossRef] [PubMed]
40. Lee, W.; Lim, S.-S.; Kim, B.; Won, J.-U.; Roh, J.; Yoon, J.-H. Relationship between long working hours and periodontitis among the Korean workers. *Sci. Rep.* **2017**, *7*, 7967. [CrossRef] [PubMed]
41. Irie, K.; Yamazaki, T.; Yoshii, S.; Takeyama, H.; Shimazaki, Y. Is there an occupational status gradient in the development of periodontal disease in Japanese workers? A 5-year prospective cohort study. *J. Epidemiol.* **2017**, *27*, 69–74. [CrossRef] [PubMed]
42. Morita, I.; Nakagaki, H.; Yoshii, S.; Tsuboi, S.; Hayashizaki, J.; Igo, J.; Mizuno, K.; Sheiham, A. Gradients in periodontal status in Japanese employed males. *J. Clin. Periodontol.* **2007**, *34*, 952–956. [CrossRef] [PubMed]
43. Ekuni, D.; Mizutani, S.; Kojima, A.; Tomofuji, T.; Irie, K.; Azuma, T.; Yoneda, T.; Furuta, M.; Eshima, N.; Iwasaki, Y.; et al. Relationship between increases in BMI and changes in periodontal status: A prospective cohort study. *J. Clin. Periodontol.* **2014**, *41*, 772–778. [CrossRef] [PubMed]
44. Shimanoe, C.; Hara, M.; Nishida, Y.; Nanri, H.; Otsuka, Y.; Nakamura, K.; Higaki, Y.; Imaizumi, T.; Taguchi, N.; Sakamoto, T.; et al. Perceived Stress and Coping Strategies in Relation to Body Mass Index: Cross-Sectional Study of 12,045 Japanese Men and Women. *PLoS ONE* **2015**, *10*, e0118105. [CrossRef]
45. Hayward, L.E.; Vartanian, L.R.; Pinkus, R.T. Coping with weight stigma: Development and validation of a Brief Coping Responses Inventory. *Obes. Sci. Pract.* **2017**, *3*, 373–383. [CrossRef]
46. Yamamoto, T.; Koyama, R.; Tamaki, N.; Maruyama, T.; Tomofuji, T.; Ekuni, D.; Yamanaka, R.; Azuma, T.; Morita, M. Validity of a Questionnaire for Periodontitis Screening of Japanese Employees. *J. Occup. Health* **2009**, *51*, 137–143. [CrossRef]
47. Damaske, S.; Zawadzki, M.J.; Smyth, J.M. Stress at work: Differential experiences of high versus low SES workers. *Soc. Sci. Med.* **2016**, *156*, 125–133. [CrossRef]
48. Zhao, J.S.; He, N.P.; Lovrich, N.; Cancino, J. Marital Status and Police Occupational Stress. *J. Crime Justice* **2003**, *26*, 23–46. [CrossRef]

RESEARCH ARTICLE

Relationship between Medical and Dental Health Expenditures of Industrial Workers

Masayuki Ueno[1], Takashi Zaitsu[2], Akiko Oshiro[3], Yoko Kawaguchi[4]

Abstract

Aim: There has been little research exploring the expenditures associated with medical and dental health services and their interrelationship. The purposes of this cross-sectional study were to describe features of annual health expenditure and to examine the relationship between medical and dental health expenditures.

Materials and methods: Data on health expenditure from a total of 9,149 haulage workers aged 18–75 years (7,343 men and 1,806 women), who belonged to a health insurance association, were drawn for the analysis using electric health insurance claims from January through December in 2015. In-patient and out-patient fees as well as the corresponding pharmaceutical fees reported in the health insurance claims were aggregated to derive total medical and dental health expenditures.

Results: The medical services utilization rate (77.4%) was significantly higher than the dental services utilization rate (42.0%) (p <0.001), and both medical and dental services utilization rates increased with age (p for trend <0.001). Per capita medical and dental health expenditures also significantly increased with age (p for trend <0.001). Per capita medical health expenditure in workers who used dental services was significantly higher than that in those who did not use dental services in persons in the 40 years and older age groups (p <0.05).

Conclusion: The present findings indicate a positive association between medical and dental health expenditures. Therefore, an improvement in oral health through workplace preventive measures may bring decrease not only of dental health expenditure but also of medical and total health expenditures in the industry.

Keywords: Dental health, Health expenditure, Health insurance, Medical health, Workplace.

Journal of Oral Health and Community Dentistry (2019): 10.5005/jp-journals-10062-0046

Introduction

Japan has introduced a universal health insurance system for the entire population since 1961. Under this system, people can receive health services including prescription medicines and dental treatment at a relatively low rate, the same fee throughout the nation. There are many types of social health insurance plans covering different groups of people, which are managed by a society-managed health insurance, mutual aid associations, quasipublic national health insurance associations, citizens' health insurance, and late elders' health insurance.[1]

Regulatory measures through a fee schedule determined and standardized by the Japanese government have contained health-related costs compared with other countries.[2] However, a steadily increasing national health expenditure in Japan has become a major concern. Japan spent 42.4 trillion yen (approximately 376 billion US dollars) on national health expenditure in the fiscal year 2015, an increase of 3.8% (1.6 trillion yen) more than in 2014.[3] The reducing health expenditure, therefore, is a key issue to be tackled in Japan.

The same is true of many industrial companies. Because of limited financial resources, reducing healthcare-related expenses of workers is an important task for decision-makers in the industry. Correctly identifying and understanding the magnitude of health expenditure is indispensable to determining the amount of resources that can be allocated to other purposes.

It is well documented that oral health is closely related to general health. Dental disease, periodontal disease in particular, is strongly associated with systemic diseases such as diabetes and cardiovascular diseases.[4,5] Since people at risk of dental disease are also considered to be at high risk of systematic disease, dental health expenditure may affect medical health expenditure. There are a few reports suggesting an association between medical and dental health expenditures.[6,7] As there has been little research exploring the expenditures associated with medical and dental health services and their interrelationship, currently available information is very limited. According to the 2015 annual report of the Japan health insurance association, dental health expenditure made up 10.7% of the total health expenditure.[8] If a positive relationship between medical and dental health expenditures exists, the reduction of dental health expenditure could lead to the reduction of medical and total health expenditures. For an industrial company, such information would assist the management of healthcare-related expenses and the development of occupational health promotion policies.

The hypothesis to be tested in this study was that an increased dental health expenditure could also be associated with the inflated medical health expenditure. Therefore, the purposes of

[1]Department of Health Sciences, Saitama Prefectural University, Saitama, Japan; Department of Oral Health Promotion, Tokyo Medical and Dental University, Tokyo, Japan

[2,4]Department of Oral Health Promotion, Tokyo Medical and Dental University, Tokyo, Japan

[3]Dental Hospital, Tokyo Medical and Dental University, Tokyo, Japan

Corresponding Author: Masayuki Ueno, Department of Health Sciences, Saitama Prefectural University, Saitama, Japan; Department of Oral Health Promotion, Tokyo Medical and Dental University, Tokyo, Japan, Phone: +81-48-973-4752, e-mail: masayuki-ueno@spu.ac.jp

How to cite this article: Ueno M, Zaitsu T, *et al.* Relationship between Medical and Dental Health Expenditures of Industrial Workers. J Oral Health Comm Dent 2019;13(2):54–58.

Source of support: Research Fund of Clinical Study for Industrial Accident and Disease by the Japanese Ministry of Health, Labour and Welfare

Conflict of interest: None

this cross-sectional study were to describe features of annual health expenditure and to examine the relationship between medical and dental health expenditures using the electronic health insurance data of haulage workers, the so-called transport industry workers, in a health insurance association.

Materials and Methods

Data Collection

The health expenditure data were drawn from a total of 9,149 haulage workers aged 18–75 years, who belonged to a health insurance association in a metropolitan area in Japan. Workers who were younger than 18 years or older than 75 years were excluded from the analysis. Information about health expenditure from January through December in 2015 was collected using electronic health insurance claims that the health insurance company owned. The data reflected expenditure for the medical and dental health services the workers received. Since all the available data of eligible workers were intended to be used in the study, no sample size determination was not made.

The demographic variables used were age and gender. As health expenditure related variables, in-patient and out-patient fees as well as the corresponding pharmaceutical fees reported in the health insurance claims were aggregated to derive the total medical and dental health expenditures for the 12-month period. Medical health expenditure was matched and linked with dental health expenditure using an individually assigned identification number. Private patients' medical or dental treatment fees such as orthodontic treatments and any prosthetic appliance such as implants were excluded from the analysis. Currency conversion was done at the rate of 1 US dollar to 122.05 yen, the average rate in 2015.

The consent of usage of the health insurance claims data of workers was obtained from the health insurance association and companies belonging to the association. Ethical approval was granted by the Tokyo Medical and Dental University Ethics Committee (Approval number: D2016-054).

Statistical Analysis

Demographic characteristics of the study subjects were based on age group (18–39 years, 40–59 years, and 60–75 years) and gender. The proportions of subjects who used medical or dental services and mean and standard error (SE) of per capita medical or dental health expenditure by age group were calculated. Medical and dental health expenditures were adjusted for age and gender using an analysis of covariance. Linear trends were tested using the Mantel–Haenszel's Chi-square statistics for medical or dental utilization rate by age group and the Jonckheere–Terpstra test for mean medical or dental health expenditure by age group. Significant differences in the mean medical health expenditure between subjects who used or did not use dental services were assessed by the independent *t* test. Multiple comparisons for the mean medical health expenditure among the tertile of dental health expenditure or number of days of dental visits were analyzed using a Bonferroni method. All statistical procedures were implemented with the IBM® SPSS® 23.0 (IBM Japan Corp., Tokyo, Japan).

Results

Demographic Characteristics of Subjects

Table 1 shows the basic characteristics of the subjects. There were 9,149 subjects: 7,343 men and 1,806 women. The overall mean age was 43.94 (0.14 SE) years; men 44.83 (0.15 SE) years and women 40.33 (0.29 SE) years. Age group 18–39 years was 38.3% of the total, 40–59 years was 46.1%, and 60–75 years was 15.6%. Those in men were 35.8%, 46.6%, and 17.6% and in women were 48.6%, 43.9%, and 17.5%, respectively.

Utilization of Medical and Dental Services

Overall medical and dental services utilization rates were 77.4% and 42.0%; rate was significantly higher for medical services (p <0.001) (Table 2). The medical services utilization rates by age group were 73.0% in the 18–39 years age group, 76.9% in the 40–59 years, and 89.4% in the 60–75 years age groups. Dental services utilization rates by age group were 36.5% in 18–39 years, 43.3% in 40–59 years, and 51.5% in 60–75 years age groups. The medical services utilization rate was nearly double that of the dental services rate and significantly higher in every age group (p <0.001 for all age groups). For both medical and dental services utilization rates, there was a statistically significant increasing trend with age (p for trend <0.001 and p for trend <0.001).

Overall medical services utilization rates in subjects who used or did not use dental services were 85.2% and 71.7%, respectively. The medical services utilization rate was significantly higher in subjects who used dental services than among those who did not (p <0.001) (Table 3). The comparison by age group also showed that medical services utilization rates were significantly higher in subjects who used dental services than among those who did not (p <0.001 for all age groups). For both dental services users and nondental services

Table 1: Subjects by age group and gender

Age group, years	*Men, % (n)*	*Women, % (n)*	*Total, % (n)*
18–39	35.8 (2,627)	48.6 (878)	38.3 (3,505)
40–59	46.6 (3,422)	43.9 (792)	46.1 (4,214)
60–75	17.6 (1,294)	17.5 (136)	15.6 (1,430)
All subjects	100.0 (7,343)	100.0 (1,806)	100.0 (9,149)

Table 2: Proportion of subjects who used medical and dental services

Age group, years	*Health services utilization rate, % (n)*		*p value for proportional difference*
	Medical	*Dental*	
18–39	73.0 (2,560)	36.5 (1,278)	<0.001
40–59	76.9 (3,239)	43.3 (1,825)	<0.001
60–75	89.4 (1,278)	51.5 (737)	<0.001
All subjects	77.4 (7,077)	42.0 (3,840)	<0.001
p for trend	<0.001	<0.001	

Table 3: Proportion of subjects who used medical services by dental services use

Age group, years	*Medical services utilization rate, % (n)*		*p value for proportional difference*
	Dental services users	*Nondental services users*	
18–39	81.4 (1,040)	68.3 (1,520)	<0.001
40–59	84.2 (1,536)	71.3 (1,703)	<0.001
60–75	94.2 (694)	84.3 (584)	<0.001
All subjects	85.2 (3,270)	71.7 (3,807)	<0.001
p for trend	<0.001	<0.001	

users, a statistically significant increasing trend of utilization rate with age was shown (p for trend <0.001 and p for trend <0.001).

Per Capita Medical and Dental Health Expenditures

Table 4 presents the per capita medical and dental health expenditures by age group. Overall, these expenditures in all subjects were $1,052.61 and $161.74 per capita, respectively. Per capita medical health expenditures by age group were $467.63 in the 18–39 years group, $1,060.04 in the 40–59 years group, and $2,464.56 in the 60–75 years group. Per capita dental health expenditures by age group were $123.71, $172.31, and $223.79, respectively. Both per capita medical and dental health expenditures significantly increased with age (p for trend <0.001 and p for trend <0.001).

Overall per capita medical and dental health expenditures in subjects who used health services were $1,360.80 and $385.35, respectively. Per capita medical health expenditures by age group were $647.41 in subjects 18–39 years old, $1,377.84 in 40–59 year olds, and $2,746.63 in 60–75 year olds. Per capita dental health expenditures by age group were $344.56, $397.50, and $426.00, respectively, in the same age groups. Both per capita medical and dental health expenditures also had significant increases with age (p for trend <0.001 and p for trend <0.001).

Per Capita Medical Health Expenditure According to Dental Services Utilization

Overall per capita medical health expenditure in subjects who used dental services was $1,219.12, which was significantly higher than $932.18 in those who did not (p <0.001). Per capita medical health expenditures in subjects who used dental services by age group were $571.75, $1,217.83, and $2,850.28 in the three age groups and in those who did not use dental services were $419.65, $937.15, and $2,024.62, respectively (Table 5). Per capita medical health expenditures in both dental services users and nondental services users increased significantly with age (p for trend <0.001 and p for trend <0.001). Significant mean differences in the per capita medical health expenditure by the use of dental services were found in the 40–59 and 60–75 years age groups ($p = 0.036$ and $p = 0.010$).

Among subjects who used dental services, per capita medical health expenditure by the tertile of per capita dental health expenditure (<$170.27, $170.27–$400.99 and >$400.99) or number of days of dental visits (1–3 days, 4–7 days, and >7 days) were $1,414.98 ($n = 1,280$), $1,417.93 ($n = 1,281$), and $1,124.57 ($n = 1,279$) or $1,381.27 ($n = 1,454$), $1,307.70 ($n = 1,113$), and $1,258.48 ($n = 1,273$), respectively (Table 6). No significant differences in per capita medical health expenditure were detected by the tertile of dental health expenditure or number of days of dental visits.

Discussion

This cross-sectional study used the data drawn from health insurance claims of national health insurance; therefore, patients' private fees for care were not included in the analysis. Japanese national health insurance covers both medical and dental care, and dental care covers most restorative and surgical treatments such as fillings, endodontics, crowns, bridges, dentures, and extractions. According to the Survey on Economic Conditions in Health Care in 2015,[9] the proportion of dental expenses provided by the national health insurance is about 85.8% of the total dental health expenditure. The proportion of expenses for medical healthcare borne by private fees only was 1.3% in 2015.[3] Further, the mean per capita medical and dental health expenditures in the sample were close to those reported in the national health expenditure report in 2015.[3] These statistics suggest that our data are a good estimate of Japanese health expenditure.

The findings show a positive relationship between medical and dental health expenditures. Both medical services use and medical health expenditure increased with age. The same positive gradient in dental services use and dental health expenditure by

Table 4: Per capita medical and dental health expenditures (US $) in all subjects and those who used health services, mean† (SE)

	Health expenditure, mean (SE)			
	All subjects		*Health services users*	
Age group, years	*Medical*	*Dental*	*Medical*	*Dental*
18–39	467.63 (65.11)	123.71 (6.48)	647.41 (85.95)	344.56 (14.43)
40–59	1,060.04 (59.19)	172.31 (5.89)	1,377.84 (75.99)	397.50 (12.01)
60–75	2,464.56 (102.12)	223.79 (10.16)	2,746.63 (121.88)	426.00 (19.07)
All subjects	1,052.61 (40.14)	161.74 (3.99)	1,360.80 (51.34)	385.35 (8.27)
p for trend	<0.001	<0.001	<0.001	<0.001

†Adjusted for age and gender

Table 5: Per capita medical health expenditure (US $) in subjects who used and who did not use dental services, mean† (SE)

	Medical health expenditure, mean (SE)		*p value for mean difference*
Age group, years	*Dental services users*	*Nondental services users*	
18–39	571.75 (69.33)	419.65 (52.47)	0.081
40–59	1,217.83 (89.44)	937.15 (78.14)	0.036
60–75	2,850.28 (222.18)	2,024.62 (229.13)	0.010
All subjects	1,219.12 (62.32)	932.18 (52.91)	<0.001
p for trend	<0.001	<0.001	

†Adjusted for age and gender

Table 6: Per capita medical health expenditure (US $) by the tertile of dental health expenditure and number of days of dental visits, mean† (SE)

Tertile of dental health expenditure			*Tertile of number of days of dental visits*		
<$170.27	*$170.27–$400.99*	*>$400.99*	*1–3 days*	*4–7 days*	*>7 days*
1,414.98 (124.70)	1,417.93 (124.23)	1,124.57 (124.76)	1,381.27 (116.99)	1,307.70 (133.39)	*1,258.48 (125.34)*

†Adjusted for age and gender

age was also observed. Previous studies found a similar association among dental services use, dental health expenditure, and age.[10–13] A Japanese web-based study showed that the frequency of dental visits and dental treatment increased with age.[13] Middle-aged or older adults were reported to have greater dental health expenditure than younger adults.[11,12] Australian people who visited a dental provider more than once a year on average had a higher dental health expenditure than those who visited less often, and a poorer oral health status was related with higher dental health expenditure.[10] These findings imply that the need for dental services might increase due to poorer oral health conditions with age, leading to increased dental health expenditure. Having dental health insurance has also been suggested to be associated with dental visits and dental services provision and thus dental health expenditure, in other countries,[12,14] but the effect of health insurance could be minimal because of the universal health insurance system in Japan.

Medical health expenditure in subjects who did not use dental services was lower than those who used the services and the amount of dental health expenditures or the frequency of dental services use did not influence the medical health expenditure. The difference of medical health expenditure by dental services use expanded in the middle and old age groups. It is well known that oral health is closely linked with general health.[15–19] People who have good oral health usually have good general health, and the subjects in our study who did not use dental services were also less likely to use medical services. A significant relationship between the subjective assessment of oral health and medical health expenditure has been reported in a previous study. Since people with good subjective oral health were considered to have good general health, they were less likely to use medical services and had lower medical expenses as a consequence.[20]

Periodontal disease has also been ascribed to the increase in medical health expenditure. People with severe periodontitis incurred higher medical health expense, probably due to the deterioration of general health caused by periodontal diseases.[18,21] The difference in medical health expenditure by dental services use observed in subjects aged 40 years or older in this study might partially be due to the increased prevalence of periodontitis. The number of teeth present was another important factor associated with medical health expenditure; people with fewer teeth incurred greater medical health expenditure.[22,23] However, the absence of information about oral health status makes it difficult to determine whether subjects used dental services less because they had no dental problems or, despite having poor dental condition, they had other reasons for avoiding dental care.

This study is subject to a couple of other limitations. First, since details of the dental care provided were not available, it was not possible to identify the type of dental services responsible for the expenditure. Second, the study used only the data of insured workers in a health insurance association. Inclusion of their family members' data would have given a more complete picture.

Within such limitations, the present findings suggest that oral health is an important contributor to health expenditure. Although dental health expenditure is a small proportion of total health expenditure, a reduction of dental health expenditure can contribute to reducing the economic burden of healthcare. Further, an improvement in oral health might bring benefits not only in terms of reduced health expenditure but also increase labor productivity by virtue of better general health.

A workplace is considered a suitable place for conducting oral health promotion activities, because many workers spend much time there. Several studies have reported that workplace oral health promotion activities contribute to reducing healthcare expenses and are cost-beneficial for employers.[6,24,25] Annual oral examinations and tooth brushing instruction in the workplace have been demonstrated to be beneficial for preventing dental diseases.[26] Prevention of dental diseases, periodontal disease in particular, requires coordinated efforts from various sections.[27] Most Japanese adults have varying levels of periodontal disease, even though it is preventable. Unlike medical examinations, dental examinations are rarely undertaken in the workplace. Dental examination with accompanying health education to provide basic information about periodontal disease and risk factors, including smoking, should be offered to all workers as a part of the health examination.

Conclusion

Health insurance claims can provide an accurate and reliable source of health expenditure information. Additional analysis of health expenditure with linked information about clinical oral status and detailed service type needs to be conducted to confirm current findings on the positive relationship between medical and dental health expenditures and to reveal dental conditions or treatment procedures associated with health expenditure of industrial workers.

Acknowledgment

This study was financially supported by the "Research Fund of Clinical Study for Industrial Accident and Disease" (Grant No. 14020101-01 and 170501-01) from the Japanese Ministry of Health, Labour and Welfare. The authors are deeply grateful to staff members of ai-Health Corp for their generous cooperation and support.

References

1. Ikegami N, Yoo BK, et al. Japanese universal health coverage: evolution, achievements, and challenges. Lancet 2011;378(9796): 1106–1115. DOI: 10.1016/S0140-6736(11)60828-3.
2. OECD. Health expenditure and financing 2017. Available from: URL: http://stats.oecd.org/Index.aspx?DataSetCode=SHA 2017.
3. Ministry of Health, Labour and Welfare. National health expenditures in fiscal year 2015. Available from: http://www.mhlw.go.jp/toukei/saikin/hw/k-iryohi/15/dl/kekka.pdf.

4. Ueno M, Takeuchi S, et al. Association between diabetes mellitus and oral health status in Japanese adults. Int J Oral Sci 2010;2(2):82–89. DOI: 10.4248/IJOS10025.
5. Linden GJ, Herzberg MC, et al. Periodontitis and systemic diseases: a record of discussions of working group 4 of the joint EFP/AAP workshop on periodontitis and systemic diseases. J Periodontol 2013;84:S20–S23. DOI: 10.1902/jop.2013.1340020.
6. Ichihashi T, Muto T. Effectiveness of worksite dental health promotion activities in terms of dental and medical expenses and number of visits for treatment. J Dent Health 2001;51:168–175.
7. Takeuchi K, Sato Y, et al. Associations of oral health status and dental health service utilization with dental and medical expenditures. J Dent Health 2017;67:160–171.
8. Japan Health Insurance Association. Annual report in fiscal year 2015. Available from: https://www.kyoukaikenpo.or.jp/g7/cat740/sb7200/sbb7200/270407.
9. Ministry of Health, Labour, and Welfare. Survey on Economic Conditions in Health Care in 2015. Available from: http://www.mhlw.go.jp/bunya/iryouhoken/database/zenpan/jittaityousa/dl/20_houkoku_iryoukikan.pdf.
10. Teusner DN, Brennan DS, et al. Individual dental expenditure by Australian adults. Aust Dent J 2013;58(4):498–506. DOI: 10.1111/adj.12108.
11. Sivaneswaran S, Taylor R, et al. Cost of dental services provided in private general practice for an insured population in New South Wales, Australia. Comm Dent Health 2000;17(4):246–253.
12. Brennan DS, Spencer AJ, et al. Insurance status and provision of dental services in Australian private general practice. Comm Dent Oral Epidemiol 1997;25(6):423–428. DOI: 10.1111/j.1600-0528.1997.tb01733.x.
13. Ando Y, Ishida T, et al. The status of routine dental visits by web-based survey in Japan. J Dent Health 2012;62(1):41–52.
14. Elstad JI. Dental care coverage and income-related inequalities in foregone dental care in Europe during the great recession. Comm Dent Oral Epidemiol 2017;45(4):296–302. DOI: 10.1111/cdoe.12288.
15. Azarpazhooh A, Leake JL. Systematic review of the association between respiratory diseases and oral health. J Periodontol 2006;77(9):1465–1482. DOI: 10.1902/jop.2006.060010.
16. Östberg AL, Bengtsson C, et al. Oral health and obesity indicators. BMC Oral Health 2012;12:50. DOI: 10.1186/1472-6831-12-50.
17. Ueno M, Izumi Y, et al. Prediagnostic plasma antibody levels to periodontopathic bacteria and risk of coronary heart disease. Int Heart J 2012;53(4):209–214. DOI: 10.1536/ihj.53.209.
18. Ide R, Hoshuyama T, et al. The effect of periodontal disease on medical and dental costs in a middle-aged Japanese population: a longitudinal worksite study. J Periodontol 2007;78(11):2120–2126. DOI: 10.1902/jop.2007.070193.
19. Ericsson JS, Ostberg AL, et al. Oral health-related perceptions, attitudes, and behavior in relation to oral hygiene conditions in an adolescent population. Eur J Oral Sci 2012;120(4):335–341. DOI: 10.1111/j.1600-0722.2012.00970.x.
20. Harada E, Moriya S, et al. Relationship between subjective assessment of oral health and medical expenses in community-dwelling elderly persons. Gerodontology 2012;29(2):e246–e252. DOI: 10.1111/j.1741-2358.2011.00459.x.
21. Sato M, Iwasaki M, et al. Association between periodontitis and medical expenditure in older adults: a 33-month follow-up study. Geriatr Gerontol Int 2016;16(7):856–864. DOI: 10.1111/ggi.12569.
22. Kanda M, Ueda H, et al. A three-year follow-up study of the relationship among the numbers of present teeth, the loss of teeth and medical expenditure in the elderly. Jpn J Gerodontol 2008;23:132–139.
23. Tsuneishi M, Yamamoto T, et al. Association between number of teeth and medical and dental care expenditures - Analysis using the receipt and health checkup information database in Japan. Jpn J Dent Prac Admin 2016;51:136–142.
24. Ichihashi T, Muto T, et al. Cost-benefit analysis of a worksite oral-health promotion program. Ind Health 2007;45(1):32–36. DOI: 10.2486/indhealth.45.32.
25. Ide R, Mizoue T, et al. Evaluation of oral health promotion in the workplace: the effects on dental care costs and frequency of dental visits. Comm Dent Oral Epidemiol 2001;29(3):213–219. DOI: 10.1034/j.1600-0528.2001.290307.x.
26. Zaitsu T, Kanazawa T, et al. Relationships between occupational and behavioral parameters and oral health status. Ind Health 2017;55:381–390. DOI: 10.2486/indhealth.2017-0011.
27. Nair AR, Prashant GM, et al. Dental education: challenges and changes. J Oral Health Comm Dent 2017;11(2):34–37.

healthcare

MDPI

Review

The Oral Healthcare System in Japan

Takashi Zaitsu, Tomoya Saito and Yoko Kawaguchi *

Department of Oral Health Promotion, Graduate School of Medical and Dental Sciences, Tokyo Medical and Dental University, Tokyo 113-8510, Japan; zaitsu.ohp@tmd.ac.jp (T.Z.); saito.ohp@tmd.ac.jp (T.S.)
* Correspondence: yoko.ohp@tmd.ac.jp; Tel.: +81-3-5803-5475

Received: 15 June 2018; Accepted: 6 July 2018; Published: 10 July 2018

Abstract: This paper describes the present Japanese oral healthcare system and outlines the future challenges and perspectives for Japan. Japan has developed a system for providing high-quality and appropriate health care efficiently through a universal health insurance system which has been in operation since 1961. This health insurance covers most restorative, prosthetic and oral surgery treatment. Therefore, all people can receive dental treatment at a relatively low cost, with the same fees applying throughout the nation. In Japan, public oral health services are provided by the local governments according to the life stage of their populations. These services are mainly conducted by private dental practitioners under contracts with local governments. National oral health data shows that the oral health of the Japanese population has improved over the last several decades. Future challenges and perspectives for Japanese dentistry include: tackling the regional differences in oral health, decreasing the cost of health expenditure, establishment of sustainable emergency oral healthcare services in times of disaster, and the development a new tele-dental system for remote areas without access to dental professionals.

Keywords: oral health; healthcare system; dental workforce; public health insurance; oral health status; Japan

1. Characteristics of Japan

Japan is located in Northeast Asia and is composed of four main islands and 6848 smaller islands. The land area is 378,000 km^2 and the capital city is Tokyo [1]. Japan's population is over 126 million and most Japanese reside in densely populated urban areas [2]. In 2016, the national gross domestic product (GDP) was 4.937 trillion United States dollars (US$) and it is the world's third largest economy [3]. Health expenditure is around 10% of GDP. Japan has developed a system for providing high quality and appropriate healthcare efficiently in its communities through a universal health insurance system which has been in operation for more than 50 years.

2. Dental Workforce

Three regulatory professional dental licenses are issued in Japan: dentists, dental hygienists, and dental technicians. For each profession, independent legislation exists: the "Dentists Act", the "Dental Hygienists Act", and the "Dental Technicians Act". These acts describe and regulate the professions' duties, roles, and ethics. There is no licensing system for dental chairside assistants. A survey of practicing healthcare professionals is conducted every two years by the Ministry of Health, Labor and Welfare (MHLW).

2.1. Dentists

In 2016, the total number of dentists was 104,533 [4]. The number of female dentists was 24,344, 23.3% of the dental workforce. The dentist ratio per 100,000 people is 82.4 practitioners, and, as in

many nations, the distribution is unequal. The highest dentist to population ratio is in Tokyo (118.2), and the lowest is Fukui Prefecture (54.7); more than twice the regional difference of dentist distribution is observed. There are 68,730 dental facilities (mainly private dental clinics) in total throughout Japan.

Table 1 shows the number and proportion of dentists according to their roles or places of practice. More than 97% of the dentists (n = 101,551) engage in providing dental treatment at private or public dental institutions. The number of public dentists who engage in full-time administration work is only 348 (0.3%). Therefore, in Japan, most of the public dental activities are conducted by private dentists on a part-time basis. The "Dentists Act" describes the duties of dentist as follows: "*Dentists shall take charge of dental treatment, provide oral health guidance, and contribute to the improvement and the promotion of public health in order to secure a healthy life for the people*".

Table 1. Numbers of dentists in Japan (2016).

Practicing Places	Number	%
Dental practice	**101,551**	**97.1%**
Private office (employer)	(59,482)	(56.9%)
Private office (employed)	(29,684)	(28.4%)
Hospital	(3,077)	(2.9%)
Education institute	(9,308)	(8.9%)
Research institute	**1195**	**1.2%**
Administration/public service	**348**	**0.3%**
Others	**1430**	**1.4%**
Total	**104,533**	**100.0%**

For example, a local government municipality contracts with a private dental practitioner to carry out the role of a school dentist. Local government pays the contracting dentist as a school dentist, and the dentist is responsible for the performance of school oral health activities, usually in a part-time capacity. This public and private mixed dental performance is one of the unique characteristics of the Japanese oral healthcare system.

In Japan, there are 29 dental educational institutions: eleven national, one local governmental, and seventeen private universities. The total enrolment in the 29 dental schools in 2017 was 2720 [5]. Dental education is based on a model core curriculum. For quality assurance of the education conducted in each dental school, computer based tests (CBTs) and objective structured clinical examinations (OSCEs) are performed during the undergraduate course before dental students start clinical training. After six years of education, all students have to take a national board dental examination. The MHLW manages this national board examination and regulates the issuing of dental licenses. The pass rate of this national board examination is relatively low, around 65–70%. In 2018, 3159 dental students took the examination and 2039 passed (64.5%) [6].

Without passing this examination, a dental graduate cannot get a dental license. Further, after successfully getting a dental license, all new graduates participate in the compulsory residency clinical training program for more than one year. Following completion of a residency program, the graduate is free to choose the career path to follow as a dentist. Most prefer further study through postgraduate university courses, or to work at hospitals to improve their academic knowledge and technical skills for several years before entering private practice.

2.2. Dental Hygienists

The number of active dental hygienists in Japan in 2016 was 123,831 [7]. The roles of dental hygienists are prevention of oral diseases, oral health education, and chairside treatment assistance. About 90% of dental hygienists (n = 112,211) work in largely private dental clinics, and about 5% (n = 6259) work in hospitals. The number of dental hygienists working in public sectors (i.e., prefectures,

municipalities, and health centers) is 2754 (2.2%), and teaching staff in education institutes is 873 (0.7%).

In total there are 166 dental hygienist education institutes. Most of these are 3-year-period vocational schools. Eleven schools however provide a 4-year-period university bachelor degree programs in the universities. Hygienists also need a national license, and the proportion of dental hygienists who pass the national examination is high and around 95%. Every year around 6500 new dental hygienists are produced.

2.3. Dental Technicians

In 2016, the total number of active dental technicians was 34,640 [7]. Dental technicians make dental prostheses, based on dentists' prescriptions. They are not allowed to take impressions directly from the patients. The number of dental technicians working in dental laboratory offices is 24,972 (72.1%) and working in hospitals or dental clinics is 9166 (26.5%).

There are 54 dental technicians' schools. Most of the schools provide 2-year-period education. Three universities have 4-year-period bachelor degree programs for dental technicians. After graduation, a pass in the national board examination is necessary to get a license to practice as a dental technician.

3. Public Health Insurance System in Japan

Japan is called a welfare country and public healthcare systems are well developed. Japan introduced a universal health insurance system for the entire population in 1961. It covers almost all medical and dental treatment and pharmacy care required by the population [8]. People can receive treatment at a relatively low cost, and the same fee is applied throughout the nation. In 2000, in response to the increasing aging of the population, Japan initiated a "long-term care insurance" to deliver health and welfare services for the elderly.

3.1. Health Insurance

Almost all practicing doctors and dentists are registered in the public national health insurance scheme as insured doctors, and provide treatment according to a fee-for-service system. In general, after receiving treatment by an insured doctor or dentist, patients pay 30% of the total cost to the clinic or hospital. The remaining 70% of the cost is paid to the clinical institutions by the insurance agency approximately two or three months later, based on the submitted fee claims. Therefore, the cost of insurance treatment provided is the same, throughout the nation, fixed by the fee schedule. There is no price difference between private and public institutions.

There are certain exemptions. Low income earners do not necessarily have to pay the cost directly to the clinic. In addition, elderly persons may pay directly but at a reduced rate (10–20% of the cost) according to their income. Moreover, the Japanese health insurance system has a reimbursement scheme for patients who receive costly treatment services such as cardiac surgery, where the patient's payment over a certain amount is refunded later. Under this health insurance system, Japanese people can receive high-quality health services at a relatively low cost, both in public and private institutions. The fee schedule is reviewed every two years and inclusions/exclusions of each treatment option within the insurance scheme is reviewed by an expert committee established through the MHLW.

Dental services under the national health insurance system are available for most restorative, prosthetic, and oral surgery treatment. They include services such as fillings, endodontic treatment, crowns, bridges, dentures, and extractions. Higher cost items (e.g., gold crowns and bridges, metal plate dentures, implants, and orthodontic treatment) are excluded. Preventive services are also excluded, as the current health insurance system only covers treatments for existing diseases. Delivery of dental treatment services to bed-ridden people at home or in aged care centers by dentists are also covered in this public health insurance scheme.

3.2. Long-Term Care Insurance

To deal with the rapidly increasing aging population, in April 2000 Japan introduced the "long-term care insurance system". This system provides various long-term care services in a comprehensive and uniform way for all eligible persons, so that they can lead independently as long as possible. The managing insurer of the long-term care insurance system is the municipality (local government), and the main eligibility criterion for those covered by the scheme is that they are aged 65 years or over.

Based on the care plan established by a patient's care manager, the patient contracts the service provider to make necessary arrangements so that the individual can use in-home care services or community-based preventive services. Facilities are also available for those in the aged care institutions. To use long-term care services, the long-term care insurance covers 90% of the service-related costs, while the remaining 10% of costs are paid by the user.

The services provided under this scheme include home visit nursing, day-care or short-stay medical service, etc. In-home healthcare guidance, doctors, nurses, dentists, dental hygienists, or other medical professionals visit the homes of users who have difficulty in making a hospital visit and provide health maintenance instruction and care according to the patient's medical and physical condition or environment.

After its launch, there was a rapid increase in the use of the long-term care scheme, especially the home care service. The long-term care insurance system has now come to have an important role as a system designed to assure an affordable and comfortable life for elderly people and their family members.

4. Life Course Oral Healthcare System

According to each life stage of the population, many policies regulate the regional health services and describe the accountability of governments, related organizations and populations in Japan. Therefore, oral health services are provided as a part of the general health service, and the programs are based on the health related laws and acts (Table 2).

Table 2. Health related law and acts in Japan.

Law/Act	Main Target Population
Maternal and Child Health Act (1965)	Infants, preschool children, pregnant women
School Health and Safety Act (1958)	Schoolchildren
Industrial Safety and Health Act (1972)	Workers
Act on Securing Medical Care for Elderly People (2008)	Elderly
Community Health Act (1947)	All population
Health Promotion Law (2003)	All population
Act on the Promotion of Dental and Oral Health (2011)	All population

In 2017, there were a total of 479 health centers throughout Japan. Among them, 363 centers were established in 47 prefectures, 93 centers in 74 designated cities, and 23 centers within the 23 special Tokyo wards. These health centers take the role of the central administrative management office for the regional public health services.

In 2000, a National Health Promotion Campaign for the 21st century, "Healthy Japan 21", was proposed to prevent lifestyle-related diseases (non-communicable diseases (NCDs) such as cancers, cardiovascular diseases, diabetes, and chronic obstructive pulmonary disease). "Healthy Japan 21" set up national goals for the year 2010 in nine specific fields for improving lifestyles, reducing risk factors, and decreasing diseases. Oral health is one of the NCD conditions identified, and specific goals were set up to prevent tooth loss. The "Health Promotion Act" was enacted in 2003 and it supported the development of health promotion activities throughout the nation.

After evaluation of the achievements on "Healthy Japan 21", the second term of "Healthy Japan 21" was initiated from 2013. Its basic goals were as follows:

- Extension of healthy life expectancy and reduction of health disparities
- Prevention of onset and progression of life-style related diseases
- Maintenance and improvement of mental and physical functions necessary for social life
- Establishment of a healthy and supportive social environment

Specific goals for the year 2022 are indicated in these six fields, and include; (1) nutrition and dietary habits; (2) physical activity and exercise; (3) rest; (4) alcohol use; (5) tobacco use; and (6) oral health. Table 3 shows the oral health goals set out in the second "Healthy Japan 21".

Table 3. Goals related to oral health in the second "Healthy Japan 21".

Indicators	Baseline Data	Goals
1. Maintenance and improvement of oral function		
Increase in proportion of persons aged 60–69 years with good mastication function	73.4% (2009)	80% (2022)
2. Prevention of tooth loss		
A. Increase in the proportion of 80-year-old persons with 20 or more teeth	25% (2005)	50% (2022)
B. Increase in the proportion of 60-year-old persons with 24 or more teeth	60.2% (2005)	70% (2022)
C. Increase in the proportion of 40-year-old persons with no missing teeth	54.1% (2005)	75% (2022)
3. Prevention of periodontal disease		
A. Decrease in the proportion of persons in their 20s with gingivitis	31.7% (2009)	25% (2022)
B. Decrease in the proportion of persons in their 40s with progressive periodontitis	37.3% (2005)	25% (2022)
C. Decrease in the proportion of persons in their 60s with progressive periodontitis	54.7% (2005)	45% (2022)
4. Prevention of dental caries		
A. Increase in the number of prefectures where >80% of 3-year-old children are caries free	6 prefectures (2009)	23 prefectures (2022)
B. Increase in the number of prefectures where 12-year-old children have fewer than 1 DMFT (decayed, missing and filled permanent teeth)	7 prefectures (2011)	28 prefectures (2022)
5. Regular dental check-up		
Increase in the proportion of persons who received a dental check-up during the past year	34.1% (2009)	65% (2022)

4.1. Preschool Children

Pregnant women receive a "maternal and child health handbook" from the municipal government for each child. Health care professionals record the health check-up data during pregnancy and after the child is born and up to six years of age. The handbook covers the child's health condition and immunization records. Mothers also record the child's growth and health concerns in the handbook by themselves. Therefore, healthcare professionals in hospitals or health centers can refer to the records within this book, as mothers always carry this book with the child.

In Japan, national programs for preschool children are conducted by local government free of charge. They include physical, medical, and dental examinations of all children. The collected data are sent to the MHLW and published every year.

(1) Health check-ups for 3-year-old children (since 1961)

(2) Health check-ups for 18-month-old children (since 1977)

Private practitioners (i.e., doctors and dentists) contribute to the conduct of these examinations in turns at the community health centers. This means they become part-time "public doctors/dentists". Medical or dental treatment is not provided at the health centers and only preventive services are

available. After the oral examination, oral health education is offered to mothers and children by dental hygienists, either in a small group or individually. Education covers oral health related habits, nutritional consultation, and brushing instructions. Topical fluoride application for caries prevention and silver diamine fluoride application for caries arrest is also provided to those who require this care, at a reasonable fee.

4.2. Schoolchildren

In Japan, every public primary, junior, and senior high school has an appointed school dentist. In 2014 the total number of school dentists holding such positions was 44,600. The school dentist is responsible for the performance of school-based oral health activities, usually in a part-time capacity, because s/he may work also as a dental practitioner in the area.

The roles of school dentists are described in the "School Health and Safety Act" and include the conduct of an oral health examination at least once a year on each child at school, and contributing to implementing the school's oral health education. According to the standard procedures and guidelines, school dentists check the oral health status of all the students for conditions such as dental caries, malocclusion, gingival status, dental plaque, and temporomandibular disorders.

If oral health problems are detected in schoolchildren, the school dentist recommends to the child and parents that they should seek dental treatment under the public health insurance scheme, described before. School dentists do not provide dental treatment in the schools at all. Schoolchildren can receive comprehensive dental care at any public or private dental offices.

In addition, oral health education is conducted by the school dentist, or the dental hygienist, in cooperation with the nursing teachers and the classroom teachers. Oral health education programs usually include prevention of dental caries and gingivitis, but the content of oral health education program depends on the individual school's curriculum and timetable.

School health surveys are conducted every year, and the data are published by the Ministry of Education.

4.3. Adulthood

According to the "Industrial Safety and Health Act", employers have to provide annual medical check-ups for all the employees in any company which has more than 50 workers. On the other hand, the Act does not include a duty for dental check-ups for employees. Only the workers who engage in jobs in acid-producing environments have to receive special dental check-ups every six months for the prevention and early detection of tooth erosion. Some companies provide good oral health promotion programs for their employees, but the number of these companies is very small.

According to the "Health Promotion Law", local governments (municipalities) are to provide free or low-cost "periodontal disease examination programs" for their adult population by way of contracts with private dental practitioners. However, the rate of participation for the eligible persons in these programs is very low, about 10–15%.

Therefore, in Japan, the oral health program for the adult population is based on an individual's personal responsibility for care, self-support and self-motivation. Many dental facilities and a public insurance system contribute to easy access for dental treatment for adults, but the proportion of regular (check-up or preventive) visits to dental clinics is not high. This adult population group should be encouraged to visit a dentist and dental clinic regularly for prevention of dental diseases.

4.4. Elderly

Japan is known as a "super aging society". The age structure (2016) shows that 12.4% of the population is aged 0–14 years, 60.3% is aged between 15 and 64 years, and just over a quarter of the population, 27.3%, is aged 65 years and older [9]. Life expectancy at birth (2016) is 81.0 years for males, 87.1 years for females, and 84.2 years for all [10].

This figure shows that Japan is one of the longest life expectancy countries in the world. Therefore, over the past several decades, Japan has become increasingly concerned at the pace of population aging and the challenges this brings to dealing with changing social systems.

Dentistry is no exception. In 1989, the Ministry of Health and the Japan Dental Association advocated a national oral health campaign, "8020 (Eighty-Twenty) campaign". The first part "80" signifies the average life expectancy for Japanese people at that time, and the second part "20" indicates the critical number of natural teeth to maintain eating and chewing function for life. Previous studies in Japan show that keeping 20 or more natural teeth is considered to be a simple and adequate threshold for maintaining good masticatory ability for eating almost any kinds of Japanese food items, which vary from soft texture food to hard texture food [11].

The objective of this campaign is to inform the general population of the importance of retaining 20 or more natural teeth until 80 years of age to maintain satisfactory masticatory abilities. The number of missing teeth increases as people get older. The concept of "8020" is to ensure all Japanese people are able to enjoy a healthy diet and a good social life by preventing tooth loss that leads to masticatory dysfunction.

This national campaign has led to many projects and research studies regarding the impact of oral health on general health and quality of life. Many studies report that improvements in oral health and masticatory function contribute to the prevention of aspiration pneumonia and to the maintenance or recovery of activities of daily living [12]. In March 2015, the Japan Dental Association hosted the world congress with co-sponsorship by the World Health Organization (WHO), and the "Tokyo Declaration on Dental Care and Oral Health for Healthy Longevity" was drafted [13].

The "8020" campaign, a community and clinic-based initiative started in 1989, has contributed to a dramatic improvement in the oral health of older people in Japan. This was followed by an accumulation of evidence, culminating in oral health being integrated into health policy in the form of the "Act on the Promotion of Dental and Oral Health" in 2011, for the purpose of oral disease prevention and general health improvement.

Oral functional impairments reduce chewing efficiency, influence nutritional deficiencies, and deter the elderly from the pleasure of eating and communication. Oral functional enhancement, along with dental prostheses and better oral hygiene has been reported to be effective in preventing swallowing difficulties in the dependent elderly. From the perspective of prevention and health promotion, it is considered to be more effective to implement interventions before health problems and functional disturbances have occurred. Therefore, at community health centers, dental professionals educate the independent elderly about the importance of oral function promotion and provide oral function promotion programs such as "tongue exercise" or "salivary grand massages".

5. Oral Health Status

In Japan, national oral health surveys have been conducted every six years from 1957 to 2011 by the MHLW. Recently, the eleventh survey was conducted in 2016, the interval between surveys being changed from six to five years. According to data from these surveys, the changing patterns of oral health status of Japanese population can be well described.

5.1. Oral Health Status of Children

For deciduous teeth, improvement is obvious. Figure 1 shows the trends in prevalence of dental caries in deciduous teeth for one- to five-year-old children. In 1957, the prevalence of dental caries in 5-year-olds and 3-year olds were 94.5% and 81.8%, respectively. In 2016, these values decreased to 39.0% and 8.6%, respectively. Figure 2 shows the changing pattern of the status of deciduous teeth from 1957 to 2016 for one- to 14-years-old children. In 1957, most carious teeth were untreated, and 5-year-olds had on average 8.7 decayed teeth (dt). As time went on, children could access and receive dental treatment, and the number of filled teeth (ft) increased. Also the number of healthy teeth increased remarkably in all ages. These figures show the dental caries status of deciduous teeth

in Japanese children improved rapidly. Figure 3 shows the changing pattern of decayed, missing and filled permanent teeth (DMFT) of 12-year-olds from national School Oral Health Survey data. In 1985, 12-year-olds had on average 4.6 DMFT, and this gradually decreased year by year and it became 0.8 DMFT in 2016 [14].

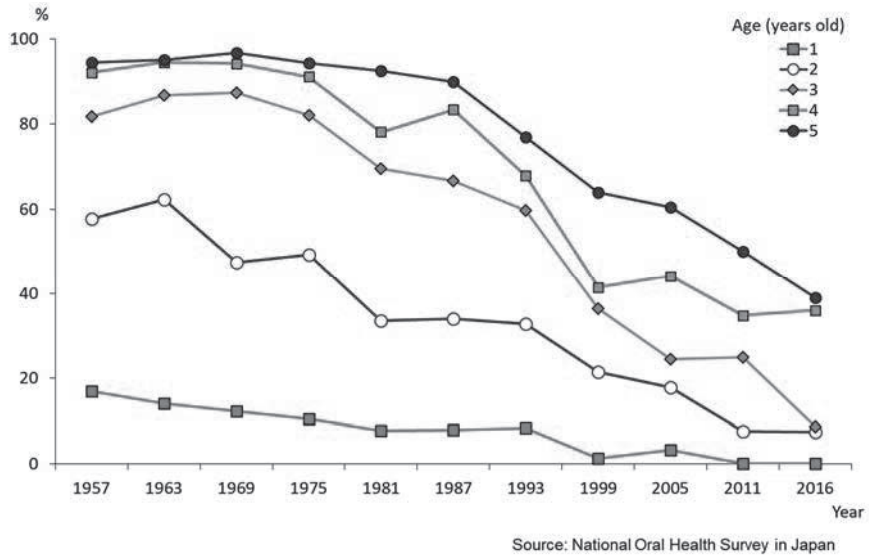

Figure 1. Trends in prevalence of dental caries, deciduous teeth (1957–2016) [15].

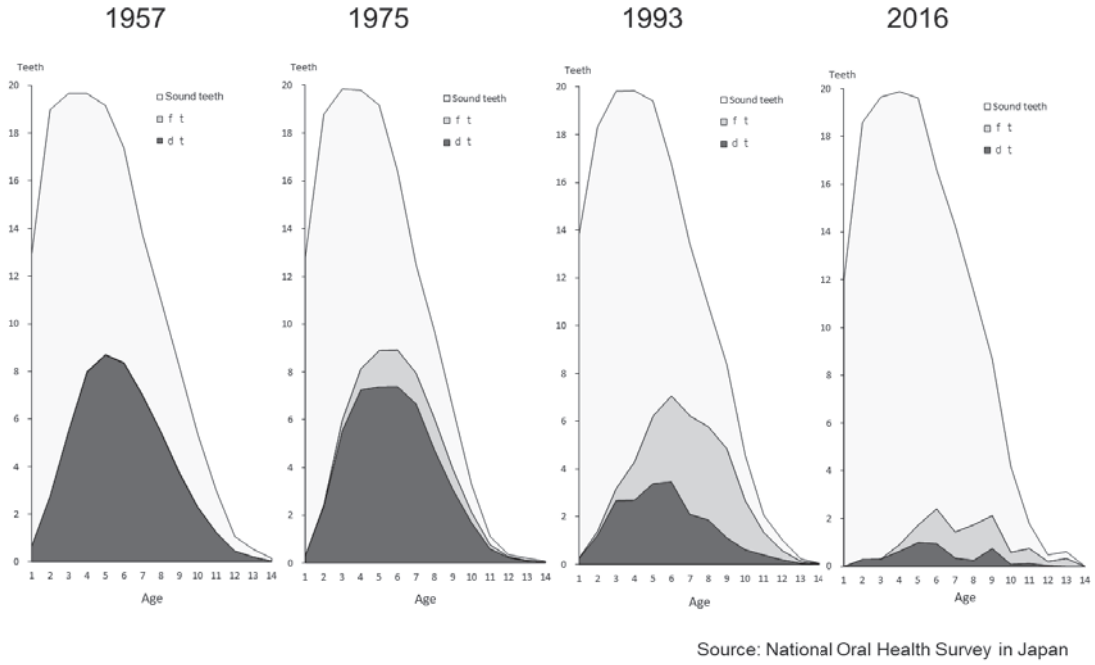

Figure 2. Changing pattern of deciduous teeth (1957–2016) [15].

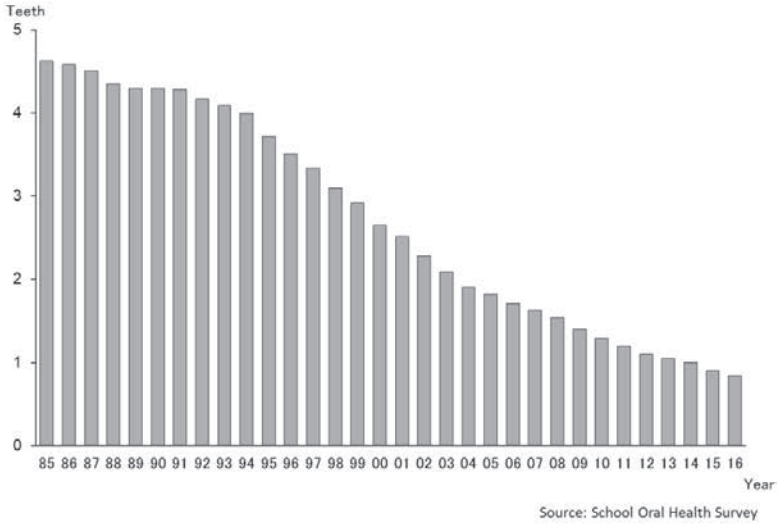

Figure 3. DMFT of in 12-year-olds (1985–2016) [14].

5.2. Oral Health Status of Adults

Figure 4 shows the mean number of teeth present for adults (35–44 years age group) and older persons (65–75 years age group) over a 60-year period from 1957 to 2016. For the 35–44-year age group, the number of natural teeth present increased from a mean of 25.1 to 28.2, a difference of more than three teeth. For the 65–74-year age group, the increase in the number of natural teeth was more remarkable, from 10.1 to 20.8 teeth. That is by a factor of ten teeth or twice the number of natural teeth present over this time period. This implies that recent Japanese populations, especially elderly people, are keeping more natural teeth than the past [15].

On the other hand, the proportion of edentulous persons decreased each year in all age groups (Figure 5). In 1957, the proportion of those with no natural teeth was about one-third in the 65–74 year-old age group (35.5%), and more than half of those 75 years and over (57.2%). In 2016, these proportions had changed to 4.1% and 14.3%, respectively. Figure 6 shows the changing pattern of the proportion of persons with 20 or more teeth. In all age groups, the proportion of those retaining 20 or more natural teeth had increased, with a substantial increase observed, especially in older age groups. This might be attributed to the national "8020" campaign which was initiated in 1989, and people's awareness for oral health which has been improving and changing oral health behaviors.

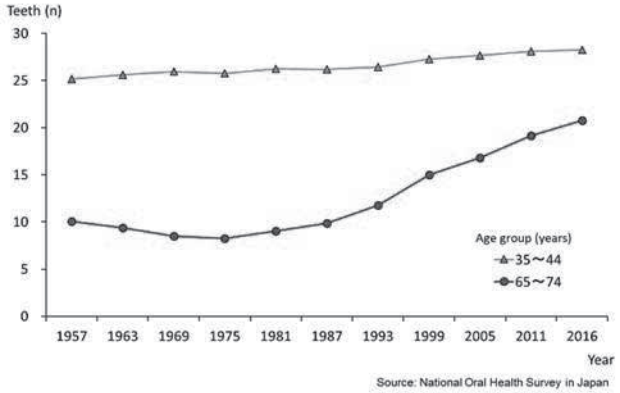

Figure 4. Changing pattern of mean number of present teeth for 35–44 and 65–74-year old groups (1957–2016) [15].

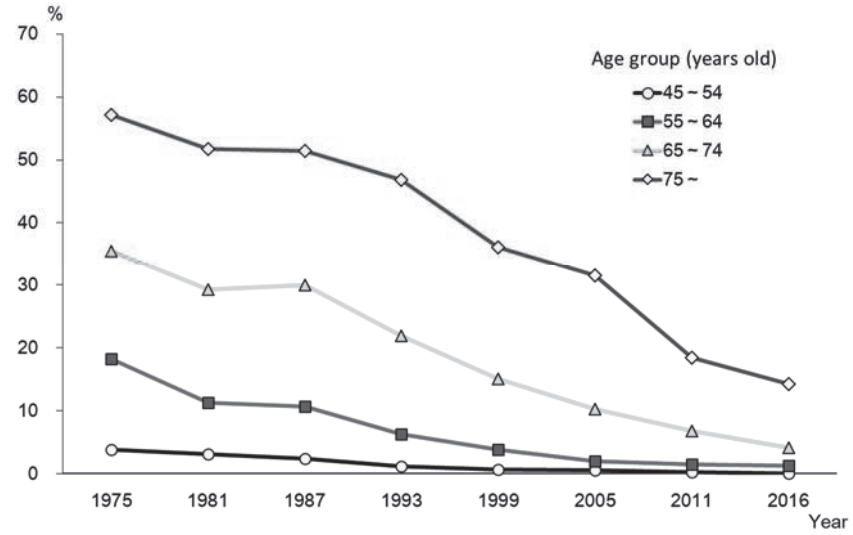

Figure 5. Trends in proportion of edentulous persons by age group (1975–2016) [15].

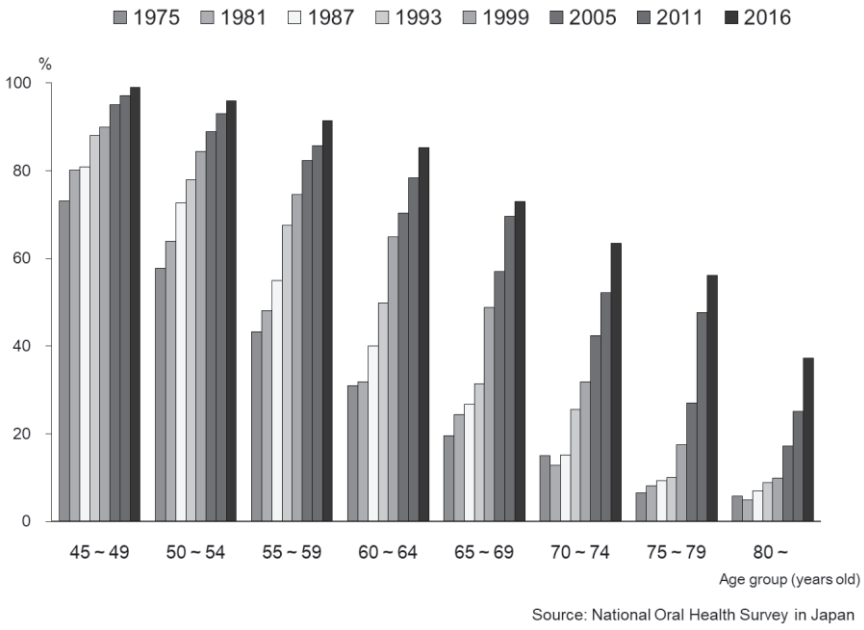

Figure 6. Proportions of persons with 20 or more teeth by age group [15].

Figure 7 shows the prosthetic status of those 15 years and over in the Japanese population in 2016. In total, the proportion without missing teeth (not needing prosthetic treatment) was 34.0%, and those who completed prosthetic treatment was 28.3%. In Japan, the public insurance covers most prosthetic treatments, such as dentures and bridges. Therefore, people can receive the prosthetic treatment they require also at a reasonable price.

Figure 8 shows the changing pattern of the status of permanent teeth. In 1957, the number of decayed teeth was greater than the number of filled teeth in all age groups. In those days, the whole Japanese population was not covered by public health insurance. In 1961, all the population entered the public health insurance system and access to dental treatment improved. The number of decayed teeth on average decreased as time went on and the average number of decayed teeth (DT) was low at 0.8 teeth in the total population aged five years and over, in 2016. The number of healthy teeth in adults also decreased, and the number of filled teeth increased. Japanese health insurance is based on the fee-for-service system, so the more filled teeth, the more fees dentists can get. It is necessary

therefore to consider the inclusion of prevention in the insurance schemes. As people keep more teeth than before, a preventive approach to dental care is more important.

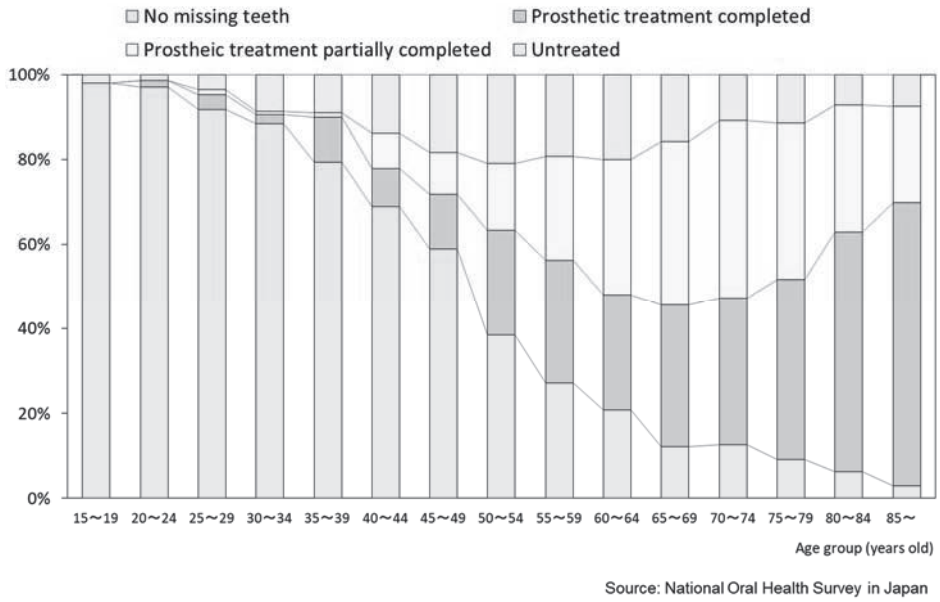

Figure 7. Prosthetic status (2016) [15].

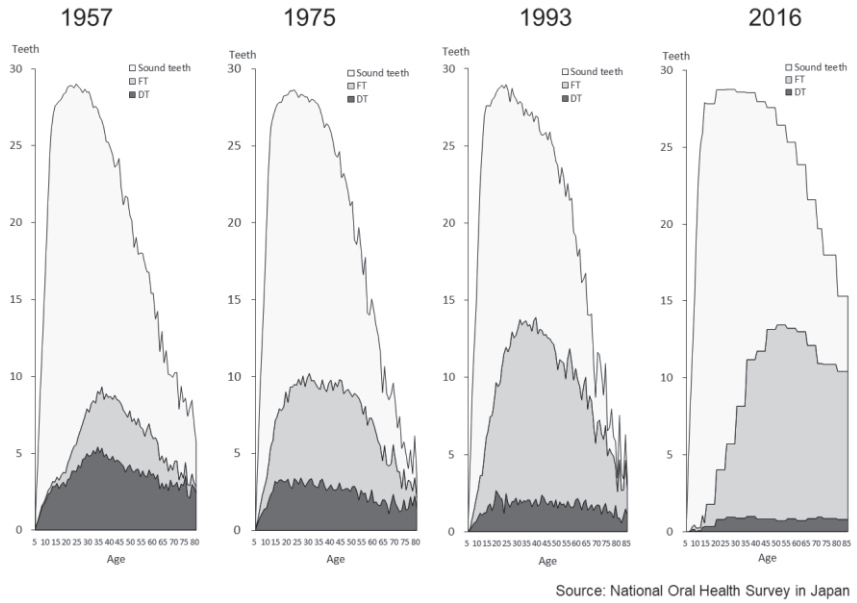

Figure 8. Changing patterns of permanent teeth (1957–2016) [15].

5.3. Data on Oral Health Related Factors

Many factors are thought to be involved in the caries reduction of both deciduous teeth and permanent teeth in Japanese children. They include increased usage of different fluoride strategies, improvement of tooth brushing behavior, reduced sugar consumption as well as improved awareness of oral health through the public oral health check-up system for preschool and school children.

In Japan there is no systemic fluoride use, and only topical fluorides are available. Figure 9 shows the trends in the proportion of persons (1–14 years of age) who received topical fluoride application. In 1969, only 6% of children received topical fluoride application. Recent data shows that this increased to about 60% and indicated a 10 times increase in exposure [15].

The market share of fluoride toothpaste has also increased dramatically from 12% (1985) to 91% in 2015 (Figure 10). According to the National Oral Health Survey, tooth brushing behavior also improved for the whole population (Figure 11). Sugar consumption per person per year decreased from on average 27.5 kg per person in 1970 to16.1 kg in 2015, a difference of 11.4 kg (Figure 12) [16].

These factors, as well as the sufficient numbers in the dental workforce and the universal coverage of the public health insurance system have contributed to the improved oral health of all Japanese people.

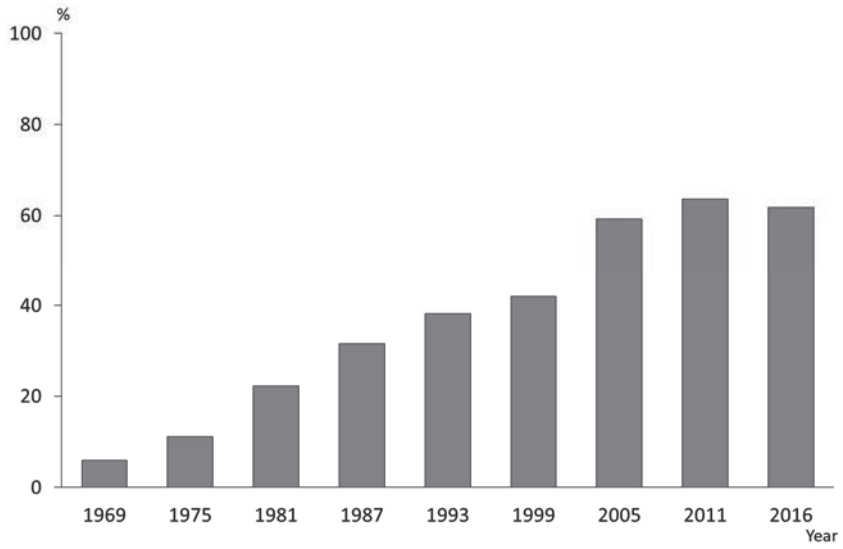

Figure 9. Proportions of persons (1–14 years of age) who had received topical fluoride application [15].

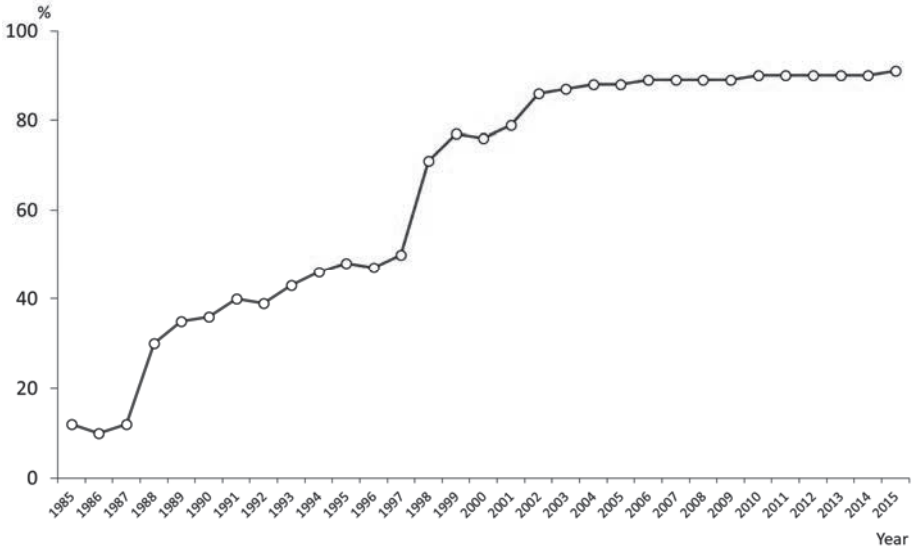

Figure 10. Market share of fluoride dentifrice (1985–2015).

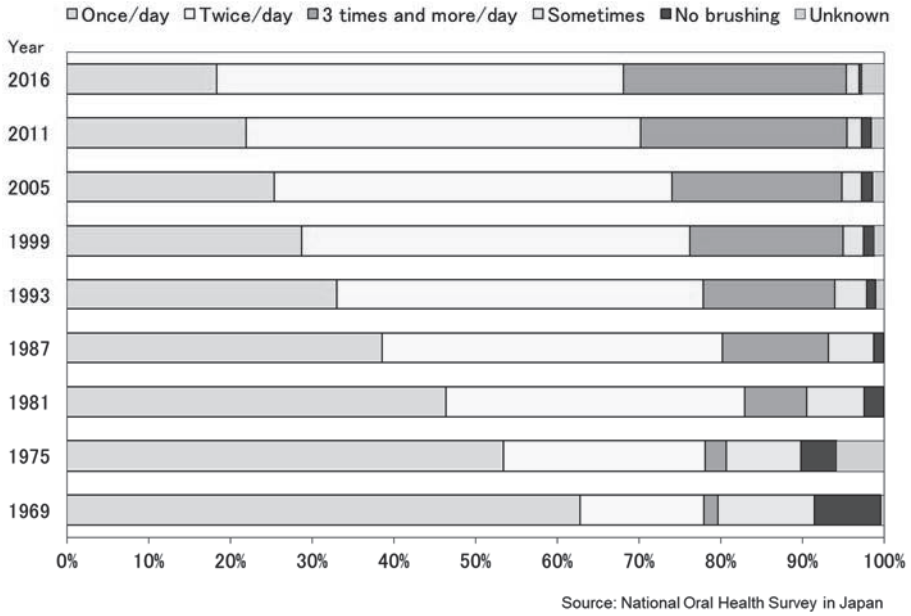

Figure 11. Reported tooth brushing habit (1969–2016) (1 year of age and over) [15].

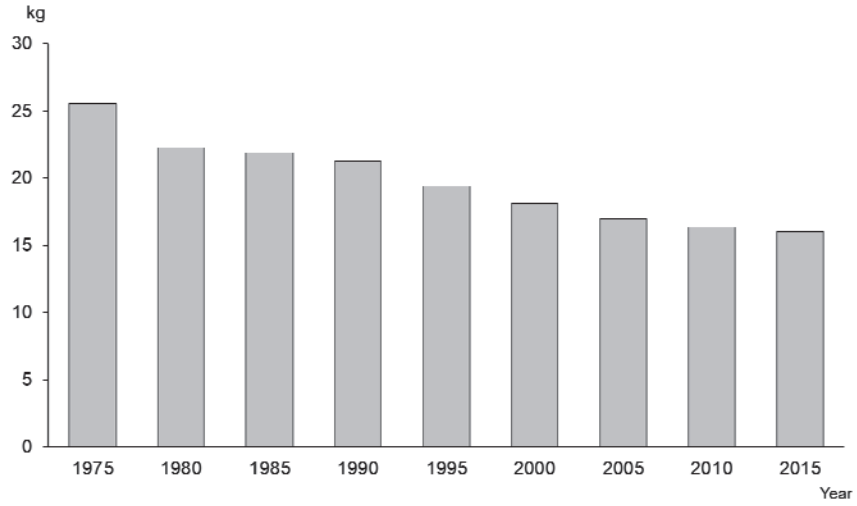

Figure 12. Sugar consumption per person per year [16].

6. Future Challenges for Japanese Dentistry

Although the oral health status of Japanese people has improved, there still remain many problems to be solved. These include: regional disparities in oral health and the total cost of health care, especially in the elderly. Further, as Japan is subject to many natural disasters, we have to establish an emergency oral healthcare system to cope in times of disaster and to train dental personnel to manage suitable intervention programs. It appears also important technologically to develop a new tele-dental system which can be used in the rural and remote areas of Japan without easy access to dental professionals to access diagnostic and preventive care—this is also one of our challenges for the future.

6.1. To Reduce the Regional Difference

Japan consists of 47 prefectures. Figure 13 shows the regional differences in caries prevalence of three-year-olds according to the data from nationwide health examinations of three-year-old children. Caries prevalence in Japanese three-year-old decreased from 77.2% in 1963 to 17.0% in 2015 [17]. However, there remain substantial regional differences. In 2015, the caries prevalence in Okinawa

prefecture (28.9%) was more than twice as high as Aich prefecture (11.2%). The number of carious deciduous teeth (dft) shows the same tendency. At present public dental services are offered based on the same rules and procedures throughout Japan. It might be advisable to develop special intensive preventive programs for high-risk persons or regions.

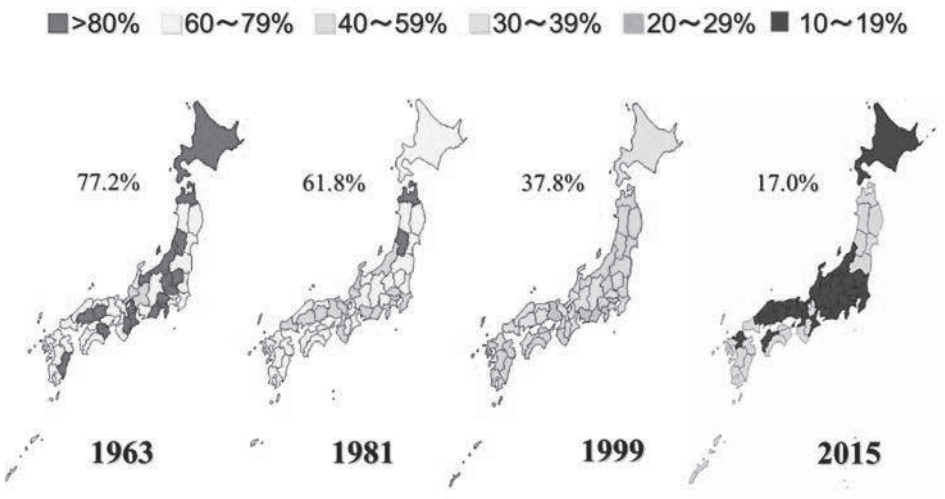

Figure 13. Regional differences of caries prevalence in 3-year-olds by year [17].

6.2. To Decrease the Cost of Health Expenditure

Figure 14 shows the total health expenditure per capita by age group in 2015 [18]. This figure is based on the total fee of both medical and dental public insurance schemes, and excludes the patients' private contribution fees. According to the Survey on Economic Conditions in Health Care in 2015 [19], the proportion of dental expenses provided by the public health insurance scheme is about 85.8% of total dental health expenditure. The proportion of medical expenses borne by private fees was only 1.2% in 2015. So this figure can explain the general outline of Japanese health expenditure between the medical and dental components of the insurance scheme. Personal contributions for dental services are far higher than for medical care.

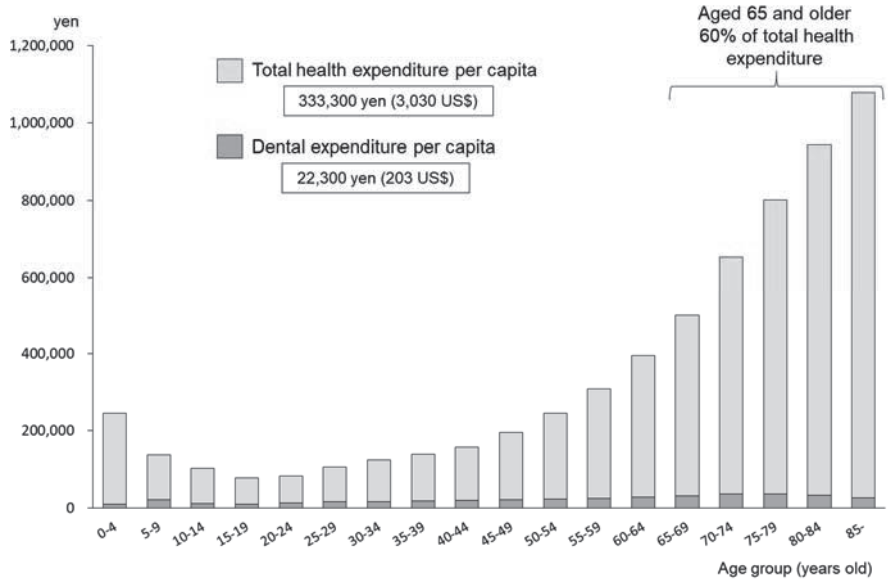

Figure 14. Total health expenditure and dental expenditure per capita by age group (Japan, 2015) (110 yen = 1 US$) [18].

Total health expenditure per capita is 333,300 yen (3030 US$), and dental expenditure per capita is 22,300 yen (203 US$). Dental expenditure occupies 6.7% of total expenditure in general. It is amazing that those aged 65 years and older use 60% of the total health expenditure. There is considerable evidence showing the relationship between oral health and general health. Effective oral health promotion programs targeting younger generations can therefore be expected to contribute to the escalation of medical health expenditure for the elderly population.

6.3. Emergency Oral Health Systems in Times of Disaster

As Japan has one of the highest frequencies of natural disaster in the world, it is recognized that special systems in the field of health are necessary as risk management tools [20]. In times of disaster, the ordinary health care system may not function. In March 2011, Japan experienced its strongest-ever recorded earthquake and tsunami disaster, and a nuclear power plant accident in Tohoku area. From this catastrophic experience, we realized that not only is medical support necessary for the population affected, but also that dental support is important to allow the people to maintain health and comfort in times of disaster.

The roles of dental professionals in such times should include the following:

For victims: Identification of victims at the request of police
For survivors: Provision of emergency dental treatment
Oral healthcare for vulnerable people (especially older citizens)
Oral health education and oral health promotion materials

In the first stage of disaster, the first dental assessment at a shelter house was conducted by non-dental personnel. Based on their assessment for the need of dental services, dental professionals were sent to the affected area to deliver adequate dental care. An example of dental assessment items at an emergency situation was developed and is shown in Table 4.

To make sure every type of dental personnel could respond appropriately to such an emergency situation, training programs are being provided for the members of Japan Dental Association and Japan Dental Hygienists' Association. Disaster dentistry is now included in the undergraduate dental curriculum in Japan.

Table 4. Dental checklist items for the people at a shelter house in times of disaster.

Dental Checklist Items		Contents
D	**D**ental high-risk population	To know the number of the dental high-risk population is important in the affected area. In the shelter house, to check the number of elderly, disabled persons, and pre-schoolchildren and to report them to the emergency disaster office is a high priority. Then the manager of the office can ask for dental support from an unaffected area.
E	**E**nvironmental settings	To keep good oral health, it is necessary to check the availability of water and water-supply facilities, not only for drinking but also for mouth-rinsing.
N	**N**ecessary support for oral hygiene behavior	Check people's oral hygiene behavior (brushing). Can they brush by themselves or do they need special care to clean their teeth and mouth?
T	**T**ool materials for oral hygiene behavior	Are there enough oral hygiene tool materials in the shelter house? (e.g., toothbrush, toothpaste, dental floss, interdental brush, mouth wash, denture cleaning tablets etc.)
A	**A**cute dental treatment needs	Do they need acute dental treatment? Is emergency dental treatment necessary, such as acute pain and loss of dentures?
L	**L**imitation: Obstacles to receiving dental treatment in the affected area	How much damage to dental facilities (i.e., clinics and hospitals) is there in the affected area? Is a mobile dental service necessary?

6.4. Tele-Dental Systems in the Remote Areas without Dental Professionals

At present, there are six astronauts working in the International Space Station (ISS). These members are special crews trained to live in the space environment with no access to a dental facility. But in the near future, space technology will develop so ordinary people will also have the chance to travel or live in space.

For the purpose of the astronauts' oral health promotion, the Faculty of Dentistry, Tokyo Medical and Dental University (TMDU) and the Japan Aerospace Exploration Agency (JAXA) cooperated to develop the "Space Oral Health Promotion Project" to tackle the current and the possible dental or oral problems in future long-term space flight [21]. It is a new challenge for us to develop "space dentistry".

In Antarctica, Japan has the Showa Station. The Japanese Antarctic Research Expedition (JARE) team has been engaging in research for more than one year in circumstances without access to a dentist. At present, TMDU conducts tele-dental conferences with doctors in the Antarctica for dental support of JARE members. Real-time diagnosis and adequate advice for dental troubles of JARE members can be provided using an intraoral camera and a TV system.

We believe that the tele-dental system could be expanded for other remote or rural areas with limited or no access to dental professionals. In such situations, oral self-care and prevention of dental diseases are the most important strategies. By giving adequate advice using recent advanced technologies, dentists can help these isolated population groups. Dentistry in the future may contribute to oral health promotion for people everywhere on earth and also in space.

7. Conclusions

Japan has developed a system for providing high-quality and appropriate oral health care efficiently. Therefore, the oral health status of the Japanese population has improved markedly. Dental caries in children decreased remarkably. In adults and older populations, untreated decayed teeth decreased and people are keeping more natural teeth than ever before.

Many factors are thought to contribute to these changes. Public oral health services are provided according to the life stage of their populations and these services are mainly conducted by private dental practitioners under contracts with local governments. The number of dental facilities increased and the health insurance system helps by providing easy access to receiving dental treatment at reasonable price. Fluoride usage has increased, and sugar consumption has decreased. People's awareness and behavior toward oral health have also improved. Japanese dentistry is now challenging to solve the newly emerged oral health problems.

Author Contributions: T.Z. prepared the manuscript; T.S. critically reviewed the manuscript; Y.K. supervised and critically reviewed the manuscript. All authors approved the final version of the manuscript.

Funding: This paper was partly supported by the "Research Fund of Clinical Study for Industrial Accident and Disease" by Ministry of Health, Labor and Welfare, Japan (170501-01) and the Sciences Research Grant by Ministry of Health, Labor and Welfare, Japan (201315006B).

Acknowledgments: We thank the staff at the Department of Oral Health Promotion, Tokyo Medical and Dental University for providing information related to this article.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Ministry of Foreign Affairs of Japan. Japanese Territory. Available online: https://www.mofa.go.jp/territory/index.html (accessed on 6 June 2018).
2. Ministry of Internal Affairs and Communications. Statistics Japan. Available online: http://www.stat.go.jp/english/index.html (accessed on 6 June 2018).
3. Cabinet Office, Government of Japan, GDP 2018. Available online: http://www.esri.cao.go.jp/jp/sna/menu.html (accessed on 6 June 2018).

4. Ministry of Health, Labour and Welfare. Survey of Physicians, Dentists and Pharmacists in 2016. Available online: http://www.mhlw.go.jp/english/database/db-hss/dl/spdp_2016.pdf (accessed on 6 June 2018).
5. Ministry of Education, Culture, Sports, Science and Technology. Dental University Admission Quota in 2017. Available online: http://www.mext.go.jp/component/a_menu/education/detail/__icsFiles/afieldfile/2017/11/02/1324090_4.pdf (accessed on 6 June 2018).
6. Ministry of Health, Labour and Welfare. The pass rate of National Board Dental Examination in 2018. Available online: http://www.mhlw.go.jp/general/sikaku/successlist/2018/siken02/about.html (accessed on 6 June 2018).
7. Ministry of Health, Labour and Welfare. The Number of Employed Dental Hygienest and Dental Technician in 2016. Available online: http://www.mhlw.go.jp/toukei/saikin/hw/eisei/16/dl/kekka2.pdf (accessed on 6 June 2018).
8. Ikegami, N.; Yoo, B.K.; Hashimoto, H.; Matsumoto, M.; Ogata, H.; Babazono, A.; Watanabe, R.; Shibuya, K.; Yang, B.M.; Reich, M.R.; et al. Japanese universal health coverage: Evolution, achievements, and challenges. *Lancet* **2011**, *378*, 1106–1115. [CrossRef]
9. Ministry of Health, Labour and Welfare. Vital statistics in Japan—Trends up to 2016. Available online: http://www.mhlw.go.jp/english/database/db-hw/dl/81-1a2en.pdf (accessed on 6 June 2018).
10. World Health Organization. Life Expectancy and Healthy Life Expecancy Data. Available online: http://apps.who.int/gho/data/view.main.SDG2016LEXREGv?lang=en (accessed on 6 June 2018).
11. Ueno, M.; Yanagisawa, T.; Shinada, K.; Ohara, S.; Kawaguchi, Y. Masticatory ability and functional tooth units in Japanese adults. *J. Oral Rehabil.* **2008**, *35*, 337–344. [CrossRef] [PubMed]
12. The Japan Dental Association. The Current Evidence of Dental Care and Oral Health for Achieving Healthy Longevity in an Aging Society: 2015. Available online: https://www.jda.or.jp/pdf/ebm2015En.pdf (accessed on 6 June 2018).
13. Fukai, K. Oral Health for Achieving Healthy Longevity in an Aging Society: Evidence and policy. *Int. J. Oral Health* **2017**, *13*, 52–57.
14. Ministry of Education, Culture, Sports, Science and Technology. School Oral Health Survey. Available online: http://www.nichigakushi.or.jp/dentist/material/investigation.html (accessed on 6 June 2018).
15. Ministry of Health, Labour and Welfare. Report on the Survey of Dental Diseases in Japan 2016. Available online: http://www.mhlw.go.jp/toukei/list/62-17b.html (accessed on 6 June 2018).
16. Japan Sugar Refiner's Association. *Year Book of Sugar Statistics*; Japan Sugar Refiners' Association: Tokyo, Japan, 2015.
17. Ministry of Health, Labour and Welfare. The Report of Community Health and Health Promotion Services in 2015. Available online: http://www.mhlw.go.jp/toukei/saikin/hw/c-hoken/15/index.html (accessed on 6 June 2018).
18. Ministry of Health, Labour and Welfare. National Health Expenditures in Fiscal Year 2015. Available online: https://www.mhlw.go.jp/toukei/saikin/hw/k-iryohi/15/index.html (accessed on 6 June 2018).
19. Ministry of Health, Labour and Welfare. Survey on Economic Conditions in Health Care in 2015. Available online: http://www.mhlw.go.jp/bunya/iryouhoken/database/zenpan/jittaityousa/dl/20_houkoku_iryoukikan.pdf (accessed on 6 June 2018).
20. Nakakuki, K. Disaster Dentistry–Management of Oral Infectious Diseases to Prevent Aspiration Pneumonia. *Int. J. Oral Health* **2017**, *13*, 5–12.
21. Zaitsu, T.; Kawaguchi, Y. Perspectives for Tele-dental System in Space and Antarctic Environments. *Int. J. Oral Health* **2017**, *13*, 13–16.