

# Changes in Tinnitus Perception in Post-9/11 Service Members and Veterans: A Five-Year Markov Analysis

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## INTRODUCTION

Tinnitus is prevalent in military Service members and Veterans<sup>1</sup>. There remain gaps in our understanding of how tinnitus develops and changes over time. To address the distribution, determinants, progression, and latent development of tinnitus during and following military service, we initiated a longitudinal epidemiological examination of active-duty Service members and Veterans recently-separated from the military. *The objective of this analysis was:*

**To describe intraindividual change in the temporal parameters of tinnitus perception in military personnel over a period of five years.**

## MATERIALS AND METHODS

### Noise Outcomes in Service members Epidemiology Study NOISE Study<sup>2</sup>

#### Study Sample:

- 535 Service member and 579 Veteran participants (total n=1,114).
- Veterans within 2.5 years of separation and Active-Duty Service members (ADSM) are eligible for the NOISE study.

#### Data Collection:

- Comprehensive audiological evaluation and self-report questionnaires, includes determination of tinnitus status.
- Follow-up questionnaires on a yearly basis over a 5-year period (n=3,260).

#### Tinnitus Classification:

- Tinnitus categories "No Tinnitus", "Temporary/Occasional", "Intermittent", or "Constant" were defined using the Tinnitus Screener (TS).<sup>3</sup>

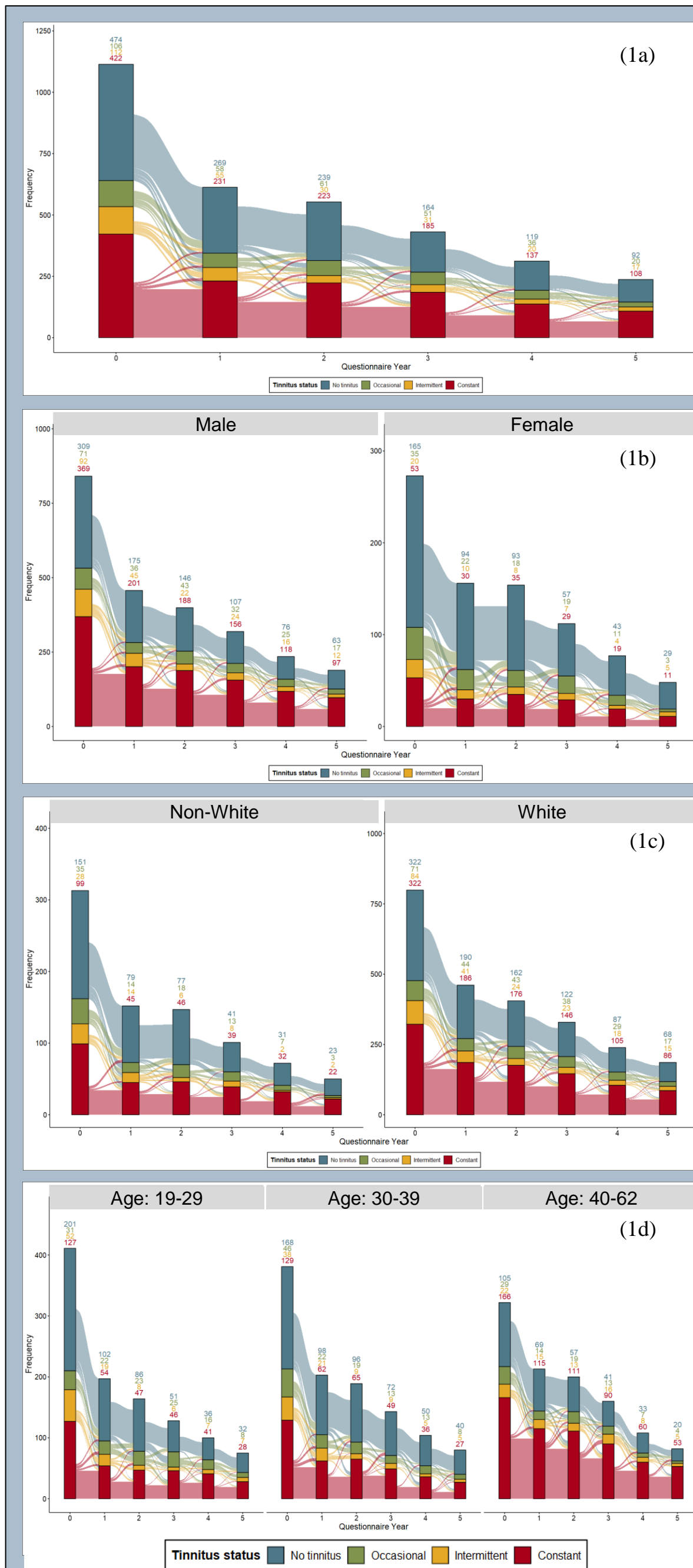
#### Statistical Methods:

- Markov chain models were used to describe and estimate (time-homogeneous) probabilistic transitions between tinnitus categories over study time points.
- Transitions across tinnitus categories by age tertiles (19-29, 30-39, 40-62 years), sex (men, women), and race (white, non-white) were examined.

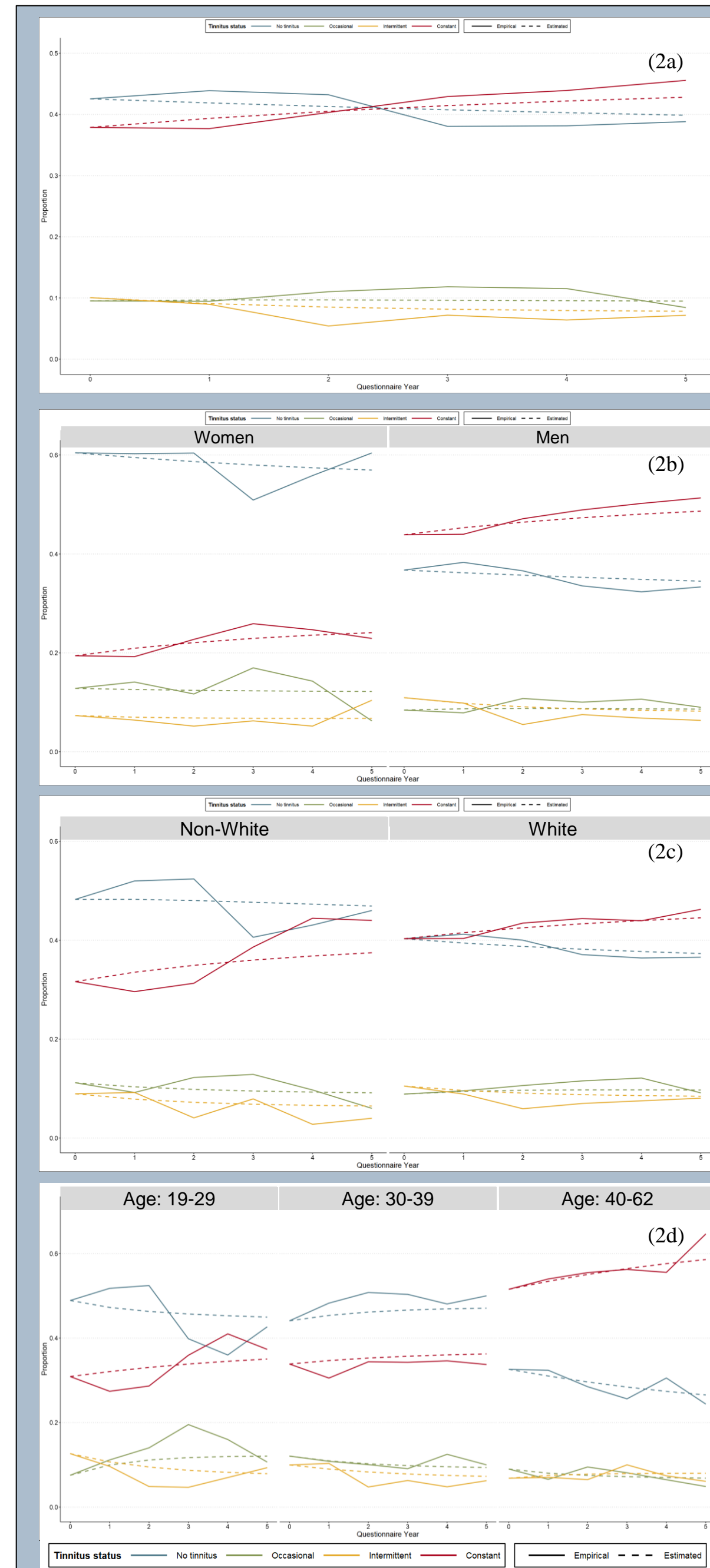
**Table 1.** Study sample demographics by tinnitus category at baseline.

	No tinnitus (N=474)	Occasional (N=106)	Intermittent (N=112)	Constant (N=422)	Overall (N=1114)
<b>Age (years)</b>	32.9 (8.46)	34.5 (8.23)	32.3 (7.51)	36.8 (9.86)	34.5 (9.10)
<b>Sex</b>					
Male	309 (65.2%)	71 (67.0%)	92 (82.1%)	369 (87.4%)	841 (75.5%)
Female	165 (34.8%)	35 (33.0%)	20 (17.9%)	53 (12.6%)	273 (24.5%)
<b>Ethnicity</b>					
Non-Hispanic	392 (82.7%)	90 (84.9%)	103 (92.0%)	363 (86.0%)	948 (85.1%)
Hispanic	77 (16.2%)	14 (13.2%)	8 (7.1%)	54 (12.8%)	153 (13.7%)
Decline to answer	5 (1.0%)	2 (1.9%)	1 (0.9%)	5 (1.2%)	13 (1.2%)
<b>Race</b>					
Non-White	98 (20.7%)	20 (18.9%)	18 (16.1%)	52 (12.3%)	188 (16.9%)
White	322 (67.9%)	71 (67.0%)	84 (75.0%)	322 (76.3%)	799 (71.7%)
More than 1 race	42 (8.9%)	12 (11.3%)	8 (7.1%)	33 (7.8%)	95 (8.5%)
Decline to answer	12 (2.5%)	3 (2.8%)	2 (1.8%)	15 (3.5%)	33 (2.9%)
<b>Military Status</b>					
Service member	289 (61.0%)	54 (50.9%)	32 (28.6%)	160 (37.9%)	535 (48.0%)
Veteran	185 (39.0%)	52 (49.1%)	80 (71.4%)	262 (62.1%)	579 (52.0%)
<b>Service (years)</b>	10.5 (7.59)	12.4 (7.68)	9.74 (6.31)	14.2 (9.14)	12.0 (8.31)
<b>Branch</b>					
Army	127 (26.6%)	29 (27.4%)	61 (54.5%)	175 (41.5%)	391 (35.1%)
Marines	29 (6.1%)	15 (14.2%)	14 (12.5%)	44 (10.4%)	102 (9.2%)
Navy	61 (12.9%)	15 (14.2%)	13 (11.6%)	56 (13.3%)	145 (13.0%)
Air Force	258 (54.4%)	47 (44.3%)	24 (21.4%)	146 (34.6%)	475 (42.6%)
<b>Combat Deployment</b>					
No	223 (47.0%)	31 (29.2%)	19 (17.0%)	90 (21.3%)	363 (32.6%)
Yes	251 (53.0%)	75 (70.8%)	93 (83.0%)	332 (78.7%)	751 (67.4%)

## RESULTS



**Figure 1a-d.** Tinnitus progression alluvial plots showing the transition of tinnitus across categories (states) over time (questionnaire year where time 0 = baseline). Each colored block represents a tinnitus category with block height proportional to the number of individuals reporting tinnitus. The width of the colored lines is proportional to the transition quantity. Panel 1a displays the overall transition. Panel 1b displays the results stratified by sex, 1c displays the results stratified by race, and 1d displays the results stratified by age.



**Figure 2a-d.** Proportion of sample with each tinnitus category over time. Each color is a different tinnitus category. Solid line plots the empirical data, and the dashed lines plot the estimated trend over time. Overall (panel 2a), the proportion of the sample with constant tinnitus (red lines) increased over time and the proportion with no tinnitus decreased (blue lines). Men are more likely than women (panel 2b) to report constant tinnitus across all time points and higher rates of transitions. Similar patterns in the proportion with constant tinnitus were observed among individuals identifying as white (2c), and among older individuals (2d).

## DISCUSSION

- Among those with no tinnitus, occasional tinnitus, or intermittent tinnitus at baseline, the probability of transitioning to a state of constant tinnitus was 5.3%, 9.2% and 16.8% year-to-year, respectively.
- Conversely, among those with occasional tinnitus, intermittent tinnitus, or constant tinnitus, the probability of transitioning to a no-tinnitus state was 25.5%, 11.1%, and 3.8% year-to-year, respectively.
- For the entire cohort, distribution of tinnitus states remained consistent year-to-year, with a slight increase in those reporting constant tinnitus and a slight decrease in those reporting no tinnitus.
- Participants 40 and older at baseline consistently reported constant tinnitus at a higher rate than any other state and at a higher rate than participants in younger tertiles.
- Men are more likely than women to report constant tinnitus and remain in the constant tinnitus state over time (92.4% and 82.2%, respectively).
- Women tend to transition to no tinnitus from every other tinnitus state at higher rates than men, but the rates are more similar when it comes to transitioning into the constant tinnitus state.
- The non-white race cohort showed lower rates of constant tinnitus than the white race cohort and higher rates of no tinnitus. Both cohorts had similar increasing estimated trends of reporting constant tinnitus.

## CONCLUSION

Understanding the distribution and changes in tinnitus over time within military populations is critical to inform prevention and disruption of tinnitus progression. Our results suggest that the frequency of experiencing tinnitus grows slightly over time, during and shortly after military service. More aggressive interventions are needed to address tinnitus progression. Next steps include examining possible tinnitus progression risk factors, such as excessive exposure to noise and traumatic brain injury.

## REFERENCES

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**Table 2.** Estimated probability of transitioning between tinnitus categories from year-to-year.

	No Tinnitus	Occasional	Intermittent	Constant
No Tinnitus	0.867	0.057	0.023	0.053
Occasional	0.255	0.590	0.062	0.092
Intermittent	0.111	0.083	0.639	0.168
Constant	0.038	0.021	0.029	0.911

**Table 3.** Estimated probability of transitioning between tinnitus categories from year-to-year stratified by sex.

	No Tinnitus	Occasional	Intermittent	Constant
<b>Men</b>				
No Tinnitus	0.862	0.051	0.026	0.061
Occasional	0.237	0.612	0.066	0.085
Intermittent	0.105	0.079	0.650	0.165
Constant	0.031	0.018	0.027	0.924
<b>Women</b>				
No Tinnitus	0.877	0.066	0.017	0.040
Occasional	0.297	0.546	0.054	0.103
Intermittent	0.134	0.099	0.596	0.171
Constant	0.087	0.044	0.047	0.822

**Table 4.** Estimated probability of transitioning between tinnitus categories from year-to-year stratified by race.

	No Tinnitus	Occasional	Intermittent	Constant
<b>Non-White</b>				
No Tinnitus	0.889	0.051	0.022	0.038
Occasional	0.335	0.529	0.043	0.092
Intermittent	0.113	0.077	0.524	0.286
Constant	0.095	0.019	0.022	0.864
<b>White</b>				
No Tinnitus	0.877	0.055	0.023	0.046
Occasional	0.285	0.568	0.054	0.093
Intermittent	0.110	0.081	0.599	0.210
Constant	0.056	0.020	0.026	0.898

**Table 5.** Estimated probability of transitioning between tinnitus categories from year-to-year stratified by age.

	No Tinnitus	Occasional	Intermittent	Constant
<b>19-29 years</b>				
No Tinnitus	0.869	0.067	0.028	0.037
Occasional	0.266	0.596	0.036	0.102
Intermittent	0.109	0.091	0.664	0.136
Constant	0.045	0.034	0.022	0.900
<b>30-39 years</b>				
No Tinnitus	0.894	0.044	0.013	0.048
Occasional	0.251	0.628	0.064	0.057
Intermittent	0.118	0.064	0.671	0.147
Constant	0.051	0.023	0.028	0.898
<b>40-62 years</b>				
No Tinnitus	0.820	0.061	0.030	0.088
Occasional	0.247	0.523	0.096	0.134
Intermittent	0.106	0.092	0.574	0.229
Constant	0.026	0.013	0.033	0.927

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