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Influence of Increased Vertical Dimension of Occlusion (VDO) on Smile Index in Complete Denture Wearers – An In Vivo Study.

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Abstract

Background: The study aims to assess the effect of increased vertical dimension at occlusion on smile index. In completely edentulous patients.

Aim & Objectives

1. To evaluate the smile Index of edentulous patients with trial denture at existing VDO.
2. To evaluate the smile Index of edentulous patients with trial denture with increase in VDO by 2mm.
3. To compare both the smile indexes.

Study Setting: In vivo study

Study Population: Completely Edentulous Patient aged 50-70 years with average edentulous span of 45-60 days having class I residual ridge morphology &class I maxillary- mandibular ridge relation

Analysis: Comparative Photographic Analysis Tests– Chi square Test.

Materials and Methodology: Final Impression was made. The master cast was poured and duplicated using alginate as the cast duplicating material. Two sets of occlusal rims were fabricated, and jaw relations for both the rims were done viz VDO+0mm (MC1) and VDO+2mm (MC2) respectively. Teeth arrangement was done. Two standardized digital photograph of the subject smiling with two trial denture bases on were taken from frontal view. Smile index (SI) was then calculated for each patient at VDO+0 mm (SI1) and VDO + 2mm (SI2) the two smile index were then compared for significance.

Result: There is a significance difference in Smile indexes with p<0.000. (SI1) ranged between **4.71 ±0.282** which decreased to (SI2) **4.21 ± 0.195**on increasing VDO.

Conclusion: Smile Index decreased on increasing vertical dimension at occlusion. Increasing the vertical dimension is desire able as it confers more youthful look to patient by lowering smile index .This also compensates for hard and short tissue age related changes occurred due to loss of VDO.

Keywords: Smile Index, Edentulous Arch, Vertical Dimension at Occlusion.

Introduction

Facial attractiveness finds a paramount role in today's modern society [1, 2, 3] and Smile being the essence of it. Smile finds keystone role in boosting an individual's self confidence about his/her facial appearance, self esteem and enhances professional performance[1,4]. Even today, attractive individuals are better judged and treated well over the un attractive ones [5]. This social bias also influences better social opportunities and employment prospects for such individual [1].Hence an esthetically pleasing and socially acceptable smile is desired by all. Smile can be defined as a facial expression characterized by upward curving of corners of mouth. Ackerman & Ackerman classified smile into 1. Duchenne smile (the natural, induced by joy or mirth) and 2. Posed / Social smile. [7]Moreover, they also developed a ratio called Smile Index (Intercommisural width/ Interlabial gap), to visualize and quantify the frontal smile. The ratio is used for comparing smiles among patients.[7]Smile Index – describes the area framed by the vermilion borders of the lips during the social smile.[8]Posed smile is used while evaluating facial esthetics and smile characteristics due to its reproducibility &voluntary in nature and can be generated by command.[7]Characteristics of smile can be frontally quantified as incisor display, gingival display, maxillary incisal edge position to lower lip distance, arch form, buccal corridor and transverse cant of maxillary occlusal plane[8].Recent advancements in technology like Digital Smile Designing ,CAD /CAM dentures etc. has made a paradigm shift inculcating technology to project better treatment outcomes, proper patient education on patients before the onset of the procedure. This gives an insight into accelerating advances and fostering better treatment objectives, rendering better quality results. Esthetic smile designing / correction with orthodontics is concerned with various hard tissue and soft tissue parameters which aims to re contour the existing smile in accordance with patient confluence. Recently Time has been included as the fourth dimension with the existing three dimensions.[6] Over a period of time, Biological Ageing in edentulous patients advances and fastens the loss of alveolar bone height due to excessive bone resorption and ridge atrophy thereby altering the resting vertical dimensions . Subsequently, loss of tooth substance which might be attributed to various etiologies such as caries, erosion abfraction, avulsion, trauma or exfoliation due to periodontal pathologies also decreases the VDO which in turn alters facial morphology, form and function.[9]Due to the aforesaid reason, dental hard tissue landmarks are lost and cannot be replicated in denture . Hence, smile index, gingival display can serve as two keystone parameter for inculcating esthetics into dentures for such patients..In recent years, a huge upsurge in the mindset of individuals 'desire to look pretty, attractive and photogenic has been noted which has revolutionized the modalities of dental treatments and up scaled esthetics into utmost consideration, and is synonymous with the natural appearance of face.

Following this trend, evaluation of esthetic appearance of the face following dentures placement has become an important issue in complete denture prosthesis.[6]The young adolescent and dentulous patients get their smile designed through orthodontic intervention. But where does the fate of our geriatric patients lie? Even though most of the geriatric population are edentulous and seek prosthodontics rehabilitation, but desires to have an esthetically pleasing denture smile. How are their facial esthetics taken into consideration. This study intends to determine the influence of increased vertical dimension at occlusion Smile Index in completely edentulous patient and highlight esthetics concerns in geriatric population.

Materials & Methodology

Source of Data

After obtaining proper ethical clearance from the Institutional Ethical Review Board of Bapuji Dental College & Hospital, Davangere, completely edentulous patients with no previous denture wearing experience will be selected from department of Prosthodontics & Crown & Bridge of Bapuji Dental College and Hospital, Davangere.

Method for collection for data

Inclusion Criteria

Completely edentulous patients in the age group of 50-70 years with an average edentulous span of 45-60 days having a class I residual ridge morphology, class I maxillary- mandibular ridge relation were selected as subjects for this study.

Exclusion Criteria

Patients with sign of infection, inflammation, and inadequate healing of oral tissues, suffering from any systemic debilitating disease were excluded. Moreover, Patients with positive history of malignancy of oral cavity, history of any neurological disease and inability or unwillingness to smile were also excluded from this study.

Materials

A cephalostat or customized set square to hold head each patient at a specific position.

1. A digital camera [CANON EOS 1200D DSLR camera, ISO 100-6400)
2. Two steel metric rulers
3. A photographic tripod
4. A trial denture base
5. Image processing and analyzing software [AutoCAD Ver.2022 (Auto Desk In. USA California)]

Methodology

An appropriate medical and dental history of each participating subject will be recorded, after which clinical examination will be conducted. Signed informed consent of the subject fulfilling the inclusion criteria was obtained.

Step – I : A primary impression of the edentulous arches were made followed by which a final impression using greenstick material and zinc oxide -eugenol impression paste were made. The impression was poured with type III dental stone. The master cast was then duplicated using alginate as the cast duplicating material and were numbered Master Cast #1 (MC1) and Master Cast #2 (MC2).

Step – II : A temporary record base using auto-polymerising resin were made ,followed by fabrication of occlusal rims on the two master casts. In the next appointment, jaw relation and vertical dimension at rest and occlusion were determined for each patient. The existing vertical dimension at occlusion [VDO) was recorded and articulated on MC1 . Another occlusal rim with increased VDO by +2mm was articulated on MC 2. Teeth selection was done for both occlusal rims followed

by teeth arrangement over the rims using Bonwill's circle as a guide for maxillary anteriors.

Step – III : The two trial denture bases , one with existing VDO and the other one ;VDO +2mm respectively were tried on in the patient's mouth. Head was positioned steadily with the help of cephalostat or the customized set square. The subjects were made to sit upright and look straight ahead with a posed smile, with the maxillary occlusal plane parallel to the floor.

Figure 1

Figure 2

Fig. 1 & 2: Depicting Patients' posed smiling profile photograph with trial dentures on and head positioned in a cephalostat . [Fig 3. trial denture with normal VDO) & (Fig 4. trial denture with VDO+2mm).

The distance between the tip of the nose and the length of the camera were fixed at 56 cm to ensure distortion free image and kept over a tripod, which was placed at a height of 112 .6 cm. Two standardized digital photographs of the subject smiling (posed smile) as viewed from the front were captured in natural day light conditions. Subjects of the study had no artificial make up or beauty enhancement products on their face.

The photographs obtained were imported to image processing software [Auto CAD; Auto Desk Inc. California USA] .The Intercommisural width and the inter labial gap was measured digitally.

Figure 3

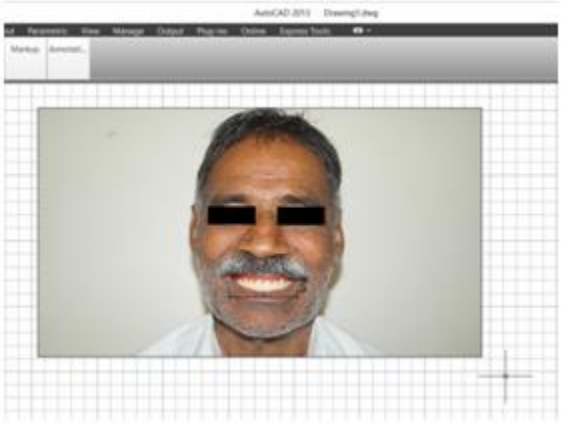

Figure 4

Fig.3 & 4 : show screen shot of AutoCAD Image processing software showing and measurements. Fig. 3 correlating to MC1 and Fig.4 correlating to MC2

Step – IV : To verify such data and to rule out bias and errors which might crept in during image processing ; at par with it ,a divider and ruler metric measurement method was followed to elicit data from subjects of this study while performing clinical chair side investigations. The data obtained from patients using metric records were verified using standard photographic techniques and then subjected to Image analysis using Auto CAD;

[Auto Desk Inc. California USA] software for markings and measurements of soft tissues were recorded.

Figure 5

Figure 6

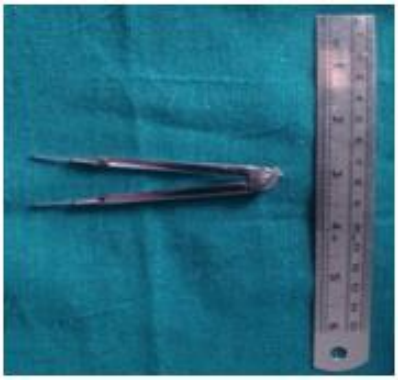

Figure 7

Fig. 5, 6 & 7: Photograph depicting Metric Measurement of Interlabial gap &Intercommisural width using divider and ruler during chair side investigation. The Data obtained was compiled in a tabulated manner and subjected to statistical analysis using SPSS (Ver.20 software).Smile index (SI) was then calculated for each patient at existing (SI1) and +2mm raised VDO(SI2) using the below mentioned formula.(7)

SMILE INDEX (SI) = INTERCOMMISURAL WIDTH / INTERLABIAL GAP

The two smile indexes were then compared for significance.

Results

Following results were obtained and relevant correlation were found as mentioned below: [Table 1]

PATIENT	VDR	VDO1	VDO2	ILG1	ILG2	ICW1	ICW2	SI1	SI2	p Value
1.	70	65	67	11.5	13	53	55	4.6	4.23	0.000
2.	69	64	66	11	13.2	52	55	4.72	4.16	
3.	66	62	64	10.6	12.4	51	53	4.81	4.27	
4.	60	56	58	12	13.1	52	51.6	4.33	3.93	
5.	73	68	70	10	11.4	51	51	5.1	4.47	
							Mean	**4.71 ±0.282**	**4.21 ±0.195**	

This study was conducted on 5 patients out of which 4 were males (80%)and 1 female patient (20%).Males reported a SI 1 ranging between (4.33 – 4.81) and SI 2 ranging between (3.93 – 4.27) whereas female patient was reported higher SI 1 (5.1) and SI 2 (4.47) as compared to males.

The Mean value for the smile index SI1; (at normal VDO)was calculated to be **4.71 ±0.282** whereas the mean value for the smile index SI2 (at VDO+ 2mm) was calculated to be 4.21 ±0.195.There is a significance difference in Smile indexes with $p<0.000$. Hence It can be stated that smile index was found to decrease with increase in vertical dimension at occlusion. VDO for this study population was noted to be 63±4.47 (VDO1). And VDO 2 was noted to be 65±4.47.

However, with increase in vertical dimension at occlusion interlabial gap height has shown positive results. Interlabial gap height at normal VDO (ILG 1) was reported to be (11.02±0.775) ; whereas Interlabial gap height at VDO+ 2mm (ILG 2)was reportedto be (11.62±0.749): [Plotted in Chart 1]

On comparison , the mean value of ILG is accordance to that of Chou et.al [10]and Desai et al[11]who reported inter labial gap height as (10.42±3.28)and much lower when compared to Razzaque et al[12] who reported

(14.69±2.52 for males and 14.61±2.41 for females) at VDO+2mm

Inter commissural width has not shown much appreciable results but a slight increase was found which is statistically insignificant. ICW1 was reported (51.8±0.863) on contrary to ICW 2 which was reported(53.12±1.863). Similar results are obtained by Desai et al[11] intercommissural width (52.24±4.43)

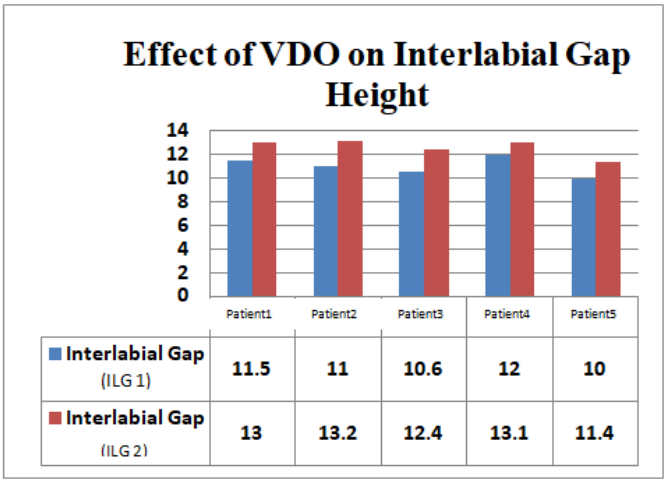

Chart 1

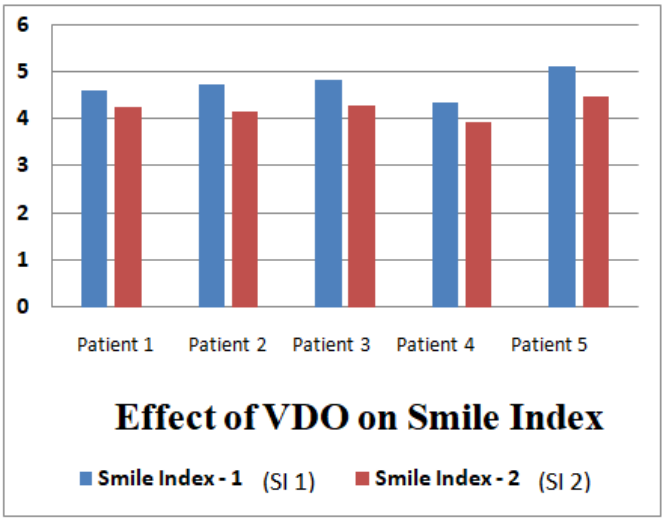

Chart 2

Discussion

The paramount objective for prosthodontics rehabilitation pertaining to fabrication of complete dentures is not only replacement of what is lost rather establishing a harmonious relation between the masticatory system, confer maximum stability &functional occlusion [12].

Achieving a proper Amalgamation of smile esthetics and balanced occlusion along with function, phonetics, retention and stability after comprehensive treatment planning is the cornerstone treatment objective of complete denture prosthetics.

An esthetically pleasing and "balanced smile" in denture wearers [12] is an well established concept. It is acknowledged as a harmonious relationship between the masticatory system , artificial teeth, the gingival scaffold and the lip frame work.(6),buccal corridor[13], smile arc[13], upperlip curvature[13], lip line[13],smile arc[6], smile symmetry[13], frontal & occlusal plane[13], gingival components[13], muscle tonicity and adequate vertical dimension adds looks esthetically pleasing as well. Fabrication of esthetic complete dentures takes into account display zone, shape , size &colour of artificial teeth , display of maxillary anterior artificial teeth , the gingival contour and display[6]Furthermore, A 2mm increase in the labiolingual inclination of maxillary incisors with subsequent elevation of VDO to 2mm is desirable; as it confers much youthful appearance of face. A VDO of 4-6mm produces stress on TMJ [14] whereas, display of mandibular anterior teeth is a factor that is seldom discussed.[15,16]

Esthetics concerns of young, adolescents and dentulous patients are well managed by orthodontic and endodontic interventions which takes into account features such as lip positions[4] , incisor display[4],gingival display[4], lower facial height , smile index etc. Inculcating these aspects in edentulous geriatric population is a challenging task and is of key importance to prosthodontics.

A prime concern of geriatric patients is established biological ageing which needs proper redressal and consideration while treatment planning. Biological ageing is etiologically accredited to collapse of vertical dimension of occlusion. These changes manifests on orofacial tissues and facial musculature which embraces an wide array of marked detrimental effects such as loss of muscle tonicity and elasticity, prominence of nasolabial folds, decreased lip volume, loss of lip architecture, and lip lengthening, diminished facial contours , dropping of commeasures. Following recession of soft tissues, underlying hard tissues recedes to undergo atrophy of maxillary and mandibular ridges [17]Also Smile gets narrower vertically and wider transversely with ageing[18,19].

Assessing the results obtained from this study, it can be concluded that with increasing VDO, the interlabial gap height increased; whereas it was noted that the values of Intercommisural width differed slightly with increasing VDO, which was statistically insignificant. These findings were found analogous to that reported by Chou *et al*.[10] {Interlabial gap 10.42 ± 3.28 mm.}

Desai et.al[11](Parmar et al[4].An increased interlabial gap facilitates more visibility of maxillary incisal display , gingival display while smiling which is considered desirable and esthetic. 4mm of incisal display and a gingival display of upto 2mm is considered ideal while lips are in resting position as stated by Mc Claren et.al.[20]

An increase in Intercommisural width attributes to wider buccal corridor on smile.[21] This is due to the action of buccinators muscles and not the circumoralmuscles which pulls the corners of the mouth laterally.[10]Generally, Intercommisural width remains unchanged because “Denture Smiles” lack buccal corridor which is greatly influenced by anteroposterioron maxilla relative to lip drape.[22] This can be accredited due to loss of muscle tonicity and ageing which plays an important role in geriatrics hence an increase in Intercommisural width was seen.

In our study, we found out that the Smile Index decreased significantly with increase in VDO. The average value of smile index in edentulous patients with normal VDO i.e. (SI1)was calculated to be **4.71 ±0.282** which decreased to an average value of **4.21 ±0.195 (** SI 2) with +2mm increase in VDO. In accordance with this study, Crawford et.al.[23]acclaimed that a lower Smile Index of **3.4** is desirable as it confers a more youthful appearance. smile, Razzaque et al [12] stated smile index to be 4.14±0.76 in females and 4.04±0.81 in males for (VDO+2mm).

A brief review of literature on smile index highlights that numerous studies are done which are exclusively limited to dentulous subjects only (Table 1). Data obtained from previous studies conducted on dentulous patients serves as a guide for planning rehabilitationin edentulous patients.

Comparing the results of this study with previously conducted studies , It can be inferred that the values of smile index obtained from our study are much less as compared to that reported in literature.

Contrasting results with Chou et al[10] , Schabel et al[24] , can be attributed to difference in ethnicity of the population being studied.

Author	Smile Index Values	Study Parameters
Present Study	4.71 ±0.282 (at normal VDO) 4.21 ±0.195 (at VDO +2mm)	• Completely Edentulous patients of age 50-70 years.
Chou et.al.[10, 28]	4.38 ± 1.29	• At VDO+8mm
Schabel et.al[24 ,28]	6.3 ± 2.4	• For most attractive smiles
Parmar et.al[4]	5.60 ± 1.66	• Photographic analysis • Age group 22-30 • Incremental increase of VDO +1, +2, +3,+4 mm • Gujarati Indian Ethnicity
Desai et.al[11,28]	8.05 ± 3.98	• Age groups – 15-70 years • Indian Ethnicity • Photographic analysis
Crawford et al[23,28]	3.4	• 12-80 years age group
Parekh et.al[25]	6.0582 mm (Males) 5.9842 mm (Females)	• Gujarati Population (INDIAN Ethnicity) • Photographic Analysis
Grover et al[26,28]	Average Growth Pattern 7.16±1.50 (?) 7.86±0.88 (?) Horizontal Growth Pattern 9.47±1.38(?) 8.93±1.62(?) Vertical Growth Pattern 5.94±1.97(?) 5.90±0.92(?)	• Among dental students • Indian Ethnicity
Orce Romero et. al[27,28]	8.04±4.10 (?) 6.23±1.66(?)	• Most Influential persons
Razzaque, *et al*.[12]	4.04±0.81 (?) at (VDO + 2mm) 4.14±0.76 (?) at (VDO + 2mm)	• Age group 21-30 • Incremental increase of VDO +2, +4, +6,+8 mm • Photographic Analysis • Kannadiga Population (INDIAN Ethnicity)

Table 1: Shows brief review of literature of previous studies done on completely dentulous patients

All the participants of this study belonged Indian ethnicity. Secondly, the results of smile index were relatively less as compared to that of Parmar et al[4]& Desai et al[11],Parekh et al[25], Grover et al[26] , despite having the same Indian ethnic individuals as subjects , the results differed because the subjects studied by Parmar et al[4]& Desai et al[11]Razzaque et al [12]were completely dentulous to that of our study who are completely geriatric edentulous patients. Also Parmar etal[4] considered young adults of age group 22-30 years as their study group.

In contrast to this study, Desai *et al*[11].& Sachdeva et al.[6], also advocated that an increase in smile index was observed with increasing age which was justified by progressive increase in length of upper lip, loss of muscle tonicity and an increase in inter commissural width at rest with progress in age. Horizontal Growers show higher smile index values followed by average growing individuals stated by Grover et al.[26] This can be aptly stated from this study that Smile is said to be more youthful with decrease in smile index as there is a confluence of increased maxillary incisal visibility and gingival display.Increased VDO also compensated for collapsed lower facial height. VDO has a positive influence on lower facial height; which adds to attractiveness.[29] Also, Increase in VDO influences the position of lower lip. Lower lip descends downwards leading to lowering of smile index while upper lip and Intercommisural width remain unaltered.[28]

The present study also found that an increase of VDO by 2mm abets to repeal the detrimental consequences on facial musculature such as collapse of lower facial height which gives a typical 'witches profile appearance, decreased lip volume, loss of lip architecture, and lip lengthening occurred due concomitant loss of VDO.[19] Also, VDO has a stated positive influence on masticatory muscles lengthening and relaxing. This was confirmed and demonstrated by reduction in electromyographic activities after increasing VDO by Carlson et.al.[30]

Therefore, an elevated VDO is stated suitable and advisable by Mahindra et.al& Razzaque et.al[19 ,12] whichis sought to provide greater interocclusal restorative and rehabilitative space. Hence, generalized and complex dental abnormalities can be minimised.

Abduo et al stated that amoderate amount of increase in VDO upto 5 mm can be easily tolerated and adapted by the masticatory system and is considered safe and without having detrimental consequences and complications.[8] In this present study , a 2 mm increase in VDO was done which is encompassed well within the safety margin (5mm) . Besides, a greater biting force was seen to have exerted when VDR >VDO[31].An adaptive tissue response elicits to maintain equilibration

of dentoalveolar , freeway space and orofacial musculature .

For image processing and analysis the use of Adobe Photoshop is widely in dentistry , specifically smile designing and corrections was stated by Mc Claren et.al.[20] With advancement in technology, computer aided designing and manufacturing has an edge over previously used software's. In this study Auto CAD a computer aided design software by [Auto Desk Inc. USA], was used . AutoCAD software in research related to dentistry was first advocated by Brunetto *et al*.[32] due to its precision, accuracy, reliability and reproducibility of measurements. Parmar et. al[4] also used same software for assessing smile index in dentulous patients.

Conclusion & Summary

In geriatric patients requiring complete denture rehabilitation a decrease in smile index is noted when an increase in VDO is contemplated . This allows more maxillary gingival display & maxillary incisal display conferring much youthful appearance. An increased VDO also counteracts the age related changes such as increased collapsed lower facial height and aids to correct lip position ,allows more interocclusal rehabilitation space. Hence ,it can be concluded that an increase in VDO up to 2mm is advisable and desirable for geriatrics for above mentioned reasons.

Scope of further studies

1. A study can be conducted for evaluating the facial muscles to increased VDO.

2. A study on completely edentulous patients to evaluate effects of facial musculature , lip position , labiolingual position of maxillary anteriors lower facial height on Smile Index can be done.

Limitations

1. Less sample size
2. Not all parameters of smile designing considered.
3. Alteration in facial musculature due to ageing also plays an important role in edentulous patients and hence needs proper consideration

Disclosure

To authors' knowledge this study is a pioneer study to document smile index on completely edentulous patients and add a note on age related changes due to collapse of VDO in geriatric population.

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