IBOM MEDICAL JOURNAL
Vol.18 No.3 | July - September 2025 | Pages 495-501
www.ibommedicaljournal.org

Establishing a best fit model of finger length to occlusal vertical dimension among students of college of health sciences Bayero University Kano

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Abstract

Background: Anthropometric measurements like finger lengths may shorten the time taken for occlusal vertical dimension (OVD) estimation in the edentulous. They have sparingly been studied in Nigerian populations
Objectives: This study aimed to develop a best fit model equation relating finger length to occlusal vertical.
Materials and Methods: The study was an analytic cross-sectional study among students of the College of Health sciences, Bayero University Kano. Finger lengths and OVD were recorded. Data was summarized with descriptive statistics. Bivariate comparisons were accomplished with Pearson's correlation. Multivariate analysis was conducted with hierarchical multiple regression. The level of statistical significance was set at $p<0.05$.
Results: Five hundred and twenty-eight participants with a mean age of 27.4±2.9 years participated in the study. Eighty three percent of the participants were male, while 93% of them were right-handed. Average OVD was 7.17 ± 0.53 cm (CI: 7.12-7.21 cm). The index finger correlated most strongly with OVD ($r = 0.56$, $p < 0.001$), although all finger lengths statistically significantly correlated with OVD ($p<0.001$). Generalized Linear model (GLM) regression between index finger and OVD incorporating gender produced a best fit equation: (OVD = 3.57 + (0.41 × Length of index finger) + (0.14 × Length of ring finger) – (0.32 × Gender).
Conclusion: Index finger length can predict OVD in a mathematically discernable manner.

Keywords: Finger length, OVD, Complete dentures, Equation

Introduction

The determination of occlusal vertical dimension (OVD) in the elderly edentulous patient is often a long and frustrating experience for both the patient and the dentist.[1,2] This is due in part to the lack of objective reference points while employing the Niswonger technique.[3,4] The demands on the coordinative abilities of the often-elderly edentulous patient, and the repetitiveness of many small stages of the process of the process make this process tasking for the patient and dentist.[5] The process may also take a minimum of forty-five minutes which may be tiring for the patient and dentist.[6]

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DOI: 10.61386/imj.v18i3.708

One of the means that has been used to shorten the time required for estimating OVD is by the use of anthropometric measurements of certain facial and hand features.[5,7] These have been found to have proportional relationships with occlusal vertical dimension in certain populations. A study conducted among a Hausa population in Kano proposed a mathematical relationship between midfacial height and OVD. This study also alluded to subtle differences between the genders and how anthropometric parameters relate to occlusal vertical dimension.[5]

Facial heights are not the only anthropometric parameter used in the estimation of OVD. The length of the fingers has also been said to correlate with the occlusal vertical dimension.[7,8] This relationship has been extensively studied with varying results in different communities worldwide.[7-11] Unfortunately, this relationship has been sparsely studied in Nigerian communities.

This study therefore sought to assess the relationship of finger lengths to OVD among a dentate cohort of adult students with the purpose of developing a best-fit predictive equation for this relationship. This will aid in making OVD determination in the edentulous more predictable and less cumbersome.

Materials and Methods

Ethical approval (NHRE/BUK-HREC/525/10/2311) was obtained from the Institutional Human Ethics Review Committee. The study was an analytical cross-sectional study involving five hundred and twenty-eight students from The College of Health Sciences, Bayero University Kano situated within The Aminu Kano Teaching Hospital Campus of the University. A proportional purposive sample among the three Faculties that make up The College was performed. The proportionate minimum samples were determined at 95% confidence level, 5% margin of error and 50% population proportion with the Sample Size Calculator (www.calculator.net). The determined sample sizes were as follows:

Allied Health Sciences: 264 from a population of 832
Clinical Sciences: 209 from a population of 455
Dentistry: 55 from a population of 63
Minimum sample size: 264 + 209 + 55 = 528

Adults of both genders who are 18 years old or older, and who signed a written informed consent form to participate were recruited. Participants had a full complement of teeth (disregarding the last molars). Participants had a stable posterior occlusion with Angles Class I jaw relationships devoid of crowding and imbrication. Participants also had all of their fingers on the non-dominant hands intact.

Potential participants who have undergone orthodontic treatment were excluded from the study, as were those who have had extensive restorations involving the occlusal surfaces of their teeth. Those who had parts of, or whole fingers missing from their non-dominant hands were also excluded from the study. Individuals who had suffered from polio, who had amputations or who are living with dwarfism or other conditions that may affect the heights they attained as adults were also be excluded from the study.

Consenting participants were sat comfortably in a chair. where the lengths of the digits on their non-dominant hand were measured with a digital caliper and recorded. The measurements were done palm side up. The distance between the most proximal crease between the digit and the body of the hand, and: the tip of the digit was taken to be the length of the digit. The participants were then sat upright with the head upright and the jaws brought to a relaxed position by asking the participant to repeat the “m” sound six to seven times. The occlusal vertical dimension was then measured with the digital caliper after the participant had been brought to comfortable centric occlusion. The measurement of occlusal vertical dimension was done from the philtrum columella angle to the mentum. The participants gender, age and ethnicity were also recorded.

Data Management and Evaluation:

The participants finger length and OVD measurements, along with their sociodemographic data were entered in an electronic spreadsheet on a personal computer and analyzed with the aid of a statistical software SPSS. IBM (version 25). Categorical data were summarized as frequencies and percentages. Means and standard deviations were determined for quantitative normally distributed data. The relationship between participant finger lengths and OVD was assessed with the Pearson correlation coefficient. Finger lengths were classified as predictor variables while occlusal vertical dimension values were categorized as outcome variables. Participants age and gender were introduced to perform a multiple hierarchical regression analysis.

A Generalized Linear Model (GLM) analysis with a Gaussian distribution, identity link function, and robust standard errors was conducted to investigate the relationship between finger lengths and occlusal vertical dimension (OVD). Two models were constructed: Model 1 examined the association between finger length and OVD, while Model 2 extended this analysis by incorporating gender as a predictor to assess its influence on the relationship.

Best fit equation was developed by evaluating Model 1 and Model 2 based on model fit ®^{2} value). Model diagnostics were conducted to evaluate the model's adequacy. The level of statistical significance was set at $p<0.05$.

Results

A total 528 participants were included in the study. The sociodemographic analysis of the study participants is shown in Table 1. Male participants accounting for 83% (n=438) were predominant, while females accounted for 17.0% (n = 90).

In terms of age distribution, the participants were relatively young, with age a mean age of 27.4 ± 2.9 years (range: 21 – 42 years). The majority were in their late 20s (65.9%, n = 348), 24.0% (n = 127) of participants were between 21-25 years, while 8.9% (n = 47) were between 31-35 years. Only 1.1% (n = 6) of participants were above 35 years. Hand dominance analysis showed that an overwhelming majority (93.9%, n = 496) of participants were right-handed, while 6.1% (n=32) were left-handed.

The anthropometric measurements recorded in this study is summarized in Table 2 and Figure 1. Finger measurements revealed an expected anatomical pattern (Figure 1), with the middle finger being the

Table 1. Sociodemographic Characteristics of Study Participants

Characteristics		n = 528
Sex		
	Male	438 (83.0)
	Female	90 (17.0)
Age, (years)		
Male	21 – 25	127 (24.0)
Female	26 – 30	348 (65.9)
	31 – 35	47 (8.9)
	> 35	6 (1.1)
Total	Mean ± SD	27.4 ± 2.9
Non-dominant hand		
Single	Left	496 (93.9)
Married	Right	32 (6.1)

SD: Standard deviation

longest (8.11 ± 0.64 cm) and the thumb and pinky finger being the shortest (5.65 ± 0.47 cm and 5.60 ± 0.57 cm, respectively). The index and ring fingers measured 7.01 ± 0.55 cm and 7.64 ± 0.65 cm, respectively. The Occlusal Vertical Dimension (OVD) averaged 7.17 ± 0.53 cm, with a range of

Table 2. Finger Lengths and Occlusal Vertical Dimension (n = 528)

Parameter(cm)	Min.	Max.	Mean±SD	95% CI
Thumb	3.50	8.40	5.65 ± 0.47	5.61 – 5.69
Index finger	5.60	8.20	7.01 ± 0.55	6.96 – 7.06
Middle finger	6.50	9.90	8.11 ± 0.64	8.05 – 8.16
Ring finger	5.50	9.80	7.64 ± 0.65	7.58 – 7.69
Pinky finger	4.50	9.20	5.60 ± 0.57	5.55 – 5.65
OVD	5.20	9.20	7.17 ± 0.53	7.12 – 7.21

SD: Standard deviation, CI: Confidence interval, OVD: Occlusal Vertical Dimension

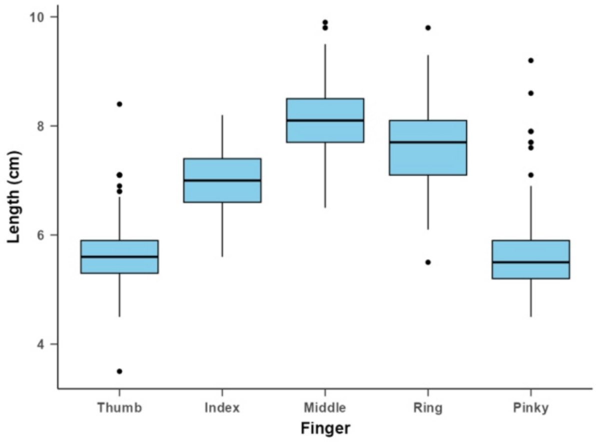

Figure 1. Distribution of Finger Length in the Study Population

Table 3: Relationship between finger length and OVD (n = 528)

	Occlusal Vertical Dimension	
Finger Length	**r**	***P*-value**
Thumb	0.26	< 0.001
Index finger	0.56	< 0.001
Middle finger	0.50	< 0.001
Ring finger	0.50	< 0.001
Pinky finger	0.18	< 0.001

SD: Standard deviation, CI: Confidence interval, OVD: Occlusal Vertical Dimension

5.20-9.20 cm and a tight 95% CI of 7.12-7.21cm.

Table 3 shows significant positive correlations between all finger lengths and OVD. The index finger exhibited the strongest correlation ($r = 0.56$, $p < 0.001$), closely followed by the middle and ring fingers (both $r = 0.50$, $p < 0.001$). In contrast, despite being statistically significant, weaker correlations were observed for the thumb ($r = 0.26$, $p < 0.001$) and pinky finger ($r = 0.18$, $p < 0.001$), suggesting that thumb and pinky finger lengths may have less influence on OVD. Scatter plot analysis (Figure 2) visually confirmed these correlations.

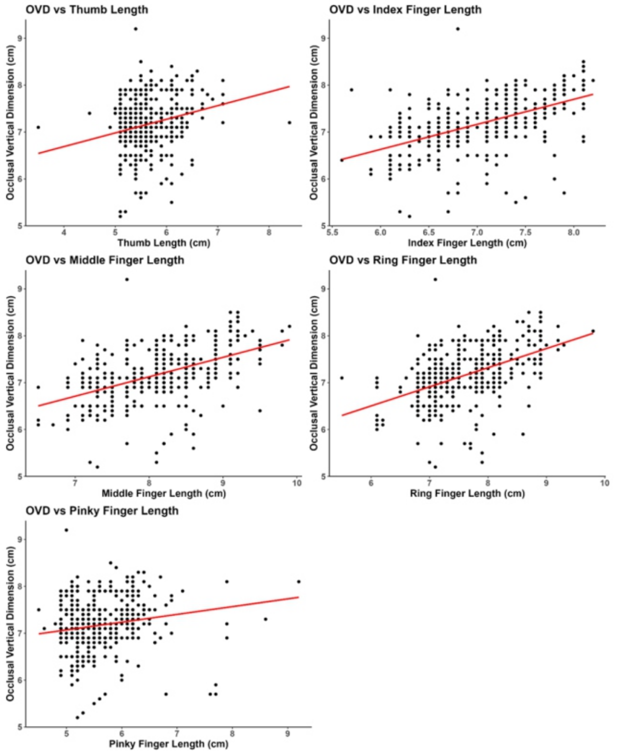

Figure 2: Scatter plot of OVD and finger length

Figure 3 illustrates the relationship between occlusal vertical dimension (OVD) and demographic parameters. The analysis revealed a very weak, statistically non-significant negative correlation between OVD and age ($r = -0.05$, $p = 0.24$).

A comparison of OVD values between males and females revealed statistically significant differences. Females exhibited higher mean OVD (7.45 ± 0.46 cm) values compared to males (7.11 ± 0.52 cm) ($p<0.001$)

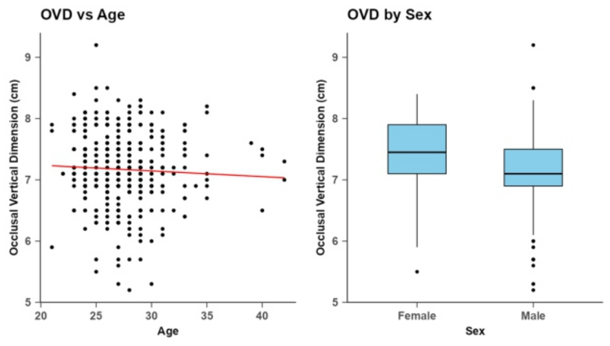

Figure 3: OVD and demographic variables

Hierarchical Multiple Regression

Potential multicollinearity tested with a correlation matrix analysis (Table 4) revealed strong interrelationships between predictor variables, particularly between Middle and Ring fingers ($r = 0.87$, $p < 0.001$) and Index and Middle fingers ($r = 0.80$, $p < 0.001$). They were thus excluded from further analysis.

Sixteen observations were excluded from the regression analysis after a Turkey Method test (outliers defined as measurements below Q1 - 1.5*IQR or above Q3 + 1.5*IQR. 512 valid observations were thus put through multiple regression (Figure 4).

Table 4. Correlation Matrix of Occlusal Vertical Dimensions (OVD) and Finger Lengths

	OVD	Thumb	Index	Middle	Ring	Pinky
OVD	1.00					
Thumb	0.26*	1.00				
Index	0.56*	0.47*	1.00			
Middle	0.50*	0.58*	**0.80***	1.00		
Ring	0.50*	0.51*	074*	**0.87***	1.00	
Pinky	0.18*	0.49*	0.45*	0.55*	0.50*	1.00

**p< 0.001*

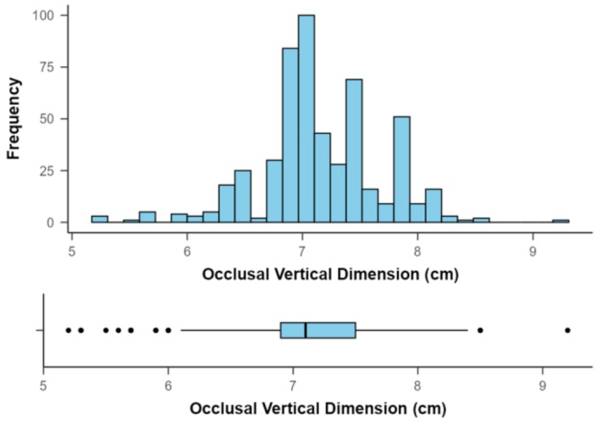

Figure 4. Histogram and Boxplot Showing the Distribution of Occlusal Vertical Dimension

The Generalized Linear Model (GLM) analysis with a Gaussian distribution, identity link function, and robust standard errors resulted in the construction of two models: Model 1 examined the association between finger length and OVD, while Model 2 extended this analysis by incorporating gender as a predictor to assess its influence on the relationship. The regression estimates for both models are presented in Table 5.

Model 1 revealed the index finger as the strongest predictor of occlusal vertical dimension (OVD), with a coefficient of 0.42 and standardized beta (β) of 0.49

Table 5. Hierarchical Multiple Regression Using Generalized Linear Models Predicting Occlusal Vertical Dimension from Finger Lengths and Gender in Young Adults (n = 512)

Model	Coaef.	95% CI for Coef.	Beta, β	P-value
Model 1				
Constant	3.44	3.00 – 387		< 0.001
Thumb finger	-0.04	-0.11 – 0.03	0.04	0.29
Index finger	0.42	0.31 – 052	0.49	< 0.001
Ring finger	0.18	0.10 – 026	0.25	< 0.001
Pinky finger	0.05	-0.12 – 0.02	0.06	014
Model 2				
Constant	3.71	3.29 – 4.13		< 0.001
Thumb finger	-0.05	-012 – 0.01	0.06	0.09
Index finger	0.41	0.31 – 0.51	0.48	< 0.001
Ring finger	0.14	0.06 – 0.23	0.20	0.001
Pinky finger	0.02	-0.05 – 0.08	0.02	0.60
Sex	-0.30	-0.37 – -0.23	0.25	< 0.001

Coef. Regression Coefficient; CI: Confidence interval.
Dependent variable: Occlusal vertical dimension
R^2: Model 1 = 42.6%, Model 2 = 48.3%
R^2 change: = 5.7% (F (1, 506) = 56.460, p < 0.001)

(p < 0.001). The ring finger also emerged as a significant predictor (coefficient = 0.18, β = 0.25, p < 0.001). In contrast, thumb and pinky measurements did not contribute significantly to OVD prediction. This model demonstrated a good fit, accounting for 42.6% of the variance in OVD (F (4, 507) = 93.94, p < 0.001).

The introduction of participants' sex (0 = female, 1 = male) in Model 2 (Table 5) significantly improved the GLM analysis, investigating its influence on the relationship between finger lengths and occlusal vertical dimension (OVD). Model 2 yielded excellent fit (F (5, 506) = 94.66, p < 0.001), with sex emerging as a significant independent predictor (coefficient = -0.30, β = 0.25, p < 0.001). The addition of sex enhanced model fit by 5.7%, and this incremental change in R^2 was statistically significant (F (1, 506) = 56.460, p < 0.001). Notably, the index finger remained the strongest predictor (coefficient = 0.41, β = 0.48, p < 0.001), followed by the ring finger, whose effect was slightly reduced but remained significant (coefficient = 0.14, β = 0.20, p = 0.001). Thumb and pinky measurements remained non-significant predictors (Table 5).

Model fit (R^2 value) revealed the extended model (Model 2) as the superior choice. This model explained 48.5% of the variance in OVD. The final predictive equation only included predictors with statistical significance (p < 0.05) and meaningful effect sizes (β). Consequently, the best fit predictive equation was:

OVD = 3.57 + (0.41 × Length of index finger) + (0.14 × Length of ring finger) – (0.32 × Sex).

Where:

- OVD, Index and ring finger lengths are in centimeters
- Sex: Male = 1, Female = 0

Model diagnostics to evaluate the model's adequacy (Figure 5) revealed a generally normal distribution of residuals, no severe influential points, and reasonable spread of residuals around zero. Although minor violations of linearity and homoscedasticity assumptions were detected, they did not substantially compromise the analysis. Overall, the model demonstrated acceptable performance.

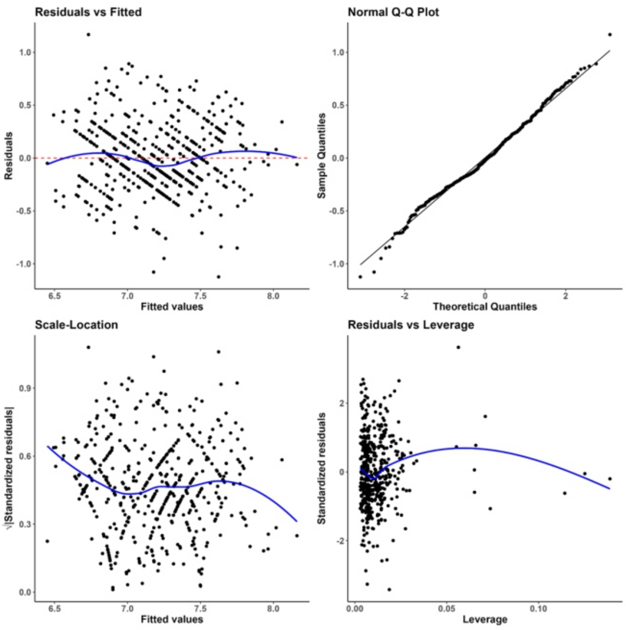

Figure 5: Diagnostic Plots Assessing Model Assumptions

Discussion

Alhajj and coworkers drew attention to the empirical nature of OVD determination for complete denture patients.[1] They advocated the use of multiple modalities by clinicians in OVD determination for these patients.[1] One of the established means of estimating OVD is the application of anthropometric measurements in its estimation. The use of facial heights to refine the estimation of OVD is one of such anthropometric measurements, and has been proposed severally in the literature.[3,4,5] However; Adeyemi et al recently propounded a best fit model equation to introduce some measure of objectivity to the process.[5] We have similarly sought to establish a similar equation for another anthropometric measure reported to be related to OVD.

The lengths of the fingers are another anthropometric measure that have also been shown to bear some relationship to the OVD in the literature.[7-11] However, there have been few attempts to develop a predictive formula for estimating OVD from these relationships. This was our prime motivation for carrying out this study. We were also encouraged to carry out this study due to a failure to find studies within Nigeria which have had similar objectives. We developed a methodology guided by the work of Adeyemi et al,[5] the successful results they obtained guided the development of our statistical model. However, we were conscious of the fact that it would be advantageous to assess and compare the relationships of all the fingers to OVD if we are to comprehensively assess potential relationships.

We employed a proportionate sampling technique to attract participation that would be representative, as much as is possible, of the population we studied. Sharma in his review article drew attention to the need to make subgroup samples proportional to the differences in their population.[12] Rahman proposed a conceptual definition of non-probability sampling to be a sampling technique where participants do not have an equal chance of selection.[13] He suggested that the purposive variant of non-probability sampling be used when the study population shares similar characteristics.[13] He advised that a quota (or proportionate) sampling is performed when there are distinct subgroups within the study population. This will allow for the selection of a representative sample from the population. These suggestions guided the sampling technique adopted in this study.

The study was set in Kano. This is a predominantly Muslim populated area of Northern Nigeria. As Alexander and Welzel pointed out, Islam is often associated with patriarchy as exemplified by the nature of mosque attendance.[14] They did however, point out that the level of patriarchy seems to reduce with increasing levels of education and the pressures of economic realities.[14] Odok drew attention to the Salafist nature of Northern Nigerian Islam and how this version refutes novelty.[15] He however recognized the institution of various women empowerment programs which have improved female participation in public life.[15] He compares this to a return to pre-Salafist Northern Nigeria where women played a greater role in public life. Scholars including Ahmed and Yola[33] have continued to propose a change in this regard.[14-16]

The age range of our participants is not unexpected. Umeizudike and colleagues in a survey of Nigerian dental students related to the impact of the COVID pandemic found an average age range of 25.3±2.4 years among their respondents[17] Adejumo and coworkers found a mean age of 21.5±2.5 years among nursing students with regards to their desire to serve as COVID volunteers.[18] The relatively older age of participants in this study cannot be divorced from the slower penetration of western education in Northern Nigeria. Ukeje and Aisiku gave a detailed review of the development of Western education in Nigeria in a textbook on the subject matter.[19]

The choice of the digits from the non-dominant hand was informed by documented asymmetry between the limbs. This has often been ascribed to slight hypertrophy of the dominant limb due to the greater levels of exercise that it receives from its increased activity. This asymmetry was alluded to by Wang and Fu in their 2019 paper on the differences in kinetic ranges between dominant and non-dominant limbs during exercise.[20] The proportion of left-handed individuals in this study is slightly less than, but still similar to the 9.3% determined by Papadatou-Pastou and coworkers in their recent metaanalysis.[21]

Gender has been shown to influence the relationship between anthropometric values and OVD. Adeyemi et al,[5] in their effort to relate facial heights with OVD found gender to affect the relationship they observed. The predictive equation they arrived at could explain 45% of the variance in OVD, while the equation we arrived at in this study can explain 48% of the variance in OVD among our respective study populations. It would be interesting to see if a combination of these two anthropometric measures can produce a predictive equation that will explain even a greater amount of the variance with OVD.

Conclusion: The students in the college of health sciences were predominantly male and right-handed. There was a strong relationship between the length of the index finger and OVD among the study participants which was influenced by gender. This relationship can be summarized mathematically as:

$$OVD = 3.57 + (0.41 \times \text{Length of index finger}) + (0.14 \times \text{Length of ring finger}) - (0.32 \times \text{Sex}).$$

(Where OVD, Index and ring finger lengths are in centimeters; Sex: Male = 1, Female = 0)

Acknowledgement: The authors are grateful to the Deaneries of the Faculties of Allied Health Sciences, Clinical Sciences and Dentistry of Bayero University Kano for furnishing us with their student population on The Aminu Kano Teaching Hospital campus of the University.

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