Nonmelanoma Skin Cancer in the United States General Population: A Systematic Review and Comparison to the United States Astronaut Corps

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Background and Objectives

- In preparation for exploration-class missions, NASA is evaluating medical risk for astronauts via an evidence-based, population-driven approach.
- One of the goals of this risk evaluation is to assess whether the current astronaut population falls within expected population norms for cancer.
- Among US astronauts, the most common types of cancer are basal (BCC) and cutaneous squamous cell carcinoma (cSCC), commonly referred to as nonmelanoma skin cancer (NMSC).
- **The purpose of this project is to review U.S. general population (GP) data for NMSC to benchmark clinical decision-making for surveillance of NMSC within the Astronaut Corps.**

Methods

- Systematic review of published literature to understand the **incidence, prevalence** and **mortality and the changes** over time for NMSC in the US adult general population using PRISMA guidelines.[1]
- Medical data on NMSC cases among astronauts was extracted from NASA records available by December 31, 2019.
- Astronaut data will be compared to general population data.

PRISMA Flow Diagram

- A total of 2,029 titles and abstracts were screened independently by two reviewers.[1]
- Full-text evaluation was conducted on 117 articles by a single reviewer, of which 19 met criteria.
- EndNote was used to manage records and data.
- Articles will be reported according to the PRISMA system.

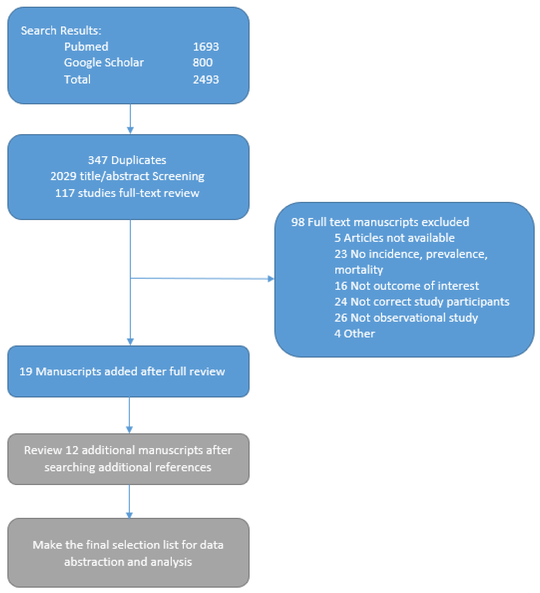

Figure 1. PRISMA flow diagram of identification, screening, eligibility and inclusion for incidence, prevalence, and mortality rates of NMSC.

Descriptive Results of NMSC among Astronauts

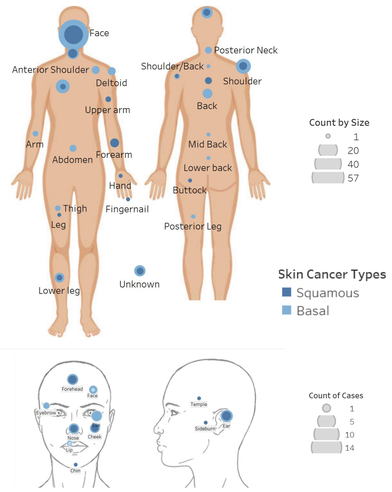

Figure 2. Anatomic Location of NMSC on NASA Astronauts and Payload Specialists through 12/31/2018.

Characteristics	Cases	Number of Crew	Range of Case Count
Basal	180	79	1-11
Squamous	73	40	1-6
Unknown Type	3	3	1
Total	**256**	**99**	**1-14**
Male	237	92	
Female	19	7	
Pre-selection	2		
Active	62		
Former	192		
Average age first case = 56 years (range 33-86)			
Average age all cases = 60 years (range 33-86)			

Table 1. Astronaut Case Data through 12/31/2019.

Results of Systematic Literature Review

Source	Study Period	Population	Outcome	Results		
				Overall	Male	Female
Incidence						
Christenson, *et al.*	1976-2003	U.S. General Population	IR	BCC: 31-35 years: 54.5 BCC: 36-39 years: 93 cSCC: 31-35 years: 7.6 cSCC: 36-39 years: 17.4		
Chuang, *et al.*	1976-1984	U.S. General Population	AAIR	BCC: 146	BCC: 175	BCC: 124
Chuang, *et al.*	1976-1984	U.S. General Population	AAIR	cSCC: 38.3	cSCC: 63.1	cSCC: 22.5
Dacosta, *et al.*	2010	U.S. General Population	AAIR	NMSC: 693		
Fears, *et al.*	1971-1972 1977-1978	U.S. General Population	AAIR	Increased for BCC & SCC from 1972 to 1978		
Grayson, *et al.*	1975-1989	U.S. Military	SIR	1.45 (0.90-2.20)		
Hoy, *et al.*	1977-1978	U.S. General Population	AAIR		BCC: 1073 cSCC: 214	BCC: 415 cSCC: 50
Lee, *et al.*	2005-2014	U.S. Military	IR	NMSC: 64.6		
Miller, *et al.*	1994	U.S. General Population	Incidence	NMSC: 900,000 – 1.2 mil		
Muzic, *et al.*	2000-2010	U.S. General Population	AAIR		BCC: 360 cSCC: 207.5	BCC: 292.9 cSCC: 128.8
Nguyen et al.	1976-2008 1989-2009 1986-2008	U.S. General Population	IR	cSCC: 1265 cSCC: 389 cSCC: 2154		
Reizner, *et al.*	1983-1987	U.S General Population	AAIR	BCC: 422	BCC: 576	BCC: 298
Rogers, *et al.*	2006 2012	U.S. General Population	Incidence	2006 NMSC: 4,013,890 2012 NMSC: 5,434,193		
Wu, *et al.*	1986-1990 2004-2006	U.S. General Population	IR		BCC: 606 BCC: 1,488	BCC: 519 BCC: 1,019
Prevalence						
Chahal, *et al.*	2005-2015	U.S. General Population	LP	BCC: 10.6% >60 y/o cSCC: 6% > 60 y/o		
McNeely, *et al.*	2014-2015	U.S. Civilian Aircrew	ASPR	NMSC: 4.09		
Mortality						
Lewis, *et al.*	1969-2000	U.S. General Population	AAMR	NGNMSC: 0.69		
Weinstock, *et al.*	1979-1987	U.S. General Population	AAMR	NMSC: 0.44		
Wu, *et al.*	1999-2010	U.S. General Population	AAMR		NGNMSC: 0.92	NGNMSC: 0.30

AAMR: age-adjusted mortality rate, AAIR: age-adjusted incidence rate (95% confidence interval) per 100,000 people, SIR: standardized incidence ratios; ASPR: age-standardized prevalence ratio (95% confidence interval), BCC: basal cell carcinoma, cSCC: cutaneous squamous cell carcinoma, IR: incidence rate (95% confidence interval) per 100,000 people, LP: lifetime prevalence, NGNMSC: non-genital nonmelanoma skin cancer, NMSC: nonmelanoma skin cancer

Table 2. Included manuscripts for data abstraction and analysis. References available upon request.

Challenges of NMSC Systematic Review

- NMSCs are excluded from national cancer registries such as Surveillance, Epidemiology and End Results (SEER).
- The few estimates of NMSC incidence in the United States utilize information from large surveys, healthcare system databases, or population-based Cohort studies.
- Regional study results vary due to latitude, sun exposure, and case definition.

Discussion

- Multiple observational studies have estimated that the incidence of NMSCs in GP surpasses the number of all other cancers combined.[2]
- NMSC incidence in GP is growing at an exponential rate — between 1976-1984 and 2000-2010, the overall incidence of basal cell carcinoma increased by 145%, and the overall incidence of cutaneous squamous cell carcinoma increased by 263%.[3]
- Increase in incidence could be true change, changes in patterns of diagnosis, and/or greater physician awareness.
- The highest rates in the general population were observed in older, white, non-Hispanic males.
- One study conducted on U.S. service members showed higher crude rates of NMSC for Air Force members compared to other branches, those with higher levels of educational attainment, and those in aviation-related occupational groups.[4]
- Female incidence is increasing, especially in younger ages.
- Prognosis for NMSC is generally excellent with low mortality rates.

Future Directions

- **Next steps**: Review additional references, complete systematic review process, and compare to U.S. Astronaut Corps data.
- **Future limitations**: Limited number of subjects in Astronauts Corps, limited number of cases and finding the analog population.
- **Potential analog populations for comparison:** military, civilian aircrew, and health care workers.
- Consider the association with space radiation and the potential correlation with incidence/prevalence/mortality.
- Understanding NMSC incidence and associated risk factors is important for planning of prevention strategies and allocations of resources in the future.
- Based on the outcomes, recommendations will be given for any changes in disease surveillance.

Sources

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4. Lee, T., Taubman, S. B., & Williams, V. F. (2016). Incident diagnoses of non-melanoma skin cancer, active component, U.S. Armed Forces, 2005-2014. Msmr, 23(12), 2-6.